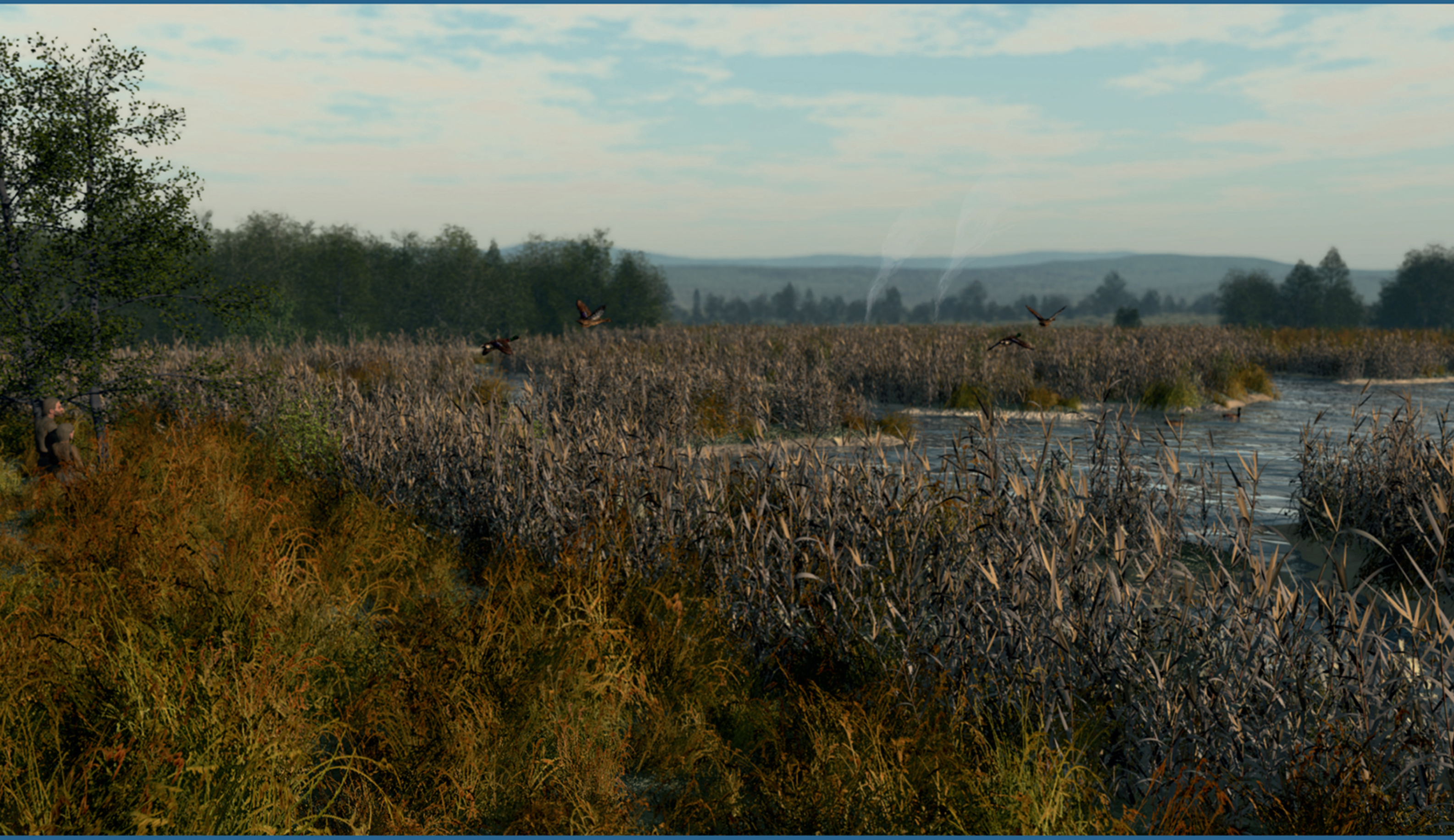

Prehistoric Ebbsfleet

Excavations and Research in Advance of High Speed 1 and South Thameside Development Route 4, 1989–2003

By Francis Wenban-Smith, Elizabeth Stafford, Martin Bates and Simon A. Parfitt

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Excavations in the Lower Ebbsfleet Valley at Northfleet Villa were managed for Oxford Archaeology by Stuart Foreman and Richard Brown. The Project Officer was Paul Murray. On-site production of digital mapping was carried out by Laura Hindmarsh. The onsite geoarchaeological and environmental strategies were implemented by Martin Bates and Elizabeth Stafford and processing by Richard James. Finds management was carried out by Claire Rawlings and Rob Radford. Supervisors on the Villa site were Emily Glass, John Payne, Simon Greenslade, Emma Noyce, Gerry Thacker, and Mike Simms. Dana Goodburn-Brown (AMTEC) provided much conservation advice and on site specialist recording of the waterlogged wood was provided by Damian M. Goodburn.

Excavations in the Upper Ebbsfleet Valley at Springhead were managed for Wessex Archaeology by Mick Rawlings. Phil Andrews directed work on both the Sanctuary site and the Roadside settlement, with Mike Trevarthen acting as Project Officer on the latter. Amongst those who deserve special mention are Barry Hennessy, Hilary Valler, Neil Fitzpatrick, Steve Thompson, and Nick Cooke. Rob De'Athe, Jon Martin, and Barry Hennessy undertook various parts of the watching briefs at Springhead as well as in the surrounding area in 2002–3. Several of the site staff were present for substantial periods of the fieldwork and deserve mention: Andrew Armstrong along with Emma Davidson and Howard Brown, as well as Rebecca Fitzpatrick, Claire Gannon, Richard Kelleher, Nick Plunkett, Gareth Thomas, and the late Gary Wickenden.

Excavations for STDR4 in the Ebbsfleet Valley were managed on behalf of KCC by Lis Dyson. Ken Welsh managed the evaluation phase for Oxford Archaeology, and Stuart Foreman the excavation and post-excavation phases. The Project Officer for the evaluation stage was Steve Lawrence, and for the excavation, Andrew Mayes. The onsite geoarchaeologist was Martin Bates. Jacksons Civil Engineering was the Principal Contractor responsible for building the road, who provided extensive engineering support for the deep cofferdam excavations.

The lengthy and equally complex programme of post-excavation work for HS1, beginning in 2005, and undertaken by the Oxford Wessex Archaeology Joint Venture, was managed by Andrew Crockett of Wessex Archaeology and the Principal Study Leader was Francis Wenban-Smith. It is appropriate here at the outset to warmly thank all of the specialists and illustrators who have made contributions to the publication of the work and these are listed individually on the title page. The post-excavation teams would like to specifically highlight and acknowledge the following contributions:

The co-ordination of much of the programme of finds assessment and analysis was undertaken by Lorraine Mepham and Leigh Allen. The programme of environmental assessment and analysis was co-ordinated by Catherine Barnett and Elizabeth Stafford, assisted by Sarah Wyles, Hayley Clark, Dawn Irving and Luke Howarth. Sandra Bonsall prepared the pollen slides for samples from the Lower Ebbsfleet Valley and the Geography Department of the University of Lancaster is thanked for the use of their laboratory facilities. The post-excavation team is particularly grateful to Georgina Slater, principal illustrator for the project, for gathering together and ordering the large number of figures and plates and ensuring consistency in their style and quality. The worked flint was drawn by Sarah Lambert-Gates and Sophie Lamb and photographed by Magdalena Wachnik. The Ebbsfleet Ware bowl from the STDR4 investigations was photographed by Lucy Martin.

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Abstract

The construction of High Speed 1 (HS1; formerly the Channel Tunnel Rail Link) entailed a major programme of archaeological investigations across Kent, Essex and Greater London. This volume, the last in a series of reports, presents the archaeological results from investigations in the Ebbsfleet Valley undertaken between 1997 and 2003 on HS1. It also incorporates the results from the associated South Thameside Development Route 4 (STDR 4) road link improvements in the Lower Ebbsfleet Valley carried out for Kent County Council in 2000 and 2001, and investigations on the Ebbsfleet Development (Northfleet Rise) site carried out in 1997. The results of the 2004 Oxford Archaeology early Palaeolithic 'Ebbsfleet elephant' excavation, carried out late in the HS1 construction programme, are reported separately (Wenban-Smith 2013).

This volume concerns the HS1 study theme defined as 'Prehistoric Ebbsfleet'. It focuses on landscape development and human occupation from the Palaeolithic through to the Early Iron Age, a span of around 300,000 years. This period incorporates fluctuating extremes of climate between harsh sub-arctic conditions when southern Britain would have been a frozen and uninhabitable treeless waste, and warmer interludes when luxuriant forest was interspersed with grassy plains, rich in what we would now regard as tropical fauna, such as lion, hippopotamus and hyaena.

The Ebbsfleet Valley and its immediate area are rich in prehistoric remains, and the area has seen numerous investigations carried out from the 19th century onwards. Despite the lack of 'modern' excavation and recording methods, these sites have produced some nationally important sites including Baker's Hole – Britain's foremost Palaeolithic site with Levalloisian flint artefacts – rare evidence for 'Long Blade' occupation of Final Palaeolithic date, and the type-site for Neolithic Ebbsfleet Ware pottery.

The approach taken in this volume is to develop a framework for the changing landscape and environment of the Ebbsfleet Valley through this period, and to present the evidence of human occupation against this background. Although direct human evidence is largely lacking from the present investigations, the prolific results of earlier work have been integrated with the environmental and dating framework established as a result of the HS1 and STDR 4 works.

The results are initially presented by Zone within the Ebbsfleet Valley, with detailed specialist reports and development of zonal environmental and dating frameworks. The zonal results are then combined into an overall synthesis and discussion. A reappraisal of the important Palaeolithic flint artefact collections from Baker's Hole and the Ebbsfleet Channel is also presented.

Zusammenfassung

Der Bau der High Speed 1-Trasse (HS1; ehemals Channel Tunnel Rail Link) erforderte ein umfangreiches Programm archäologischer Untersuchungen in Kent, Essex und im Großraum London. In diesem Band, dem letzten einer Reihe von Monografien, werden die archäologischen Ergebnisse der HS1-Untersuchungen im Ebbsfleet-Tal zwischen 1997 und 2003 vorgelegt. Außerdem werden auch die Ergebnisse des für die Grafschaftsverwaltung von Kent in den Jahren 2000 und 2001 im Rahmen der South Thameside Development Route 4 (STDR 4) durchgeführten Straßenausbaus im unteren Ebbsfleet-Tal sowie die 1997 durchgeführten Untersuchungen am Baugebiet Ebbsfleet Development (Northfleet Rise) berücksichtigt. Die Ergebnisse der 2004 von Oxford Archaeology vorgenommenen Ausgrabung des frühpaläolithischen „Ebbsfleet-Elefanten", die gegen Ende des HS1-Bauvorhabens stattfand, wurden bereits separat vorgelegt (Wenban-Smith 2013).

Dieser Band ist dem HS1-Forschungsschwerpunkt „Prähistorisches Ebbsfleet" gewidmet. Das Hauptaugenmerk liegt auf Landschaftsentwicklung und menschlicher Besiedlung vom Paläolithikum bis zur frühen Vorrömischen Eisenzeit, einer Zeitspanne von rund 300.000 Jahren. In diesem Zeitraum schwankten Klimaextreme zwischen harten subarktischen Bedingungen, in denen der Süden Großbritanniens eine eisige und unbewohnbare baumlose Wüste war, sowie wärmeren Zwischenphasen, in denen üppiger Wald mit grasbewachsenen Ebenen durchsetzt war und eine reiche Fauna mit Löwe, Flusspferd und Hyäne aufwies, die wir heute als tropisch bezeichnen würden.

Das Ebbsfleet-Tal und seine unmittelbare Umgebung ist reich an prähistorischen Hinterlassenschaften, und seit dem 19. Jahrhundert wurden hier zahlreiche Untersuchungen durchgeführt. Trotz des Fehlens „moderner" Ausgrabungs- und Dokumentationsmethoden finden sich unter diesen Fundstellen einige national wichtige Fundplätze, darunter Baker's Hole – Großbritanniens wichtigster paläolithischer Fundort für Feuersteingeräte in Levallois-Technik – sowie seltene Hinweise für die Anwesenheit von „Long Blade" Gruppen endpaläolithischen Datums und der Referenzfundort der neolithischen „Ebbsfleet Ware" Keramik.

Der Band verfolgt den Ansatz, einen Rahmen für die sich in dieser Zeit verändernde Landschaft und Umwelt des Ebbsfleet-Tals zu entwickeln und die Hinweise auf menschliche Besiedlung vor diesem Hintergrund darzustellen. Obwohl direkte menschliche Nachweise in den vorliegenden Untersuchungen weitgehend fehlen, wurden die umfangreichen Ergebnisse früherer Arbeiten in den Umwelt- und Datierungsrahmen integriert, der auf Grundlage der Untersuchungen im Rahmen von HS1 und STDR 4 erarbeitet wurde.

Die Ergebnisse werden eingangs nach Zonen innerhalb des Ebbsfleet Tals getrennt präsentiert, mit detaillierten Fachberichten sowie der Entwicklung zonaler Umwelt- und Datierungsrahmen. Die nach Zonen getrennten Ergebnisse werden dann in einer Gesamtsynthese zusammengefasst und diskutiert. Darüber hinaus wird auch eine Neubewertung der wichtigen Fundsammlungen paläolithischer Feuerstein-Artefakte aus Baker's Hole und dem Ebbsfleet-Kanal vorgenommen.

Translation: Jörn Schuster,
ARCHÆOLOGICALsmallFINDS

Résumé

La construction de High Speed 1 (HS1 ; anciennement la liaison ferroviaire rapide avec le tunnel sous la Manche = Channel Tunnel Rail Link) a nécessité un important programme d'investigations archéologiques dans le Kent, l'Essex et le Grand Londres. Ce volume, le dernier d'une série de rapports, présente les résultats des fouilles archéologiques menées dans la vallée d'Ebbsfleet entre 1997 et 2003 sur le HS1. Il intègre également les résultats des travaux d'amélioration de la route 4 de l'aménagement de la rive sud de la Tamise (STDR 4) dans la basse vallée d'Ebbsfleet, réalisés pour le conseil du comté du Kent en 2000 et 2001, et des études sur le site d'aménagement d'Ebbsfleet (Northfleet Rise), réalisées en 1997. Les résultats des fouilles d'Oxford Archaeology de 2004 sur l'éléphant d'Ebbsfleet, datant du début du Paléolithique, effectuée tardivement dans le programme de construction du HS1, étaient présentés séparément (Wenban-Smith 2013).

Ce volume se concerne avec le thème d'étude HS1 défini comme « Ebbsfleet préhistorique ». L'accent est mis sur le développement du paysage et l'occupation humaine depuis le Paléolithique jusqu'au début de l'Âge du Fer, une période d'environ 300 000 ans. Cette période comprend des conditions climatiques extrêmes fluctuantes entre des conditions subarctiques extrêmes où le sud de la Grande-Bretagne aurait été un désert froid sans arbres et inhabitable, et des intermèdes plus chauds où la luxuriante forêt était parsemée de plaines herbeuses, riches en ce que nous considérons maintenant comme une faune tropicale comme le lion, l'hippopotame et hyène.

La vallée d'Ebbsfleet et ses environs immédiats sont riches en vestiges préhistoriques, et la région a fait l'objet de nombreuses recherches depuis le XIXe siècle. Malgré l'absence de méthodes de fouille et d'enregistrement « modernes », ces localités ont produit certains sites d'importance nationale, notamment Baker's Hole – le plus important site paléolithique de Grande-Bretagne avec des artefacts en silex levalloisien – preuve rare de l'occupation « Long Blade » datant du Paléolithique finale, et localité de référence des poteries néolithique du « Ebbsfleet Ware ».

L'approche adoptée dans ce volume consiste à élaborer un cadre pour le paysage et l'environnement changeant de la vallée d'Ebbsfleet durant cette période et à présenter les preuves de l'occupation humaine dans ce contexte. Bien qu'il manque largement des preuves humaines directes dans les présentes recherches, les résultats prolifiques des travaux antérieurs ont été intégrés au cadre environnemental et de datation établi à la suite des travaux du HS1 et du STDR4.

Les résultats sont d'abord présentés par zone dans la vallée d'Ebbsfleet, avec des rapports spécialistes détaillés et l'élaboration de cadres environnementaux et de datation par zone. Les résultats zonaux sont ensuite combinés en une synthèse globale et une discussion. Une réévaluation d'importantes collections d'artefacts en silex du Paléolithique provenant de Baker's Hole et du canal d'Ebbsfleet est également présentée.

Traduction: Jörn Schuster,
ARCHÆOLOGICALsmallFINDS

Part I

Introduction and Background

Chapter 1

Introduction

by Francis Wenban-Smith, Elizabeth Stafford and Edward Biddulph

Archaeology and High Speed 1

The Channel Tunnel Rail Link (CTRL), now known as High Speed 1 (HS1), was built by London & Continental Railways Ltd between 1996 and 2004, after securing the necessary act of parliament (the *Channel Tunnel Rail Link Act* 1996) under which due account was required to be taken of its environmental impact, including appropriate mitigation of any archaeological impact. HS1 extends for 109km between St Pancras station in London and the entrance to the tunnel (Fig 1.1). It was built in two sections: Section 1 lies entirely within Kent and extends from Folkestone to Fawkham Junction (Gravesham). The Ebbsfleet Valley is located at the southern end of Section 2, which runs from Pepper Hill to London St Pancras, crossing under the Thames between Swanscombe and Purfleet, and then passing through Essex and East London.

A major programme of archaeological investigation was undertaken to mitigate the impact of engineering and construction work on the archaeological resource along the HS1 route. Desk-based assessment and route planning commenced in the early 1990s, followed by an extensive programme of evaluations comprising fieldwalking, geophysics, trial trenching, deep test pitting and borehole investigation, largely undertaken between 1997 and 2001. Archaeological sites that were revealed, and which could not be avoided or preserved *in situ*, were then excavated in advance of construction. Mitigating excavations associated with Section 2 in the Ebbsfleet Valley took place between April 2001 and March 2003, covering: the HS1 route itself; a connecting line to the existing North Kent Line; the footprint of the Ebbsfleet International Station; and associated landscape re-modelling and station access roads (Fig 1.1). The archaeological contractors for these works, described in more detail in Chapter 3, were Oxford Archaeology and Wessex Archaeology, supported by a range of external specialists.

Separate investigations were carried out by Oxford Archaeology in 2004 when the Ebbsfleet elephant skeleton was discovered late in the day, in the south-west corner of the overall development area. The results of this excavation are reported separately, in one of the companion volumes in the HS1 Ebbsfleet publications series (Wenban-Smith 2013).

South Thameside Development Route 4 and Northfleet Rise

In 2000 Oxford Archaeology was also commissioned on behalf of Kent County Council to undertake a programme of archaeological works along the line of the South Thameside Development Route 4 (STDR4) in the Lower Ebbsfleet Valley (Fig 1.1). This was part of a broader programme of infrastructural development and investment in the Ebbsfleet area. The STDR4 road scheme provided a bypass for Northfleet along with additional access to Ebbsfleet International Station. The route of the new road runs between Gravesend and Dartford about 1.5km south of the River Thames, parallel to HS1, and turns north-east through a new tunnel under the existing North Kent Line before linking to the A226. The archaeological resource encountered in relation to STDR4 was clearly intimately associated with that encountered in relation to HS1, so it was agreed that results from both projects would be reported on jointly, under the aegis of the monograph series resulting from the HS1 archaeological programme, of which this volume forms a part.

On the same basis, the results of the archaeological evaluation of the Ebbsfleet Development (Northfleet Rise) area, carried out by Oxford Archaeology in 1997 for Blue Circle Industries, prior to the start of the HS1 investigations, have also been incorporated into this study.

Previous Investigations

The Ebbsfleet Valley and its immediate vicinity are rich in prehistoric evidence from the Lower Palaeolithic to the end of the Iron Age. The archaeological background is discussed in more detail in Chapter 2; at this point, it is merely necessary to emphasise that numerous investigators since the 19th century have carried out fieldwork in the Ebbsfleet Valley (Table 1.1), recovering important evidence from deposits directly affected by HS1 and the associated works. Unfortunately, the majority of this work has either taken place in a different era, without what we would now regard as adequate recording, or, even when having been carried out in the relatively modern era, was poorly recorded and has been minimally published. Nonetheless, the previous work has been sufficient to identify the locale as containing diverse nationally important remains – in particular:

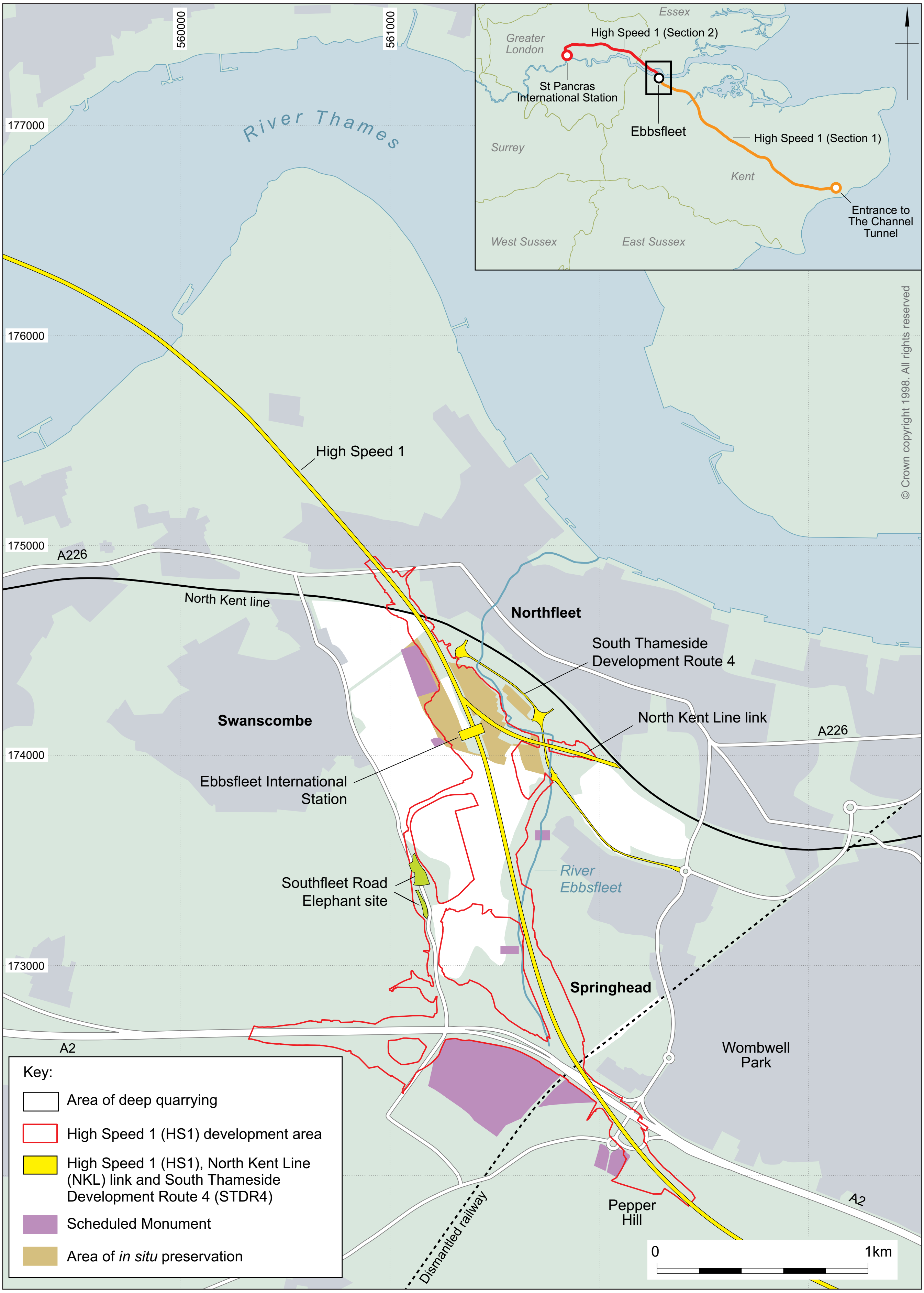


Figure 1.1 Location map (a) HS1 Sections 1 and 2 (b) the Ebbsfleet Valley and surrounding area showing HS1 and STDR4 development areas

Table 1.1 Main previous prehistoric investigations in the Ebbsfleet Valley

Date	Principal investigator(s)	Focus of investigation	Key results	Extant archive material	Sources
1880s	F C J Spurrell	Collecting Palaeolithic flint artefacts and Pleistocene faunal remains	First discovered Ebbsfleet Valley as containing richly fossiliferous Pleistocene deposits with Palaeolithic artefacts; identified "tortoise-core" technology: "Tramway Cutting" site	Various material held in British Museum and Natural History Museum, but lacking good provenance	Spurrell 1883; 1884
1906–1908	J Cross	Collecting Palaeolithic flint artefacts	Noted expansion of new quarry "Southfleet Pit" in 1907, and got British Museum involved	Artefact collection held by Pitt Rivers Museum, Oxford; but poorly provenanced	Abbott 1911
1910	British Museum (R A Smith and H Dewey)	More-controlled recovery of Palaeolithic flint artefacts and faunal remains	Larger and less-selective collection of artefacts from Coombe Rock in Southfleet Pit ("Baker's Hole") plus some faunal remains	Artefacts held by British Museum; faunal remains held by Natural History Museum	Smith 1911
1930s, 1950s	J P T Burchell	Collecting Palaeolithic flint artefacts and faunal remains; palaeo-environmental investigations (esp. molluscs)	Discovered new parts of site with different artefact-bearing and fossiliferous deposits; made large lithic and small faunal collections with reasonable provenance; identified interglacial "Temperate Bed" site	Artefacts mostly held by British Museum, but collection dispersed see Table 17.1; faunal remains held by Natural History Museum; non-existence of primary location and provenance records reduces their research potential	Burchell 1933; 1935a; 1954; 1957
1930s	J P T Burchell	Collecting late prehistoric flintwork and pottery from alluvium	Discovered artefact-bearing horizons and other occupational evidence within Holocene Ebbsfleet alluvium (including SAM Kent 268a/268b)	Artefacts and pottery held by British Museum	Burchell 1938; Burchell and Piggott 1939
1950s, 1960s	AT Marston and J N Carreck	Collecting faunal remains and stratigraphic descriptions	Discovered a new area of fossiliferous Pleistocene sediments, rich in mammalian fossils and molluscs: "Northfleet Allotments" site; records and small faunal collections from other locations	None known, but good descriptions of both individual fossils and their provenance in Carreck's MPhil (1972)	Carreck 1972
1960	British Museum (G Sieveking)	Re-investigation of Holocene alluvium sites	Reinvestigation of Burchell's original Holocene sites. Possible (^{14}C dated) Neolithic trackway (at SAM Kent 268a)	Artefacts and pottery held by British Museum	Sieveking 1960; Barker and Mackey 1963, 105
1969–1971	British Museum (G Sieveking and M P Kerney)	Re-investigation of Northfleet Allotments ("Site A") and Temperate Bed ("Site B") sites	Made good records of key sediment sequences at both sites; carried out more detailed molluscan investigations; recovered large faunal and small lithic collections	Artefacts held by British Museum; faunal remains held by Natural History Museum; poor provenance of faunal remains reduces their research potential	Kerney and Sieveking 1977
1989–1995	F F Wenban-Smith	Re-investigation of: Northfleet Allotments ("Site A"); Temperate Bed ("Site B") sites; and other surviving sediments, mostly also noted by Carreck ("Sites C, D, E and F")	More detailed primary records of locations and sequences of surviving deposits; more intensive palaeo-environmental work covering molluscs, small vertebrates and ostracods; chronometric dating with OSL and amino acid racemisation	Small lithic and faunal collections held by British Museum and Natural History Museum, respectively	Wenban-Smith 1990b; 1995; 1996

a) providing Britain's foremost Palaeolithic site with Levalloisian flint artefacts – "Baker's Hole";

b) providing rare evidence of Final Palaeolithic "Long Blade" occupation;

c) being the eponymous location for the type of Neolithic pottery categorised as Ebbsfleet Ware.

Despite the relatively poor quality of published research, important remains and associated records from this previous work survive in museum collections. This volume provides the opportunity to present a definitive account of the prehistory of the Ebbsfleet Valley. It integrates the recent HS1 investigations carried out to the highest contemporary standards, with a synthesis of the important unpublished evidence from over a century of previous work. It includes the relatively recent investigations carried out by Wenban-Smith in the 1990s (Wenban-Smith 1996), the planned publication of which was postponed to allow their incorporation here with the HS1 works that swiftly superseded them.

Scope of Volume

This report concerns the principal study defined as 'Prehistoric Ebbsfleet' (CTRL Minor Works Contract URN-000-ARC-200), focusing on Palaeolithic, Mesolithic and Neolithic, Bronze Age and Early Iron Age activity within the valley. The study incorporates data from several archaeological and geoarchaeological evaluations, a series of major open-area excavations, and numerous specific interventions and other recording episodes such as borehole surveys and watching briefs (Chap 3). The majority of these projects recovered material from a wider period range than the prehistoric scope of this volume. The later, proto-historic and historic era material has been incorporated into a separate study (Andrews *et al* 2011a) and where necessary, cross references are made. As described earlier in this chapter, this volume also integrates the prehistoric results from the HS1 works with material from other related projects, such as STDR4, and previous investigations. This report integrates information from specialist studies, however, the full reports may be found at: https://owarch.co.uk.

This Prehistoric Ebbsfleet study does, however, necessitate a distinct treatment compared to the other period studies resulting from the HS1 archaeological project. The great span of prehistoric time and human prehistory represented in the deposits investigated covers at least 250,000 years. This period incorporates fluctuating extremes of climate between harsh sub-arctic conditions when southern Britain would have been a frozen and uninhabitable treeless waste, and Mediterranean-like conditions, often slightly warmer than the present day, when luxuriant forest was interspersed with grassy plains, rich in what we would now regard as tropical fauna such as lion, hippopotamus and hyaena.

The approach taken in this volume is to develop a framework of the changing landscape and environment of the Ebbsfleet Valley through this period, and to present the evidence of human occupation against this background. Due to the vagaries of chance, and the fact that the majority of sediments have already been extracted by quarrying, the archaeological evidence of human occupation in the valley has mostly been recovered by previous workers. Deposits investigated more recently, especially for HS1, mostly lack direct human evidence from pre-Holocene deposits, and the challenge has been to integrate the prolific evidence previously recovered with the more detailed environmental and dating framework resulting from the recent work. Nonetheless, it has proved possible to:

a) provide a date for Levalloisian occupation early in marine isotope stage (MIS) 7, *c* 230,000 BP (years Before Present);
b) improve understanding of site formation processes and consequent dating difficulties for the main "Baker's Hole" Levalloisian collection;
c) provide a new and more detailed framework for the key period of MIS 7, between *c* 240,000 and 190,000 BP, in relation to which discoveries of early Neanderthal occupation from other parts of the UK and northwest Europe can be understood.

After the major occupational hiatus of the Last Glacial Maximum between *c* 24,000 and 14,000 years ago, the Ebbsfleet Valley contains a record of latest Pleistocene and Holocene human presence from final Upper Palaeolithic hunter-gatherers early in the post-glacial period, *c* 12,000 BP, through the subsequent Mesolithic, Neolithic, Bronze Age and Iron Age as the landscape evolved towards its present form.

Editorial Note

The bulk of the post-excavation assessment and subsequent analysis was undertaken between 2005 and 2012. In 2013 the text was revised and updated following peer review, but no further substantial updating has been undertaken.

Chapter 2
Background

by Francis Wenban-Smith, Elizabeth Stafford, Edward Biddulph, Martin Bates and Chris Hayden

Quaternary Geological Framework

This volume, encompassing the prehistoric past of the Ebbsfleet Valley, necessarily covers a much longer time period than the companion volumes in the *Settling the Ebbsfleet Valley* series whose main focus is the Roman, Saxon and later phases of occupation (Andrews *et al* 2011a–b; Biddulph *et al* 2011; Barnett *et al* 2011). While these volumes cover at most a few centuries of activity, set against the backdrop of a climate and landscape broadly similar to today, the prehistory of the Ebbsfleet Valley stretches deep into the past, spanning several hundred thousand years and embracing major climatic oscillations and landscape change.

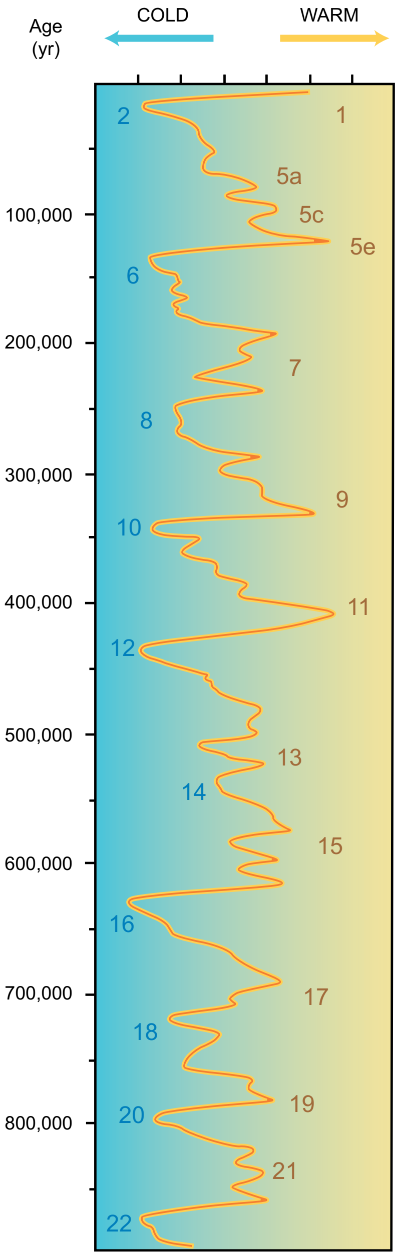
The initial Palaeolithic occupation and subsequent settlement of Britain occurred during the Quaternary, a period of time characterised by the onset and recurrence of a series of alternating cold (glacial)/warm (interglacial) climatic cycles (Lowe and Walker 1997). Over 60 cycles have been identified during the last 1.8 million years, corresponding with fluctuations in proportions of the oxygen isotopes ^{16}O and ^{18}O in foraminifera from deep-sea sediment sequences. These marine isotope stages (MIS) have been numbered by counting back from the present-day interglacial (MIS 1), with interglacial peaks having odd numbers and glacial troughs even numbers (Fig 2.1). Individual stages have been dated by a combination of radiometric dating and tuning to the astronomical timescale of orbital variations (Hays *et al* 1976; Martinson *et al* 1987), which have been recognised as a fundamental causative agent of the Quaternary climatic fluctuations. These stages provide the fundamental dating and climatic framework for the Quaternary, within which Palaeolithic remains need to be placed to understand them better.

The Quaternary is divided into two epochs – the Holocene and the Pleistocene. The Holocene represents the present-day interglacial, covering the warm period since the end of the last ice age *c* 11,700 BP (years Before Present). The Pleistocene represents the remainder of the Quaternary and is divided into Early, Middle and Late parts. It is generally agreed that MIS 5d through to MIS 2, dating from *c* 115,000–11,700 BP cover the last cold stage (Devensian, in British terminology – where possible, MI Stages are referenced to named terrestrial stratotype locations, and these vary between countries; here we follow British terminology as far as possible, although some stratotypes are better understood in the Netherlands), and that MIS 5e, dating from *c* 115,000–128,000 BP, correlates with the peak warmth of the last interglacial (Ipswichian). Beyond that, disagreement increases although many British workers feel confident in accepting that MIS 12, which ended abruptly *c* 425,000 BP, correlates with the major Anglian glaciation when ice-sheets reached as far south as the northern outskirts of London (Shackleton 1987; Bridgland 1994) and diverted the River Thames south into the present estuary.

Archaeological Framework

The Palaeolithic in Britain covers the time span from initial colonisation in the Early Pleistocene, possibly as long as MIS 21, *c* 850,000 years ago based on evidence from Happisburgh on the Norfolk coast (Parfitt *et al* 2010), to the end of the Late Pleistocene, corresponding with the end of the last cold stage *c* 11,700 years ago. Thus, the Palaeolithic period occupies almost 850,000 years, and includes at least 10 major glacial-interglacial cycles and numerous minor cycles (Fig 2.1), which nonetheless represent significant swings of climate for sustained periods. These cycles would have been accompanied by dramatic changes in climate, landscape and environmental resources. At the cold peak of glacial periods, ice-sheets hundreds of metres thick would have covered significant parts of Britain, reaching on occasion as far south as London, and the country must have been uninhabitable. At the warm peak of interglacials, mollusc species that now inhabit the Nile were abundant in British rivers, and warm-climate fauna such as hippopotamus and straight-tusked elephant were common in the landscape. For the majority of the time, however, the climate would have been somewhere between these extremes.

The early hominin evidence at Happisburgh consists of a very simple core and flake lithic industry, and was presumably made by a form of *Homo erectus/ergaster*, known to be present in Central/Eastern Eurasia from over 1.7 million BP (Gabunia *et al* 2000) or their descendants. Given the lack of hominin remains from Britain and northwest Europe at this time, it is not possible to identify the species involved at Happisburgh, or to establish whether it descends from the *erectus/ergaster* line, or is related to *Homo antecessor*,



Epoch sub-series	*MIS*	*Traditional stage (Britain)*	*Climate and landscape*
Holocene	1	Flandrian	Rise of Channel and North Sea levels to form Britain as an island
Late Pleistocene	2	Devensian	Mainly cold; coldest in MIS 2 with the maximum advance of the Devensian ice sheets; occasional short-lived periods of relative warmth ("interstadials"), and more prolonged warmth in MIS 3 Britain periodically connected to the continent across the Channel and North Sea
	3		
	4		
	5a-5d		
	5e	Ipswichian	Warm - full interglacial Britain is an island
Middle Pleistocene	6	Saalian complex*	Alternating periods of cold and warmth; period includes more than one glacial - interglacial cycle; changes in faunal evolution and assemblage associations help to distinguish the different stages
	7		
	8		
	9		
	10		
	11	Hoxnian	Warm - full interglacial Britain probably first becomes an island with the breaching of the Dover Straits
	12	Anglian	Cold - maximum extent southward of glacial ice in Britain; may incorporate interstadials that have been confused with Cromerian complex interglacials
	13-19	Cromerian Complex and Beestonian glaciation	Cycles of cold and warmth; still poorly understood due to obliteration of sediments by subsequent events
Early Pleistocene (last part)	20-22	Bavelian Complex (late part of)	Cycles of cold and warmth; but generally not sufficiently cold for glaciation in Britain

* Netherlands terminology - undefined in Britain

Figure 2.1 British Quaternary and Marine Isotope Stage framework

known to be present in Spain *c* 1 million to 800,000 BP (Klein 2009).

Similar evidence from Pakefield, another early East Anglian interglacial site perhaps dating to MIS 17 to 19 (Parfitt *et al* 2005), shows the repeated occupation in Europe of this early population, probably expanding their range northwards as climate warmed, but dying out in their northern range as climate cooled (Dennell *et al* 2011). Following these early occurrences, there are a number of UK Palaeolithic sites dating from the pre-Anglian interglacial MIS 13, *c* 500,000 BP, associated with the later western European *Homo heidelbergensis*, particularly at Boxgrove in Sussex, where (alongside hominin skeletal remains comprising a tibia and two teeth from a lower jaw) an extensive area of undisturbed evidence from handaxe manufacture and faunal exploitation is associated with a rich range of other palaeoenvironmental indicators (Roberts and Parfitt 1999).

From the Anglian onwards, during which the climate must have been too harsh for occupation, Palaeolithic occupation becomes more frequent in Britain, although not continuous. Numerous sites, some of them with exceptional quantities of lithic remains, attest to relatively prolific occupation in the period from after MIS 12 to MIS 8 (Wymer 1988; 1999). After this, there seems to have been a decline of activity in the UK through MIS 7, and it appears that Britain was deserted during MIS 6 and the Ipswichian interglacial, MIS 5e (Ashton and Lewis 2002; Stringer 2006). Until recently, the earliest post-Ipswichian presence in the UK was thought to have occurred in MIS 3, between *c* 60,000

Table 2.1 British prehistoric periods

Traditional period	Updated period	Hominin species	Lithic artefacts and other material culture	MI Stage	Date (BC)	UK/Dutch geo stage
Bronze Age	Bronze Age	Anatomically modern humans (*Homo sapiens*)	Some intensively worked ceremonial lithic artefacts, barbed and tanged arrowheads; Beaker pottery and use of Bronze weaponry	1	700–2400	Flandrian
Neolithic	Neolithic		Polished stone axes, scraper-dominated lithic assemblages and leaf-shaped arrowheads; Ebbsfleet Ware pottery		2400–4000	
Mesolithic	Mesolithic		Unpolished tranchet axes, blade-based microlithic and scraper industry		4000–9500	
Upper Palaeolithic	Upper Palaeolithic		Dominance of blade technology and standardised tools made on blade blanks; personal adornment, cave art, bone/antler points and needles	2–3	9500–35,000	Late Devensian
Middle Palaeolithic	British Mousterian	Neanderthals *(Homo neanderthalensis)*	The appearance of *bout coupé* handaxes; discoidal flake/core reduction strategies	3–5d	35,000–115,000	Early/Middle Devensian
	–	–	Britain uninhabited	5e	115,000–125,000	Ipswichian
	Lower/Middle Palaeolithic	Early pre-Neanderthals, evolving into *Homo neanderthalensis*	Some handaxe-dominated sites (Cuxton; Harnham), but growth of more standardised (Levalloisian) flake and blade production techniques (Crayford; Baker's Hole)	6–10 11a–b	125,000–390,000	Saalian complex
Lower Palaeolithic			Handaxe-dominated (eg, Swanscombe); industry without handaxes (Clactonian) in early part of interglacial	11c	390,000–425,000	Hoxnian
	–	–	Britain uninhabited	12	425,000–480,000	Anglian
	Lower Palaeolithic	*Homo heidelbergensis?*	Handaxe-dominated (eg, Boxgrove), with occasional unstandardised flake core production techniques and simple unstandardised flake-tools; occasional unifacial flake-tool industries without handaxes (High Lodge)	13	480,000–500,000	Cromerian Complex IV
		Homo heidelbergensis? Homo antecessor? Homo ergaster??	Simple flake/core industries with no standardised flake-tools (Pakefield)	13–17	500,000–650,000	Cromerian Complex I–III
			Simple flake/core industries with no standardised flake-tools (Happisburgh 3)	18–21?	650,000–850,000	Bavelian Complex (late part of)

and 40,000 BP, when there are a number of sites in Wales and southern England with distinctive *bout coupé* handaxes, thought to represent a late Neanderthal population. A newly discovered site at Junction 2 of the M25, near Dartford, Kent suggests, however, that there might also have been earlier Neanderthal incursions into the UK during MIS 5d–5a, *c* 100,000 BP (Wenban-Smith *et al* 2010).

The British Palaeolithic has for a long time (eg, Wymer 1968; 1982; Roe 1981) been divided into three broad, chronologically successive stages – Lower, Middle and Upper – based primarily on the changing types of stone tool (Table 2.1). This framework was originally developed in the 19th century (Mortillet 1872), before any knowledge of the types of human ancestor associated with the evidence of each period, and without much knowledge of the timescale. This tripartite division has nonetheless broadly stood the test of time, proving, at least across Britain and northwest Europe, both to reflect a general chronological succession of lithic technology, and to correspond with the evolution of different ancestral hominin species. Typical Lower and Middle Palaeolithic remains have been shown to date before *c* 40,000 BP, and to be associated with the extinct Neanderthal lineage and their ancestors ('Archaic' *Homo*). Upper Palaeolithic remains date from after *c* 40,000 BP, after which no Neanderthal remains are known from northern Europe, and are associated with the appearance of anatomically modern humans.

It has, however, become clear in recent decades, with improved dating and lithic analysis of several key sites, that the definition and distinction of Lower and Middle Palaeolithic are less clear-cut in Britain than has hitherto been thought. Earlier "Lower Palaeolithic" sites embrace a variety of lithic technologies besides handaxe manufacture, and typically "Middle Palaeolithic" Levalloisian technology has its origins much earlier than previously realised, occurring alongside (typically "Lower Palaeolithic") handaxe manufacture, for example at Red Barns, in Hampshire (Wenban-Smith *et al* 2000). It also seems that later handaxe industries persist alongside fully developed Levalloisian technology in Britain in the period MIS 8–7, for instance at Harnham, Wilts (Whittaker *et al* 2004) and Cuxton, Kent (Wenban-Smith *et al* 2007a), which both date to *c* 250,000 BP, contemporary with Levalloisian activity in the Ebbsfleet Valley (this volume) and Purfleet, Essex (Schreve *et al* 2002).

In the light of these problems, it is perhaps better to talk about a combined Lower/Middle Palaeolithic for the post-Anglian and pre-Ipswichian period, and to reserve the term "Lower Palaeolithic" for pre-Anglian phases of occupation. After the Ipswichian absence, it seems that *bout coupé* handaxes are specifically associated with occupation from MIS 3 in the middle of the last (Devensian) glaciation (White and Jacobi 2002), so, whether or not labelled "Middle" they genuinely represent a distinct phase of later occupation. In this volume, the post-Ipswichian phase of Neanderthal occupation prior to their demise and the advent of modern humans is defined as "British Mousterian". This nomenclature is summarised in the accompanying table (Table 2.1), which also outlines the correspondence of cultural stages of the Palaeolithic with the geological and MIS framework.

The Upper Palaeolithic commences with the arrival of modern humans and their associated range of lithic and bone/antler artefacts, characterised as Aurignacian, after the site of Aurignac in France (Mellars 2004). The first influx into central Europe seems to have occurred from the south-east in the second part of the Last Glacial period (the Devensian), in MIS 3 *c* 40,000 BP. Low sea levels during the Last Glacial would have exposed much the Channel and the western continental shelf as a wide plain, and this would have facilitated the spread of these early modern humans into Britain. There are a number of British sites with Upper Palaeolithic evidence dating between *c* 30,000 and 26,000 bc (uncalibrated radiocarbon years), particularly Kent's Cavern in Devon and Paviland Cave on the Gower peninsular in Wales (Jacobi 1999). Early Upper Palaeolithic sites in Britain are concentrated in the south-west, and it seems possible that the route of Upper Palaeolithic colonisation of Britain was from the south-west by the Atlantic sea-board. There is no Upper Palaeolithic evidence in Britain during the coldest part of the last glaciation, the Last Glacial Maximum, or LGM, between *c* 26,000 and 18,000 BP (Otte 1990). Britain was then resettled *c* 14,000 BP, when a late phase of Upper Palaeolithic occupation corresponded with a brief phase of climatic amelioration before the final cold pulse – the "younger Dryas" – of the last glaciation, which lasted *c* 12,800 to 11,500 BC. Evidence for occupation during this period has been recovered from cave site such as those in Devon (Broken Cave, Pixie's Hole, and Mother Grundy's Parlour; Barton 1999, 25) as well as the open sites at Hengistbury Head, Dorset and Brockhill, Surrey (Barton 1992).

The cultural changes that occurred during the post-glacial period, particularly in the area of Kent and the Thames Estuary, are set against a background of significant landscape change. Towards the end of the Devensian, sea level was substantially lower than the present day with extensive areas of lowland, termed Doggerland, in the area now occupied by the North Sea (Gaffney *et al* 2009). The rivers were freshwater, and the surface of the Late Glacial deposits, onto which soil formation occurred, formed the landscape topography at the start of the Holocene. Climatic amelioration and subsequent sea-level rise as a result of the retreating glaciers submerged much of the lowland areas of the North Sea Basin, which eventually lead to the breaching of the Weald/Artois land bridge *c* 6000 cal BC. The effect of rising sea levels on the inland margins in the Lower Thames area would have resulted in the backing up of freshwater systems and the expansion of wetland environments such as alder carr, fen, and reedswamp (see Bates and Stafford 2013). The final "Long Blade" phase of the Palaeolithic, exemplified by the site of Three Ways Wharf, Uxbridge (Lewis with Rackham 2011), has its roots in the Younger Dryas, and persists into the pre-Boreal phase of the early Holocene, after which microlithic industries of the Mesolithic take over, leading in turn to the later prehistoric industries of the Neolithic and Bronze Age (Table 2.1). This also marks the transition from a nomadic hunter-gatherer existence to a more settled farming way of life and the growth of more complex societies. The links, or otherwise, between these observed changes in material cultural tradition and the movement, or otherwise, of groups of actual people remains the subject of much debate. There is much evidence of quite a gradual internal UK transition between Mesolithic and Neolithic, as well as of some episodes of migration between Britain and the Continent in the Neolithic and Bronze Age (see below).

The Ebbsfleet Valley

Location

The Ebbsfleet Valley is located in North West Kent, on the south side of the Thames Estuary between Northfleet and Swanscombe (TQ 615735). The HS1 route runs roughly north–south through the Ebbsfleet Valley, passing along the west flank of the remnants of the Ebbsfleet, one of numerous small partly tidal streams that feed into the Thames Estuary, hence the proliferation of the suffix -fleet in the place names of the region (after Old English *fleot*). Works for HS1 have affected the majority of the valley (Fig 1.1). Besides the route of the track itself, there has been construction of an international station straddling the track with a substantial rectangular footprint, and also subsidiary landscaping of the surrounding area for car parks, road links and enhancement of the surrounding infrastructure including the STDR4 road scheme.

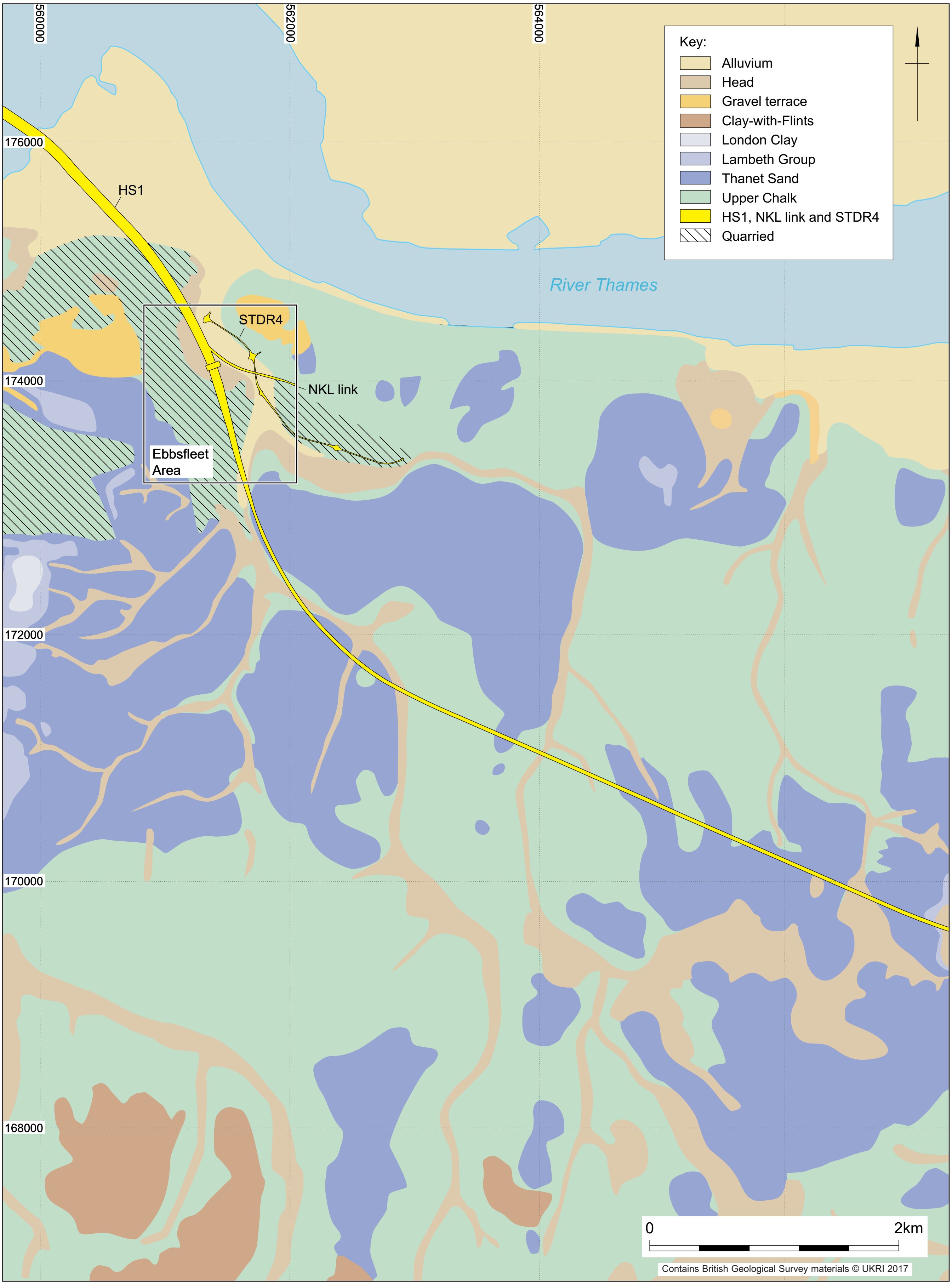


Figure 2.2 Landscape and geological context of Ebbsfleet Valley

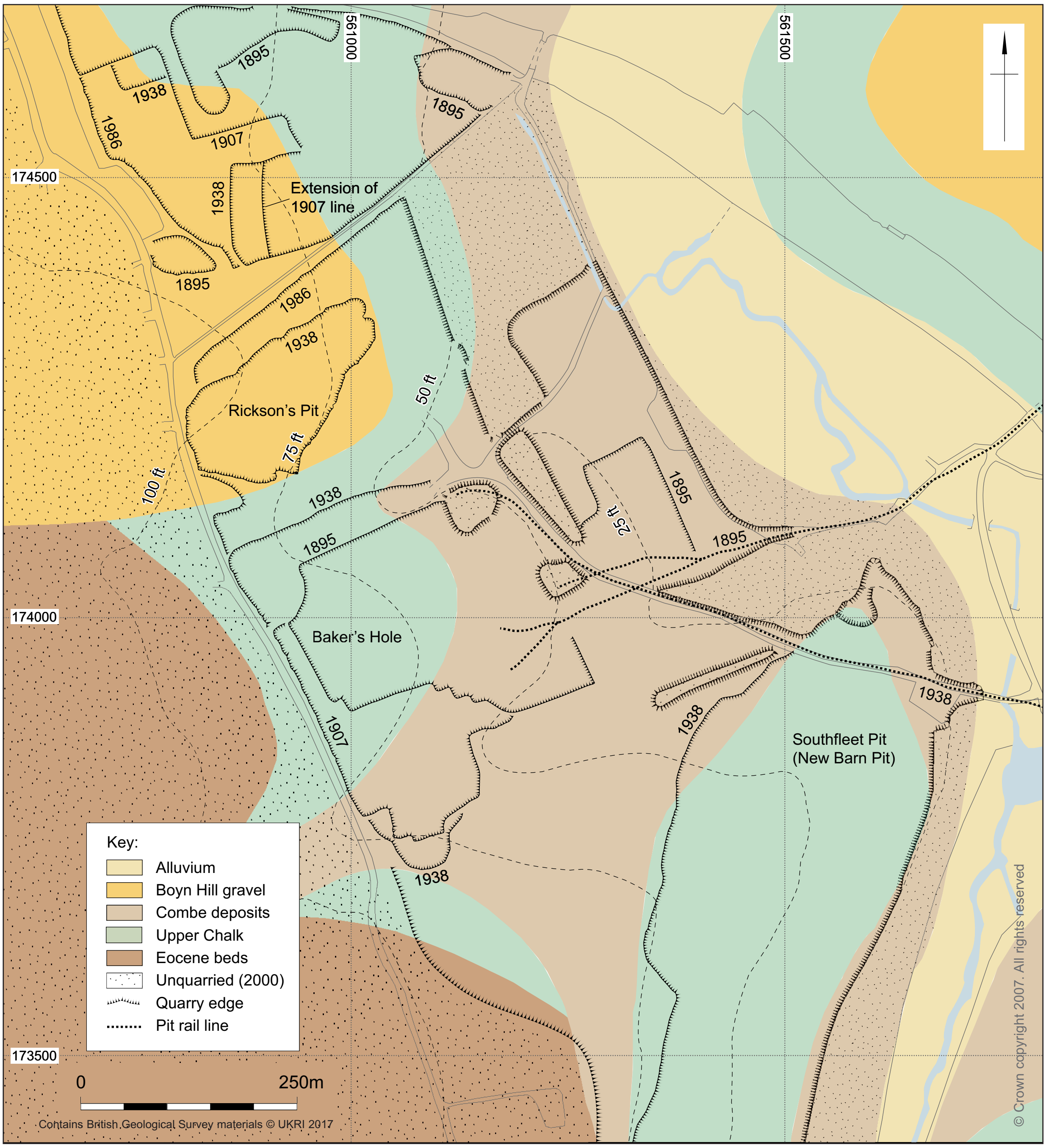


Figure 2.3 Quarrying and development history

Landscape, Topography and Geology

The Ebbsfleet is currently a pitifully small stream, mostly dried up and virtually stagnant, which rises at Springhead and struggles north for *c* 2km through the heavily quarried chalk landscape of this part of North West Kent to join the Thames at Northfleet. However, as can be seen from geological mapping (Fig 2.2) it has a far nobler history as a relatively substantial drainage course with its catchment extending much further south to the crest of the North Downs. It passed from the Chalk landscape of the North Downs capped with Clay-with-Flints through a fold in the Chalk bedrock filled with Tertiary Thanet Sand that flanks the south side of the Thames, before exiting at Northfleet. Just before reaching the Thames, the Ebbsfleet cuts through the Pleistocene deposits of the Swanscombe '100-foot terrace' outcrop (mapped as part of the Boyn Hill Terrace, but more properly regarded as part of the Orsett Heath Formation, see Bridgland 1994) that line its southern bank here, underlying the villages of Swanscombe and Northfleet that are situated on the higher ground (above 25m OD) each side of the mouth of the Ebbsfleet.

The current Ebbsfleet Valley cuts transversely north–south through the Swanscombe '100-ft terrace' deposits and into the underlying Chalk bedrock, and is filled with a complex sequence of younger, lower-lying

Figure 2.4 1865 OS survey (1st edition, 6")

(below 15m OD) Pleistocene and Holocene deposits. Pre-MIS 8 deposits occur at higher levels above its west bank (see Chap 16), but these were not impacted by the HS1 works discussed in this volume. Later investigations in this area led to discovery and investigation of the Ebbsfleet elephant butchery site, separately reported on (Wenban-Smith *et al* 2006; Wenban-Smith 2013).

The lower level Ebbsfleet deposits have been shown by research throughout the 20th century to contain significant Palaeolithic and later prehistoric archaeological evidence (see below). The Ebbsfleet Pleistocene deposits fall into two main categories: water-lain deposits (fluvial silts, sands and gravels), and slopewash deposits (colluvial and solifluction deposits). The fluvial deposits include horizons from warmer periods of relative landscape stability, and are generally buried beneath sometimes substantial accumulations of colluvial and solifluction deposits. These latter deposits reflect colder periods when the banks were exposed and de-vegetated and the surrounding land surface was de-stabilised, leading to downslope movement and accumulation in the valley bottom of substantial bodies of sediment.

The base of the Ebbsfleet Valley is filled with a complex sequence of Holocene alluvial and estuarine deposits, filling a sometimes deeply-incised Last Glacial channel containing sands and gravels, and interdigitating at its edges with colluvial deposits. The only published data on the sedimentary history of the Holocene infill, prior to the HS1 investigations, derives from the limited work undertaken by Burchell in the

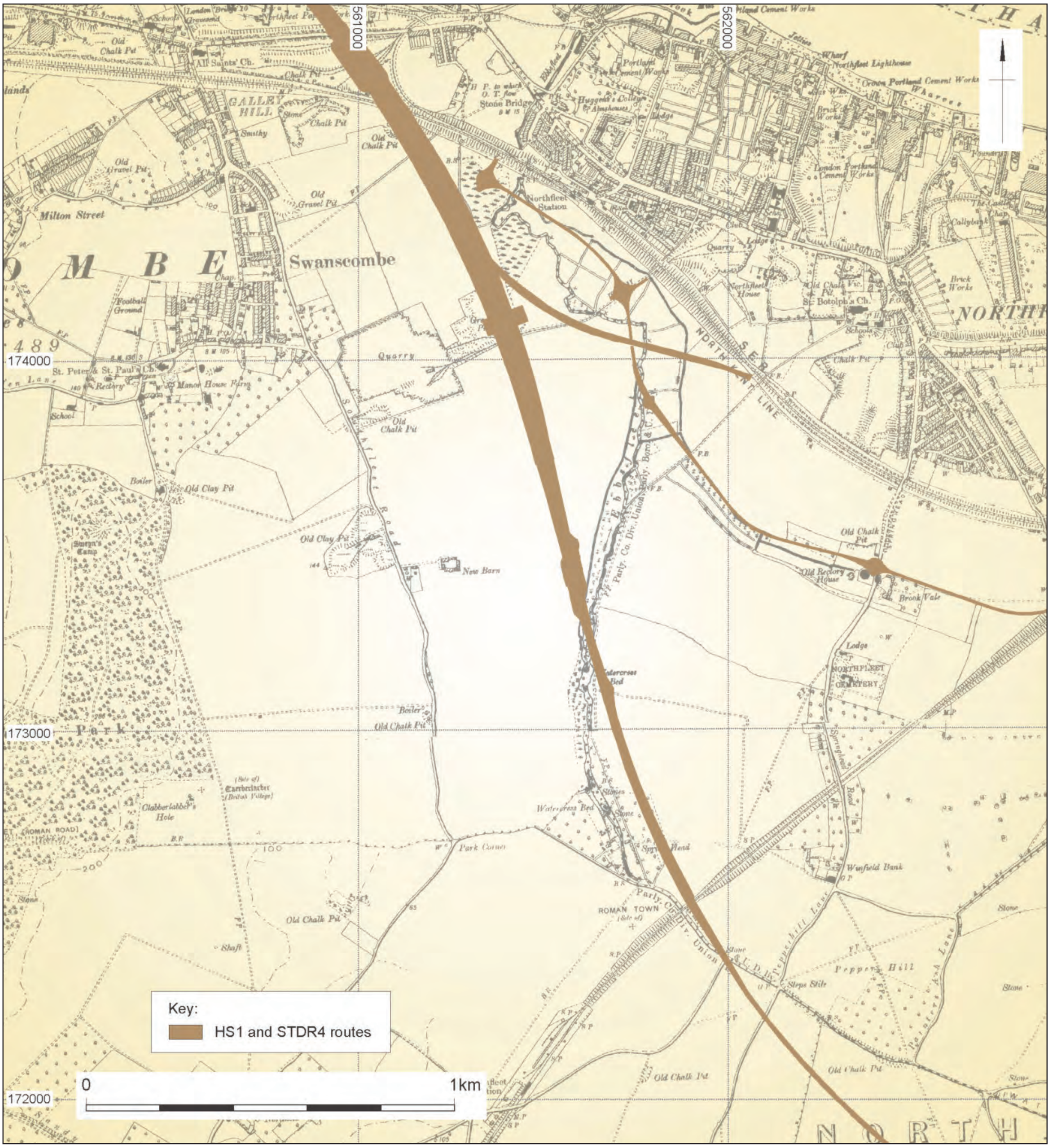


Figure 2.5 1895 OS survey (1st revision, 6")

1930s (Burchell and Piggott 1939), discussed in more detail below.

Quarrying and Development History

The Ebbsfleet Valley has been formally exploited for minerals since 1871 (Fig 2.3) when the Portland Cement company was granted planning permission to extract chalk and to build narrow-gauge pit railway lines for their transport to the factories and warehouses on the banks of the Thames at Northfleet. Prior to this, the 1st edition of Ordnance Survey 6" mapping (in 1865) shows a virtually pristine landscape with just one tiny pit, presumably from chalk extraction, halfway up its western flank (Fig 2.4). Quarrying rapidly expanded in the last decades of the 19th century, fuelled by European and American industrialisation and urban expansion, and the need for chalk as the vital ingredient in cement, and in particular in the quick-drying and strong Portland Cement recipe, patented at this time.

By 1895 (Fig 2.5) the tiny chalk pit of 1865 had expanded into a substantial quarry, Baker's Hole, accompanied by a pit rail line *c* 1km long linking it to the

Figure 2.6 1907 OS survey (2nd edition, 6")

Northfleet wharf. Remnants of this first rail development in the Ebbsfleet Valley still survive, with the riveted iron bridge from the original 1870s pit line to Baker's Hole quietly rusting in the reedbeds in the shadow of its 21st-century high-speed descendant (Pl 2.1). A decade later, by 1907 (Fig 2.6), chalk quarrying had expanded into the north-west part of the valley, and a small incipient pit, the Southfleet Pit, had just opened, aimed at quarrying the spur of chalk that lined the western side of the southern arm of the Ebbsfleet. The next major survey, of 1938 (Fig 2.7), shows not only how the Southfleet Pit had expanded to 1km in length, but also the continuing expansion of quarrying into other parts of the valley, including its east side. Quarrying continued to expand throughout the 20th century, as developing mechanisation made removal of increasing depths of Pleistocene overburden increasingly economically viable. By the end of the 20th century (Fig 2.3), only tiny pockets of unquarried land remained west of the Ebbsfleet, protected by excessive depth of overburden, the presence of industrial infrastructure such as pylons or conveyor belts, and for two small outcrops their identification in the 1970s as ancient monuments of Palaeolithic importance.

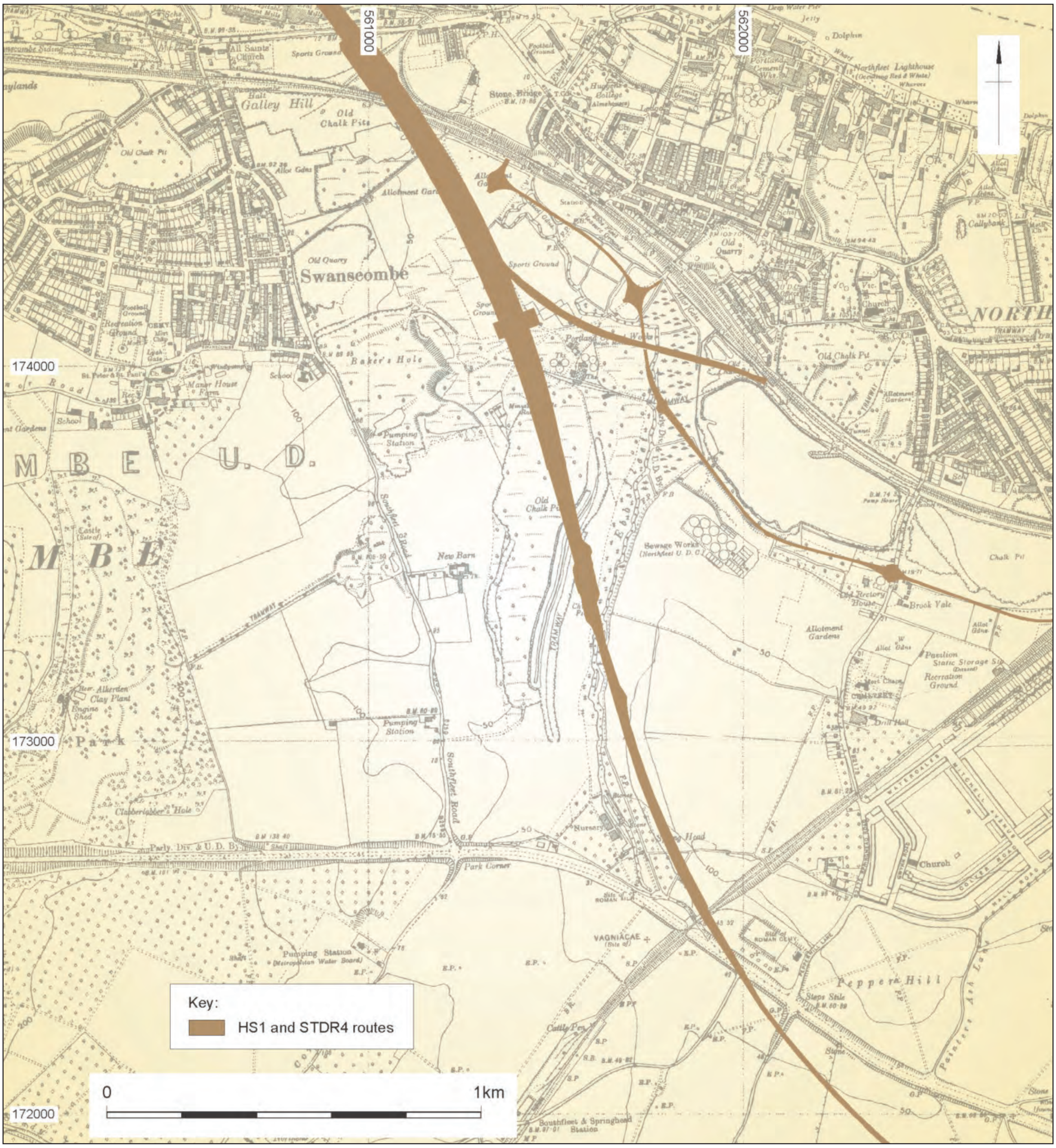


Figure 2.7 1938 OS survey (3rd edition, 6")

Archaeological Background and Previous Investigations

Lower and Middle Palaeolithic

The Ebbsfleet Valley has been subject to repeated investigations from the later part of the 19th century, through the 20th century and continuing into the 21st with those carried out in advance of HS1. The review below focuses upon the work which is best known following from its publication and the retention of resulting remains and documents in museum archives, and consequently most incorporated into today's Palaeolithic archaeological discourse. Much additional work is known to have been carried out, of which tantalising glimpses are present in some museum archives, but for which there is insufficient documentation (known at present) to contribute to any current research. For instance, Henry Stopes was a vigorous collector in the 1890s, but never kept adequate records of the provenance of any of the material he found (Wenban-Smith 2004b; 2009). Later, Louis Leakey, when at Cambridge University in the mid-1930s, recovered substantial quantities of lithic remains from an unknown location in Rickson's Pit (also known as Barracks Pit). The lithic remains from Leakey's work are preserved in the Cambridge University Museum of Archaeology, and various site documents are preserved in the British Museum. Likewise, Kenneth Oakley (Natural History Museum – NHM) and William Grimes (later director of the London Institute of Archaeology) also carried out investigations in the late 1940s, for which very sketchy documentary evidence is preserved in the Natural History Museum archives. The review below summarises the work carried out and the main results of the previous investigators who have made the most telling contribution to today's understanding of the site. However, as alluded to previously (Chap 1), much of the potential of even this work has remained unrealised due to inadequate recording and incomplete publication. Where possible, relevant remains and information from this pre-HS1 work have been reassessed in this volume, and modern analytical techniques that were not available to the early workers applied to surviving remains. These new results are incorporated where relevant later in the volume.

The workers who carried out the most important investigations prior to those for HS1 are:

- Flaxman Spurrell, working as a private antiquarian in the later 19th century;
- Reginald Smith and Henry Dewey, working professionally together in the early 20th century on behalf of the British Museum and the Geological Survey respectively;
- James Burchell, another private antiquarian, working in the 1930s;
- John Carreck, of Queen Mary College, Department of Geology, working mostly in the 1950s;
- Gale Sieveking, of the British Museum, working in the late 1960s and early 1970s;
- Francis Wenban-Smith, as a doctoral student at University of Southampton, Department of Archaeology, whose fieldwork began in 1989, and continued through to 1995.

The most significant locations of this body of work are shown in relation to the pre-HS1 landscape (Fig 2.8), and more details are given below.

F C J Spurrell

Flaxman Spurrell, investigating in the late 1870s or early 1880s, was the first to identify prehistoric remains of any sort in the Ebbsfleet Valley. Spurrell (1883) collected large quantities – "many thousand" (*ibid*, 103) – of lithic artefacts and Pleistocene fauna from a "kind of beach" (*ibid*, 102) visible in a tramway cutting at *c* 20 feet above OD. The location of this cutting (Fig 2.8) has been established by reference to the 1895 OS 6" survey (Fig 2.5), which shows a pit rail line heading WSW across the Ebbsfleet into the expanded chalk quarry of Baker's Hole, and the topographic correspondence of the North-facing side of this cutting with the diagram drawn by Spurrell of the North-facing section of a "tramway half

Plate 2.1 Late 19th-century pit-rail rivet bridge across the Ebbsfleet into Baker's Hole and Southfleet Pit

a mile east of Swanscombe church" held in Dartford by Kent County Library Services (Fig 2.9). Kennard (1940) later described the deposits as consisting of "a series of loams, gravels and sands ... banked against a buried chalk cliff". Spurrell's section diagram of the tramway cutting – which also shows a "Denehole" – does not specifically identify the context of his lithic and faunal material, making it impossible to provenance his finds to a specific deposit. The lithic artefacts he found included classic Levalloisian "tortoise-cores" (showing the scar from the removal of single large flake from a domed radially prepared surface), Levalloisian flakes themselves and cortical flint nodules used as hammerstones. The fauna he found included "Mammoth remains of great size, also those of Rhinoceros, Bos, Bison, Horse and Deer" (Spurrell 1883, 102).

R A Smith and H Dewey

Following the work of Spurrell the Ebbsfleet Valley was well known to collectors in the 1890s and early 1900s as a source of Palaeolithic artefacts and fossils. Abbott (1911) describes how in 1907 the Associated Portland Cement Manufacturers (APCM) opened a new chalk quarry, officially named the Southfleet Pit (Fig 2.6). According to Abbott, the local collector James Cross was the first to discover that the new Southfleet Pit was a prolific source of Palaeolithic artefacts. On 14 July 1908, Cross wrote to the British Museum (letter held in the British Museum archives) proposing to visit and show them "what is apparently a new series of stones". This was followed up by the British Museum, albeit without involving Cross, and during 1909 and 1910 there were numerous letters (also held in British Museum archives) between R A Smith (Deputy Keeper of Antiquities in the Department of Prehistoric and Romano-British Antiquities) and G W Butchard of the APCM discussing archaeological work at the Southfleet Pit, and the storage of the artefacts and fossils found.

It seems that no formal controlled excavation took place (as clarified by Scott 2010, and *contra* Wenban-

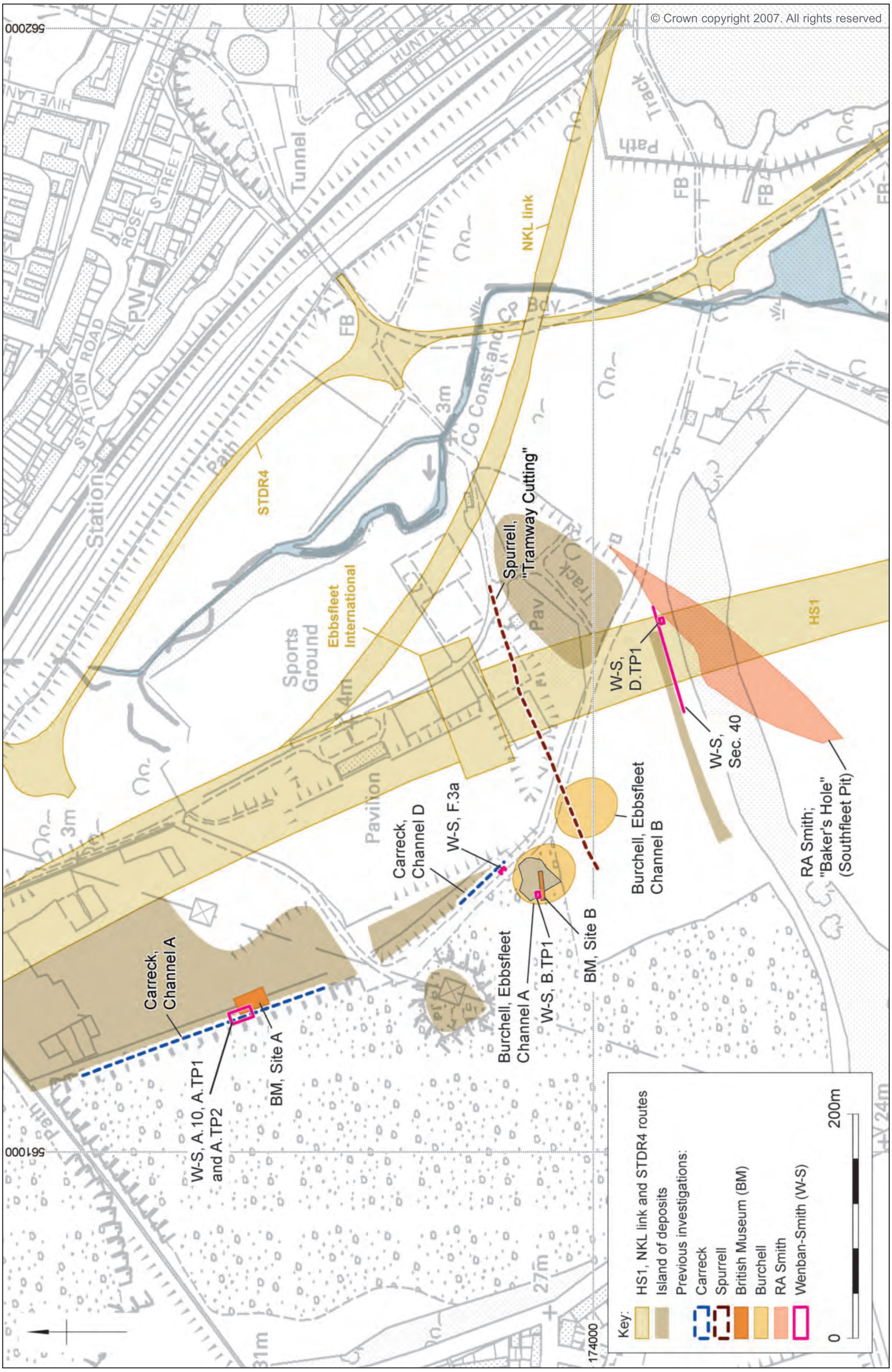


Figure 2.8 Locations of previous work: Spurrell; RA Smith; Burchell; Carreck; British Museum; and Wenban-Smith

Smith 1995), despite Smith's stated intention to do so. Focus upon Palaeolithic remains was diverted by discovery of a Roman building complex at the pit entrance (Andrews *et al* 2011a). However, recovery of lithic remains was encouraged by a bonus paid to the quarry diggers – "the men appear to be well-pleased with the money… so I am hopeful now of obtaining anything of interest they come across" (letter from G W Butchard to R A Smith, 16 January 1909), followed five months later by: "In addition to finding a large number more flint implements, we have come across a great number of pieces of pottery, tile… part of a brooch, a bone pin and a small bronze implement...not far from where the flint implements were found" (letter from G W Butchard to R A Smith, 17 June 1909). The flints were then packed in boxes and stored in the works office at Gravesend pending analysis (letter from G W Butchard to R A Smith, 26 October 1909). Shortly after (letter from G W Butchard to R A Smith, 19 November 1909), Smith visited to examine both "the Southfleet chalk quarry, known to some as Baker's hole" and the "Barnfield chalk pit at Swanscombe" where "at one time a great number of highly finished implements were found". The next paragraph of the same letter agrees to "scientific investigation of the deposits" without specifying one or other of the aforementioned sites. There are subsequent specific mentions of both "the proposed excavation of the Southfleet pit" (letter from G W Butchard to R A Smith, 17 April 1910) and investigation of "the Swanscombe gravels... [of which there are] about 30 feet deep exposed at our Barnfield chalk quarry" concerning which "I have already spoken to one of my directors (Mr Bamber)... and they consented at once" (letter from G W Butchard to R A Smith, 16 September 1910). There is no further mention of controlled investigation at either of these sites until late 1911, when: "if you want to do anything at the Milton Street pit [ie, the Barnfield quarry], no time should be lost as we have ordered another steam navvy to remove the gravel there" (letter from G W Butchard to R A Smith, 9 November 1911). Although there are several mentions during this period of facilitating examination of the Southfleet Pit flint artefact and faunal collection, prior to public presentation of the results, read as a paper at the Society of Antiquaries on 4 May 1911 and published shortly after (Smith 1911), it seems that no formal excavation took place. Smith's paper states that analysis of the flint collection is based upon "a large number in the possession of the company working the pit" (*ibid*, 515), and also that "the implements and bones were mainly excavated by the workmen" (*ibid*, 519). Therefore, it seems likely that the APCM flint and fossil collection from Southfleet Pit, later donated to the British Museum and the Natural History Museum respectively in 1914, was recovered by the quarry workers under a cash incentive scheme.

For a long time, the location of Cross's/Smith's Southfleet Pit site (also known by many as Baker's Hole or New Barn Pit) was forgotten, although it is now clear (Wenban-Smith 1990b) from the combination of information in Smith's published paper and a number of archival sources (eg, Fig 2.10) that it was from a specific artefact-rich deposit in the north-west part of the long north-south quarry west of the Ebbsfleet (Figs 2.7 and 2.8). The material recovered came from a bed of Coombe Rock (chalk-rich slopewash deposit) capping the Chalk bedrock, and occurring between 5–15 feet below the ground surface (which was at *c* 45 feet above OD). It can be seen from the geological mapping of the day (British Geological Survey, Kent sheet X-NW, edition of 1910, with additions of 1920 by C N Bromehead; Fig 2.3) that although the ground surface here dipped northward, the artefact-bearing Coombe Rock was part of a major suite of mixed colluvial and solifluction deposits that dipped and thickened north-west from the spur of chalk quarried for Southfleet Pit, into the dry valley on its western flank. The surviving section in the vicinity of the site was recorded by F N Hayward in 1920 (see Fig 2.11).

Smith's publication focused on the lithic and faunal collection as providing important evidence of a post-Boyn Hill '100-foot terrace' era of Middle Palaeolithic prehistoric occupation during cold climatic conditions for which no English evidence had yet been recovered (apart from by Spurrell, at Crayford and previously in the Ebbsfleet Valley itself). Smith emphasised the abundance of a classic "tortoise-core" Levalloisian knapping industry in the lithic collection, and on some similarities with material from the Le Moustier cavern in the Dordogne, thus proving evidence of the Mousterian period in England and close connection "in culture if not in blood" (Smith 1911; 525) between the makers.

The work by Smith and Dewey – who, as representatives of the British Museum and the Geological Survey, and who then presented their work to the Society of Antiquaries can be regarded as at the heart of the academic establishment of the day – put "Baker's Hole" on the map as Britain's foremost Levalloisian site, a position it retains to the present day. Later re-analysis of the APCM lithic collection (Wenban-Smith 1995; 1996) has, however, revealed internal variety and potential complexity not taken account of, or perhaps glossed over, by Smith. This is not addressed here, but is considered subsequently (Chap 17), when it comes to reviewing the evidence of Palaeolithic occupation in the Ebbsfleet Valley, and placing it within a wider context.

J P T Burchell

Burchell carried out fieldwork in the Ebbsfleet Valley through the 1930s, investigating Pleistocene deposits in various locations. Despite recovering importance evidence from a number of locales, his work unfortunately leaves much to be desired, even by the standards of his time. He published not a single plan showing the location of any of the sites he investigated, nor are any plans known from archival sources, bar one thumbnail sketch accompanying two stratigraphic summary diagrams, held at the British Museum

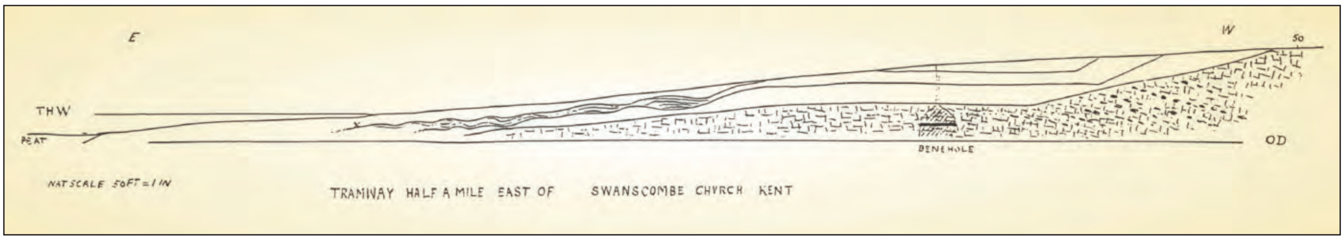


Figure 2.9 Spurrell's Tramway Cutting

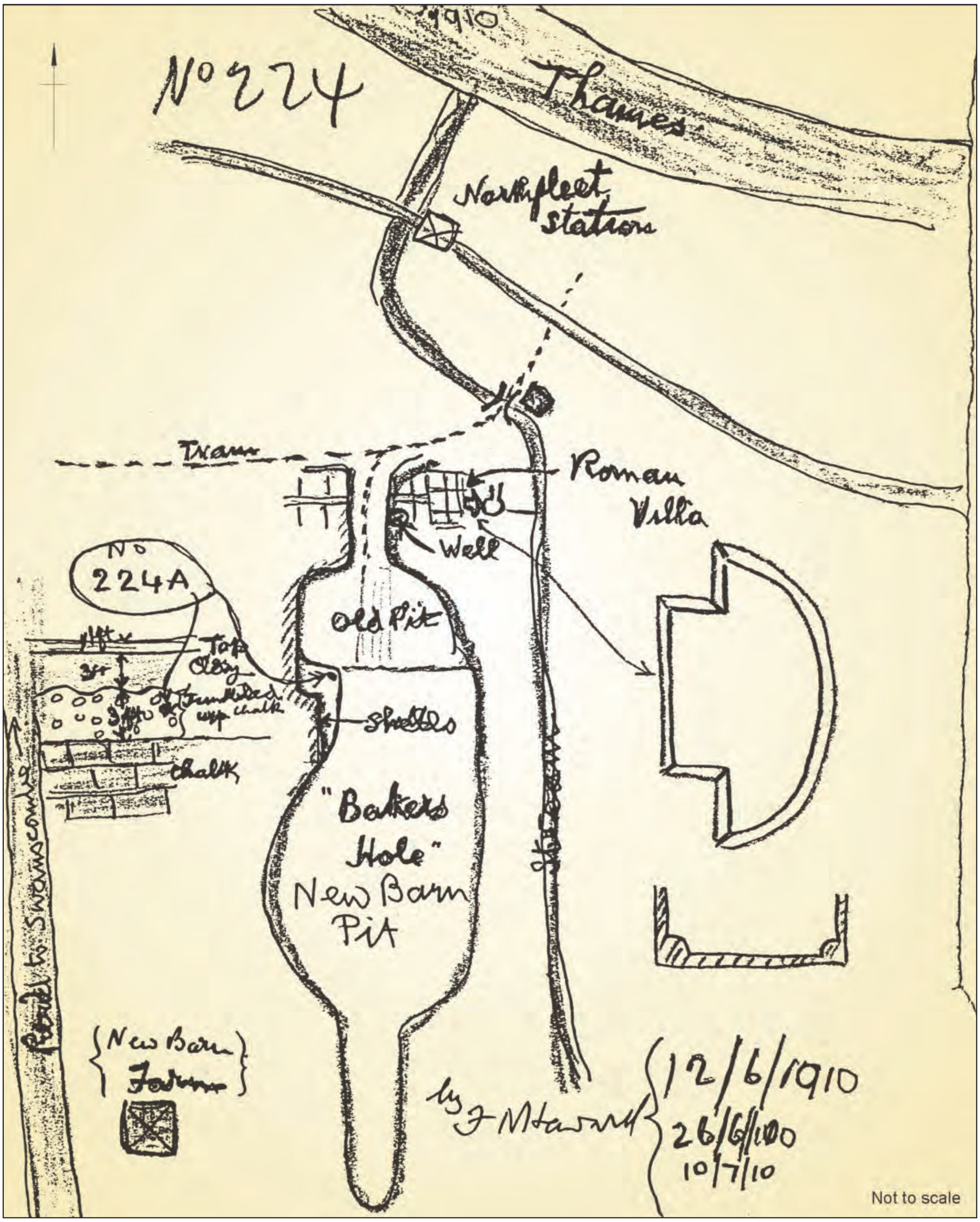


Figure 2.10 Hayward's 1910 sketch map of Baker's Hole/New Barn Pit

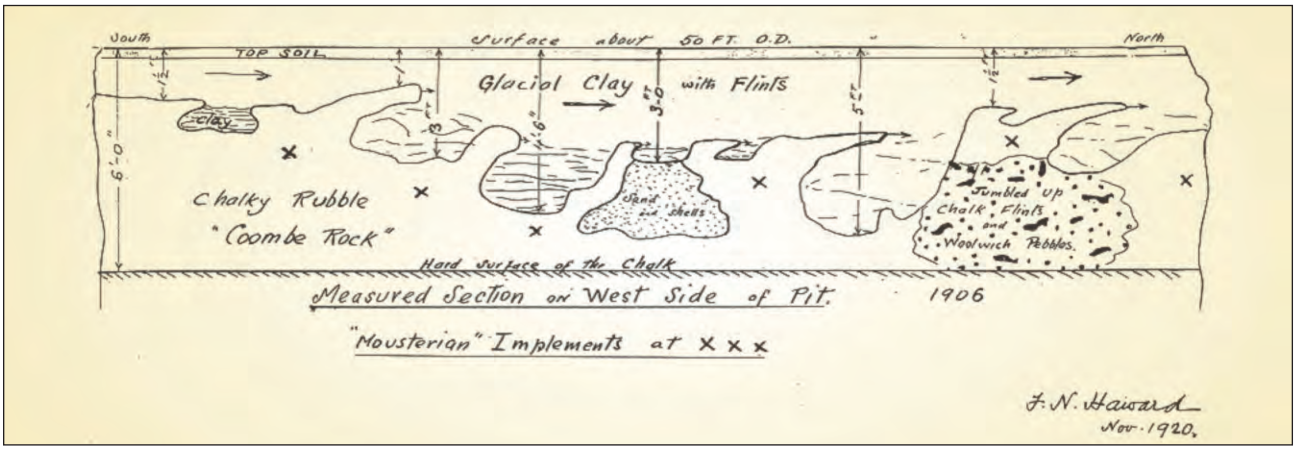


Figure 2.11 East-facing section at north-west corner of Southfleet/New Barn Pit, as recorded by F N Hayward

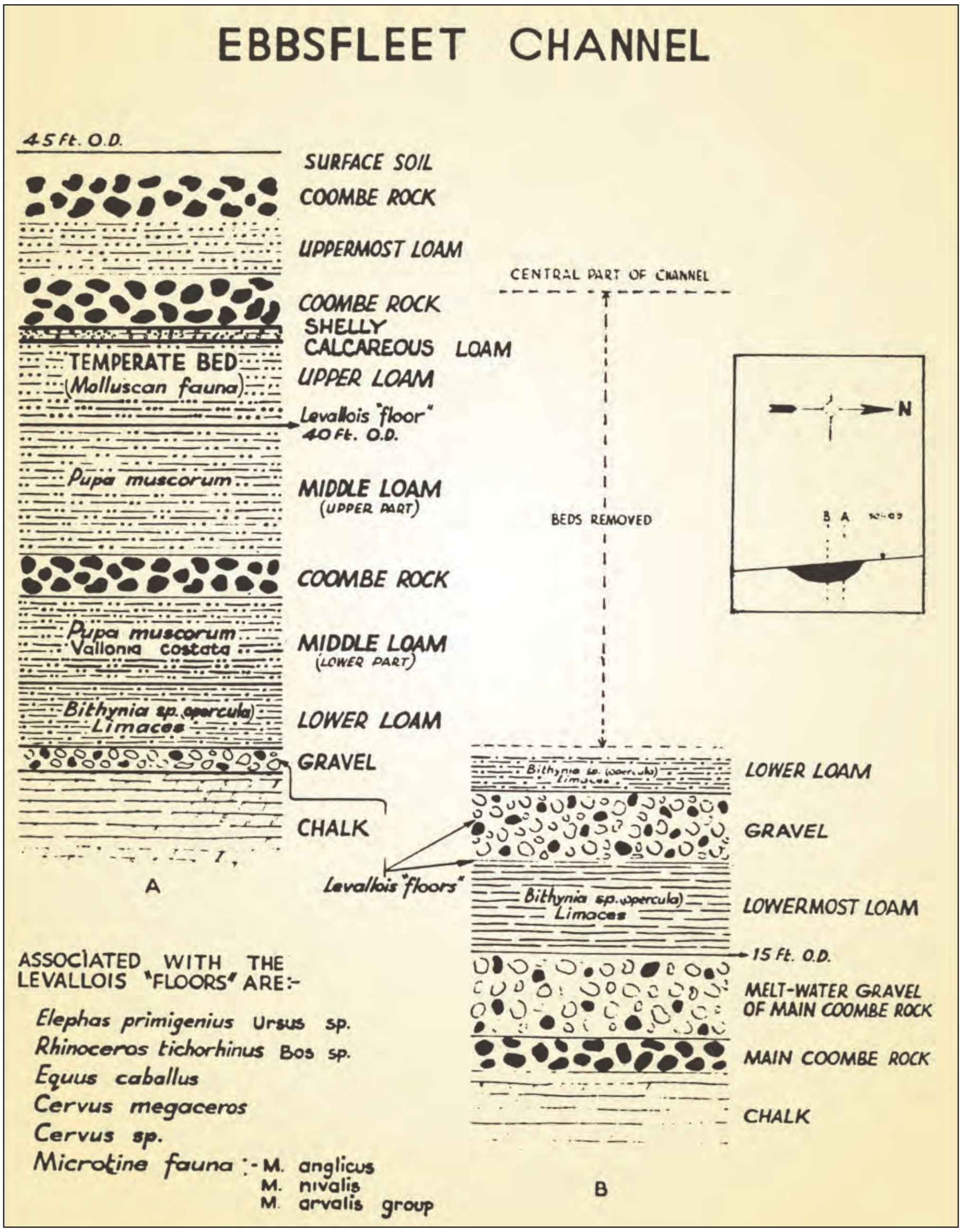


Figure 2.12 Burchell's Ebbsfleet Channel sites A and B, and thumbnail location sketch

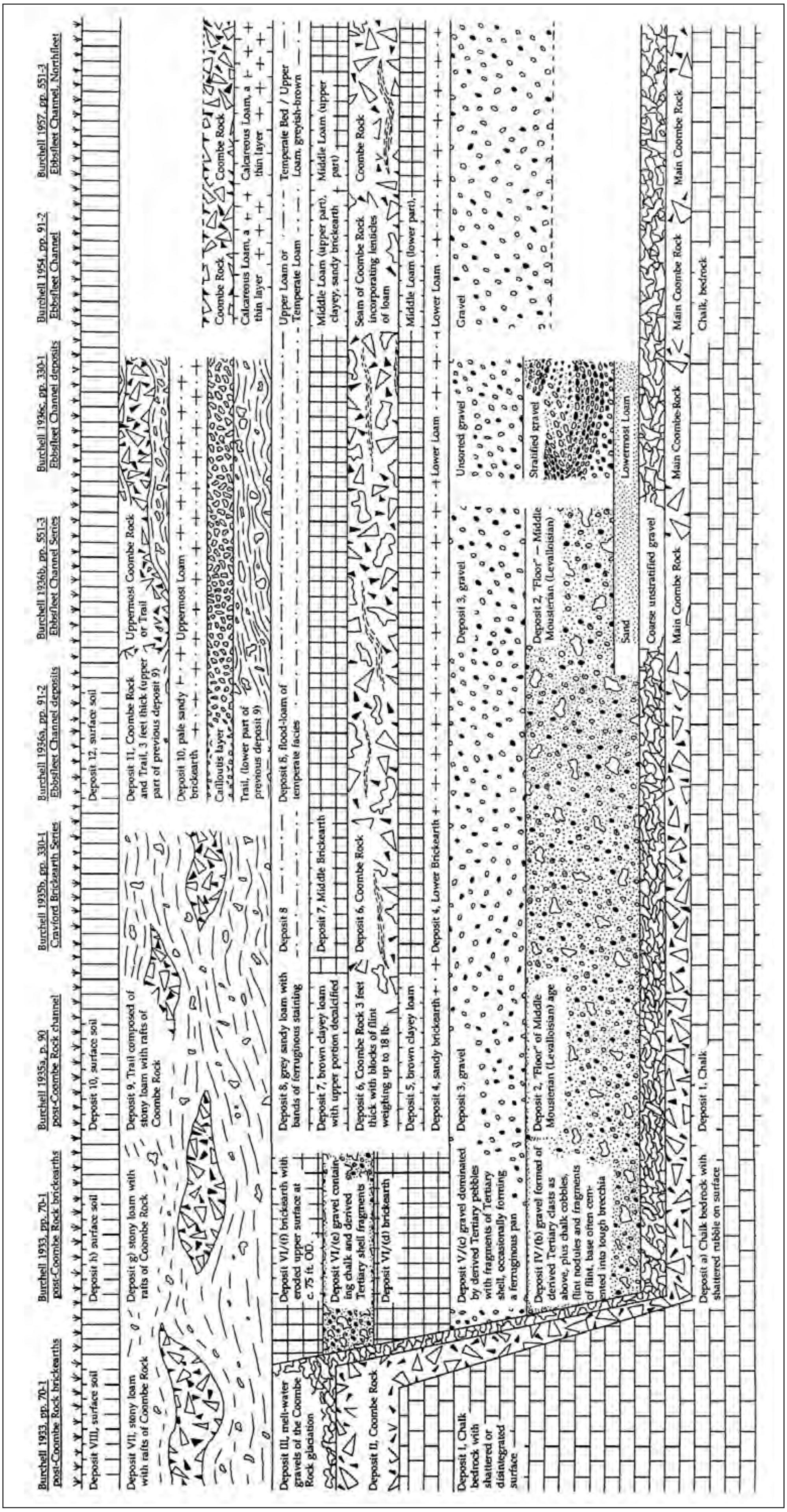


Figure 2.13 Stratigraphic summary diagram of Burchell's sequences and nomenclature

(Fig 2.12). He made no accurately scaled stratigraphic drawings from any of his sites, restricting his stratigraphic records to unpublished summary diagrams incorporating his own unsubstantiated correlations between deposits from different locations. Furthermore, he continually renamed deposits and reassessed their stratigraphic correlation (Fig 2.13), leading to a virtually impenetrable web of information published in piecemeal fashion, mostly between 1933 and 1936 (Burchell 1933; 1934a–b; 1935a–b; 1936a–c; Burchell and Moir 1933), but with two late additional papers in the 1950s (Burchell 1954; 1957).

In short, even allowing for the period he was working in, the record-keeping and scientific rectitude was quite inadequate, compared for instance with contemporary work at nearby Barnfield Pit following Marston's discovery of the Swanscombe skull (Swanscombe Committee 1938) and Spurrell's much earlier work at Crayford (eg, Spurrell 1883). This is greatly to the detriment of our present understanding of the British Palaeolithic, for Burchell investigated a number of very important locales in the Ebbsfleet Valley (Fig 2.8). Despite his poor record-keeping and the lack of primary data in his numerous publications, his work can contribute to current debate to a limited extent. He had a number of academic collaborators who have left both a paper trail of archival information and also secondary publications, such as Zeuner (1945; 1959). He was followed in his work by first Carreck and then Sieveking, both of whose work is discussed further below. Carreck provided a relatively detailed written record of his own fieldwork locations and their locations with respect to Burchell's locales, where known (Carreck 1972). Sieveking carried out more detailed excavation and recording at Burchell's main "Temperate Bed" site, and also instigated its preservation as a Scheduled Ancient Monument, thus protecting it from further quarrying and leading to its preservation through to the present day. Finally, besides the large lithic collection resulting from Burchell's work that survives, mostly in the British Museum and the Cambridge University Museum of Archaeology, and upon many artefacts of which he has written details of their stratigraphic horizon, there are also a small number of molluscan and mammalian remains preserved in the collection of the Natural History Museum.

Burchell's investigations were focused, not on the chalk-rich slopewash deposits that flanked the north-west angle of the Southfleet Pit, and which had produced the large APCM collection reported on by Smith, but on deeper and more varied gravel and finer-grained sand and clay-silt deposit several hundred metres to the west. Burchell's two major discoveries were:

(1) Identification of a "Temperate Bed" with a fully interglacial mollusc fauna towards the top of a significant thickness of sediments – his "Ebbsfleet Channel" sequence, generally described by him as "the Crayford Brickearth series". The underlying deposits of this sequence contained sedimentological and faunal indicators of having formed under cold climatic conditions.
(2) Recovery of abundant mint condition Levalloisian lithic remains from what he called "floors" towards the base of the Ebbsfleet Channel sequence.

The full sequence overlay, and abutted, chalk-rich Coombe Rock that he equated with Smith's Coombe Rock, and was capped by evidence of a return to cold conditions. The sequence thus contained evidence both of a full new glacial–interglacial–glacial cycle between the interglacial conditions known from the Swanscombe '100-foot terrace' and those of the present day, and of Levalloisian occupation within this new cycle.

The most informative diagram from Burchell's work (Fig 2.12) shows sequences at two different Ebbsfleet Channel locations, A and B, alongside a thumbnail sketch showing their relative position. We know from subsequent published work (Carreck 1972; Kerney and Sieveking 1977; Wenban-Smith 1995), and from the survival of the site in the present day thanks to its protection by Sieveking, the location of his channel-edge Site A (Fig 2.8). We do not know, however, the location of the second channel-centre Site B, although its general area can be estimated (Fig 2.8). The important point here, and one that is later returned to (Chap 6), is that Burchell's interpretation of the stratigraphic correlations between these sites must be recognised as highly suspect, with interpretive consequences for the artefactual and faunal material recovered.

J N Carreck

Following World War II, Burchell's work was expanded by Carreck, who, whilst avoiding the specific locations where Burchell had excavated, investigated a number of other fossiliferous deposits. Most importantly, he made location plans of his work (Fig 2.14) and produced section drawings of the stratigraphic sequences he saw, accompanied by lithological descriptions (Carreck 1972). Carreck investigated a new section – his Channel D (Fig 2.8) – directly to the north of Burchell's main Temperate Bed Site A, on the opposite side of a pit rail line cutting – importantly, a different cutting to that examined by Spurrell more than 50 years earlier. He also identified a major, and wholly new, fossiliferous sequence that had horizons rich in both mammalian and molluscan remains – his Channel A (Fig 2.8) – 300m further north, on the east side of the relatively recently quarried Rickson's/Barracks Pit. Frustratingly, despite Carreck's good records of the sequences he saw, the large fossil collection he made is currently lost. However, the quality of his records and his detailed descriptions of many of the fossil mammal specimens he recovered make his work still useful as a source of primary data for reconsideration in the present day. He also recorded important details of correspondence between Burchell and his academic collaborators, preserving extra, unpublished information on the species identifications and provenance of small vertebrate

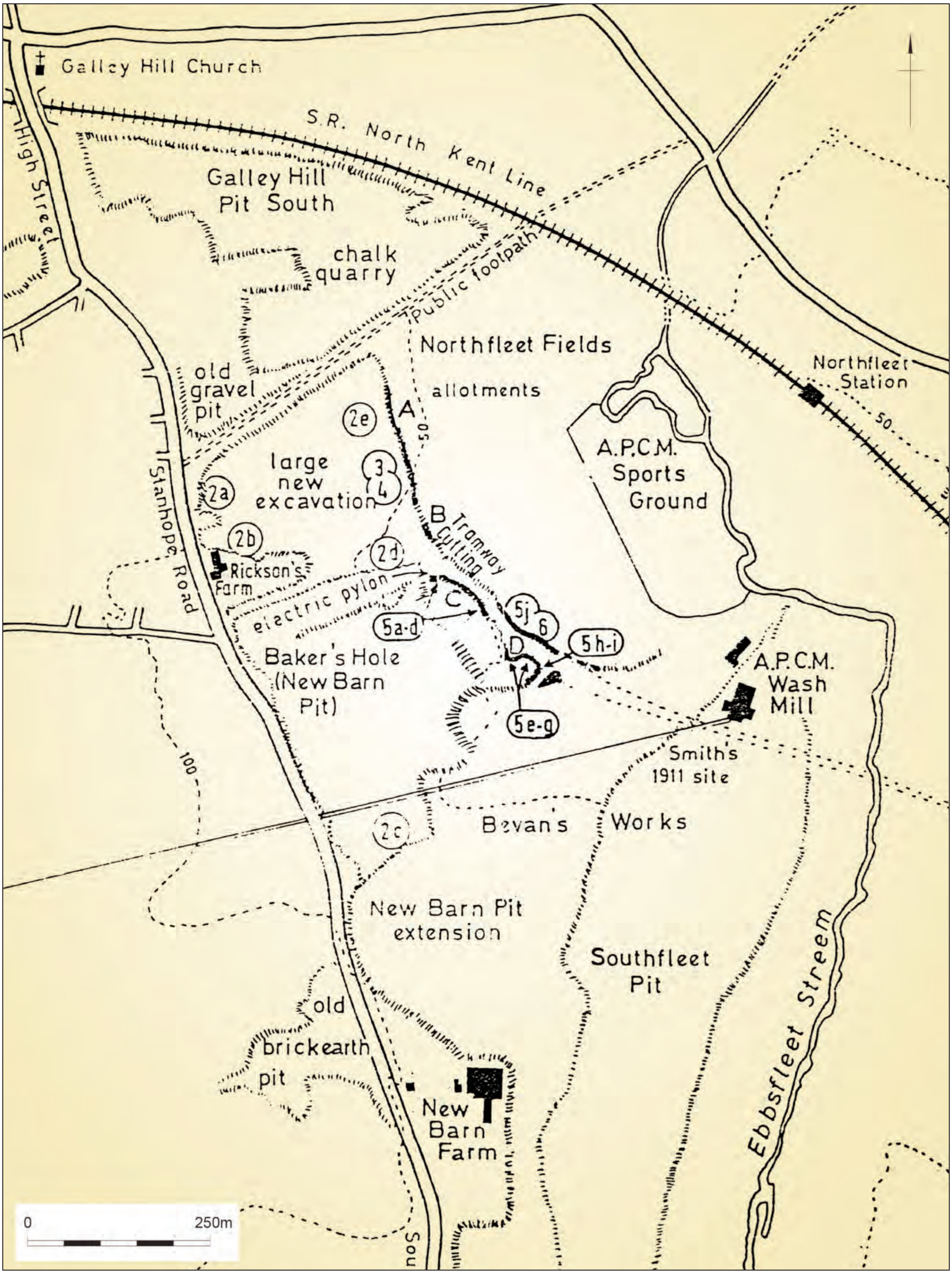


Figure 2.14 Carreck's location summary diagram

remains recovered by Burchell from his Ebbsfleet Channel sites.

British Museum (G de G Sieveking)

Gale Sieveking was curator of prehistory at the British Museum for several decades, and throughout this period directed fieldwork virtually every summer at numerous Palaeolithic and later prehistoric sites across Britain, amongst them in the Ebbsfleet Valley (Fig 2.15). His work in the Ebbsfleet Valley was compromised by inadequate field recording and the minimum of subsequent publication. Cursory paragraphs were produced following each field season (Sieveking 1970; 1971; 1972), and there was one slightly more expansive summary report that included much key data produced with his collaborator Michael Kerney for the 1977 INQUA Congress, based that year in the UK (Kerney and Sieveking 1977). Following a preliminary investigation in 1965, Sieveking carried out excavations between 1969 and 1971 at a number of locations, most of them never recorded, but the most important of which were: (1) his Site B, in 1969 (site code EB 69), which was at the same location as Burchell's Ebbsfleet Channel Site A and close to Carreck's Channel D; and (2) his Site A, in 1970 and 1971 (site codes NO 70 and NO 71), which was at the same location as Carreck's Channel A (Figs 2.8 and 2.14).

At his Site A, Sieveking cleared a substantial thickness of sterile overburden from an area of *c* 20 x 10m and carried out an open-area excavation of the main fossiliferous horizon. It was generally believed at the time of his work that there was just one major interglacial, the Ipswichian, between the Hoxnian (as represented in the Swanscombe '100-foot terrace') and the interglacial of the present day, therefore the horizon (which contained various temperate indicators, particularly molluscs) was *a priori* regarded as Ipswichian. Deposits of this period in the UK are characterised by an abundance of hippopotamus remains, and a lack of human presence, making the Ebbsfleet Valley of particular importance if human occupation could be confirmed in the Ipswichian, and Sieveking may have hoped to find hippopotamus remains to support an Ipswichian date. Thus, a number of what were later identified as broken red deer tines, were recovered and recorded as hippopotamus canines (A Currant pers comm). Secondly, one of the curious characteristics of material from some horizons at the site is that it has undergone severe abrasion at some point in its history, leading to the flattening of some facets on faunal remains, and giving protrusions on flint nodules a smooth shiny "melted" appearance of silica gloss, interpreted by Sieveking as humanly caused by vigorous rubbing of animal hide (*cf* Meeks *et al* 1982 for more detailed discussion). Thus the site was initially presented as a river-bank Ipswichian hippopotamus-butchery and hide-processing factory, a claim that subsequently rapidly evaporated under closer scrutiny.

Nonetheless, Sieveking's work recovered a large fossil mammal collection from his Site A and a smaller

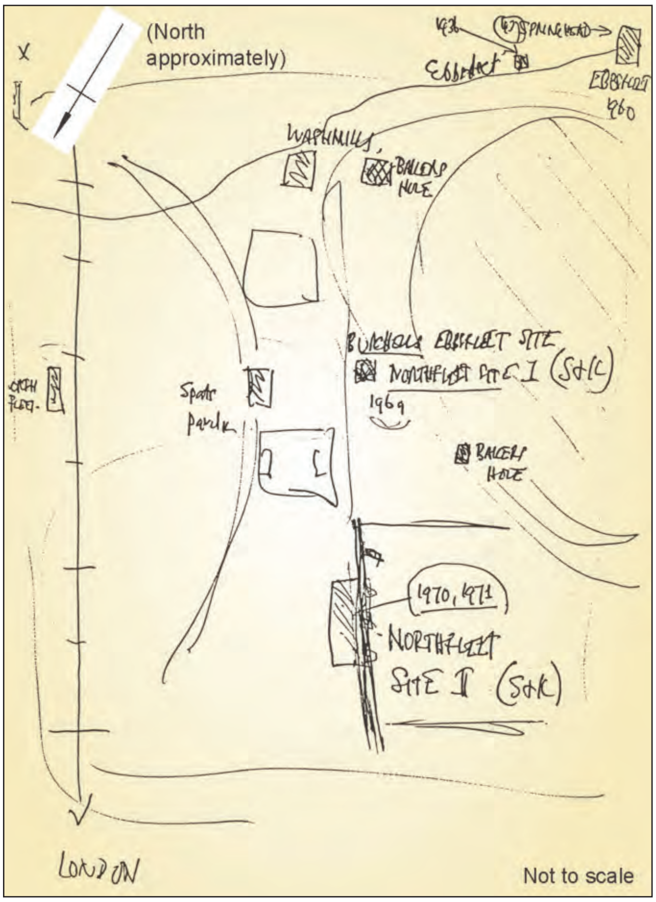


Figure 2.15 Sieveking's site location summary diagram

one from his Site B, as well as various other faunal material from unrecorded locations in the general vicinity. Unfortunately, the great majority of this material (held at the Natural History Museum) cannot now be provenanced to any specific stratigraphic horizon, greatly reducing its interpretive potential. He also recovered a small lithic artefact collection from his Site B, which can be tied in with the recorded stratigraphic sequence.

Despite some shortcomings, Sieveking's work did however achieve a number of useful outcomes. Firstly, he organised accurate scale drawings tied in with OD of the stratigraphic sequences exposed at Carreck's Channel A (see Fig 5.2) and revealed by his own trench at Burchell's Ebbsfleet Channel Site A (see Fig 6.2). Secondly, his collaborator Michael Kerney, who had also worked with Carreck and Burchell, carried out molluscan sampling at both sites, the results of which are preserved in the British Museum archives. The molluscan results remain important for reinterpretation today (Chaps 5 and 6), although the exact location of much of this work was not recorded. And finally, despite a fundamental misunderstanding of the nature of his Site A, Sieveking persuaded the relevant curatorial authorities (then based in the Department of the Environment) that both his Sites A and B were of national importance, causing them to be scheduled as Ancient Monuments (Kent 267a and 267b), and thus securing their protection through to the present day.

F Wenban-Smith

The final pre-HS1 phase of Palaeolithic fieldwork in the Ebbsfleet Valley was carried out by Wenban-Smith between 1989 and 1995 (Table 2.2; Appendix A), done as part of doctoral research (supported by the British Academy, and based at the Department of Archaeology, University of Southampton) the initial objective of which was a general investigation of the Levalloisian in Britain (Wenban-Smith 1996). Baker's Hole was at this time well-established as Britain's pre-eminent Levallois site (with the possible exception of Crayford, at that time under investigation by J Cook of the British Museum). At the start of this work, although Sieveking's Site A (ie, Carreck's Channel A) and Site B (ie, Burchell's Ebbsfleet Channel Site A and Carreck's Channel D) were known and protected, the location of Smith's 1911 "Baker's Hole" Southfleet Pit site was uncertain, although it was generally agreed to have been quarried away (Carreck 1972; Wymer 1968; Roe 1981; Robinson 1986). The general objectives of the fieldwork and associated archival research were: (a) to carry out a thorough survey of surviving Pleistocene sediments in the Ebbsfleet Valley; (b) to tie them in with previously investigated sites, particularly Smith's 1911 Southfleet Pit; and (c) to carry out field investigations and subsequent off-site analyses that would put the Pleistocene deposits of the Ebbsfleet Valley, and the recovered artefactual evidence of human occupation, into a coherent chrono-stratigraphic framework, integrated with the wider MIS framework and the wider context of Lower/Middle Palaeolithic occupation of Britain.

Surviving islands of Pleistocene deposits were identified at six main locations (Areas A–F) in amongst the heavily-quarried landscape, including several not previously investigated (see Fig 2.16). Field investigation at Area A, and specifically at the location identifiable as Sieveking's Site A – recognisable as a

Table 2.2 F Wenban-Smith fieldwork summary

Date	Locations investigated	Details of work
May 1989	–	General recce
October–November 1989	Site C (pylon island)	Surveyed outline; drew south-east-facing section
	Site B (SAM 267b)	Surveyed outline; drew south-east-facing and north-facing sections
	Site F	Surveyed and drew south-west-facing section
July 1990	Site A (SAM 267a)	Logged sequence at corner of Sieveking's Site A excavation and took vertical sample series for molluscs (Section A.10, location A.10.a)
	Site F	Logged south-east end of section (location F.3.a)
April 1992	Site D	Recorded north-facing section; took some samples from sand lenses in Coombe Rock; dug test pit (D.TP1) from which came mammoth tooth SF 1097
	Site E	Cursory examination, found Levallois core SF 1098 in face
May 1993	Site A	Excavated test pit TP A1 (= A.TP 1) at N end of Sieveking box, took bulk samples through sequence, plus series of pollen/ostracod samples and recovered various large vertebrate remains; clast lithological sampling of basal gravel
	Site B	Excavated test pit TP B 1 (= B.TP 1) into Temperate Bed and took bulk and pollen/ostracod samples (loc B-TP1.b)
June 1993	Site B	Bulk sampling from upper part of Temperate Bed
July 1993	Sites A–B, D–E	OSL sampling
May 1994	Site A	Further environmental sampling at test pit A.TP 1, and recovery of large vertebrate remains
	Site B	Further environmental sampling at test pit B.TP 1; opened another test pit B.TP 2, and did other bulk sampling from main north-facing Site B section
	Site C	Bulk environmental sampling
	Site D	Bulk environmental sampling from wavy sand beds within base of Upper Coombe Rock at east corner of site
	Site E	Bulk environmental sampling at logging location E.43.c
October 1995	Site A	Opened new test pit (A.TP 2) for QRA visit (Wenban-Smith 1995); recovered various further large vertebrate remains; 2nd batch of OSL sampling; dinoflagellate sampling
	Site B	Re-opened test pit B.TP 1 for QRA visit; 2nd batch of OSL sampling

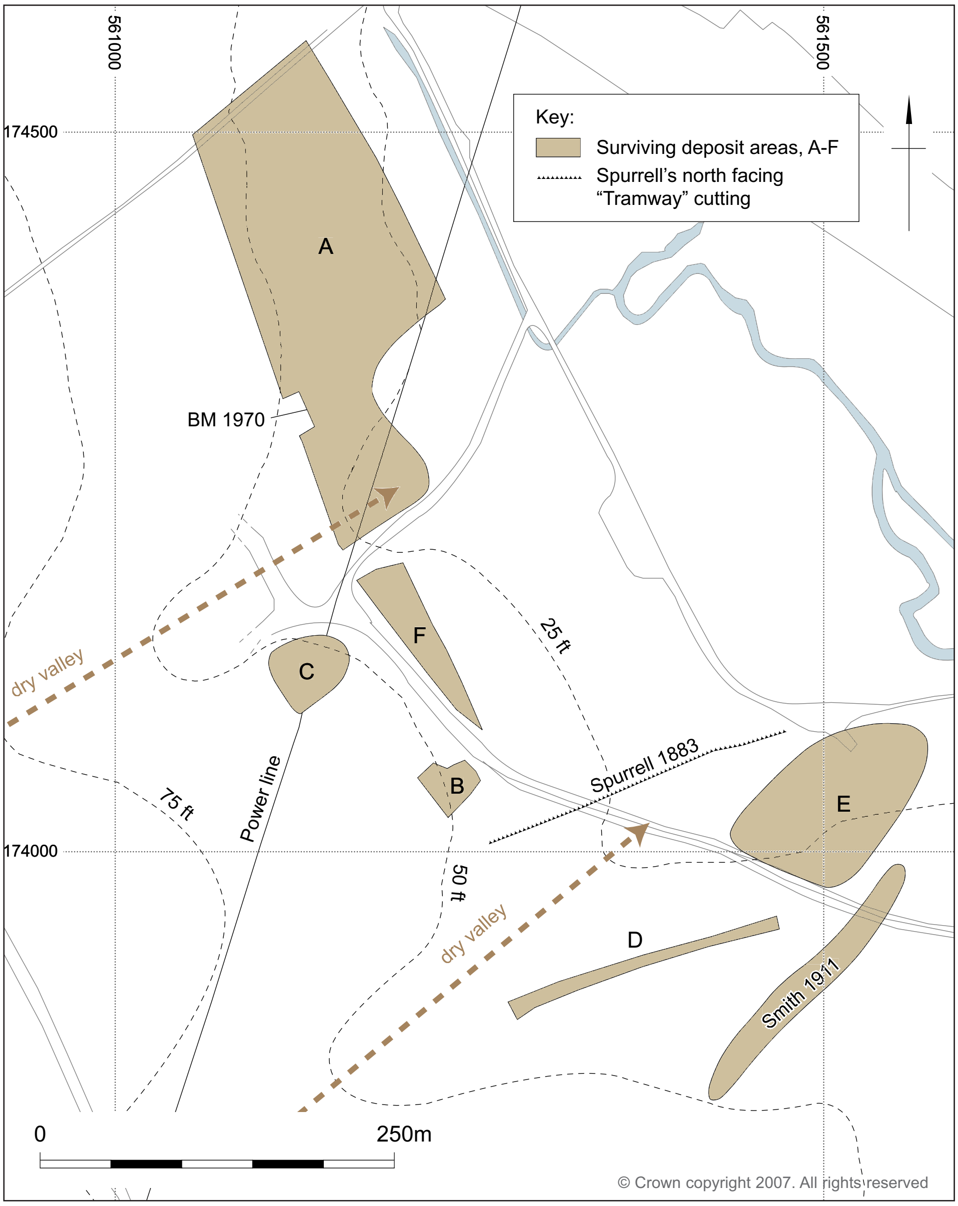


Figure 2.16 Wenban-Smith's Areas A–F

major hole in the surviving section of Carreck's Channel A – was initially aimed solely at recovery of molluscan remains for amino acid dating. This was later extended to include bulk sampling for small vertebrate recovery and ostracod sampling, and several large vertebrate remains were also recovered. Investigations at Area B (also Sieveking's Site B), were likewise primarily aimed at molluscan recovery for dating and environmental reconstruction from the Temperate Bed, and small vertebrate recovery. No mollusc-rich deposits were found at Site B, but a rich small vertebrate assemblage was recovered from the Temperate Bed, and a number of lithic artefacts were also found. Optically stimulated luminescence (OSL) dating was also carried out at both locales A and B. The results of this work, including new dating results and analyses of the small vertebrate and other environmental remains recovered, are reported in Chapters 5 and 6.

Later Prehistoric Remains

by Chris Hayden and Elizabeth Stafford

Although the Ebbsfleet Valley has given its name to a widely distributed style of earlier Neolithic pottery, there are few later prehistoric sites in and around Ebbsfleet which can rival the significance of the Palaeolithic finds. Even the naming of Ebbsfleet Ware reflects the propitious timing of the discoveries by Burchell more than the significance of the site itself. The pots which Piggott used as a starting point to define Ebbsfleet Ware (Burchell and Piggott 1939; Fig 2.17) were discovered shortly after Piggott had published his synthesis of Neolithic pottery in the British Isles (Piggott 1931). The report on the Ebbsfleet vessels (Burchell and Piggott 1939) contained few details of the site itself, and perhaps as a result, the site has attracted little attention since.

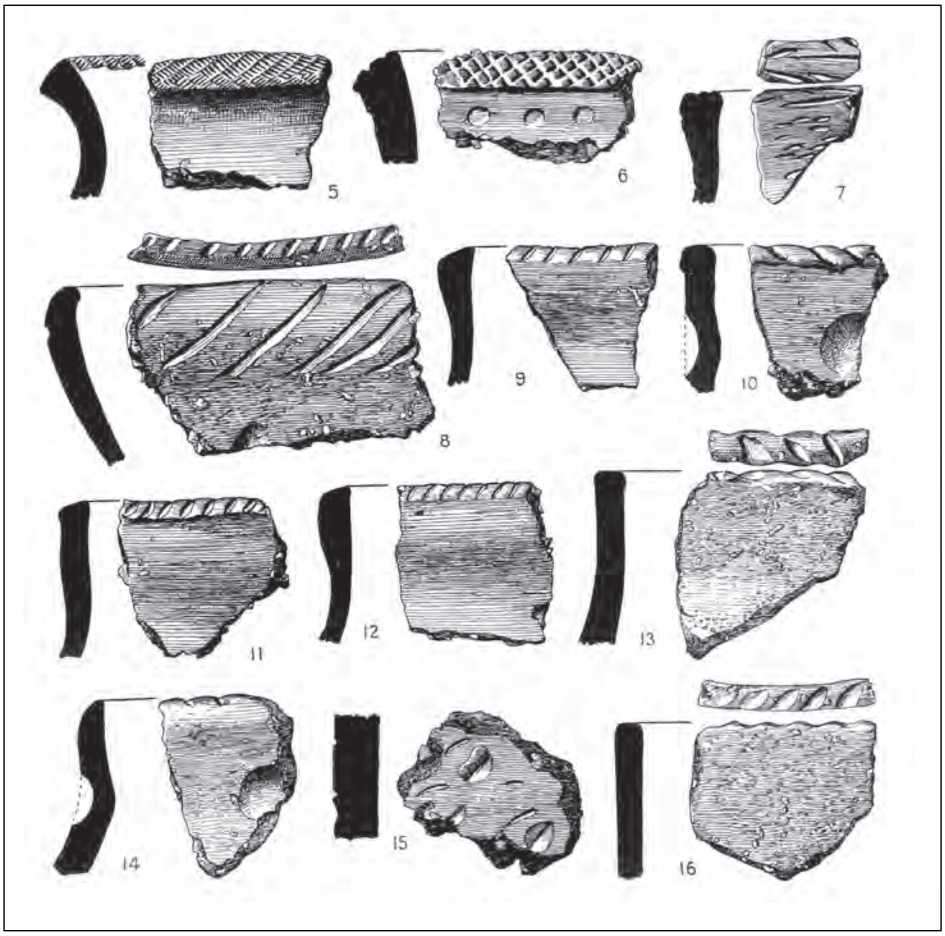


Figure 2.17 Ebbsfleet Ware pottery (Burchell and Piggott 1939)

The limited role the site has played in later interpretations of the Neolithic may also, however, reflect the difficulties of interpreting what was found, and, in the context of the wider evidence for the Neolithic, which was dominated by monuments, the paucity of comparable sites. A series of recent excavations, some of which lie close to the Ebbsfleet Valley, but which include also sites elsewhere along the Thames, such as Runnymede Bridge (Needham 2000), the Eton Rowing Lake (Allen *et al* 2013), the Stumble (Wilkinson *et al* 2012) and numerous other sites to the north of the river in London and Essex (eg, Stafford with Goodburn and Bates 2012; Brown and Murphy 1997), now provide a much richer context within which to situate the finds from Ebbsfleet.

The sites close to the Ebbsfleet Valley in Kent include a number that were excavated during major projects which have redefined the archaeology of the county. Extending to the south and east of the Ebbsfleet Valley, the first phase (Section 1) of HS1 (Booth *et al* 2011), is the largest and most significant of these projects. A number of sites which form part of this scheme – Whitehill Road (Bull 2006a), Pepper Hill (Biddulph 2006), Northumberland Bottom (Askew 2006), Tollgate (Bull 2006b) and Cobham Golf Course (S Davis 2006) – lie close to the Ebbsfleet Valley and have provided results which are relevant to its later prehistory. Excavations along the A2 (Allen *et al* 2012), which follow the line of HS1 at its eastern end to the south of Gravesend, have also provided significant later prehistoric evidence. To the west of the Ebbsfleet, a number of excavations in and around the Darent Valley, in and to the south-east of Dartford, have also recently been published (Simmonds *et al* 2011). Alongside important earlier excavations, such as those by Philp (1984; Philp and Garrod 1992; Philp *et al* 1998; Philp and Chenery 2001) in the Darent Valley, and by Mudd (1994) at Coldharbour Road, Northfleet, there is now a considerable body of archaeological evidence from the areas surrounding the Ebbsfleet Valley. The Thames has been as important as a means of communication as it has been as a barrier, and it is important to note too that the evidence from the northern side of the Thames Estuary is as rich as that from the south (eg, Bates and Stafford 2013; Stafford with Goodburn and Bates 2012; Howell *et al* 2011; Medlycott 2011).

Due to the large number of sites and find spots, it would be impossible here to mention all of the evidence in the region around Ebbsfleet. In addition, the nature of much of the evidence makes any attempt to provide a comprehensive coverage even more difficult. Although the excavations around Ebbsfleet have revealed some clear foci of activity, which can be regarded as quite well defined sites (such as settlements or monuments), much of the evidence is fragmentary, consisting of more or less isolated features or scatters of artefacts. Such fragmentary evidence is much more difficult to describe and summarise than larger more coherent sites, and often appears less significant. It nonetheless seems likely that the apparently fragmentary character of much of the evidence reflects a significant aspect of the way in which the landscape was exploited, whether that evidence consists of small Mesolithic or Neolithic flint scatters or of isolated Middle or Late Bronze Age pits or burials (*cf* Allen *et al* 2012).

The wider archaeology of Kent has been the subject of a number of syntheses (Williams 2007; Booth *et al* 2011; Ashbee 2005; South-East Research Framework (SERF): http://www.kent.gov.uk/leisure-and-community/history-and-heritage/south-east-research-framework), and discussion here is thus largely restricted to the area immediately around Ebbsfleet.

Final Palaeolithic

The area around the Ebbsfleet Valley is one of the few locations in Kent with well-provenanced evidence of occupation during the very latest stages of the Devensian glaciation. Investigations for HS1 on Swanscombe Marsh, immediately north of the Ebbsfleet International Station, recovered a moderately sized flint assemblage likely to date to the Late Glacial interstadial (Bates and Stafford 2013). In addition, a distinctive Final Palaeolithic assemblage type known as “Long Blade”, after its characteristic outsize and solid blades and *lâmes machurées*, was recovered by Burchell (1938) from the “lower Mesolithic floor” (Fig 2.18) at one of his Springhead trenches (Jacobi 1982). According to Jacobi’s analysis of the lithic material, the molluscan fauna, and a radiocarbon date (Kerney 1977), this assemblage could either date from the last part of the Devensian glaciation or the early part of the Holocene, but probably the former. Long Blade material is also known from the large collection made by Henry Stopes around Swanscombe (Wenban-Smith 2004b), and close to the Ebbsfleet Valley two blades, one with the bruising which is typical of Long Blade industries, were found in residual contexts on Site A on the A2 excavations (Allen *et al* 2012). The southern side of the Thames Estuary in the Ebbsfleet Valley area thus provides a significant source of evidence for activity in the Final Palaeolithic during the transition from the Late Glacial to the early Holocene.

Finds of similar date have been made at a small number of other sites in Kent such as Oare (Jacobi 1982, 12–13; Wymer 1982), Saltwood Tunnel (Riddler and Trevarthen 2006, 7), Riverdale near Canterbury (Barton 1998, 162), and at Underdown Lane, Herne Bay (Gardiner *et al* 2015) and Lullingstone (Garwood 2011). Although the number of finds is limited (Garwood 2011, fig 3.3), sites from this period are rare nationally, and the evidence from Kent, and the Ebbsfleet Valley, is thus of particular significance. Long Blade material is known from other parts of south-east England (Barton 1991) both from Late Glacial and the early Holocene contexts including a number of sites along the Thames Valley (eg, the HS1 site at Tankhill Road, Essex: Leivers *et al* 2007; Beam Washlands, Dagenham: Champness *et al* 2015; Three Ways Wharf, Uxbridge: Lewis with Rackham 2011; the Eton Rowing Lake, Dorney: Allen *et al* 2013; Weir Bank Stud Farm, Bray: Montague 1995; Gatehampton Farm, Goring: Allen *et al* 1995; Drayton: Barclay *et al* 2003; and Charvil: Lovell and Mepham 2003).

Mesolithic

Although the significance of the Mesolithic evidence from tributary valleys of the Thames has been highlighted by work in the Colne Valley (Lewis with Rackham 2011) and the Lower Lea (eg, Hiller and Wilkinson 2005; Corcoran *et al* 2011, 172; Powell 2012), the Mesolithic evidence in and around the Ebbsfleet Valley is limited and generally of poor quality. Along the A2, for example, although Mesolithic flint was found widely, it was residual and, apart from two concentrations at Site B and at the boundary of Sites F and G, occurred in small quantities. Material in the Ebbsfleet Valley and elsewhere in its immediate surroundings is equally sporadic, although flints attributed to the Mesolithic were recorded on the route of Northfleet’s southern by-pass (Vale 1989, 414) and near Springhead Nurseries. A probable Mesolithic wooden paddle, discovered at Swanscombe, but now lost, is a more exceptional find (Champion 2007).

The scarcity of finds in the immediate vicinity of Ebbsfleet is consistent with the wider distribution in Kent, in which finds are relatively numerous on the Lower Greensand, with fewer finds on the Chalk (although there is a concentration of find spots on the Chalk around the Darent Valley) and even fewer finds from the Weald Clay (Harding 2006, 15, fig 6). It is, however, worth noting that a small assemblage of Mesolithic flint was recovered from the Chalk at Cobham Golf Course (Devaney 2005; S Davis 2006).

The potential of areas such as the Ebbsfleet Valley is, however, clearly revealed by discoveries on the north side of the Thames Estuary. At Beam Washlands, Dagenham, for example, *in situ* scatters of Early and Late Mesolithic flint were found on a fluvial deposit that had been sealed in the Late Mesolithic by a layer of peat (Champness *et al* 2015). Nearer to the Ebbsfleet Valley, a large scatter of Late Mesolithic flint and burnt flint perhaps derived from hearths was found at the HS1 site at Tankhill Road, Essex in deposits again sealed by peat (Bates and Stafford 2013; Leivers *et al* 2007).

On the southern side of the Thames, a large assemblage of Late Mesolithic flint was recovered from excavations on the Erith Spine Road (Bennell 1998).

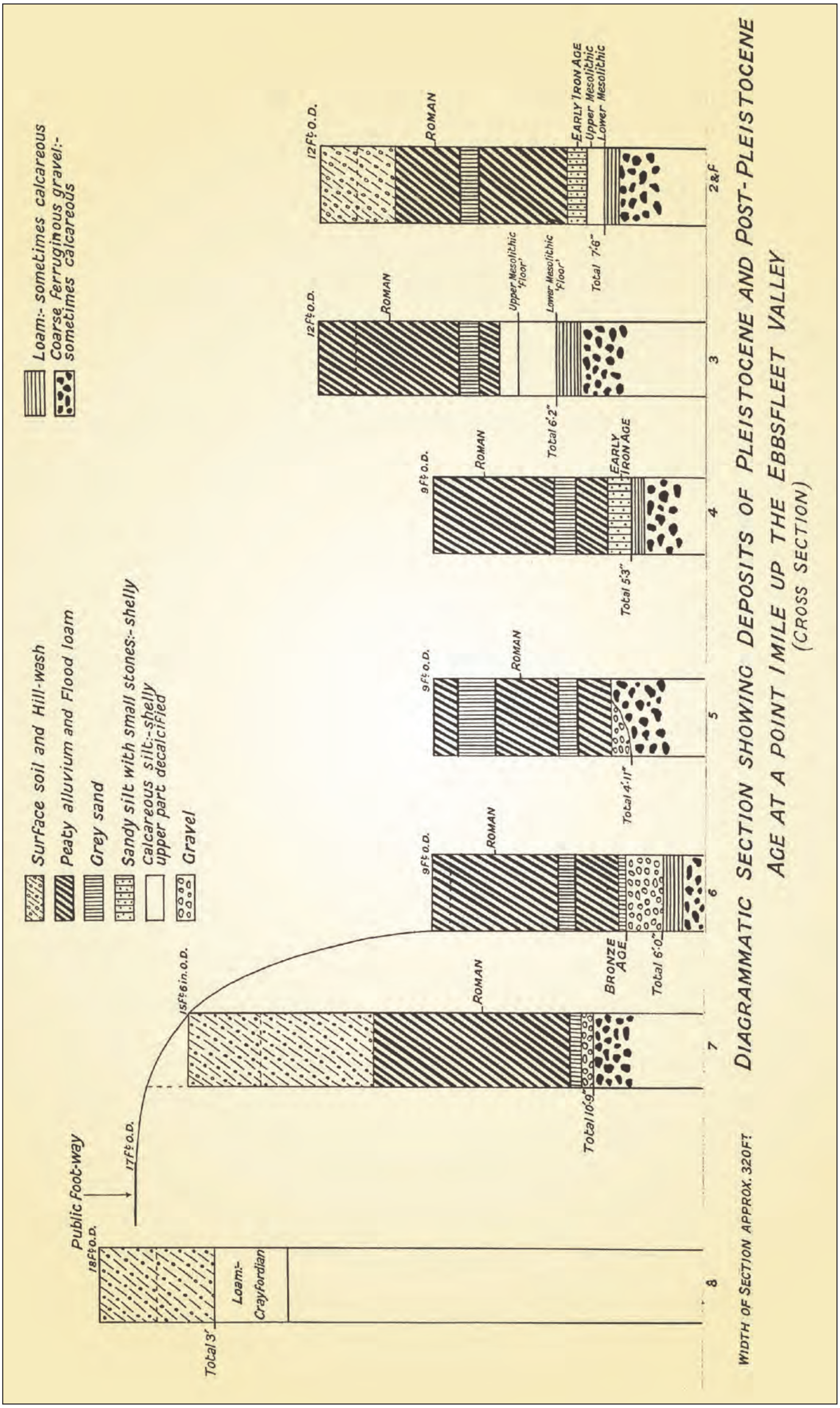


Figure 2.18 Section of Holocene sequences recorded by Burchell during the 1930s investigations

Large assemblages of Mesolithic and Late Mesolithic/Early Neolithic flint which contrast with the small numbers of residual finds often found on excavations have also been recovered closer to the Ebbsfleet Valley at the Darenth Court Farm Villa (Woodcock 1984) and at the Darenth Gravel Pit (Philp *et al* 1998).

Early Neolithic

The earlier Neolithic evidence around the Ebbsfleet Valley presents a series of similarities and contrasts with the preceding Mesolithic evidence.

Perhaps the most striking contrast in the archaeological record of Kent is the appearance of well-defined structures and monuments, although little of this evidence lies in the immediate surroundings of the Ebbsfleet Valley. The earliest of these structures are the two long houses at the HS1 sites of White Horse Stone and Pilgrim's Way (Hayden and Stafford 2006). The radiocarbon dates from the White Horse Stone structure are amongst the earliest for the Neolithic in Britain. Dates almost as early have been obtained from Coldrum, although as Healy notes, the diversity of the Medway megaliths may reflect differences in date (S Griffiths pers comm; Whittle *et al* 2011; Healy nd; Wysocki *et al* 2013). These early dates form part of a wider pattern in which earlier Neolithic structures and monuments in Kent are slightly earlier than those for similar sites elsewhere in southern England (Whittle *et al* 2011), supporting the idea that their origins, whether due to migration or acculturation, involved contacts across the Channel from the south-east. This pattern of chronological priority extends also to causeway enclosures which date from a slightly later phase of the Early Neolithic, perhaps implying ongoing connections across the channel.

In the immediate vicinity of the Ebbsfleet Valley there is little evidence for comparable structures and monuments. A possible 'mortuary' enclosure identified as a cropmark at Tollgate (Bull 2006b) was not excavated but might date from the earlier part of the Neolithic, and could have been as early as Coldrum. The only potential evidence for Neolithic monuments slightly later in the Early Neolithic, perhaps contemporary with the causewayed enclosures is a large ramped posthole found on Site G along the A2 from which radiocarbon dates of 3640–3380 cal BC (NZA-30123) and 3630–3370 cal BC (NZA-32317) were obtained. The closest causewayed enclosure is probably that at Burham (Whitttle *et al* 2011). Other examples in Kent include Chalk Hill, Kingsborough and Kingsnorth on the Isle of Sheppey and, across the Thames at Orsett, Thurrock, Essex (Whittle *et al* 2011; Oswald *et al* 2001; Dyson *et al* 2000; Allen *et al* 2008; Hedges and Buckley 1978).

Although these structures and monuments define a marked contrast between the earlier Neolithic and Mesolithic evidence, some of the remaining evidence suggests more continuity, although much of it is difficult to date with precision. For example, the large assemblage of worked flint (16,000 pieces) recovered from peat filling a former lake at the Darenth Gravel Pit has been dated to the Late Mesolithic/Early Neolithic, although small quantities of pottery and animal bone were also recovered showing clearly that some of the activity represented was Neolithic (Philp *et al* 1998). Sequences of buried soils were also found along the A2/A282 in the Darent Valley which contained small assemblages of Late Mesolithic/Early Neolithic lithics (Simmonds *et al* 2011). An assemblage of Neolithic flint, including a leaf-shaped arrowhead, was recovered from Wansunt Pit, Crayford (Biddulph 2005, 382). A number of possibly earlier Neolithic flint scatters were found along the A2, although they could not be dated with much precision (Allen *et al* 2012). Upstream, and on the northern side of the Thames, small scatters of Early Neolithic lithics and pottery have been found along the A13 (Stafford with Goodburn and Bates 2012) and at Yabsley Street, Blackwall (near to the Early Neolithic burial; Coles *et al* 2008)

Although some of these probably date from the earliest part of the Neolithic, characterised by Carinated Bowl pottery, there is also similar evidence from slightly later in the Neolithic, associated with Decorated Bowl pottery and Ebbsfleet Ware. Across the river, at Great Arnold's Field, Mildenhall pottery was found with 'midden' deposits, rich in charcoal (Howell *et al* 2011), which had been deposited in a ring-ditch. The earliest pottery from the scatters along the A13 was also in the Mildenhall style (Stafford with Goodburn and Bates 2012). The Ebbsfleet type site provides a further example of a surface scatter of material (Burchell and Piggott 1939).

Although earlier Neolithic artefact scatters and large assemblages interpreted as midden deposits are known from a number of sites, only small numbers of pits have been found in the vicinity of the Ebbsfleet Valley. A number of pits were found on the A2/A282 in the Darent Valley (Simmonds *et al* 2011) and two groups of probably earlier Neolithic pits were found nearby at Blackdale Farm (Philp and Chenery 2001). More widely in Kent, however, earlier Neolithic pits (including examples containing Carinated, Plain and Decorated Bowl pottery, as well as Ebbsfleet Ware) have now been identified at a number of sites (eg, White Horse Stone, Beechbrook Wood, Saltwood Tunnel, Tutt Hill, Eyhorne Street, Sandway Road, Mill Road, Wingham and Grovehurst: Garwood 2011; Healy nd). Aside from the structures at White Horse Stone (Hayden and Stafford 2006), the only possible evidence for structures has been found across the Thames at Brookway, Rainham, where Mildenhall pottery was found with worked flint, pits, a hearth, and traces of a post-built structure (Meddens 1996).

It is worth adding too, that some of the earliest wooden structures surviving along the Thames – two trackways or platforms at Belmarsh Prison in Greenwich

– date from the earlier Neolithic (*c* 4000–3700 cal BC; Hart 2009).

Middle and Late Neolithic

Evidence for Middle Neolithic activity in the vicinity of the Ebbsfleet Valley is limited, a pattern which this area shares with the rest of Kent. Although the later styles of Peterborough Ware (Mortlake and Fengate) have been found at a small number of sites elsewhere in Kent, few of these lie close to the Ebbsfleet Valley (Barclay *et al* 2006). The one exception to this is Fengate Ware recovered from Darenth (Smith 1984). Mortlake Ware has also been recovered from the A13, to the north of the river. Elsewhere in Kent, the later styles of Peterborough Ware have been recovered from a number of sites, usually consisting of pits (eg, White Horse Stone/Pilgrims Way, Sandway Road, Tutt Hill, Little Stock Farm, and Saltwood Tunnel; Garwood 2011), although it has also been found at causewayed enclosures at Castle Hill, Folkstone and Ramsgate (Barclay *et al* 2006; Barclay nd). It is worth noting, too, that the wooden trackway at Fort Street, Silvertown, upstream, to the north of the Thames, dates from the Middle Neolithic (*c* 3340–2910 cal BC; Crockett *et al* 2002).

Late Neolithic evidence is equally scarce. The only finds in the immediate vicinity are pits containing Grooved Ware on the A2/A282 in the Darenth Valley (Simmonds *et al* 2011). A further probably Late Neolithic pit was found nearby at Blackdale Farm (Philp and Chenery 2001). Finds elsewhere in Kent are also limited, and mostly distributed along the east coast of the county. There are, however, finds of Grooved Ware from pits further to the west (eg, at White Horse Stone/Pilgrim's Way; Garwood 2011).

It is worth noting that the monuments typically associated with the Middle and Late Neolithic – cursus monuments and henges – are rare in Kent. Garwood (2011) mentions the possible existence of a cursus on the Isle of Thanet, and the only henges are the small monument at Ringlemere (Needham *et al* 2006) and a possible example, recently identified at Hollingbourne (http://www.kentonline.co.uk/kentonline/news/2012/september/8/henge.aspx). These recent finds suggest that the apparent absence of monuments may be more a product of Kent's agricultural past than of an original absence (Parfitt 2006a).

It is, however, difficult to account for the scarcity of evidence for the Middle and Late Neolithic in the area around Ebbsfleet. The evidence from surrounding areas, although not plentiful, is sufficient to suggest that this is not just a matter of limited sampling. The absence of conspicuous monuments and settlement evidence (beyond pits) elsewhere, may provide part of the explanation. The absence of evidence for these periods along the A2 and the northern end of HS1 suggests, however, a genuinely low level of activity. Given the relatively frequent occurrence of earlier Neolithic finds as artefacts scatters and midden deposits in estuarine and riverine contexts, the scarcity of comparable later Neolithic finds might also be taken to indicate significant changes in settlement patterns and systems of resource exploitation.

Early Bronze Age

Evidence from the Early Bronze Age is more plentiful, but is focused primarily to the south of the Ebbsfleet Valley (rather than to the north in riverine and estuarine contexts). A grave containing the skeletons of two adults and one child, associated with Beakers, was found at Northumberland Bottom (Askew 2006). No ring-ditch or traces of any barrow were found, so the burial may either have been a flat grave or have been associated with a barrow without a ring-ditch which has been ploughed out. A possibly slightly later cremation burial contained within a Collared Urn was found on the same site (Askew 2006). More striking grave goods were recovered from a double ditched barrow, constructed in phases, at Whitehill Road (Bull 2006a). A grave cut into the fills of the inner ring-ditch contained an inhumation burial from around the shoulders and neck of which 21 amber beads, no doubt originally forming a necklace, were recovered. A radiocarbon date on the burial indicates a date late in the Early Bronze Age or perhaps early in the Middle Bronze Age (*c* 1620–1440 cal BC). A further ring-ditch was found at Cobham Golf Course, and a bowl barrow – the Mount – has been recorded at Ashenbank Wood (Askew 2006). In neither case were burials discovered. Fragments of Collared Urn and Food Vessel were, however, found in the fills of the ring-ditch at Cobham Golf Course.

Alongside these burials and monuments, the excavations along the A2, in particular, revealed small groups of pits associated with Beaker pottery. Such small groups were found on Sites D, F and G (Allen *et al* 2012). A further possible example was found at Tollgate (Bull 2006b). Flint scatters dated to the Late Neolithic/Early Bronze Age were also identified along the A2 (Allen *et al* 2012) and at Tollgate (Bull 2006b). Residual Late Neolithic/Early Bronze Age flint was recovered from the Dartford Football Club (Simmonds *et al* 2011), and residual pottery at Coldharbour Road (Mudd 1994).

Together, these sites now define a concentration of finds of Beaker pottery in Kent. Most of the other finds are concentrated in the east of the county, between Dover and Thanet (Garwood 2011). The extent to which this distribution may reflect a real concentration of activity is uncertain. In part, however, it must reflect the intensity of fieldwork in the area to the south-east of Ebbsfleet (and in the east of Kent), and it is noticeable that the excavations along the route of HS1 further to the south revealed a number of sites with Beaker pottery in an area where previously little was known (Garwood

2011, figs 2.2–3). Finds of Early Bronze Age pottery (Collared Urns, Food Vessels and Biconical Urns) in Kent are too limited for any potentially significant patterning to be apparent (Garwood 2011).

Although Late Neolithic/Early Bronze Age flint scatters have been identified at a number of sites near Ebbsfleet – at Dartford Football Club, along the A2, and at Tollgate, for example – it is nonetheless noticeable that finds of this period are rare in riverine and estuarine contexts to the north. In the investigations along the A13, for example, the rarity of Late Neolithic and Early Bronze Age finds (compared to the earlier Neolithic and the later Bronze Age) was noted (Stafford with Goodburn and Bates 2012; see also Howell *et al* 2011).

Burial in the Middle and Late Bronze Age

The Middle Bronze Age evidence from the area around Ebbsfleet is typical of the transitional character of the period more widely found in southern England. Funerary evidence reflects a certain degree of continuity with the Early Bronze Age, whilst the evidence for settlement and field systems reflects significant changes in patterns of settlement, the subsistence economy, and, no doubt, social structure.

A Middle Bronze Age ring-ditch found on the Eynsford to Horton Kirby pipeline provides evidence of continuity with the Early Bronze Age (Simmonds *et al* 2011). A cremation burial was found in the secondary fills of the ditch. A further Middle Bronze Age ring-ditch, associated with an inhumation burial, was found on the A2 Activity Area excavations (Dawkes 2010). A cremation burial from the pipeline, however, and a number of cremation burials found along the A2 and at the A2 Activity Park reflect the trend for burials to increasingly occur without any association with barrows, either in isolation, or associated with field systems (Allen *et al* 2012). This pattern continues into the Late Bronze Age. Isolated cremation burials dated to the Late Bronze Age have been found on Site B along the A2 and on the A2/A282, and five cremation burials and a pit containing pyre debris, dated to the Late Bronze Age/Early Iron Age were found at Dartford Football Club (Simmonds *et al* 2011). A group of shallow pits, 16 of which contained deposits of cremated human remains that have been dated to the Late Bronze Age, has also recently been found at Pinden Quarry, to the north of Longfield (Hayden and Score in prep.) the latest of which dates to the 9th century cal BC.

It is also worth noting some more exceptional finds. Along the A2, an isolated pit containing cremated animal bone and fired clay associated with Deverel-Rimbury pottery suggests ritual activity (Allen *et al* 2012). Even more strikingly, a group of spears, armour and human bone recovered in 1825 at Clay Lane Wood suggests the possible existence of a ritual site (Ashbee 2005).

Settlement from the Middle Bronze Age to Late Bronze Age

Alongside the gradual shift in the contexts of burials, the Middle Bronze Age is characterised by the first widespread evidence for field systems (although the earliest examples – on Thanet – may date from the Early Bronze Age: Barclay *et al* 2011). An example of such a system, associated with a trackway, dated to the Middle to Late Bronze Age, was found extending from the Coldharbour Road excavations across the A2 Activity Park and into the A2 excavations (Mudd 1994; Dawkes 2010; Allen *et al* 2012). A further possible example was found at Cobham Golf Course (S Davis 2006).

The clearest examples of Middle Bronze Age foci of settlement in the vicinity of Ebbsfleet are provided by two L-shaped enclosures found on the A2 (Allen *et al* 2012). One of the enclosure, on Site G, was associated with a possible roundhouse, as well as pits, hollows and a cobbled trackway.

Elsewhere, however, more fragmentary and isolated Middle Bronze Age features have been found. These include a U-shaped enclosure, not apparently associated with a focus of settlement on the A2/A282 (Simmonds *et al* 2011), and pits at various sites, including Princes Road, Dartford (Hutchings 2003) and at Site A on the A2 (Allen *et al* 2012). The presence of these widely scattered features, which do not seem to form parts of wider complexes indicating domestic occupation, suggest that rather than being focused on particular settlements, much Middle Bronze Age activity was dispersed across the landscape. Late Bronze Age pits at Cobham Golf Course contained briquetage suggesting that salt may have been produced nearby (Davis 2006; Morris 2006).

Alongside the evidence for settlement to the south of Ebbsfleet, there is more extensive evidence for exploitation of the estuarine environments to the north. Wooden structures, consisting of trackways dating predominantly from the Middle to Late Bronze Age have been found at numerous locations along the Thames, including examples at Beckton and Rainham (Stafford with Goodman and Bates 2012). A pebble and burnt flint causeway at Dagenham probably also dated from the Late Bronze Age (Meddens 1996).

Evidence for settlement in the Late Bronze Age presents an equally complex distribution of features. Apparently isolated pits have been identified at a number of sites (East of Henhurst Road: Bull 2006b; at Pepperhill Junction: URS 2001; on the Eynsford to Horton Kirby pipeline; on the A2/A282 and at Dartford Football Club: Simmonds *et al* 2011), suggesting that the Late Bronze Age was also characterised by a dispersed ‘taskscape’. A burnt mound found along the A2/A282 provides another example of an isolated feature. More extensive remains of activity suggesting the existence of foci of domestic activity have been found at only a few sites around Ebbsfleet. At Cobham Golf Course a concentration of postholes and pits, dating probably to the 10th–9th centuries was identified

(S Davis 2006), and at Darenth Gravel Pit, a possible roundhouse and a number of four-post and related structures, dating from the Early to Middle Iron Age were found.

Aside from the possible examples at Site G on the A2 and at the Darenth Gravel Pit, it is noticeable that no roundhouses have been identified. This absence is not restricted to the area around Ebbsfleet. Very few roundhouses of either later Bronze or Iron Age date have been identified in Kent (see Champion 2011, 210–12 for the few possible examples) and a number of examples are known on the northern side of the Thames (Medlycott 2011). The scarcity of roundhouses may reflect either the fact that in much of Kent such structures were built in a way which left little archaeological trace, or that a different tradition of house building existed which, however, has again not proved archaeologically visible. Any such archaeologically invisible tradition would, of course, make the identification of sites as settlements more difficult, and could thus explain why so much of the Late Bronze and Iron Age settlement evidence around Ebbsfleet appears so fragmentary.

It is also noticeable that nothing similar to the ringworks on the northern side of the Thames (at South Hornchurch and Mucking: Guttman and Last 2000; Bond 1988) has been clearly identified in Kent, although it has been suggested that a circular crop mark near Wrotham Road to the south of Gravesend, might be a Late Bronze Age enclosure (Allen *et al* 2012, 4).

Early and Middle Iron Age

The settlement evidence from the Early Iron Age is in some respects similar to that from the Late Bronze Age. There is, however, more extensive evidence for foci of settlement. There is, as has just been noted, little evidence for roundhouses – although possible examples have been noted at Site K on the A2 and in the Darenth Valley (Philp *et al* 1998). The presence of four-post structures on a number of sites, however, suggests that they may have been centres of domestic occupation. Such structures were identified at several sites along the A2 (Sites C, E and G) as well as at the Darenth Gravel Pit (Philp *et al* 1998) and Darenth Park Hospital in Dartford (Batchelor 1990).

At a number of sites, including the M25 pond treatment site to the south of Dartford (Simmonds *et al* 2011), Northumberland Bottom (Askew 2006), Tollgate (Bull 2006b), Coldharbour Road (Mudd 1994), Site L on the A2 (Allen *et al* 2012) and at the A2 Activity Park (Dawkes 2010), more isolated groups of features, especially pits, have been found.

Similar evidence for Middle Iron Age settlement has been found at a number of sites, and includes pits on the A2/A282 (Simmonds *et al* 2011), four-post structures at Northumberland Bottom (Askew 2006), and at several sites along the A2 (Allen *et al* 2012). A number of more distinctive forms of settlement have, however, also been identified. At Site B on the A2 a banjo enclosure as well as other enclosures were found, and at the boundary of Sites B and C there were further enclosures, a cobbled trackway, four-post structures and pits. At Northumberland Bottom, possible animal pens, a metalworking area, a waterhole, as well as enclosures, droveways and four-post structures were found (Askew 2006).

No Early Iron Age burials have been identified in the vicinity of Ebbsfleet, but a variety of Middle Iron Age examples were found on the A2 (Allen *et al* 2012). A long boundary ditch on Sites A and L on the A2 contained an adult inhumation burial above which a neonate had been interred. Further crouched inhumation burials were found in a pit beside the ditch and on Site B. More intriguingly, a pit on Site B contained the disarticulated remains of a pair of human feet.

Chapter 3

Aims, Methods and Fieldwork Overview

by Francis Wenban-Smith, Elizabeth Stafford and Martin Bates

Research Framework

At its outset Rail Link Engineering (RLE) devised an *Archaeological Research Strategy* (ARS) for the whole of the HS1 archaeological programme (Drewett 1997). This defined five broad archaeological periods, and identified five broad landscape zones through which the route passes. For each period a number of key research objectives were specified. It was then considered for each of the HS1 route's landscape zones, what the priorities were for archaeological investigation in terms of the period/s and quality of surviving remains.

The overall ARS was later supplemented for the Section 2 works by a more detailed *Research Strategy for Palaeolithic Archaeology and Pleistocene Geology* (RSPAPG) (Roberts 2000). This provided more specific details of research objectives for different areas of Palaeolithic/Pleistocene remains along Section 2 between Pepper Hill and the St Pancras terminus.

The Ebbsfleet Valley and Springhead area straddle two landscape zones, the 'Greater Thames Estuary' and the 'North Kent Plain'. Priority research themes for these landscape zones were highlighted in the initial ARS as:

- Prehistoric hunter-foragers
- Early agriculturalists
- Farming communities

For this Prehistoric Ebbsfleet study, its Palaeolithic/Pleistocene element is entirely subsumed within the broad theme of "prehistoric hunter-foragers", supplemented by the subsequent RSPAPG. The later prehistoric element includes aspects of all three themes. Under the ARS and the RSPAPG, three main research aims were defined for Palaeolithic archaeology and Pleistocene geology in the Ebbsfleet Valley, each with a number of specific subsidiary objectives (Table 3.1); and 10 main research objectives were defined for later prehistoric archaeology and the Holocene (Table 3.2).

Approaches to Investigation

Even before the HS1 route was finalised, desk-based studies were carried out along its full length to identify the route with the minimum environmental impact, taking account of numerous factors, just one of which was the historic environment. The Ebbsfleet Valley was recognised at the outset of this exercise as having a particular Palaeolithic/Pleistocene potential and complex quarrying history, so a separate desk-based assessment was commissioned (Wenban-Smith 1992a) which identified unquarried areas of surviving sediment, assessed their Palaeolithic/Pleistocene importance and fed into the overall *Assessment of Historic and Cultural Effects* (URL 1994). This identified the Ebbsfleet Valley,

Table 3.1 Research objectives for Palaeolithic archaeology and Pleistocene geology in the Ebbsfleet Valley

Landscape zone research objectives	Subsidiary objectives	Details
1. Investigation of Pleistocene landscape history and evolution	1a	Clarification of the sequence, lithostratigraphic relationships and geometry of Pleistocene deposits present
	1b	Recovery of faunal remains and biological palaeoenvironmental evidence from well-provenanced Pleistocene contexts
	1c	Interpretation of the mode of formation of Pleistocene deposits
	1d	Integration/correlation of surviving Pleistocene deposits with those known from earlier work
2. Investigation of the range and locations of early hominin activity	2a	Identification and investigation of undisturbed occupation horizons
	2b	Recovery of archaeological artefacts from well-provenanced Pleistocene contexts
	2c	Recovery of faunal remains and biological palaeoenvironmental evidence associated with lithic artefacts
3. Investigation of the effect of climatic and environmental changes on early hominin lifeways and adaptive strategies	3a	Integration/correlation of previously investigated artefact-bearing horizons and surviving Pleistocene sediments into overall regional framework
	3b	Integration/correlation of newly discovered artefact-bearing horizons and Pleistocene sediments into overall regional framework

Table 3.2 Research objectives for later prehistoric archaeology and Holocene geology in the Ebbsfleet Valley

Theme	RLE landscape zone research objectives
Prehistoric hunter-foragers (400,000–4000 BC)	4. Reconstruction of the changing environment of this part of the Greater Thames Estuary throughout the Holocene, in terms of its geomorphology, vegetation and climate
	5. Characterisation of the nature of human exploitation of the floodplain and its margins (including terrace and intertidal zone) and how it changes through time
	6. Determination of the effect of climatic and environmental changes on human lifeways and adaptive strategies
Early agriculturists (4000–2000 BC)	7. Definition of the nature of the contemporary environment
	8. Determine the nature and effect of clearance and agricultural activity
	9. Define ritual and economic landscapes and their relationships
	10. Determine the nature and changes in economic lifeways eg, relative importance of hunter-foraging and agriculture studies especially through recovery of faunal and charred plant remains
Farming communities – the Later Bronze Age and Iron Age landscape	11. Determine spatial organisation of the landscape in terms of settlement location in relation to fields, pasture, woodland, enclosed areas and ways of moving between these
	12. Consider environmental change resulting from landscape organisation and reorganisation
	13. Determine how settlements were arranged and functioned over time

despite its substantial history of quarrying, as of high archaeological potential on numerous grounds; the Palaeolithic/Pleistocene and later prehistoric evidence are the focus of this volume. Twelve areas of unquarried deposits were identified (Table 3.3; Fig 3.1), including a number of areas statutorily protected as Scheduled Ancient Monuments (SAMs) or Sites of Special Scientific Interest (SSSI).

In addition, a major desk-based evaluation of the route corridor across the alluvial tracts of the HS1 route was produced by Oxford Archaeology in 1999 (Bates and Stafford 2013; URN and URS 1999). These documents provided a framework for the interpretation and understanding of the likely nature of the preserved later prehistoric sequences in the valley bottom as well as methods and approaches that might be appropriate to their investigation. In combination with Wenban-Smith's 1992 report these documents formed the basis for investigation of the study area.

Having decided that, despite its archaeological potential, the Ebbsfleet Valley was still on the preferred HS1 route, a phased programme of field evaluation and mitigating excavation was implemented (Table 3.4). In the lower reaches of the valley this programme was considerably more complex than most archaeological programmes for a number of reasons. Firstly, three different work streams ran concurrently: (a) a major programme with two phases of evaluation leading to a number of mitigating excavations focused upon the route of HS1, its link to the existing North Kent line and the footprint of the new Ebbsfleet International Station; (b) a programme for pylon ZR4, in the SAM 267a (DBA Area 8); and (c) a separate programme for pylon ZR3A. Secondly, with the exception of work relating to ZR4, all of this archaeological work encountered remains from multiple periods, requiring both diverse on-site methods and subsequent filtering and division of project archival material for diversion into different post-excavation work streams and reports. Thirdly, a number of non-HS1 projects were also carried out concurrently into the same sediment landscape, particularly investigations in advance of the new STDR4 road link commissioned by Kent County Council, and the Northfleet Rise field evaluation programme commissioned by Blue Circle Industries Plc.

Different field methods were applied in different parts of this work. Borehole drilling (together with some geophysical survey work) played a major role in several evaluation projects as a minimally invasive way of initially investigating the presence and nature of Quaternary sediments, particularly in areas of deep alluvium below the water table in the floor of the Ebbsfleet Valley. The resulting cores provided raw material for numerous dating and environmental analyses, and the lithological data enabled broad modelling of the subsurface stratigraphy in advance of any test pitting (Bates and Stafford 2013; URN and URS 1999). Test pits and trenches of various sizes were dug for both evaluation and mitigation. Conventional archaeological evaluation trenches between 10 and 30m long were dug, stripping the topsoil and any modern made ground to investigate for subsurface archaeological features. Smaller, but much deeper, test pits were dug to provide a greater assessment than was possible from the borehole data of the nature and Palaeolithic as well later prehistoric potential of deeper Quaternary sediments and Holocene alluvial deposits in various parts of the site, with sieving for lithic artefacts and sampling for environmental remains. A small number of larger stepped trenches were dug in areas of higher Quaternary/Palaeolithic interest to allow proper recording of the complex sediment sequences exposed, to create links between sequences exposed in different test pits, and to provide greater opportunity for bulk

Table 3.3 Palaeolithic/Pleistocene desk-based assessment areas

DBA area	Palaeolithic importance	Comments	Acceptable impact and mitigation
1	High significance	Part of SSSI and also a Scheduled Ancient Monument (Kent, 267a: Baker's Hole). This area is particularly important on environmental and chrono-stratigraphic grounds, being one of a few sites in Britain reliably dated to MIS 7, and containing a range of biological remains	No part should be lost
2	High significance	Part of SSSI and also a Scheduled Ancient Monument (Kent, 267b: Baker's Hole Levallois). This site is particularly important for the sequence of environmental change it presents, accompanied by Levalloisian artefactual evidence	No part should be lost
3	High significance	Part of SSSI. Its south-eastern end contains the lower part of the same sequence of deposits as Area 2, with a particularly clear section across the channel, showing its bank cut into the underlying chalk bedrock. Lithic artefacts and faunal remains have been recovered from the channel fill	No part should be lost
4	High potential	Part of SSSI. Potentially significant fluvial silts are visible at its eastern corner, and may also be present on the northern side, judging by the local topography and its proximity to known sites. This site is one of high potential, rather than of proven significance	Requires field evaluation; a small mitigated impact could be acceptable
5	High significance	Contains a continuation of the Coombe Rock that produced the APCM "Baker's Hole" Levalloisian and faunal collection	A small mitigated impact could be acceptable
6	High significance	Contains a continuation of the Coombe Rock that produced the APCM "Baker's Hole" Levalloisian and faunal collection	A small mitigated impact could be acceptable
7	High significance	Part of the Swanscombe '100-ft terrace', known to be rich in Palaeolithic evidence, both faunal and artefactual	A small mitigated impact could be acceptable
8	High potential	Uninvestigated but must be considered as of high Palaeolithic potential due to its closeness to Area 1	Requires field evaluation; a small mitigated impact could be acceptable
9	High significance	Part of the Swanscombe '100-ft terrace', known to be rich in Palaeolithic evidence, both faunal and artefactual	A small mitigated impact could be acceptable
10	Low potential	Not known, or likely, to contain any evidence of Palaeolithic significance	Requires field evaluation; no mitigation may be required
11	High potential	Uninvestigated although there are reports of significant fluvial silts within it; may contain Pleistocene deposits of Palaeolithic significance	Requires field evaluation; a small mitigated impact could be acceptable
12	High potential	Uninvestigated, but may contain an upstream extension of the same deposits as Area 1, which would make it of high importance	Requires field evaluation; a small mitigated impact could be acceptable

environmental sampling and dating studies. Similarly, cofferdams were constructed to allow excavation through the alluvium to examine buried later prehistoric archaeology. Finally, open-area excavations took place. The majority of the work reported in this volume results from borehole, test pit and stepped trench or cofferdam investigations, since the open area excavations were primarily aimed at the Roman and Anglo-Saxon remains. The latter did however occasionally encounter prehistoric material relevant to the theme of this volume, which is included here.

The scope of, and background to, each of the different phases of fieldwork that provided material that contributes to the Prehistoric Ebbsfleet theme of this volume is reviewed below, outlining how the results of different phases of work fed into others. More details of the methods applied in each phase of work are given in the original project reports, available through the Archaeology Data Service (ADS) as part of the on-line supplementary resource resulting from the HS1 archaeological programme. Methodological details of some particularly important interventions are also given where relevant throughout the remainder of this volume.

The underlying principles adopted in this study have been developed through the experience of the joint team working within a developing framework for landscape history in southern England. At the outset of the project, it was recognised that the primary level of analysis needed to be at the scale of the landscape, whereby any evidence collected in the field or collated from archive sources must be articulated within the wider framework of the local and regional landscape of the Ebbsfleet Valley and the Lower Thames. This approach contrasted perhaps to previous works in the area where many of the investigations were piecemeal, where the interpretation of the 'site' took precedence, and where articulation of data within the landscape only occurred

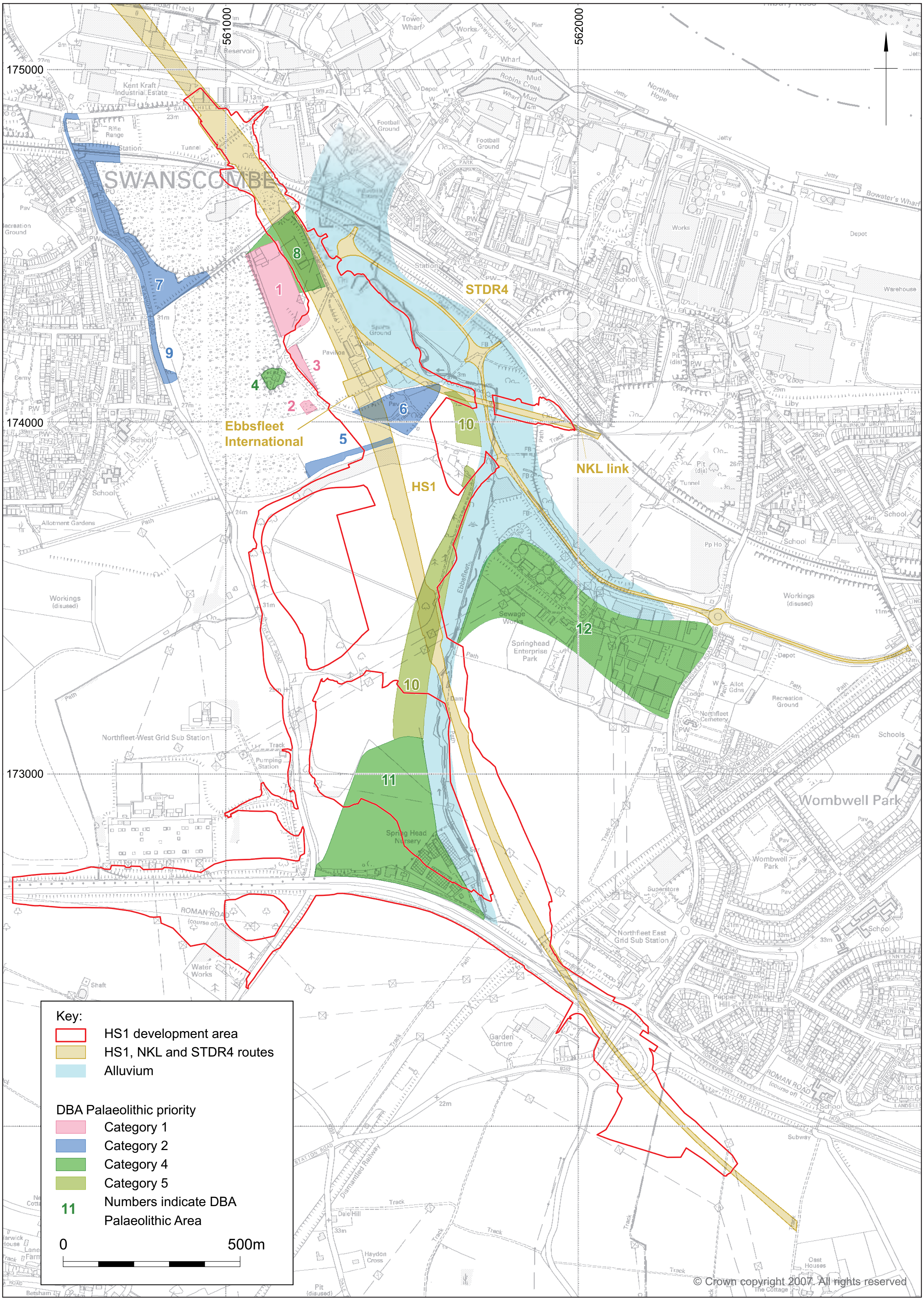


Figure 3.1 Site layout showing Pleistocene/Palaeolithic desk-based assessment areas, HS1 and STDR4 areas of impact

Table 3.4 Prehistoric Ebbsfleet associated fieldwork events

Date	Scope of work	Fieldwork event name	Site code	Report reference	Palaeolithic/ Pleistocene	Holocene/ later prehistoric
HS1 investigations in the Lower Ebbsfleet Valley						
Feb–Apr 1997	Evaluation	Ebbsfleet Valley	ARC EFT97	URL 1997	✓	✓
Jan 1998	Evaluation	Pylon ZR4	ARC ZR498	URL 1998	✓	–
Apr–May 2000	Excavation	Pylon ZR4	ARC ZR400	URN 2000a	✓	–
Apr 2000	Evaluation	Pylon ZR3A	ARC ZR3A00	–	✓	✓
Apr–Jun 2000	Excavation/ Watching Brief	Pylon ZR3A	ARC ZR3A00	URN 2000b	✓	✓
Mar–May 2001	Evaluation	Ebbsfleet Sports Ground	ARC ESG00	URN 2001a	✓	✓
Oct 2001 – Mar 2003	Excavation	Ebbsfleet Valley Detailed Mitigation	ARC EBB01	URN 2003a	✓	✓
Oct 2001 onwards	Watching Brief	342 Watching Brief, Ebbsfleet West	ARC 342W02	URN 2003a	✓	✓
Other related investigations in the Lower Ebbsfleet Valley						
Jun–Jul 1997	Evaluation	Northfleet Rise Area: Blue Circle sports ground complex	EBBS97	OAU 1997	–	✓
Aug–Sept 2000	Evaluation	South Thameside Development Route 4	STDR400	OAU 2000	–	✓
Mar–May 2001	Excavation	South Thameside Development Route 4	STDR401	OAU 2006	–	✓
HS1 investigations in the Upper Ebbsfleet Valley						
Sep 2000 – Sep 2002	Excavation	Springhead Roman Town	ARC SPH00	URN 2003b	–	✓
Oct–Dec 2001	Excavation	Ebbsfleet River Crossing	ARC ERC01	URN 2001b, 2002	–	✓
Feb 2002 – Mar 2003	Excavation	Springhead Nursery	ARC SHN02	URN 2003c	–	✓

at a later stage in the works. Within the Ebbsfleet, understanding the palaeolandscape context of the historic Palaeolithic archaeological collections remains important, not simply to expand our interpretive horizons for the collected artefacts and any excavated material obtained during the field programme, but also in a wider context that helps us to better understand the likely locations in the present landscape in which we may expect to find Palaeolithic evidence. Furthermore, it aided in developing and applying suitable approaches to investigation and interpretation in accordance with the varying spatial and temporal scales of the sedimentary contexts associated with finds and biological materials.

When developing our approach, it was recognised that attempts to reconstruct past Pleistocene landscapes are often hampered by fragmentary evidence, incomplete sequences, poor dating control and an absence of material to examine the faunal and floral aspects of the landscapes. In part these problems applied to the Ebbsfleet (although many have been successfully addressed during the course of the project). Additionally, in some cases the recent land-use history of the valley has exacerbated the problems of fragmentary evidence as a result of quarrying having removed not just sediment bodies but, in some cases, entire geomorphological features that define the original context of many of the surviving sediments. Coupled to these problems is the likelihood that Pleistocene landscapes in the UK do not have modern analogues and therefore a modified 'principle of uniformitarianism' needs to be applied in attempting to reconstruct such landscapes. Another significant problem to be faced in this study is the scale of the site and quantity of past records available for the area. Within the context of the UK, the volume of information from past investigations coupled with the very significant numbers of interventions during the life history of the project (for such a restricted area) exceeds that at any other Pleistocene 'site' in the UK and presents unique problems of data overload and filtering necessary in order to allow meaningful interpretations to be drawn from the data.

However, despite these problems, a robust approach to investigation has been adopted that has been from the outset multi-disciplinary and ranged across scales of investigation from smaller scales and shorter time intervals up to the scale of the region. Because the scale of the development of HS1 within the Ebbsfleet was considerable, and the impact of the scheme varied across the landscape, the response to development varied considerably. Use in the field was made of a range of methods from geophysics through boreholes (shell and auger, Mostap, window sampling) to test pits, trial trenches and open area excavations. The result of this mixed method approach to the investigation of the area was that the level of detail of information obtained from individual investigations varied across the site and in order for all the information to be of use a baseline set of parameters needed to be outlined in order that all spatially discrete data points could be used within the framework of investigation. Furthermore, where there were a large number of investigations that provided detailed information on the precise nature of the sediments, it was recognised that neither the time nor resources were likely to be available to fully analyse each intervention and a process whereby the detail in the sequence that related to landscape scale issues could be identified and separated from that of purely local significance had to be determined. It should be noted that this exercise in no way ignored the local information but such evidence was only considered in detail where questions relating to its relationship to archaeological and biological material or to the history and phasing of landscape evolution were pertinent.

The approach adopted was to attempt to construct a landscape scale framework within which individual boreholes, trenches etc could be articulated. Lithological data was recorded from boreholes (logged in the field and subsequently from retained cores in the laboratories) by field geoarchaeological staff, remotely from the edge of test pits by staff with Quaternary science expertise and directly from sections by context by both Quaternary scientists and archaeological site staff. Consequently, the archive data varies in the quality and level of detail. Thus, in order to make the data from individual locations useful this lithological data was subsequently grouped into sequences of sediments with common basic characteristics that were likely to be mappable across areas of the sites. These groups were identified through their lithological properties, geomorphological context and/or inferred environments of deposition (either on the basis of sedimentological evidence or through a combination of sedimentology and associated biological data). By default, these groups of mappable sediments typically reflected climato-stratigraphic units (usually but not always) and consequently could be articulated within the MI Stage framework that is now used as the yardstick for interpretation of Quaternary history and Palaeolithic archaeology. At a practical level these groups of mappable sediments are identified as individual phases within the zone-by-zone descriptions for Pleistocene sediments. A slightly different approach to the Holocene sediments has been taken where a terminology describing the main lithological units was identified early in the project history and this terminology has been retained through the history of the project.

Fieldwork Phases

Each phase of archaeological fieldwork associated with the HS1 works was given a designated code prefixed ARC. Each phase of work was carried out according to a Written Scheme of Investigation (WSI), which designated the quantities and locations of test pits and other interventions, along with fieldwork objectives. These were, nonetheless, often modified once in the field (with the approval of the client and Kent County Council) to reflect additional priorities and specific ground conditions. In general, all fieldwork in the lower part of the Ebbsfleet Valley in the vicinity of Ebbsfleet International Station was carried out by Oxford Archaeology. The investigations in the upper parts of the valley around Springhead were carried out by Wessex Archaeology.

General Fieldwork Aims

The detailed aims and objectives for each phase of work were outlined in the original WSI produced for each phase of work, contained within the project archives. Overall, the following aims were generally common to each investigation:

- Establish the presence/absence, extent, condition, character, quality and date of any archaeological remains within the area of the investigation;
- Identify the horizontal and vertical extent and sedimentological character of Pleistocene/ Palaeolithic deposits and potential to correlate with previous work within Baker's Hole;
- Determine whether Upper Palaeolithic, Mesolithic, Neolithic, later prehistoric or historic archaeological deposits overlie Lower/Middle Palaeolithic deposits and to assess the potential to correlate with previous work in the valley (eg, Burchell);
- Evaluate the depth, character and extent of made ground, Holocene and Pleistocene deposits and surviving topography of chalk bedrock within the investigation area, providing a geological model of the geometry of sedimentological facies and major depositional units;
- Assess the potential to place sedimentological facies and major depositional units in a secure litho-, chrono- and bio-stratigraphic framework;
- To link archaeological material with interpretations of depositional processes for stratigraphic units;
- Determine the presence and assess the potential of environmental and economic indicators preserved in archaeological features and sediment sequences;
- Assess the influence of sea-level change both directly and indirectly on the sedimentation and vegetation history of the valley;
- Assess the local, regional, national and international importance of archaeological and palaeoenvironmental remains and the potential for further archaeological fieldwork to fulfil local, regional and national research objectives;
- Assess the impact of any proposed or possible works on the archaeological resource.

HS1 Investigations in the Lower Ebbsfleet Valley

Ebbsfleet Valley Stage 1 evaluation: ARC EFT97
This was the first field intervention in the Ebbsfleet Valley associated with the HS1 investigations (Fig 3.2). The initial stage of the evaluation involved an array of boreholes at the northern end of the site (DBA Area 8, Figs 3.1 and 3.2) to determine the general character and extent of Pleistocene deposits in this area. Following this, the second stage of the evaluation consisted of the excavation of a series of test pits to allow further examination of the Pleistocene/Palaeolithic deposits and to allow the retrieval of artefacts and ecofacts. The recording of two extant sections (Sections 193 and 3,

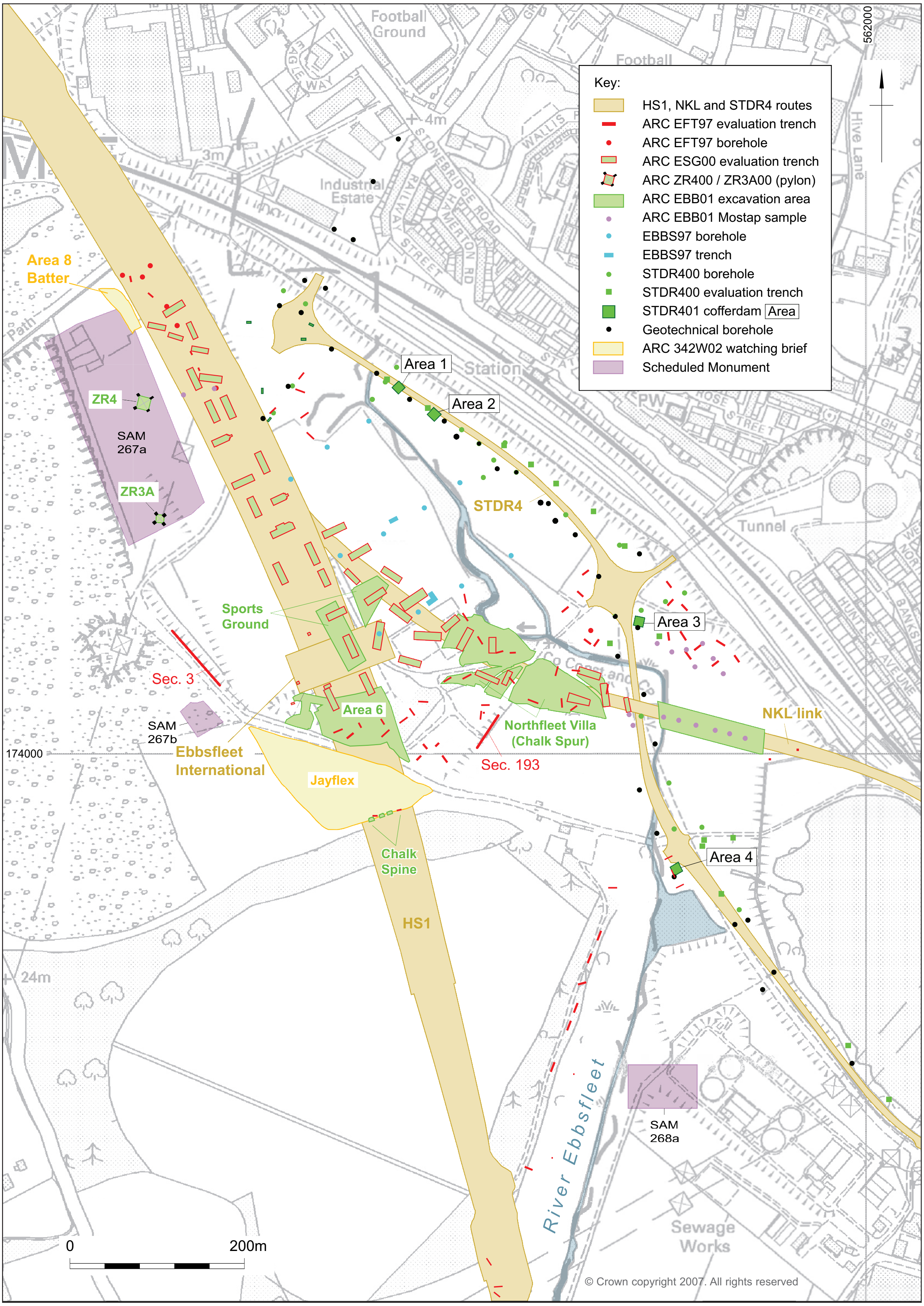


Figure 3.2 Site layout showing areas of HS1 and STDR4 investigation within the Lower Ebbsfleet Valley

Fig 3.2) was also carried out; one to the south of the Northfleet Villa site (DBA Area 6, Fig 3.1), and a second close to the Scheduled Ancient Monument Kent 267b (DBA Area 3, Fig 3.1). This work confirmed the presence of unquarried Pleistocene deposits and in particular indicated: (a) that Section 193 probably represented a continuation of the Coombe Rock that produced the Southfleet Pit ("Baker's Hole") Associated Portland Cement Manufacturers (APCM) Levalloisian lithic collection; and (b) that DBA Area 8 contained a particularly important suite of deposits including fluvial sediments of last interglacial (Ipswichian) age. Important remains at a number of locations were discovered during this early phase of work, and these are all discussed later in the volume, particularly: Borehole 0021SA (Chap 7) and Section 193 (Chap 11).

An array of 67 trenches and two test pits (Fig 3.2) were excavated to investigate the Holocene development and post-glacial archaeology of the HS1 site. In general, the Holocene alluvial sequences comprised unconsolidated organic-rich sediments overlying sands and gravels of Late Pleistocene or early Holocene date. Two main peat units were identified in the area upstream of Northfleet Roman Villa, similar to those published by Burchell and Piggott (1939), interbedded with organic silts. Downstream of the Northfleet Villa the sequences became less organic, dominated by inorganic blue-grey clay-silts. Evaluation of the archaeological remains was however difficult, hampered by the presence of 20th-century dumped deposits. This was a particular problem in the low-lying areas, where the thickness of made ground varied from 1m to more than 2m. The evaluation confirmed the presence of Neolithic and Bronze Age remains within the upstream sequence associated with the organic sediments. This comprised a small assemblage of struck flint and pottery in relatively fresh condition indicating minimal post-depositional disturbance, and the possible presence of an *in situ* Neolithic horizon. A limited programme of palaeoenvironmental assessment indicated excellent organic preservation suitable for landscape reconstruction.

ZR4 pylon investigations: ARC ZR498 and ARC ZR400

Three phases of work comprised this field event (Fig 3.2), an initial field evaluation (ARC ZR498), followed by a mitigating excavation and watching brief (ARC ZR400). The initial evaluation (ARC ZR498) involved excavation of test pits in each of the four pylon footings, their depths corresponding with the eventual depth of impact. The test pits in the two compression footings (on the eastern side of the new pylon) were substantially shallower than those in the uplift footings, which were on the western side of the new pylon. Subsequent more detailed excavation (ARC ZR400) focused upon the uplift footings only.

The initial test pits in the uplift footings (3423TP and 3424TP, see Chap 5, Fig 5.9) were excavated to just over 5m deep, within one half of the impact caused by the proposed footing footprint. The subsequent mitigating test pits (3776TP and 3777TP) in the other half of the footing footprints reached a similar depth, and then the sequence was extended further down by another 0.5m by auguring, before an impenetrable gravel was reached 5.5m below the ground surface, at *c* 5.3m OD. The fieldwork revealed a deep sequence of nationally important Pleistocene deposits containing a wide range of well-preserved biological evidence including large mammals, small mammals, amphibians, fish, birds, molluscs and ostracods. The results are discussed in detail in Chapter 5.

ZR3A pylon investigations: ARC ZR3A00

This field event (Fig 3.2) comprised three distinct phases of work (evaluation, mitigation and watching brief) following closely after each other. As for the nearby ZR4 pylon, evaluation was focused in one half of each footing footprint, the other half being preserved for possible mitigation. The test pits in the two compression footings (on the western side) were substantially shallower than those in the uplift footings (on the eastern side). Subsequent more-detailed excavation focused upon just one of the uplift footings.

A deep sequence of colluvial sediments was found, overlying Pleistocene fluvial sand and gravel. The upper part of the colluvium was of Holocene origin, and the lower part probably Pleistocene. The evaluation did not discover any significant Palaeolithic/Pleistocene remains. Nonetheless Pleistocene deposits were present, with the possibility of associated faunal remains (molluscs and small vertebrates), so further mitigating work was carried out involving bulk environmental sampling. Samples taken during the mitigating fieldwork proved to be barren of useful remains, so this part of the fieldwork makes little contribution to the rest of this volume.

Ebbsfleet Valley Stage 2 evaluation: ARC ESG00

This fieldwork event constituted the main field evaluation of the Lower Ebbsfleet Valley area impacted by HS1 and Ebbsfleet International Station (Fig 3.2). Overall 47 trenches 30m long were dug evenly across the site, with deep test pits at one or both ends. A number of trenches were widened and stepped for deep access along their full length. Coarse sieving of sample spits was carried out on-site for artefacts and large mammalian remains, and fine sieving off-site of samples from potentially suitable sediments for molluscs and small vertebrates.

With reference to the Pleistocene in DBA Area 8 (Fig 3.1), a complex suite of deposits was present. Generally, the deposits were dominated by coarse basal soliflucted facies overlain by fluvial and subsequent finer colluvial sediments. Fluvial sediments occurred at two main levels, and were overlain, and truncated, by thick bodies of colluvial deposits, which dipped and thickened downslope to the south-east. Molluscan remains were found in two trenches, and a particularly important suite of deposits was exposed in 3789TT. Key results from this phase of work are discussed in Chapter 7.

Further south, the western half of DBA Area 6 (Fig 3.1) was dominated by chalk-rich colluvial and solifluction deposits, probably corresponding in part to some of those previously investigated by Smith and Burchell, which produced Levalloisian archaeological evidence in association with faunal remains. The remnant tramway which crossed 3805TT and 3808TT (see Chap 10, Fig 10.1), corresponds to that in the cutting of which Spurrell (1883) discovered the first Palaeolithic archaeological remains in the Ebbsfleet Valley, further along it to the west (*cf* Chap 2; Fig 2.9). In the eastern half of DBA Area 6, palaeoenvironmental remains were found. Molluscs, including fairly frequent *Pupilla muscorum*, were present in deposits probably of colluvial/solifluction origin (3830TT, 3833TT, 3834TT and 3835TT; see Chap 11, Fig 11.1). Rodent molars and incisors (including lemming) were present in the thick sands, thought to be Late Pleistocene colluvial/solifluction deposits that constituted the majority of the sequence (3834TT and 3835TT).

Further assessment of the waterlogged Holocene alluvial sequences confirmed the preservation of palaeoenvironmental remains offering the potential for documenting changes in climate, sea-level change, vegetation and human land-use. Pollen, waterlogged plant macrofossils and insects were all abundant and evidence for broad-scale environmental change was detectable from the trench samples assessed. Geoarchaeological modelling of the major stratigraphic units, using 376 stratigraphic logs was used to generate projections of the extent of the wetlands in the Neolithic, Bronze Age and Roman periods, and cross-sections correlating the major stratigraphic units. Evidence for Neolithic and Bronze Age activity was generally sparse, for the most part comprising redeposited worked flint. However, possibly *in situ* concentrations of artefacts, including pottery as well as flint, were present in 3835TT and 3836TT. This included a single sherd of Ebbsfleet Ware pottery. In addition, an ephemeral roundwood structure in 3815TT was radiocarbon dated to the Middle Bronze Age (Chap 22, Figs 22.8c and 22.10).

Ebbsfleet Valley Detailed Mitigation: ARC EBB01

This fieldwork event comprised the main mitigation of Palaeolithic remains identified by previous evaluations (Fig 3.2). Work took place in three areas: DBA Area 5 (Chalk Spine); DBA Area 6 (west); and DBA Area 6 (east, Northfleet Villa/Chalk Spur).

In Area 5 (Chalk Spine), the primary aims were:

- To establish an accurate geological and chronological framework for the deposits;
- To recover palaeoenvironmental data and relate any to this framework;
- To recover securely provenanced artefactual remains;
- To investigate in more detail the date, origin and formation processes of key; sediment bodies, particularly the artefact-bearing Coombe Rock;
- To relate, where possible, the sequences to those in other relevant areas of the Ebbsfleet Valley.

After an early failed attempt to dig three trenches (3965TT, 3966TT and 3967TT), abandoned as they were located on a main plant route and above a steep bank, three stepped trenches (4018TT, 4019TT and 4020TT) were eventually dug. A total of 13.26 cubic metres of Coombe Rock was sieved, representing *c* 3% of the surviving sediment. Several lithic artefacts were recovered, and OSL dating was carried out from above and below the Coombe Rock (Chap 9).

In the west part of DBA Area 6, primary aims initially were:

- To extend evaluation test pits 3805TT and 3808TT to the south-east (new stepped trenches 3972TT and 3971TT respectively) to provide a more detailed understanding of the Pleistocene deposits and to relate them to the artefact-bearing Coombe Rock of DBA Area 5;
- To recover palaeoenvironmental remains and artefacts from secure contexts, and to carry out suitable dating studies.

  Following this work, a third stepped trench (4017TT) was excavated with the specific aims:
- To clarify the stratigraphic relationship of the tufaceous and colluvial deposits at the NW end of 3972TT with the laminated fluvial or colluvial deposits at the NW corner of the Jayflex site;
- To investigate for undisturbed Levalloisian landsurfaces in the higher surviving sediments towards the site boundary;
- To investigate the tufaceous deposits found in 3972TT for further faunal and artefactual evidence;
- To investigate the mode of formation of the laminated sands/silty sands in the NW corner of the Jayflex site, ie, whether fluvial or colluvial;
- To gain more information on the geometry of these Pleistocene deposits in the landscape, and the topography of the underlying Chalk bedrock surface.

These three large, stepped trenches exposed good sequences through a complex series of Late Middle and Late Pleistocene sediments. A full range of archaeological remains was found, including: flint artefacts; large mammalian remains; and a range of palaeoenvironmental remains (molluscan, ostracod and small vertebrate). Numerous OSL dating samples were taken from throughout the sequences in the two largest trenches (3971TT and 3972TT).

In the eastern part of Area 6 (Northfleet Villa/Chalk Spur), the aims of the Palaeolithic/Pleistocene investigations were:

- To recover further information on the stratigraphy and geometry of Pleistocene deposits to aid their

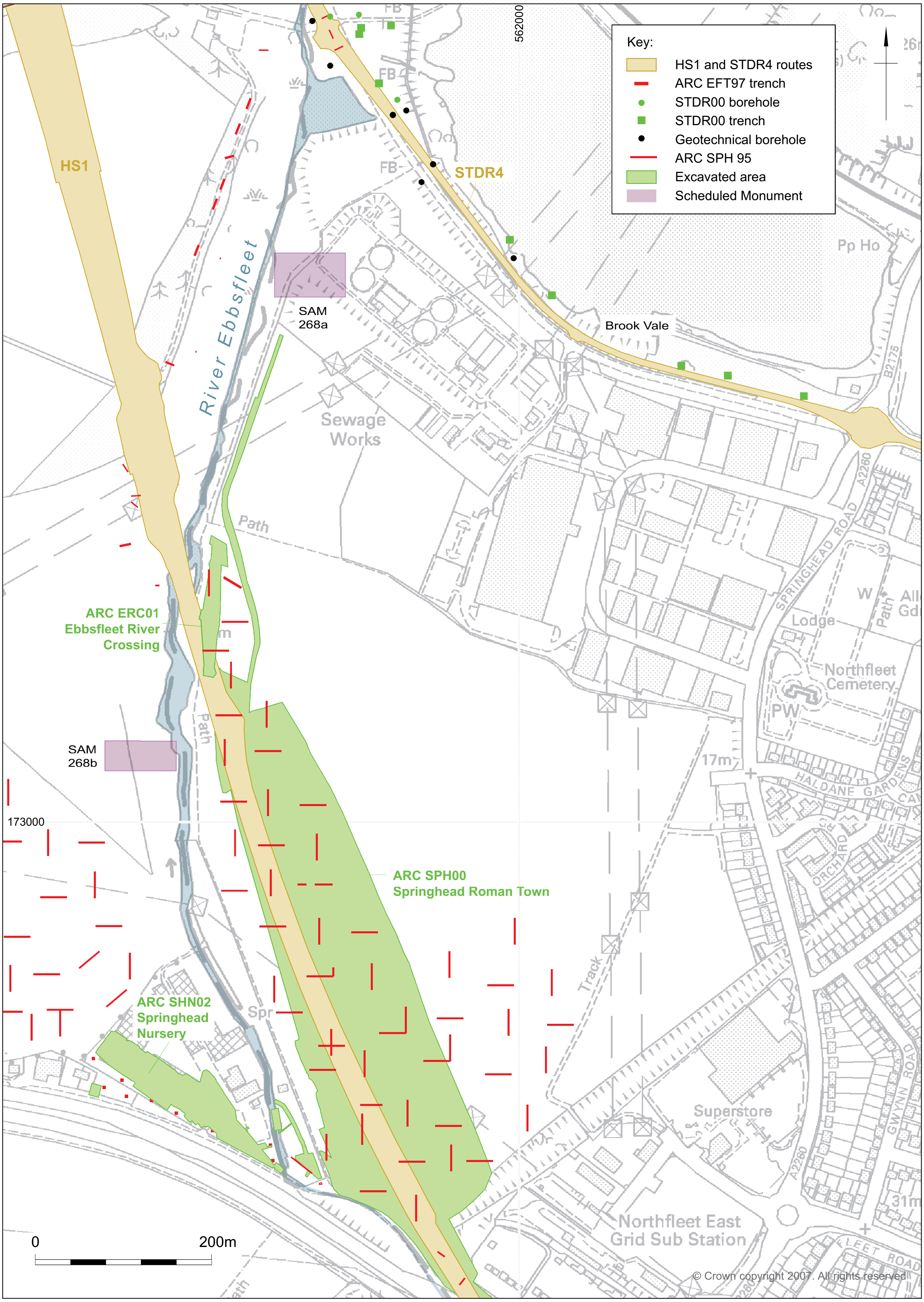


Figure 3.3 Site layout showing areas of HS1 and STDR4 investigation within Brook Vale and the Upper Ebbsfleet Valley

dating, interpretation of mode of formation and correlation with other sediment beds;
- To recover further biological evidence from the sands near 3835TT to aid in establishing their date and mode of formation.

Two trenches were dug (3973TT and an unnumbered 'Villa' Trench) through the Pleistocene sequence underlying Northfleet Roman Villa, the main record of which was Section 18044. In addition, faunal remains were recovered and environmental sampling was carried out in two sections (Sections 18531 and 18532 – see Chap 11, Figs 11.1, 11.5 and 11.7) through Pleistocene deposits exposed after excavation of Roman revetment structures. These interventions produced a rich record of palaeoenvironmental remains, namely: large mammals, molluscs, ostracods and small vertebrates. OSL dating was also carried out through the sequence in the main Villa Trench section. The results from interventions in this part of the site are discussed in Chapter 11.

With reference to the later prehistoric period, the large area excavations at the Northfleet Villa and Sports Ground sites (Fig 3.2) were largely focused on mitigating the impact of HS1 on remains preserved at shallower depths on the slightly higher areas, marginal to the valley bottom alluvial sequences. The later prehistoric horizons at these locations were shown to be heavily disturbed by Roman and later activity; Neolithic worked flint and pottery was largely recovered as redeposited material in later deposits (Chap 21). However, a series of Bronze Age pits were recorded, filled with burnt and worked flint and pottery, along with the truncated remains of ring-ditches, a small number of cremation burials and linear features (Chap 22).

Watching Brief, Ebbsfleet West: ARC 342W02

A general watching brief was carried out during construction of HS1. With reference to Palaeolithic/Pleistocene remains this was focused in two areas: (1) Northfleet Landfill remediation site, where Jayflex Ltd were contracted to remove the existing mixed landfill; and (2) along the eastern side of DBA Area 8, where it abutted the HS1 footprint (Fig 3.2). Work was aimed at: (a) recovering further information on the stratigraphy and geometry of Pleistocene deposits to aid their dating, interpretation of mode of formation and correlation with other sediment beds; and (b) recovering sufficient biological evidence to aid in establishing their date, mode of formation and associated palaeo-climate and environment. In the Jayflex extraction area, archaeological recording was carried out involving: survey of exposed geological sub-strata; photographic, drawn and digital survey of the exposed vertical section at the north side of the extraction area; sampling for palaeoenvironmental remains; OSL dating; and a walkover survey for Palaeolithic artefacts, quite a few of which were recovered. In Area 8, a digital survey was made of the sediments exposed in the sloping cut (Section 103020) along the west side of the HS1 construction area, along the east bank of SAM Kent 267a. Molluscs were visible in several beds, and these were bulk-sampled for molluscan and other palaeoenvironmental recovery.

A more general watching brief on the Holocene sequences recorded a series of Bronze Age wooden structures within the alluvial deposits of the valley bottom. This included concentrations of roundwood that may represent the remains of trackways or routeways along the wetlands margins, as well as a more substantial oak piled structure interpreted as a footbridge across a channel (Chap 22).

STDR4 and Other Investigations in the Lower Ebbsfleet Valley

Northfleet Rise, Blue Circle Sports Ground: EBBS97

This phase of work was carried out by Oxford Archaeology in 1997 for Blue Circle Industries Plc, prior to outline planning consent for development of land adjacent to the HS1 route. The investigation was focused on the area to the north-east of the proposed Ebbsfleet International Station and specifically targeted the deep Holocene alluvial and peat sequences of the valley floor (Fig 3.2). Eleven boreholes and three test pits were excavated, and a limited programme of geophysical survey (surface direct current (DC) electrical sounding) was undertaken along one of the borehole transects, in order to determine the nature of the sub-surface stratigraphy and location of archaeologically sensitive deposits. The data obtained was used to construct a series of transects across the study area.

The evidence indicated Late Pleistocene chalk solifluction sediments formed a wedge thinning towards the valley axis which were in turn overlain by fluvial gravels. Analysis of the elevation of the surface of the Pleistocene deposits, forming the Early Holocene topography of the valley bottom, revealed a deep Outer Basin downstream of Northfleet Villa. The Holocene sequences filling this basin consisted of more than 10m of fine-grained sediments. A shallower Inner Basin was located upstream of the villa. The site of Northfleet Villa itself appeared to be located on a promontory or 'spur' extending from the western slopes of the valley. This promontory would have remained an area of higher drier ground throughout much of the Holocene. The Pleistocene sediments along the valley axis were sealed by soft unconsolidated Holocene sediments comprising a lower clay silt, possibly representing an early marine incursion, and a major freshwater peat bed. The peat was sealed by further deposits of alluvium and then substantial depths of made ground. Struck and burnt flint was recovered from BH11 and TP1 and TP2 within and below the main peat unit (Chap 12).

STDR4 evaluation: STDR400

Following a desk-based assessment and an initial watching brief on geotechnical investigations (Barham and Bates 1995), two phases of archaeological investigations were undertaken along the route corridor of the proposed South Thameside Development Route 4 (STDR4). The evaluation included 20 targeted boreholes that were drilled to complement and add to existing evidence provided by previous investigations the Holocene sediment sequence. Subsequently, 15 evaluation trenches were excavated (Figs 3.2–3).

The sequences indicated that the range of stratigraphic units identified within previous investigations continued within the STDR4 study area. However, more complex stratigraphy was recorded within the sedimentary units than previously defined within the western part of the valley. This was particularly highlighted by the occurrence of tufa deposits within the main peat sequence.

The environmental samples recovered demonstrated a high level of potential for analysis of selected deposits in both defining, and testing a model for sea-level change, the ecological history of the valley and the impact of human occupation and alteration within it. Artefactual material was recovered from five of the trenches. This material derived entirely from within or upon the surface of deposits and was not contained in definable features. Most notable of the assemblages was the occurrence of Ebbsfleet Ware pottery in Trench 11 within peat deposits, in association with burnt and worked flint, probably representing the use of an *in situ* Neolithic land surface (Chaps 13 and 21). Probable Neolithic and Bronze Age flintwork was also recovered from similar horizons within Trench 8 associated with worked wooden stakes. Situated within 250–300m of Burchell's Ebbsfleet Ware type site (SAM 268a, Fig 3.2), these trenches suggested considerable activity over a large distance in association with the Ebbsfleet water course. Colluvial sequences investigated within a largely dry valley tributary branching off to the south-east of the Ebbsfleet stream along the STDR4 corridor (Brook Vale) similarly produced prehistoric finds assemblages, although largely much occurred as reworked material associated with medieval artefacts (Chap 14).

STDR4 cofferdam excavations: STDR401

The second phase of investigation was specifically designed to characterise a representative sample of the archaeology and geology within the area affected by road construction with particular priority being given to remains of Neolithic date. The work aimed to contribute to knowledge of Ebbsfleet Ware and investigate the role of human agency with regard to possible evidence for extensive tree clearance within the pollen record and determine the nature of any woodland management during the Neolithic.

Four 10 x 10m cofferdams were excavated (STDR01, Areas 1–4) through the entire depth of Holocene alluvial stratigraphy (Fig 3.2, Chaps 12 and 13). In Area 1 the main peat bed appeared to have been eroded and scoured by a complex sequence of channels. Aligned along the edges of the channel sequence was a series of ephemeral wooden 'structures', probably the remains of revetment structures, associated with some Late Bronze Age pottery. Gravel 'consolidation layers' sealing the channel sequence contained occupation debris which included Early to Middle Iron Age pottery and animal bone (Chap 22). In Areas 2, 3 and 4 *in situ* worked flint scatters were located beneath and within the main Neolithic to Bronze Age peat bed. Bronze Age artefact scatters, comprising pottery and burnt and worked flint, was also identified on the surface of the peat (Chaps 21 and 22). Extensive palaeoenvironmental sampling of the Holocene alluvial and peat sequences was carried out during the area excavations. Key sequences from Areas 1 and 4 were selected for assessment in order to augment the large body of data produced during previous phases of investigation.

HS1 Investigations in the Upper Ebbsfleet Valley at Springhead

An extensive phase of evaluation trenching carried out in the upper reaches of the Ebbsfleet Valley in 1997 (ARC SPH95) covered three main site areas that were the subject of later detailed excavation (ARC SPH00, ARC ERC01 and ARC SHN02, Fig 3.3). The areas of excavation revealed archaeological remains extending over 4–5 hectares, although the majority of evidence related to Roman and later periods of occupation. *In situ* evidence of prehistoric activity was sparser, as in the vicinity of Northfleet Roman Villa prehistoric occupation horizons had been heavily disturbed by the later activity.

The excavations at the site of Springhead Town (ARC SPH00) and Springhead Nursery (ARC SPN02) recovered a sizable assemblage of Final Upper Palaeolithic to Bronze Age worked flint and prehistoric pottery. Although much of this comprised material reworked into Roman and later deposits, significant groups of worked flint were recovered from Bronze Age colluvial layers at Springhead Town. The flint from the latter was in a relatively fresh condition and a number of refitting pieces suggest it had not moved far from the original place of deposition (Chaps 20 and 21). The Final Upper Palaeolithic flint is of particular note, fulfilling the criteria established by Barton (1998) for a Long Blade assemblage and found in close proximity to the site of Burchell's 'Mesolithic floor' (Chap 20). Beneath the Roman Sanctuary complex at Springhead a series of Bronze Age features were also recorded that included the two intersecting ring-ditches that may represent the remains of barrows, one with a central cremation burial, along with significant concentrations of burnt flint (Chap 22).

Slightly downstream at the Ebbsfleet River Crossing (ARC ERC01), sealed beneath colluvial deposits, a series of Bronze pits filled with burnt flint were recorded, similar to those excavated at Northfleet Villa.

These pits were found in association with a possible structure defined by a pit, flanked by gullies and postholes (Chap 21). A sequence of prehistoric waterlogged organic deposits, infilling a palaeochannel of the River Ebbsfleet, was also examined at this location, through a series of stepped trenches (Chap 15).

Post-excavation Analysis

The programme of post-excavation analysis for this study was coordinated by Andrew Crockett for Oxford Wessex Archaeology, and the Principal Study Leader was Francis Wenban-Smith. Following a rapid assessment stage an Updated Project Design (UPD, URN 2006) was produced. The UPD drew together the results of all the various phases of investigation, outlining the aims and scope of work required for full analysis along with proposals for publication. The analysis stage comprised two work streams, the Palaeolithic and the later prehistoric, with an appropriate team of specialists allocated to each.

With reference to division of the HS1 areas of investigation the following terminology is used in this report:

- **DBA Palaeolithic Areas 1–12:** refer exclusively to areas of differing potential defined during the pre-fieldwork desk-based studies (described above; Fig 3.1);
- **Valley Zones 1–12:** refer to divisions within the valley based on topography and the perceived character of the main sediment sequences used during the post-excavation analysis stages (Chap 4);
- **Open area excavations:** the names of the various excavation areas utilised during the fieldwork stages in lower part of the valley (ARC EBB01) have been retained during the post-excavation analysis for consistency and have been labelled on the various maps throughout this volume. These areas comprise Northfleet Villa; the Sports Ground; Area 6 and the Chalk Spine (Fig 3.2). A watching brief was carried out in much of the HS1 land take, two areas are of note that are specifically labelled on the plans and referred to in the text; Area 8 batter and the Jayflex remediation area (ARC 342W02, Fig 3.2). In the upper part of the valley three areas are of note (Fig 3.3), each with its own site code; Springhead Town (ARC SPH00); Springhead Nursery (ARC SHN02) and the Ebbsfleet River Crossing (ARC ERC01);
- **Landscape Phases 1–4:** are outlined in Chapter 16 and provide a synthesis of the key environmental and landscape changes that occurred in the Ebbsfleet Valley. Phases 1–3 cover the Pleistocene from MIS 8 to MIS 2 and Phase 4 the Late Glacial (post-LGM) and Holocene;
- **Landscape Stages 1–4:** refer exclusively to environmental changes that occurred during Landscape Phase 4 in the lower reaches of the valley (Chap 16). These stages primarily describe the development of wetland environments as a result of rising sea levels in the Thames Estuary and are comparable to recently published models for the region (eg, Bates and Stafford 2013; Bates and Whittaker 2004).

Throughout all stages of investigation in the Ebbsfleet Valley interpretation of the sedimentary sequences and their associated archaeological remains has relied heavily on archaeological science. In addition to work on the artefactual assemblages (Table 3.5; Chaps 17–22; Wenban Smith, Appendix F; Anderson-Whymark, Appendix I; Barclay and Seager Smith, Appendix H) and human bone (McKinley, Appendix S); the laboratory work for the post-excavation stage included a range of analysis encompassing geo-archaeological, bioarchaeological and scientific dating methods. Summaries of the results of the various analyses are included in the main text of this report for each valley zone. For the Pleistocene, the results are

Table 3.5 Summary of Palaeolithic and later prehistoric artefactual material and human remains recovered from HS1 and STDR4 investigations in the Ebbsfleet Valley reported upon in this volume

	Site Code	EBBS97	ARC EBB01	ARC EFT97	ARC ESG00	ARC ZR400	ARC 342W02	ARC ERC01	ARC SPH00	ARC SHN02	STDR400/01	Total Items
Palaeolithic												
Worked flint	App. F		16	7	16	1	7	–	10	–	–	**57**
Later prehistoric												
Worked flint	App. J	15	1567	164	385	–	23	898	5687*	1250	2527	**12, 516**
Pottery	App. H	–	138 (704g)	5 (64g)	11 (80g)	–	–	132 (537g)	115 (2070g)	–	164 (1841g)	**564 (5296g)**
Human remains (cremation burial/ pyre deposits)	App. S	–	3 (289.5g)	–	–	–	–	–	–	–	–	**3 (289.5g)**

* Including Final Upper Palaeolithic from ARC SPH00

Table 3.6 Summary of key Pleistocene faunal assemblages, dating and other scientific analyses from HS1 and previous investigations in the Ebbsfleet Valley reported upon in this volume

Chapter	Intervention	Small vertebrates (No. ID fragments)	Large mammal (No. ID fragments)	Molluscs (No. samples with ID specimens)	Ostracods (No. samples with ID specimens)	Micromorphology (No. samples)	OSL dating (No. horizons/ contexts dated)	AAR (No. horizons/ contexts dated)
Chapter 5: Upper Valley-side North (Zone 1)	*Site A	✓	✓	✓	✓	–	✓	✓
	3776TP	23,684	12	14	14	2	2	6
	3777TP	825	–	1	24	1	1	3
	Area 8 batter	–	–	3	1	–	–	2
Chapter 6: Valley-side West (Zone 2)	*Site B (Burchell Channels A and B	✓	✓	✓	✓	✓	✓	✓
	*Site F	–	✓	–	–	–	–	–
Chapter 7: Lower Valley-side North (Zone 3)	BH 0021-SA	–	–	9	5	–	–	2
	3787TT	–	–	1	–	–	–	–
	3789TT	2	–	1	–	–	–	1
	3790TT	–	–	8	–	–	–	1
Chapter 9: Chalk Spine (Zone 5)	*Site D	–	✓	–	–	–	–	–
	4019TT	–	–	–	–	–	2	–
	4020TT	–	–	–	–	–	1	–
Chapter 10: South Embayment (Zone 6)	3971TT	–	–	–	–	2	5	–
	3972TT	<10	–	16	4	–	7	2
	4017TT	–	–	4	11	–	–	1
	Jayflex	–	–	–	–	–	4	–
Chapter 11: Chalk Spur (Zone 7)	Site E, Section 193	–	–	5	2	3	5	1
	Villa Trench	<10	–	1	6	3	3	–
	3833TT	–	–	–	–	–	–	1
	3973TT	2	–	19	2	–	–	1
	Revetment sections	<10	4	–	–	–	–	–
	Total	**24,513**	**16**	**82**	**69**	**11**	**30**	**21**

* Previous investigations in which samples/assemblages were re-assessed as part of this study

primarily outlined in Chapters 5–11, and for the later prehistoric, Chapters 12–15. Where not subsumed within the main text the detailed methods and results for the key specialist analysis can be found in the relevant appendices of this report.

Pleistocene Sequences

The investigation of the Pleistocene sequences (Table 3.6) included extensive analysis of the faunal assemblages, not only from the HS1 investigations but also collections held at the Natural History Museum from previous investigations in the valley (Parfitt *et al* Appendix C1; Parfitt, Appendix C2; Lister, Appendix C3 and Stewart, Appendix C4). Analysis of other remains included ostracods (Whittaker, Appendix D) and molluscs. The results of the latter are included in their entirety in Chapters 5–11. Sediment and soil analysis included micromorphology (Macphail, Appendix B).

Scientific dating was key in providing additional chronological data for the Pleistocene sequences and methods included Optically Stimulated Luminescence dating (OSL) and Amino Acid Racemization (AAR). The programme of OSL dating that formed part of the HS1 post-excavation analysis (Chaps 5–11) was carried out at the Luminescence Dating Laboratory at the Research Laboratory for Archaeology and the History of Art (RLAHA), University of Oxford. The results of previous Thermoluminescence dating (TL) by H Rendell in the 1980s at Site A (Chap 5) are also reported. The AAR was carried out at the University of York (Penkman, Appendix E), but reference is also made to the results of previous dating work at Site A by D Q Bowen and G Sykes (then of University of Wales, Aberystwyth; Wenban-Smith 1996, 243; Chap 5).

Holocene Sequences

The interpretation of the Holocene deposit sequences (Table 3.7) relied heavily on the analysis of microfossils to determine vegetation change, hydrology and environments of deposition (eg, pollen, Huckerby *et al*, Appendix J; diatoms, Cameron, Appendix K; and ostracods and foraminifera, Whittaker, Appendix L) along with analysis of macrofossils (eg, waterlogged plant remains, W Smith, Appendix O; insects, Robinson, Appendix N and molluscs, Wyles, Appendix M).

Overall the animal bone recovered from secure later prehistoric contexts was sparse (254 fragments; Strid, Appendix R) but include both wild and domesticated species with some evidence of butchery. Other direct evidence of human activities (Chaps 21 and 22) was elucidated by the analysis of material such as charcoal (21 samples; Barnett, Appendix Q). Unfortunately, apart from occasional charred hazelnut shell, no charred plant remains such as cereal grains were recovered from secure later prehistoric contexts. Soil micromorphology, chemistry and magnetic susceptibility analyses were carried out on Bronze Age burnt mound and associated deposits at Springhead in order to elucidate site formation processes (see Chap 22; Macphail and Crowther, Appendix T). The results of the analysis of the wooden structures by Damian Goodburn, recorded in the floodplain area of the Lower Valley, are integrated entirely within the text of Chapters 21 and 22. A selection of samples of waterlogged wood from the prehistoric structures was submitted species identification (39 samples; Barnett and Druce, Appendix P).

Radiocarbon dating (Table 3.8) was the primary scientific method used for dating the Holocene sediment sequences as well as providing supporting data for the interpretation of archaeological features and finds assemblages. Methodological details and the full list of dates are presented in Barnett and Stafford, Appendix G. Tables of cited dates are also included in Chapters 12–15 and Chapters 21–22. The majority of the samples were submitted for Accelerator Mass Spectrometry (AMS) dating, mainly at the Rafter Radiocarbon Dating Facility at Lower Hutt, New Zealand but also from the Scottish Universities Environmental Research Centre (SUERC) at East Kilbride, Scotland. Additionally, samples had been submitted for radiometric dating at the radiocarbon dating facility, University of Waikato during earlier phases of work. Radiocarbon determinations presented in this report have been calibrated using OxCal ver 3.10 (Bronk Ramsey 1995; 2001) utilising the atmospheric data presented by Stuiver *et al* (1998) and expressed at the 94.5% confidence level and to 2 sigma level, with the end points rounded outwards to 10 years following the form recommended by Mook (1986).

Cross-reference with Springhead–Northfleet

The report on prehistoric Ebbsfleet is one part of a two-part study of the Ebbsfleet Valley. The Late Iron Age, Roman, Anglo-Saxon and medieval activity, contributing to the 'Springhead and Northfleet' principal study, is the subject of separate reports (Andrews *et al* 2011a–b; Barnett *et al* 2011; Biddulph *et al* 2011). There is a degree of overlap between the two principal studies, particularly with reference to Springhead itself (ARC SPH00). The Roman temple and sanctuary complex at *Vagniacis* developed from an area of Iron Age activity, apparently of ritual or

Table 3.7 Summary of scientific analyses of key Holocene sediment sequences reported upon in this volume

Chapter	Site Code	Intervention	Diatoms	Ostracods and foraminifera	Pollen	Molluscs	Waterlogged plant remains	Insects
Chapter 12: Outer Basin (Zone 8)	STDR400	BH7	12	15	35	–	–	–
	EBBS97	BH11	–	–	–	–	4	–
	EBBS97	Tr. 2	–	–	–	–	7	–
	STDR401	Area 1	–	10	6	–	–	–
Chapter 13: Inner Basin (Zone 9)	STDR401	Area 3	–	–	–	–	5	–
	STDR401	Area 4	–	1	14	2	9	2
	STDR400	Tr. 9	10	3	37	4	7	1
Chapter 14: Brook Vale (Zone 10)	STDR400	Tr. 16	–	–	–	9	–	–
Chapter 15: Springhead (Zone 11)	ARC ERC01	Tr. 1	–	–	–	6	–	–
	ARC ERC01	Tr. 4	–	–	24	–	–	–
	ARC SPH00	Section 7486/7; 7630	–	–	–	22	–	–
		Totals	**22**	**29**	**116**	**43**	**32**	**3**

Table 3.8 Summary of radiocarbon dates from HS1 and STDR4 investigations in the Ebbsfleet Valley

Chapter	Context	Valley Zone	Site Code (Intervention)	No. dates
PART II: Landscape and Environment				
Chapter 12: Outer Basin (Zone 8)	Alluvial and peat sequences	8	STDR400 (BH7, BH8); EBBS97 (BH5, BH9, BH11, Tr 2)	14
Chapter 13: Inner Basin (Zone 9)		9	STDR400 (Tr. 8, Tr. 9); STDR401 (Area 3, Area 4)	21
Chapter 15: Springhead (Zone 11)		11	ARC ERC01 (Tr. 4)	4
PART III: Occupation and Activity				
Chapter 21: Neolithic and Early Bronze Age	Associated with Ebbsfleet Ware pottery	9	STDR400 (Tr. 11)	4
	Burnt flint spreads and features	11	ARC ERC01; ARC SPH00;	7
		7	ARC EBB01	1
		4	ARC EBB01	3
Chapter 22: Middle Bronze Age to Middle Iron Age	Burnt flint spreads and features	11	ARC ERC01; ARC SPH00;	3
	Cremation/pyre deposits	7	ARC EBB01	4
	Waterlogged wooden structures	8	ARC ESG00; ARC 342W02; STDR401	9
	Miscellaneous	8	STDR401	2
			Total	**72**

ceremonial character, in the vicinity of the Ebbsfleet spring. It may be argued that the ritual use of the landscape began in the Middle Bronze Age with the construction of barrows next to the springs. The prehistoric evidence is therefore of profound importance for the understanding of the origins of Roman Springhead. The Late Iron Age remains are discussed and described in detail in Springhead and Northfleet Study Volume 1 (Andrews *et al* 2011a), while the Bronze Age and earlier Iron Age evidence is briefly considered in chapter 4 of that volume. Attention is also drawn to Volume 3 of the Springhead and Northfleet study, specifically chapter 3 (Barnett *et al* 2011) (prehistoric–Roman sedimentary sequences and landscape) and chapter 4 (prehistoric–Roman environ-mental remains from archaeological deposits). A number of the sedimentary sequences span multiple periods and their analysis is not neatly separated between the principal studies. But in any case, some deposits of prehistoric date have been reported briefly in that chapter in order to provide a longer perspective of environmental changes and human activity.

Structure of Volume

The remainder of this volume is divided into three further parts. Part II, which is the substantive heart of this volume, pulls together the great quantity and variety of information from previous investigations, the HS1 programme and other recent work to provide a fundamental framework of environmental change and landscape development in the Ebbsfleet Valley through the later Middle and Late Pleistocene to the Holocene, as represented in the sediments investigated. So far as possible, sediments in different parts of the valley are firstly dated in relation to each other, and then tied in with the wider regional/national Quaternary framework and ultimately the global MIS framework. The overall Ebbsfleet Valley area was divided into 12 zones, and evidence within each zone was synthesised separately before being combined with evidence from other zones to provide an overall framework; this is discussed in more detail in the introduction to Chapter 4.

Following this, Part III attempts to place the evidence of human occupation and activity within this framework, so far as possible. Part IV then identifies a number of themes and observations that emerge from this body of work for further discussion within the wider regional, national and international contexts. The concluding comments summarise the key outcomes of this substantial programme, and identify some directions for future work in the Ebbsfleet Valley. They also consider some wider lessons and suggestions for future archaeological programmes on this gigantic scale tied in with major infrastructural development.

Part II

Landscape and Environment

Chapter 4

Valley Zones – Framework for Investigation

by Francis Wenban-Smith, Martin Bates and Elizabeth Stafford

In order to develop an overall framework of the history of landscape development and climatic/environmental change represented in the Quaternary sediments of the Ebbsfleet Valley, it has been necessary to apply a structured approach to the vast amount of information available, resulting both from previous and HS1 investigations. The site area was divided into 11 separate valley zones for initial analysis (Table 4.1), based on a combination of geomorphological situation, prior chronological and depositional understanding of sediments from pre-HS1 investigations (*cf* Chap 2), and preliminary analysis and lithostratigraphic modelling from the evaluation phases of the HS1 work. Zones 1–7 are relatively small and precisely defined in the area of concentrated fieldwork on the west side of the northern end of the Ebbsfleet Valley (Fig 4.1), and correspond with the areas of greatest interest for Palaeolithic/Pleistocene deposits. Zones 8–11 in contrast (Figs 4.1 and 4.2), cover relatively large areas of the alluvial floor of the Ebbsfleet Valley, extending both south up the main arm of the valley towards Springhead (Zones 9 and 11), and eastward along the relatively minor Brook Vale arm (Zone 10); these zones correspond with the areas of greatest interest for Holocene deposits and later prehistoric archaeology.

The approach was to take each zone in turn, integrating all evidence from field interventions and published/archival sources. After this was done for each zone, the separate zonal syntheses were combined and integrated, using geo-topographic correlation, dating results and biostratigraphic interpretation where appropriate, to create an overall chrono-stratigraphic, landscape development and climatic/environmental framework throughout the Ebbsfleet Valley. The results presented in this volume are not a comprehensive report on every field intervention within each zone. For that, an interested researcher should go to the primary fieldwork reports. Rather, key locations and fieldwork events that contribute to development of the zonal syntheses, and ultimately the Ebbsfleet-wide framework, have been

Table 4.1 Site zones for post-excavation analysis

Zone	Name	Details
1	Upper Valley-side (North)	MIS 7 fluvial deposits, under thick colluvial sands/silts, on the west side of the Ebbsfleet, on the Upper Valley-side in the northern part of the site, broadly corresponding with DBA Area 1 and the west edge of Area 8
2	Valley-side (West)	MIS 7 fluvial deposits, under thick colluvial sands/silts, on the west side of the Ebbsfleet, in the western part of the site, corresponding with DBA Areas 2, 3 and 4
3	Lower Valley-side (North)	MIS 5 (?) fluvial deposits, under thick colluvial sands/silts, on the west side of the Ebbsfleet, on the Lower Valley-side in the northern part of the site, broadly corresponding with DBA Area 8, and the southern edge of Area 1
4	Valley-side (Central)	MIS 5–2 (?) deposits immediately to the west of the Ebbsfleet alluvial floor; silts/sands remnant in the base of previously quarried and made areas, continuing to east under edge of Holocene alluvium
5	Chalk Spine	Coombe Rock surviving as narrow spine of deposits to NW of old Southfleet Pit, under path of previous conveyor belt, corresponding with Wenban-Smith's Site D and DBA Area 5
6	South Embayment	Topographic depression in chalk bedrock, linking with dry valley joining Ebbsfleet from south-west; filled with wide range of deposits, including possible estuarine sediments and tufa; corresponds with west part of Wenban-Smith's Site E and DBA Area 6
7	Chalk Spur	Major body of Devensian (?) silts/sands, abutting Coombe Rock; dipping/thickening north and east from north end of Chalk Spur that was quarried as Southfleet Pit under present-day alluvial floor of the Ebbsfleet; corresponds with east part of Wenban-Smith's Site E and DBA Area 6, and extends under alluvium
8	Outer Basin	Lower Ebbsfleet Valley floodplain area containing up to *c* 10m of intercalated Holocene alluvium and peat deposits infilling a deep, at times tidally influenced, basin. Deposits thin against the Pleistocene deposits of the valley slopes
9	Inner Basin	Lower Ebbsfleet Valley floodplain area containing similar deposits to Zone 8 but at shallower depths in a more sheltered location. The sequences generally demonstrate greater complexity with a higher organic content and less tidal influence during the mid Holocene.
10	Brook Vale	A dry tributary valley on the east side of the Lower Ebbsfleet Valley. Infilled with thick deposits of Holocene colluvium
11	Springhead	Located towards the head of the Ebbsfleet Valley. Comparatively shallow Holocene alluvial and peat sequences, in places heavily truncated by later channelling and Roman activity, particularly around the springs

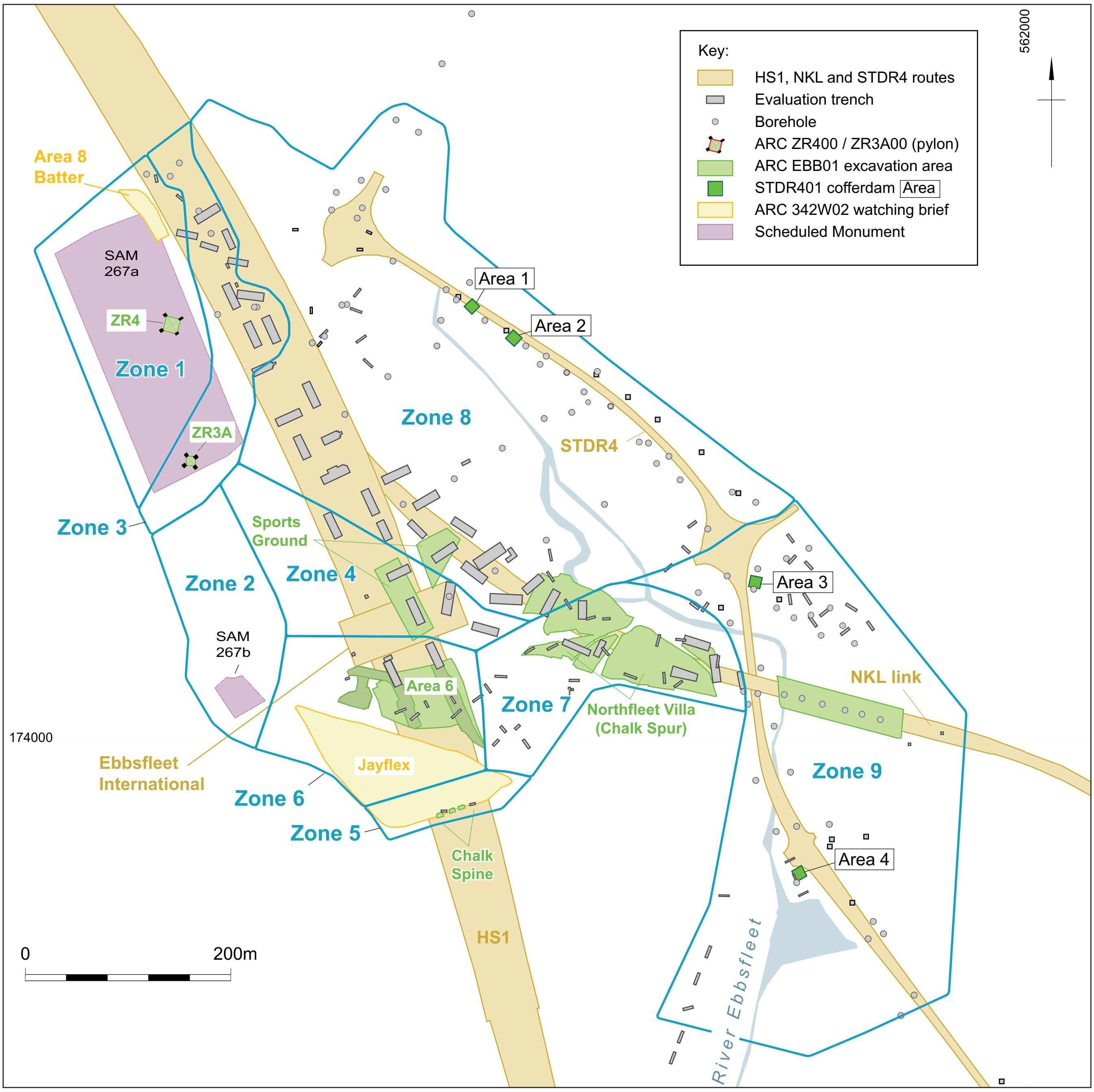


Figure 4.1 Distribution of site Zones 1–9 and fieldwork locations

selected for reporting in this volume. These key locations range in scope from single test pits or boreholes where one deposit has produced important remains (eg, 3789TT and Borehole 0021SA in Zone 3) to huge stepped trenches up to 100m long (eg, 3971TT and 3972TT in Zone 6) that have produced a variety of environmental, artefactual and dating evidence. Each site zone has been subject to a varied intensity of investigation and likewise has produced a varied record of important locations with interpretive potential for development of the overall landscape framework (Table 4.2).

Zones 1 and 2 have a sustained history of investigation, with Zone 1 in particular having been subject to both numerous previous investigation as well as interventions as part of the HS1 archaeology programme. Zone 2 was not investigated for the HS1 programme, but contains critical evidence for the overall environmental and dating framework, and of Palaeolithic occupation in relation to this framework, so is included in this synthesis. Zone 3 has relatively few interventions with important remains or sequences, but contains deposits in one small part that represent a phase of landscape development for which there is very little other evidence in the Ebbsfleet Valley. Zone 4 produced no environmental remains or datable evidence, but the sequences provide lithostratigraphic links between the adjacent zones. Zone 5 was relatively small, but was intensively investigated as it represented one of the last surviving remnants of Coombe Rock near

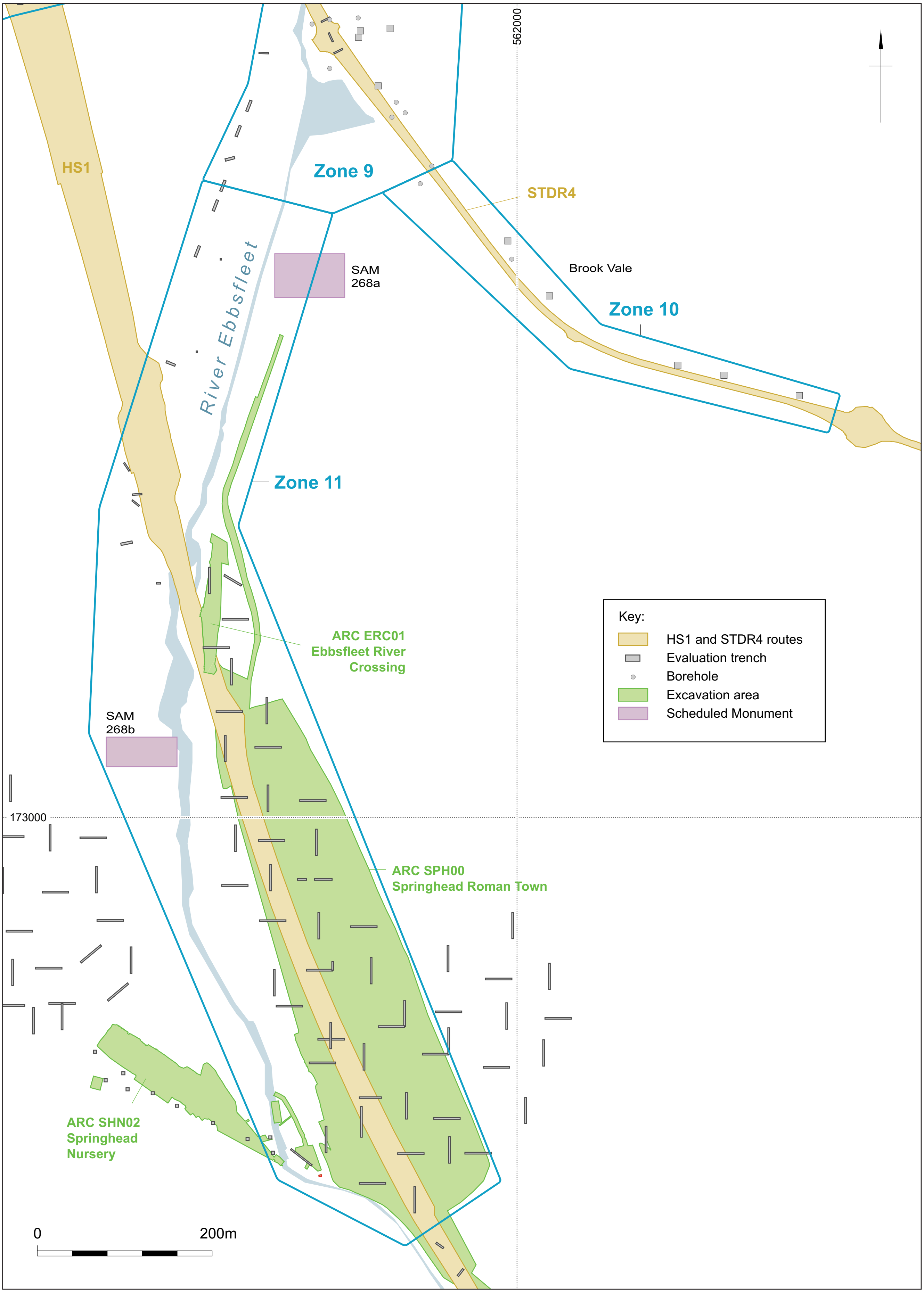


Figure 4.2 Distribution of site Zones 9–11 and fieldwork locations

Table 4.2 Site zones, phases of work and key fieldwork locations

Zone	Project	Key location/s	Notes, key factors
1	J N Carreck (1950s)	Channel A	Collecting from quarry face of substantial faunal collection; some mollusc sampling
	British Museum (1970–1971)	Site A	Excavation of substantial faunal collection; mollusc sampling (by M P Kerney)
	Wenban-Smith (1990; 1993–1995)	Sec. 10, loc A.10.a BM Site A, test pit A.TP 1 BM Site A, test pit A.TP 2	Excavation of small faunal collection; mollusc and small vertebrate sampling; OSL and AAR dating
	ARC ZR498	3423TP 3424TP	Evaluation test pits in deeper uplift footings of new pylon ZR4
	ARC ZR400	3776TP 3777TP	Excavation of remaining sediment in deeper uplift footings of new pylon ZR4: large small-vertebrate collection; OSL and AAR dating
	ARC ESG00	2005TP 2006TP	Stratigraphic records and mollusc sampling from north end of Zone 1
	ARC 342W02	Area 8 batter	Major exposure, mollusc and ostracod sampling
2	J P T Burchell (1930s)	Ebbsfleet Channel, sections A and B	Various faunal and molluscan material from poorly recorded locations; AAR dating on old material
	J N Carreck (1950s)	Channel D	Faunal collection
	British Museum (1969)	Site B	Stratigraphic recording; mollusc sampling (by M P Kerney)
	F F Wenban-Smith (1993–1995)	BM Site B, test pit B.TP 1 Site F [= Carreck's Channel D]	Small vertebrate sampling; OSL dating
3	ARC EFT 97	BH 0021-SA	Borehole with molluscs and AAR dating
	ARC ESG 00	3783TT 3787TT 3789TT 3790TT	Major stratigraphic exposures, mollusc-rich deposits sampled in 3789TT and 3790TT
	ARC ZR3A 00	3821TT	Stratigraphic info and extensive bulk environmental sampling, but little found
4	ARC ESG 00	3806TT 3807TT 3828TT 3837TT	No palaeoenvironmental remains found, but several lithic artefacts, and some important stratigraphic links between sequences in Zones 6 and 7 with those at the edge of the Holocene alluvial basin
5	R A Smith (APCM 1914)	Southfleet Pit ("Baker's Hole")	Excavation of substantial Levalloisian and faunal collection from Coombe Rock in "NW angle of pit"
	F F Wenban-Smith PhD	Site D, section 40 D. TP1	Recording of major section of surviving Coombe Rock deposits; recovery of faunal remains including mammoth tooth
	ARC EFT 97	2019TP 2020TP	Evaluation test pits into Coombe Rock deposits recorded as FW-S Site D, recovery of lithic artefacts
	ARC EBB 01	4018TT 4019TT 4020TT	Trial trenches to mitigate impact of CTRL through Site D Coombe Rock; recovery of lithic artefacts and OSL dating
6	ARC ESG 00	3805TT 3808TT 3829ATP 3829BTP	Evaluation test pits into Coombe Rock deposits and recovery of lithic artefacts
	ARC EBB01	3971TT 3972TT 4017TT	Larger-scale mitigating excavations into Coombe Rock and other sediments; recovery of lithic artefacts, diverse palaeoenvironmental remains, OSL and AAR dating
	ARC 342W02 (Jayflex)	Sec. 50552 Sec. 50553	Recording of major section through Pleistocene sequence east of Site B; recovery of lithic artefacts and OSL dating
7	Wenban-Smith (1992–1993)	Site E, Sec. 43	Recording of Pleistocene sequence at preserved remnant north-west face of old Southfleet Pit; recovery of Levalloisian lithic material
	ARC EFT97	Sec. 185 Sec. 193 2063TP	More detailed recording, environmental sampling and OSL dating of Pleistocene sequence at preserved remnant north-west face of old Southfleet Pit
	ARC ESG00	3830TT 3833TT 3834TT 3835TT	Evaluation test pits identifying major Late Pleistocene sand body extending under Ebbsfleet alluvium; recovery of molluscan, ostracod and small vertebrate remains
	ARC EBB01	3973TT Sec. 18044 Sec. 18531 Sec. 18532	Further investigations of sand body extending under Ebbsfleet alluvium; recovery of molluscan, ostracod and vertebrate remains (large and small) and OSL dating

Table 4.2 Continued

Zone	Project	Key location/s	Notes, key factors
8	STDR400	BH7	One of the deepest most complete Holocene sequences sampled in Zone 8 (Outer Basin). Good preservation of a range of palaeoenvironmental remains and good dating potential
	STDR401	Area 1	Contrasting sediment sequence to BH7 where the main Holocene peat unit had been truncated by later channel activity associated with the Upper Clay Silts. Includes stratified Late Bronze Age and Early Iron Age activity including wooden structures
	EBBS97	BH 11 Tr. 1/2	Comparative sediment sequences to BH7. Mesolithic/Neolithic worked flint and charcoal associated with the Lower Organic Silt and main peat unit
9	STDR400	Tr. 9 Tr. 11	Trench 9 contained one of the deepest most complete Holocene sequences sampled in Zone 9 (Inner Basin) . Good preservation of a range of palaeoenvironmental remains and good dating potential. Artefactual material including Ebbsfleet Ware pottery, worked flint and faunal remains were recovered from the peat in Trench 11
	STDR401	Areas 3/4	Areas 3 and 4 also contained deep sediment sequences comparative to Trench 9, with stratified archaeological remains dating from the Neolithic and Bronze Age. Area 4 includes a possible Late Neolithic trackway
10	STDR400	Tr. 13–17	Evaluation trenches recording colluvial deposits in dry tributary valley
11	ARC ERC01	Tr. 4 Tr. 1	Two sections through alluvial and peat deposits infilling former course of Ebbsfleet. Samples provide environmental data for Neolithic and Bronze Age activity on the adjacent higher ground
	ARC SPH00	Sec. 7486/7 Sec. 7630	Two sections through colluvial deposits infilling the spring area. Samples provide environmental data for Bronze Age activity

the location that produced the Southfleet Pit/“Baker’s Hole” APCM Levalloisian lithic collection; it was also substantially impacted by the HS1 route, which went right through it. Zone 6 was also intensively investigated as it proved to contain unsuspected quantities of undisturbed deposits preserved at relatively low levels, below the impact of previous quarrying, and between the locations of the APCM Levalloisian site and the areas where Spurrell and Burchell made their discoveries. Zone 7 included a surviving section (Section 193 from ARC EFT97) from the north-west face of the original Southfleet Pit. This was preserved *in situ* after appropriate recording work. It also included the area of Northfleet Roman Villa complex under which lay a major body of Pleistocene sands dipping north and east under the Holocene alluvium. These sands were investigated by means of a number of deep test pits and recording of a cross-section exposed in a stepped trench made after excavation of the overlying Roman evidence – Section 18044, in the ‘Villa Trench’. Zones 8 and 9 lie in the valley bottom and are dominated by thick Holocene floodplain sequences. Zone 8 corresponds to a deeper ‘Outer Basin’ and Zone 9 a shallower ‘Inner Basin’. Zone 10 incorporates Brook Vale, a dry tributary valley leading eastwards off the main Ebbsfleet Valley, infilled by Holocene colluvial deposits. This zone was largely investigated during the STDR4 evaluation phase (STDR400). Zone 11 covers the investigations in the upper reaches of the Ebbsfleet Valley in the vicinity of Springhead.

The key evidence from each zone is reviewed in turn in Chapters 5–15, and then the overall landscape, environment and dating framework is presented in Chapter 16.

Chapter 5

Upper Valley-side North (Zone 1)

by Francis Wenban-Smith, Martin Bates, Richard I Macphail, Simon A Parfitt, Kirsty Penkman, Richard Preece, Ed Rhodes, Jean-Luc Schwenninger, John R Stewart, Tom S White and John E Whittaker

Introduction

Zone 1 lies at the northern end of the Ebbsfleet Valley study area (Fig 4.1), on the upper western slopes of the valley. Surface elevations range from *c* 15m down to 8m OD and the slope descends in a gentle fashion to the north-east. Prior to the construction of HS1 this zone was dominated by recently abandoned allotments and scrub vegetation. Much of this zone lies within the Baker's Hole Scheduled Ancient Monument (SAM Kent 267a). The northern boundary of the zone is marked by a narrow footpath crossing from Swanscombe towards Northfleet, with the quarried area known, in recent times, as "Bevans Pit" to the north. The term "Bevans Pit" has, incidentally, been applied to at least two other entirely different quarried areas in the Ebbsfleet Valley since the late 19th century, being: (a) the original name of the first large chalk quarry later known as Baker's Hole; and (b) a shortened version of "Bevan's Wash-pit" a wholly different pit to the west of Southfleet Road, quarried for brick-making clay originally, then re-used as a gravel washing plant. Both sites were first investigated by Spurrell (1883; 1890) and Stopes (Wenban-Smith 2004b; 2009). The eastern boundary of Zone 1 is marked by Zone 3. The western boundary is defined by the edge of previous quarrying – the eastern edge of the 1930s–1950s quarry variously known as both Rickson's and Barracks Pit. Previous work in Zone 1 was undertaken by Marston and Carreck in the 1950s (Carreck 1972), the British Museum in the 1970s (Kerney and Sieveking 1977) and Wenban-Smith in the 1990s (Wenban-Smith 1995 and 1996) (Table 4.2). Sediments from within Zone 1 were also included in an early thermoluminescence dating study of presumed loessic sediments across south-east England (Parks and Rendell 1988; 1992).

Preliminary evaluation for HS1 in 1997 included drilling of boreholes and the excavation of test pits in the vicinity of the proposed route corridor (ARC EFT97). This was followed by evaluation in the centre of the zone in relation to the erection of a new pylon ZR4 within the SAM (ARC ZR498). Mitigating works at ZR4 were then undertaken in 2000 (ARC ZR400). Investigation of the ZR4 footings at both evaluation and mitigation stages focused on the excavation of the two "uplift footings" of the four pylon support footings which were significantly deeper than the two compression footings. Evaluation of each of the footings resulted in the removal of half the area of impact within each footing, with the remainder being excavated as mitigation. Further evaluation along

Table 5.1 Zone 1 key interventions and range of specialist and dating studies

Project	Key locations	Secondary locations	Soil micro-morphology and particle-size analysis	Large mammals	Small vertebrates	Molluscs	Ostracods	Amino acid analysis	OSL dating	Worked flint
Carreck	Channel A	–	x	X	x	X	x	–	–	X
British Museum	Site A (NO 70)	–	–	X	–	X	–	–	–	–
Rendell	Site A	–	–	–	–	–	–	–	x (TL)	–
Wenban-Smith PhD	Loc A.10.a (EV 1990)	–	–	X	X	X	–	X	–	–
	A.TP 1 (EV 1993–1994)	–	–	X	X	–	X	–	X	–
	–	A.TP 2 (EV 1995)	–	X	–	–	–	–	X	–
ARC EFT97	–	2005TP	–	–	–	X	–	–	–	–
	–	2006TP	–	–	–	X	–	X	–	–
ARC ZR498	–	3423TP	–	X	X	X	–	–	–	–
	–	3424TP	–	X	X	X	–	–	–	–
ARC ZR400	3776TP	–	X	X	X	X	X	X	X	–
	3777TP	–	X	–	X	X	X	X	X	–
ARC ESG00	–	3784TT	–	–	–	–	–	–	–	–
ARC 342W02	Area 8 batter	–	–	–	x – frags	X	X	X	–	–

KEY: X – important evidence; x – minor presence

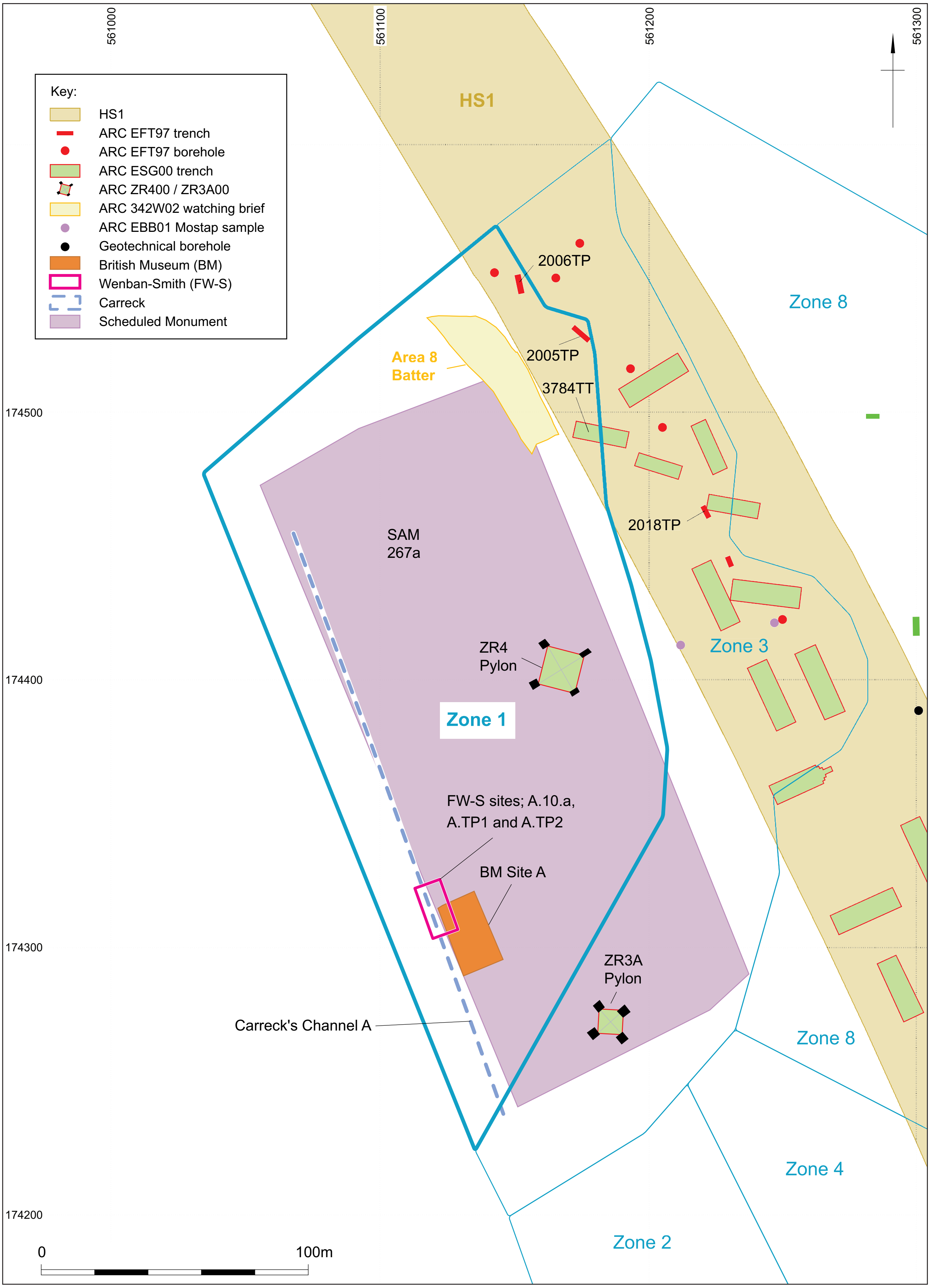


Figure 5.1 Zone 1 layout and key intervention locations

the finalised route corridor which just clipped the NE edge of Zone 1 was undertaken in 2001 (ARC ESG00). Finally, a watching brief was undertaken on the Area 8 batter in late 2002.

Key interventions from the HS1 programme that have produced important stratigraphic, palaeo-environmental, archaeological or chronological data are summarised (Table 5.1), along with those from previous work, and their locations within the zone are also shown (Fig 5.1). The evidence from these key interventions is discussed in detail below.

Site A

by Francis Wenban-Smith, Martin Bates, Simon A Parfitt, Kirsty Penkman, Richard Preece, Ed Rhodes, John R Stewart and John E Whittaker

Introduction

Site A was initially identified as a richly fossiliferous location by A T Marston (of Swanscombe skull fame) in the 1950s, exposed along the north-east face of the quarry excavation variously known as Rickson's or Barracks Pit (*cf* Fig 2.3). Systematic fossil collection from the exposed face and some stratigraphic recording was first carried out by J N Carreck (1972), who assigned it to his "Channel A" (Fig 5.1). Further work, involving more detailed stratigraphic recording and hand-excavation of an area of the most fossiliferous part of the sequence (Figs 5.2a and 5.2b), was then carried out in 1970 and 1971 by G de G Sieveking (for the British Museum), aided by M P Kerney who carried out molluscan sampling (Kerney and Sieveking 1977). The most recent work, carried out by F F Wenban-Smith between 1990 and 1995 (Wenban-Smith 1995; 1996), involved digging two test pits A.TP 1 and A.TP 2 in the large boxed area dug into the main section by Sieveking (Fig 5.2c). The full sequence was recorded in more detail, with the taking of new mollusc samples and recovery of further faunal material from the sediments investigated by Sieveking (Table 5.2). Of most importance, faunal remains (including small vertebrates and *Bithynia* opercula for AAR dating) were recovered from the sandy gravel at the base of the sequence, and OSL dating was also carried out.

Lithological Succession

Seven main lithological phases (BMA-A to BMA-G) have been identified at Site A (Fig 5.2b and 5.3). These can be divided into two separated vertical series (Table 5.3); there is a stratigraphic disturbance/hiatus between the main, more northerly sequence at the site of the 1970 British Museum excavation and Wenban-Smith's test pits (phases BMA-A to BMA-C, overlain by phases BMA-F and BMA-G), and the sequence further south (phases BMA-D and BMA-E, likewise overlain by phases BMA-F and BMA-G. This creates an element of uncertainty over whether the gravel (BMA-B) at the base of the main excavation sequence is the same as the very slightly lower gravel (BMA-D) at the base of the sequence further south.

Unfortunately, no sampling or dating work was carried out at the more southerly location when it was exposed in the 1970s; nor were any sedimentological descriptions made, beyond the few annotations on the copy of the section drawing held at Franks House (British Museum). So, the focus of developing understanding of Site A is upon the sequence at the main British Museum excavation site later re-investigated by Wenban-Smith (Fig 5.3), where substantial faunal recovery has taken place, together with OSL and amino acid dating. The sequence here contains at least two stratigraphic junctions that may represent major depositional hiatuses, previously unrecognised. Firstly, at the top of bed 2 there is a co-occurrence of fine silt, gravel and large flint nodules, some of which show smoothed patches of silica gloss (as recorded in A.TP 1 – Wenban-Smith 1996, 301, fig 7.1). This may represent a break in fluvial deposition, and exposure of a land surface that was buried by a thin layer of slopewash and loessic sediments before reversion to fluvial conditions (*cf* Site A overview, below). Secondly, there is a sharp stratigraphic boundary between the top of bed 3e and the base of bed 5a, which may represent a truncational unconformity.

The lithological summary table (Table 5.3) also shows the correspondence of the lithological phasing of Site A with previous workers' stratigraphic sequences.

Vertebrates

Carreck, Sieveking (for the British Museum) and Wenban-Smith all recovered vertebrate remains from Site A (as discussed in more detail in Chap 2). Most of the finds are housed in the Natural History Museum, although a few pieces from Sieveking's excavation remain with the artefacts at Franks House (British Museum). Carreck's collection has not been located, but his unpublished dissertation (Carreck 1972) gives detailed stratigraphical information and his identifications are regarded as trustworthy. Sieveking's collection includes a substantial collection of large mammal remains from a number of sites within the Ebbsfleet Valley. The potential importance of this collection is negated by the paucity of associated documentation. Only 44 of the bones collected by Sieveking can be linked to Site A, on the basis of find numbers with the site code NO 70, which is thought to relate to the 1970 field season at his Site A; however, few of these have information on their stratigraphical provenance. The most informative collection derives from excavations undertaken by Wenban-Smith in the 1990s. As well as yielding a substantial sample of small vertebrate remains recovered by systematic processing of bulk samples, the Wenban-Smith excavations also recovered an important sample of well-stratified large mammal remains.

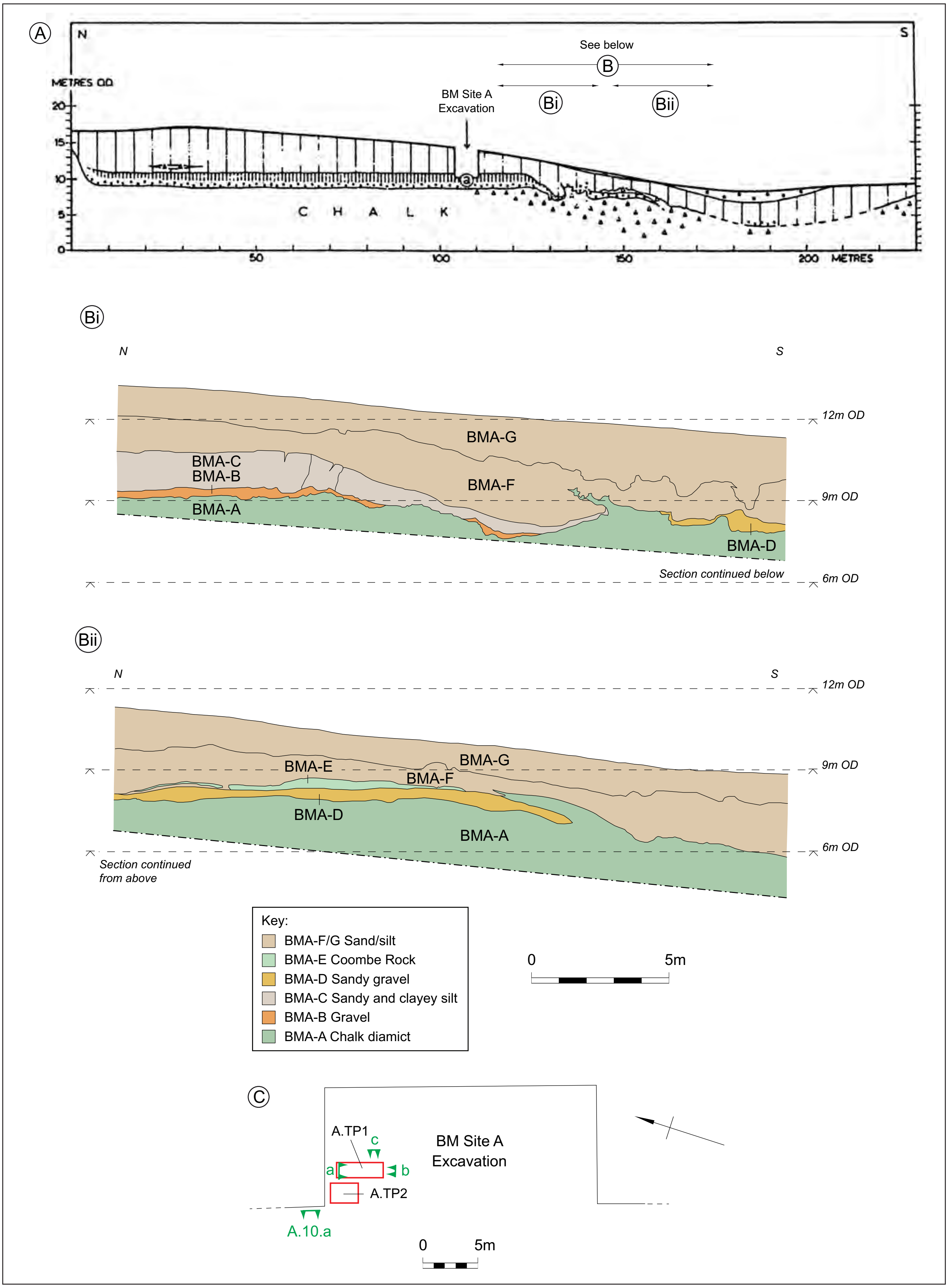


Figure 5.2 (a) British Museum section drawing, Northfleet allotments, Site A; (b) stratigraphic phasing and sequence south of Site A; (c) Wenban-Smith test pit locations at Site A

Table 5.2 Phases of Wenban-Smith's fieldwork and environmental sampling at Site A

W-S stratigraphy (1995)	**EV 1990**	**EV 1993**		**EV 1994**		**EV 1995**
Location	**A.10.a**	**A.TP1.a**		**A.TP1.b**	**A.TP1.c**	**A.TP 2**
Sampled for	**Molluscs**	**Small Vertebrates**	**Pollen /ostracods**	**Small vertebrates**	**Small vertebrates**	**Dinoflagellates**
5d-Upper sandy loam						
5c-Compacted sandy loam	<1>					
5b-Bedded sandy loam	<2>					
5a-Bedded silty loam	<3>		<1>			
	<4>		<2>			
	<5>		<3>			<DF-1>
			<4>			<DF-2>
			<5>			<DF-3>
3e-Upper olive silt	<6>					
	<7>					<DF-4>
	<8>		<6>			
	<9>					
	<10>					
3d-Mottled silt	<11>					
	<12>		<7>			
	<13>					
	<14>					
	<15>	<"137-top">	<8> *5	<1> 28kg		
	<16> <17>					
	<18>	-167kg	<9> *5			
	<19>		<16>			
	<20>			<2> D		
	<21>		<10> *4			
	<22>					
	<23>					
	<24> *1			<3> 27kg		
	<25>					
	<26>					
	<27>	<"137-bottom">	<11> *5, <17>			
	<28>			<4> D		
	<29> *2	-225kg				
	<30>					
	<31>					
	<32>			<5> 24kg		
	<33>					
	<34>					
3c-Lower olive silt	<35>					
	<36>					
	<37>			<6> 24kg		
	<38>	<"138">	<12> *4, <18>			
	<39>					
	<40>	-251kg		<7> D		
	<41> *2					
	<42>					
	<43>			<8> D		
	<44>					
	<45>					
3b-Chalky silt	<46>			<9> 28kg		
	<47>		<13> *4			
	<48>			<10> 15kg		
	<49> *3		<14>			
	<51>			<11> 21kg		
3a-Brownish-yellow silt	<52>			<12> 18 kg		
			<15> *4			
				<13> 25kg		
2c-Speckled clayey band	<53>			<13a> 4kg	<1> 23kg	
2b-Upper sandy gravel				<14>	<2> 26kg	
				20+17kg *6	<3> 30kg	
2a-Lower sandy gravel		<"141">		<15>	<4> 28kg	
		-16kg		27+17kg *6	<5> 16kg	
					<6> 14kg	
1-Coombe Rock						

Notes:
<nn> ostracod analysis by John Whittaker; *1 Two *Microtus* incisors; *2 *Microtus agrestis* morph (molars)
*3 *Microtus/Pitymys* sp. (Determinations by Andy Currant; specimens now lost); *4 Checked by Rob Scaife for pollen – none found
*5 abundant ostracods acc. J Holmes; *6 Two bags combined in one sample; D – discarded

Table 5.3 Site A stratigraphic sequence, phasing and correlations between bed nomenclature of different workers

Part of site	Phase	Sediment description	Wenban-Smith (1995)	Kerney and Sieveking (1977)	Carreck (1972)
BM excavation 1970	BMA-G	Sand/silt with fine gravel trails dipping shallowly to E	5d-Upper sandy loam	5-Sandy deposits	VIII-Trail
	BMA-F	Massive structureless sand/silt	5c-Compacted sandy loam	"	VII-Light-brown sands
		Finely wavy-bedded clay-silts/silts/sands	5b-Bedded sandy loam	"	"
		Finely wavy-bedded clay-silts/silts/sands, generally coarsening upwards	5a-Bedded silty loam	"	"
	BMA-C	Pale olive-grey sandy clay-silt	3e-Upper olive silt	4-Freshwater silts	VIc-Greenish silty loam
		Mottled orange/olive-grey sandy silt; well-developed "race" band towards top	3d-Mottled silt	"	VIb-Greenish/ochreous mottled silty loam
		Stiff pale olive-grey clay-silt, slightly sandy	3c-Lower olive silt	"	VIa- Greenish silty loam
		Sandy/clayey silt, gen. coarsening up, with flint cobbles and pebbles at base	3b-Chalky silt 3a-Brownish-yellow silt	"	V-Greyish/ochreous sandy loam
	BMA-B	Black-speckled clay-silt	2c-Speckled clayey band	3-Freshwater gravel	IV-Black speckled loam
		Firm clayey/silty flint gravel	2b-Upper sandy gravel	"	III-Coarse grey gravel
		Soft very sandy flint gravel	2a-Lower sandy gravel	"	II-Sandy gravel
	BMA-A	Chalk diamict with flint pebbles and nodules	1-Coombe Rock	1-Main Coombe Rock	I-Main Coombe Rock
BM section 1970 (to S of excavation site)	BMA-G	Sand/silt (as for BMA-G above)	–	–	–
	BMA-F	Wavy-bedded sand/silt (as for BMA-F above)	–	–	–
	BMA-E	Brownish silty Coombe Rock with Tertiary pebbles	–	–	–
	BMA-D	Sandy gravel	–	–	–

A summary list of identifiable vertebrate remains is given (Table 5.4), with quantitative data for the mammal assemblages recovered by Wenban-Smith and Carreck tabulated separately (Table 5.5), as are the large mammal remains recovered by Wenban-Smith (see Table 5.8). Information on the small vertebrates recovered by wet-sieving is listed separately (Table 5.6), while taphonomic information on the small mammal assemblages from these samples is summarised in an accompanying table (Table 5.7). A discussion of the taphonomy, palaeoecology and dating implications of the Site A vertebrate assemblages follows below; detailed taxonomic and taphonomic information and comparisons are deferred to the accompanying appendix (Parfitt *et al* Appendix C1–4).

The surface of the chalky diamict (phase BMA-A) yielded a complete left humerus from a woolly rhinoceros (*Coelodonta antiquitatis*). This represents the only securely stratified specimen of woolly rhinoceros from the Ebbsfleet Valley, previous records being misidentified or of uncertain stratigraphical provenance. The woolly rhinoceros was a highly specialised grazer generally associated with extensive steppic vegetation and cool to extremely cold, arid conditions during the latter part of the Pleistocene (Kahlke and Lacombat 2008). Although these conditions favoured the woolly rhinoceros, Stuart (1982) records its occurrence in association with boreal forest during a short period of climatic amelioration (Chelford Interstadial) in the Last Cold Stage (Devensian) in Britain.

A total of 47 taxonomically identifiable mammal bones and teeth were recovered from lithofacies BMA-B. This deposit can be divided into a gravelly lower part (2a, 2b) and an overlying silt-rich horizon (2c). Large mammal material is relatively sparse, but bulk sieving recovered 375 small vertebrate bones and teeth (Table 5.7), which are concentrated in the lower sandy gravel facies. The relatively diverse fish fauna from the lower part of this unit suggests an aquatic depositional environment, but a trend towards drier conditions is indicated by the dramatic decrease in fish and amphibian remains in the upper part of the lithofacies (Table 5.4; Fig 5.4). A single bird bone was also found in bed 2a, of an undetermined duck (Stewart, Appendix C4).

The large mammal remains from lithofacies BMA-B are well-preserved, mid-brown in colour with extensive manganese and iron staining and occasional carbonate concretions. The sample is too small to provide detailed taphonomic information, but carnivore gnawing was noted on a pelvis fragment of a red-deer sized artiodactyl from bed 2b. Another bone fragment from the same unit exhibits the early stages of weathering. The large mammal fauna includes the only well-stratified record of brown bear (*Ursus arctos*) from the Ebbsfleet Channel, as well as narrow-nosed rhinoceros (*Stephanorhinus hemitoechus*), steppe mammoth (*Mammuthus trog-*

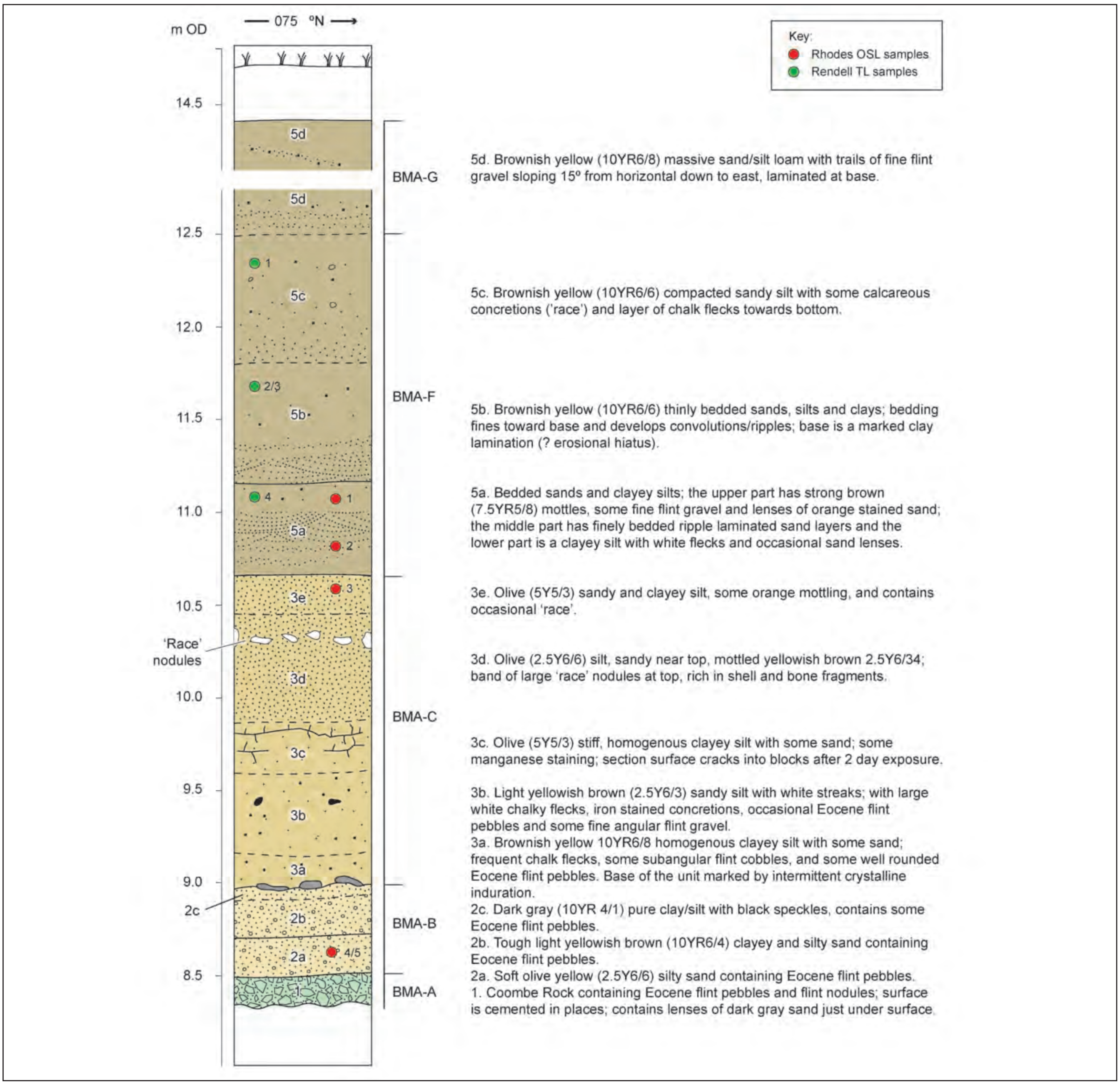


Figure 5.3 Site A sequence at test pit A.TP 1, and stratigraphic position of OSL and TL dating samples

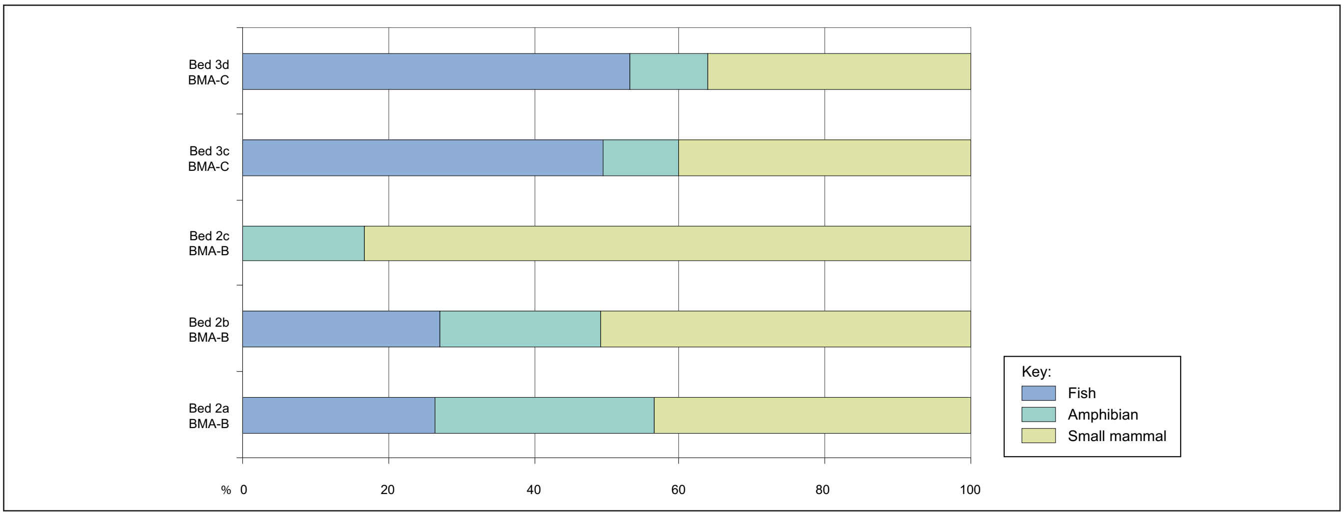


Figure 5.4 Changes in the composition of the small vertebrate assemblages through Site A, beds 2 and 3

Table 5.4 Stratigraphical occurrence of vertebrates from Site A

Phase	**BMA-A**	**BMA-B**				**BMA-C**								**BMA-F**	**U/S**
W–S bed number	**1**	**2a**	**2b**	**2b**	**2c**	**3a/b**	**3c**	**3c**	**3c/ 3d**	**3d**	**3d**	**3e**	**3e**	**5a**	
Ck bed number				**III**		**V**		**VIa**			**VIb**		**VIc**		
Collection	**W-S**	**W-S**	**W-S**	**Ck**	**W-S**	**Ck**	**W-S**	**Ck**	**W-S**	**W-S**	**Ck**	**W-S**	**Ck**	**W-S**	**BM (NO 70, 71)**
PISCES															
Esox lucius L., pike	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–
Cyprinidae gen. et sp. indet., carp family	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–
Anguilla anguilla (L.), eel	–	+	–	–	–	–	+	–	–	–	–	–	–	–	–
Gasterosteus aculeatus L., three-spined stickleback	–	+	–	–	–	–	+	–	–	–	–	–	–	–	–
Gasterostidae, stickleback	–	–	+	–	–	–	–	–	–	+	–	–	–	–	–
AMPHIBIA															
Triturus sp., newt	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–
Rana temporaria L., common frog	–	+	–	–	–	–	+	–	–	–	–	–	–	–	–
Rana sp., common frog	–	–	–	–	–	–	+	–	–	–	+	–	–	–	–
Anuran indet., indeterminate frog or toad	–	–	+	–	+	–	–	–	–	+	–	–	–	–	–
AVES															
Anser sp., goose	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+
Aves indet., indeterminate bird	–	+	–	–	–	–	+	–	–	+	–	–	–	–	–
MAMMALIA															
Soricomorpha															
Sorex minutus L., pygmy shrew	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–
Neomys sp., water shrew	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–
Crocidura sp., white-toothed shrew	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–
Lagomorpha															
Lepus sp., hare	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–
Rodentia															
Clethrionomys glareolus (Schreber), bank vole	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–
Arvicola cantianus (Hinton), water vole	–	+	+	–	–	–	+	–	–	+	–	–	–	–	–
Microtus agrestis (L.) or *M. arvalis* (Pallas), field or common vole	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–
Microtus oeconomus (Pallas), northern vole	–	+	–	–	–	–	+	–	–	–	–	–	–	–	–
Microtus sp., vole	–	+	+	–	+	–	+	–	–	+	+	–	–	–	–
Apodemus sp., mouse	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–
Rodentia indet., indeterminate rodent	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+
Carnivora															
Canis lupus L., wolf	–	–	–	–	–	–	–	+	–	–	–	–	–	–	+
Ursus arctos L., brown bear	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–
Crocuta crocuta Erxleben, spotted hyaena	–	–	–	–	–	–	–	+a	–	–	–	–	–	–	–
Panthera leo (L.), lion	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–
Proboscidea		–													
Mammuthus trogontherii (Pohlig), steppe mammoth	–	+	–	–	–	+	–	+	–	–	–	–	–	–	+
Mammuthus sp., mammoth	–	–	–	–	–	–	–	–	–	–	+	–	–	–	–
Elephantidae gen. et sp. indet., indeterminate elephant	–	–	–	–	–	–	+	+	–	+	–	–	–	–	+
Perissodactyla															
Equus ferus Boddaert, horse	–	+	–	–	–	–	+	–	–	+	–	–	+b	–	+
Stephanorhinus hemitoechus (Falconer), narrow-nosed rhinoceros	–	–	–	–	–	–	–	–	–	–	–	–	+c	–	+
Coelodonta antiquitatis Blumenbach, woolly rhinoceros	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Rhinocerotidae gen. et sp. indet, indeterminate rhinoceros	–	–	–	–	–	–	+	+	–	–	–	–	–	–	–
Artiodactyla															
Cervus elaphus L., red deer	–	–	–	+	–	–	+	+	+	+	+	+	+	–	+
Cervidae gen. et sp. indet, indeterminate deer	–	–	+	–	–	–	+	+	–	+	–	+	+	+	+
Bos primigenius Bojanus or *Bison priscus* Bojanus, aurochs or bison	–	+	–	–	–	–	–	+	–	–	–	–	–	–	+

KEY: Ck, Carreck Collection; BM, British Museum Collection, Sieveking excavations; W-S, Wenban-Smith Collection; + – present
[a] spotted hyaena identified by Carreck (1972) from gnawing marks on a mammoth metacarpal
[b] surface of VIC or VIII
[c] cranium fragment in Dartford Museum, found on talus heap by a local collector in the 1950s and ascribed to loam VIc by Carreck (1972)

Table 5.5 Quantitative overview of mammal remains from the Carreck and Wenban-Smith collections, Site A

Lithofacies	**BMA-A**	**BMA-B**				**BMA-C**								**BMA-F**
W-S bed number	**1**	**2a**	**2b**	**2b**	**2c**	**3a/b**	**3c**	**3c**	**3c/3d**	**3d**	**3d**	**3e**	**3e**	**5a**
Ck bed number				**III**		**V**		**VIa**			**VIb**		**VIc**	
Collection	**W-S**	**W-S**	**W-S**	**Ck**	**W-S**	**Ck**	**W-S**	**Ck**	**W-S**	**W-S**	**Ck**	**W-S**	**Ck**	**W-S**
Soricomorpha														
Sorex minutus L., pygmy shrew	–	–	–	–	–	–	1	–	–	–	–	–	–	–
Neomys sp., water shrew	–	–	1 (1)	–	–	–	–	–	–	–	–	–	–	–
Crocidura sp., white-toothed shrew	–	2 (1)	–	–	–	–	–	–	–	–	–	–	–	–
Lagomorpha														
Lepus sp., hare	–	–	–	–	–	–	–	1	–	–	–	–	–	–
Rodentia														
Clethrionomys glareolus (Schreber), bank vole	–	1 (1)	–	–	–	–	–	–	–	–	–	–	–	–
Arvicola cantianus (Hinton), water vole	–	5 (1)	3 (2)	–	–	–	2 (1)	–	–	1 (1)	–	–	–	–
Microtus agrestis (L.) or *M. arvalis* (Pallas), field or common vole	–	1 (1)	–	–	–	–	–	–	–	–	–	–	–	–
Microtus oeconomus (Pallas), northern vole	–	2 (1)	–	–	–	–	1 (1)	–	–	–	–	–	–	–
Microtus sp., vole	–	18	4	–	2	–	7	–	–	1	1	–	–	–
Apodemus sp., mouse	–	3	–	–	–	–	–	–	–	–	–	–	–	–
Rodentia indet., indeterminate rodent	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Carnivora								–						
Canis lupus L., wolf	–	–	–	–	–	–	–	4	–	–	–	–	–	–
Ursus arctos L., brown bear	–	–	1 (1)	–	–	–	–	–	–	–	–	–	–	–
Crocuta crocuta Erxleben, spotted hyaena	–	–	–	–	–	–	–	+a	–	–	–	–	–	–
Panthera leo (L.), lion	–	–	–	–	–	–	–	2	–	–	–	–	–	–
Proboscidea														
Mammuthus trogontherii (Pohlig), steppe mammoth	–	1 (1)	–	–	–	–	–	7	–	–	–	–	–	–
Mammuthus sp., mammoth	–	–	–	–	–	1	–	1	–	–	2	–	–	–
Elephantidae gen. et sp. indet., indeterminate elephant	–	–	–	–	–	–	1	–	–	1	–	–	–	–
Perissodactyla														
Equus ferus Boddaert, horse	–	1 (1)	–	–	–	–	2 (1)	–	–	1 (1)	–	–	6b	–
Stephanorhinus hemitoechus (Falconer), narrow-nosed rhinoceros	–	–	–	–	–	–	–	–	–	–	–	–	1c	–
Coelodonta antiquitatis Blumenbach, woolly rhinoceros	1 (1)	–	–	–	–	–	–	–	–	–	–	–	–	–
Rhinocerotidae gen. et sp. indet, indeterminate rhinoceros	–	–	–	–	–	–	1	2	–	–	–	–	–	–
Artiodactyla														
Cervus elaphus L., red deer	–	–	–	1	–	–	1 cf.	17	1	3 (1)	2	1 (1)	3	–
Cervidae gen. et sp. indet, indeterminate deer	–	–	2	–	–	–	1	5	–	12	–	2	3	1
Bos primigenius Bojanus or *Bison priscus* Bojanus, aurochs or bison	–	1 cf.	–	–	–	–	–	2	–	–	–	–	–	–

Note: Numbers are: Number of Identified Specimens (NISP) and Minimum Number of Individuals (MNI) in brackets, calculated for the Wenban-Smith collection only
KEY: Ck, Carreck; W-S, Wenban-Smith
[a] spotted hyaena identified by Carreck (1972) from gnawing marks on a mammoth metacarpal
[b] surface of VIC or VIII
[c] cranium fragment in Dartford Museum, found on talus heap by a local collector in the 1950s and ascribed to loam VIc by Carreck (1972)

Table 5.6 Site A small vertebrates (Wenban-Smith bulk samples)

Phase	**BMA-B**			**BMA-C**			
W–S bed number	**2a**	**2b**	**2c**	**3a**	**3b**	**3c**	**3d**
No. of samples (weight kg)	**5 (118)**	**3 (93)**	**2 (27)**	**2 (43)**	**3 (64)**	**2 (275)**	**5 (471)**
Fish	62 (12)	15 (2)	–	–	–	99 (5)	25
Amphibian	84 (3)	14	(1)	–	–	22	5
Reptile	–	–	–	–	–	–	–
Bird	2	–	–	–	–	2	1
Small mammal	125	32	5	–	–	84	17
Total	**288**	**63**	**6**	–	–	**212**	**47**
NISP/kg	2.4	0.7	0.2	–	–	0.8	0.1

Note: The fish assemblage is dominated by stickleback; other fish taxa (counts given in parenthesis after the stickleback count) are uncommon. Likewise, the amphibian assemblage is dominated by remains of anurans (frog or toad) whereas remains of newt (numbers in parenthesis) are rare

Table 5.7 Site A small mammals and taphonomy (Wenban-Smith bulk samples)

Phase	**BMA-B**			**BMA-C**	
W-S bed number	**2a**	**2b**	**2c**	**3c**	**3d**
Skeletal part in NISP (MNE)					
Skull	5	–	–	9	1
Maxilla	1	1	–	–	–
Mandible	2 (1)	1	–	3 (2)	1
Incisor	17 (12)	6 (4)	3 (2)	12 (8)	4 (4)
Molar	34	8	6	8	4
Vertebra	8 (8)	1	–	6 (4)	–
Rib	1	–	–	3 (1)	–
Scapula	–	–	–	1	–
Humerus	5 (4)	3 (3)	–	3 (1)	2 (1)
Radius	3 (3)	–	–	4 (4)	–
Ulna	5 (3)	2 (2)	–	–	–
Innominate	2 (1)	–	–	–	–
Femur	2 (2)	–	–	3 (2)	–
Tibia	5 (4)	1	–	4 (2)	1
Calcaneus	1	–	–	3 (3)	–
Astragalus	1	–	–	–	–
Metapodial	9 (8)	2 (2)	1	7 (7)	–
Phalange	11 (11)	–	–	8 (8)	–
Total NISP	112	25	10	74	13
Breakage					
Humerus	–	–	–	–	–
complete	–	–	–	–	–
proximal	1	–	–	–	–
shaft	1	1	–	2	1
distal	3	2	–	1	1
Femur	–	–	–	–	–
complete	–	–	–	–	–
proximal	1	–	–	2	–
shaft	–	–	–	–	–
distal	1	–	–	1	–
Tibia	–	–	–	–	–
complete	–	–	–	–	–
proximal	1	–	–	2	–
shaft	3	–	–	–	–
distal	1	1	–	4	1
Digestion					
Incisors (N)	17	6	3	12	4
light	2	–	1	1	–
moderate	4	–	–	–	–
heavy	1	–	–	1	1
extreme	–	–	–	1	–
Total digested, n(%)	7 (41.2%)	0 (0)	1 (33.3%)	3 (25%)	1 (25%)
Molars (N)	34	8	6	8	4
light	1	–	–	–	–
moderate	–	–	–	–	–
heavy	–	–	–	–	–
extreme	–	–	–	–	–
Total digested, n(%)	1 (2.9%)	0 (0)	0 (0)	0 (0)	0 (0)
Puncture marks (by mammalian carnivore)	Yes	–	–	No	–
Digestion of spongy bone	Yes	–	–	No	–
Gnaw marks (by rodents)	No	–	–	No	–
Parallel grooves (by insects?)	No	–	–	No	–
Weathering	No	–	–	No	–
Fine striations (by trampling)	No	–	–	No	–
Rounding of breaks	No	–	–	No	–
Polishing	No	–	–	Yes	–
Root corrosion	Yes	–	–	No	–
Mn concretions	Yes	–	–	No	–
Fe staining	No	–	–	Yes	–
Diagenetic pitting & exfoliation	No	–	–	No	–

Table 5.8 Large mammal remains from Site A (Wenban-Smith excavations)

Context	Taxon	NISP	MNI	Skeletal part
5a	Cervidae gen. et sp. indet.	1	1	Antler frag.
3e	*Cervus elaphus*	1	1	Astragalus
	Cervidae gen. et sp. indet.	2	1	Antler frag., sacrum frag.
	Indeterminate large mammal	1	–	Cervical vertebra frag.
3d	*Elephantidae* gen. et sp. indet.	1	1	Cheek tooth frag.
	Equus ferus	2	1	Radius proximal epiphysis and shaft frag.; pisiform
	Cervus elaphus	3	2	Antler shed base, antler base with brow and bez tines,
	Cervidae gen. et sp. indet.	12	–	Antler frag. (12)
	Indeterminate large mammal	8	–	Mandible frag.; rib frag. (2), long bone shaft frag.
3d/c	*Cervus elaphus*	1	1	M_1 or $_2$
3c	Elephantidae gen. et sp. indet.	1	1	Pisiform
	Equus ferus	2	1	Tibia distal epiphysis frag. (2)
	Stephanorhinus sp.	1	1	Phalanx proximal epiphysis
	cf. *Cervus elaphus*	1	1	Naviculo-cuboid
	Cervidae gen. et sp. indet.	1	1	Antler frag.
	Indeterminate large mammal	6	–	Skull frag.; lumbar vertebra frag. (2), rib frag., indet.
3b	Indeterminate large mammal	1	–	Indeterminate bone frag.
3a	Indeterminate large mammal	4	–	Long bone shaft frag., indet bone frag. (3)
2b	*Ursus arctos*	1	1	M^2
	Cervidae gen. et sp. indet.	2	1	Humerus distal epiphysis, pelvis frag.
2a	*Mammuthus trogontherii*	1	1	Milk molar
	Equus ferus	1	1	Metacarpal (distal epiphysis missing)
	? Bovidae gen. et sp. indet.	1	1	Femur distal epiphysis
1	*Coelodonta antiquitatis*	1	1	Humerus

ontherii), red deer (*Cervus elaphus*) and an indeterminate large bovid. The rich small vertebrate fauna includes at least six mammalian taxa. Notable is the presence of white-toothed shrew (*Crocidura* sp.) and bank vole (*Clethrionomys glareolus*), both of which are of palaeoenvironmental significance. White-toothed shrews are notable as interglacial indicators and although extremely rare in the British Pleistocene (Stuart 1982), they are invariably associated with a climate as warm, or warmer than, the present day (but see Tosh *et al* 2008). Bank vole is common in many British interglacial assemblages. Today, it has a strong preference for dense vegetation in woods, but it is also common in scrub and may even occur in grassland providing there is some dense undergrowth. Intriguingly, neither white-toothed shrew nor bank vole is present in the much richer interglacial small mammal assemblage from ZR4 3776TP (*cf* ZR4 3376TP, below), possibly indicating that the interglacial deposits at ZR4 and Site A represent different aggradations.

Overall, freshwater depositional environment is indicated by the abundance of fish remains, which are dominated by three-spined stickleback (*Gasterosteus aculeatus*), with pike (*Esox lucius*), carp (cyprinids) and eel (*Anguilla anguilla*) forming a minor component of the assemblage. Surrounding terrestrial habitats must have included areas of damp grassland or marsh with newt (*Triturus* sp.), common frog (*Rana temporaria*), water vole (*Arvicola* sp.) and northern vole (*Microtus oeconomus*); drier grassland with white-toothed shrew and horse (*Equus ferus*); together with areas of denser vegetation that may have included scrub or even woodland with wood mouse (*Apodemus* sp.) and bank vole.

Lithofacies BMA-C is notable for the rich assemblage of large mammal remains collected by Carreck (1972). The bulk of Carreck's finds are from his Horizon VIa, equivalent to the bone rich 'Bed 3c' of Wenban-Smith (1995), where the densest concentration of large mammal bones was observed (13 fragments). Bones were also concentrated in the basal part of the overlying bed 3d (10 fragments). These bones are generally well-preserved but fragmentary. They can be distinguished from the large mammal remains from lithofacies BMA-B by their lighter colour. Most of the bones have patches of manganese staining and several from the upper part exhibit a characteristic dendritic or sinuous pattern of iron-staining. Few surface markings were detected, with only two of the 54 bone fragments from beds 3c and 3d showing any trace of weathering or rootlet corrosion. However, several bones are polished and rounded, exhibiting areas with a glossy lustre that is usually associated with fine parallel scratches. As discussed by Carreck (1972, 147–150), these alterations are probably the result of depositional or post-depositional abrasion, rather than being evidence of hominin tool use. Finally, three of the bones have been gnawed by a carnivore.

Red deer is the most common large mammal species in the BMA-C assemblage, with subordinate taxa that include other large herbivores, such as horse, steppe mammoth, narrow-nosed rhinoceros and a large bovid (Table 5.5). Despite the relatively small size of the assemblage, carnivores are well represented with lion (*Panthera leo*) and wolf (*Canis lupus*), as well as the possible presence of spotted hyaena (*Crocuta crocuta*) inferred from characteristic chewing marks (see Carreck

1972). The presence of digested small mammal teeth (Table 5.7) indicates that at least some of the small vertebrate bones were deposited at the site by a predator. One bird bone was found in Wenban-smith's sieved bulk samples from Bed 2d, a proximal right carpometacarpus of an undetermined passerine. An earlier tentative identification of this specimen as pine grosbeak (*Pinicola enucleator*) or a parrot crossbill (*Loxia pytyopsittacus*) (Wenban-Smith 1995; 1996, 244) cannot be confirmed.

The small vertebrate fauna from lithofacies BMA-C was recovered by wet-sieving 853kg of sediment through a 0.5mm mesh. The most abundant remains recovered are those of small freshwater fish. Abundant stickleback indicate deposition in an aquatic environment (Fig 5.3), but the scarcity of other fish taxa (with the exception of a few small eel vertebrae from bed 3c) suggests that this environment may have been one of shallow pools that were prone to drying-out. Small mammal remains are sparse with water vole and northern vole suggestive of damp or waterlogged grassland. Extensive grassland would also have favoured the large mammal taxa.

To summarise, the vertebrates from Site A provide a clear indication of changing environmental conditions during the deposition of lower part of the succession (ie, BMA-A, BMA-B, BMA-C). Although only a small area of the basal chalk diamict (BMA-A) was excavated, this horizon yielded a humerus of woolly rhinoceros. Cold-to-cool open steppe-like conditions are indicated by this species.

The chalky diamict is overlain by very sandy gravel and silty sand (BMA-B) that yielded a range of fish species, consistent with a slow-flowing river or stream. The associated mammal fauna includes thermophilous warm temperate taxa, the most significant of which is white-toothed shrew. Although records of white-toothed shrews are rare in the British Pleistocene, their occurrences are correlated with peak interglacial conditions; this is consistent with the southerly present-day distribution of the genus in Europe. Bank vole was also a member of this temperate fauna. This vole is often common in British interglacial faunas, generally in association with palaeobotanical evidence for deciduous woodland. It is therefore surprising that bank vole is absent from the much richer interglacial small mammal fauna from ZR4 (see below). Its absence is unlikely to be due to taphonomy or sample bias, but more probably an indication that the interglacial deposits at Site A and ZR4 represent different temperate episodes.

The range of vertebrate species from BMA-C, the predominance of mammoth, horse, deer and associated predators, combined with the increase in amphibians and rodents, and decreasing numbers of fish remains through the sequence, are indicative of a trend from aquatic to a marshland and locally open grassland conditions. The climate was probably cooler than during the deposition of BMA-B.

The fossiliferous deposits at Site A were initially correlated with the Last (Ipswichian) Interglacial (Kerney and Sieveking 1977, but see Zeuner 1959). As discussed previously in the archaeological background (Chap 2), this was based on the presumption that there were only two pre-Holocene interglacials represented in the terrace deposits of the Lower Thames Basin, the Hoxnian and the Ipswichian, and that the "Ebbsfleet Channel" interglacial was post-Hoxnian and pre-Holocene. Subsequent work on mammalian faunas (Sutcliffe 1975; 1976; Currant 1989), combined with further interpretation of the Lower Thames terraces (Bridgland 1994), has identified terrace formations from at least two additional glacial–interglacial–glacial cycles between the Hoxnian (MIS 11) and Ipswichian (MIS 5e). These additional terraces, each associated with a distinctive mammalian fauna (Schreve 2001a; b), have been correlated with MIS 9 and 7 (Bridgland 1994). Characteristic elements of the Ipswichian (MIS 5e) fauna include abundant hippopotamus (*Hippopotamus amphibius*), fallow deer (*Dama dama*) and straight-tusked elephant (*Palaeoloxodon antiquus*). This so-called 'Hippopotamus fauna', represented in the Thames Valley at Trafalgar Square (central London), is notable for the absence of horse and mammoth. The absence of hippopotamus and the presence of both horse and mammoth in the large assemblages recovered from Site A in both the fully temperate stage (BMA-B), as well as the overlying grassland phase (BMA-C), suggests that these deposits are unlikely to be of Ipswichian age. Indeed, a closer match is with assemblages from higher terrace deposits of the Mucking Formation, at sites such as Ilford (Uphall Pit), Aveley, West Thurrock (Lion Pit) and Crayford. At all of these sites, a second distinctive mammal fauna is present, including a more primitive and generally small form of mammoth, the "Ilford type" together with large horse, and often with the same distinctively large northern vole as found here in BMA-B as a conspicuous element of the small mammal fauna. Widely correlated with MIS 7, these 'mammoth-horse faunas' are generally associated with fully temperate conditions, sometimes with indications for woodland, but more commonly with temperate grassland; there are also indications for colder climatic conditions at sites such as Crayford (Bridgland 1994).

Of particular interest is the presence of a complete milk tooth of mammoth from the basal part of BMA-B at Site A. This tooth exhibits 'annulations' of the enamel surface (Lister, Appendix C3) that often characterises molars of the 'Ilford-type' mammoth, considered by Lister and Sher (2001) to be a late form of *Mammuthus trogontherii*. The associated biological remains leave no doubt about its temperate context at Site A. The later fauna from BMA-C is more limited, but includes the same combination of large horse, mammoth and distinctive northern vole (Parfitt *et al*, Appendix C1). This assemblage appears to indicate more open, possibly cooler conditions. Although there are strong arguments for correlating the Site A sequence with MIS 7, assigning this short terrestrial sequence to any of the marine isotope substages in MIS 7 is problematic. Currently, details of the mammalian succession within MIS 7 remain poorly understood, and its attempted division into 'early' and 'late' groups (Schreve 2001a and b) is of dubious validity (Lewis *et al* 2011; Pettitt and White 2012). Nevertheless, the succession at Site A suggests that temperate fluvial deposition followed a major cold event, represented by the chalky diamict; whether or not this sequence can be related to a specific sub-stage within MIS 7 is considered further below (Zone 1 synthesis).

Molluscs

Kerney took a monolith in 1965 for molluscan analysis at Site A. His notes on the monolith (held in the British Museum) record a sequence of calcareous clayey silts, iron-stained in places and ranging in colour from 7.5YR 6/6 (reddish-yellow) to 5Y 6/2 (light olive grey) to 5Y 7/3 (pale yellow), through the "Freshwater Silts" of Kerney and Sieveking (1977), equivalent to Bed 3 of Wenban-Smith (1995) and here considered as phase BMA-C (Table 5.3). Samples were analysed for molluscs every 50mm through the monolith and the results (data from the British Museum archive at Franks House) are presented here as absolute abundance as number of shells/kg (Fig 5.5). Few shells were recovered in the bottom part of BMA-C (Wenban-Smith bed 3a and the bottom two-thirds of bed 3b), but they include a number of species of land snails that were not found in the much richer samples higher in the sequence. A number of aquatic species were also present in these lower levels, suggesting a floodplain subject to periodic flooding. Shells become more common above this, through to near the top of phase BMA-C. The assemblages are dominated throughout by aquatic species, in particular *Galba truncatula* and *Anisus leucostoma*, with *Radix balthica* as a subordinate. The dominant species characterize small stagnant pools, often those prone to drying out in summer. *Galba truncatula* is amphibious and can live on damp muddy areas on floodplains and similar situations. The changing frequencies of the dominant taxa, together with the varying prevalence of other species show that conditions were not constant. The occurrence of a range of aquatic species (eg, *Anisus vortex* and *Bathyomphalus contortus*) in the lower part of the sequence suggests the presence of a small, well-oxygenated waterbody. The existence of this waterbody appears to have been short-lived because swampy stagnant conditions are reflected by the molluscan assemblages towards the top of the sequence, where there is a marked absence of more purely aquatic species above the middle of bed 3d. There is an intriguing occurrence of *Hydrobia* sp., which was probably reworked from Tertiary deposits. The molluscan assemblages indicate a temperate climate but they provide no biostratigraphic indications on the age of the deposits.

Further sampling was carried out for molluscs at Site A by Wenban-Smith in 1990, at location A.10.a on the north-west corner of the British Museum excavated box (Fig 5.2c). This work (Wenban-Smith 1996, 243) provided a sequence comparable to the previous investigation (Fig 5.6), enabling reliable litho-stratigraphic correlation between the deposits investigated (and other faunal remains found) in these different phases of work. Wenban-Smith's work also provided specimens for amino acid dating (see dating, below), and produced some small vertebrate remains, thus precipitating bulk sampling for small vertebrates on a much larger scale (*cf* Table 5.2).

Ostracods

Following Carreck's recognition of ostracod presence in the upper part of phase BMA-C (Carreck 1972, 137), 12 samples were investigated from the sequence in Wenban-Smith's test pit A.TP 1 for analysis of their microfauna. The analysed samples came from the bedded silty loam at the base of phase BMA-F (bed 5a) and from throughout phase BMA-C (beds 3b, 3c, 3d through to 3e). A preliminary report by Jonathan Holmes (then of University of Kingston) found that ostracods were present in some of Wenban-Smith's samples from these and other horizons (*cf* Table 5.2).

The results of the analysis are shown (Table 5.9). The samples are arranged left to right, upward through the sequence. The upper part of the table shows other items of interest found in the samples. Molluscs (freshwater and/or terrestrial) were found in samples 1 and 7–18 inclusive. Earthworm granules, which indicate the proximity of a terrestrial habitat, were found in the lower part of the sequence only (samples 8, 9, 18, and 14). Small pieces of bone were very rare and indeterminate, but there was a barbed stickleback spine in sample 8. Charophyte oospores (calcified reproductive bodies of the stonewort) were found in samples 9 and 11. These indicate the presence of clean, shallow, slow-flowing water.

Six species of Pleistocene freshwater ostracods were found in the section, being present in 8 of the 12 samples examined. For the most part they were represented by common juveniles of *Candona* and *Pseudocandona*. At first sight they look very much alike, but instars of the latter are pitted and more sub-rectangular in shape. Only in sample 9 were complete adult valves of these two taxa present and which enabled a specific identification to be made, viz. *Candona neglecta* and *Pseudocandona marchica*, respectively. Broken fragments of a very large species (probably *Herpetocypris* sp.) were found in sample 3 only. Two species of *Ilyocypris* were present, but rare: one was the spinose *Ilyocypris monstrifica*, the other a smooth species, which seems to differ in shape from the common, smooth *Ilyocypris bradyi*. It is probably *Ilyocypris lacustris* which is known from several Middle Pleistocene sites, including Barling, Essex (Bridgland *et al* 2001). More specimens would be required to be sure. It is, nevertheless, if correctly identified, the only species from the site which does not appear to be living in Britain today. The final species is the small *Cyclocypris* in sample 9 only.

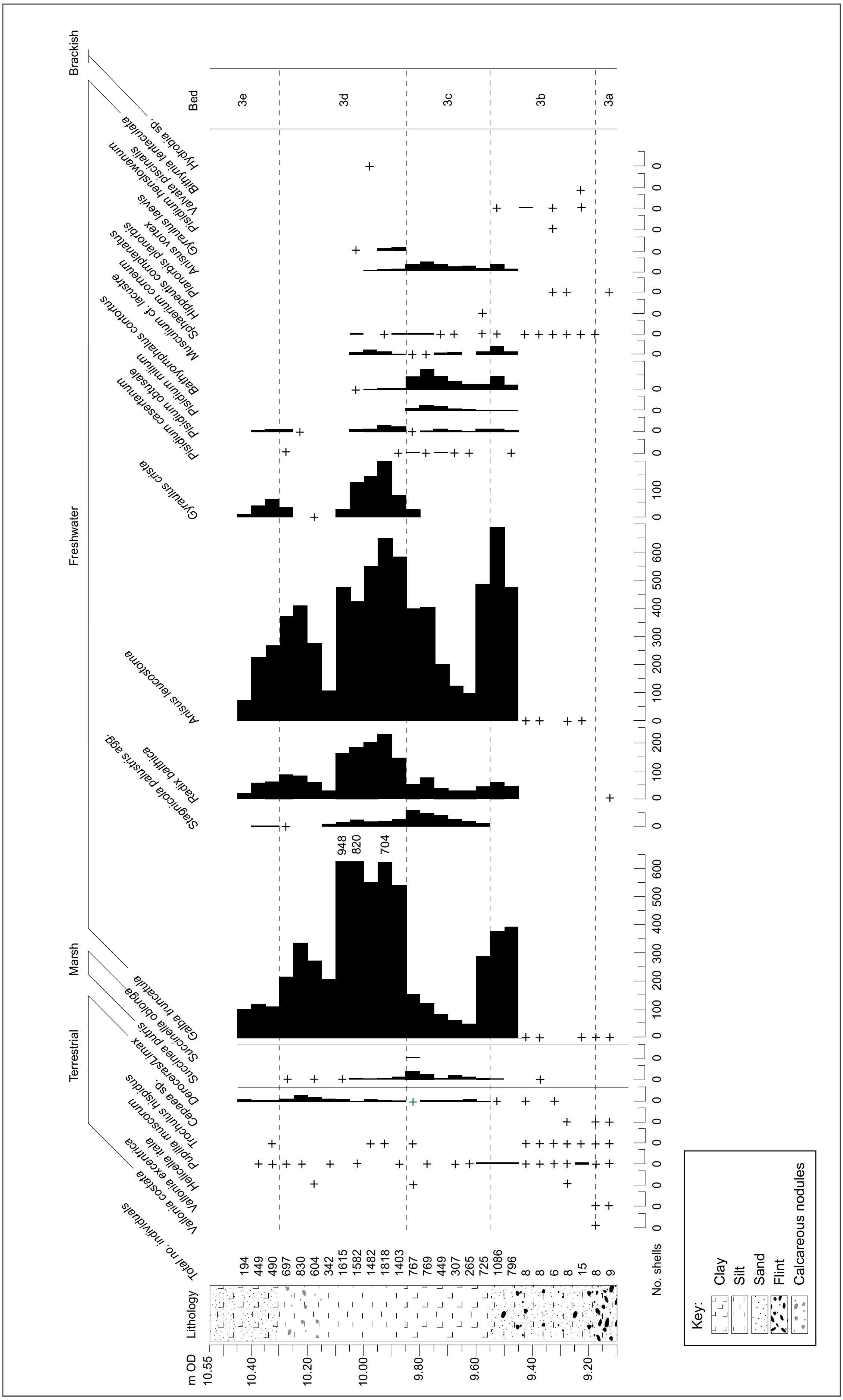


Figure 5.5 Kerney Site A mollusc sequence

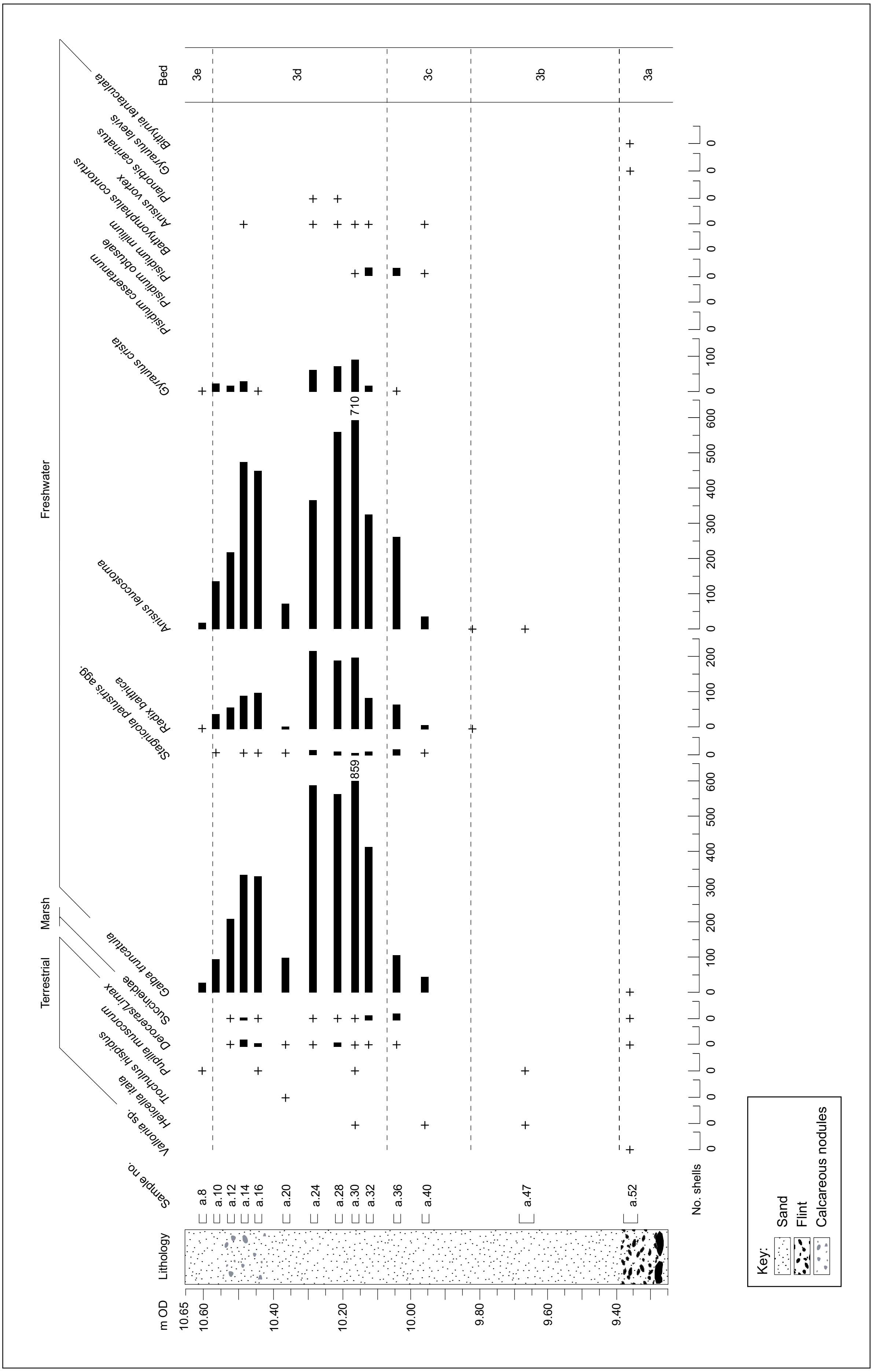


Figure 5.6 Wenban-Smith Site A mollusc sequence, location A.10.a

Table 5.9 Ostracods from Wenban-Smith's test pit A.TP1, Site A

Phase	BMA-C B									BMA-F		
Bed	3b	3c	3d		3e					5a		
microfauna/sample	14	18	11	9	8	7	6	5	4	3	2	1
molluscs	–	x	x	x	x	x	–	–	–	–	–	x
freshwater ostracods	–	x	x	x	x	x	–	–	x	x	x	–
earthworm granules	x	x	–	x	x	–	–	–	–	–	–	–
charophyte oospores	–	–	x	x	–	–	–	–	–	–	–	–
Freshwater ostracod species												
Candona neglecta Sars, 1887	–	xx	xx	xx	xx	xx	–	–	x	–	o	–
Pseudocandona marchica (Hartwig, 1899)	–	xx	xx	xx	x	o	–	–	–	–	o	–
Ilyocypris monstrifica (Norman, 1862)	–	–	–	–	–	o	–	–	–	–	o	–
Herpetocypris sp.	–	–	–	–	–	–	–	–	–	x	–	–
Cyclocypris laevis (O.F. Muller, 1776)	–	–	–	x	–	–	–	–	–	–	–	–
Ilyocypris cf. *lacustris* Kaufmann, 1900	–	x	–	o	–	–	–	–	–	–	–	–

KEY: o – one specimen; x – present (several specimens); xx – common

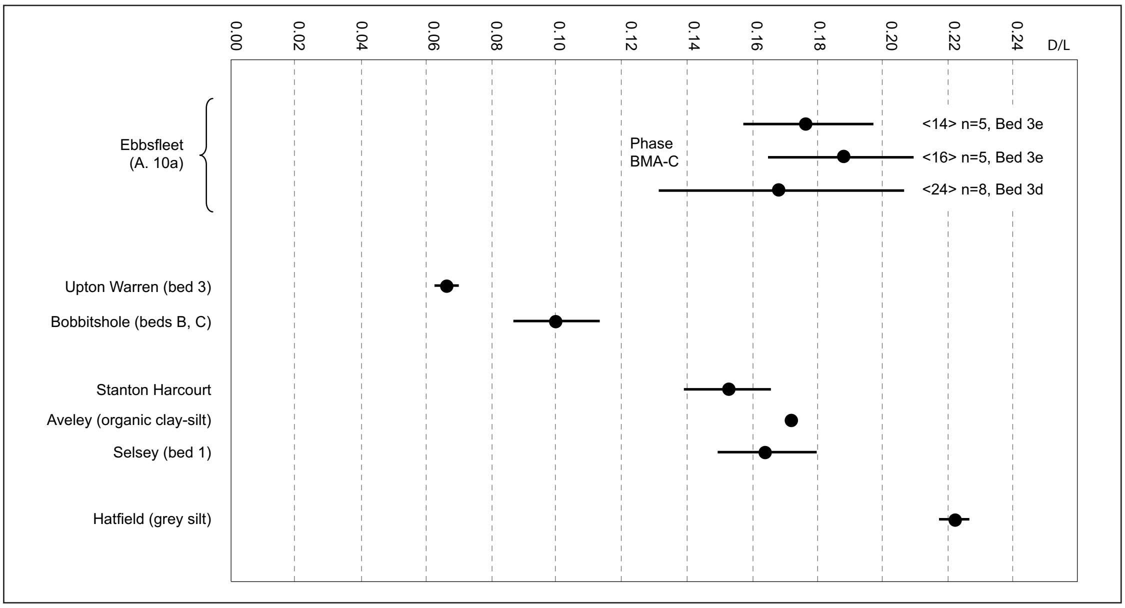


Figure 5.7 Amino acid ratios from *Lymnaea peregra* from test pit A.TP 1 (bed 3d)

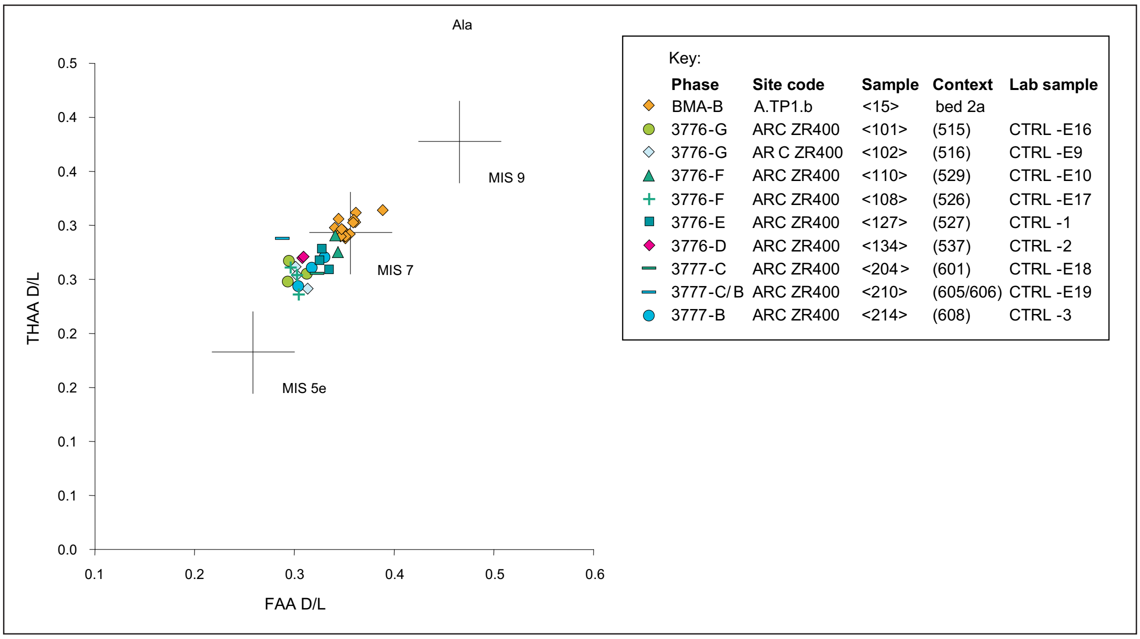


Figure 5.8 Amino acid ratios (Alanine) from *Bithynia* opercula from A.TP 1, 3776TP and 3777TP

Table 5.10 OSL dating results from Wenban-Smith's test pit A.TP2, Site A

Bed	Sample	Depth (m)	De (Gy)	Dose rate (mGy/a)	Lab code	Dating result KBP
5a	EF 1	3.70	230 ±18	1.92 ± 0.11	OxL-1260	120 ± 11
5a	EF 2	4.30	317 ± 11	2.14 ± 0.11	OxL-1261	148 ± 10
3e	EF 3	4.60	325 ± 15	1.87 ± 0.10	OxL-1262	174 ± 12
2a	EF 4	6.20	198 ± 4	1.17 ± 0.06	OxL-1263	169 ± 10
2a	EF 5	6.20	200 ± 6	1.18 ± 0.06	OxL-1264	170 ± 11

Because this can be seen to have the left valve overlapping the right valve, it is *Cyclocypris laevis*, rather than *Cyclocypris ovum*.

Ostracods were only common in phase BMA-C (samples 7 down to 18 inclusive), and these were represented almost entirely by juveniles (of *C. neglecta* and *P. marchica*), or if adults were present, by fragments. This phenomenon may either reflect their life cycles (adults would only be found April–July in the former species, and in June–July and October–November in the latter), but is more likely to be the result of transport or reworking, where the large adults would in these circumstances, be more liable to breakage. Both *C. neglecta* and *P. marchica* live in permanent and temporary small waterbodies in open field or woodland, or in small slow-moving streams. The co-occurrence of *Ilyocypris* spp and *Candona laevis* (which like slow-moving open water, with aquatic vegetation) and of charophytes in sample 9, bed 3d, suggests that this phase had at least (shallow) open water (yet still very near terrestrial habitats, as evidenced by the earthworm granules). Some form of subsequent transport or reworking of these sediments or a very curious annual depositional cycle, it must be remembered, would still be required to account for the curious population structure of the *Candona* and *Pseudocandona* fauna.

Dating

Three different sources of evidence provided dating indications, reviewed below. These mostly indicated an MIS 7 date for the interglacial beds 2 and 3 at the base of the sequence, although a slightly younger date was indicated by the OSL results. Possible explanations for this discrepancy, and which results are most reliable, are discussed further below in the following overview for Site A, and then in the overall synthesis for Zone 1.

Two phases of amino acid dating took place, at two different horizons in test pit A.TP 1. In the first phase, shells of *Lymnaea peregra* from samples 14, 16 and 24, all from the upper half of bed 3d (Fig 5.6) A/I determinations (the ratio of D-alloisoleucine to L-isoleucine) were made in the early 1990s by Professor D Q Bowen and Dr G Sykes, then of University of Wales, Aberystwyth (Wenban-Smith 1996, 243). The resulting ratios (Fig 5.7) gave similar results to several sites thought to date to MIS 7, and were clearly differentiated from MIS 5e sites such as Bobbitshole (Bowen *et al* 1989). A second phase of amino acid work was carried out in 2008, by Dr K Penkman (University of York) using a new protocol that has been shown to produce consistently reliable results (Penkman, Appendix E). Separate determinations were carried out on eight *Bithynia* opercula from bed 2a (sample 15) from the 1994 work at location A.TP 1.b (Table 5.2). The results (Fig 5.8) clearly show the material from bed 2a as closely matching the independently dated MIS 7 reference material from Aveley (which of two main MIS 7 horizons is unrecorded), Ilford (Uphall pit) and Lion Pit (Bed 3 brickearth, temperate freshwater) (Schreve *et al* 2006; Penkman *et al* 2008).

An early phase of TL dating was carried out at Site A by H Rendell in the late 1980s – "Site 1, Northfleet" in her nomenclature. Although there is no precise record of the sampled locations, it appears from the published data (Parks and Rendell 1992) that sample NF1 corresponded with Wenban-Smith's bed 5c, sample NF2/3 with bed 5b and sample NF4 with bed 5a (Fig 5.3). The results of this work corresponded with the stratigraphic order of the samples and, based on the more reliable "Additive Dose" protocol, gave a date of between *c* 180,000 and 160,000 BP for this part of the sequence, indicating a pre-Ipswichian age for the underlying interglacial sediments. A second phase of OSL dating was then carried out at the site in 1995 by Dr E Rhodes (then of University of Oxford), at Wenban-Smith's test pit A.TP 2, which was opened for the Quaternary Research Association's spring field meeting in the Lower Thames region (Wenban-Smith 1995). This time, work was focused on the lower part of the sequence – beds 2a, 3e and 5a (Fig 5.3) – with dating samples supported by *in situ* gamma-ray dosimetry readings. The results (Table 5.10) suggested a similar date of approximately 170,000 BP for both beds 2 and 3, and then a younger date in the range *c* 120,000 to 150,000 BP for the immediately overlying bed 5a.

Biostratigraphically, there are a number of indicators from the vertebrate mammalian fauna that suggest a MIS 7 date for the interglacial beds 2 and 3 (phases BMA-B and BMA-C). The large vertebrate faunal assemblage of bed 3, dominated by mammoth (*Mammuthus*), horse (*Equus ferus*) and a large form of red deer (*Cervus elaphus*), is a typical *Mammuthus-Equus* fauna suggested by Green *et al* (1984) and Currant (1989) as characteristic of MIS 7. The mammoth teeth, including those described by Carreck (1972, 113–116)

Table 5.11 Site A synthesis

Phase	Bed (W-S 1995)	Depositional environment	Climate	Local environment	Dating (MIS) AAR	OSL	Biostrat.
BMA-G	5d	Colluvial slopewash, with some aeolian input	–	–	–	–	–
BMA-F	5c	Colluvial slopewash, with some aeolian input	–	–	–	6	–
	5b	Colluvial slopewash; wavy sand/silt bedding at base suggests poss. water flow	–	–	–	>5e	–
	5a	Colluvial slopewash; wavy sand/silt bedding suggests poss. water flow	?	Ostracods suggest small waterbodies, permanent or temporary	–	6–5e	–
BMA-C	3e	Marshland, gen. drier than lower deposits (little info)	Temperate, perhaps cooling	Drying marshland	–	6	–
	3d	Fluvial, transition to swampy marshland	Temperate, perhaps cooling	Marshland and alluvial floodplain with expanding grassland	7	–	7
	3c	Fluvial, low energy	Temperate	Swampy marshland and alluvial floodplain with grassland, no evidence of woodland	–	–	7
	3b 3a	Alluvial floodplain with periodic flooding	–	–	–	–	–
BMA-B	2c	Drier, poss. colluvial/loessic or alluvial	–	–	–	–	–
	2b	Fluvial, mod. high energy	Temperate, few data	Woodland/grassland? Few data	–	–	–
	2a	Fluvial, mod. high energy	Warm temperate, peak interglacial	Mosaic marsh and grassland with scrub and woodland patches	7	6	7
BMA-A	1	Solifluction on chalk valley-slope	Cold, periglacial conditions, poss. associated with warming at end of cold phase	Open grassland, steppe	–	–	–

and the milk tooth from Wenban-Smith's test pit A.TP 1, show annulations on the occlusal surface typical of the small "Ilford-type" mammoth thought to characterise MIS 7 (*cf* Parfitt *et al*, Appendix C1). Finally, the northern vole (*Microtus oeconomus*) assemblage from bed 2, although of small size, shows typical features of the distinctive form of the species associated with MIS 7 (*cf* Parfitt *et al*, Appendix C1).

Site A Overview

The sedimentary sequence and associated landscape development represented at Site A are summarised (Table 5.11). The evidence documents conditions spanning one cold/temperate climate cycle and possibly more. Sediment accumulation begins with deposition of a chalky diamict ascribed to BMA-A or bed 1 (*cf* Table 5.2). These deposits are devoid of faunal remains except for a complete left humerus of a woolly rhinoceros (*Coelodonta antiquitatis*). The deposit is certainly of cold climate origin and probably represents solifluction activity on the valley edge/at the base of the valley side in which pieces of faunal material have become incorporated, probably broadly coeval with sediment deposition.

Overlying the basal cold stage deposits are a sequence of sediments that generally get finer upwards from sandy flint gravels to clay-silts that are olive grey in places. This sequence – BMA-B (units 2a–2c) and BMA-C (units 3a–3e) – contains a wide range of faunal remains that track changing depositional environments as well as local habitats. Vertebrates found in association with the basal part of the sequence (BMA-B) indicate aquatic environments with a diverse fish fauna, but a trend towards swampier conditions towards the top of this unit may be indicated by the dramatic decrease in fish and amphibian remains in the upper part of the lithofacies. The grain-size changes in this sequence (2a–2c) also indicate a shift from higher energy fluvial conditions to lower energy environments associated with clay-silt deposition. The presence of intense manganese and iron staining and occasional carbonate concretions in this part of the sequence may also attest to changes in ground water conditions and possible periodic drying through this part of the sequence. Terrestrial habitats must have included areas of damp grassland or marsh, drier grassland together with areas of denser vegetation that may have included scrub or even woodland. The presence of white-toothed shrews (*Crocidura* sp.) indicate interglacial conditions with a climate as warm as, or warmer than, the present day (see Tosh *et al* 2008). Bank vole (*Clethrionomys glareolus*) is also a common British interglacial indicator. There may be a hiatus at the top of this phase of deposition, represented by the co-occurrence (in bed 2c) of large flint nodules and flint gravel in a fine speckled clayey silt matrix.

The basal part of BMA-C consists of a brownish-yellow silt (3a) from which occasional molluscs were recovered, including terrestrial species and some aquatics. This assemblage, although sparse, appears to document a floodplain surface into which occasional flooding carried aquatic molluscs. The overlying sediments forming the middle/upper part of BMA-C (3b–3d) consist of sandy silts probably deposited under aquatic conditions, although becoming marshier and without a permanent waterbody above the upper part of 3d. Molluscs through 3b and 3c are indicative of well oxygenated waters surrounded by slow or stagnant water developed in pools. Similar environments are inferred from the ostracods where terrestrial habitats are indicated close by. The abundance of stickleback indicate deposition in an aquatic environment but the scarcity of other fish taxa suggests that this environment was also one of shallow pools that were prone to drying-out. Small mammal remains are sparse with water vole (*Arvicola* sp.) and northern vole (*Microtus oeconomus*) suggestive of damp or waterlogged grassland. Extensive grassland would also have favoured the large mammal taxa. All evidence of scrub or woodland has disappeared. Finally, the upper parts of this sequence (3d/3e) contain molluscs favouring swampy aquatic and stagnant water conditions suggesting drying of the environment was protracted through this phase with the emergence of smaller bodies of water and temporary pools. Charophyte oogonia have also been recovered from 3d, suggesting aquatic conditions.

OSL and TL dating (see dating, above) suggests that the upper part of the sequence may span the period MIS 6–5e, with the peak interglacial sediments at the base of the sequence pre-dating the Last Interglacial MIS 5e. It is perhaps worthy of note that the age estimates for the base of BMA-B and top of BMA-C are statistically identical and may suggest (irrespective of the actual age of the sequence) that both bodies of sediment accumulated rather rapidly. These results are contradicted by those from amino acid geochronology, which suggest an earlier MIS 7 date for both Phase BMA-B (bed 2a) and BMA-C (bed 3d). Likewise, the biostratigraphic indicators also indicate an MIS 7 date for both these beds. Considering the coherence and reproducibility of the AAR and biostratigraphic indicators (Penkman, Appendix E; Parfitt *et al*, Appendix C1), we are confident here in attributing Phases BMA-B and BMA to MIS 7, with the implication that the OSL results must, for some reason, be giving a misleadingly young date.

Sediments of units BMA-F and BMA-G are probably primarily slope-wash sequences formed by downslope movement of sediment from the west. The only faunal material recovered from these sediments is a sparse ostracod assemblage from the base of bed 5a that appears to indicate temporary pools. No indication of contemporary climate can be derived either from the ostracod fauna from the base of the sequence or the sediments above, but deposition under either cool temperate or cold climate conditions is likely.

The sequence appears to document changes from cold climate conditions, possibly at the end of a glacial, through parts of a subsequent interglacial, with a peak of warm, more wooded conditions gradually giving way to widening expanses of surrounding grassland; it is unclear, however, whether this shift is associated with climatic cooling, or just evolution of the landscape. Aquatic environments dominate through most of the accumulation of the interglacial sediments, probably part of the floodplain of the river although temporary emergence and drying of the environments has been inferred in places, perhaps in response to lateral changes in channel position. The interglacial sequence is buried by slope-wash sediments (phase BMA-F), which probably reflect climatic cooling. TL and OSL dates from phase BMA-F suggest at least an MIS 6 date for this part of the sequence. The uppermost part of the sequence (phase BMA-G) has no data upon which to base a dating or climatic interpretation, although the presence further downslope to the east (in 2018TP, ARC EFT97) of Neolithic pottery and worked flint *c* 3.00m below the surface in a possibly equivalent deposit suggests this uppermost part of the sequence may be considerably younger, and date to the Holocene era (Chap 21; URL 1997a, 31).

3776TP (ARC ZR498/00)

by Francis Wenban-Smith, Martin Bates, Adrian M Lister, Richard I Macphail, Simon A Parfitt, Kirsty Penkman, Richard Preece, Ed Rhodes, Jean-Luc Schwenninger, John R Stewart and John E Whittaker

Introduction

Construction of HS1 through the Ebbsfleet Valley required relocation of the National Grid Company pylon ZR4 to a new position within the Baker's Hole SSSI and Scheduled Ancient Monument (SAM) Kent 267a. The new pylon required the excavation of four 4 x 4m footing foundation holes, two of them 4.5m deep (uplift footings), and two of them 1.8m deep (compression footings). These holes were positioned in a square separated by approximately 15m diagonally and 10m between the faces of adjacent holes (Fig 5.9). The sediments present were first investigated during the evaluation in 1998 when four test pits were excavated (3421–3424TP), each covering half the footprint of each of the four pylon footings.

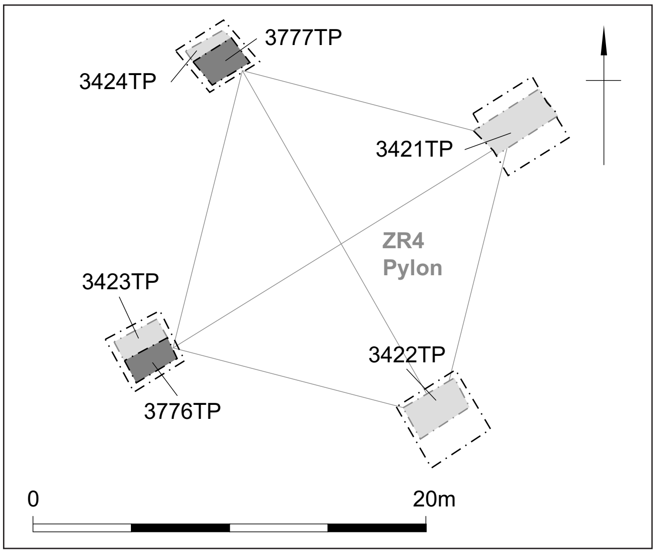


Figure 5.9 ZR4 site layout

Plate 5.1 3776TP, excavation shoring

Significant deposits rich in biological evidence, mostly fluvial clays and silts, were identified in the two deeper uplift footing test pits 3423TP and 3424TP, and particularly in 3423TP. The main significance of these deposits was their abundant micro-biological evidence, including fish, amphibians, reptiles and small mammals, although certain sedimentary units also contained larger mammalian remains. Therefore, a mitigating programme was agreed which involved more detailed excavation and sampling of these deposits, followed by a watching brief during construction of the new pylon ZR4. Sediments remaining within the deeper uplift footing footprint associated with 3423TP were excavated as 3776TP; and sediments in the other uplift footing footprint, associated with 3424TP, were excavated as 3777TP (see below). Work was carried out between April and June 2000, under the project code ARC ZR400. These sequences lie within the middle of the SAM Kent 267a, *c* 100m to the north of Site A (see above) and attitudinally lower by *c* 5m. The sequence at 3423/3776TP is slightly upslope of the sequence recorded in 3424/3777TP.

Excavation techniques differed between the evaluation and mitigation stages. During evaluation, the test pit was dug to the proposed depth of disturbance, and trench box shoring was used to allow access to the floor and ends of the excavation. During the mitigation phase, the trench was excavated by mechanical excavator down to the surface of the significant Pleistocene deposits and steel trench-sheet shoring put

Table 5.12 Lithological succession, 3776TP

Phase	Context	Sample	Original sample size (litres)	Small Vertebrates	Molluscs	Ostracods	Amino acid samples
3776-H	501–524	–	–	–	–	0	–
	534	114	50	✓	–	0	–
3776-G	515	101	20	✓	✓	0	✓E16
		116	10	✓	–	–	–
	516	102	50	–	✓	0	✓E9
		160	150	✓	–	–	–
	519	104	40	✓	✓	0	–
3776-F	522	118	30	–	–	–	–
	523	119	40	–	–	✓	–
	520	124	30	0	–	✓	–
		120	20	0	–	✓	–
	530/521	121	20	0	–	✓	–
	525	107	100	0	0	0	–
		111	100	0	–	0	–
		112	100	✓	✓	0	–
		109	100	✓	–	0	–
	529	110	10	✓	✓	–	✓E10
	526	108	250	✓	✓	–	✓E17
3776-E	527	126	100	✓	✓	0	–
		127	100	✓	✓	✓	✓1
3776-D	528	129	150	✓	✓	0	–
		132	50	✓	✓	0	–
		130	150	✓	✓	0	–
		131	150	✓	✓	0	–
	537	134	40	✓	✓	✓	✓2
3776-C	536	133	100	✓	✓	–	–
3776-B	538	139	–	–	–	0	–
	539	140	–	–	–	0	–
3776-A	540	141	–	–	–	0	–

Note: contexts and samples in stratigraphic order, from base
KEY: (✓) Present and analysed; (0) Absent; (–) Not investigated or present in insignificant quantities

in place, supported by an internal frame of hydraulic braces (Pl 5.1). Hand-excavation then proceeded through the significant deposits with trench sheets progressively lowered as excavation proceeded.

A vertical series of hand-excavated bulk samples were taken through the significant Pleistocene deposits in *c* 0.10m spits, following the slope of the stratigraphic layering and taking care not to cross stratigraphic boundaries for sedimentary units less than 0.10m thick. Samples of at least 100 litres were taken from each spit where there was sufficient sediment – smaller samples were unavoidable from thin sedimentary units – and larger samples of up to 250 litres were taken from spits within the sediments identified in the evaluation as being particularly rich in environmental evidence. Sub-samples of *c* 2 litres from each bulk sample were set aside for molluscan analysis. The prime purpose of the bulk samples was to sub-sample them for molluscan evidence and then to sieve them for the recovery of the small vertebrate evidence whose abundance was determined at the evaluation stage. Sub-samples of each bulk sample were, however, also taken for pollen, insect and ostracod analysis (URN 2000a). When the full depth of hand excavation was reached at the base of the footing foundations impact, a hand auger was used to investigate the underlying sedimentary sequence and to recover samples from it.

Lithological Succession

The lithology recorded in the mitigation excavation lies between elevations of *c* 6m and 11m OD. Pleistocene deposits were not bottomed due to the presence of a dense flint gravel at the base of the recorded sequence, which could not be penetrated by hand-augering. A log of the full sequence is shown (Fig 5.10), with phasing (described below) and also showing amino acid dated horizons (see dating, below). A drawing of the key part of the sequence is given, showing both the north-facing side and east-facing end of the trench (Fig 5.11), showing key locations for sampling. The sequence is described below, and summarised in Table 5.12, which also shows the association of key environmental samples with specific horizons. The sequence of deposits can be subdivided into, from the base, eight major groups of sediments:

3776-A: Brown sandy flint gravel (context 540) lying below 5.91m OD. This was encountered in the borehole augered below the trench base.

3776-B: Sands fining upwards to a silty sand, including contexts 538 and 539.

3776-C: Light grey silty fine sand (context 536).

3776-D: A group of two contexts, consisting of clay-silts and sandy-silts exhibiting sub-horizontal laminations, and laterally varying from pinkish silt (537) to dark brown clay (528).

3776-E: A grey clay silt (context 527). This context is the uppermost of the context groups from 3776-B to 3776-E, all with broadly sub-horizontal geometry (Fig 5.10), and which exhibit a broad fining upwards trend culminating in the silty clay of 528 and the clay-silt of context 527. The sediments also contain a rich array of faunal remains (see below).

3776-F: This group consists of a series of coarser, sand-dominated contexts (520, 521, 522, 523, 525, 526,

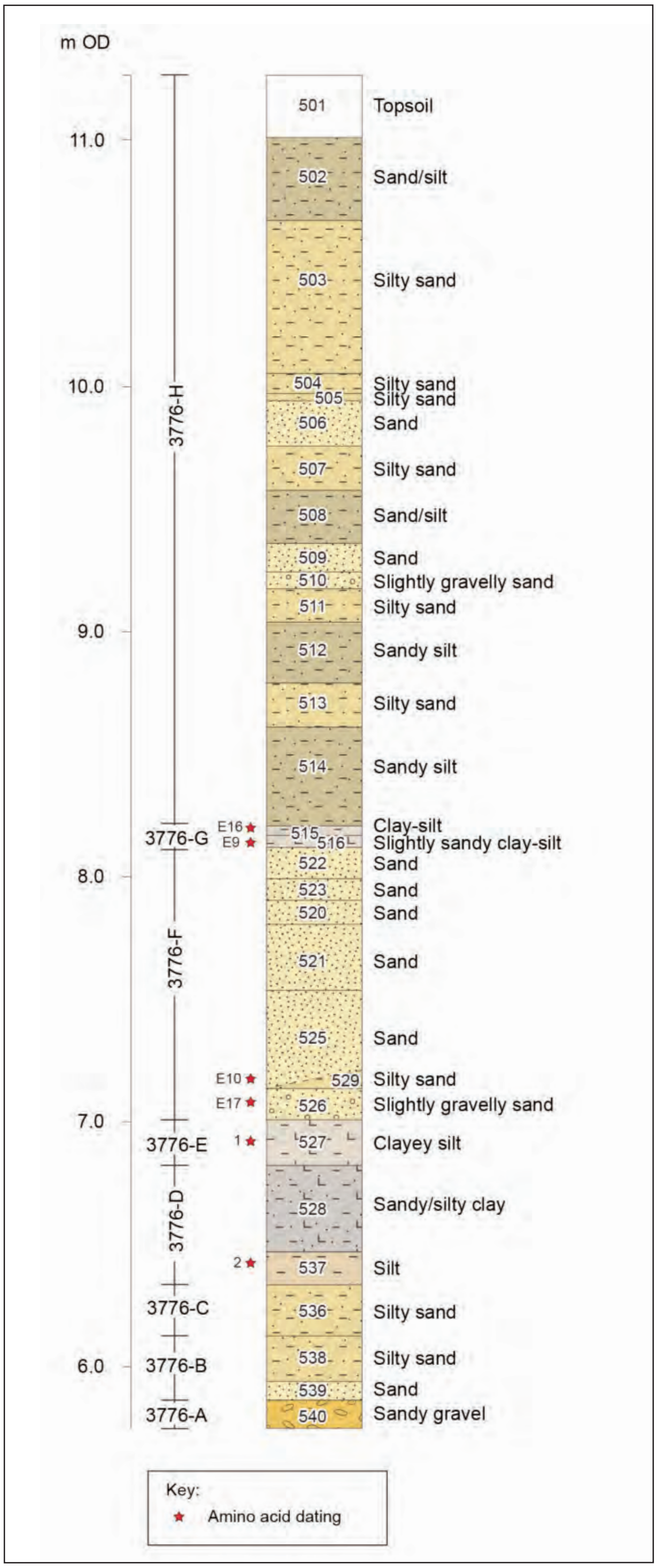


Figure 5.10 3776TP: log of full sequence, showing contexts, phasing and sample locations

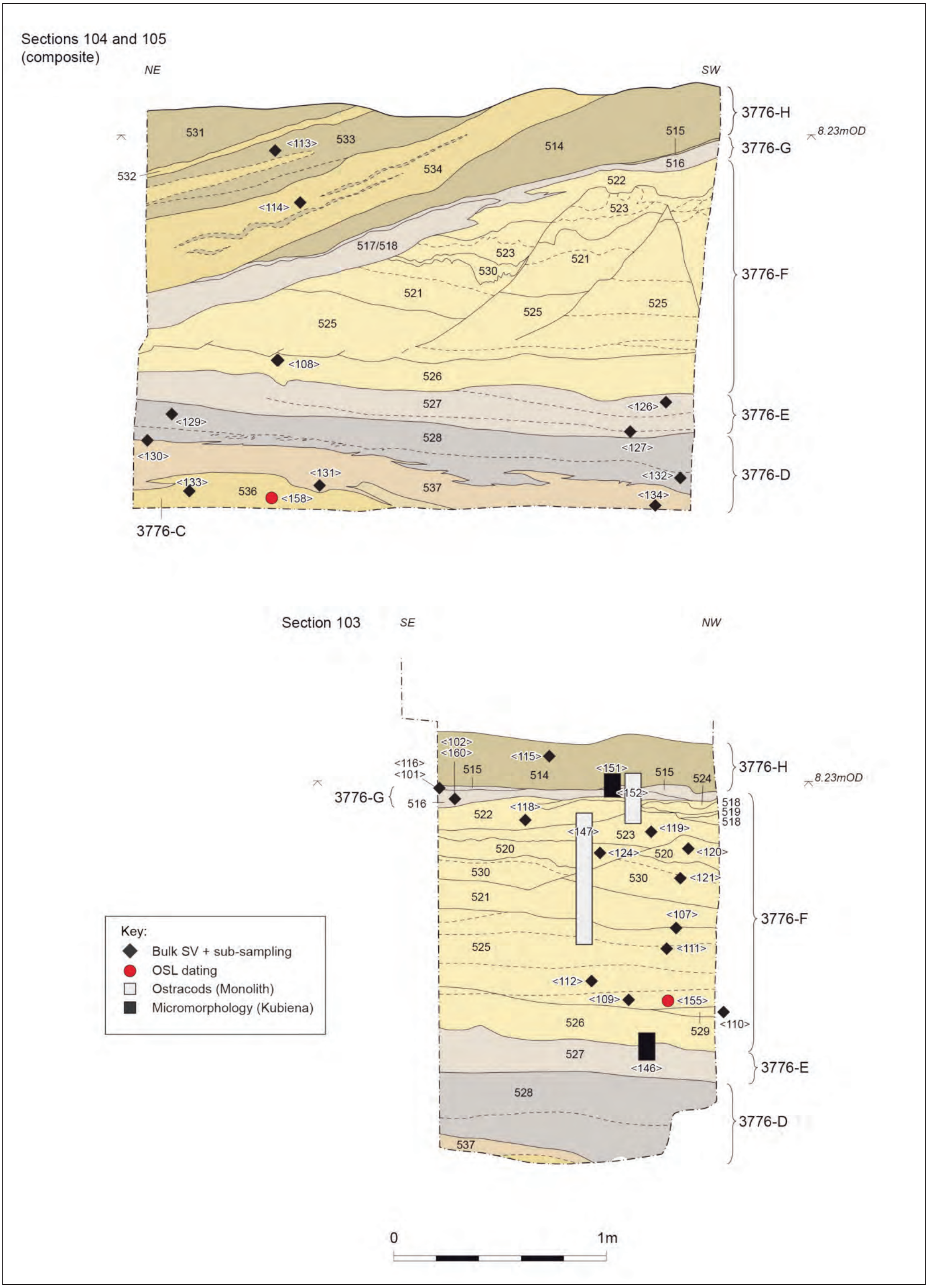


Figure 5.11 3776TP: faulted sands (contexts 521, 522 and 525)

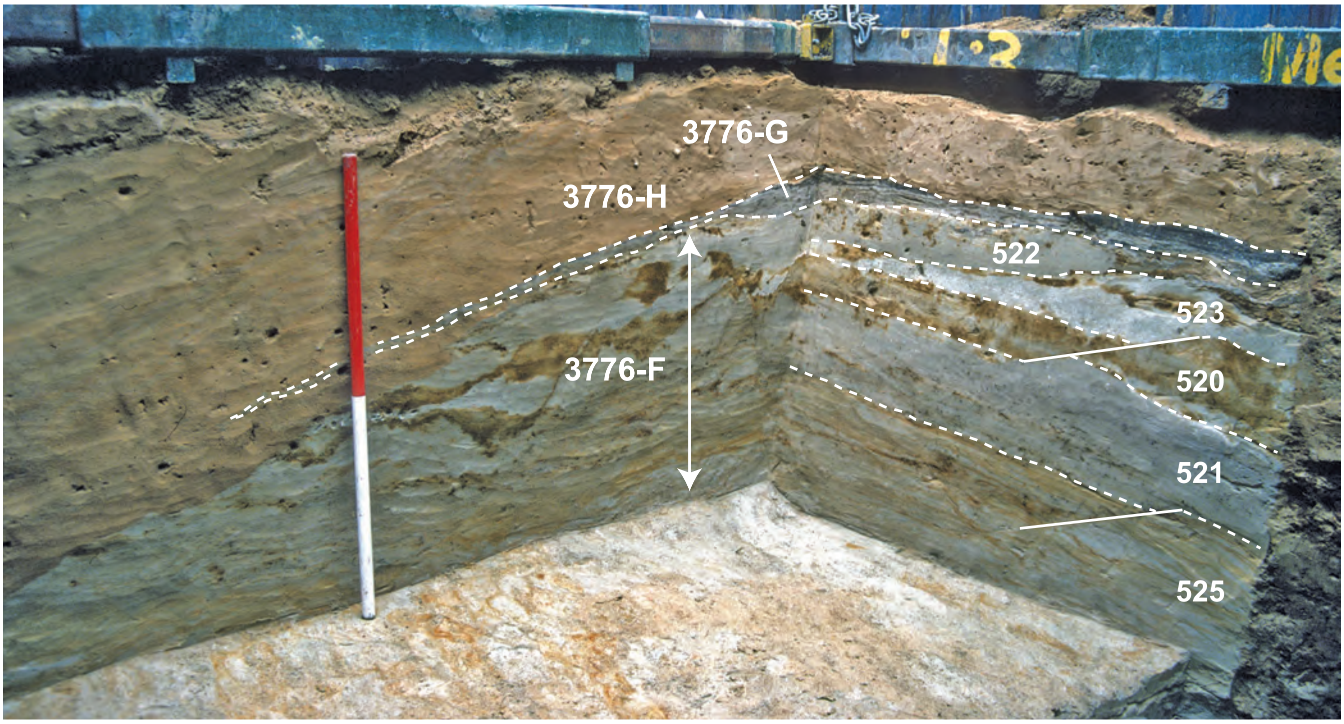


Plate 5.2 3776TP, faulted sands (contexts 521, 522 and 525)

529 and 530). A sudden return to the accretion of coarser sediments occurs at 7.06m with a gravelly sand (526) becoming finer sands upwards to 8.17m OD (525 to 522). This sequence remains broadly sub-horizontally bedded but normal faulting characterises these sediments (Fig 5.11; Pl 5.2). The upper part of this unit contains complex microfaulting where normal faults with throws of up to 50mm are noted in places. Iron tubes, nodules, and precipitates (often goethite) are also found in parts of the sequence (in contexts 522, 520, 521 and 525) and these may be associated with weathering or near-surface groundwaters or pedogenic activity.

3776-G: This group marks a return to finer-grained sedimentary deposition, represented by the clay-silt complex of contexts 515 and 516. The latter is a pliable pale olive clay-silt occurring stratigraphically lower, and the former is a dark grey well-compacted clay-silt, possibly a hardened capping of 516 rather than a distinct sedimentary bed. The two beds forming this group occur only between 8.17m and 8.23m OD in the logged sequence at the western end of 3776TP. They appear to be dipping downslope conformably with the overlying deposit group (3776-H) at the eastern end of the drawn longer section (Fig 5.11) and unconformably truncating the underlying group 3776-F. However, this may be a misleading impression resulting from erosion of the underlying sediments leading to their conflation and faulting. It was clear from observations made during the evaluation and watching brief that deposits of group 3776-G thickened further to the west of the illustrated sections, with their base broadly horizontal but their surface rising. In this part of the sequence, they appeared broadly conformable with the underlying sand-rich sediments of group 3776-F, but unconformably truncated by the overlying group of sediments (3776-H, *cf* below).

3776-H: A group of predominantly sand/silt sediments, all exhibiting a strong downslope dip broadly parallel with the present ground surface, and with well-developed pebble trails both within beds and at junctions between beds (contexts 502, 503, 504, 505, 506, 507, 508, 509, 510, 511, 512, 513 and 514). The base of this group of deposits is at *c* 8.20m OD at the west end of the trench, although they then dip eastward, and marked by a silt containing angular flint clasts as well as rounded chalk pellets. Throughout the group sediment beds are characterised by intermittent laminations with broadly parallel dipping laminae. Occasional flint clasts occur throughout the sequence. The upper boundary of this group of sediments occurs at *c* 11m OD, where they are capped by present day topsoil (501). White carbonate precipitate is patchily developed as infilled networks of tubular concretions throughout this sequence of deposits. The deposits contain many modern roots, more common in their upper levels, as well as root voids infilled with topsoil and subsoil, as well as white precipitate material.

The sediments present in the excavated area form a relatively coherent picture of a developing fluvial sequence in which sedimentation in a high-energy river system (3776-A) gives way up-profile to lower energy deposition in a floodplain situation (3776-B to 3776-G). The basal gravel unit (540) although not penetrated and recorded is typical of a high-energy system that appears to give way to finer grained sedimentation upwards. These overlying sediments (539–515) appear to be associated with low-energy fluvial sedimentation in floodplain situations. Two cycles of sedimentation (3776-B to 3776-E, and subsequently 3776-F to 3777-G) appear to be represented within this sequence (539–527 and 526–515) exhibiting fining upwards trends to clay-silt units. These cycles may be of local significance only. The presence of iron tubules, nodules and precipitates in certain horizons indicates fluctuating groundwater table and periodic drying-out of the sequence.

A major change in sediment type and sequence geometry is noted at the lower boundary of group 3776-H, which unconformably truncates the sub-horizontally bedded underlying sediment groups. This boundary exhibits a shift towards the deposition of sands/silts with fine laminations dipping downslope. Coupled with this is the presence of small flint fragments (often angular) and rolled chalk pellets. These deposits appear to be indicative of slope depositional processes. Microfaulting at the top of the underlying sequence does not appear to extend into the colluvial sequences of 3776-H and therefore suggests that faulting occurred during the interval between the depositions of 3776-G and 3776-H. The development of this feature may have occurred during downcutting and erosion transforming a valley floor into a valley-side situation. The uppermost sequence of silts and sands (503–502) are also slope deposits and may be relatively recent (Holocene) in age, although the precise location within group 3776-H of a Pleistocene/Holocene junction is very uncertain.

Sediment Micromorphology

Sediment micromorphological investigation was undertaken on slides prepared from two monoliths from this trench. Contexts 526 and 527 were analysed from sample M146; contexts 514 and 516 were analysed from M151 (Macphail, Appendix B). These are discussed in turn below, progressing upwards through the sequence.

Context 527 (3776-E, top): This is a fine to medium silt to very fine calcareous sand exhibiting parallel laminations. The deposit contains a few rounded clay clasts and an example of (probable) local (non-rounded) coprolitic bone. Trace amounts of humic staining and iron staining are present. This unit is interpreted as exhibiting features consistent with deposition in alluvial situations and possible weathering associated with incipient soil formation.

Context 526 (3776-F, base): This is a partially disturbed laminated fine to medium weakly calcareous sand with some well-sorted coarse silt (as in 527 below). Also present are coarse inclusions of gravel size flint, chalk and coprolitic (scat) bone (Pl 5.3b–d), and sub-rounded fragments of micrite impregnated sediment, which sometimes show root traces (Pl 5.3a). This unit was probably deposited under alluvial conditions where relatively higher-energy fine sands were introduced that included eroded, weathered and rooted soil formed in context 527-like material, along with coarse chalk, flint and bone.

There is a possible erosional hiatus between contexts 526 and 527, suggested by the presence of eroded fragments previously rooted and with $CaCO_3$ impregnated 527-like sediment (Pl 5.3a).

Context 516 (3776-G, top): This is composed of massive very fine and fine quartz sands, with a non-calcareous or poorly calcareous fine fabric, and evidence of fine rooting and a weakly prismatic structure. Major secondary micritic calcite impregnation including root pseudomorphs, and major iron and possible iron and manganese impregnation/staining of biologically worked microfabric, are all visible (Pl 5.3e). This is interpreted as an alluvial sediment, which became biologically homogenized and weathered (decalcified) as a result of plant growth on a vegetated surface (subsequently eroded). Later, a rise in base level ground water and a fluctuating water table resulted in iron and iron and manganese impregnation.

Context 514 (3776-H, base): This is composed of finely laminated, moderately sorted calcareous coarse silt and fine and medium sand, with abundant shell fragments up to 4mm in size. Some shell fragments include occasional (probably humus-stained) snail shell fragments an example of a 1mm size soil clast was also noted. Laminae sometimes occur as fine calcareous pans, and some laminae are weakly iron-stained because of the relative concentrations of replaced fine amorphous organic matter that are present (Pl 5.3f). This context appears to be the result of a colluvial flow. Fine calcareous sediment of the coarse silt to medium sand size deposit also appears to have washed into the underlying context 516. The contained mollusc shell (some humus stained), humic soil clasts and micropans along with laminae with concentrations of iron-replaced organic matter, all indicate erosion of humic topsoils from upslope including perhaps their surface organic matter (pararendzinas/humic cryosols; *cf* Duchaufour 1982, 184). This sediment was subsequently affected by post-depositional rooting, structure formation and secondary calcium carbonate impregnation.

Vertebrates

Excavation of the trench for 3776TP ceased at about 5m below the surface. At this depth, the base of the fossiliferous deposits had not yet been reached. The richest concentrations of bones were encountered at the base of the sequence, in deposits thought to represent predominantly fluvial deposition (phases 3776-C through to the basal parts of 3776-F). A rich assemblage was also recovered from phase 3776-G, at the top of the fluvial sequence. The bottom layer of the overlying colluvial sediments, phase 3776-H (context 534, sample 114), yielded sparse small vertebrate material, albeit probably reworked. The vertebrate assemblage from 3776TP is notable for the exceptional abundance of

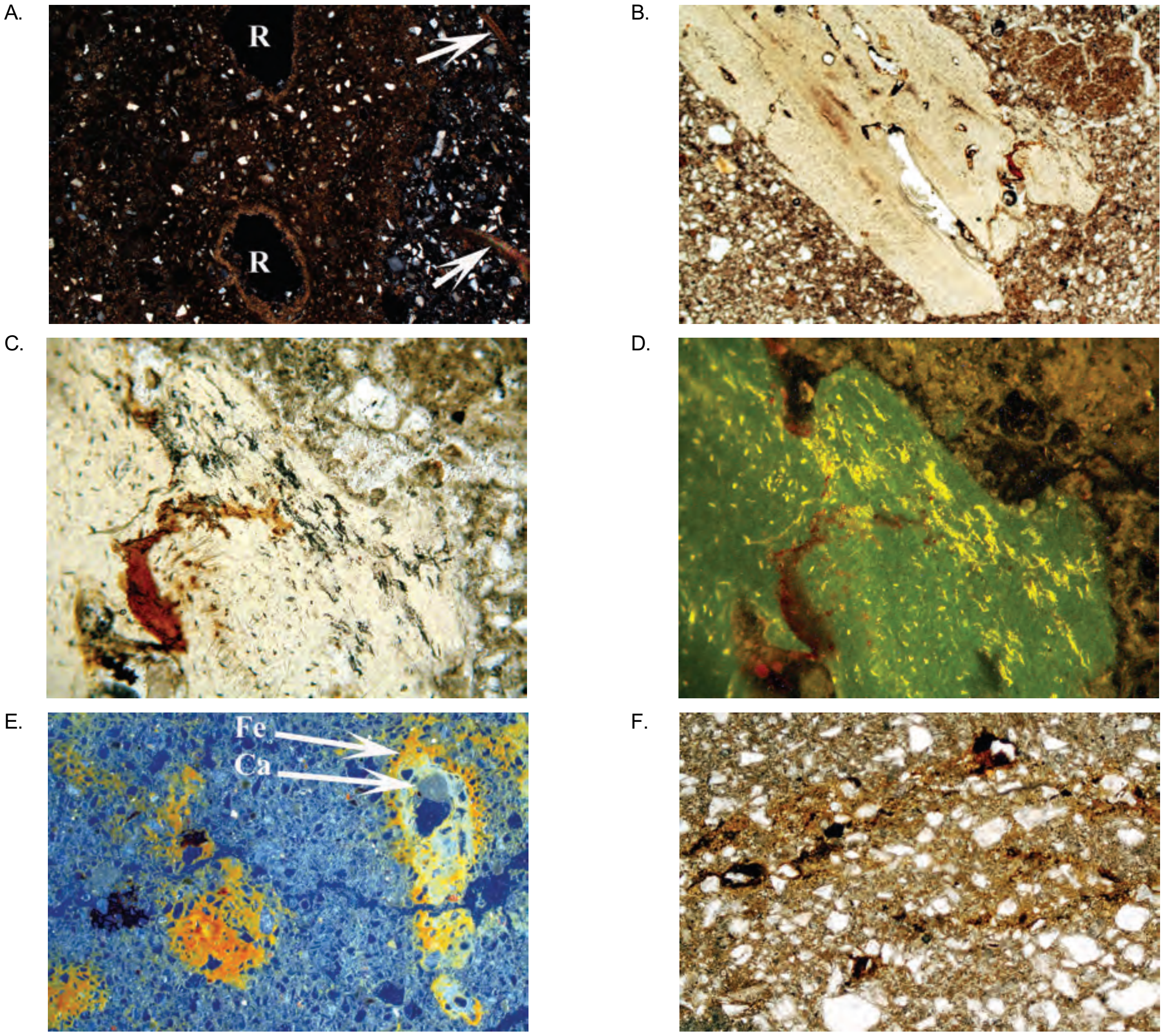


Plate 5.3 Micromorphology photographs from sediments analysed from 3776TP (ARC ZR400) in Zone 1 (selected from Appendix B, see Fig B1, 25–30 for details)

small vertebrate remains totalling 23,684 identifiable fragments; in contrast, only 12 identified large mammal specimens were recovered (see Table 5.17). The small vertebrate assemblage includes, fish, amphibians, reptiles, birds as well as small mammals.

The exceptional faunal richness of the site was identified during evaluation in 1998 and subsequent large-scale sampling was undertaken in 2000. Most of the small vertebrate bones were extracted from bulk samples sieved off-site. In all, 76 samples were processed specifically for small vertebrate analysis, totalling 1852 litres (Table 5.13). These samples were wet-sieved through a 0.5mm mesh and the residues were then sorted with the aid of a binocular microscope. The first batch of samples collected in 1998 was coarsely picked for larger identifiable remains to assess the potential of the site. Residues from the second phase of excavation in 2000 were sorted more carefully and every fragment of identifiable small vertebrate bone larger than 1mm was kept. In addition to samples taken specifically for vertebrate analysis, small mammal remains were also picked from samples processed for molluscan analysis. Direct comparison of these sets of samples should, therefore, be made with caution. Bone counts derived from the different batches of samples have been tabulated separately below, and analysis of skeletal element representation and taxonomic composition has been undertaken only on the material from samples collected in 2000.

The quantitative distribution of amphibian, fish, small mammal remains through the succession is given (Fig 5.12; Table 5.13), with a list of identifications showing taxa present in each context (Table 5.14) and a breakdown by sample for small mammals (Table 5.15). The results of the taxonomic analysis of the small mammals are summarised in Figure 5.13. In this diagram, the results are presented in histogram form in terms of absolute abundance because of the generally low totals throughout the sequence. Details of the small mammal taphonomy are also summarised (Table 5.16; see Appendix C2 for details). Vertebrate remains occur in variable amounts in all of the five stratigraphical phases for which bulk sampling was carried out (3776-C to 3776-G); deposits from lower-lying phases were investigated by hand auger, and no faunal remains were noted in the tiny resulting samples.

Table 5.13 Small vertebrate groups by sample from 3776TP

Phase	3776-C				3776-D														3776-E		
Context	536	536	536	536	537	537	537	528	528	528	528	528	528	528	528	528	528	528 [=314]	527	527	527
Sample	133	133	133	133	134	134	134	131	131	131	132	132	130	130	129	129	129	8	127	127	127
Sorting	4	2	2	3	4	2	3	4	2	3	3	2	2	3	4	2	3	1	4	2	3
No. of samples (volume in L.)	1 (5)	1 (20)	1 (20)	1 (75)	1 (5)	1 (10)	1 (25)	1 (2)	1 (20)	1 (128)	1 (40)	1 (10)	1 (20)	1 (130)	1 (2)	1 (20)	1 (128)	1 (9)	1 (5)	1 (20)	1 (75)
Fish	8 (6)	9 (3)	25 (7)	224 (31)	25	3 (1)	168 (3)	7 (1)	93 (14)	854 (136)	1003 (40)	24 (2)	27 (5)	1990 (111)	9 (2)	6 (4)	444 (37)	–	5 (12)	13 (15)	13 (85)
Amphibian	32 (4)	46 (4)	87 (7)	285 (30)	58 (9)	45 (4)	383 (16)	28 (1)	199 (4)	2152 (90)	847 (11)	49 (2)	77 (1)	2601 (55)	25	76	790 (6)	22	–	65	104
Reptile	–	–	–	–	–	–	–	–	–	10	–	–	–	5	–	–	3	–	–	–	–
Bird	–	1	–	–	–	–	1	–	1	22	3	–	–	18	–	–	10	–	–	1	–
Small mammal	6	7	9	40	7	14	37	1	33	513	147	23	19	544	5	17	263	2	12	13	12
Total	56	70	135	610	99	67	608	38	344	3777	2051	100	129	5324	41	103	1553	24	31	107	214
NISP/L.	11.2	3.5	6.7	8.1	19.8	6.7	24.2	19	17.2	29.5	51.2	10	6.4	40.19	20.5	5.1	12.1	2.7	6.2	5.3	2.8

Phase	3776-E					3776-F														
(Context)	527	527	527	527 [=313]	527 [=313]	526	526	526	526 [=312]	529	529	525	525	525	525	525	525 [=311]	521	521	520
Sample	126	126	126	6	5	108	108	108	4	110	110	112	109	112	111	107	14	122	121	120
Sorting	4	2	3	1	2	2	3	4	1	3	2	2	2	3	2	2	1	2	2	2
No. of samples (volume in L.)	1 (5)	1 (20)	1 (75)	1 (18)	1 (28)	1 (40)	1 (208)	1 (2)	1 (30)	1 (90)	1 (10)	1 (20)	1 (20)	1 (80)	1 (20)	1 (20)	1 (20)	1 (20)	1 (10)	1 (10)
Fish	2	40 (2)	785 (14)	1 (2) [2]	1	75 (7)	1876 (53)	1 (1)	9 (3) [1]	16	3		14 (3)	12 (1)	–	–	2	–	–	–
Amphibian	–	120 (1)	759 (2)	35	26 (1)	103	941 (7)	–	56	1	6	2	27 (1)	21 (1)	–	–	1	–	–	–
Reptile	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Bird	16	1	4	–	1	2	1	–	–	–	–	–	–	–	–	–	–	–	–	–
Small mammal	–	25	169	3	24	56	321	2	24	5	2	4	21	13	–	–	4	–	–	–
Total	18	189	1711	43	53	243	3199	4	93	22	11	6	66	48	0	0	7	0	0	0
NISP/L.	3.6	9.4	22.8	2.4	1.9	6.1	15.4	2	3.1	0.2	1.1	0.3	3.3	0.6	0	0	0.3	0	0	0

Phase	3776-F			3776-G																
(Context)	520	523	522	519	519	519	518	516	516	516	516 [=308]	516 [=308]	515	515	515	515	515 [=307]	514	534	533
Sample	124	119	118	104	104	104	103	160	102	102	3	2	116	101	101	101	1	115	114	113
Sorting	2	2	2	4	3	2	2	3	4	2	1	1	3	4	3	2	1	2	2	2
No. of samples (volume in L.)	1 (10)	1 (10)	1 (10)	1 (2)	1 (28)	1 (10)	1 (10)	1 (150)	1 (5)	1 (10)	1 (10)	1 (10)	1 (10)	1 (2)	1 (8)	1 (10)	1 (20)	1 (10)	1 (10)	1 (10)
Fish	–	–	–	1	12 (1)	–	–	185 (41)	1	1 (1)	0 (1)	3 (3) [1]	12 (3)	–	5 (1)	2	[1]	–	–	–
Amphibian	–	–	–	6	93 (4)	31	2	1357 (23)	–	35	75	34 (3)	163 (4)	36	107 (3)	45 (3)	104 (1)	–	–	–
Reptile	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Bird	–	–	–	–	–	–	–	3	–	–	–	–	–	–	–	–	–	–	–	–
Small mammal	–	–	1	–	11	–	–	45	18	–	2	3	6	2	6	1	5	–	5	0
Total	0	0	1	8	121	31	2	1631	19	37	78	47	188	38	122	51	111	–	5	0
NISP/L.	0	0	0.1	4	4.3	3.1	0.2	10.9	3.8	3.7	7.8	4.7	18.8	19	15.2	5.1	5.5	0	0.5	0

KEY: 1 – Sorted for assessment (1998 processing); 2 – Sorted to 1mm (2000 assessment); 3 – Sorted to 0.5mm (* rapid scan); 4 – Mollusc sample, sorted to 0.5mm

Table 5.14 All vertebrate taxa by context from 3776TP

Phase	**3776-C**	**3776-D**		**3776-E**	**3776-F**				**3776-G**			
Context	**536**	**537**	**528**	**527**	**526**	**529**	**525**	**522**	**519**	**516**	**515**	**534**
PISCES												
Esox lucius L., pike	+		+	+	+		+			+		
Cyprinidae gen. et sp. indet., carp family	+		+	+	+		+					
Anguilla anguilla (L.), eel			+	+	+				+	+	+	
Gasterosteus aculeatus L., three-spined stickleback				+	+		cf.			+		
Pungitius pungitius L., nine-spined stickleback												
Gasterostidae, stickleback	+	+	+	+	+	+	+		+	+	+	
Platichthys flesus L., flounder												
AMPHIBIA												
Triturus sp., newt	+	+	+	+	+		+		+	+	+	
Bufo bufo L., common toad				+								
Bufo sp., toad			+		+						+	
Rana temporaria L., common frog				+					+	+	+	
Rana sp., common frog		+	+	+	+		+			+	+	
Bufo sp. or *Rana* sp., toad or frog	+											
REPTILIA												
Ophidia undet., unidentified snake			+									
AVES												
Anatinae indet., duck			+									
Passeriformes indet., song bird			+	+	+							
? Passeriformes indet., ? song bird			+	+	+							
Phalacrocorax carbo, great cormorant			+									
Aves indet., indeterminate bird	+	+	+	+	+					+		
MAMMALIA												
Soricomorpha												
Sorex minutus L., pygmy shrew			+	+	+		+			+	+	
Sorex araneus L., common shrew			+									
Sorex cf. *araneus* L., ? common shrew		+	+									
Sorex sp., medium-sized shrew			+	+	+							
Neomys sp., water shrew			+	+	+							
Soricidae gen et sp indet., indeterminate shrew	+	+	+	+	+	+	+		+	+		
Chiroptera												
Pipistrellus sp., pipistrelle			+									
Rodentia												
Arvicola cantianus (Hinton), water vole	+	+	+	+	+		+					
Microtus agrestis (L.), field vole		+	+									
Microtus agrestis (L.) or *M. arvalis* (Pallas), field or common vole	+	+	+									
Microtus oeconomus (Pallas), northern vole			+	+	+		+			+		
Microtus sp., vole	+	+	+	+	+	+	+	+		+	+	+
Microtinae gen. et sp. indet., indeterminate vole		+	+		+							
Apodemus sylvaticus (L.), wood mouse		+	+									
Apodemus maastrichtiensis van Kolfschoten, extinct mouse	+		+									
Apodemus sp., mouse			+									
Carnivora												
Mustela lutreola (L.), European mink			+									
Large carnivore (gnawing marks)			+	+	+							
Proboscidea												
Elephantidae gen. et sp. indet., indeterminate elephant			+									
Perissodactyla												
Equus ferus Boddaert, horse			+	+	+							
Artiodactyla												
Cervidae gen. et sp. indet, indeterminate deer			+									
Bison priscus Bojanus, bison			+									
Bos primigenius Bojanus or *Bison priscus* Bojanus, aurochs or bison			+									

KEY: + – present

Table 5.15 Small mammal taxa by sample from 3776TP

Phase	3776-C	3776-D						3776-E			3776-F						3776-G			
Context	**536**	**537**	**528**	**528**	**528**	**528**	**528**	**527**	**527**	**527**	**526**	**525**	**525**	**525**	**525**	**522**	**519**	**516**	**515**	**534**
Sample	**133**	**134**	**131**	**132**	**130**	**129**	**8**	**5**	**127**	**126**	**108**	**110**	**109**	**112**	**111**	**118**	**104**	**160, 3**	**101, 116, 1**	**114**
Soricomorpha																				
Sorex minutus L., pygmy shrew	–	–	–	1 (1)	1 (1)	1 (1)	–	–	–	4 (1)	1 (1)	–	1 (1)	–	–	–	–	3 (1)	4 (1)	–
Sorex araneus L., common shrew	–	–	1 (1)	–	1 (1)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Sorex cf. *araneus*	–	4 (1)	17 (4)	5 (4)	11 (3)	2 (1)	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Sorex sp., medium-sized shrew	–	–	–	–	3	3	–	–	–	1	1	–	–	–	–	–	–	–	–	–
Neomys sp., water shrew	–	–	10 (1)	2 (2)	19 (6)	2 (1)	–	–	–	4 (2)	1 (1)	–	–	–	–	–	–	–	–	–
Soricidae gen et sp indet., indeterminate shrew	3	1	4	2	17	8	–	–	–	2	2	1	–	–	–	–	1	1	–	–
Chiroptera																				
Pipistrellus sp., pipistrelle	–	–	1 (1)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Rodentia																				
Arvicola sp., water vole	2 (1)	2 (1)	29 (5)	5 (1)	53 (6)	17 (3)	1 (1)	–	5 (2)	6 (2)	6 (1)	–	–	1 (1)	–	–	–	–	–	–
Microtus agrestis (L.), field vole	–	1 (1)	4 (3)	2 (2)	2 (1)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Microtus agrestis (L.) or *M. arvalis* (Pallas), field or common vole	1 (1)	3 (2)	8 (5)	2 (1)	1 (1)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Microtus oeconomus (Pallas), northern vole	–	–	1 (1)	–	–	–	–	1 (1)	1 (1)	4 (2)	11 (7)	–	1 (1)	–	1 (1)	–	–	2 (2)	–	–
Microtus sp., vole	1	2	27	8	36	7	–	7	2	27	68	1	5	3	1	1	–	14	7	3
Microtinae gen. et sp. indet., indeterminate vole	–	5	24	18	–	10	–	–	–	–	11	–	–	–	–	–	–	–	–	–
Apodemus sylvaticus (L.), wood mouse	–	3 (2)	10 (3)	3 (1)	10 (3)	1 (1)	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Apodemus maastrichtiensis van Kolfschoten, extinct mouse	1 (1)	–	5 (2)	4 (2)	3 (1)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Apodemus sp., mouse	–	–	5	–	2	3	–	–		–	–	–	–	–	–	–	–	–	–	–
Carnivora																				
Mustela lutreola (L.), European mink	–	–	1 (1)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Table 5.16 Small vertebrate taphonomy, 3776TP

Lithofacies	**3776-C**	**3776-D**				**3776-E**	**3776-F**	**3776-G**
Context	**536**	**528**	**528**	**528**	**537**	**527**	**526**	**516**
Sample	**133**	**130**	**131**	**132**	**134**	**126**	**108**	**160**
No. of samples (weight)								
Skeletal part								
Skull	–	–	–	–	–	–	–	–
Maxilla	–	1 (1)	–	–	–	1 (1)	4 (4)	–
Mandible	1 (1)	15 (7)	19 (8)	1 (1)	1 (1)	9 (6)	5 (3)	2 (1)
Incisor	8 (5)	82 (35)	82 (36)	32 (12)	6 (6)	17 (10)	52 (15)	6 (4)
Molar	7	103	108	37	12	33	93	10
Vertebra	2 (2)	55 (41)	62 (57)	6 (3)	2 (2)	–	15 (14)	1 (1)
Rib	–	3 (3)	3 (1)	2 (2)	–	3 (1)	2 (1)	–
Scapula	–	1 (1)	2 (2)	–	–	2 (2)	4 (4)	1 (1)
Humerus	–	11 (5)	9 (6)	2 (2)	–	6 (4)	4 (3)	1 (1)
Radius	–	8 (6)	4 (4)	1 (1)	–	2 (2)	5 (4)	–
Ulna	–	14 (14)	13 (10)	3 (3)	–	4 (3)	6 (5)	1 (1)
Innominate	–	3 (3)	1 (1)	1 (1)	–	1 (1)	5 (4)	–
Femur	–	6 (5)	6 (3)	4 (4)	–	4 (3)	2 (2)	1 (1)
Tibia	–	9 (7)	12 (6)	2 (1)	–	–	7 (4)	2 (1)
Calcaneus	–	7 (7)	7 (7)	1 (1)	–	1 (1)	10 (10)	–
Astragalus	–	5 (5)	11 (10)	3 (3)	–	–	2 (2)	–
Metapodial	5 (3)	58 (42)	48 (33)	15 914)	1 (1)	18 (14)	34 (24)	4 (2)
Phalange	13 (13)	69 (57)	38 (37)	20 (19)	4 (4)	29 (29)	54 (54)	9 (9)
Total NISP	36	450	425	130	26	140	304	38
Breakage								
Humerus	–	–	–	–	–	–	–	–
complete	–	–	–	–	–	–	–	–
proximal	–	1	3	–	–	1	1	–
shaft	–	5	4	2	–	2	2	–
distal	–	5	5	–	–	4	1	1
Femur	–	–	–	–	–	–	–	–
complete	–	–	–	–	–	–	1	–
proximal	–	4	3	3	–	–	–	–
shaft	–	1	1	1	–	4	1	–
distal	–	–	1	–	–	–	1	1
Tibia	–	–	–	–	–	–	–	–
complete	–	–	–	–	–	–	–	–
proximal	–	–	–	–	–	–	1	1
shaft	–	3	7	1	–	1	4	1
distal	–	7	4	1	–	1	2	–
Digestion								
Incisors (N)	8	82	82	32	6	17	52	6
light	2	13	14	5	–	7	17	3
moderate	–	3	3	1	–	–	1	–
heavy	–	2	1	1	–	–	1	–
extreme	–	–	–	–	–	–	1	–
Total digested, n(%)	25	21.9	21.9	21.9	0	41.2	38.5	50
Molars (N)	6	89	88	32	10	21	93	10
light	1	23	26	9	3	5	12	2
moderate	–	5	8	–	2	3	3	–
heavy	–	–	3	1	–	–	–	–
extreme	–	–	–	–	–	–	–	–
Total digested, n(%)	16.7	31.5	42	31.2	50	38.1	16.1	20
Puncture marks (by mammalian carnivore)	–	–	–	–	–	–	Yes	–
Digestion of spongy bone	–	–	Yes	–	–	Yes	–	–
Gnaw marks (by rodents)	–	–	–	–	–	–	–	–
Parallel grooves (by insects?) *	Yes	–	Yes	–	–	–	–	Yes
Weathering	–	–	–	–	–	–	–	–
Fine striations (by trampling)	–	–	–	–	–	–	–	–
Rounding of breaks	–	–	–	–	–	–	–	–
Polishing	Yes	–	Yes	–	–	Yes	–	–
Root corrosion	Yes	–	Yes	–	–	–	Yes	–
Mn concretions	Yes	–	–	–	–	–	–	–
Fe staining	–	–	–	–	–	–	–	–
Diagenetic pitting & exfoliation	–	–	–	–	–	–	–	–

* on amphibian bones

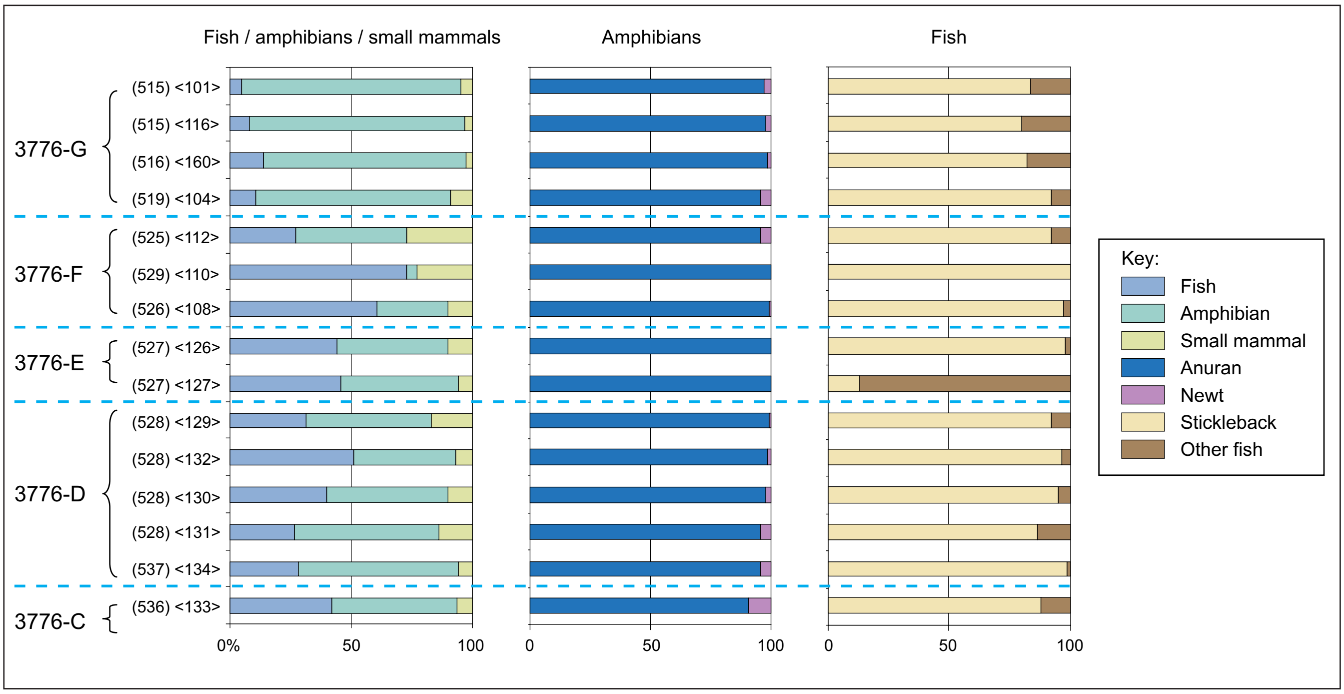


Figure 5.12 3776TP: Summary of the small vertebrates from 3776TP, showing: (a) relative abundance of fish, amphibians and small mammals as a percentage of the total number of identified specimens; (b) proportion of anurans (frogs and toads) to newts; (c) proportion of sticklebacks (Gasterostidae) to other fish taxa

3776-C

The earliest vertebrate assemblage is from a silty sand layer (536) at the base of the excavated sequence. Four sub-samples were analysed, yielding an assemblage dominated by fish and amphibians comprising 92.8% of the assemblage (total number of identified specimens (NISP) = 871). This assemblage is unequivocally indicative of a freshwater aquatic environment. The fish remains are overwhelmingly dominated by stickleback; other taxa include pike (*Esox lucius*) and carp (cyprinids) making up 12% of the total number of identifiable fish remains picked from the >0.5mm residue. Pike, stickleback and a range of cyprinid taxa can be found together in many freshwater habitats from small ponds to large lakes, weedy meres and the slow-flowing zones of streams and rivers. Although pike occur in brackish water and three-spined sticklebacks (*Gasterosteus aculeatus*) thrive in near-shore marine environments, cyprinids are generally intolerant of salinity. The small mammal assemblage is insufficient to comment in any detail on the taphonomy, climate or palaeoecology. Qualitatively, the assemblage is very similar to that of the overlying phase 3776-D. A single bird bone was also found, of an undetermined passerine (Stewart, Appendix C4).

3776-D

Five samples (analysed as 14 sub-samples) were taken through a sequence of horizontally-bedded silts and silty clays (537 and 528). Because of lateral variation in colour and texture, two sets of samples were collected comprising one column of three samples through context 528 (129, 130, 131) from the eastern end of the trench (*cf* Fig 5.10) and a further two samples (132, from the middle of context 528; and 134 from pink silt context 537, which was a lateral equivalent of the basal part of context 528) from the western end. Sample 130 and 132 are from the same sandy clay horizon, whereas samples 131 and 134 are from distinct facies that may represent separate layers rather than merely lateral variation within a single horizon. Notable features of the vertebrates from this phase include abundant and well-preserved large mammal bones in the top of context 528 and the extraordinarily rich assemblage of small vertebrate remains, which includes several rare small mammal taxa.

Ten taxonomically identifiable large mammal bones were recovered from context 528 (Table 5.17), most of which were found in the upper 0.1m. The sample includes taxa ranging in size from elephant to red deer-sized cervid. Elephant (most probably *Mammuthus* sp.) is represented by a metapodial fragment, a magnum, and a third and fourth metacarpal, both of which are complete and can be rearticulated; the fused epiphyses indicate that the animal was fully mature or at least fully grown at the time of death. The small size of the mammoth remains is consistent with the MIS 7 Ilford-type, although this is not definitive due to the difficulty of sexual dimorphism (Lister, Appendix C3). Bovids are represented by a complete metatarsal of bison (*Bison priscus*), together with an upper molar and second phalanx of a *Bos*- or *Bison*-sized bovid. The remaining taxa are represented by single bones and include horse (*Equus ferus*), identified from a femur shaft of a juvenile individual, and a cervid represented by the tip of an antler tine. Finally, the taxonomically unidentifiable

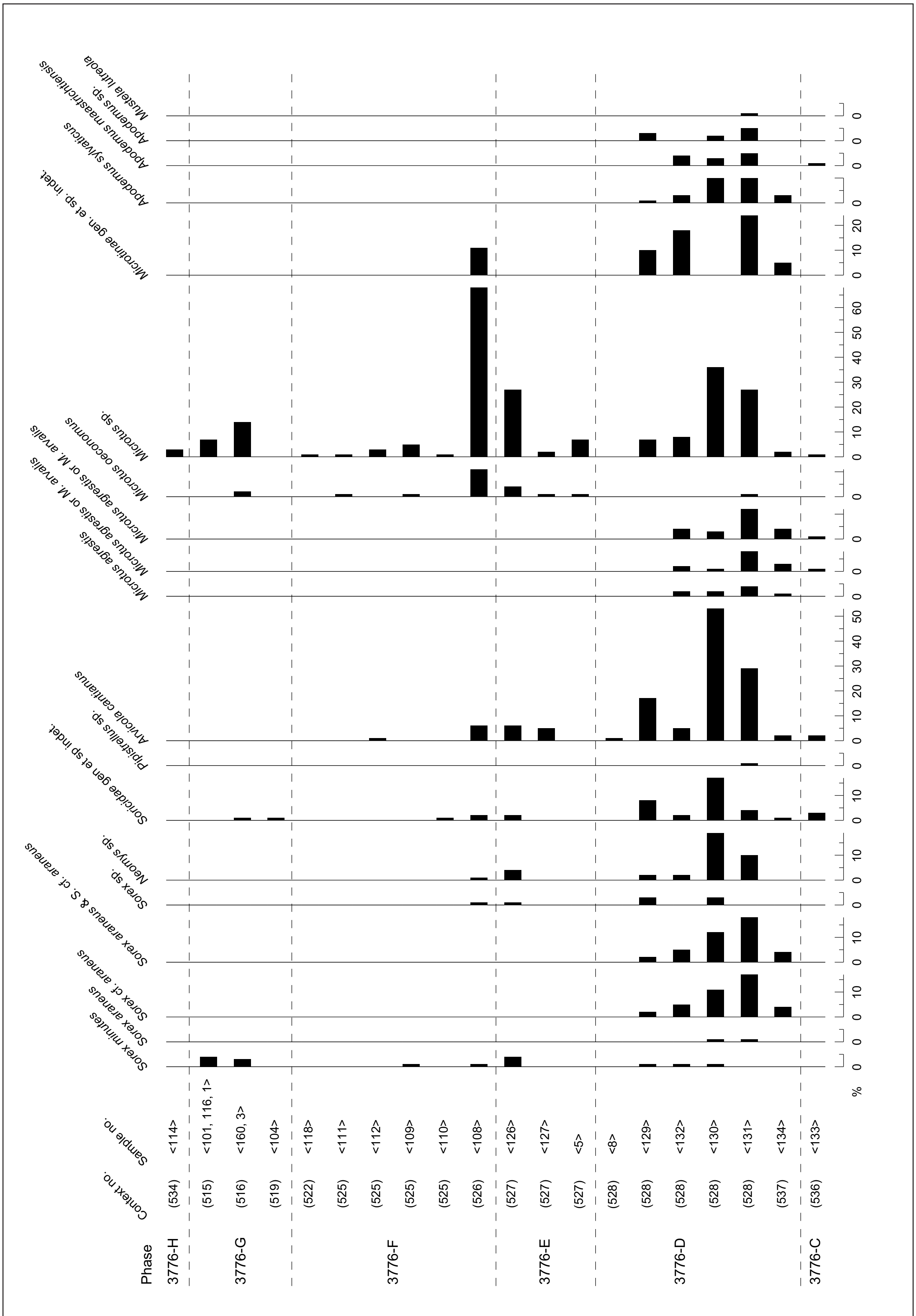


Figure 5.13 Quantitative distribution of rodents and insectivores in the 3776TP succession; bars show absolute abundance based on NISP (number of identified specimens)

Table 5.17 Large mammals by context from 3776TP

Phase	Context	Taxon	NISP	MNI	Skeletal part
3776-F	529	Indeterminate large mammal	4	–	Cervical vertebra; sesamoids; indet. bone frag. (2)
	526	*Equus ferus*	2	1	Tooth (upper cheek tooth frag.); metatarsal distal epiphysis frag.
		Indeterminate large mammal	17	–	Skull frag. (2); rib frag.; indet. bone frag. (14)
3776-E	527	*Equus ferus*	1	1	Mandible frag.
		Indeterminate large mammal	2	–	Rib frag.; indet. bone frag.
3776-D	528	*Mammuthus* sp.	4	1	Metacarpal II and III, magnum; metapodial frag.;
		Equus ferus	1	1	Femur shaft frag. (juvenile)
		Cervidae gen. et sp. indet.	1	1	Antler frag.
		Bison priscus	1	1	Metatarsal
		Bos primigenius or *Bison priscus*	2	1	Tooth (M^1 or ^{2}); phalanx II
		Indeterminate large mammal	9	–	Cervical vertebra; thoracic vertebra (3); lumbar vertebra (3); rib frag. (2)

bones include seven more-or-less complete vertebrae and two rib fragments from bovid/horse-sized ungulates. All of the bones are well-preserved and have a characteristic pink-purple hue that is reminiscent of some of the bones recovered by Burchell from Site B (Chap 6). Notable features of the assemblage include the presence of the least durable parts of the skeleton (eg, vertebrae) as well as skeletal elements from the same individual. None of the bones is weathered, but the bovid second phalanx has carnivore gnaw-marks; ungulate chewing was present on the antler tine. These characteristics suggest that the bones accumulated over a relatively short period of time and that burial occurred in a low-energy depositional environment.

Looking at the broad taxonomic composition (Fig 5.12), the percentage of fish, amphibian and small mammals show only slight fluctuation through the sequence with fish (~40%) and amphibians (~50%) dominating throughout; small mammals constitute less than 20% of the assemblage. Two stickleback species, nine-spined stickleback (*Pungitius pungitius*) and three-spined stickleback (*Gasterosteus aculeatus*), are extremely abundant and together make up about 85% of the identifiable fish remains. Other fish taxa include pike and cyprinids. The relatively small size of the pike and cyprinid elements are indicative of relatively small individuals, possibly an indication of shallow water or the small size of the waterbody. This interpretation may be supported by the abundance of sticklebacks in the assemblage. Both identified species prefer slow-flowing or still water with an abundant growth of aquatic vegetation, but the nine-spined stickleback can tolerate stagnant conditions and oxygen depletion. Ecologically, the fish assemblage is consistent with a small, possibly ephemeral pool on the floodplain or the weedy slow-flowing backwaters of a river or stream. Such an environment would have provided favourable habitats for frogs, toads and newts, which are the major component of the assemblage.

Grassland voles are the dominant small mammals constituting over 80% of the rodent molars. The vole assemblage comprises nearly equal proportions of water vole (*Arvicola*) and field vole (*Microtus agrestis*), together with a single specimen of northern vole (*Microtus oeconomus*) (Table 5.14). Ecologically, all of the vole species can be found in marsh or damp meadows. Denser vegetation, which may have included scrub or even woodland, is indicated by the wood mouse (*Apodemus sylvaticus*). This species, together with the extinct mouse (*Apodemus maastrichtiensis*) are relatively well represented. Obligate woodland mammals include a pipistrelle bat (*Pipistrellus* sp.) and European mink (*Mustela lutreola*). Although it was not possible to identify the pipistrelle to species, the extremely small size of the mandible fragment suggests the either common pipistrelle (*Pipistrellus pipistrellus*) or soprano pipistrelle (*Pipistrellus pygmaeus*) is represented. Pipistrelles frequently feed over water or water meadows and along the edges of woods, where they roost and hibernate. The record of European mink is of particular interest. This is an endangered mustelid, today extinct in Britain and previously only known from early Middle Pleistocene interglacial deposits at Boxgrove, West Sussex (Parfitt 1999). The habits of the nocturnal European mink closely resemble those of the otter. It is closely associated with slow-moving freshwater, especially in lowland and wooded areas where it spends the daylight hours in burrows in banks, hollow trees, under roots of fallen trees, or under clumps of reed. It feeds principally on rodents such as water voles and on frogs, molluscs, fish and water-fowl, which it catches in and around water (Youngman 1990).

Three species of shrew have been identified of which the most common are the water shrew (*Neomys* sp.) and common shrew (*Sorex araneus*); pygmy shrew (*Sorex minutus*) is scarce. The water shrew is a semi-aquatic animal that prefers riparian vegetation of still freshwater bodies, bogs and slow-flowing streams and rivers. Common and pygmy shrews are also found in humid habitats that include riverine forests, reedbeds, swamps or meadows and support other evidence of relatively wet conditions.

Looking at the evidence for individual samples (Table 5.13; Figs 5.12–4), several trends are apparent. The most striking change occurs in small vertebrate bone density, which peaks in samples 130–2 with a

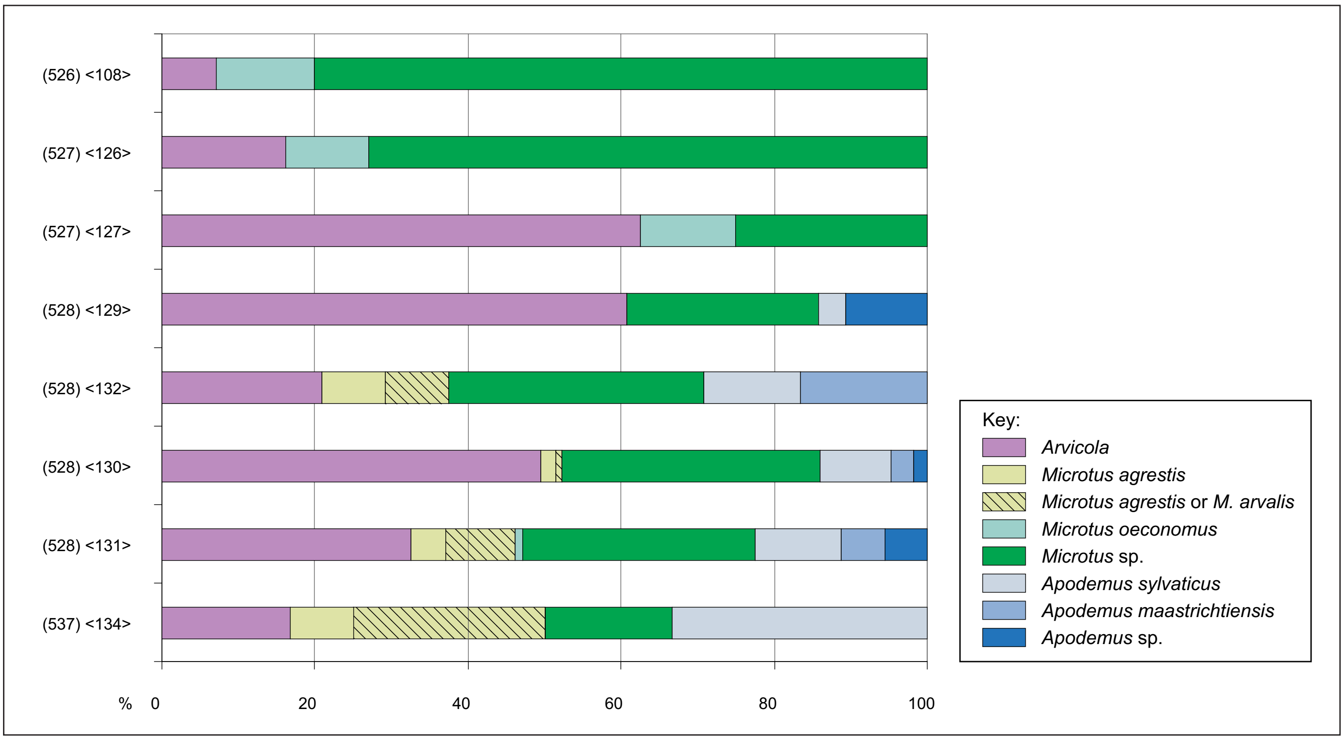


Figure 5.14 Changes in the proportions of voles and mice through 3776-D, 3776-E and the base of 3776-F

maximum of ~51 bones per litre of sediment, followed by a dramatic drop in the upper part of the unit (~20 bones per litre in sample 129). Fluctuations in the relative abundance of fish bones mirror those of bone density with a peak in the relative abundance of fish remains in the middle part of the sequence. Amphibian representation is relatively constant, but small mammal abundance shows an antithetic relationship to that of the fish. Other trends include a decrease in newt bones, a decrease in woodland species, and an increase in water voles through the sequence (Figs 5.13–4).

Overall, the vertebrates indicate fully temperate conditions and a mixed environment. Climatically, the presence of wood mouse is important as today its geographical range extends northwards only as far as the southern part of Fennoscandia. The composition of small vertebrate fauna, which is dominated by freshwater and wetland species indicates a slow-flowing waterbody, bordered by marshy vegetation with sedges or riparian grassland. Although most of the mammals are more common in such open environments, several prefer denser vegetation and some areas of woodland must also have been present in the immediate vicinity to support pipistrelle bats and European mink. Curiously, bank vole (*Clethrionomys glareolus*), is absent. This absence is all the more striking given the large size of the assemblage and the fact that bank vole generally occurs together with wood mouse in British Pleistocene interglacial faunas. At Site A, bank vole is present in the relatively tiny assemblage from the basal interglacial deposits (*cf* Site A, vertebrates, above), suggesting that these deposits are unlikely to be contemporaneous with these temperate horizons at ZR4.

Several bird bones were found in bulk samples from context 528, including specimens of cormorant (*Phalacrocorax*), duck (Anatinae), and undetermined passerines (Stewart, Appendix C4). Cormorant is found today in either freshwater (eg, rivers and lakes), or marine habitats. They nest in trees or on rocky shorelines (Heinzel *et al* 1972). Cormorants feed mostly on small fish, which are caught in shallow water 1–3m deep. They generally avoid widespread floating vegetation (Cramp and Simmons 1977).

3776-E

Eight sub-samples were taken from context 527, four from the upper and four from the lower part of the unit. Small mammal remains constitute only ~10% of the assemblage, whereas fish and amphibian remains, which make up the bulk of the small vertebrate assemblage, are equally well represented. The small mammals record a significant and sustained change in faunal composition. Voles indicative of dank grassland, specifically water vole together with significant numbers of northern vole, are the dominant elements in this assemblage. Of particular environmental significance is northern vole, which today occurs in a wide range of open habitats that include saltmarsh, fens, bogs and meadows and banks of small streams, particularly amongst grassy waterlogged vegetation. The northern vole molars are of biostratigraphical significance, being the particularly large form with a distinctive occlusal morphology characteristic of MIS 7 and early MIS 6 (*cf* Parfitt *et al*, Appendix C1). Shrew remains are also relatively well represented, with pygmy shrew and water shrew being the common soricid taxa based on the number of

Table 5.18 Molluscs from 3776TP

	Silty sand	Pink silt	Brown silty clay	Brown silty clay	Brown silty clay	Brown silty clay	Clayey silt	Clayey silt	Gravelly sand	Clay silt	Soft faulted sands	Shelly clay silt beds	Shelly clay silt beds	Shelly clay silt beds
Phase (BMA-)	**C**	**D**	**D**	**D**	**D**	**D**	**E**	**E**	**F**	**F**	**F**	**G**	**G**	**G**
Context	**536**	**537**	**528**	**528**	**528**	**528**	**527**	**527**	**526**	**529**	**525**	**519**	**516**	**515**
Sample	**133**	**134**	**131**	**130**	**132**	**129**	**127**	**126**	**108**	**110**	**112**	**104**	**102**	**101**
Dry weight (kg)	**5**	**5**	**2**	**2**	**2**	**2**	**5**	**5**	**2**	**2**	**20**	**2**	**5**	**2**
Freshwater taxa														
Viviparus contectus	–	–	–	–	–	–	–	–	–	–	–	–	5	2
Valvata cristata Müller	70	141	162	–	88	2	10	2	2	–	–	35	188	11
Valvata piscinalis (Müller)	48	38	41	–	5	–	8	–	9	8	–		3	–
Bithynia tentaculata (Linnaeus) shells	55	43	52	–	115	26	166	1	6	4	–	11	110	21
Bithynia tentaculata opercula	179	51	118	+	116	132	331	13	10	2	1	79	69	67
Bithynia troschelii (Paasch) shells	–	–	–	–	–	–	3	–	–	–	–	–	1	1
Bithynia troschelii opercula	–	1	5	–	–	1	20	1	1	–	–	–	2	–
Physa fontinalis (Linnaeus)	–	–	–	–	1	–	–	–	–	–	–	–	–	–
Galba truncatula (Müller)	3	19	9	–	15	8	2	–	2	–	–	10	65	6
Stagnicola palustris agg. (Müller)	+	1	1	–	2	–	–	–	–	–	–	–	10	–
Lymnaea stagnalis (Linnaeus)	–	1	–	–	–	–	–	–	–	–	–	–	–	–
Radix balthica (Müller)	6	6	4	–	9	–	–	–	–	1	–	3	36	–
Planorbis planorbis (Linnaeus)	8	85	43	–	22	2	2	–	–	–	–	3	4	–
Anisus leucostoma (Millet)	1	9	–	–	30	–	1	–	–	–	–	–	12	3
Anisus vortex (Linnaeus)	3	7	–	–	–	–	–	–	–	–	–	–	3	–
Bathyomphalus contortus (Linnaeus)	6	47	3	–	1	–	–	–	–	–	–	–	–	–
Gyraulus albus (Müller)	5	10	2	–	–	–	1	–	2	–	–	–	–	–
Gyraulus crista (Linnaeus)	–	1	–	–	2	–	–	–	–	–	–	1	–	–
Gyraulus riparius (Westerlund)	–	–	–	–	–	–	–	–	–	–	–	–	4	–
Gyraulus spp.	3	–	–	–	–	–	–	–	–	–	–	–	–	–
Hippeutis complanatus (Linnaeus)	4	1	–	–	1	–	–	–	–	–	–	–	–	–
Planorbarius corneus (Linnaeus)	10	6	4	–	1	4	11	1	1	–	–	2	1	1
Planorbidae undet.	16	–	–	–	–	–	–	–	–	–	–	–	9	–
Acroloxus lacustris (Linnaeus)	2	–	1	–	–	–	–	–	–	–	–	–	–	–
Sphaerium corneum (Linnaeus)	?1	–		–	2	–	–	–	–	–	–	–	–	–
Musculium lacustre (Müller)	2	1		–	2	–	–	–	–	–	–	–	4	–
Pisidium obtusale (Lamarck)	1	15	1	–	1	–	–	–	–	–	–	–	1	–
Pisidium milium Held	–	?1	1	–	–	–	–	–	–	–	–	–	–	–
Pisidium subtruncatum Malm	?3	4	3	–	–	–	–	–	–	–	–	–	–	–
Pisidium spp.	5	4	4	–	2	–	8	3	–	–	–	1	1	–
Land taxa														
Carychium minimum Müller	6	39	11	–	2	–	–	–	–	–	–	–	–	–
Succineidae	3	31	12	–	6	–	1	–	–	–	–	–	–	1
Cochlicopa sp.	–	1	–	–	2	–	–	–	–	–	–	–	–	–
Vertigo antivertigo (Draparnaud)	–	3	2	–	2	–	–	–	–	–	–	–	–	–
Vertigo spp.	–	2	–	–	–	–	–	–	–	–	–	–	–	–
Pupilla muscorum (Linnaeus)	–	–	–	–	–	–	–	–	–	–	–	–	1	–
Vallonia pulchella/excentrica	–	3	–	–	4	–	–	–	–	–	–	–	–	–
Spermodea lamellata (Jeffreys)	–	1	–	–	–	–	–	–	–	–	–	–	–	–
Discus rotundatus (Müller)	3	1	11	–	–	–	–	–	–	–	–	–	–	–
Vitrea crystallina (Müller)	2	3	–	–	–	–	–	–	–	–	–	–	–	–
Vitrea sp.	2	–	–	–	–	–	–	–	–	–	–	–	–	–
Nesovitrea hammonis (Ström)	–	1	–	–	–	–	–	–	–	–	–	–	–	–
Aegopinella nitidula (Draparnaud)	–	3	–	–	–	–	–	–	–	–	–	–	–	–
Zonitoides nitidus (Müller)	4	12	2	–	2	–	–	–	–	–	–	–	–	–
Deroceras/Limax spp.	2	5	2	+	2	4	–	–	–	1	–	4	24	2
Clausiliidae	1	6	–	–	–	–	–	–	–	–	–	–	–	–
Cepaea/Arianta	2	6	–	–	1	1	–	–	–	–	–	–	–	–
Total	**272**	**608**	**494**	**+**	**436**	**180**	**564**	**21**	**33**	**16**	**1**	**66**	**548**	**113**

KEY:+ – present

identifiable remains. Mice and field vole are absent, which are important elements in the earlier assemblages.

Identifiable large mammal bones are rare and the only species represented is horse, identified from a fragment of mandible with pitting and scoring indicative of carnivore chewing.

The fish fauna from the lower part of the unit is unusual in that sticklebacks form an insignificant part of the assemblage, which is otherwise dominated by pike, eel (*Anguilla anguilla*) and cyprinids. This suggests a temporary shift towards deeper water, followed by a return to sluggish, possibly stagnant and shallower conditions in the upper part of the unit.

The occurrence of eel and cyprinids also provide an indication of the prevailing climate. Eels require relatively warm summer temperatures (Lister *et al* 1990; Kettle *et al* 2008), as do cyprinids for their eggs to hatch (Wheeler 1977). The small mammal fauna is climatically uninformative. There are no obligate thermophiles or cold-adapted taxa and all of the species represented are widespread with geographical ranges that extend north of the Arctic Circle. However, the total absence of any indication of woodland may be indicative of a more open grassland environment than in underlying deposits associated with cooler conditions, with the switch from a field vole dominated assemblage to one with frequent northern vole suggesting climatic deterioration. Four bird bones were also found in context 527, all of undetermined passerines (Stewart, Appendix C4).

3776-F

Seven units were sampled, of which only the basal two layers (contexts 526 and 529) yielded a reasonable quantity of identifiable small vertebrate remains (Table 5.15). Large mammal remains were present only in context 526 and 529. These large mammal bones are all light brown in colour, often with extensive manganese staining. Horse is represented by an upper cheek tooth fragment and the distal end of a metatarsal, but the other 21 fragments cannot be identified to taxa. Carnivore activity is indicated by score-marks on the metatarsal fragment as well as pitting on two of the indeterminate bone fragments.

A shift away from aquatic depositional conditions is indicated by the steady increase in small mammals and the sharp fall in fish remains during the deposition of these lower units. Nevertheless, the local environment was probably still one dominated by marsh and damp grassland. Grassland voles continued to predominate, with northern vole becoming even more dominant, with almost twice as many identifiable molars as water vole (Table 5.15). Three bird bones were also found, in context 526, two of undetermined passerines and one of a duck-sized bird (Stewart, Appendix C4).

3776-G

The sediments comprise beds of clayey/silty fine sand and fine-grained sediments (contexts 519, 516 and 515), which form the top of the fluvial sequence, and are unconformably truncated by overlying colluvial sediments of phase 3776-H. Bone density peaks in context 515 with 19 identifiable bones per litre of sediment (sample 101). Frogs and toads are the dominant elements in the assemblage comprising as much as 80% of the identifiable fragments; fish and small mammals occur in approximately equal proportions and show a steady decrease in numbers up the profile. *Microtus* voles again dominate the small mammal fauna. The occurrence of northern vole together with the overwhelming dominance of frogs and toads indicates marshland. A single bird bone was also found in context 516, of an undetermined passerine (Stewart, Appendix C4).

Molluscs

Fourteen samples were analysed from Section 3776TP (Fig 5.11). Although these do not derive from a continuous column they are presented in stratigraphic order, ascending up through the sequence left to right (Table 5.18). In total, 24 aquatic and 15 terrestrial taxa were recovered. The shells have been subjected to diagenetic processes and have a weathered appearance. This is most notable in the shells of *Bithynia tentaculata*, the sutures of which have been over-deepened by these processes. Separating the shells of this species from *Bithynia troschelii*, distinguished from *B. tentaculata* by characteristically deeper sutures and a rounder operculum, was therefore more difficult. However, the *Bithynia* opercula are well-preserved and indicate an assemblage dominated by *B. tentaculata*. The molluscan assemblages appear to fall into three groups, all indicating a substantial and permanent waterbody that would have supported a rich aquatic vegetation, but with some finer variations. The lower three samples 133, 134 and 131 (from 3776-C and the lower half of 3776-D) and upper three samples 104, 102 and 101 (all from phase 3776-G) both form groups dominated by *Valvata cristata*, which outnumbers *B. tentaculata*; whereas the latter is the dominant species in the middle group of samples 132, 129, 127, 126 and 108 (the upper half of 3776-D, 3776-E and the lower part of 3776-F). Other levels yielded low numbers of shells precluding further comment. Despite their dominance by *V. cristata*, the lower and upper groups show a number of differences. The lower group has yielded a greater range of aquatic species that includes *Valvata piscinalis* as an important subordinate. This may suggest that the waterbody was slightly deeper at this time. Fourteen species of land snail were also recovered from the lower group, compared with only three in the upper group. Most of the land species in the lower group are hygrophilous taxa characteristic of marshes and other wetland habitats. The occurrence of a specimen of *Spermodea lamellata* in sample 134 is noteworthy since this species is generally confined to damp deciduous woodland.

Another noteworthy species was recovered from the upper group. Four specimens of *Gyraulus riparius* were

Table 5.19 Ostracods from 3776TP

Phase (3776-)	**D**	**E**	**F**												**G**				**H**	
Context	**537**	**527**	**526**	**529**	**525**	**521**	**530/521**		**520**		**523**		**522**		**519/524**	**517/518**	**516**	**515**	**514**	**533**
Sample	**134**	**127**	**108**	**110**	**147/9**	**147/7**	**121**	**124**	**120**	**147/5**	**147/2**	**119**	**147/1**	**152/5**	**152/4**	**103**	**152/3**	**152/2**	**152/1**	**113**
Candona neglecta	x(j)	x(j)	xx(j)	xx	–	–	xx(j)	xx(j)	xx(j)	x(j)	xx(j)	xx(j)	xx(j)	x(j)	–	x(j)	–	–	x(j)	–
Ilyocypris sp.	–	x	–	x	–	–	–	x	–	–	–	–	–	–	–	x	–	–	–	–
Prionocypris zenkeri	x	–	x	x	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Eucypris pigra	x	x	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Note: Organic remains are logged on a presence (x)/absence basis only
KEY: Ostracods are logged as follows: x – a few specimens; xx – common; (j) mainly juveniles

Table 5.20 OSL dating results from 3776TP and 3777TP

Zone	Site Code	Intervention	Phase	Context	Sample	Lab ID	Depth (m)	OSL date (KBP)	Error range (± KBP)
1	ARC ZR400	3776TP	3776-F	525	155	X-275	4.10	128.28	11.43
1	ARC ZR400	3776TP	3776-C	536	158	X-276	4.75	–	–
1	ARC ZR400	3777TP	3777-B	606	233	X-277	4.20	48.34	7.14

found in sample 102 (context 526, 3776-G). This species has a large range extending from the Urals, southwards to the Caspian and westwards into southern Scandinavia and The Netherlands (Meier-Brook 1983). It has not been found living in the British Isles but it is known as a fossil at one British site (Histon Road, Cambridge), thought to date to MIS 7, where a single shell was reported (Preece 2003). The diversity of the aquatic assemblages from this sequence indicate, in the sampled horizons, a substantial and permanent waterbody that would have supported a rich aquatic vegetation. The terrestrial taxa indicate that this would have been bordered by marshland, with some evidence of deciduous woodland at the base of phase 3776-D. The assemblage indicates deposition during a temperate climate.

Ostracods

In total, 20 samples were investigated in detail of which only 14 contained ostracods (Table 5.19). Only four species of ostracods were discovered. For the most part the ostracods are represented by juvenile candonids (probably *Candona neglecta*) throughout much of the sequence. Additional species (*Prionocypris zenkeri*, *Eucypris pigra* and *Ilyocypris* sp.) are present at the base of the sequence (contexts 529–537, 3776-D to 3776F). This information indicates spring-fed pool contexts; however, there is a possibility that reworking or sediment sorting and a complex taphonomic history may be associated with these faunas.

Dating

Three different sources of evidence provided dating indications are reviewed below. The amino acid approach was applied to *Bithynia* opercula from the main part of the sequence (Table 5.12), and gave a consistent MIS 7 result for all horizons dated. Biostratigraphic indications also suggested MIS 7. The single OSL date (Table 5.20) gave, in contrast, a much younger date of *c* 130KBP, equating with MIS 6–5e, for the fluvial sand bed 525, towards the base of depositional phase 3776-F. The wealth of independent evidence for MIS 7, together with the long-standing geological recognition that fluvial deposits of Last Interglacial age would be very unexpected at the altitude of the interglacial horizons investigated here, mean that this OSL result must be recognised as erroneous.

Bithynia opercula from a series of samples throughout the fluvial interglacial sequence, covering phases 3776-D through to 3776-G (*cf* Table 5.12), were analysed for multiple D/L amino acid ratios (Appendix E). The results (Fig 5.8) consistently show all the dated horizons as being attributable to MIS 7. Interestingly, they cluster a little younger than both the independently dated MIS 7 reference point – derived on material from Ilford (Uphall Pit) and Lion Pit (Freshwater Brickearth (Schreve *et al* 2006; Penkman *et al* 2008) – and the assemblage from bed 2a at Site A. Within the sequence, there is a weak coherence with stratigraphical order. The two topmost samples, E16 and E9 from 3776-G both give the youngest-looking results. Beneath this level, patterning is less clear-cut, with the oldest-looking results coming from sample E10, from the middle of the sequence, and the samples from the base of the sequence (phase 3776-D) giving results only marginally older than those from the top.

OSL dating was carried out at the site in 2000 by Dr E Rhodes (then of University of Oxford). Two determinations were attempted from 3776TP, one from the major fluvial sand body of phase 3776-F (context 525), and the other from towards the base of the exposed sequence, phase 3776-C (context 536). The latter proved problematic to process (E Rhodes pers comm) and no dating result was obtained. The former

Table 5.21 Synthesis, 3776TP

Phase	Context	Depositional environments	Climate	Environment	Dating (AAR)	Dating (OSL)	Dating (biostrat)
3776-H	501–514	Low energy slopewash		Slope			
3776-G	515 516	Periodic alluvial flooding and weathering	Temperate	Marshland with periodic flooding from active channel; some weathering	MIS 7 MIS 7	–	–
3776-F	522 523 520 521 525	Fluvial channel and bars in medium to high energy situations	No data	Channels and bars	–	MIS 6/5e	–
	529	Fluvial	Temperate	Marshland surrounded by damp grassland	MIS 7	–	–
	526	Fluvial with erosion of underlying sequences	Temperate	Marshland surrounded by damp grassland	MIS 7	–	–
3776-E	527	Fluvial with variable water depths, deeper at bottom, becoming shallower and stagnating upward	Temperate	Local marsh and damp, open grassland	MIS 7	–	–
3776-D	528 537	Low energy fluvial, freshwater	Fully temperate, peak interglacial	Aquatic slow moving/still water in back channel with local springs. Local marsh and reed-beds, swamps, damp grassland, scrub and deciduous woodland	MIS 7	–	MIS 7
3776-C	536	–	–	Freshwater	–	–	–
3776-B	538	–	–	–	–	–	–
	539	–	–	–	–	–	–
3776-A	540	–	–	–	–	–	–

gave a result of *c* 128.28±11.43KBP towards the end of MIS 6 or the start of MIS 5e (Table 5.20). However, this contradicts the wealth of other evidence suggesting MIS 7, particularly the multiple amino acid determinations, so this OSL result must be regarded as suspect.

There are at least two biostratigraphical indicators that also independently suggest a MIS 7 date for the interglacial sequence. In the vertebrate fauna, the variant of northern vole (*Microtus oeconomus*) present through the sequence, scarce in many levels, although abundant in samples 126 and 108 from phases 3776-E and 3776-F, is consistently of the distinctive form associated with MIS 7 and MIS 6 (*cf* Parfitt *et al*, Appendix C1). Furthermore, the small-sized mammoth material is consistent with, although not definitive of considering its meagre quantity, the small sized 'Ilford-type' mammoth characteristic of MIS 7 (Lister, Appendix C3).

3776TP Overview

The combined evidence from the investigations at 3776TP suggest that the lower half of the sequence seen represents the build-up of water-lain deposits through part of MIS 7 including at their base a fully temperate episode (Table 5.21). The lowest recorded deposit was the gravel of phase 3776-A, the upper surface of which occurred just below 6m OD, and the base of which was not established. There is no information on the climatic and environmental conditions associated with its deposition, but, according to Bridgland's (2001) model, one would expect this to be a fluvial gravel laid down at the end of a cold climatic phase preceding the amelioration represented in the overlying deposits. There are likewise no biological data in the immediately overlying sand/silty sand deposits of phase 3776-B, although they appear, on sedimentological grounds, to represent a continuation of fluvial deposition under quieter conditions than the underlying gravel.

After this, there is rich faunal evidence for depositional conditions, climate and local environment for the overlying phases 3776-C through to 3776-G. All the deposits through this sequence contained evidence suggesting fluvial deposition under temperate conditions. The deposits of phases 3776-C through to 3776-E represent an initial cycle during which a permanent waterbody gradually becomes slightly less energetic, and perhaps shallower. The climate at this time is the warmest represented in the sequence, with evidence of fully temperate conditions and local woodland at the base of the sequence (3776-D), with more open grassland in 3776-E, possibly associated with slightly cooler conditions. After this, there is a further cycle with a return to slightly more active conditions represented in the coarser, bedded sands of 3776-F, probably laid down by a substantial waterbody. These deposits mostly lack faunal remains, apart from in their basal contexts 526 and 529 which show an increase in small mammals reflecting an expansion of local marsh and grassland.

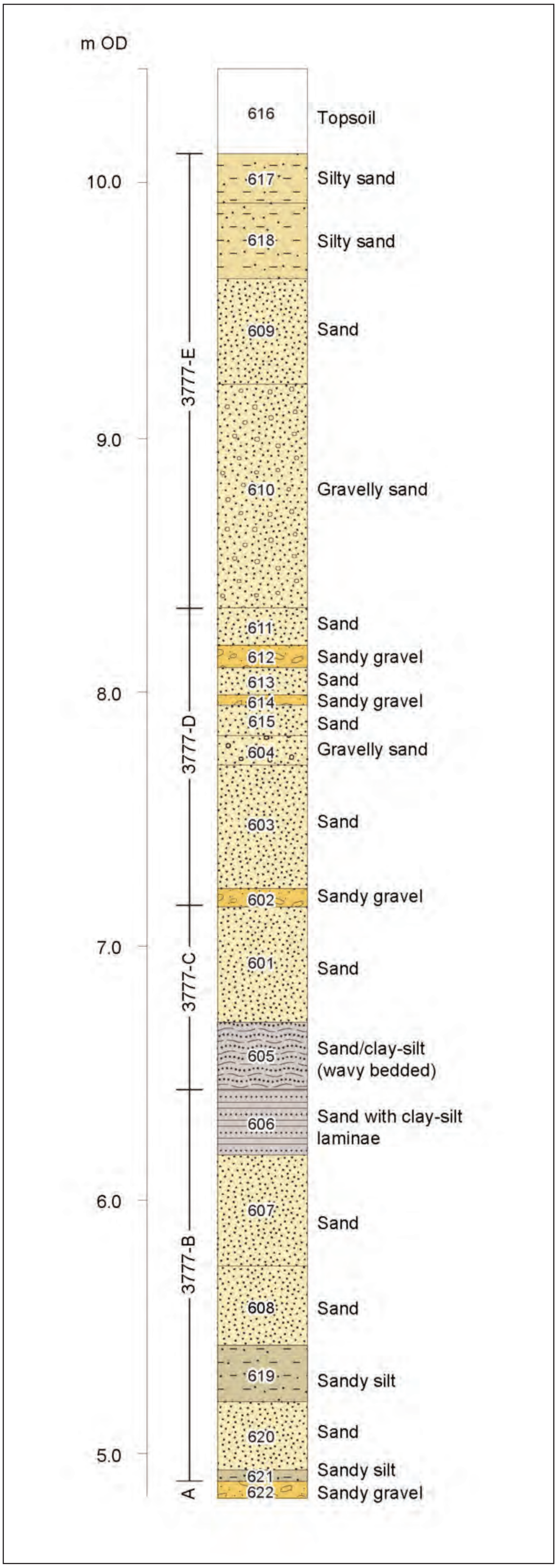


Figure 5.15 3777TP: log through full sequence with phasing

Above these, there is a phase of stagnation and drying represented in deposits of phase 3776-G. These contained molluscs representing periodic alluvial flooding, alongside sedimentological and small vertebrate indications of stagnating marshland, with a massive dominance of amphibians and evidence of weathering and biological homogenisation of the sediment. The cohesive olive silts of context 516 of this phase, which thicken and rise to the east, are very similar in appearance and nature to beds 3c, 3d and 3e at Site A, which outcrop *c* 70m to the west in the section of Carreck's Channel A (*cf* Fig 5.1). Although appearance and sedimentological consistency are insufficient grounds for correlation, the similarity of the depositional and environmental indicators – stagnating marshland with open grassland and mild temperate, but not warm, conditions – are also very similar, making it worth considering whether these deposits are direct lateral equivalents despite the contrasting mollusc assemblages; if these deposits were laterally equivalent, the greater fluvial elements from phase 3776-G could represent a lower more fluvially active part of the deposit.

Finally, the sequence is capped by a substantial thickness of colluvial slopewash sediments (phase 3776-H), which dip to the east conformably with the present-day ground surface. These sediments contain no environmental indicators (other than a few ostracods that may have been reworked) or archaeological remains, nor were any OSL dates attempted. They are likely to be of late Middle or Late Pleistocene age in their lower parts, and probably include at some point a transition to Holocene sediments in their upper part.

3777TP (ARC ZR498/00)

by Francis Wenban-Smith, Martin Bates, Richard I Macphail, Simon A Parfitt, Kirsty Penkman, Richard Preece, Ed Rhodes, Jean-Luc Schwenninger, John R Stewart and John E Whittaker

Introduction

This trench represents another part of the works associated with the new ZR4 pylon, explained in detail above, and represents the second deep excavation, for the other uplift footing. Despite being only 10m away, and a little downslope to the north-east (Fig 5.9), a very different sequence of deposits was discovered, hence the need for a separate section to outline the results. Previous evaluation of the northern half of this footing footprint was carried out as test pit 3423TP under project ARC ZR498.

Lithological Succession

The lithology recorded in the mitigation excavation 3777TP lies between *c* 4.80m and 10.50m OD. As in

Table 5.22 Lithological succession, 3777TP

Phase	Context	Sample	Original sample size (litres)	Small Vertebrates	Molluscs	Ostracods	AAR
3777-E	616	-	-	-	-	-	-
	617	-	-	-	-	-	-
	618	-	-	-	-	-	-
	609	-	-	-	-	-	-
	610	-	-	-	-	-	-
3777-D	611	-	-	-	-	-	-
	612	-	-	-	-	-	-
	613	-	-	-	-	-	-
	614	-	-	-	-	-	-
	615	-	-	-	-	-	-
	604	-	-	-	-	-	-
	603	-	-	-	-	-	-
	602	-	-	-	-	-	-
3777-C	601	201	100	0	0	0	-
		202	100	0	✓	0	✓E11
		203	100	0	✓	0	-
		204	100	0	✓	✓	✓E18
	605	205	100	0	✓	✓	-
		206	100	-	✓	-	-
		207	100	0	✓	-	-
3777-B /3777-C	605/606	208	100	-	✓	-	-
		209	250	0	✓	✓	-
		210	250	✓	✓	-	✓E19
3777-B	607	211	250	0	-	✓	-
		212	100	0	✓	✓	-
		213	100	✓	✓	✓	-
	608	214	150	✓	✓	✓	✓3
		215*	0.25	-	-	0	-
		216*	0.25	-	-	0	-
		217*	0.25	-	-	0	-
	619	218*	0.25	-	-	0	-
		219*	0.25	-	-	✓	-
	620	220*	0.25	-	-	0	-
		221*	0.25	-	-	✓	-
		222*	0.25	-	-	0	-
	410	20**	10	✓	-	-	-
	411	17**	10	✓	-	-	-
	621	223*	0.25	-	-	0	-
3777-A	622	224*	0.25	-	-	✓	-

Note: contexts and samples in stratigraphic order, from base
KEY: ✓ – Present and analysed; 0 – Absent; otherwise (-), not investigated or present in insignificant quantities
* Auger samples; ** Samples from evaluation phase ARC ZR4 98, 3424 TP

3776TP, Pleistocene deposits were not bottomed due to the presence of a dense flint gravel at the base of the recorded sequence (below 5.70m OD, the sequence was recorded by hand augering). The lithological sequence can be subdivided into five major groups of sediments, from the base phases 3777-A up to 3777-E, described below. A diagrammatic log through the full sequence is shown (Fig 5.15), and the accompanying table (Table 5.22) summarises the attribution of contexts to different phases, and the association of key environmental and dating samples with specific horizons. The north-facing and east-facing sections through the most significant part of the sequence is illustrated (Fig 5.16), alongside a photograph (Pl 5.4), which emphasises the contrast between deposits seen in this trench and those of 3776TP.

3777-A: The lowermost deposit consists of a pale brown chalk and flint gravel lying below 4.90m OD. This was encountered at depth in the borehole augered below the trench base (context 622).

3777-B: A sequence of sand and silty sands sometimes exhibiting laminations and occasional flint clasts (Pl 5.4). These deposits lay between 6.42m and 4.90m OD and consisted of contexts 606, 607, 608, 619, 620 and 621. The uppermost context of this group (606) has contorted wavy sub-parallel bedding, and there is an abrupt junction with the base of the overlying context 605, indicative of a depositional hiatus.

3777-C: Yellowish to brownish-yellow sands thickening upslope to the south-west. Laminated in places with some laminations dipping downslope. The sediments

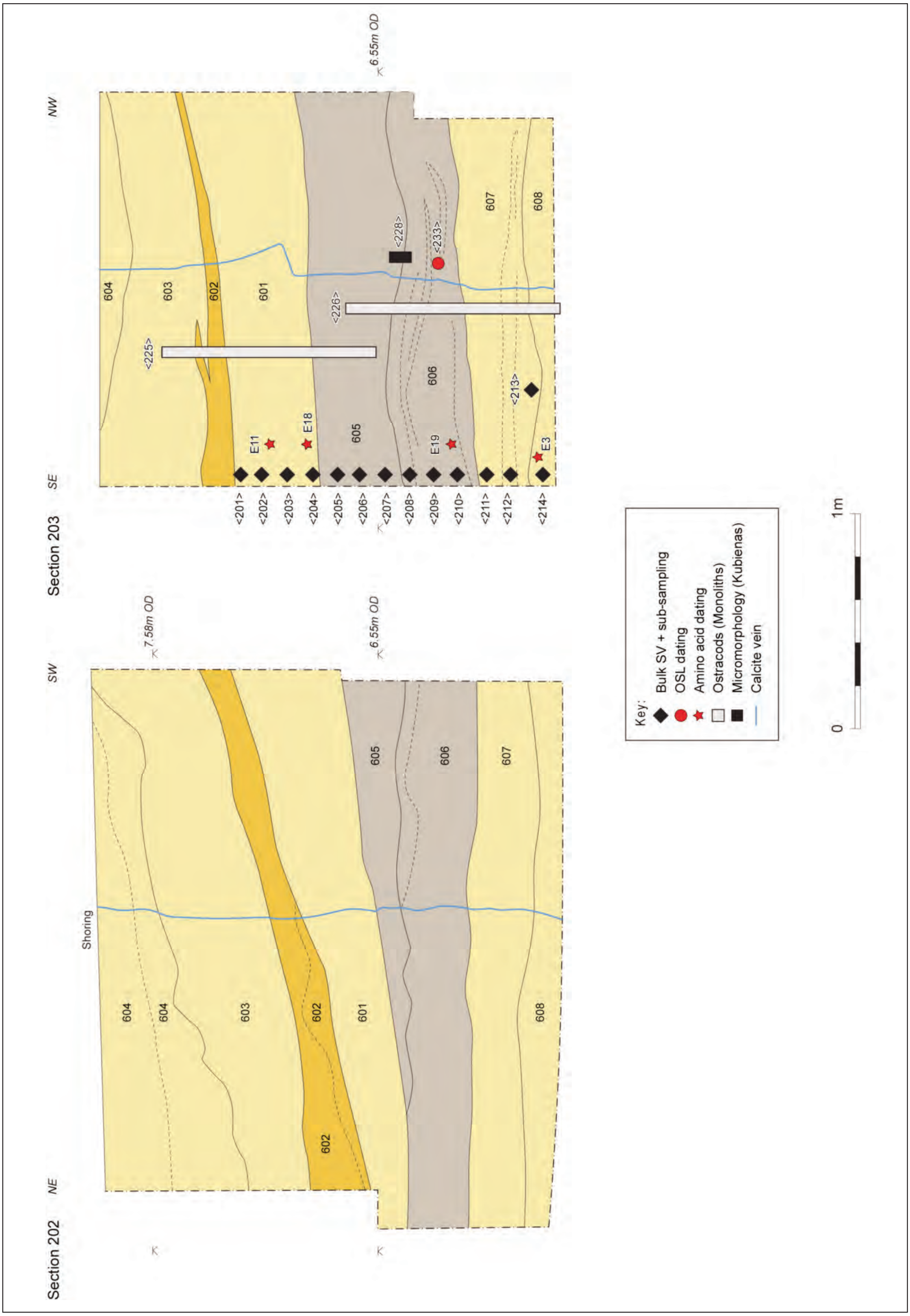


Figure 5.16 3777TP: combined north-west-facing and north-east-facing section through key deposits with contexts, phasing, and key environmental sampling and dating locations

Plate 5.4 3777TP, section 202 (north-west-facing)

lie between 6.42m and 7.16m OD, thinning downslope. This group includes only the two contexts 601 and 605.

3777-D: A group of contexts (611, 612, 613, 614, 615, 604, 603 and 602) consisting of sands, silty-sands and sands with gravels exhibiting a downslope trend (including internal laminations dipping downslope). These deposits occur between 7.16m and 8.32m OD.

3777-E: An upper group of gravels, sands and silty sands all exhibiting downslope trends including 616, 617, 618, 609 and 610.

This sequence of five major groups suggests a progression from high energy fluvial conditions at the base of the sequence (3777-A) towards lower energy channel and floodplain sediment upwards into 3777-B. It is less clear from sedimentary grain-size and structure under what conditions 3777-C accumulated although the overall sediment body geometry suggests a colluvial origin for these deposits. This is investigated below, taking account of a range of micro-faunal evidence. The upper parts of the sequences (3777D and 3777-E) are certainly of colluvial origin.

Sediment Micromorphology

Sediment micromorphological investigation was undertaken on slides prepared from monolith 228, crossing the junction between contexts 606 and 605 (Fig 5.16). The upper part of context 606 and the bottom part of 605 were analysed (Pl 5.5a), representing the transition from phase 3777-B to 3777-C. Full details of the observations are presented in Appendix B, and highlights are given below.

Context 606 (at 60–75mm): This is a massive well-sorted moderately calcareous coarse silt/fine sand consisting of quartz and chalk grains. Some relict fine laminae and humic stained fine fabric traces that are now weakly iron-stained are also noted. There are also occasional very fine iron and manganese impregnations. The sediment displays fine fissures, channels and broad burrow traces. This is interpreted to be a formerly well laminated, well-sorted sediment (a fine colluvium) that was subsequently overprinted by the possible weak development of a humic topsoil and associated structures (rooting and burrowing). When buried by the coarser finely laminated sediments of context 605, minor thin burrowing by an extant small invertebrate mesofauna, mixed the 1–2mm wide boundary between contexts 605 and 606.

Context 605: Three distinct sub-units were noted within the part of context 605 seen in the monolith. Between 30–60mm this context is composed of some 23 very fine (500–1000μm-thick) laminations of relatively 'clean' (elutriated) coarse silt-fine sand size quartz and chalk, and clasts of 'humic soil' and amorphous organic matter (Pl 5.5b–c). The organic matter is now iron and/or iron-manganese replaced. These cyclothems (Reineck and Singh 1986, 184) probably record cool climate, diurnal (seasonal) inwash of eroded 'humic' topsoil (humic cryosols). Between 20–30mm a massive micritic marl with very few included silt, is present (Pl 5.5a). It is slightly iron stained, with minor iron and manganese impregnation, and shows slight fragmentation. This is a pond marl, which formed during a period of very little minerogenic deposition, and presumably records a period of stability. Subsequently, the marl became slightly weathered and fragmented, possibly by ensuing cooler conditions.

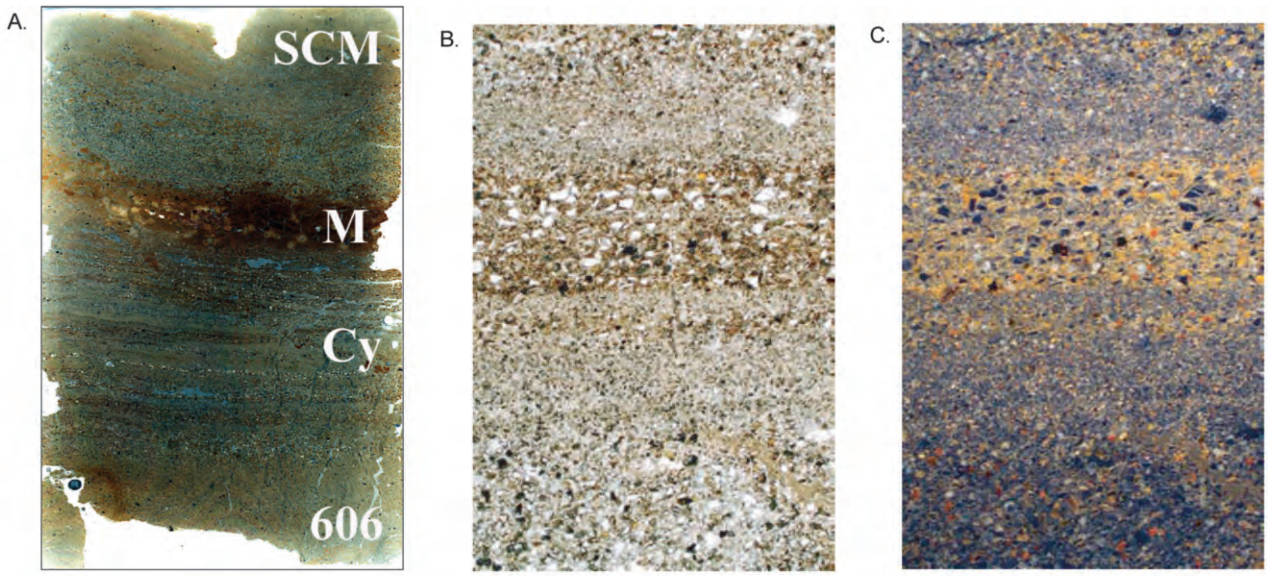


Plate 5.5 Micromorphology photographs from sediments analysed 3777TP (ARC ZR400) in Zone 1 (selected from Appendix B, Fig B1, 4, 31 and 32): (a) Scan of M228; at the base, context 606 is a massive well sorted calcareous coarse silt-fine sand; above, context 605 is composed of regular laminae – cyclothems (Cy) (see B and C), an iron-stained marl (M) and an overlying silty calcareous mud (SCM). Width is ~50mm; (b) M228 (context 605); example of 'clean' silts (centre) and laminae sometimes rich in very fine humic soil fragments (top) – forming some 23 'cyclothems' (see A). PPL, frame height is ~4.62mm; (c) As B, under OIL; showing iron-stained fine humic soil fragments in top layer

Table 5.23 Small vertebrate summary, 3777TP, species presence/absence

Phase	3777-B			3777-C/3777-B
Context	**608**	**607**	**607**	**606**
Sample	**214**	**213**	**410**	**210**
PISCES	–			
Esox lucius L., pike	+	+	–	–
Cyprinidae gen. et sp. indet., carp family	+	+	–	–
Gasterostidae, stickleback	+	+	–	–
Platichthys flesus L., flounder	–	+	–	–
AMPHIBIA				
Triturus sp., newt	+	+	–	–
Bufo sp., toad	–	+	–	–
Rana temporaria L., common frog	+	–	–	–
Rana sp., common frog	–	+	–	–
Anuran indet., indeterminate anuran	+	+	+	+
REPTILIA				
Ophidia undet., unidentified snake	–	+	–	–
AVES				
? Passeriformes indet., ? song bird	–	+	–	–
MAMMALIA				
Soricomorpha				
Sorex minutus L., pygmy shrew	–	+	–	–
Sorex cf. *minutus* L., ? pygmy shrew	–	+	–	–
Neomys sp., water shrew	+	+	–	–
Rodentia				–
Arvicola cantianus (Hinton), water vole	–	+	–	–
Microtus sp., vole	+	+	–	+

KEY: + – present

Finally, the upper 20mm consists of massive calcareous coarse silt-fine sands, which display relict fine laminae; the latter have been mixed and fragmented by burrowing. These develop upwards into a fine silty calcareous mud (Pl 5.5a). This sub-unit records renewed colluvial calcareous deposition and minor *in situ* weathering.

Vertebrates

In comparison to the complex succession observed in 3776TP, the sequence at 3777TP is condensed and none of the deposits are particularly rich in vertebrate remains (Tables 5.23–25). Samples from four contexts (upward through the sequence: 620, 608, 607 and 606), yielded sparse assemblages of identified vertebrates (Table 5.24), together with many fragments. These contexts all come from within phase 3777-B, although the sample from context 606 may include some sediment from the base of the overlying phase 3777-C; these overlying deposits were, however, devoid of faunal remains in all other samples, so it is likely that the few remains found come from context 606. The fauna that could be identified is very similar in content to that from phase 3776-G in 3776TP, with a dominance of amphibians and very low numbers of fish and small mammal remains (Fig 5.17). The sparse small mammal fauna (Table 5.24) also resembles that of 3776-G, with vole (*Microtus* sp. and *Arvicola*) being the most abundant small mammal taxa. Water shrew (*Neomys* sp.) and pygmy shrew (*Sorex minutus*) are surprisingly common in this small assemblage. The faunal similarities are not just restricted to the taxonomic composition of the small mammal fauna or the relative proportions of small mammal, amphibian and fish remains. The fish assemblage is likewise overwhelmingly dominated by sticklebacks, with lesser quantities of pike (*Esox lucius*) and cyprinids. Of particular interest is the presence of flounder (*Platichthys flesus*), identified from a single dermal denticle in context 607. Flounder may not necessarily indicate brackish conditions. Although they spend most of their life in brackish estuaries and bays, flounders commonly penetrate upstream into the lower reaches of rivers, especially in colder regions. Although flounder is not present in 3776TP, the faunal similarities suggest an association between the fossiliferous sediments of phase 3777-B and those of phase 3776-G (*cf* ZR4 *3777TP Overview*, below).

A single bird bone was also found in context 607 (phase 3777-B), of an undetermined passerine (Stewart, Appendix C4).

Molluscs

Twelve samples were analysed from this sequence (Table 5.26), only one of which (sample 214, context 608, 3777-B) yielded significant numbers of shells. The assemblage from this sample is dominated by opercula of *Bithynia tentaculata* and both *Valvata cristata* and *Valvata piscinalis* are present. There are some apparent similarities between this sample and the samples of phase 3776-D, in the balance of the three dominant species and the frequency of land snails; there are, however, more *Pupilla*. A similar environment is represented. Higher up the sequence, the three samples from context 601 (phase 3777-C) show quite a different fauna, consisting entirely of land taxa and dominated by *Pupilla muscorum* (bar two *Bithynia* opercula, probably derived).

Table 5.24 Identified small mammals, 3777TP

Phase	**3777-B**		**3777-C/ 3777-B**
Context	**608**	**607**	**606**
Sample	**214**	**213**	**210**
Soricomorpha			
Sorex minutus L., pygmy shrew	–	1 (1)	–
Sorex cf. *minutus* L., ? pygmy shrew	–	1 (1)	–
Neomys sp., water shrew	1 (1)	1 (1)	–
Rodentia			
Arvicola cantianus (Hinton), water vole	–	3 (2)	–
Microtus sp., vole	1	9	1

Ostracods

Twenty-four samples contained ostracods in this sequence, from phases 3777-A through to 3777-C (Table 5.27). Although never common, there are at least 10 species present, of which four are cold indicators (colour-coded blue on Table 5.27). Although *Candona neglecta* is present, both as adults and juveniles, the majority of candonids are *C. candida*. Despite being a common species today, as is *Limnocytherina sanctipatricii*, both are considered to be cold/cool indicators. These are joined by the extinct cold indicator species, *Leucocythere batesi* and *Amplocypris tonnensis*. The strongest indication of cool conditions comes from context 606 towards the top of phase 3777-B, where many samples showed co-occurrence of more than one

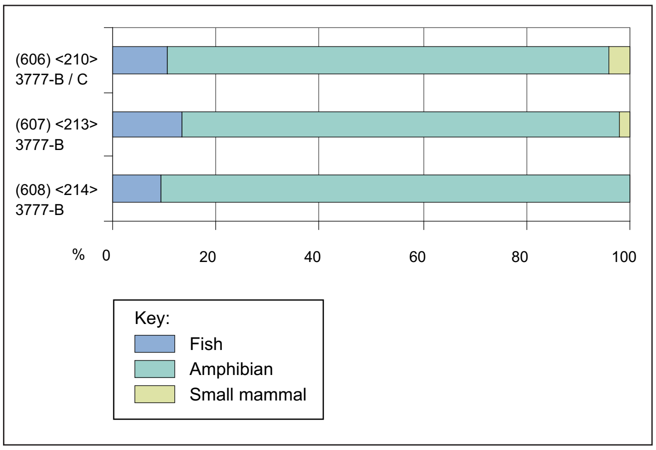


Figure 5.17 Graph showing changes in the composition (% number of identified specimens) of the small vertebrate assemblages from 3777TP

Table 5.25 Sample details, 3777TP

Phase	**3777-B**							**3777-C/B**			**3777-C**				
Context	**410 [=620]**	**608**	**608**	**607**	**607**	**607**	**607**	**606**	**606**	**605**	**605**	**601**	**601**	**601**	**601**
Sample	**20**	**214**	**214**	**213**	**213**	**212**	**211**	**210**	**209**	**207**	**205**	**204**	**203**	**202**	**201**
Sorting	**1**	**2**	**3**	**3***	**2**	**2**	**2**	**3**	**2**	**2**	**2**	**2**	**2**	**2**	**2**
No. of samples (Volume in L.)	1 (2)	1 (30)	1 (120)	1 (80)	1 (20)	1 (20)	1 (40)	1 (250)	1 (40)	1 (20)	1 (20)	1 (20)	1 (20)	1 (20)	1 (20)
Fish	–	–	27 (4)	287 (10)	–	–	–	–	–	–	–	–	–	–	–
Amphibian	1	21	48 (1)	298 (9)	16	1	–	8	1	–	–	–	–	–	–
Reptile	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–
Bird	–	–	–	6	–	–	–	–	–	–	–	–	–	–	–
Small mammal	2	3	8	66	4	–	–	3	–	–	–	–	–	–	–
Total	**3**	**24**	**88**	**677**	**20**	**1**	**0**	**11**	**1**	**0**	**0**	**0**	**0**	**0**	**0**
NISP/L.	1.5	0.8	0.7	8.5	1	0.05	0	0.04	0.02	0	0	0	0	0	0

Table 5.26 Molluscs from 3777TP

	Sand	Horizontally laminated sands/silts	Horizontally laminated sands/silts	Laminated sands/silts	Laminated sands/silts	Laminated sands/silts	Laminated sands/silts	Laminated sands/silts	Laminated sands/silts	Sands/silts	Sands/silts	Sands/silts
Phase (3777-)	**B**	**B**	**B**	**B/C**	**B/C**	**B/C**	**B/C**	**B/C**	**B/C**	**C**	**C**	**C**
Context	**608**	**607**	**607**	**605/6**	**605/6**	**605/6**	**605/6**	**605/6**	**605/6**	**601**	**601**	**601**
Sample	**214**	**213**	**212**	**210**	**209**	**208**	**207**	**206**	**205**	**204**	**203**	**202**
Sample volume/weight	**20 l**	**20 l**	**20 l**	**5 kg**	**5 kg**	**5 kg**	**20 l**	**20 l**	**20 l**	**20 l**	**20 l**	**20 l**
Freshwater taxa												
Valvata cristata Müller	25	3	–	–	–	–	–	–	–	–	–	–
Valvata piscinalis (Müller)	7	1	–		–	–	–	–	–	–	–	–
Bithynia tentaculata (Linnaeus) shells	19	1	1	–	–	–	–	–	–	–	–	–
Bithynia tentaculata opercula	126	9	4	3	–	–	–	–	–	1	–	1
Galba truncatula (Müller)	12	2	–	–	–	–	–	–	–	–	–	–
Radix balthica (Müller)	4	1	–	–	–	–	–	–	–	–	–	–
Planorbis planorbis (Linnaeus)	2	+	–	–	–	+	–	–	–	–	–	–
Anisus leucostoma (Millet)	18	–	–	–	–	–	–	–	–	–	–	–
Anisus vortex (Linnaeus)	1	–	–	–	–	–	–	–	–	–	–	–
Planorbidae indet.	2	–	–	–	–	–	–	–	–	–	–	–
Gyraulus crista (Linnaeus)	3	2	–	–	–	–	–	–	–	–	–	–
Planorbarius corneus	1	–	–	–	–	–	–	–	–	–	–	–
Musculium lacustre (Müller)	3	–	–	–	–	–	–	–	–	–	–	–
Pisidium henslowanum (Sheppard)	1	–	–	–	–	–	–	–	–	–	–	–
Pisidium nitidum Jenyns	1	–	–	–	–	–	–	–	–	–	–	–
Pisidium spp.	4	1	–	–	–	1	–	–	–	–	–	–
Land taxa												
Carychium minimum Müller	–	–	–	–	–	–	–	–	–	–	3	1
Succineidae	2	–	–	–	–	–	–	–	–	–	–	–
Vertigo sp.	1	–	–	–	–	–	–	–	–	–	–	–
Pupilla muscorum (Linnaeus)	5	–	1	2	–	1	–	7	–	–	4	12
Deroceras/*Limax* spp.	5	–	–	–	–	–	–	1	–	–	–	–
Total	242	20	6	5	0	2	0	8	0	1	7	13

KEY: + – present

Table 5.27 Ostracods from 3777TP

Phase	**3777-D**		**3777-C**							**3777-B**					
Context	**603**		**601**		**605**					**606**					
Sample	**225/2**	**225/6**	**225/11**	**204**	**205**	**225/15**	**226/1**	**226/2**	**226/3**	**209**	**226/5**	**226/6**	**226/7**	**226/8**	**226/9**
*Leucocythere batesi**	–	–	x	–	–	–	–	x	–	–	–	–	–	–	–
Eucypris pigra	–	–	–	–	–	–	–	x	–	x	–	–	–	x	–
Candona candida	–	–	–	–	–	–	–	–	x	x	x	x	x	x	x
Ilyocypris sp.	–	–	–	x	x	–	–	–	x		–	–	x	x	x
Potamocypris zschokkei	–	–	–	–	–	–	–	–	–	x	–	x	–	–	–
Candona neglecta	–	–	–	–	–	–	–	–	–	x	–	–	–	–	–
Limnocytherina sanctipatricii	–	–	–	–	–	–	–	–	–		–	–	–	–	x
*Amplocypris tonnensis**	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Cyclocypris sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Pseudocandona sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Phase	**3777-B**												**3777-A**
Context	**607**							**608**			**619/620**	**620**	**622**
Sample	**211**	**226/10**	**226/11**	**212**	**226/12**	**213**	**226/13**	**214**	**226/14**	**226/15**	**219**	**221**	**224**
*Leucocythere batesi**	x	–	–	–	–	–	–	–	–	–	–	–	–
Eucypris pigra	–	–	x	–	x	–	–	–	x	x	–	–	–
Candona candida	x	x	x	x	xx	x	x	x	x	xx	x	x	x
Ilyocypris sp.	x	–	x	x	–	x	–	x	x	x	–	x	–
Potamocypris zschokkei	x	–	x	x	–	–	–	x	x	x	x	–	x
Candona neglecta	x	–	–	x	–	–	–	x	–	–	–	x	–
Limnocytherina sanctipatricii	–	–	–	–	–	–	–	–	–	–	–	–	–
*Amplocypris tonnensis**	–	x	x	–	x	–	–	–	–	–	v	–	–
Cyclocypris sp.	–	–	–	x	x	x	x	–	x	x	x	–	–
Pseudocandona sp.	–	–	–	–	–	–	x	–	x	–	–	–	–

* species extinct within MIS 5–2
KEY:
Ostracods are logged as follows: x – a few specimens; xx – common; (j) mainly juveniles
Shaded blue – cold/cool ostracod indicators

cold indicator species. The presence of the ostracod *Potamocypris zschokkei* suggests this was a fauna developing in a spring-fed pool.

Dating

Two different sources of evidence provided dating indications. The amino acid approach was applied to both *Pupilla muscorum* (context 601, phase 3777-C) and *Bithynia* opercula (contexts 608 and 605/606 from phase 3777-B, and context 601, phase 3777-C) – see Table 5.22; full results are given in Appendix E, and a summary of the key points is given here. All of the *Bithynia* gave a consistent MIS 7 result (Fig 5.8). However, opercula were extremely scarce in contexts 601 and 605/606, suggesting possible derivation. The framework for dating *Pupilla* is much less robust than for *Bithynia* opercula. Nonetheless, results for a range of amino acids were compared for *Pupilla* from a number of horizons in Zones 1 and 3, in the hope of (a) investigating their relative dates and (b) getting an idea of their absolute date in comparison to dated reference material (Fig 5.18). The results suggest a date in the range of MIS 7 to MIS 6 for the shells from context 601, just a little younger than the Harnham result (late MIS 8) (Bates *et al* 2013), but not so young as the Cassington result (MIS 5a).

The single OSL date (Table 5.20) gave, in contrast, a very much younger date of *c* 50,000 BP (48.34±7.14KBP), in the middle of the last glaciation, MIS 3, for context 606, towards the top of depositional phase 3777-B. The sample was "well suited for OSL dating" (E Rhodes pers comm) so there is no intrinsic reason to reject this date from the analytical viewpoint. These discrepancies are considered in the following sub-section, which presents an interpretive overview of the evidence from 3777TP.

3777TP Overview

The evidence from 3777TP presents a number of contradictions. Firstly, the ostracod evidence from phase 3777-B gives a clear indication of cool/cold climate in spring-fed pools, whereas the molluscan evidence suggests a major permanent flowing waterbody during temperate conditions, with similarities to the molluscan assemblage from phase 3776-D, from the peak interglacial horizon towards the base of the 3776 sequence. Secondly, the small vertebrate fauna from 3777-B likewise are consistent with temperate climatic conditions, but this time exhibit marked similarities to the fauna from phase 3776-G at the top of the 3776TP interglacial sequence. Thirdly, there are the discrepancies between the MIS 3 OSL dating result from context 606 towards the top of phase 3777-B and: (a) the MIS 7 AAR result from a single *Bithynia* operculum from the same horizon; (b) the MIS 7 AAR results from both a *Bithynia* operculum and some amalgamated *Pupilla* from the higher context 601; and (c) the MIS 7 AAR results from three opercula from the slightly lower context 608. Finally, despite being only 10m to the north-east of 3776TP, there is the fundamentally different nature of the lower/middle parts of the sequence, with the sequence at 3777TP lacking any deposits at all similar to the sands, clays and silts of phases 3776-C to 3776-G.

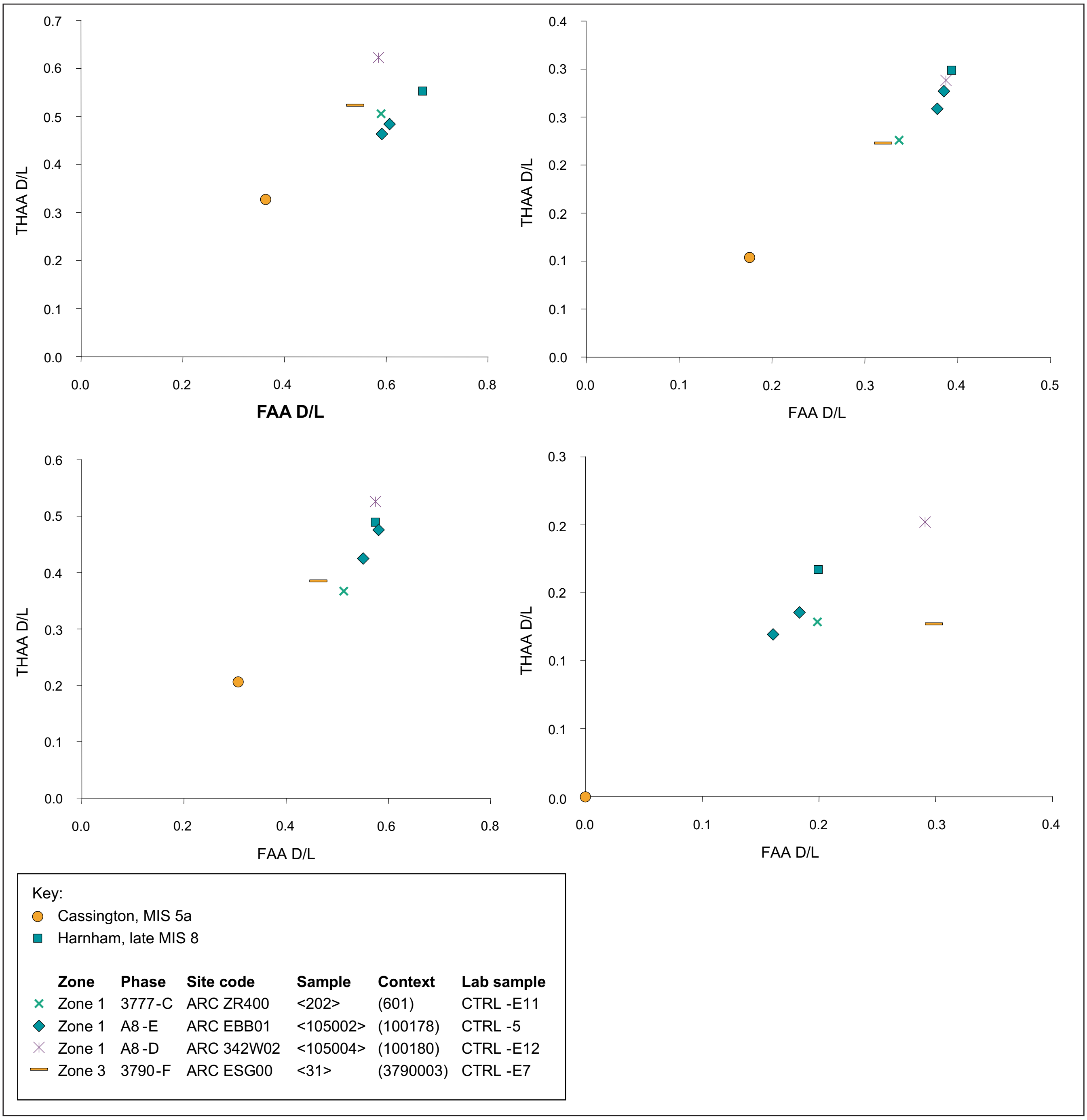


Figure 5.18 Amino acid dating of *Pupilla* from Zones 1 and 3: 3777TP; 3790TT; and Area 8 batter

Although there are no environmental remains or dating indicators, other than some cool/cold ostracods from the upper part of the Phase 3777-A gravel, it seems likely that the basal gravels in both sequences are equivalent, being so close together and with the upper surfaces at similar altitudes (between 5m and 6m OD). Above this, the appearance of deposits of phase 3777-B is quite similar to the basal parts of phase 3776-H, as seen dipping to the north-east in Section 105 of 3776TP, at an angle which would, if continued to the north-east, marry up with the deposits of phase 3777-B. We suggest here that the cold climate ostracod fauna from 3777-B is most likely to be genuinely autochthonous, and that the contrasting environmental indications from the mollusc and small vertebrate remains results from them having been reworked from previously underlying deposits equivalent to phases 3776-C through to 3776-G.

This would also explain the discrepancies between the OSL and the AAR dating results. Although the MIS 3 OSL result cannot perhaps be relied upon, considering the proven fallibility of the MIS 5e/6 result from 3776TP, it may indicate a younger date for a phase of colluvial mobilisation after the MIS 7 aggradation. The opercula dated to MIS 7 from context 608 would all be derived under this scenario, despite their abundance.

Higher up the sequence, for phases 3777-C through to 3777-E, the micro-morphological evidence from the

605/606 junction, the molluscan evidence from context 601 and the general sedimentary structure and geometry of the deposits will provide good evidence of a continuing build up of colluvial slopewash sediments. The scarce *Bithynia* opercula dated to MIS 7 from contexts 605/606 and 601 are likely to be derived. The *Pupilla* from context 601 would be less likely to be derived, particularly as this species was virtually absent in the sequence from 3776TP. The framework for dating *Pupilla* by AAR is much less robust than for *Bithynia* opercula, but, taken at face value, the result suggests the period MIS 7 to MIS 6 for deposition of context 601, both of which are possible as MIS 7 incorporates a significant cool stadial MIS 7b (or MIS 7.4 *sensu* Bassinot *et al* 1994), during which large-scale colluvial mobilisation is highly feasible, as well as other lesser cool/cold fluctuations. There are no other indications of dating through the sequence, although it probably includes the Pleistocene/Holocene boundary at some point within phase 3777-E.

Area 8 Batter (ARC 342W02)

by Francis Wenban-Smith, Martin Bates, Kirsty Penkman, Richard Preece, Tom S White and John E Whittaker

Introduction

The route of HS1 passed through DBA Area 8, immediately to the east of the area of Scheduled Ancient Monument Kent 267a (which was labelled as DBA Area 1). The west side of the HS1 cutting thus formed a major sloping section – a 'batter' – along the east side of Area 1. This exposed a series of sediments that were cleaned and recorded (under the Ebbsfleet West watching brief project ARC 342W02) as Section 103020 over a distance of *c* 80m at the northern end of Area 1, at its boundary with Area 8 (Fig 5.1). Environmental sampling was carried out from certain finer grained horizons, leading to recovery of molluscs and ostracods, discussed below. As well as these remains, a number of unidentifiable small vertebrate remains were also recovered from one of the bulk samples, 105004 from context 100180, but these were of no analytical potential, so are not considered further.

Lithological Succession

The sequence recorded lies between *c* 4.5 and 11m OD. Pleistocene deposits were not bottomed to the Chalk bedrock along the majority of the recorded section, although bedrock rose immediately to its north, forming a bank against which the Pleistocene sequence abutted. The sequence is illustrated (Fig 5.19), which also shows the bulk sampling locations. The deposits, described below, can be sub-divided into five major groups of sediments.

A8-A: The stratigraphically oldest deposit consists of a pale chalk rubble deposits at the northern end of the batter (100188).

A8-B: A sequence of two chalk-rich deposits, one containing flint clasts (100187) and the other silt, sand and gravel (100186), overlie A8-A and are noted to finger out into the A8-E deposits.

A8-C: This consists of a single layer (100185) consisting of a flint gravel with a sandy matrix rich in derived Tertiary shell fragments. The base of this deposit was not reached, although was shown in a nearby service trench to extend down at least 0.75m. Its upper surface was gently undulating along the exposure seen, varying in elevation between 4.50m and 5.15m OD, rising shallowly to the south-west.

A8-D: This phase directly overlies gravel 100185, and consists of cross-bedded fine-medium sands with occasional derived Tertiary shell fragments (100184) that mostly themselves directly overlie the gravel, but occasionally there is a thin sandy clay-silt layer (100180) interspersed between the gravel and the cross-bedded sands. The upper surface of this group of deposits is a sharp unconformable truncation, and that deposits themselves seem to have been contorted during the process of deposition of the overlying sediments. A 50-litre bulk environmental sample 105004 was taken from the clay-silt 100180, sub-sampled for molluscan and ostracod analysis, and the remainder processed for small vertebrate remains.

A8-E: An upper group of sediments, dominating the sequence, and mostly consisting of silty sand bodies (100181 and 100183) with fine parallel sand and silt bedding. The upper of these sand bodies (100181) incorporated a sand/gravel filled gully (100182); and the lower (100183) incorporated towards its base a series of thin bands of pale grey, more clay-silty, fine sand (100177, 100178 and 100179), one of which was observed in the field to contain mollusc remains. One 20-litre bulk environmental sample was taken from each of these latter three layers, 105001, 105002 and 105003 respectively. The latter sample was lost but the others were sub-sampled for ostracod analysis, and the remainder processed for small vertebrate and molluscan remains.

This sequence suggests a progression from slope-derived cold climate solifluction deposits (A8-A/B) resting in valley marginal situations towards fluvial conditions away from the valley side. High-energy fluvial conditions abutting the solifluction deposits are noted (A8-C) that pass upwards to lower energy fluvial sands (A8-D). The full sequence is buried unconformably by a series of sediments of probable colluvial derivation (A8-E) with the edge of a possible fluvial channel (100182). The uppermost parts of A8-E are probably Holocene in age, but the position of the base of the Holocene sequence is uncertain.

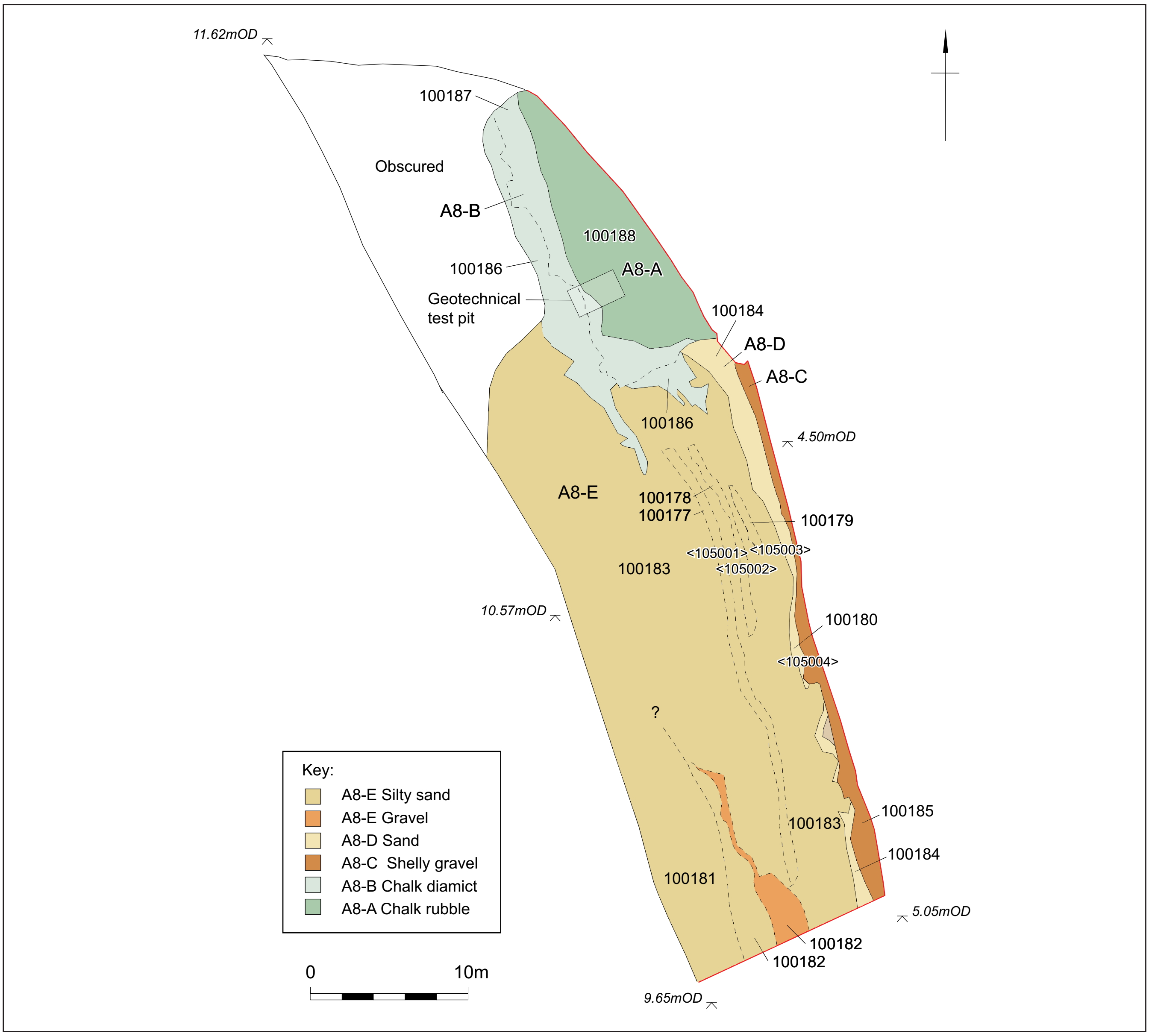


Figure 5.19 Area 8 batter, Section 103020, showing lithological phasing and sampling locations (plan view)

Molluscs

Only three samples survived from the four originally recovered from the Area 8 batter section, sample 105003 being mislaid. Two of these samples (samples 105001 and 105002, contexts 100177 and 100178 respectively) derived from clay-silt beds towards the bottom of the silty sands of colluvial origin from A8-E, while the other sample (105004, context 100180), derived from A8-D, immediately above gravel 100185. The latter sample contained only eight shells, but molluscan remains were progressively more abundant further up the sequence (Table 5.28). All contained a similar fauna dominated by the amphibious gastropod *Galba truncatula* and the land snail *Pupilla muscorum*. The latter dominates by a factor of 7–10 in the lower two samples, but in the highest sample the situation is reversed and *G. truncatula* is almost twice as abundant as *P. muscorum*, with the additional minor presence of two freshwater species. This fauna is consistent with deposition during a cold stage, although accumulation in a more temperate climate cannot be excluded as there are no obligate cold-adapted taxa. Also present were a number of derived fossils, including the distinctive Tertiary planorbid (*Anomalorbina* sp.), which has been noted in assemblages from other zones of the site, and a Tertiary hydobiid.

Ostracods

The assemblage from Area 8 batter (Table 5.29), albeit from only one ostracod-bearing sample (105001), phase A8-E, the same sample as produced the most abundant mollusc fauna, dominated by *Galba truncatula* – contains six species (that are also present in 3777TP, although never all in the same sample). These include four cold indicators (*Candona candida, Amplocypris tonnensis,* *Leucocythere batesi and Limnocytherina sanctpatricii*), providing a clear indication that this deposit formed under cold climatic conditions.

Dating

Pupilla from the lowermost sample 105004, from context 100180 (phase A8-D), and from sample 105002, from context 100178 (towards the base of phase A8-E), were selected for amino acid dating. Even though there is no robust national framework for interpreting amino acid racemisation results from *Pupilla*, it was hoped to establish an internal relative chronology for different *Pupilla*-bearing horizons within the Ebbsfleet Valley, and at the same time to gain some idea of their absolute age relative to other sites in south-east England. The results (Fig 5.18) were quite clear-cut, and show a consistent difference in age between the two horizons, with the lower one giving a result indicating an age of *c* MIS 8–7, not very different from the material from Harnham (Whittaker *et al* 2004; Bates *et al* 2013), and the higher one giving a result of *c* MIS 7–5c, clearly older than the material from Cassington, which is attributed to MIS 5a (Maddy *et al* 1998).

Area 8 Batter Overview

The basal gravel A8-C did not produce any dating or environmental evidence. It is part of a sub-horizontal sheet of gravel that extends south-west to at least the ZR4 pylon site, and was also identified in trench 3784TT, a short distance to the east (Fig 5.1), where its base was at *c* 4m OD (Fig 5.20). It is probably of fluvial origin, and may be associated with the transition from cold to warm at the start of the MIS 7 sub-stage associated with deposition of the interglacial sequence in 3776TP (see Zone 1 synthesis below for further discussion). Environmental evidence from the base of the overlying cross-bedded sands suggests these were laid down under cool, open conditions, whether following directly from deposition of the underlying gravel, or after a major hiatus is uncertain; the *Pupilla* amino acid result (MIS 7–5c) from the base of this horizon suggests that perhaps there is no hiatus. These deposits are in turn disrupted and truncated by deposition of the thick overlying beds of A8-E. Environmental and dating evidence from the bottom part of this phase indicates distinctly cold climatic conditions, with the co-occurrence of four cold-loving ostracod species in sample 105001, associated with a date of *c* MIS 7–5c, again based on amino acid racemisation of *Pupilla*. As discussed further below, the upper part of A8-E almost certainly includes a significant thickness of Holocene colluvium, although the position of the Holocene/Pleistocene boundary is not clear. It may be associated with the gravel-filled channel halfway up the deposit, which may reflect more intense slope activity associated with cold conditions, or may be the edge of a fluvial channel.

Table 5.28 Molluscs, Area 8 batter

	Clay-silt laminations	Clay-silt laminations	Clay-silt laminations
Phase (A8-)	**-D**	**-E**	**-E**
Context	**100180**	**100178**	**100177**
Sample	**105004**	**105002**	**105001**
Sample volume (litres)	**20**	**20**	**20**
Freshwater taxa			
Galba truncatula (Müller)	1	16	412
Anisus leucostoma (Millet)	–	–	10
Pisidium sp.	–	–	2
Land taxa			
Pupilla muscorum (Linnaeus)	7	126	231
Derived taxa			
Tertiary planorbid	–	–	1
Tertiary hydrobiid	1	–	–
Cretaceous ostracods	+	+	+
Total	**9**	**142**	**656**

KEY: + – present

Zone 1 Synthesis

Zone 1 is characterised by the presence of two major deposit sequences, one at Site A, and the other at 3776TP, both of which include evidence in their lower parts of fully temperate peak interglacial woodland conditions. Both peak interglacial phases are overlain in their respective sequences by deposits with evidence of continuing temperate conditions, but with a reduction of woodland and expansion of grassland, possibly accompanied by slight cooling. However, there is compelling evidence that different fully temperate episodes are represented, both linked with MIS 7.

Firstly, if one considers the geomorphological situation of these two sequences in respect to each other (Fig 5.20), the temperate basal gravel (phase BMA-B,

Table 5.29 Ostracods, Area 8 batter

Phase	A8-D	A8-E	A8-E
Context	**100180**	**100178**	**100177**
Sample	**105004**	**105002**	**105001**
Candona candida	–	–	x
*Amplocypris tonnensis**	–	–	x
*Leucocythere batesi**	–	–	x
Limnocytherina sanctipatricii	–	–	x
Eucypris pigra	–	–	x
Pseudocandona sp.	–	–	x(j)

* species extinct within MIS 5–2
KEY: Ostracods are logged as follows: x – a few specimens; (j) mainly juveniles
Shaded blue – cold/cool ostracod indicators

bed 2a) of the Site A sequence is at least 3m higher than the basal gravel (phase 3776-A) of the 3776 sequence less than 100m away, suggesting distinct aggradations separated by a phase of downcutting. Secondly, the sparse small vertebrate assemblage from bed 2a at Site A includes two thermophilous species – white-toothed shrew (*Crocidura* sp.) and bank vole (*Clethrionomys glareolus*) – that are completely lacking in the huge assemblage from the peak interglacial sequence at 3776TP representing similar environmental conditions (phase 3776-D); and nor are either of these species present in any of the overlying interglacial beds (phases 3776-E, F and G). It is inconceivable that if both assemblages were from the same population at the same period, then both species would be entirely absent in the 3776TP sequence. And thirdly there is clear clustering of the bed 2a amino acid dating results (Fig 5.8) suggesting that this deposit is older than any of the dated parts of the 3776TP sequence. The bed 2a clustering also suggests a very similar age to the dated MIS 7 reference horizons – Lion Pit Tramway Cutting (Essex), (Freshwater Brickearth; Schreve *et al* 2006) and Ilford, Essex (Uphall Pit; Kennard and Woodward 1900). In contrast, the AAR results from 3776TP, while still within the range of the MIS 7 reference data, consistently cluster in area suggesting a slightly younger date than both bed 2a and the reference data.

Climate history through MIS 7 has been investigated by Reille *et al* (2000), Roucoux *et al* (2008) and Kleinmann *et al* (2011). Based on pollen analysis from sites in France (Velay), north-west Germany (Nachtigall) and north-west Greece (the Ioannina basin), these studies demonstrate three fully temperate episodes in MIS 7, all associated with woodland development. There is an initial woodland phase (7e) followed by a sharp climatic deterioration and a prolonged dry, grassland phase (7d). This is then followed by a more prolonged phase of predominantly warmer climate with renewed woodland development (7c and 7a), interrupted by a relatively minor cooler stadial (7b/7.2) with a short return to more open grassland conditions. Based on the biostratigraphic and AAR evidence, it seems likely that bed 2a at Site A, the older of the fully temperate interglacial horizons in Zone 1, relates to one or other of the earlier two warm sub-stages, 7e or 7c; and that the peak interglacial horizon of phase 3776-D at 3776TP relates to a subsequent substage, 7c or 7a.

After this, there is also the problem of whether each of these sequences represents steady aggradation following the interglacial peak, or whether they include any major hiatuses. At Site A, the co-occurrence of clay-silt, flint gravel and large polished flint nodules at the boundary between phase BMA-B (bed 2) and phase BMA-C (bed 3) may indicate a major depositional hiatus. There is some molluscan evidence from the bottom part of phase BMA-C (beds 3a and 3b) that suggests marshy conditions with a local grassland environment. Higher up in phase BMA-C (beds 3c, 3d and 3e), the palaeoenvironmental evidence (vertebrates and molluscs) suggests a generally temperate climate with continuing grassland, and with drying up of the waterbody that deposited the lower parts of phase BMA-C. An earlier protocol for amino acid dating – A/I measurement as per Bowen *et al* (1989) – has indicated an MIS 7 date for these deposits, a conclusion supported by biostratigraphic indications from the mammal assemblages. There is no basis for linking them with any substage, other than they must be younger than the underlying bed 2a.

At 3776TP, there is no equivalent evidence of a major hiatus above the peak interglacial phase 3776-D (contexts 537 and 528), although there is a change of sediment character upwards with a coarsening progression through the clay-silt of phase 3776-E up to the fluvial sands of bed 3776-F, before a reversion to finer-grained alluvial overbank flooding deposition in the uppermost interglacial phase 3776-G. These latter deposits contain a small vertebrate fauna reflecting similar climatic and environmental conditions to beds 3c–3e in the upper part of phase BMA-C at Site A. The amino acid dating from 3776TP shows very similar results from the basal and the top beds of the interglacial sequence, supporting their aggradation in the same episode without a major depositional hiatus. It is also worth noting that the appearance and lithology of the main context (516) of the top interglacial phase 3776-G, which was a cohesive speckled pale olive, slightly sandy clay-silt, is very similar to beds 3c–3e at Site A, and that context 516 rose and thickened towards Site A, making it feasible to suggest that they may be lateral equivalents (Fig 5.20). Both sets of deposits also represent the same depositional trend, of a drying fluvial body tending towards marshland and stagnation; the slightly more alluvial character of context 516 would reflect the fact that it is nearer the centre of the palaeochannel, whereas Site A is closer to the valley-side bank.

Two possible scenarios are presented here (Fig 5.21). In scenario A, the interglacial phases BMA-B and BMA-C at Site A (beds 2a through to 3e) aggraded throughout the same warm sub-stage of MIS 7 (one of the first two: MIS 7e or 7c), and then these deposits are cut through during climatic deterioration of the following cool sub-stage, which is followed by deposition of the sequence 3776-A through to 3776-G, which includes a fully temperate interglacial horizon towards its base. If the first warm sub-stage associated with BMA-B/C is 7c then the younger warm sub-stage associated with 3776-C through to 3776-G is definitely MIS 7a. If the first warm sub-stage associated with BMA-B/C is MIS 7e, as seems most likely from the amino acid dating evidence, then that associated with 3776-C through to 3776-G could either be MIS 7c or MIS 7a).

Alternatively, under scenario B, there is a major hiatus between phases BMA-B and BMA-C at Site A; downcutting associated with post-BMA-B climatic deterioration reaches the top of BMA-B and cuts more deeply down further to the north-east, followed by build-up of the sequence 3776-A through to 3776-G,

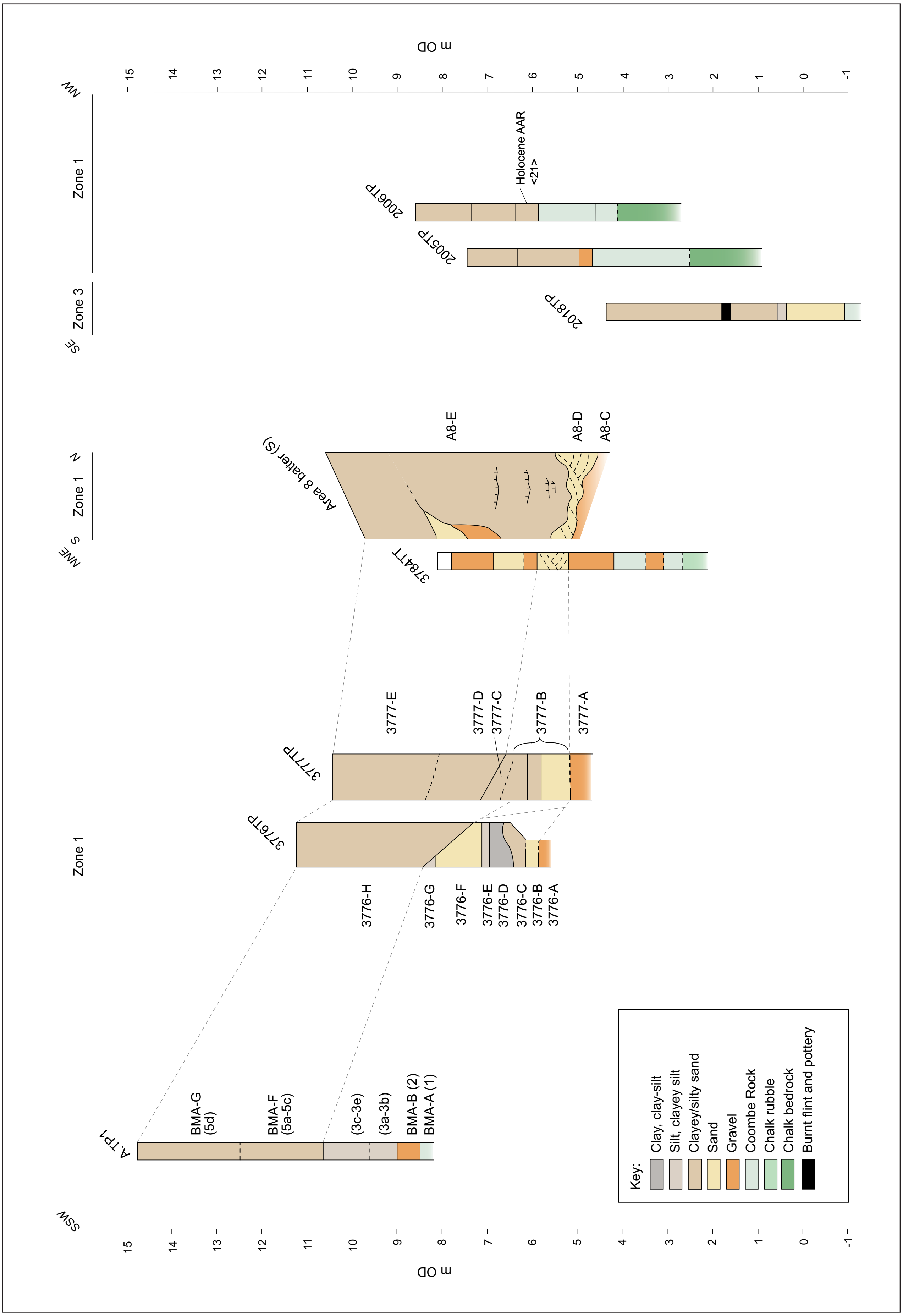


Figure 5.20 Summary cross-section through Zone 1 deposits

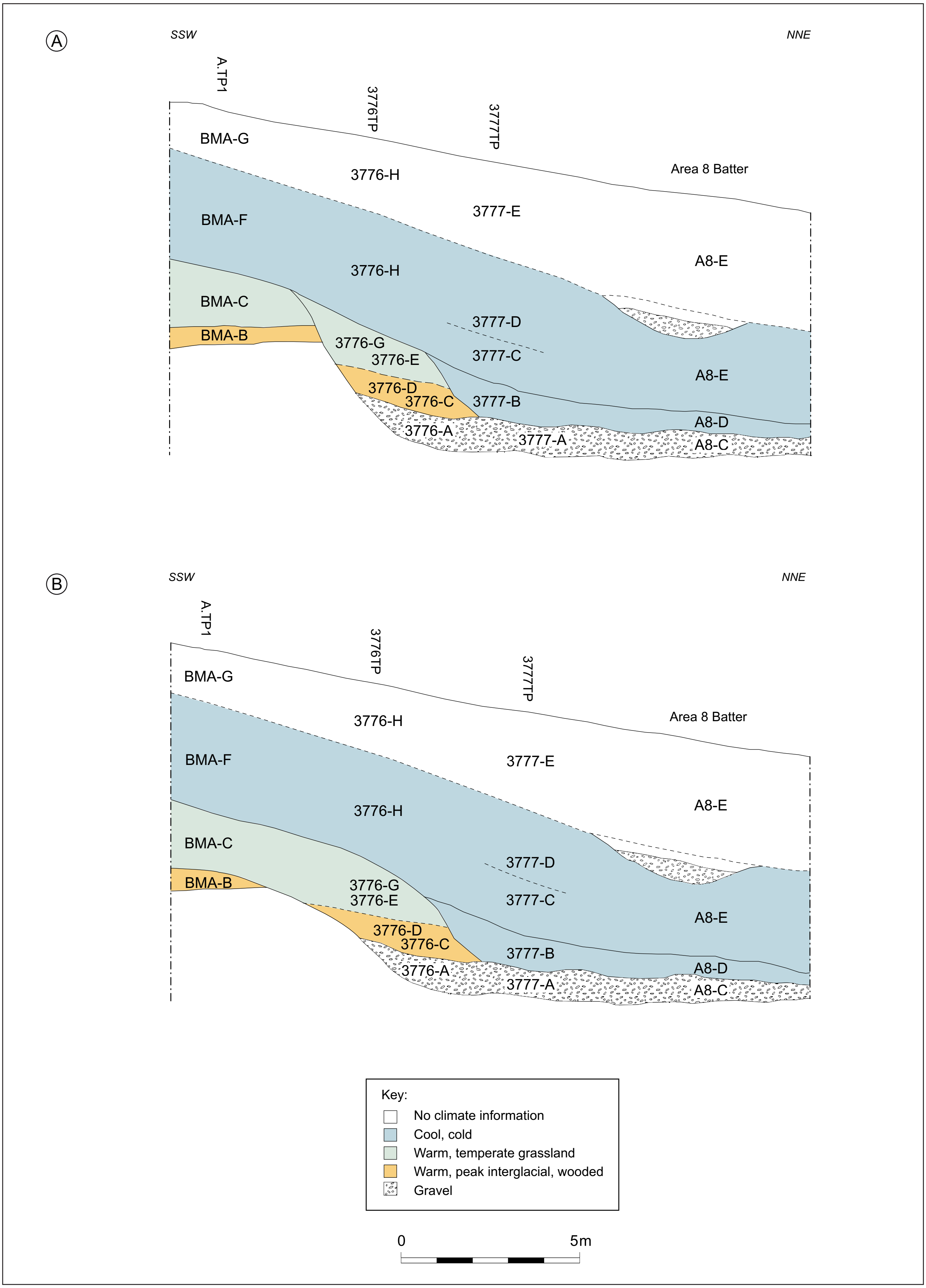


Figure 5.21 Alternative options for relationship between horizons BMA-C and 3776-D/E/F/G

which includes temperate phases 3776-C through to 3776-G. Under this scenario, the alluvial clay-silt of 3776-G is taken as a lateral equivalent of BMA-C, and aggrades back up the valley-side to the south-west, overlapping the remnant sand/gravel terrace of BMA-B. This latter deposit would still date to the same warm sub-stage of MIS 7 as under scenario A, but, in contrast, the overlying sediments BMA-C *and* the interglacial sediments at 3776TP would date to the same, subsequent MIS 7 sub-stage, MIS 7c or 7a. Other scenarios are also possible, but these two are preferred as the most credible.

Both sets of interglacial deposits are then overlain by a thick build-up of slopewash sediments, predominantly fine-grained sandy clay-silts, but including some gravel-rich beds. These have relatively meagre environmental and dating evidence, although some evidence has been recovered from their lower parts at 3777TP and the Area 8 batter. Amino acid dating results from 3777TP, although based on *Pupilla muscorum*, and so less robust than the *Bithynia*-based evidence from the interglacial fluvial deposits, suggest that the bottom parts of these deposits date to MIS 7–6, or perhaps 5b–5d.

Finally, the uppermost parts of the thick colluvial slopewash sequence in this zone probably date to the Holocene. Mollusc evidence from the nearby test pit 2006TP (Fig 5.1; ARC EFT97, URL 1997a) produced specimens of *Trochulus hispidus* more than 2m below the ground surface (Fig 5.20), which were amino acid dated to the Holocene. These deposits also produced a small number of Neolithic struck flints, in the upper layers associated with Saxon pottery sherds. And in test pit 2018TP (ARC EFT97, *ibid*), which was only 20m south-east of the Area 8 batter, a layer of burnt flint and Late Bronze Age pottery sherds was found 2.85m below the ground surface (Fig 5.20), sealed beneath reddish-brown sandy clay-silt deposits indistinguishable from those that formed the upper parts of the colluvial slopewash sequence at Site A, 3776TP and 3777TP, and the Area 8 batter.

Chapter 6

Valley-side West (Zone 2)

by Francis Wenban-Smith, Martin Bates, Russell Coope, Adrian M Lister, Simon A Parfitt, Kirsty Penkman and Ed Rhodes

Introduction

This zone (Fig 6.1) lies on the western side of the Ebbsfleet and includes the SAM Kent 267b (Site B in Fig 2.16), preserved as an unquarried 'island' within the otherwise almost entirely quarried area between the HS1 development area and Swanscombe. The zone corresponds with what would have been an area of higher ground between two former dry valleys running eastwards towards the modern Ebbsfleet, although this is only apparent from examination of early OS mapping (Fig 2.16), as the topography of the landscape has been so drastically altered by quarrying (Fig 2.3). The western margin of the zone lies within the largely-quarried area including the SAM 267b (=Site B) while the eastern boundary lies just beyond the longitudinal wedge of deposits (Site F in Fig 2.16) at the west side of what used to be football pitches, and incorporated within the Baker's Hole SSSI. To the north, the boundary coincides with the more northerly of the small dry valleys previously alluded to, which divides Zone 2 from Zone 1, seen in section at the southern end of the British Museum section diagram (Fig 5.2a). The curving south-eastern boundary abuts Zone 6, which contains the unquarried deposits of DBA Area 6, which are mostly at lower levels than those in Zone 2.

Historically this zone is important. It includes the locations of key phases of work undertaken by Burchell, Carreck, the British Museum (Sieveking) and Wenban-Smith (Table 6.1; Chap 2). Burchell was the first to identify the importance of deposits in this zone, establishing in the 1930s the presence of a sequence that: (a) appeared to demonstrate the existence of a complete glacial–interglacial–glacial sequence between the interglacial represented in the Swanscombe '100-foot terrace' and that of the present day; and (b) contained evidence of Levalloisian occupation horizons and rich faunal remains. As discussed further below, he identified important sequences in at least two different locations: in his terminology, 'Ebbsfleet Channel Site A' where the sequence included the so-called 'Temperate Bed' near the bank of the presumed channel, and 'Ebbsfleet Channel Site B' nearer the presumed centre of this channel.

Burchell's work was followed by Carreck, in the 1950s, and then by Sieveking in 1969. Carreck identified a new sequence of deposits – labelled by him as 'Channel D' (Fig 6.1) – to the north of Burchell's Ebbsfleet Channel Site A, at the southern end of the wedge of deposits later labelled as Wenban-Smith's Site F (Fig 2.16). Sieveking carried out further work at Burchell's Ebbsfleet Channel Site A, although Sieveking named it as 'Site B' (Fig 6.1), nomenclature which has subsequently been followed. Kemp (1991) also carried out micromorphological investigation at Sieveking's site. Finally, Wenban-Smith carried out further work at both these locations. A long section of Carreck's Channel D was drawn (Section 3, Fig 6.1), and a detailed log made of the sequence at the south-east end (location F.3.a). A small test pit (B.TP 1) was excavated beside Sieveking's 1969 Site B trench (Fig 6.1), where Temperate Bed deposits are present.

Table 6.1 Zone 2 key interventions and range of specialist and dating studies

Project	Key locations	Secondary locations	Soil micro-morphology	Large vertebrates	Small vertebrates	Molluscs	Ostracods	Amino acid analysis	OSL dating	Worked flint
Burchell	Ebbsfleet Channel Site A		–	X	X	X	–	X – Bith	–	X
		Ebbsfleet Channel Site B	–	X	X	X	–	X – Bith	–	X
Carreck	Channel D		–	X	–	–	–	–	–	X
BM	Site B (EB 69)		–	x	–	X	–	–	–	X
FFWS PhD	B. TP 1 (EV 1993–1994)		–	–	X	–	–	–	X	X
	Site F	Loc F.3.a (EV 1989-1990)	–	x	–	–	–	–	–	–

KEY: X – important evidence; x – minor presence; Bith – amino acid dating study based on *Bithynia* opercula

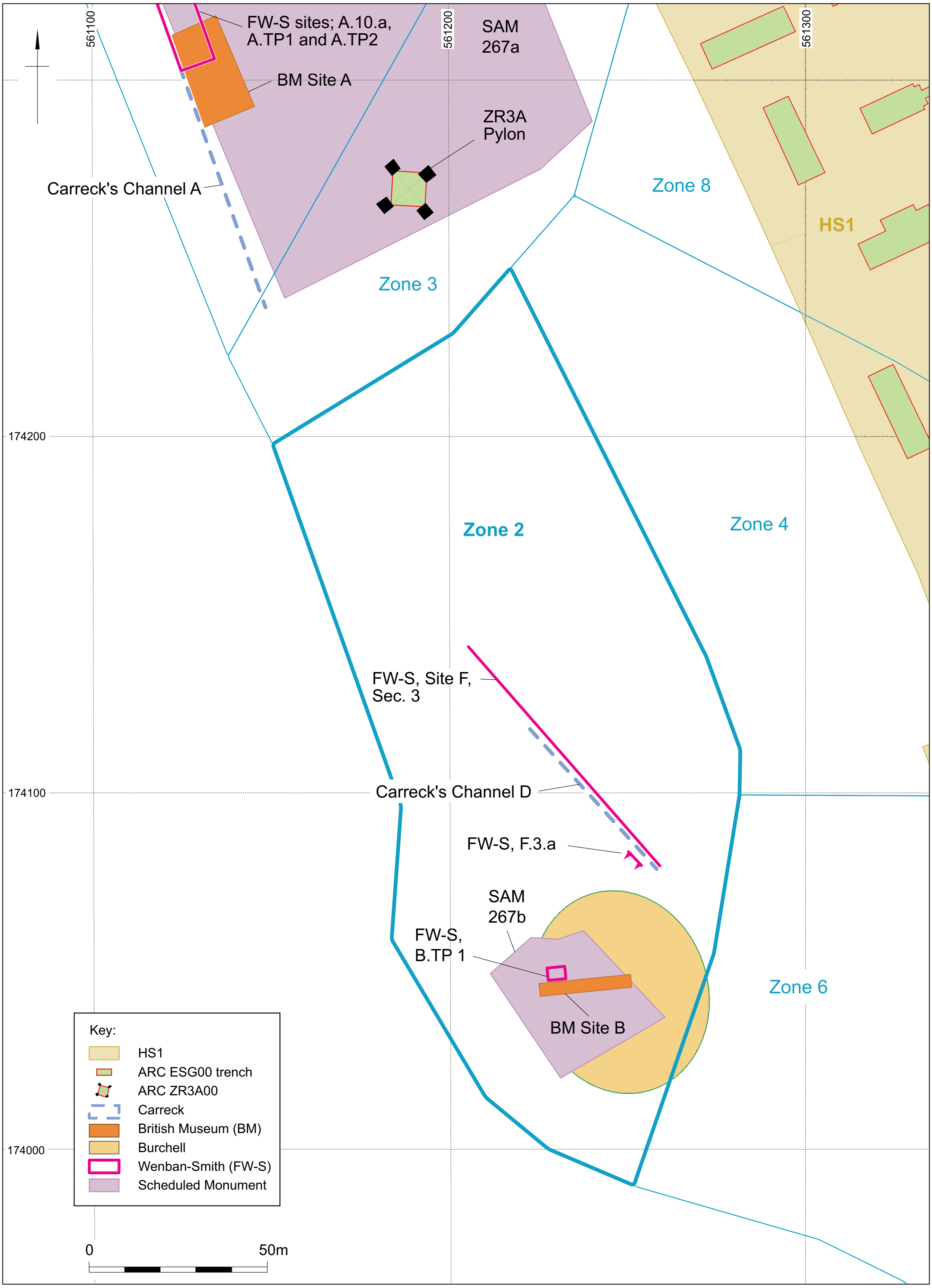


Figure 6.1 Zone 2 layout and key intervention locations

This zone was largely unaffected by the HS1 works, so there are no specifically HS1-related interventions to consider. However, it has produced essential evidence for contextualising the HS1 investigations in adjacent zones. It also contained the best-provenanced evidence of Levalloisian occupation in the Ebbsfleet Valley, establishing a framework for which was one of the key goals of the HS1 Palaeolithic/Pleistocene mitigation programme. Results from these various pre-HS1 interventions are reviewed and synthesised below, incorporating much previously unpublished evidence and new analyses.

Site B (including Burchell's Ebbsfleet Channel Sites A and B)

Introduction

Deposits in the vicinity of what is now regarded as Site B were first investigated by Burchell in the 1930s, as his 'Ebbsfleet Channel Site A' (Fig 2.12). He identified a sequence of deposits banked against a sloping erosional cut through Chalk bedrock (Burchell 1933). Towards the top of the sequence he found a 'Temperate Bed' rich in molluscan remains, including woodland species indicating peak interglacial conditions (Burchell 1935a; 1957). He also found various other faunal and artefactual remains throughout the sequence.

As previously discussed (Chap 2), two of the problems with revisiting Burchell's work are the complete absence of primary site records and his unsubstantiated speculative correlations between different sequences. Thus, evidence from his 'Ebbsfleet Channel Site B' (Fig 2.12), which he regarded as stratigraphically equivalent to the base of his 'A' site, has to be regarded as from a separate sequence, since there are no records of either its location or any lithostratigraphic relationships between it and his 'A' site. However, some of his faunal and artefactual discoveries can be linked with reasonable confidence to one or other of his Ebbsfleet Channel 'A' and 'B' sequences, increasing their interpretive value. The faunal remains from these sites are considered below in this section, and the artefactual evidence is considered subsequently (Chap 18).

Burchell's Ebbsfleet Channel Site A

The sequence at Burchell's 'A' site was subsequently reinvestigated by Sieveking in 1969, who labelled it 'Site B' (Fig 6.1), nomenclature that has subsequently been followed here. Sieveking dug a major trench through the sequence, providing a good primary record tied in with OD (Fig 6.2). In conjunction with Sieveking's work, Kerney carried out molluscan sampling, both in the Temperate Bed (from a trench in an unrecorded location where un-decalcified sediment was present), and from deposits lower down in the sequence in the main trench (Fig 6.2b). Work was also carried out by Kemp (1995) on the surface of the deposits below the Temperate Bed, investigating for evidence of soil development and weathering indicative of a palaeo-landsurface. Following Sieveking's investigation, which also led to recovery of further lithic artefacts, the site was identified as of sufficient Palaeolithic importance to be scheduled as an Ancient Monument (Kent 267b), leading to its subsequent preservation for future research.

The most recent phase of work at the site was carried out by Wenban-Smith between 1993 and 1995, who excavated a small test pit (B.TP 1) into the Temperate Bed part of the sequence, just behind the still-standing (at that time) section from Sieveking's work (Fig 6.1). This work was aimed primarily at molluscan recovery for dating and construction of a palaeoenvironmental record tied in with the surviving deposits, although no mollusc-bearing un-decalcified sediment was found. However, bulk-sampling led to recovery of a rich small vertebrate assemblage from the Temperate Bed (see vertebrates, below); OSL dating was also carried out (see dating, below).

Burchell's Ebbsfleet Channel Site B

The location of Burchell's 'Ebbsfleet Channel Site B' is unknown, although it is probably now quarried away. According to Burchell's sketch map (Fig 2.12) it was in the centre of his putative Ebbsfleet Channel, to the south of his 'A' site. According to the published record of his work there (Burchell 1936b, 553) 'Investigation of the left part of the Ebbsfleet Channel having been completed [his 'A' site], attention has been directed to the central portion of the channel [his 'B' site]'. Therefore, it seems likely that this second site was in the now-quarried area to the south-east of Site B (Fig 2.8), this being the only area where the channel sequence could have thickened in a southerly direction from the 'A' site, which contains the western bank of a channel cut into Chalk bedrock that runs approximately SSW–NNE. Carreck's plan of the Ebbsfleet Valley (1972, 19, fig 4) shows a tiny shaded area here, that coincides with Oakley's and Grimes' 1948 'Excavation 2', thought to represent Burchell's Ebbsfleet Channel Site B (ms in Natural History Museum).

Lithological Succession

Site B (=Burchell's Ebbsfleet Channel Site A)

The lithological succession at this location, which represents the classic 'Ebbsfleet Channel' locality, lies between *c* 6m and 13m OD, exposed in a south-facing section *c* 30m long (Fig 6.2). The deposit groupings and descriptions are based upon the drawn section of Sieveking's trench; Wenban-Smith's fieldwork and re-examination of Sieveking's still-standing section, Wenban-Smith's (1995) reappraisal of Burchell's and Carreck's work. As with Site A (see Chap 5), the quantity of previous investigation by different workers has led to a proliferation of nomenclature. An updated correlation table is also given here, suggesting correlations between Wenban-Smith and Sieveking's

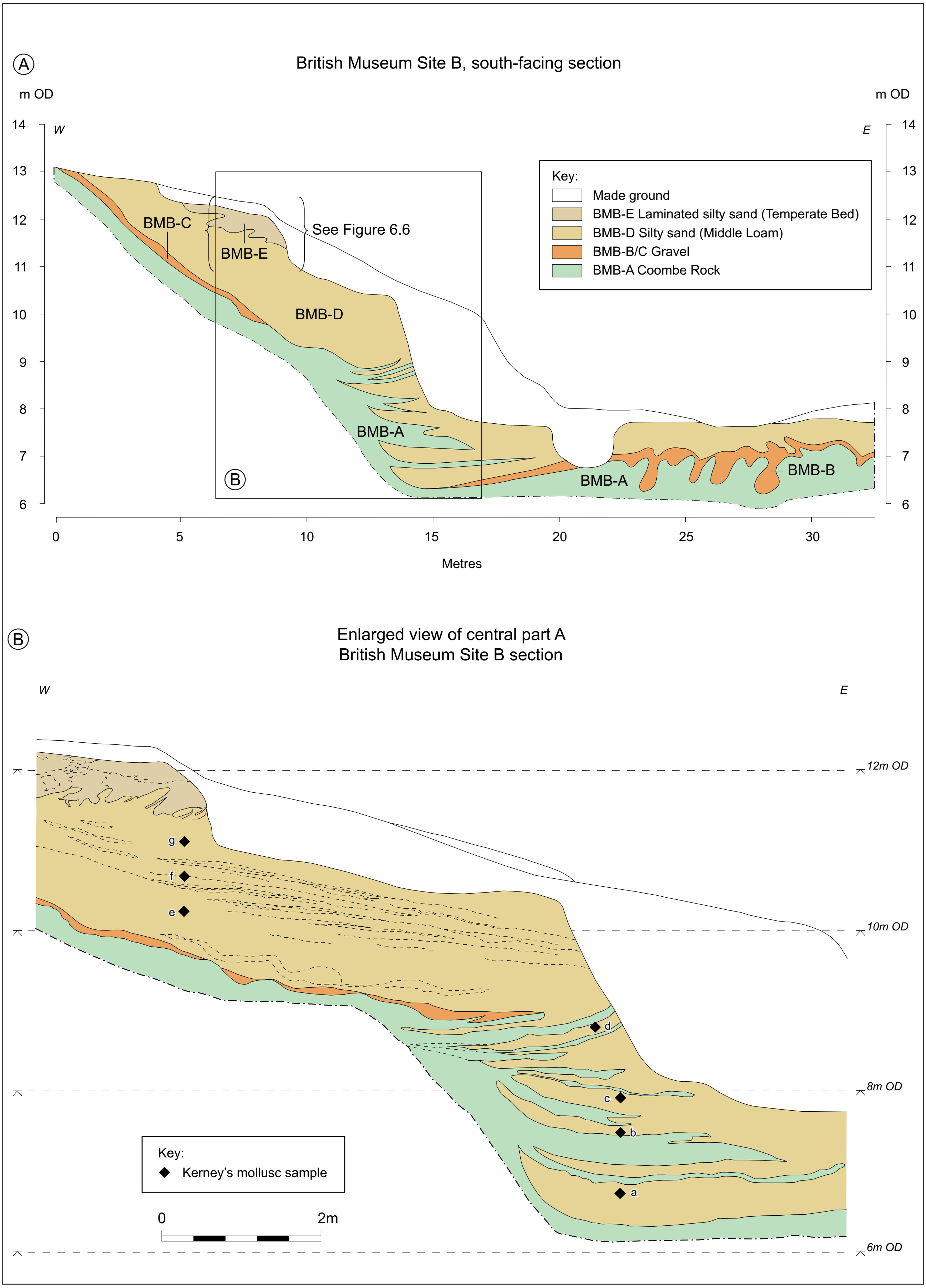


Figure 6.2 Site B section: (a) overview of sequence (Kerney and Sieveking 1977); (b) extract of section showing sediment structures in Middle Loam and Kerney's mollusc sampling locations a–g

Table 6.2 Stratigraphic phasing and correlation at Site B (Burchell Ebbsfleet Channel Site A)

Phase	Deposit name	Wenban-Smith 1995	Kerney and Sieveking 1977	Burchell Ebbsfleet Channel Site A
BMB-F	Calcareous Loam	6 – Calcareous Loam	–	Calcareous Loam
BMB-E	Temperate Bed	5 – Temperate Silt	5 – Freshwater Silt	– Temperate Bed (= "Upper Loam")
BMB-D	Middle Loam	4 – Middle Loam 4c – Orange band (Kemp's soil and weathering horizon) 4b – Upper Middle Loam 4a – Lower Middle Loam	4 – Weathering Horizon 3 – Aeolian/solifluction silt	– Upper Middle Loam – Middle Coombe Rock – Lower Middle Loam – Lower Loam (= "Lower (fluviatile) Brickearth")
BMB-C	Sloping gravel bed	3 – Solifluction Gravel	2 – Solifluction Gravel (western upper part)	–
BMB-B	Contorted gravel	2 – Fluviatile Gravel	2 – Solifluction Gravel (eastern lower part)	– Gravel, fluviatile – (= "Lower Gravel")*
BMB-A	Coombe Rock	1 – Coombe Rock	1 – Coombe Rock and frost-heaved chalk	– Coombe Rock

* Burchell never used the term "Lower Gravel" in print, but he wrote this on many artefacts, and much faunal or lithic material is catalogued as such in museum collections

deposit groupings and various deposits horizons identified by Burchell (Table 6.2).

Five main phases are recognised, from the base BMB-A through to BMB-E (Table 6.2). These are overlain by modern dumping (M), the majority of which probably relates to Sieveking's work, but which also includes an earlier phase maybe relating to Burchell's, Oakley's and Grimes' investigations. The section records a complex sequence of interdigitating slopewash deposits ('loams') and chalky lenses, indicative of episodic bank instability, with fluvial deposits surviving at the base of the sequence (gravel BMB-B, and perhaps the bottom part of the Middle Loam BMB-D), and as a small outcrop high up in the sequence (the Temperate Bed BMB-E). Although the chalky interdigitating layers were interpreted by Burchell as a distinct cold stage solifluction event within the build-up of the Middle Loam (see Fig 2.12) – Burchell probably focused on the thickest layer between mollusc samples a and b in Figure 6.2 – there is no supporting evidence to indicate colder conditions or a depositional hiatus, and they thus merely reflect the proximity of the chalk bank.

BMB-A Coombe Rock: This deposit lies at the base of the sequence. It consists of very poorly-sorted chalk pebbles embedded in a very pale brown chalk silt matrix with occasional flint pebbles, including very well-rounded derived Tertiary pebbles, and pieces of flint nodule. The deposit grades down into the degraded surface of Chalk bedrock. This deposit has produced various flint artefacts, all of them probably reworked, and discussed subsequently (Chap 18).

BMB-B Contorted gravel: This deposit consists of a thin sub-horizontal layer of flint gravel, *c* 0.30 to 0.75m thick, with its base at *c* 6.5m OD in the eastern half of the drawn section, in a sandy matrix, with occasional Tertiary shell fragments and sandy lenses. The base is heavily contorted, filling pockets in the underlying Coombe Rock. This is probably at least in part due to post-depositional solution, but also perhaps from contortion in a fluid state due to other post-depositional processes, possibly associated with massive slopewash deposition of the overlying body of sand/silt (phase BMB-D). The upper surface is also very uneven, similarly affected by post-depositional processes. The deposit is interpreted as a fluvial gravel, on the basis of its predominantly horizontal geometry and the presence of remnant bedding, albeit now heavily contorted by post-depositional processes. This deposit has produced various large vertebrate faunal remains, and flint artefacts in various conditions, including perhaps mint condition material from one of Burchell's 'floors' if: (a) this deposit is equated with the 'Gravel' at the base of Burchell's Channel A diagram; and (b) he was reliable in provenancing material to the deposit. The faunal remains are discussed below, and the artefacts subsequently (Chap 18).

BMB-C Sloping gravel bed: This deposit consists of a thin bed of flint gravel in a sandy matrix, only 0.10 to 0.20m thick, that lines the sloping surface of the chalk bank against which the Site B sequence is built up. It is interpreted as a slopewash deposit, possibly associated with solifluction, and probably presaging the deposition of the finer-grained overlying Middle Loam (BMB-D).

BMB-D Middle Loam: This deposit consists of a thick body of silty, very fine to fine, sand. It contains numerous sub-parallel laminations of fine sand alternating with silt, which dip shallowly to the east parallel with the underlying chalk bank and sloping gravel bed on the west side of the section, and then level off conformably with the trend of the surface of the underlying gravel on the east side. Its bottom part is slightly paler and sandier on the east side. The deposit interdigitates with thin lenses of the chalk-rich west bank deposits, particularly at the point between *c* 12 and 15m along the base line, where the bank drops more steeply (Fig 6.2). This deposit was divided into an upper and a lower part by Burchell, with the chalk-rich interdigitations between them being interpreted as a distinct phase of deposition representing a glacial episode. This latter suggestion can now be recognised as erroneous, merely representing minor intrusion from the chalk bank without any evidence of a cold climatic episode. Nonetheless, the sediment body can be seen from its fine laminations to have built up progressively from its base, so it can still be subdivided into upper and lower parts, although without any suggestion of any intervening episode of climatic variation. Burchell's 'Lower Loam' (also called by him 'Lower Brickearth (fluviatile)) is probably represented in the bottom part of this deposit in the eastern half of the section, where its lower, sandier part overlies the gravel of phase BMB-B. The Middle Loam has produced molluscan remains, discussed below. It also appears to have produced various vertebrate faunal remains that were originally attributed by Burchell to 'Lower Loam', but which were subsequently re-attributed in the Natural History Museum provenance information with the collection to the 'Middle Loam, lower part'. It is uncertain who made this re-attribution, or when and why.

The top 0.5–0.10m of the Middle Loam is slightly reddened, and firmer, giving rise to its early interpretation as a weathered palaeo-landsurface, firstly by Burchell (1957) and later by Zeuner (1959). As discussed by Kemp (1991; 1995) this bed does contain evidence of soil development associated with a palaeo-landsurface, which was then inundated by a rising Ebbsfleet waterbody, after which the overlying 'Temperate Bed' (phase BMB-E) was deposited.

BMB-E Temperate Bed: This deposit overlies the weathered upper surface of the Middle Loam, surviving as a small outcrop high up in the sequence at the western side of the exposed section (Fig 6.2), the majority of the deposit having been excavated by previous workers, particularly Burchell. It has a very uneven basal junction in places, resulting from deformation of the underlying sediment while in a saturated condition and intermingling between the Temperate Bed and the upper Middle Loam deposits (Kemp 1991; 1995). This junction slopes shallowly to the east, from *c* 12.50m to 11.0m OD.

The deposit consists mostly of very fine, silty sand, laminated in sub-horizontal beds *c* 3–5mm thick, along which it has a tendency to break, with the beds divided by thin orange Fe-stained layers. The deposit contains pointed 'tendrils' of pinkish clay-silt that interdigitate into it from the sloping western bank. There is also, towards the top of the exposed sequence, a thin band *c* 5mm thick of flint pebbles and angular small cobbles with fine chalk gravel and flecks, likewise coming in from the western bank and presumably representing an episode of slopewash deposition.

The Temperate Bed has produced molluscan remains, discussed below. Burchell also recovered large vertebrate faunal remains and flint artefacts. Wenban-Smith recovered significant quantities of small vertebrate faunal remains, as well as a few further flint artefacts. The faunal remains are discussed below, and the artefacts subsequently (Chap 18).

Overlying deposits: Although deposits higher up the sequence are no longer preserved, Burchell recorded (1954; 1957), confirmed in the field by Zeuner (1959), a sequence of cold-climate deposits that unconformably overlay the Temperate Bed, and represent a subsequent onset of cold, glacial or stadial, conditions. These comprised, from the base: a thin layer of "Calcareous Loam" overlain by chalk-rich solifluction deposits 'Coombe Rock'.

Site B (Burchell's Ebbsfleet Channel Site B)

As reported in Burchell's publications (Burchell 1936b; Burchell 1936c) and in his unpublished diagram (Fig 2.12), he identified a more restricted sequence of deposits at his Channel-centre site 'B' sequence, which he equated with the bottom part of his Ebbsfleet Channel Site A sequence. He identified a new deposit: the 'Lowermost Loam' in the new channel-centre sequence, from which he recovered *Bithynia* remains and a 'microtine fauna', and on the surface of which he recorded an occupation 'floor' with mint condition lithic remains as well as 'mammoth, rhinoceros, horse etc.' (Burchell 1936b, 553). This correlation has to be recognised as suspect. There are no primary records of the precise location of this second locality or its stratigraphic sequence tied in with OD. Two versions of an unpublished summary diagram survive (Fig 2.12). The version shown here indicates the basal junction of the Lowermost Loam at 15 ft OD [*c* 4.60m], where it overlay a basal gravel bed described by Burchell as 'coarse, unstratified meltwater gravel' (*ibid.*). Another version (probably a later one, held in the British Museum), shows this level as 20ft OD. It is uncertain if either of these heights can be regarded as accurate. The Lowermost Loam was overlain by another gravel deposit, which Burchell equated with the lower 'Gravel' from his main Channel A sequence. At his 'B' site, the gravel above the Lowermost Loam was described as stratified in its lower part 'with layers of manganese and fine material' (Burchell 1936c, 262) but unstratified in its upper part. This gravel – often called 'Lower Gravel' by Burchell in archival records, verbatim (see Carreck 1972, 151) and museum collections, although never in print – contained at least two distinct Levalloisian 'floors', one at the basal junction with the Lowermost Loam (as described above), and the other within the middle of the gravel, presumably in its stratified part although Burchell never specifies this. The top deposit in the sequence was not described, but was equated by Burchell with the Lower Loam at his Ebbsfleet Channel Site A, which was likewise reported as containing *Bithynia* opercula and 'Limaces' (*Limacidea*).

Vertebrates

Site B is one of the most important localities in the Ebbsfleet Valley because of the rich vertebrate and molluscan remains that are associated with the archaeological evidence. The vertebrate remains were collected by several workers over a period of about 50 years, initially by Burchell during the 1930s and 1940s, followed by Carreck (1950s–1970s), Sieveking between 1965 and 1971, and more recently by Wenban-Smith in 1993–94. Grimes and Oakley also undertook field investigations in the vicinity of the site in 1948; this work remains unpublished although there are some notes held in the Natural History Museum archives, consulted for this report. The faunal remains, mostly housed in the Natural History Museum, provide tantalizing indications for climatic change during the infilling of the 'Ebbsfleet Channel'. Elements of the fauna indicate cold conditions and there is molluscan evidence for at least one fully interglacial (woodland) episode. Reappraisal of this evidence is hampered by confusion over the precise relationship of the faunal remains to the stratigraphy. With the exception of Wenban-Smith's collection, there are major doubts over precisely where, and from what horizon, most of the vertebrate remains originated – particularly those from investigations by Burchell and Sieveking. Nonetheless, the section cleared by Sieveking (Fig 6.2) helped to clarify the stratigraphy, and the recording of sections by Grimes, Oakley and Carreck provides a further link between Burchell's confusing (and continually varying) stratigraphic nomenclature and the surviving deposits.

Burchell's vertebrate collection

Burchell carried out fieldwork in the Ebbsfleet Valley in the 1930s, which he continued after military service during the Second World War, where he reached the rank of Major. He excavated various sections in the heavily-quarried landscape of the Ebbsfleet Valley, mostly, so far as we can tell, in the vicinity of the pit-rail 'Tramway' cutting previously investigated by Spurrell, which passed the southern side of what is now Site B heading towards the original Baker's Hole chalk quarry (Fig 2.8). As discussed above (despite the absence of primary records), the location of Burchell's main 'Ebbsfleet Channel' site [ie, his 'Ebbsfleet Channel Site A', *sensu* Fig 2.12] is established by Carreck's and Sieveking's work, and also from archival notes by Oakley and Grimes (held in the Department of Earth Sciences, Natural History Museum), who visited the site with Burchell. Burchell undertook some sieving of the deposits and this work yielded a substantial quantity of molluscan remains (studied in conjunction with A G Davis) and rare small vertebrates, together with an assemblage of large vertebrate remains and lithic artefacts recovered from his excavations.

Burchell (1933; 1935a) documented the discovery of mammoth, woolly rhinoceros and horse alongside a vole fauna (*Microtus anglicus, Microtus nivalis* and *Microtus arvalis*) in the lower gravel at his Ebbsfleet Channel Site A (here equated with gravel BMB-B). In a later paper (Burchell 1936b) he recorded the discovery at his Ebbsfleet Channel Site B of mammoth, rhinoceros and horse in a presumed extension of the same gravel, and a microtine fauna in the underlying Lowermost Loam. Later (Burchell 1957), he listed mammoth, rhinoceros, giant deer ('*Cervus megaloceros*') and horse from the Temperate Bed (BMB-E). Finally, in the earlier version of his unpublished Ebbsfleet Channel diagram (Fig 2.12) he listed: '*Elephas primigenius*, *Ursus* sp., *Rhinoceros tichorhinus*, *Bos* sp., *Equus caballus*, *Cervus megaceros*, *Cervus* sp.' with a microtine fauna of '*M. anglicus*, *M. nivalis* and *M. arvalis* group'. In the later version of this diagram, he added 'teeth of *Esox ferox*' (pike) as being present in 'Fluviatile loams', presumably referring to the Lower and Lowermost Loams. Characteristically, the mammalian fauna are not provenanced to specific horizons or localities, but described en bloc as associated with Levallois "floors". These are shown at four distinct horizons (see Fig 2.12): at the base of the Temperate Bed and in the lower gravel at his 'A' locality, and at the surface of the Lowermost Loam and within the overlying gravel at his 'B' locality. Although he never published (or made) a detailed inventory, Burchell eventually presented most of his Ebbsfleet fossils to the Natural History Museum.

The accession catalogue and archival documentation for the Ebbsfleet Channel collection at the NHM contain contradictory information. Hand-written labels still associated with the bones originally indicated that the collection derives from two horizons, namely the 'Upper Loam' (ie, the 'Temperate Bed', BMB-E) and the 'Lower Loam', here equated with a basal sandy bed of the Middle Loam (phase BMB-D) that directly overlies the Lower Gravel (BMB-B). However, 'Lower Loam' has been deleted throughout the documentation, and substituted by 'Lower Gravel'. In view of the broad correspondence between the species listed from the lower gravel by Burchell (1933; 1935a) and the material in the NHM originally labelled as from the 'Lower Loam' but re-attributed to 'Lower Gravel' (Table 6.3), it is presumed here that this material corresponds with that reported by Burchell in his 1933 and 1935a papers as from the 'lower gravel'. A J Sutcliffe (formerly curator of Quaternary Mammals, Natural History Museum) also noted that the 'Lower Loam' of Hopwood equates with Burchell's 'Lower Gravel' (archive notes in the Department of Palaeontology, NHM), suggesting that at some point Hopwood labelled the material as "Lower Loam" but that this was later revised, possibly by Sutcliffe.

There are however some contrasts between the range of species listed by Burchell (and their provenances) and the surviving collection. He reports "*Ursus* sp." as one of the species from a Levallois "floor" in his unpublished diagram (Fig 2.12). There is no specimen of this in the surviving collection, but there is a right second metacarpal attributable to *Panthera leo* (lion) that has a label attached specifying it as "*Ursus*", which must correspond with this specimen.

Burchell's (1933; 1935a) records woolly rhinoceros (*Rhinoceros tichorhinus*) in the 'Lower Gravel'. This species is not present in the surviving collection in the

Table 6.3 Mammalian fauna recovered by Burchell from his 'Ebbsfleet Channel' localities

	'Lower Gravels' (BMB-B)			'Temperate Bed' (BMB-E)		
	a	**b**	**c**	**a**	**b**	**c**
Panthera leo (L.), lion	–	–	1	–	–	–
Mammuthus trogontherii Pohlig, steppe mammoth ("Ilford-type")	+	4	4	+	3	2
Equus ferus Boddaert, horse	+	4	3	+	–	6
Stephanorhinus hemitoechus (Falconer), narrow-nosed rhinoceros	–	–	2	–	–	2
Coelodonta antiquitatis Blumenbach, woolly rhinoceros	+	–	–	–	–	–
Rhinocerotidae gen. et sp. indet., indeterminate rhinoceros	–	1	–	+	2	–
Megaloceros giganteus (Blumenbach), giant deer	–	*7 **	*10 **	+	*7 **	*10 **
Bos primigenius Bojanus or *Bison priscus* Bojanus, aurochs/bison	+	–	1	–	–	–

Note: For each named deposit: a – species reported by Burchell (see Burchell 1933 and 1935a for 'Lower Gravels' list, and 1957 for 'Temperate Bed' list); b – species identified by Carreck in the 1960s; c – determinations based on material in the NHM

Key: * Position of *Megaloceros* uncertain, as discussed in text; it is also reported from the upper Middle Loam, and from the Lowermost Loam at Burchell's Channel B locality
'+' denotes that a species is present, and figures are the numbers of identified specimens (NISP); note taxonomy has been updated

Natural History Museum. However, the collection does include two specimens of narrow-nosed rhinoceros (*Stephanorhinus hemitoechus*) from the 'Lower Gravel' together with two more from the 'Temperate Bed'; these latter specimens were attributed to '*Rhinoceros* sp.' by Burchell and Carreck, but have now been attributed as narrow-nosed rhinoceros.

The stratigraphical provenance of the *Megaloceros* material is more uncertain. Giant deer (*Megaloceros giganteus*) was reported by Burchell (1957) from the 'Temperate Bed' and as one of the species from Levallois "floors" in his summary diagram (Fig 2.12). However, Carreck (1972) only identified *Megaloceros* in the 'Lower Gravel', based on its entry in the NHM register. The same seven specimens (M16306–12) recorded by Carreck were re-examined in 1993 (by A Currant, former curator of mammals at the NHM), and Carreck's attribution to *M. giganteus* was confirmed. It was also noted that the bones were listed as part of the assemblage from "Lower Loam", later re-attributed to "Lower Gravel", in the original handwritten list accompanying donation of the collection to the NHM, thought to have been written by Burchell himself. The bones are probably from the same individual and appear to have been found together with several vertebrae, in similar condition and of giant deer size. It thus seems that either Burchell was mistaken in attributing these specimens to the 'Temperate Bed' in his 1957 publication, or that the fossils are wrongly registered in the NHM collection. Ultimately, this issue may be resolved by an analysis of the sediment adhering to the fossils or by chemical analysis of the specimens; in the meantime, the stratigraphic position within the Ebbsfleet Channel sequence of giant deer should be considered uncertain.

In addition to these specimens, giant deer is also represented by a humerus donated by Burchell to Ipswich Corporation Museum. A letter (dated 15 January 1935, held in the NHM archives) from Burchell to Dorothea Bate (of the NHM, who identified the bone) records *Megaloceros* at another horizon altogether. Burchell states that:

> *Although the bone may be said to have come from the lower part of the section the precise horizon is that of the Middle Brickearth (upper part). I have marked the exact place in the table of the latest report enclosed herewith.*

This reprint (Burchell 1936b) has been located in the Department of Earth Sciences at the NHM and the position is marked in the summary table on page 554 as the higher deposit of 'Middle Loam – sub-aerial (older series)' = 'Upper Middle Loam' (ie, equivalent to the upper part of phase BMB-D in Fig 6.2) with a note by Bate stating:

> *Mr B. giving this to Ipswich Corporation Museum*

Another vertebra of *Megaloceros* at the Museum of London, possibly from Oakley's and Grimes' 1948 investigation, is reported by Carreck (1972, 49) as from the Lowermost Loam. This information contradicts (or adds to) Burchell's published reports, in which large vertebrate bones were recorded only in the lower gravel at the base of the Ebbsfleet Channel sequence, the "floors" between the base of the lower gravel and the Lowermost Loam, and the 'Temperate Bed'.

Mammoth remains were reported by Burchell from the lower gravel at both his Channel A and Channel B sites. It is now impossible to determine which of the specimens in the NHM collection attributed to "Lower Gravel" come from one or other of these locations. He describes (Burchell 1936b, 553) those from his "B" location as coming from the "floor" at the base of the gravel overlying the Lowermost Loam. The NHM collection contains six specimens from Burchell's work, two of them from the Temperate Bed (M25042 and

Table 6.4 Small mammals reported by Burchell from the 'Ebbsfleet Channel'

	'Lowermost Loam' (Channel B)		'Lower Gravels' (Channel A)		'Lower Loam' (Channel A)
	b	d	a	c	c
Evotomys cf. *kennardi* Hinton	1	–	–	–	–
Clethrionomys glareolus (Schreber)	–	2	–	–	–
Arvicola abbotti Hinton	5	–	–	–	–
Arvicola cantiana (Hinton)	–	"several"	–	–	–
Microtus agrestis (L.)	–	1	–	–	–
Microtus anglicus Hinton	–	–	+	2	1 (3 cf.)
Microtus arvalis group (Pallas)	–	–	+	1	–
Microtus cf. *malei* Hinton	3	–	–	–	–
Microtus nivalis (Martins)	–	–	+	–	–
Microtus sp.	–	–	–	–	2

Note: a – species reported by Burchell (1935a); b – species identified by Bate (in litt.); c – species identified by Hinton (in litt.); d – determinations by Stuart (in litt.).
KEY: '+' denotes that a species is present, and figures indicate the numbers of identified specimens (NISP)

M25047, both corresponding with M16294 from the original handwritten collection listing) and four from the Lower Gravel (M25043, M25044, M25045 and M25046, corresponding with M16297 through to M16300 on the handwritten list, although not in the same order – see Lister, Appendix C3). All six specimens form a coherent group conforming to the Ilford-type mammoth *Mammuthus* cf. *trogontherii* with clear diagnostic examples of this mammoth form in both the Temperate Bed and the Lower Gravel assemblages (see Lister, Appendix C3).

An attempt to summarise this contradictory and ambiguous information is made (Table 6.3), which compares the surviving large mammals recovered by Burchell from the 'Ebbsfleet Channel' with lists given in his publications.

Burchell was the first person to discover small vertebrate remains in the Ebbsfleet Valley Pleistocene deposits. He (Burchell 1935a) reported a vole fauna (*Microtus anglicus, Microtus nivalis* and *Microtus arvalis*) in the lower gravel at his Ebbsfleet Channel Site A (here equated with gravel BMB-B). In a later paper (Burchell 1936b) he recorded a microtine fauna in the (presumed) underlying Lowermost Loam at his "B" site, nearer the centre of the channel. There are also letters in the NHM archive (see below) reporting on microtine fauna (and pike teeth) from the 'Lower Loam'. These latter were, however, subsequently re-attributed to the 'Middle Loam – upper portion' (letter to Oakley of 11 October 1948, NHM archive), the same re-attribution incidentally as for *Megaloceros*. Burchell submitted the small mammal material to the BM (NH) for determination. These were eventually reported on by Dorothea Bate and Martin Hinton in letters to Burchell (copies of which survive both in the NHM archive, and as direct quotes in Carreck's MPhil (1972, 35)), who incorporated their identifications into his publications (Burchell 1935a; 1936b). Although the collection was re-examined by A J Stuart in the 1970s, it has not been possible to trace any of these small mammal remains for reappraisal. Stuart, in a letter to A J Sutcliffe (Sutcliffe Archive, NHM), casts doubt on some the earlier identifications, but does not give details of the stratigraphical origin of the finds. Recently, some small vertebrate material has been rediscovered amongst Burchell's unsorted shell debris in the mollusc collection now stored in the Natural History Museum (Department of Palaeontology). These previously unrecorded remains include rodent and anuran material that are ascribed to the 'Temperate Bed' and the overlying 'Calcareous Loam'. The small mammalian fauna recorded by Burchell, based on determinations by Hinton and Bate is tabulated (Table 6.4). In this table, *Evotomys* cf. *kennardii* and *Clethrionomys glareolus* are synonyms for the same specimens, likewise *Arvicola abbotti* and *Arvicola cantiana*.

This table shows one discrepancy, which is the lack of a specialist reference to *M. nivalis*, despite its appearance in Burchell's (1935a, 90) publication. Supplementing the record of Table 6.4, there is a second table (Table 6.5) in the NHM archives (letter to Oakley from Burchell, 11 October 1948) that gives the same species list, with just one difference: material from the "Lower Loam" has been re-attributed to the 'Middle Loam – upper portion'. The horizon names have been retained as recorded by Burchell, and thus inevitably incorporate his stratigraphical presumptions; for instance, the material in the middle column was from the lower gravel excavations at his first, Channel A site, where there was no Lowermost Loam.

In their review of British Pleistocene rodents, Sutcliffe and Kowalski (1976, 60) gave details of the small mammals from the 'Ebbsfleet Channel'. This is based on identifications by A J Stuart, who examined Burchell's Ebbsfleet Channel specimens along with

Table 6.5 Small mammals reported by Burchell from the 'Ebbsfleet Channel' deposits, letter to Oakley of 11 October 1948

	Lowermost Loam	Gravel between Lower Loam and Lowermost loam	Middle Loam – upper portion
Evotomys cf. *kennardi* Hinton	+	–	–
Arvicola abbotti Hinton	+	–	–
Microtus anglicus Hinton	–	+	+ (dwarf form as at Ightham Fissures)
Microtus arvalis group (Pallas)	–	+	–
Microtus malei Hinton	+	–	–
Microtus nivalis (Martins)	–	+	–

Table 6.6 Small vertebrates from Burchell's mollusc samples in the Natural History Museum, London

	'Temperate Bed' Lower part	Upper part	Undifferentiated	'Calcareous Loam'
AMPHIBIA				
Anuran, indeterminate frog or toad	–	1	1	–
MAMMALIA				
Microtus oeconomus (Pallas), northern vole	–	2	2	–
Microtus sp., indeterminate vole	2	5	3	1

others recovered by Kerney and Sieveking. In a letter to Sutcliffe (dated 3 March 1975), Stuart records the presence of two molars of the bank vole *Clethrionomys glareolus*, an upper second molar of the field vole *Microtus agrestis*, a first lower molar of *M.* cf. *agrestis* and several teeth of the water vole *Arvicola cantiana*, the latter with 'enamel clearly differentiated (as in *Mimomys*) no intermediate or '*terrestris*' types present). Similarities between Stuart's list and that of Burchell suggest that he examined material from the 'Lowermost Loam' since his identifications in column "d" of Table 6.4 are consistent with the earlier identifcations of material from the Lowermost Loam by Bate (column "b") but using newer synonyms. Significantly, Stuart was unable to confirm the presence of two of the species (ie, *M. nivalis* and *M. anglicus*) reported by Burchell (1935a). It is probable that the specimens identified by Bate and Hinton (*Microtus anglicus*, *M. arvalis* group, *M.* cf. *malei* and *Microtus nivalis*) represent variants of *M. oeconomus*, molars of which display an unusually wide range of variation during this period in Britain (see Nadachowski 1982; Parfitt *et al*, Appendix C1). Unfortunately, because of the loss of most of Burchell's collection, it is not possible to check this suggestion.

Recently, several batches of small vertebrate material have been rediscovered in the mollusc collection in the Department of Palaeontology at the Natural History Museum. These were collected by Burchell from the 'Temperate Bed' and the overlying 'Calcareous Loam'. The material from the 'Temperate Bed' includes four first lower molars of the northern vole *Microtus oeconomus*, together with fragmentary small mammal bones and teeth and amphibian remains; a single molar of *Microtus* sp. is from the 'Calcareous Loam' (Table 6.6). Problems associated with the identification of *M. oeconomus* at the site are further highlighted by a previous identification of one of these specimens as being 'indistinguishable from the field vole *Microtus agrestis* (Linné) (det. R.W. Hayman)'.

Table 6.7 List of mammalian remains from the British Museum excavations at Site B

	Site B (EB 69)
Mammuthus trogontherii Pohlig, steppe mammoth	4
Equus ferus Boddaert, horse	9
Stephanorhinus cf. *hemitoechus* (Falconer), narrow-nosed rhinoceros	1
Coelodonta antiquitatis Blumenbach, woolly rhinoceros	2
Rhinocerotidae gen. et sp. indet., indeterminate rhinoceros	2
Bos primigenius Bojanus or *Bison priscus* Bojanus, aurochs/bison	1

Grimes and Oakley's 1948 work

Grimes and Oakley recovered bones from two separate layers that they correlated with Burchell's 'Lowermost Loam' and 'Lower Gravels'. The whereabouts of the vertebrate remains is unknown, but archive notes from the fieldwork (which includes information on the stratigraphy) are housed in the Natural History Museum (Oakley Archive, Department of Earth Sciences). One sediment sample from the 1948 excavation is also stored in the Natural History Museum (Anthropology Collection), but it proved to be barren when sieved. Carreck (1972, 49) listed three specimens from Burchell's Ebbsfleet Channel deposits in the Museum of London, and it is likely they result from Grimes and Oakley's 1948 work. These specimens are: a vertebra of *Megaloceros* from the Lowermost Loam; a mammoth mandible from "chalky gravel above the Lowermost Loam"; and a limb bone of "Rhinoceros? sp." from the Temperate Bed.

Sieveking's excavations

The largest surviving collection of large mammal material from Site B was recovered during excavations directed by G Sieveking on behalf of the British Museum. Work at a number of locations in the vicinity of Site B was undertaken on a number of occasions between 1965 and 1971, in collaboration with MP Kerney of Imperial College. The vertebrate remains, some of which are marked with find numbers, are now housed in the Natural History Museum. Unfortunately, there are no provenance records of any sort, and consequently none of the finds can be assigned with certainty to any one of the several different strata recorded in section drawings. With the notable exception of woolly rhinoceros, this assemblage is remarkably similar in composition to that recovered by Burchell from the 'Lower Gravels' at Site B and by Carreck from his Channel D, horizon C at Site F (see below). The four specimens of woolly rhinoceros, which include a partial skull (Find number (FN) 99) and an upper molar (FN 195), possibly from the same individual, are of uncertain provenance. The only published note (Kerney and Sieveking 1977, 46) reports the presence of "a cold mammalian fauna" in "the lower solifluxion material", and it is therefore likely that the

Table 6.8 Wenban-Smith's phases of fieldwork and sampling at Site B, test pit B.TP 1

W-S strat (1995)	EV 1993 (initial)	EV 1993 (follow-up)			EV 1994
Location	B.TP1.a	B.TP1.a	B.TP1.b - Column 1	B.TP1.b - Column 2	B.TP1.c
For	Small vertebrates	Small vertebrates	Pollen /ostracods	Pollen /ostracods	Small vertebrates
5–Temperate Silt (upper)			<1>	–	
			<2>		
		<1-"top"> – 37kg	<3>		<1> – 8kg
			<4>		
			<5>		
			<6> *		
	<228-"top"> – 9kg		<7>		<2> – 5kg
		<2> – 30kg	<8>		
		<2–&–3> – 32kg	<9>		
			<10>		
			<11>		
			<12>		
		<3> – 31kg	<13>		
			<14> *		
			<15>		<3> – 63kg
			<16>		
			<17>		
		<4> – 32kg	<18>		
			<19>		
			<20>		
5–Temperate Silt (middle – pink clayey lens)	<"228-middle"> – 6kg	–	<21>	<22>	<4> – 29kg
5–Temperate Silt (lower, including basal pink clayey part)		–	–	<23>	<5a> – 31kg
				<24>	
				<25>	
				<26>	<5b> – 26kg
				<27>	
	<"228-bottom"> – 4kg			<28> *	
				<29>	<5c> – 25kg
				<30>	
				<31>	
				<32>	<5d> – 17kg
				<33>	
				<34>	
				<35>	
				<36> *	
4–Middle Loam (top, Kemp's palaeosol)	–	–	–	<37>	–
				<38>	
4–Middle Loam (upper part, below Kemp's palaeosol)	–	–	–	<39>	<6> – 24kg
				<40>	
				<41>	
				<42>	

NOTE: * Checked by Rob Scaife for pollen – none found

woolly rhinoceros material (Table 6.7) comes from these levels (BMB-A, BMB-B, and possibly also BMB-C).

Wenban-Smith's small vertebrate sampling

In 1993 and 1994, sections at Site B were re-excavated and sampled by Wenban-Smith in a newly dug test pit B.TP 1 (Fig 6.1). Sixteen samples (385kg) were processed from different levels through the Temperate Bed (Table 6.8; see Fig 6.7) and these yielded a substantial assemblage of small vertebrate remains, whereas the only sample (24kg) from the top part (bed 4c) of the underlying Middle Loam was barren. Results are presented here in tabular form (Tables 6.9–11) and plotted graphically (Figs 6.3 and 6.4).

The Temperate Bed proved especially rich in small mammal remains (n=855) but no identifiable large mammal remains were found. Frogs and toads are present in relatively low numbers (~11% of the total identifiable small vertebrate assemblage) and fish remains are surprisingly rare being represented by a pike tooth and a pharyngeal tooth of a cyprinid, both from upper part of the unit (Fig 6.3). There are only minor changes in the composition of the small mammal assemblage through the sequence (Fig 6.4); most notably there is a clear peak in small mammal abundance in the upper part and a decline in the number of frog/toad bones towards the top of the unit. The general scarcity of fish remains may be attributed to

Table 6.9 Identified small vertebrates from Temperate Bed, Wenban-Smith fieldwork

Summary by stratigraphic horizon of processed sample weights and small vertebrate counts

Phase	BMB-D	BMB-E		
W-S bed number	4		5	
		Base	Middle	Top
No. of samples (weight Kg)	1 (24)	5 (103)	2 (35)	9 (247)
Fish	0	0	0	2
Amphibian	0	21	6	48
Reptile	0	0	0	0
Bird	0	0	0	1
Small mammal	0	112	19	569
Total	0	133	25	620
NISP/L.	0	1.29	0.71	2.5

Detailed breakdown by sample of processed sample weights and small vertebrate counts

Sample location	B.TP1.a					B.TP1.b			B.TP1.c								
Phase	BMB-E								BMB-D	BMB-E							
Context			228 top			228 Base	228 Middle	228 Top		228 Base				228 Middle		228 Top	
Sample	4	3	2 and 3	2	1				6	5d	5c	5b	5a	4	3	2	1
No. of samples (weight)	1 (32)	1 (31)	1 (32)	1 (30)	1 (37)	1 (4)	1 (6)	1 (9)	1 (24)	1 (17)	1 (25)	1 (26)	1 (31)	1 (29)	1 (63)	1 (15)	1 (8)
Fish	–	–	1	–	–	–	–	–	–	–	–	–	–	–	1	–	–
Amphibian	9	8	4	3	2	–	–	7	–	1	6	11	3	6	15	–	–
Reptile	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Bird	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Small mammal	47	128	83	73	45	3	0	19	–	15	34	26	37	19	132	15	24
Total	57	136	88	76	47	3	0	26	0	16	40	37	40	25	148	15	24
NISP/L.	1.8	4.4	2.75	2.5	1.3	0.7	0	2.9	0	0.9	1.6	1.4	1.3	0.9	2.3	3	3

Table 6.10 Identified small vertebrates and minimum number of individuals (MNI) from Temperate Bed, Wenban-Smith fieldwork

Phase		**BMB-E**	
W-S bed number		**5**	
	Base	**Middle**	**Top**
Soricomorpha			
Neomys sp., water shrew	2 (1)	–	–
Rodentia			
Microtus oeconomus (Pallas), northern vole	3 (2)	–	23 (16)
Microtus sp., vole	33	7	131

Note: W-S – Wenban-Smith

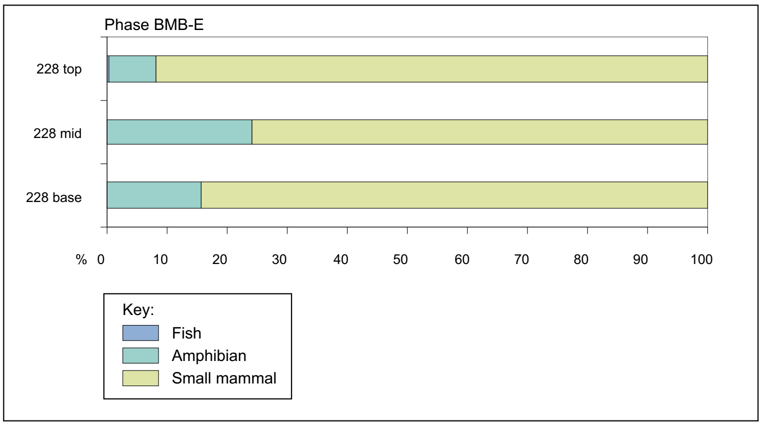


Figure 6.3 Summary of changes in the relative abundance of amphibians and small mammals (% number of identified specimens) through the Temperate Bed at Site B

Table 6.11 Skeletal element abundance from Temperate Bed, Wenban-Smith fieldwork

Sample location	**B.TP1.a**					**B.TP1.b**			**B.TP1.c**							
Phase	**BMB-E**															
Context	**228 top**					**228 bot.**	**228 mid.**	**228 top**	**228 bot.**				**228 mid.**	**228 top**		
Sample	**4**	**3**	**2&3**	**2**	**1**				**5d**	**5c**	**5b**	**5a**	**4**	**3**	**2**	**1**
No. of samples (weight kg)	**1 (32)**	**1 (31)**	**1 (32)**	**1 (30)**	**1 (37)**	**1 (4)**	**1 (6)**	**1 (9)**	**1 (17)**	**1 (25)**	**1 (26)**	**1 (31)**	**1 (29)**	**1 (63)**	**1 (15)**	**1 (8)**
Skeletal part																
Skull	4	19	9	15	2	–	–	–	–	5	1	4	4	13	3	2
Maxilla	–	–	–	–	1	–	–	–	–	–	–	–	–	1	–	–
Mandible	4 (1)	3 (1)	1	3 (2)	–	1	–	1	–	–	–	1	–	6 (5)	–	–
Incisor	6 (5)	28 (10)	17 (7)	17 (5)	12 (4)	–	–	2 (2)	4 (2)	10 (4)	2 (2)	10 (3)	7 (3)	26 (13)	6 (3)	1
Molar	23	30	21	15	25	2	–	2	5	4	14	11	7	34	4	12
Vertebra	2 (2)	9 (8)	5 (5)	–	–	–	–	2 (2)	–	–	1	–	–	7 (7)	–	–
Rib	–	–	2 (1)	–	–	–	–	2	–	–	–	–	–	–	–	–
Scapula	–	2 (2)	–	–	–	–	–	–	–	1	–	–	–	–	–	–
Humerus	1	4 (3)	4 (2)	3 (2)	–	–	–	–	–	2 (1)	1	3 (3)	–	2 (2)	1	–
Radius	1	5 (2)	4 (2)	2 (1)	–	–	–	–	–	1	1	–	–	–	–	1
Ulna	4 (2)	2 (1)	2	1	–	–	–	–	–	1	1	–	–	8 (5)	–	–
Innominate	1	1	1	–	2 (1)	–	–	–	–	–	–	–	–	1	–	–
Femur	1	3 (2)	1	2 (2)	–	–	–	–	2 (1)	2 (1)	–	4 (2)	–	3 (2)	–	2 (1)
Tibia	2 (1)	–	1	1	–	–	–	1	3 (2)	1	–	1	–	4 (3)	–	1
Calcaneus	2 (1)	2 (2)	1	2	–	–	–	1	–	–	–	–	1	2 (2)	1	–
Astragalus		4 (3)	1	1	–	–	–	–	–	1	–	–	–	2 (2)	–	–
Metapodial	5 (3)	14 (10)	11 (8)	6 (5)	1	–	–	3	1	4 (2)	3 (2)	1	1	6 (6)	–	1
Phalange	–	2 (2)	2 (2)	3 (3)	–	–	–	2	–	–	1	–	–	6 (6)	–	–
Total																
Breakage																
Humerus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
complete	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
proximal	–	–	2	2	–	–	–	–	–	–	–	–	–	–	–	–
shaft	1	3	2	2	–	–	–	–	–	1	–	1	–	–	1	–
distal	–	1	1	–	–	–	–	–	–	1	1	3	–	2	–	–
Femur	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
complete	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–
proximal	–	2	–	2	–	–	–	–	1	1	–	2	–	2	–	–
shaft	–	1	–	–	–	–	–	–	1	–	–	–	–	–	–	1
distal	1	1	1	–	–	–	–	–	1	1	–	2	–	1	–	1
Tibia	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
complete	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
proximal	1	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–
shaft	2	–	1	–	–	–	–	1	1	–	–	–	–	–	–	–
distal	1	–	–	–	–	–	–	1	2	1	–	1	–	–	–	–
Digestion																
Incisors (N)	21	11	12	17	11	–	–	2	4	10	2	10	7	26	6	1
light	2	3	7	5	–	–	–	–	–	2	–	2	2	9	1	–
moderate	–	–	–	1	–	–	–	–	–	–	–	2	–	1	1	–
heavy	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–
extreme	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–
Total digested, n (%)	**2 (9.5)**	**5 (45.4)**	**7 (58.3)**	**6 (35.3)**	**0**		–	**1 (50)**	**0 (0)**	**2 (20)**	**0 (0)**	**4 (40)**	**2 (28.6)**	**10 (38.5)**	**2 (33)**	**0**
Molars (N)	23	20	22	15	25	2	–	2	5	4	14	11	7	34	4	12
light	1	8	5	3	1	–	–	1	–	1	2	1	1	3	1	3
moderate	–	2	–	1	2	1	–	–	1	–	–	3	–	–	–	1
heavy	–	–	1	–	–	–	–	–	–	–	–	–	–	1	–	–
extreme	–	–	–	–	–	–	–	–	–	–	–	–	1	2	–	–
Total digested, n (%)	**1 (4.3)**	**10 (33.3)**	**6 (27.3)**	**4 (26.7)**	**3 (12)**	**1 (50)**	– –	**1 (50)**	**1 (20)**	**1 (25)**	**2 (14.3)**	**4 (26.7)**	**2 (28.6)**	**6 (17.6)**	**1 (25)**	**4 (33)**

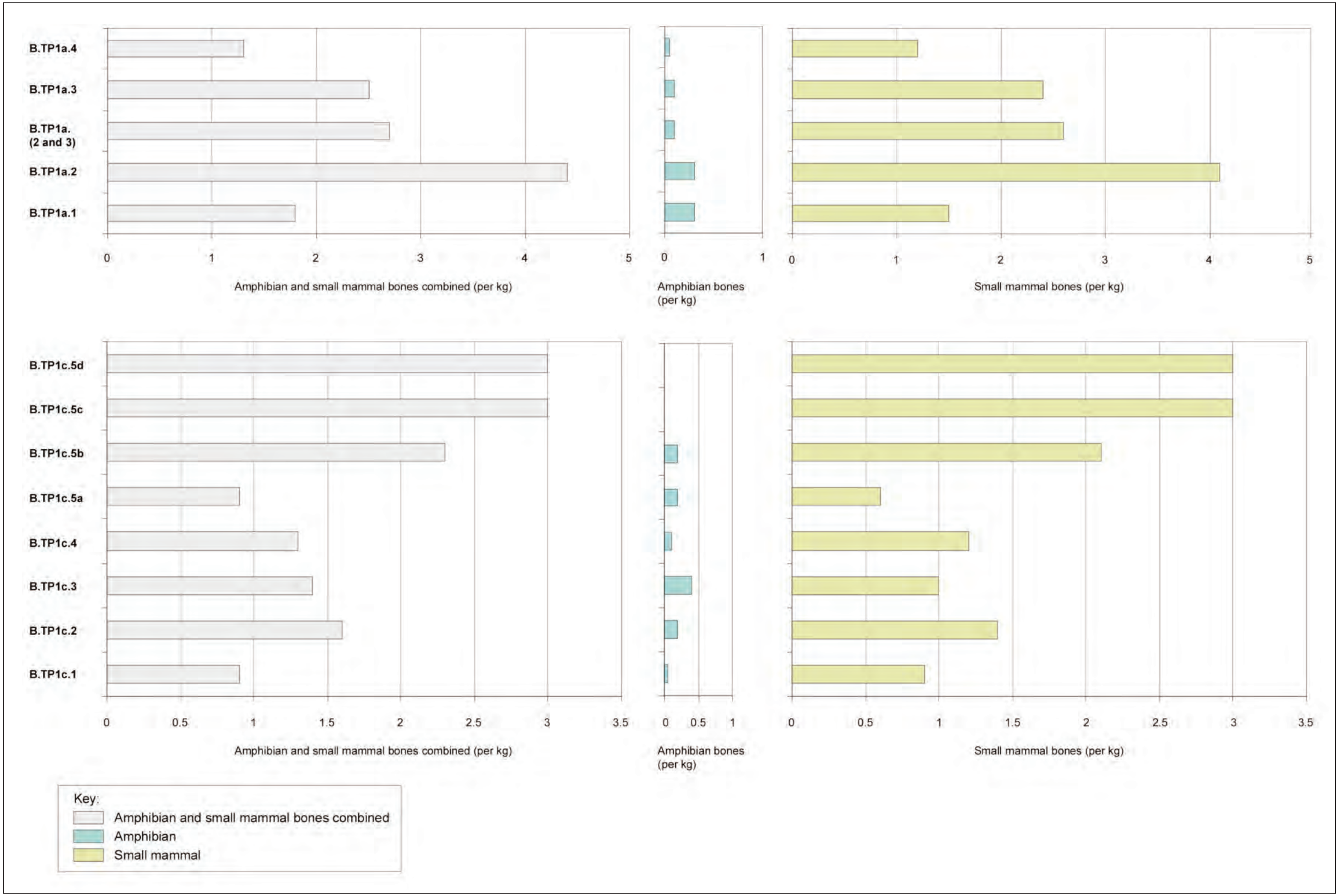


Figure 6.4 Histograms show changes in concentration (bones per kg) of amphibian and small mammal remains through the 'Temperate Silt' from two locations at Site B: (a) BTP1a; and (b) BTP1c

Table 6.12 Summary of vertebrates from Site B

Deposit/phase	**Lower-most Loam**	**Lower Gravels**	**BMB-E**				**BMB-F**	**Unstratified**
W-S bed number				**5**			**6**	
Ck bed number								
Collection	**Burchell**		**Wenban-Smith**			**Burchell**		**Kerney/ Sieveking**
			Lower	**Middle**	**Upper**			
PISCES								
Esox lucius L., pike	–	–	–	1	1	–	–	–
Cyprinidae gen. et sp. indet., carp family	–	–	–	–	–	–	–	–
AMPHIBIA								
Auran indet., indeterminate frog or toad	–	–	+	+	+	2	–	–
MAMMALIA								
Soricomorpha								
Neomys sp., water shrew	–	–	2	–	–	–	–	–
Rodentia								
Clethrionomys glareolus (Schreber), bank vole	2	–	–	–	–	–	–	–
Arvicola cantianus (Hinton), water vole	+	–	–	–	–	–	–	–
Microtus agrestis (L.), field vole	1 (1 cf.)	–	–	–	–	–	–	–
Microtus oeconomus (Pallas), northern vole	–	–	3	–	23	4	1	–
Microtus sp., vole	–	–	33	7	131	10	–	–
Carnivora								
Panthera leo (L.), lion	–	1	–	–	–	–	–	–
Proboscidea								
Mammuthus trogontherii Pohlig, steppe mammoth	–	5	–	–	–	1	–	4
Perissodactyla								
Equus ferus Boddaert, horse	–	4	–	–	–	–	–	9
Stephanorhinus hemitoechus (Falconer), narrow-nosed rhinoceros	–	2	–	–	–	2	–	cf.
Coelodonta antiquitatis Blumenbach, woolly rhinoceros	–	–	–	–	–	–	–	2
Rhinocerotidae gen. et sp. indet., indeterminate rhinoceros	–	–	–	–	–	–	–	2
Artiodactyla								
Megaloceros giganteus (Blumenbach), giant deer	–	10	–	–	–	–	–	–
Bos primigenius Bojanus or *Bison priscus* Bojanus, aurochs or bison	–	1	–	–	–	–	–	1

a shallow water or bank-side location, as suggested by the topographic situation of the sampling location. A picture of the local environment is also provided by the small mammal fauna, which is dominated by northern vole *M. oeconomus* (26 first lower molars). Northern vole favours damp grassland, which would have also provided suitable habitats for the water vole *Neomys* sp. (identified from a mandible and first lower molar) and the anurans.

A notable feature of small mammal remains from the Temperate Bed is the presence of vole mandibles with teeth still in their sockets. Burial conditions that favour preservation of such fragile small mammal remains include rapid burial under gentle depositional environment and minimal post-depositional sediment compaction (see Parfitt, Appendix C2). As discussed above, Burchell also recovered small vertebrate remains from the Temperate Bed (Table 6.6), although these were never mentioned in any of his publications. This previously unpublished material includes vole teeth and anuran bones, which were found in samples processed for molluscs. This material and the assemblage collected by Wenban-Smith show close correspondence in taphonomy and taxonomic composition, supporting a common origin for the two faunal assemblages and confirming that Burchell and Wenban-Smith sampled the same deposit. In Burchell's samples the associated molluscan assemblages contain woodland taxa indicative of fully temperate conditions, seemingly at odds with the presence of northern vole, which is an open-ground animal with a predominantly boreal Eurasian distribution at the present day. Unfortunately, molluscs were not preserved in the sediments sampled by Wenban-Smith, but the molluscan evidence from the Temperate Bed (see below) records an upward change from woodland conditions to more open grassland conditions, possibly indicating a deterioration of climate in the upper part of the Temperate Bed. In view of this transition in the molluscan fauna, it is significant that the only well-stratified northern vole remains in Burchell's collection came from the upper part of the unit, possibly coinciding with the peak abundance of small mammal remains in Wenban-Smith's section. Confirmation of cool, open conditions in the upper part of the Temperate Bed is provided by the presence of the boreo-alpine beetle *Otiorhynchus arcticus* in the same deposit (see Coope, below).

Summary of vertebrate finds

Interpretation of the vertebrate collections from Site B (Table 6.12) is hampered by a lack of detailed primary excavation records from Burchell's work and the British Museum excavations, combined with a paucity of well-stratified material from other interventions and the loss of critical specimens and documentation. Nevertheless, the main sequences at Burchell's main (Ebbsfleet Channel A) and second (Ebbsfleet Channel B) sites are well-established, as are the positions within these

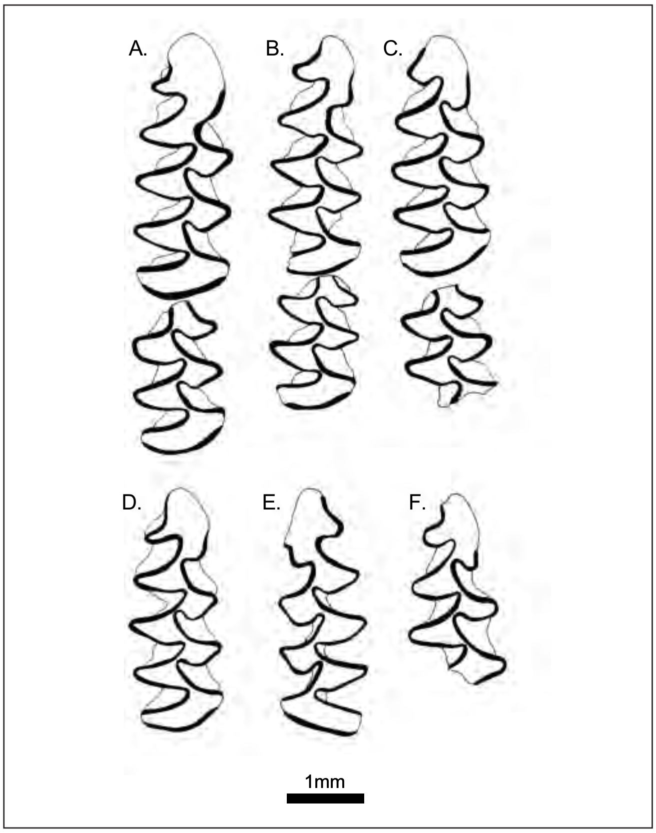


Figure 6.5 Comparison of first lower molars of northern vole (*Microtus oeconomus*) collected by Wenban-Smith (a–d) and Burchell (e–f), from Site B. The specimens illustrate the wide variation in morphology that is characteristic of British northern vole populations from the late Middle Pleistocene (eg, MIS 7), with a dominance of '*malei*' (b, e) and '*nivalis*' (c, d, f) morphotypes (as defined by Nadachowski 1991). The '*oeconomus*' morphotype (a), which is dominant in most living populations, is uncommon in the Ebbsfleet sample. Wenban-Smith collection: (a) Right mandible with M1 and M2 (TP B1, BTP 1a (2), context 5, 228 top, no. 729); (b) R. mandible with M1 and M2 (TP B1, B (2+3), context 5, 228 top, no. 739); (c) R. mandible with M1 and M2 (TP B1, BT-P1a (4), context 5, 228 top, no. 781); (d) R. M1 (TP B1, B (3), context 5, 228 top, no. 775). Burchell collection: (e) L. M1 (Temperate Bed. Originally identified as *Microtus agrestis*); (f) R. M1 frag. (Temperate Bed, Ex. AG Davis, associated with molluscs, including *Discus rotundatus*, Clausilids and *Azeca goodalli*, confirming attribution to the Temperate Bed)

sequences of the richest vertebrate horizons: the Lower Gravel, the Lowermost Loam and the Temperate Bed. These assemblages are somewhat unusual in that red deer is absent (although Carreck did record a single specimen of red deer from an adjacent section – see Site F below). Horse is well represented, and woolly rhinoceros may either derive from the earlier (pre-channel?) Coombe Rock, or from one or other of the lower gravel deposits (phases BMB-B or BMB-C), which may include other horizons than those identified by Burchell. Climatically, the mammalian fauna is not particularly informative as all of the species are known from both temperate episodes and cold stages during the late Middle Pleistocene in Britain. Local vegetation can be inferred from the dominant elements of the fauna (steppe mammoth, horse, narrow-nosed rhinoceros), which are all indicative of open grassland. Small mammals from the lower parts of the channel fills, at Burchell's Ebbsfleet Channel A and B sites, indicate a mix of grassland (water vole *Arvicola* and field vole *Microtus agrestis*) with scrub or woodland (bank vole *Clethrionomys glareolus*). The sparse large mammal assemblage recorded by Burchell from the 'Temperate Bed' is not particularly informative, but the abundant presence of the northern vole *M. oeconomus* is consistent with damp grassland.

Because of the potential biostratigraphical significance of the northern vole *M. oeconomus* assemblage from Site B, a detailed morphometric study of this material has been undertaken (see Parfitt *et al*, Appendix C1). Several studies have noted the distinctive morphology of late Middle Pleistocene *M. oeconomus* from sites, such as Clevedon Cave, Somerset; Erith, Bexley, Greater London; Crayford, Bexley, Greater London; Tornewton Cave, Devon; Marsworth Buckinghamshire, and Norton Farm, West Sussex (Hinton 1907 a and b; Chaline 1972; Sutcliffe and Kowalski 1976; Nadachowski 1991; Murton *et al* 2001; Bates *et al* 2000), which are now assigned to either MIS 7 or early MIS 6. The morphology of *M. oeconomus* from the Site B sample (Fig 6.5) is entirely consistent with the samples assigned to MIS 7 or early MIS 6.

In the wider Ebbsfleet deposits, *M. oeconomus* is also present in the small mammal assemblages from ZR4 3776TP (Table 5.15), where it is dominant but increasingly scarce in the upper phases of the interglacial sequence (3776-F and 3776-G), moderately common in the middle part (3776-E), but virtually absent in the rich assemblage from the peak interglacial deposits at the base of the sequence (3776-D). Other samples (eg, Site A) are too small for detailed analysis and comparison. A cluster analysis of M1 morphotypes of the largest samples (from Site B and ZR4 3776TP) shows that they fall into separate groups (Parfitt *et al*, Appendix C1)

The sample from the upper part of the Temperate Bed at Site B (FW-S context 228 and Burchell's Temperate Bed) clustered with those from Norton Farm and Clevedon Cave, whereas the ZR4 samples (mostly from context 526, at the base of the fluvial phase 3776-F) fall in a separate cluster, together with poorly dated MIS 7 samples from Tornewton Cave and Crayford. This analysis suggests that the samples from ZR4 and Site B are from different populations and are therefore unlikely to be contemporaneous. Although the composition of the vertebrate fauna from Site B is consistent with MIS 7, it is currently not possible to assign the Temperate Bed assemblage to any particular sub-stage of MIS 7 on solely biostratigraphic grounds (*cf* Chap 16).

Molluscs

Burchell identified molluscan remains from various deposits, presented throughout his prolonged series of published "notes" on his work in the Ebbsfleet Valley. In his (1935b) paper he published a species list (n=24) from the Temperate Bed (Table 6.13), which established its interglacial character and at the same time its fluvial origin, *contra* his previous interpretation (1935a) as a "loam of sub-aerial origin". In his (1936b) paper he listed *Bithynia tentaculata* as present in the Lowermost Loam at his central, Channel B site. In his (1954) paper he gave counts for the changing quantities of *Pupilla muscorum* and *Vallonia costata* through the Middle Loam (Table 6.13), showing a steadily increasing predominance of *Pupilla* through the lower part of the deposit into its central chalk-rich layer (the "Middle Coombe Rock" *sensu* Burchell), and then nothing but *Pupilla* in its upper part. He also drew attention to a progressive decline in molluscan diversity through the Temperate Bed, culminating in an even more restricted fauna in the overlying Calcareous Loam, albeit without listing any specific species. This was rectified in the final paper in his Ebbsfleet series (1957), where he gives a second, longer list (n=41) of species present in the Temperate Bed (Table 6.13), as well as listing seven species for the overlying Calcareous Loam. This was interpreted as representing a renewed onset of glacial conditions, following the interglacial episode of the Temperate Bed. In addition to this published information, the archive diagram of his two channel sites, A and B (Fig 2.12), lists much the same molluscan data for the parts of the sequence below the Temperate Bed, with the important addition of *Bithynia* opercula in the Lower Loam at both localities, as well as in the Lowermost Loam at the Channel B locality.

Burchell's work was important in establishing that the Temperate Bed represented a water-lain deposit laid down during peak interglacial conditions, and in recovery of a much more restricted molluscan fauna from both overlying and underlying deposits, indicative of cool, dry and much more open conditions. The recovery of *Bithynia* opercula from the lower horizons is also important in retrospect, as they provided material for amino acid dating and may indicated fluvial conditions, although one has to consider that they may be reworked.

Kerney, working with Sieveking in 1969, subsequently took a vertical series of samples through the Middle Loam and Temperate Bed, the records of which are preserved in the British Museum (in the Franks House archive), and which have been drawn up as a diagram here, along with Burchell's record from the overlying Calcareous Loam (Fig 6.6). The location of Kerney's Temperate Bed sequence (samples A–H) is unknown, although the archive record establishes that it represents eight consecutive samples of 0.10m thickness, ie, covering 0.80m through the Temperate Bed. This corresponds well with the thickness recorded by both Sieveking and Wenban-Smith, so it is likely that it is somewhere in the vicinity of the known surviving outcrop. The positions of samples a–g, from the Middle Loam, are shown in Sieveking's Site B section drawing (Fig 6.2b).

Table 6.13 Molluscan records from Site B

Sample (see Key)	2	4a	4b	5#1	5#2	5#3	6
Land (shade)							
Aegopinella nitidula	–	–	–	P	15	–	–
Aegopinella pura	–	–	–	–	6	1	–
Arianta arbustorum	–	–	–	–	fgs	2	–
Azeca goodalli	–	–	–	–	5	12	–
Carychium tridentatum	–	–	–	–	22	6	–
Clausilia bidentata	–	–	–	–	10	2	–
Discus rotundatus	–	–	–	–	38	20	–
Vitrea contracta	–	–	–	–	4	2	–
Vitrea crystallina	–	–	–	P	1	–	–
Land (open-country)							
Cernuella virgata	–	–	–	P	–	–	–
Pupilla muscorum	–	103	45	P	81	121	57
Truncatellina cylindrica	–	–	–	P	–	–	–
Vallonia costata	–	36	–	P	19	9	–
Vallonia excentrica	–	–	–	P	19	7	1
Vallonia pulchella	–	–	–	P	20	10	1
Vertigo pygmaea	–	–	–	P	2	1	–
Catholic							
Cepaea nemoralis	–	–	–	P	fgs	–	–
Cepaea sp.	–	–	–	–	–	1	–
Cochlicopa lubrica	–	–	–	P	6	5	–
Cochlicopa lubricella	–	–	–	–	–	1	–
Derceras/Limax	–	4	–	P	8	8	2
Nesovitrea hammonis	–	–	–	–	1	3	–
Oxychilus cellarius	–	–	–	–	8	–	–
Oxychilus sp.	–	–	–	–	–	2	–
Punctum pygmaeum	–	–	–	P	2	2	–
Trochulus hispidus	–	–	–	P*	31	24	–
Trochulus plebeius	–	–	–	–	–	2	–
Marsh							
Carychium minimum	–	–	–	–	30	67	–
Oxyloma pfeifferi	–	–	–	P	31	16	10
Succinea putris	–	–	–	P	–	3	–
Vertigo antivertigo	–	–	–	P	–	–	–
Zonitoides nitidus	–	–	–	–	8	4	–
Freshwater							
Galba truncatula	–	–	–	P	65	28	3
Anisus leucostoma	–	–	–	P	–	1	–
Radix balthica	–	–	–	P	120	12	3
Stagnicola palustris agg.	–	–	–	P	2	–	–
Gyraulus carista	–	–	–	–	2	2	–
Pisidium casertanum	–	–	–	–	12	21	–
Pisidium obtusale	–	–	–	–	–	1	–
Pisidium personatum	–	–	–	–	11	14	–
Planorbis planorbis	–	–	–	–	23	3	–
Gyraulus laevis	–	–	–	P	3	8	–
Pisidium henslowanum	–	–	–	P	9	2	–
Valvata cristata	–	–	–	–	10	1	–
Valvata piscinalis	–	–	–	–	4	2	–
Ancylus fluviatalis	–	–	–	–	1	1	–
Bithynia tentaculata	P	–	–	P	9	5	–
Corbicula fluminalis	–	–	–	–	fgs	–	–

Note: 2 – Lowermost Loam (Burchell 1936b); 4a – Lower Middle Loam (Burchell 1954); 4b – Upper Middle Loam (Burchell 1954); 5#1 – Temperate Bed (Burchell 1935b); 5#2 – Temperate Bed (Burchell 1957); 5#3 – Temperate Bed (Kerney 1959); 6 – Calcareous Loam over Temperate Bed (Burchell 1957);
KEY: P – present; fgs – fragments; * – abundant

The resulting molluscan record shows a very restricted cold climate and open grassland fauna through the Middle Loam, supporting interpretation as a slopewash rather than fluvial sediment right down to the basal level of sample "a". In the Temperate Bed, the lowest sampled parts have a greater presence and diversity of land, and particularly shade-loving, species. Above this, there is a decline in the proportion of land and shade-loving species, and a tendency up through the sequence towards a predominance of *Pupilla muscorum* as a proportion of the total land assemblage. Freshwater

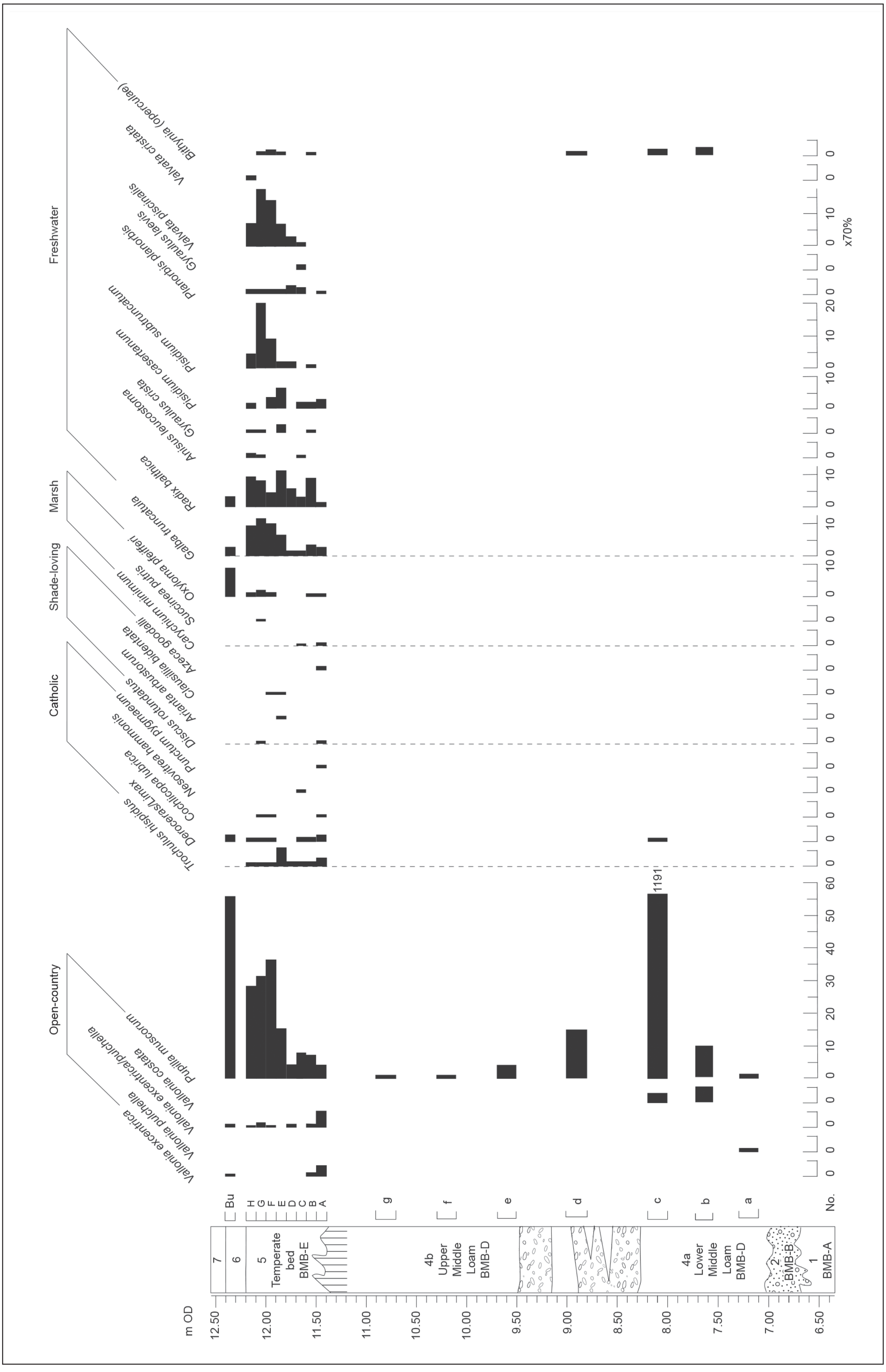


Figure 6.6 Site B mollusc diagram, showing: Kerney's sampling A–H through Temperate Bed and a–g through Middle Loam; and Burchell's record from overlying Calcareous Loam

species are present throughout the sequence, indicating fluvial/alluvial deposition.

Insects

A single head of *Otiorhynchus arcticus* was recovered from the upper part of the Temperate Bed (from Wenban-Smith's test pit B.TP1, sampling location "c", context 228, sample 3). The head was heavily encrusted with a limonitic deposit and was from an oxidised horizon. The occurrence of beetle fossils in oxidised sediments is remarkably rare but since *Otiorhynchus* skeletons are extraordinarily robust it is likely that any other insect remains that the sediment may have contained have been decomposed by oxidation. A detailed account of the biology of *O. arcticus* has been given by Böcher (1988). It is a medium-sized weevil that feeds on a wide variety of herbaceous plants; the larvae live underground and feed on roots. It is frequently found in open, fairly dry grasslands and heathlands where the soil is sandy. In Fennoscandia, it is found on the seashore but in central Europe it is found exclusively above the tree line. Its geographical distribution is largely boreo-alpine with an extensive North Atlantic range that extends from Greenland, Iceland, the Faroes, coastal Fennoscandia, Scotland and western Ireland. In central Europe, it is found in the Pyrenees, Auverne, the Sudeten and Carpathian Mountains (Holdhause and Lindroth 1939). As a Quaternary fossil, it is often abundant in association with exclusively arctic and continental beetle species (Coope *et al* 1961; Coope 1968).

Dating

Burchell's final sentence in his (1957) Ebbsfleet paper thanked A G Davis for his work on the molluscan material, and stated that both molluscan and mammalian remains from his Ebbsfleet investigations were stored at the British Museum (Natural History). The molluscan remains from the A G Davis collection were recently rediscovered in the Natural History Museum collections, and, besides various mollusc shells and the small vertebrate remains previously reported, they contained *Bithynia* opercula from a number of horizons. Typically for Burchell, the nomenclature for half these horizons did not exactly match any of his previously used terms. Apart from material from the upper (n=1) and lower (n=2) parts of the Temperate Bed, there were opercula from the "Lower Brickearth, fluviatile" (n=3) and the "Lowermost Brickearth" (n=3). It seems clear that the latter is equivalent to the Lowermost Loam of Burchell's Ebbsfleet Channel site B, as Burchell used "brickearth" and "loam" synonymously throughout his work and he only identified Lowermost Loam at one location. It also seems likely that the "Lower Brickearth, fluviatile" equates to the Lower Loam which Burchell regarded as fluviatile (eg, 1936b, 554), perhaps on the basis of the presence of the *Bithynia* opercula). However, it is uncertain whether this was the Lower Loam at his Channel site A, the (correlated) "Lower Loam" capping the sequence at his Channel site B (see discussion in Zone 2 synthesis, below), or "Lower Loam" at yet another locality. The results of the amino acid analyses carried out on this material by K Penkman (Fig 6.8) show that the opercula from the Temperate Bed all cluster slightly younger than the mean centre-point of the MIS 7 reference data. The results from the "Lowermost Brickearth" (ie, the Lowermost Loam) at the Channel B site all cluster around the centre-point of the MIS 7 reference data. Unexpectedly, the results from the "Lower Brickearth" cluster around the MIS 9 reference centre-point. This anomalous result could arise for various reasons; there could have been an unrecognised outcrop of older deposits; material from MIS 9 deposit might have been reworked, or heating of the opercula could have affected their degree of racemisation to produce an older result.

There are a number of biostratigraphic indications that link the vertebrate-rich deposits with MIS 7 and Early MIS 6. Firstly, the specific form of the northern vole *Microtus oeconomus* that predominates in both the Temperate Bed, and is also likely represented in Burchell's *Microtus anglicus*, *M. nivalis* and *M. malei* group in the Lower Gravel (at Channel A) and the Lowermost Loam (at Channel B) is that well-established as distinctive to MIS 7 and early MIS 6 (Parfitt *et al*, Appendix C1). Secondly, the mammoth teeth from both the Temperate Bed and the "Lower Gravel" (although it is uncertain whether they come from Lower Gravel at Burchell's Channel A or B locality), show small size and occlusal enamel annulation features typical of the "Ilford-type" of mammoth also characteristic of MIS 7 (Lister, Appendix C3). And finally, the general faunal assemblages from the main horizons are typical of the "*Mammuthus-Equus*" faunas characteristic of MIS 7 (Green *et al* 1984; Currant 1989); the presence of horse through the sequence emphasises that it is not Last Interglacial MIS 5e (Sutcliffe 1995).

Two OSL dating samples, EF 6 and EF 7 were taken by E. Rhodes from the Temperate Bed sequence exposed in test pit B.TP 1 in September 1995 for the Quaternary Research Association field visit to the Lower Thames region. The positions of these samples are

Table 6.14 OSL dating results from B.TP 1

Sample	Depth (m)	De (Gy)	Dose rate (mGy/a)	Lab code	Dating result (years before 2000 AD)
EF 6	2.00	363 ± 28	1.86 ± 0.06	OxL-1265	196,000 ± 18,000
EF 7	2.00	364 ± 17	1.93 ± 0.10	OxL-1266	188,000 ± 13,000

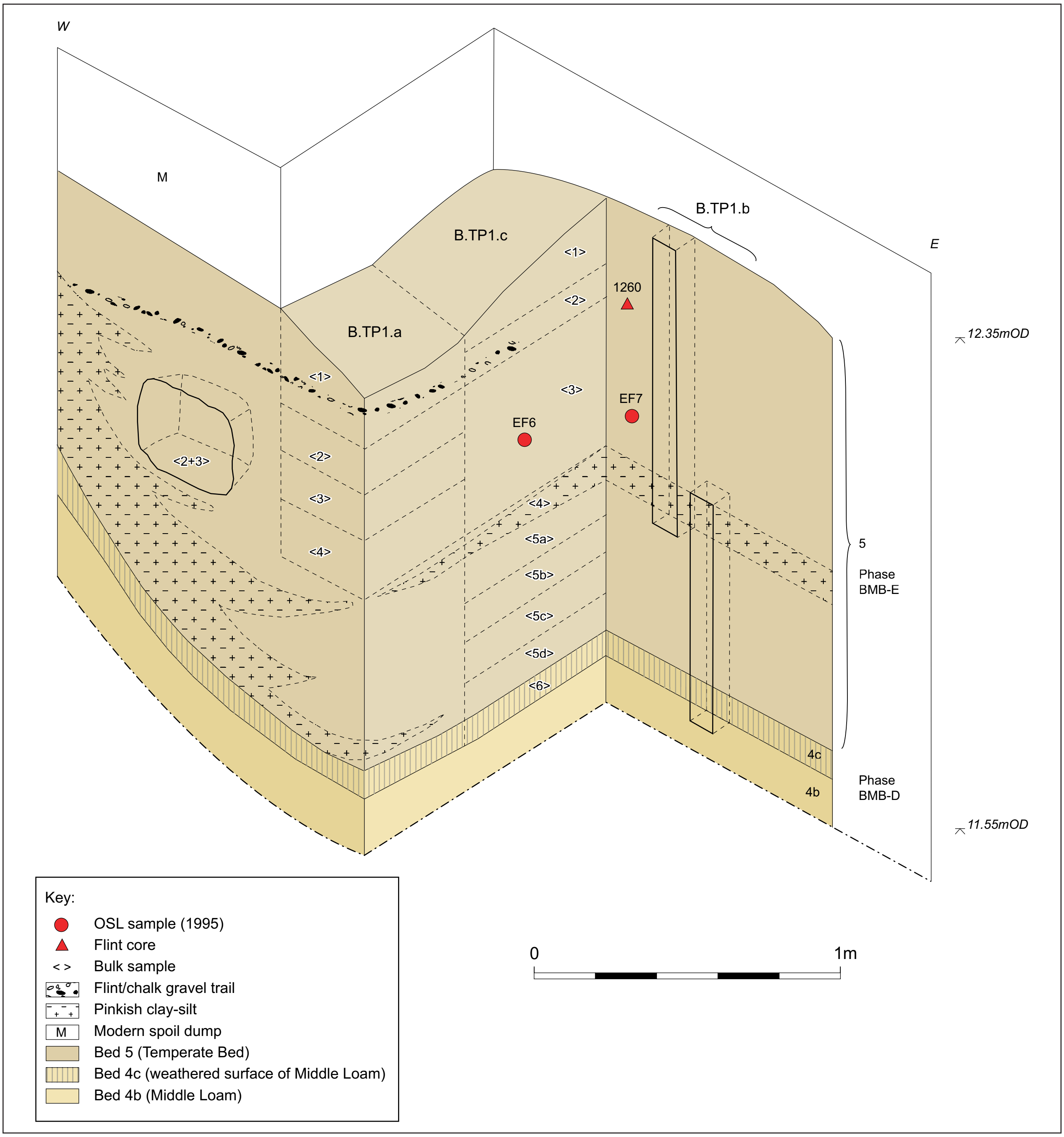


Figure 6.7 Wenban-Smith's test pit B.TP1 section (east-facing and south-facing faces), showing bulk sampling locations a, b and c from the Temperate Bed, and OSL sampling locations EF 6 and EF 7

shown in the test pit section diagram (Fig 6.7). The results (Table 6.14) suggest a date towards the end of MIS 7, which ties in with the biostratigraphic and amino acid dating indications.

Site B Overview

Understanding of the overall sequence at Site B is hampered by the lack of certainty over the locations of much of Burchell's and Sieveking's work, together with a lack of reliable provenance for much of the material they found. The main sequence at Burchell's Ebbsfleet Channel Site A is, however, well-understood, having been subsequently investigated and recorded in more detail by Sieveking and Wenban-Smith. The basal phase (BMB-A) is Coombe Rock representing cold climatic conditions. This is followed by downcutting and fluvial gravel deposition (phase BMB-B), followed by a major phase of slopewash deposition under cool, open and dry conditions (phase BMB-D, Middle Loam), indicated by a sparse terrestrial molluscan fauna throughout the

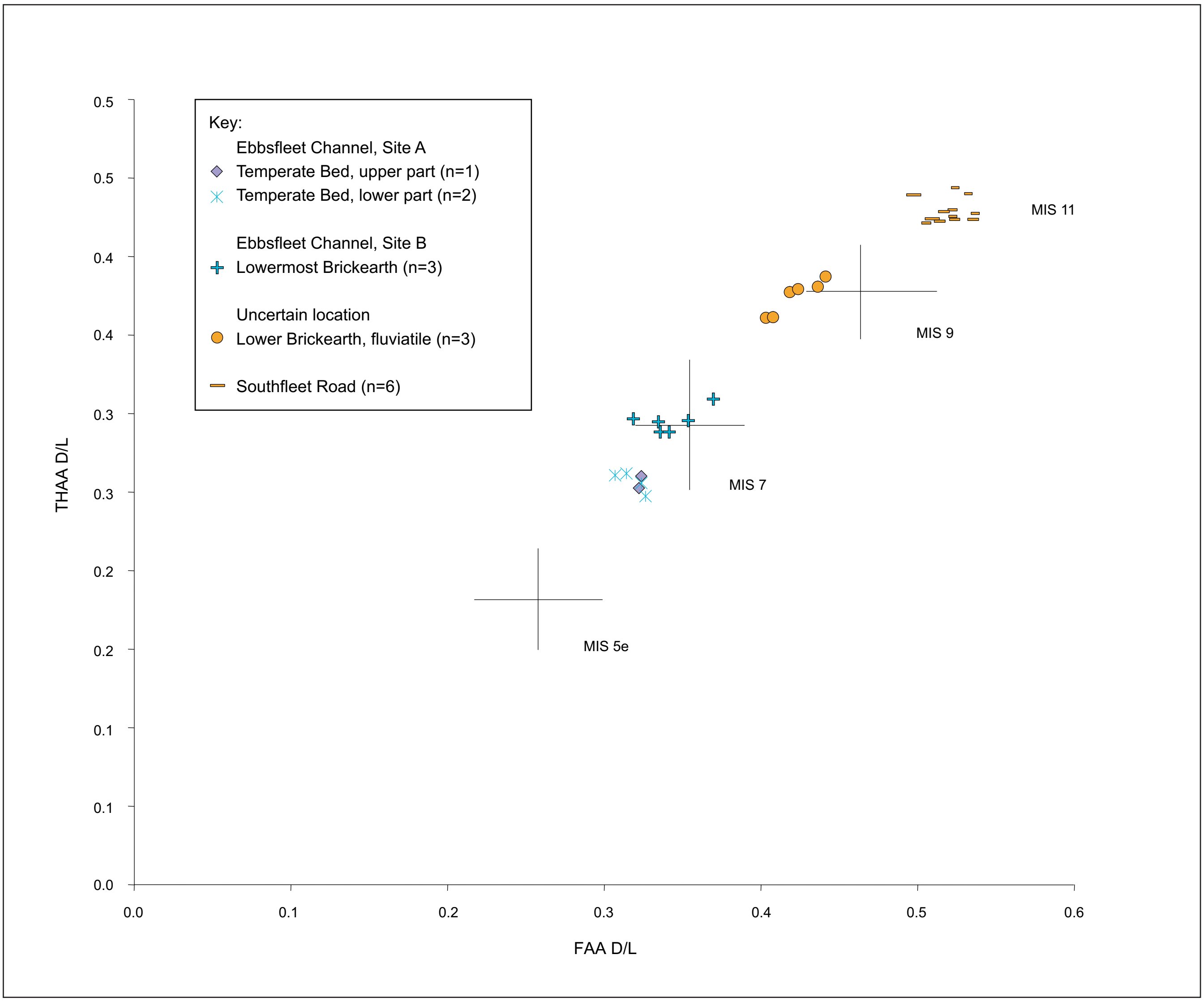


Figure 6.8 Amino acid results (alanine) on *Bithynia* opercula from Burchell's Ebbsfleet Channel sites, with reference points for MIS 5e, 7 and 9, and material from the Southfleet Road elephant site (MIS 11) (for methods see Appendix E)

deposit. There is then a hiatus in aggradation, during which a landsurface develops on the sloping surface of the Middle Loam, which is then subsequently inundated by rising water levels of the Ebbsfleet and fluvial/alluvial deposition of the Temperate Bed. The molluscan and faunal material from the Temperate Bed establish that its lower parts were laid down under peak interglacial conditions with surrounding woodland, and that the local environment became much more open and grassland-dominated higher up through the Temperate Bed sequence, probably associated with climatic cooling. The temperate bed is then unconformably capped by a thin "Calcareous Loam" with a much reduced molluscan fauna, suggesting much cooler and more open conditions. This deposit is in turn overlain by a chalk-rich solifluction deposit ("Coombe Rock"). This part of the sequence probably, as suggested by Burchell, represents an onset of glacial, or at least stadial, conditions.

Two lines of evidence establish that the Temperate Bed formed during one of the later sub-stages of MIS 7, MIS 7c or 7a. Amino acid ratios from the Temperate Bed (Fig 6.8) indicate a younger date within MIS 7 than those from opercula from the Lowermost Brickearth. This presumed stratigraphically lower deposit also contains a temperate small mammal assemblage with bank vole (*Clethrionomys glareolus*). It therefore represents evidence of an earlier different temperate MIS 7 sub-stage than the Temperate Bed.

Site F

Introduction

Site F comprises the narrow wedge-shaped area of deposits to the north of the island of deposits that is SAM Kent 267b (Fig 2.16), and is included in the Baker's Hole SSSI. The first reliable record of its investigation is that of Carreck (1972, 84–6), who, aided by AT Marston, identified his Channel D at its southern end (Fig 6.1), and recovered large vertebrate remains from one horizon "C" (see large vertebrates, below). The sequence at the southern end was also later

Table 6.15 Log of sediments at location F.3.a, and correlations with previous work

W-S context	Description	Wenban-Smith (1995; 1996) Site F deposit	Carreck (1972, 84–6) Channel D deposit
108, 144	STONY LOAM. Mottled dark-brown and grey clayey loam with common angular flint gravel, some rounded pebbles and frequent chalk flecks; contains thin sub-horizontal beds of sand and shell fragments. Upper part of deposit is probably recently made ground; lower part possibly also	Bed 3b	–
145	STONY/CLAYEY LOAM. Very well-consolidated, strong brown clayey/silty sand (VF-F) with moderately common VF-VC flint pebbles	Bed 3a	–
146	SANDY GRAVEL. Brownish-yellow VF-F sand with very common sub-angular to well-rounded (derived Tertiary) flint pebbles (F-VC) and derived Tertiary shell fragments	Bed 3a (base)	C – "light-brown water-lain sands" (upper/main part)
147	GRAVELLY SAND. Brownish-yellow VF-F sand with derived Tertiary shell fragments and occasional sub-angular to well-rounded (derived Tertiary) flint pebbles	Bed 2b (top)	C – "light-brown water-lain sands" (bottom part); flint flake found at base
148	SAND. Brownish-yellow VF-F sand, moderately consolidated and slightly clay-silty, with sub-horizontal beds of coarser sand with occasional VF-M flint pebbles	Bed 2b (upper/main)	B.ii – "greyish loam of loessic texture"
149	SAND/GRAVEL. Brownish-yellow, cross-bedded M-C sand with moderately common flint pebbles and lenses rich in derived Tertiary shell fragments; sediments generally becomes coarser downward, with a much more gravelly layer at the base	Bed 2b (lower)	B.i – "Melt-water gravel"; seven flint flakes, including a typical Levalloisian flake, found by Marston
150	SANDY SILT. Structureless slightly sandy (VF-F) silt, yellowish-brown with occasional strong brown/reddish patches; contains occasional chalk and flint pebbles, and carbonate concretions. Decayed large mammal bone found towards base	Bed 2a	–
151	SAND WITH FLINTS. Yellowish-brown slightly silty VF-F sand with frequent large angular and well-rounded flint (VC pebbles to small cobbles), and large flint nodules 100–300mm maximum dimension at the base. Flint flake found	–	–
152	COOMBE ROCK. Very pale brown, well-consolidated chalk diamict in chalk silt matrix with occasional flint pebbles and flint nodules, whole and broken	–	A – "Main, Baker's Hole Coombe Rock"

KEY: F – fine; VF – very fine; VC – very coarse; M – medium; C – Coarse

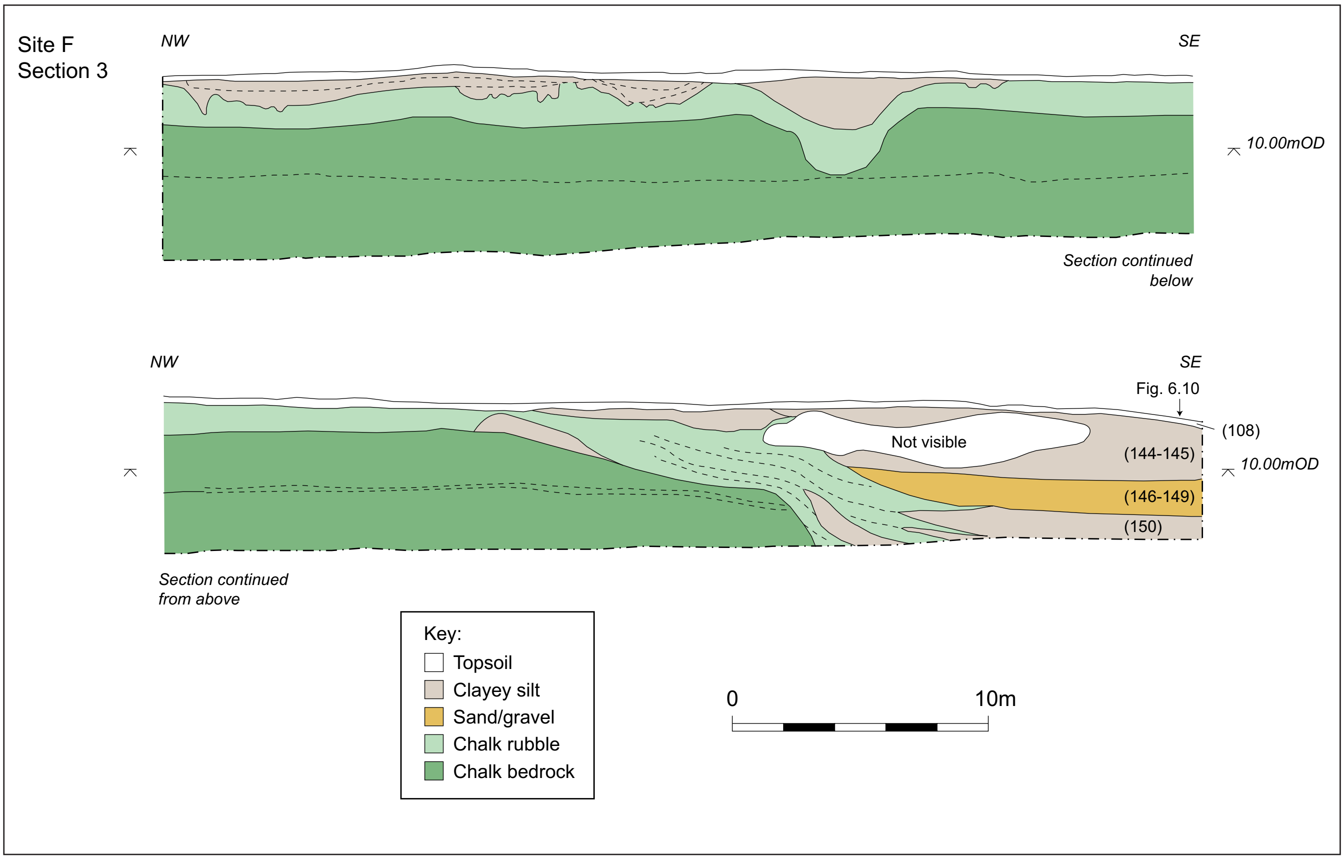


Figure 6.9 Site F, Section 3, drawn in 1990 (south-west-facing)

logged by Wenban-Smith, as location F.3.a (Fig 6.1). Carreck and Marston also recovered various artefactual remains from this locality, as shown in the lithology table (Table 6.15).

Lithological Succession

The best record of the sequence at Site F is that of Wenban-Smith, who both recorded the whole exposed section in 1990, showing a channel-cut at its southern end filled with fine-grained sediments banked against chalk (Fig 6.9), and later made a more detailed log of the channel-fill sequence (Fig 6.10). Descriptions of the sediments filling the channel are given in Table 6.15, along with proposed correlations with the sequence recorded by Carreck at the same location.

Large Vertebrates

Wenban-Smith found one unidentifiable piece of large mammal bone in context 150, towards its base. Carreck (1972, 86, 143–4), in contrast, found abundant faunal remains in his Bed C, equated here with contexts 146 and 147 of Wenban-Smith's logged sequence. Carreck's faunal material comprised a milk molar of a mammoth, various other pieces of mammoth tooth and post-cranial material, an incisor and a vertebra from horse, a red deer metapodial and some post-cranial material from *Bos*/*Bison* sp. (radius, distal end of a left humerus and distal end of a left femur). In addition, the same gravel deposit produced a mammoth molar found by Kerney, now in the Natural History Museum collection (M.18924). The assemblage is not very informative as regards climate and environment, but indicates the presence of scrub and grassland. Kerney's mammoth molar appears of typical *M. primigenius* form, perhaps indicating an incursion of this form during a cooler part of MIS 7, or that this particular deposit may be later, for instance MIS 6 (Lister, Appendix C3).

Site F Overview

The evidence from Site F shows a channel-fill sequence abutting a bank cut into Chalk bedrock. A thin layer of chalk solifluction (context 152) lies at the base of the sequence, grading down to Chalk bedrock. This deposit was not recorded by Carreck, who perhaps logged the sequence a bit further to the north or did not uncover its basal parts. Above this, there is almost one metre of fine sandy silt (context 150), coarsening downward and becoming rich in gravel and flint nodules at the base (context 151). Above this, context 149 is equated with bed Bi of Carreck's sequence; cross-bedding in this context suggests fluvial deposition. Above this in turn, the clay-silty context 148 was equated with bed Bii of Carreck's sequence. Overlying this, were two contexts (146 and 147) that were respectively equated with the

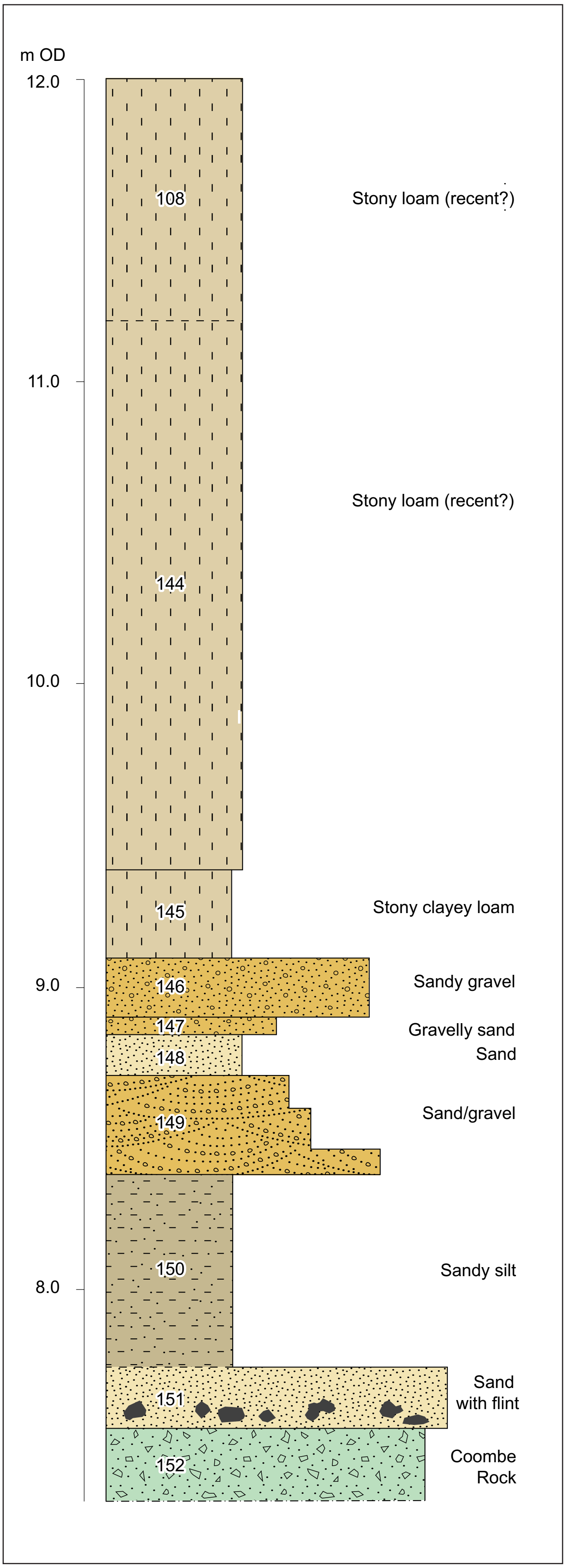


Figure 6.10 Log through sequence of deposits at Site F, location F.3.a

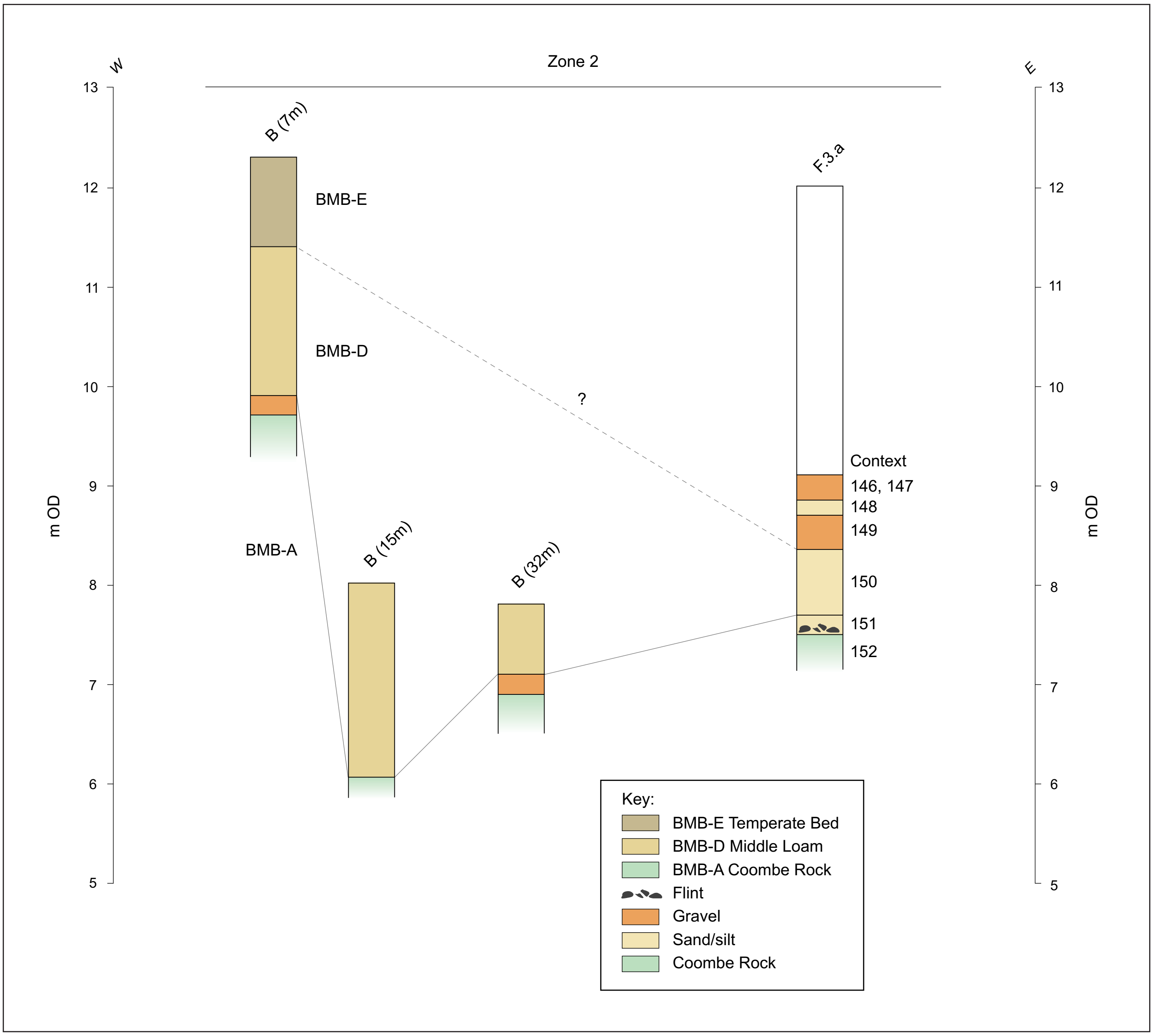


Figure 6.11 Relationship and proposed correlations between deposits at Site B and location F.3.a

upper and lower parts of Carreck's bed C, in which Kerney found a woolly mammoth tooth (*Mammuthus primigenius*). As discussed by Lister in Appendix C3, this would suggest a cold-climate interlude within MIS 7, or a post-MIS 7 cold stage. It has also been suggested (Lister and Sher 2001; Lister *et al* 2005) that some late MIS 7 sites like Marsworth Lower Channel had *trogontherii* and *primigenius* co-existing. The upper parts of the sequence (contexts 108, 144 and 145) comprise stony/clayey loam with common flint and chalk pebbles. If not recent made ground, these are likely to be of solifluction or colluvial origin.

The important aspect of Site F is how exactly the sequence relates to that at Site B, *c* 30m to the south. The proximity of these sites, and the similar geometries and altitudes of the sequences present, suggest that both sites represent different parts of the west bank of the same NNE–SSW oriented channel, with a base level of *c* 6–7m OD. Both channel-bank sequences also share a similar specific geometric feature, namely a distinct break of slope at *c* 9m OD, above which the chalk surface rises more shallowly to the west. Below this, it dips much more steeply down to the east, approaching vertical, perhaps reflecting more rapid downcutting and infill of the bottom part of the sequence.

It was noted by Wenban-Smith in 1989 when the deposit was exposed that the sandy silt (context 150) towards the bottom of the sequence at location F.3.a was very similar to the nearby exposed parts of Sieveking's deposit 3, "aeolian/solifluxion silt" (here, phase BMB-D, Middle Loam), the fine laminations within (Fig 6.2b) which have a downward north-east trend towards the same level as context 150 at location F.3.a. If one looks at the relative positions of these sequences in relation to each other (Fig 6.11), this proposed correlation seems very reasonable. This would have the implication that context 150 at location F.3.a is probably mostly the same slopewash deposit as the Middle Loam.

The gravels at the base of the sequences at both Site B and Site F, may once have been fluvially lain, but the contortions evident in the wider view provided by Sieveking's section indicate post-depositional deformation, maybe due to subsequent slopewash deposition and/or periglacial heaving. Likewise, there may be finer-grained fluvial sands/silts preserved in places between the gravel and the base of the Middle Loam (as suggested by Burchell for his Lower Loam), or within the bottom part of the deposits phase BMB-D here identified as Middle Loam, although this has yet to be established on any faunal or sedimentological grounds.

Above this, there are no obvious correlations between other parts of the sequences, although the overlying sands and gravels at location F.3.a (contexts 146–9) may represent the basal levels of the aggradation that culminates in deposition of the fluvial/alluvial deposits of the Temperate Bed at Site B. This would, however, require the presence of typical *M. primigenius* in MIS 7, at the bottom of the sequence that culminates in the Temperate Bed. This is possible according to Lister (pers comm and in Lister, Appendix C3) if the gravel with the mammoth tooth is interpreted as from a colder episode, for instance sub-stage MIS 7d, when sea levels were low enough for the mammoth to cross into Britain.

Zone 2 Synthesis

The overall sequence represented by deposits at Sites B and F, both those still present and those previously investigated but now lost to quarrying, is highly confused – primarily because of inadequate recording by Burchell, who without doubt investigated many important sequences and recovered significant archaeological remains discussed subsequently (Chap 18). However, the importance of his archaeological finds is substantially diminished because of the inability to relate many of them accurately to any specific stratigraphic horizon.

There is no known surviving correlate of the lower parts of Burchell's sequences – the Lowermost Loam and stratified Lower Gravel – from which he recovered the majority of his archaeological finds and a number of significant faunal remains from possibly undisturbed "floors". He regarded these horizons as fitting in stratigraphically below the Middle Loam of his main Ebbsfleet Channel Site A sequence, here attributed to phase BMB-D of Sieveking's Site B sequence. Faunal remains recovered by Burchell from various deposits attributed by him to these horizons reflect a MIS 7 date, based on both biostratigraphic interpretation of material from mixed, uncertain locations, and amino acid dating of *Bithynia* opercula from "Lowermost Loam" at one location.

However, at one location, a deposit he called "Lower Brickearth (fluviatile)" – which can be equated with his "Lower Loam" as discussed above, and which should stratigraphically be positioned above the Lower Gravels and below the Middle Loam (= phase BMB-D) – has produced *Bithynia* opercula that give an amino acid date for MIS 9. This would cast doubt on the MIS 7 attribution of any material, faunal or archaeological, from underlying gravel that he might have called "Lower Gravel".

However, we have no record of the precise provenance of the dated opercula; they may have been reworked, come from a different locality or merely have provided a misleading result due to having been heated. Therefore, this anomalous result cannot contribute to dating the known sequence.

Further possibilities for confusion are suggested by a worrying comment reported by Carreck (1972, 151). He quotes Burchell as correlating Carreck's horizons B.i and C at his Channel D site – here equated with contexts 149 and 147 respectively at location F.3.a (Table 6.15) – with the "Lower Gravel stage of his Ebbsfleet Channel series" on the basis of the evidence of the flint implements found within these deposits by Carreck and Marston, which apparently included one typical Levalloisian flake (Carreck 1972, 146). If this exemplifies Burchell's basis for stratigraphic correlations of his various "Lower Gravel", "Lower Loam" and "Lowermost Loam" localities, then there is even more justification for regarding his stratigraphic provenances as highly dubious – which is very regrettable, considering the quantity and quality of archaeological material he found in these horizons (Chap 18). Nonetheless the array of surviving evidence when studied in combination with the surviving deposits does allow some robust conclusions to be drawn.

The middle and upper parts of the Ebbsfleet Channel sequence recorded by Burchell are much better understood, thanks to better recording by subsequent workers and their continuing preservation. The majority of the surviving sequence at Site B is represented by the Middle Loam (phase BMB-D), which mostly corresponds with Burchell's Middle Loam, and may also include in its bottom part one manifestation of Burchell's Lower Loam. This deposit seems to represent a major slopewash aggradation during cool open grassland conditions, and has produced a sparse molluscan fauna but no artefactual or mammalian remains (apart perhaps from some of the limited material attributed by Burchell to "Lower Loam", which may have come from the basal part of the surviving bed BMB-D at Site B). The surface of the Middle Loam – where it survives, sealed by the overlying Temperate Bed – preserves evidence of soil development and weathering, reflecting existence of a palaeo-landsurface and a depositional hiatus in the sequence.

The Middle Loam of Site B is here correlated with the basal sand/silt bed (context 150) at location F.3.a, providing a stratigraphic link between these two sequences and their contained faunal and archaeological remains. This has important implications, for it would mean that the overlying, predominantly gravelly, sequence of contexts 146–9 with their base level at *c* 8.5m OD may represent the base of the aggradation that includes, in its top part, the alluvial deposit of the Temperate Bed higher up on the west side of the Site B sequence.

As previously discussed (Site B, above), the Temperate Bed is securely dated to a later substage of MIS 7, and contains an important and distinctive small vertebrate and molluscan fauna reflecting development from peak interglacial woodland conditions to cooler more open grassland. The deposit is also associated with a number of flint artefact finds, some maybe from the palaeo-landsurface on top of the Middle Loam; these are discussed subsequently (Chap 18).

The Temperate Bed is, in turn overlain by a sequence of uncertain age reflecting much colder conditions. This final part of the sequence could date to any cold phase, from one closely following deposition of the Temperate Bed, through to any time in the last, Devensian glacial period.

The possible relationships of the sequences at Site B with (a) those in other parts of the site, particularly those in Zone 1, and (b) specific sub-stages of MIS 7 are considered later (Chap 16).

Chapter 7

Lower Valley-side North (Zone 3)

by Francis Wenban-Smith, Martin Bates, Simon A Parfitt, Kirsty Penkman, Richard Preece, Tom S White and John E Whittaker

Introduction

This zone corresponds with the lower parts of the valley side in the northern area of the HS1 impact zone (Fig 4.1). It lies downslope of Zone 1, immediately to its east, curving round to the south-west to include pylon ZR3A. Ground surface elevations range from *c* 8m OD at the western side to *c* 4m OD at its eastern and south-eastern edges, where it flattens out and abuts the floodplain. Until the construction of HS1 this area was occupied by allotments.

Investigations within this zone began with a phase of preliminary borehole and test pit excavations in 1997 (ARC EFT97 URL 1997a; Chap 3). One of the boreholes, 0021SA, produced a deep sequence with molluscan remains, thought to possibly represent Last Interglacial (MIS 5e) deposits on the basis of amino acid dates. One of the test pits, 2018TP, produced a layer with burnt flint and Bronze Age pot sherds 2.80m below the ground surface, emphasising the depth of Holocene late prehistoric remains. This was followed in April–May 2001 by a more closely spaced series of trenches (ARC ESG00, URN 2001a; Chap 3). Two of these (3789TT and 3787TT) were located near Borehole 0021SA, and partly aimed at investigating the possible Last Interglacial deposits in more detail.

The majority of interventions revealed slopewash deposits, chalk-rich at the base, dipping downslope towards the Ebbsfleet floodplain (URN 2001a). However, more interesting deposits and molluscan remains were present in the afore-mentioned two trenches near Borehole 0021SA, and in 3790TT, 20m upslope to the east of 3789TT. Finally, a representative cross-section across the slopewash sequence was exposed and recorded in 3783TT, which also produced two lithic artefacts; these were interpreted as derived due to their context in coarse slopewash sediments. The key interventions that produced important stratigraphic, palaeoenvironmental, archaeological or chronological data are summarised in the Table 7.1, and their locations within the zone are also shown in Figure 7.1. The evidence from these key interventions is discussed in detail below.

Borehole 0021SA (ARC EFT97)

Introduction

This borehole was drilled to a total depth of 10m below the ground surface. Surface elevation of the borehole was 3.71m OD and the borehole lay close to the eastern margin of the zone and near the edge of the modern floodplain. Within the borehole (Fig 7.2) a total of 5.75m of unconsolidated sediments were found resting on chalk bedrock. Drilling was undertaken by a shell and auger drill rig and nine U4/U100 core samples were taken.

Logging and description of the cores was undertaken to produce the basic lithology. Assessment of 17 samples through the nine U4/U100 cores was undertaken for the ARC EFT97 report to ascertain the nature and potential of the contained molluscs (URL 1997a). Dating of elements of the fauna was undertaken by amino acid dating at the Amino Acid Laboratory in the Department of Geology, University of Bergen, Norway. Further environmental analysis and amino acid dating was

Table 7.1 Zone 3 key interventions and range of specialist and dating studies

Project	Key locations	Secondary locations	Soil micro-morph.	Large vertebrates	Small vertebrates	Molluscs	Ostracods	Amino acid	OSL dating	Worked flint
ARC EFT97	BH 0021SA	–	–	–	–	X	X	X - *Bithynia** X - *Cepaea*	–	–
ARC ESG00		3783TT	–	–	–	–	–	–	–	x
	3787TT	–	–	–	–	X	–	–	–	–
	3789TT	–	–	–	X	X	–	X - *Bithynia*	–	–
	3790TT	–	–	–	–	X	–	X - *Bithynia* X - *Pupilla*	–	–
ARC ZR3A00	–	3821TP	–	–	x	–	–	–	–	–

KEY: * *Bithynia* shells were analysed by the older A/I protocol in 1997; and *Bithynia* opercula were analysed by newer protocols in 2010
X – important evidence; x – minor presence

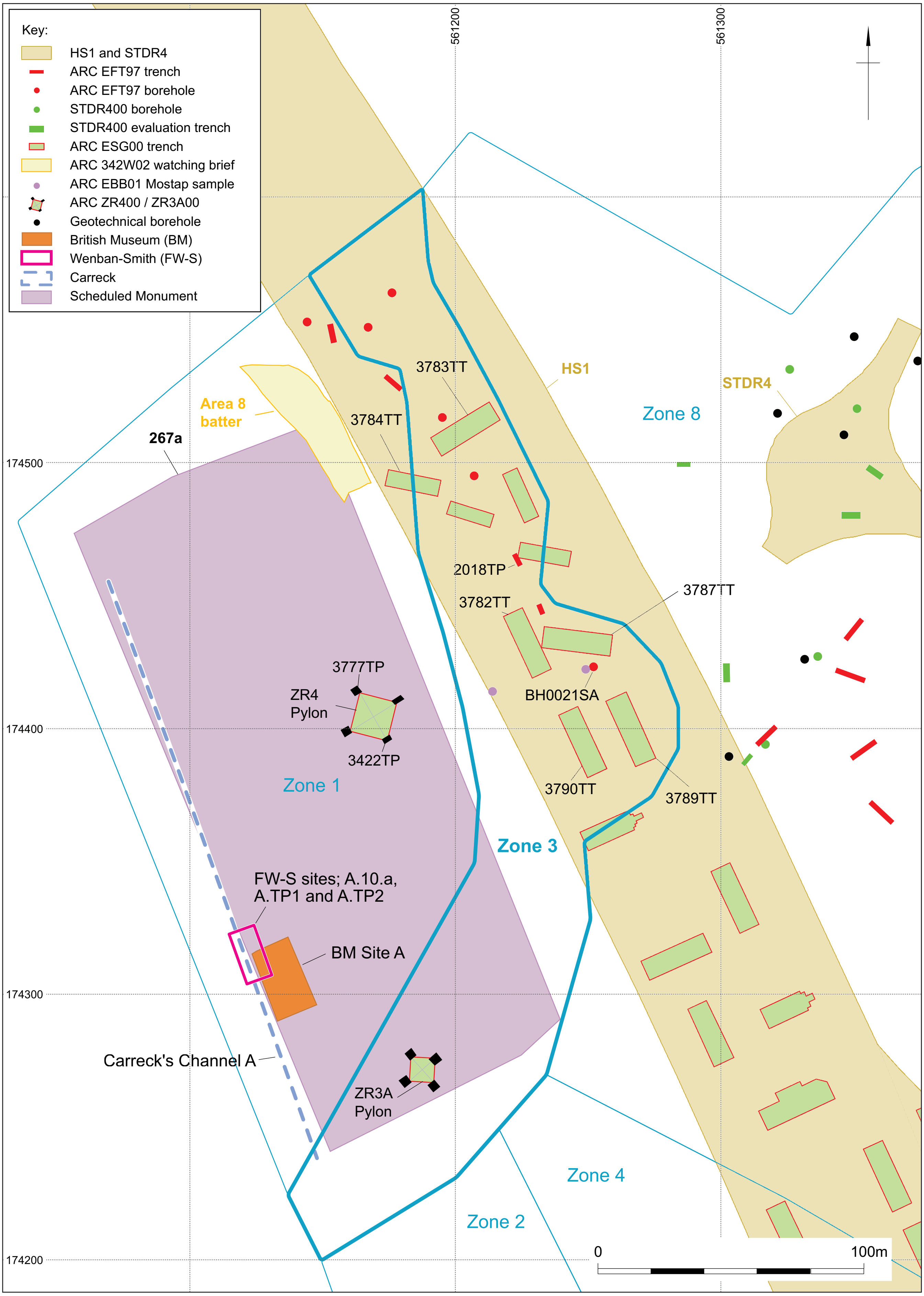


Figure 7.1 Zone 3 layout and key intervention locations

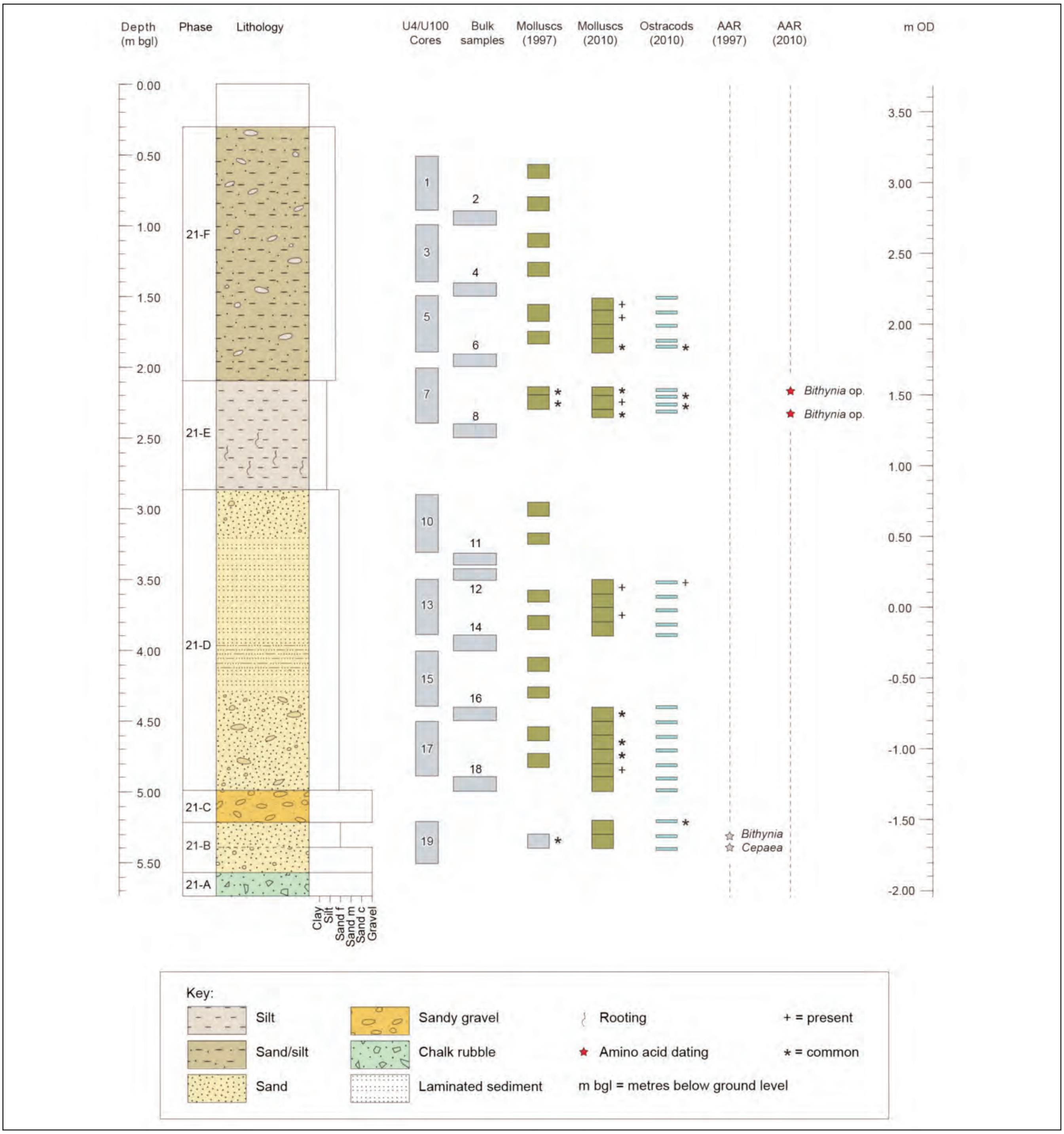


Figure 7.2 Borehole 0021SA sequence and sampling (NB the stratigraphic provenance of the 1997 molluscs and AAR dated material, reported as from Phase 21-B, is now thought unreliable, see mollusc section)

subsequently carried out, and reported on here. The logged sequence through the borehole is shown, with levels subject to environmental and dating analyses highlighted (Fig 7.2).

Lithological Succession

Seven main sedimentary facies were identified within the borehole (Table 7.2):

21-A, 5.62 to 5.75m (-1.91m to -2.04m OD): These deposits consist of angular chalk fragments.

Fresh chalk bedrock was present between 5.75m and the bottom of the borehole at 10.0m.

21-B, 5.25 to 5.62m (-1.54m to -1.91m OD): This unit consists of a relatively fine sand in which shell fragments are common.

21-C, 5.00m to 5.25m (-1.29m to -1.54m OD): This is a gravelly deposit in which shell fragments are common throughout.

21-D, 2.88m to 5.00m (0.83m to -1.29m OD): In unit 21-D the gravel content decreases up profile and sorting becomes better towards the top, clay-silt laminae appear towards the top of unit. Shell fragments are common throughout this sequence.

Table 7.2 Borehole 0021SA stratigraphic sequence, phasing and distribution of environmental and amino acid dating evidence

Phase	Lithology	Inferred environments of deposition	Palaeoenvironmental data	Dating (AA)
0021-F	Sands and gravels	Colluvial slopewash during cool to cold climate	Ostracods (few) Molluscs	–
0021-E	Silts and sands with rooting and carbonate precipitation	Floodplain surface with phases of emergence and weathering and pedogenesis	Molluscs Ostracods	*Bithynia* opercula
0021-D	Sands with some gravels, sands becoming finer upwards. Laminated in places, molluscs present	Fluvial sand bar and channel deposition on active floodplain	Ostracods (few) Molluscs	–
0021-C	Flint gravel with sandy matrix	Fluvial moderate energy channel deposit	–	–
0021-B	Sand with occasional flint cobbles	Fluvial, moderate energy	Ostracods	*Bithynia* and *Cepaea* shells
0021-A	Chalk rubble	Cold climate solifluction slope deposition	–	–

21-E, 2.15m to 2.88m (1.56m to 0.83m OD): This deposit is predominantly silt. Some rounded sand grains are present. Secondary carbonate precipitate is present throughout as concretions and filling root canals. Mollusc shells and associated fragments are common throughout this sequence.

21-F, 0.33m to 2.15m (3.41m to 1.56m OD): This group of sediments consists of variably silty-sands with gravel clasts (maximum diameter 25mm). The gravel fraction is dominated by flint but chalk is also present. Thin clay-silt horizons are noted throughout the sequence. Modern roots penetrate full depth of deposit.

0.00 to 0.30m: Modern topsoil.

The interpretation of the sequence has been based on the observations made on the drill-core samples and no direct observations of the sediments were made in the field. Fluvial sands and gravels were present at the base of the sequence at -1.91 to 0.83m OD (5.62m to 2.88m depth, 21-B to 21-D; Fig 7.2) possibly becoming finer upwards indicating a shift from higher to lower energy conditions up-profile. Deposition within an active floodplain system dominated by sand bar and channel sequences may give way to lower energy floodplain contexts upwards (Allen 1965; Brown 1997). The shift to floodplain environments between 0.83 and 1.56m OD (2.88m and 2.15m, 21-E) is clear; within this interval weathering and pedogenesis are indicated by carbonate precipitation and rooting clearly signifying the emergence of the deposits above water and the development of plant growth. The uppermost part of the sequence (21-F) is less easily interpreted with two distinct possibilities. A return to active sand deposition in higher energy fluvial conditions may be possible; an alternative hypothesis could be deposition by colluvial processes at the base of the slope.

Molluscs

A brief description of the molluscan faunas preserved in this group of samples was given in Appendix 12 of the evaluation report (URL 1997a) where Preece noted that countable molluscs were only present in three samples, one from the base of the sequence (phase 21-B) and two from higher up (phase 21-E). The total number of shells recovered was generally low (see below; Table 7.3).

Preece concluded that the species composition in all three samples indicated that the sediments accumulated under fully temperate conditions. The presence of *Belgrandia marginata* (exclusively interglacial in Britain), *Segmentina nitida* and *Helicodonta obvoluta* are all strong indicators of warm conditions. The assemblages include a mixture of aquatic and terrestrial elements and the depositional environment seems to have been a slow-flowing stream with a surrounding marshland. There is no direct evidence from the species composition for the age of the assemblage. It is, however, unlike most Holocene assemblages from southern England and may represent a pre-Holocene interglacial.

Further samples from Borehole 0021SA were then examined in 2010, covering a wider spread of the deposits (Table 7.3; Fig 7.2). The sample residues are all relatively small and often contain low quantities of countable shells, although they provide useful additional information. Interpretation has been undertaken with caution due to the small assemblage sizes (sometimes only a single shell). There were no Pleistocene molluscs from the lower part of the sequence (phase 21-B), where the evaluation had indicated a rich interglacial assemblage. Taking account of the ostracod data (see below), we now believe that the lower evaluation sample was mis-provenanced, and there was just one interglacial represented, in phase 21-E where similarly rich assemblages, between 1.91 and 0.11m OD (3.6m to 1.8m depth), of both aquatic and terrestrial snails suggest a slow-flowing stream surrounded by marshland. This is underlain by samples which contain only shells of *Pupilla muscorum*, a species which prefers dry, open grassland habitats, and occasional slug plates. The molluscan evidence from the borehole sequence is therefore suggestive of dry open grassland at the base (phase 21-D), overlain higher up the sequence (phase 21-E) by deposits representing freshwater deposition during fully temperate interglacial conditions.

Deposits from this warm episode are in turn overlain towards the top of the sequence (phase 21-F, above 1.91m OD, 1.8m depth) by deposits with a molluscan fauna (*Pupilla*, slug-plates and earthworm granules) suggesting a return to dry open grassland.

Table 7.3 Molluscs from Borehole 0021SA

Phase	**21-B**		**21-C/B**	**21-D**										**21-E**					**21-F**							
Sample	**26**	**25**	**24**	**23**	**22**	**21**	**20**	**19**	**18**	**17**	**16**	**15**	**14**	**13**	**12**	**11**	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**
Depth (m)	5.30–5.40*	5.30–5.40	5.20–5.30	4.90–5.0	4.80–4.90	4.70–4.80	4.60–4.70	4.50–4.60	4.40–4.50	3.80–3.90	3.70–3.80	3.60–3.70	3.50–3.60	2.30–2.35	2.20–2.30*	2.20–2.30	2.15-2.20*	2.15–2.20	1.80– 1.90 U4 5	1.80–1.90	1.70– 1.80 U4 5	1.70–1.80	1.60– 1.70 U4 5	1.60–1.70	1.50–1.60 U4 5	1.50–1.60
Sample weight (kg)		0.44	0.42	0.74	0.63	0.56	0.71	0.54	2.35	0.55	0.6	0.54	0.55	0.19		0.06		0.31	0.64	0.59	0.61	0.74	0.6	0.68	0.71	0.63
Freshwater taxa																										
Valvata cristata	+	–	–	–	–	–	–	–	–	–	–	–	1	1	+	1	–	–	–	–	–	–	–	–	–	–
Belgrandia marginata	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Bithynia tentaculata	+	–	–	–	–	–	–	–	–	–	–	–	–	4	+	–	+	2	–	2	–	–	–	–	–	–
B. tentaculata opercula	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	1	–	1	–	–	–	–	–	–
Physa fontinalis	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Galba truncatula	–	–	–	–	–	–	–	–	–	–	–	–	1	1	+	–	–	2	11	5	–	–	–	–	–	–
Stagnicola palustris agg.	+	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	+	–	–	–	–	–	–	–	–	–
Radix balthica	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–
Planorbis (planorbis) sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	+	–	1	–	–	–	–	–	–	–
Planorbarius corneus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–
Anisus leucostoma	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	1	–	–	5	4	–	–	–	–	–	–
Anisus vortex	+	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–
Gyraulus crista	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1	–	–	–	–	–	–
Hippeutis complanatus	+	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–
Segmentina nitida	+	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–
Sphaerium corneum	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Pisidium casertanum	+	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	1	1	–	–	–	–	–	–	–
Pisidium milium	+	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–
Pisidium nitidum	–	–	–	–	–	–	–	–	–	–	–	–	–	5	–	–	–	–	–	–	–	–	–	–	–	–
Pisidium obtusale	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–
Pisidium subtruncatum	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	1	–	–	–	–	–	–	–	–	–	–
Terrestrial taxa																										
Carychium minimum	+	–	–	–	–	–	–	–	–	–	–	–	–	3	+	1	–	1	–	–	–	–	–	–	–	–
Carychium tridentatum	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–
Oxyloma/Succinea	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–
Cochlicopa lubrica	+	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–
Discus rotundatus	+	–	–	–	–	–	–	–	–	–	–	–	–	–	+	+	–	+	–	–	–	–	–	–	–	–
Pupilla muscorum	–	–	–	–	5	26	16	–	4	–	1	–	–	–	–	–	–	–	–	–	–	–	1	1	1	–
Vallonia costata	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3	2	–	–	–	–	–	–
Vallonia pulchella	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	1	–	–	–	–	–	–	–	–	–	–
Deroceras/Limax spp.	–	–	–	–	–	–	5	–	6	–	–	–	–	1	–	–	–	–	–	–	–	–	–	1	1	1
Cernuella virgata	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	+	+	–	–	–	–	–	–
Vertigo sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–
Zonitoides nitidus	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	1	–	–	–	–	–	–	–	–	–	–
Vitrea contracta	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–
Nesovitrea hammonis	+	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–
Aegopinella nitidula	+	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–
Euconulus fulvus	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Helicodonta obvoluta	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–
Clausiliidae	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–
Cepaea sp.	+	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–
Earthworm granules	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	+	+	–	+	+	+
Ostracods	–	–	–	–	–	–	–	–	+	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–
Reworked Tertiary frags	–	+	+	+	–	–	–	+	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–

KEY: + – present; * Samples examined by Preece in 1997 (Appendix 12, URL 1997) – NB sample 26, reported as from the base of the 1997 sampling sequence, is now thought to be mis-provenanced, and most likely from 21-E, along with the other two mollusc-bearing samples from the 1997 work

Ostracods

Twenty-four samples from Borehole 0021SA, covering the interval 1.50–5.42m, were analysed. Samples and sample depths are given below:

Depth in borehole (m)	Weight processed (g)
1.50–1.52	75
1.60–1.62	110
1.70–1.72	85
1.80–1.82	60
1.85–1.87	110
2.15–2.17	95
2.20–2.22	60
2.25–2.27	95
2.30–2.32	110
3.50–3.52	110
3.60–3.62	85
3.70–3.72	160
3.80–3.82	75
3.88–3.90	55
4.40–4.42	225
4.50–4.52	85
4.60–4.62	175
4.70–4.72	110
4.80–4.82	110
4.90–4.92	155
4.98–5.00	115
5.20–5.22	90
5.30–5.32	70
5.40–5.42	115

The samples were all bone-dry on receipt. Twenty of the 24 samples were processed as follows. Hot water was poured over each sample in a ceramic bowl with a little sodium carbonate added to help remove the clay fraction. After soaking the samples broke down easily after being washed through a 75-micron sieve with hot water. They were then returned to their bowls and dried in an oven. Because four of the samples (interval 2.15–2.32m) were observed to contain molluscs and *Bithynia* opercula (used for AAR dating) might also be present, they were soaked and washed with cold water, instead, and left to dry naturally. When finally broken down and dry, each sample was stored in a labelled plastic bag. Picking was undertaken under a binocular microscope. First the residue was put through a nest of dry sieves (>500, >250 and >150 microns) and the ostracods picked out with a fine camel-haired brush from a tray, a fraction at a time. The ostracod species are listed by sample semi-quantitatively in Figure 7.3, whilst other organic remains are noted on a presence/absence basis.

Of the 24 samples, only five contained freshwater ostracods and none of these was age or climatically diagnostic. These occurred between 1.86 and 1.46m OD (1.85–2.25m depth), near the top of the borehole. There was also a single sample near the base where ostracods were common at -1.49 to -1.51m OD (5.20–5.22m depth), although just one species was present (*Ilyocypris bradyi*). All, however, when present seem to indicate shallow water, probably a pool or the fringes a slow flowing river. One of these samples (at 1.85–1.87m) contained charophyte oogonia which also supports the suggestion of a permanent shallow, clean waterbody at this time.

Pleistocene molluscs were found in 14 samples but were mostly fragmentary. They were best preserved in the interval 1.85–2.32m, which also coincides with the best ostracod faunas and the single charophyte occurrence. Five small fragmentary *Bithynia* opercula were found in sample 2.20–2.22m. They were passed on to Kirsty Penkman (BioArch, York) for analysis (see dating, below).

Almost all the samples contained rhizoliths and/or rhizoconcretions. In parts of the borehole (interval 1.50–1.82m and especially 3.60–4.92m) they are extremely common and suggest a semi-terrestrial environment, with the rhizoliths being formed around (semi-aquatic) plant rootlets which have been subjected to drying out, either due to climatic factors or the river frequently changing course (or both). The presence of slug plates in several samples suggests, however, that the climate or associated habitat was damp at least for some of the time.

Dating

Mollusc remains from the base of the borehole were dated by amino acid racemisation at the evaluation stage (URL 1997a). This was done using A/I protocols in the amino acid laboratory at Bergen, Norway. Shells from two species were dated, *Bithynia* and *Cepaea*, both from the base of the fluvial sequence, sample U4 19. The results (Fig 7.4) were equivocal. The data from *Cepaea* suggested a Last Interglacial age, comparable with MIS5e sites such as Trafalgar Square (Bowen *et al* 1989). The data from *Bithynia* were in contrast mixed, suggesting either a post-MIS 5e date (such as MIS 5a–5d) with younger contaminants, or a much younger Last Glacial date with older reworked material.

A later second phase of dating (by K Penkman, University of York) was undertaken on *Bithynia* opercula from higher up the sequence, sample U4 7 between 2.15 and 2.35m from the ground surface (phase 21-E). The conclusion of this was that the *Bithynia* from this horizon probably date to early in MIS 5e (Fig 7.5; Penkman, Appendix E). Implications of this dating result are discussed further below.

Borehole 0021SA Overview

The likelihood that the molluscan evidence was mis-provenanced in the evaluation, leads to the recognition that the lower part of the sequence of deposits (phase 21-B through to 21-D) was not fluvial as previously thought in the evaluation. There is minimal evidence for the base of the sequence (phase 21-B), but the presence

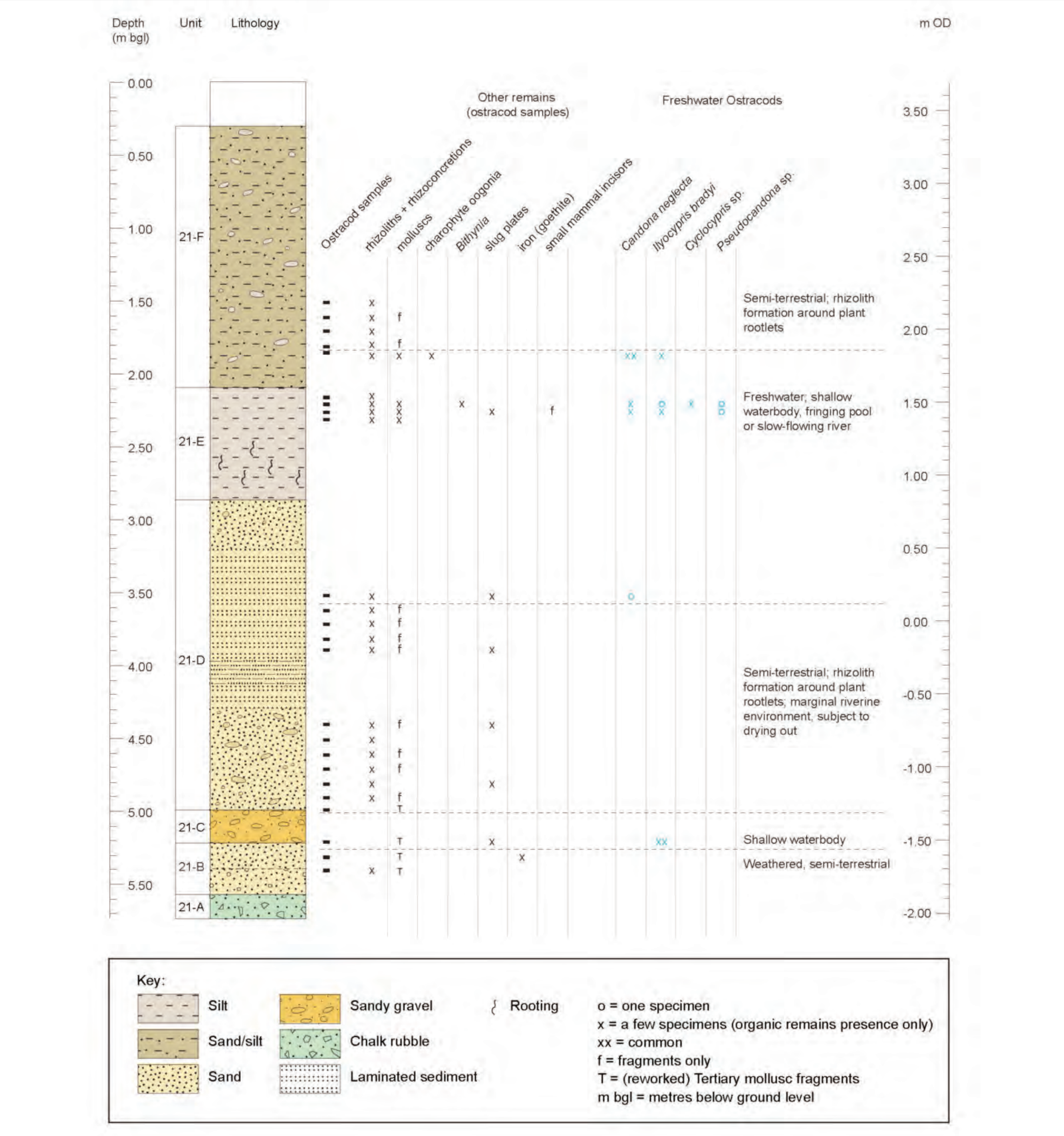


Figure 7.3 Borehole 0021SA ostracod recovery

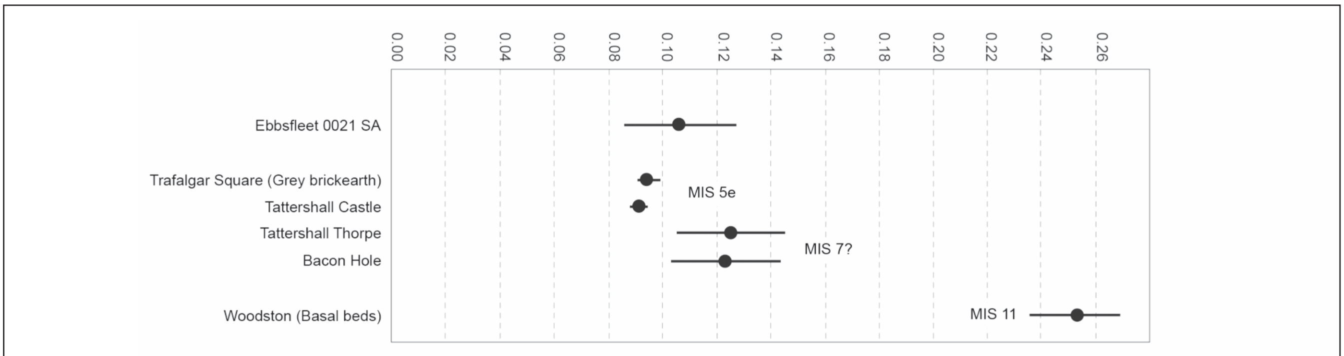


Figure 7.4 Borehole 0021SA amino acid results (A/I) from *Cepaea*, compared with other sites; data from Bowen *et al* (1989)

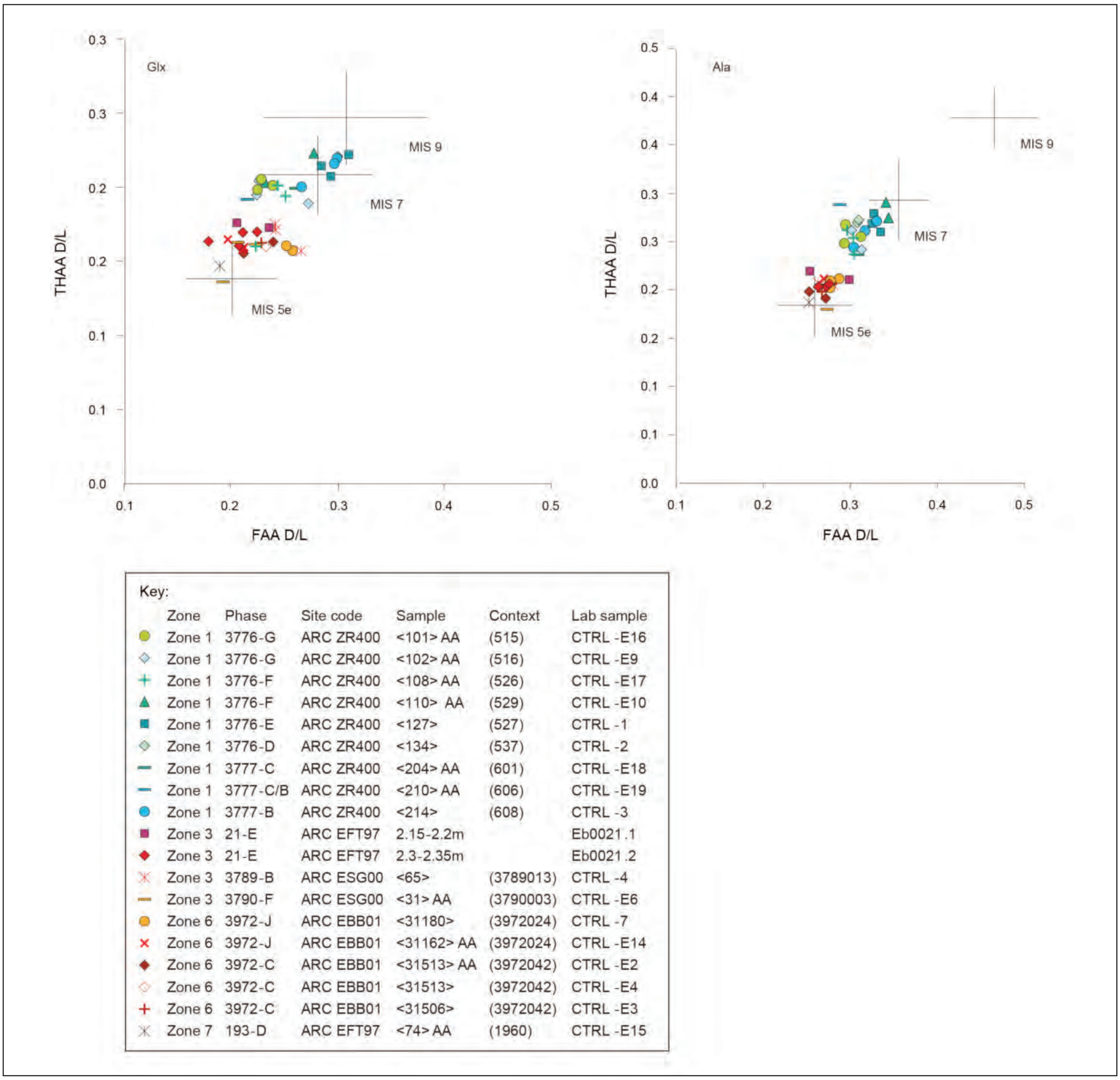


Figure 7.5 D/L amino acid results for glutamic acid (Glx) and alanine (Ala) for *Bithynia* opercula from Borehole 0021SA (Eb0021.1 and Eb0021.2), and other HS1 sites in this study

of rhizoliths and goethite suggests weathering and a predominantly terrestrial environment. Above this the sandy gravel of phase 21-C represents shallow, flowing freshwater, which is overlain by a thick body of sediment (phase 21-D) that represents a period that may combine fluvial and slopewash deposition, associated with dry open grassland conditions. Above this, molluscan remains from the upper part of phase 21-D (above 0.21m OD, 3.5m depth) suggests the renewed onset of fluvial deposition, culminating in phase 21-E, between *c* 0.5 and 1.5m OD, where there are strong molluscan indicators of freshwater deposition under warm interglacial conditions. Above this, there is a return to open grassland conditions in the bottom part of phase 21-F (at 1.91m OD, 1.8m depth). The most recent and most reliable amino acid dating on *Bithynia* opercula from phase 21-E suggests a date early in MIS 5e. The altitude of the sediments is comparable to MIS 5e deposits at Trafalgar Square, 30km to the west, and at a significantly lower level than the reliably dated mid–late MIS 7 fluvial sediments at 3776TP (ARC ZR400), 100m to the west, which were at 6–8 m OD (see Fig 7.10).

3787TT (ARC ESG00)

Introduction

This test pit was dug immediately next to Borehole 0021SA, in the hope of a more detailed examination of the sedimentary sequence which was at that time thought to be predominantly fluvial. However, when the

Table 7.4 Lithostratigraphic sequence and sampling at 3787TT (ground surface at 3.70m OD)

Depth (m)	Context	Description of unit	Samples	Palaeoenvironmental material	Archaeological material	Interpretation
0.00–0.30	3787001	Topsoil and turf	–	–	–	Topsoil and turf
0.30–1.35	3787002	Moderately-well compacted and structureless sandy clay-silt/clay-silty sand with freq f-c flint pebbles and occasional chalk and charcoal flecks, generally dark brown	–	Charcoal fragments seen, but not sampled	Sharp flint artefacts seen	Holocene colluvium
1.35–1.45	3787003	Moderately-well compacted layer of sandy clay-silt with charcoal flecks and freq. sub-angular vf-m chalk pebbles, gen. colour yellowish brown	50	Charcoal fragments seen, but not sampled	–	Holocene colluvium, base of plough zone??
1.45–2.00	3787004	Moderately compact and structureless sandy silt/silty sand with common f-c angular to sub-angular flint pebbles, flecks of black Mn staining	–	Charcoal fragments seen, but not sampled	Prehistoric pottery, flint artefacts, fire-cracked flint	Holocene colluvium
2.00–2.20	3787005	Moderately firm slightly sandy silt with occasional f-m flint pebbles, yellowish red	–	–	–	Pleistocene: alluvial with slopewash input
2.20–2.30	3787006	Moderately loose sand with gravely patches, generally brownish yellow	–	–	–	Pleistocene: alluvial with slopewash input
2.30–2.63	3787007	Moderately compacted and cohesive slightly sandy clay-silt, yellowish red	–	–	–	Pleistocene: alluvial
2.63–2.74	3787008	Moderately loose and unconsolidated slightly silty fine sand with thin layer f-m flint gravel at top of unit, generally strong brown	–	–	–	Pleistocene: fluvial
2.74–6.25 base not reached	3787009	Moderately soft fine sand, brown, fine sub-parallel laminations in places dipping downslope to east, with occasional well-developed carbonate precipitation along laminate plane, and occasional fine gravel trails	51 52	–	–	Pleistocene: colluvium interspersed with fluvial/alluvial episodes

KEY: vf – very fine; f – fine; m – medium, c – coarse

Table 7.5 Molluscs from 3787TT

Sample	Context	*Bithynia tentaculata*	*Valvata piscinalis*	*Galba truncatula*	*Radix balthica*	*Stagnicola palustris* agg.	*Anisus leucostoma*	*Musculium lacustre*	*Pisidium henslowanum*	*Pisidium obtusale*	*Pupilla muscorum*	*Vallonia costata*	*Vallonia excentrica*	*Vallonia pulchella/excentrica*	*Cernuella virgata*	**TOTAL**
51	3787009	3	1	9	5	3	5	+	1	+	1	1	2	3	6	**40**

test pit was dug the lithological succession (see below) appeared to mostly represent colluvial deposition. Nonetheless, environmental sampling was carried out, and mollusc remains proved to be present in one sample.

Lithological Succession

The sequence of deposits in 3787TT is presented in Table 7.4. The presence of charcoal fragments, prehistoric pottery, sharp flint artefacts and fire-cracked flint in the top 2m confirms this part of the sequence as Holocene colluvium. Below that, the horizontally stratified fine-grained contexts 3787005, 3787006, 3787007 and 3787008 appear fluvial, with an upward trend from coarser to finer sediment reflecting decreasing water energy. These occur at the same level as the upper fluvial phase 21-E in the nearby Borehole 0021SA. The lowest context 3787009, which comprised the lower 3.5m of the sequence, showed fine sub-parallel laminations and fine pebble trails dipping downslope to the east, suggestive of slopewash rather than fluvial deposition.

Molluscs

A single sample from towards the top of context 3787009 was analysed (Table 7.5). The sample was recovered from a depth of 1.04m to 0.89m below OD from brownish-yellow (10YR6/6) medium sand. Initial results yielded a single species, *Galba truncatula*, an aquatic snail that can inhabit damp ground and is almost amphibious. Its presence provides no indication regarding climatic conditions or age of the deposit. Subsequently, more detailed examination yielded a small assemblage of 40 shells that shows some

Table 7.6 Stratigraphic sequence and sampling (ground surface 3.89m OD), 3789TT

Depth (m)	Context	Description of unit	Samples	Palaeo-environmental material	Archaeological material	Interpretation
0.0–0.40	3789001	Topsoil and turf	–	–	–	Topsoil and turf
0.40–0.75	3789002	Friable sandy clay-silt with occasional f-c flint pebbles and layers 60mm thick rich in vf-m chalk pebbles at top and base	–	–	Some flint artefacts	Holocene colluvium
–	3789003–7	Miscellaneous archaeological features	–	–	Some fire-cracked flint frags	Prob. late prehistoric or Roman activity
0.75–1.05	3789008	Friable sandy clay-silt with common f-c flint pebbles, generally orangey brown with some iron pan development	–	–	–	Holocene colluvium
1.05–1.80	3789009	Moderately compacted slightly sandy clay-silt with occasional gravely patches, yellowish red *Sharp, erosive basal junction, rises to NW*	–	–	–	Holocene colluvium
1.80–2.40	3789010	Dense and compact slightly sandy clay-silt with occasional sandy and gravelly patches, yellowish red	–	–	–	Pleistocene colluvium
2.40–3.20	3789011	Yellowish brown silty fine sand with lenticular beds f-m sand, pink carbonate bands and occasional nodular carbonate concretions ; occasional f-m gravel patches *Sharp, horizontal basal junction*	63	Mollusc frags	–	Pleistocene colluvium
3.20–4.75	3789012	Yellowish brown slightly sandy silt, generally soft and unconsolidated, with occasional f-m rounded flint pebbles *Sharp basal junction, dips to SE and rises to NW*	64 68	–	–	Pleistocene colluvium
4.75–4.90	3789013	Moderately firm, mottled greenish grey/brownish yellow slightly sandy silt with common sub-angular f-m flint pebbles, dipping SE *Diffuse basal junction, rises to NW*	65	Pleistocene molluscs, small vertebrates	–	Pleistocene: colluvium/floodplain/fluvial?
4.90–5.00	3789014	Moderately firm slightly sandy silt with occasional fine angular flint pebbles, pinkish brown with strong brown mottles *Sharp basal junction, rises shallowly to NW*	69	–	–	Pleistocene: colluvium/floodplain?
5.00–6.20 base not reached	3789015	Yellow silt coarsening downward to yellowish brown sandy silt and fine sand; common nodular carbonate concretions at top	66 70	–	–	Pleistocene colluvium/floodplain?

KEY: vf – very fine; f – fine; m – medium, c – coarse

similarities to the molluscan assemblages from 3789TT (see below). *Belgrandia marginata* does not occur here, but the sample is too small for this absence to be regarded as significant.

3787TT Overview

The results of this test pit showed broad correspondence with the sequence from Borehole 0021SA. Contexts 3787005 through to 3787008 suggested fluvial deposition at a similar level to phase 21-E, but lacking equivalent interglacial mollusc remains. Deposits below these (context 3787009) contained a mollusc assemblage suggesting freshwater deposition with surrounding marsh and grassland. Amino acid dating was not applied to the molluscan remains as it was not clear how the deposit containing them related to adjacent test pits. When considered in conjunction with the other sequences from Zone 3 (see Zone 3 synthesis, below), they contribute to the overall picture of the Last Interglacial and slopewash sediments of the zone.

3789TT (ARC ESG00)

Introduction

This test pit was mechanically excavated to a total depth of 6.2m below ground surface. The ground surface elevation at the logged section was 3.89m OD. Bedrock was not attained in this test pit.

A series of bulk sediment samples was taken from fine-grained units throughout the sequence to assess for the presence of small vertebrate and molluscan remains (Table 7.6; Fig 7.6). Remains were found to be present in one sample (65), from context 3789013, phase 3789-B (see below). Mollusc specimens were taken for amino acid dating. All results are discussed in turn below.

Lithological Succession

Five main groups of sediments were identified in the sequence (Table 7.7; Fig 7.6):

3789-A, 5.0m to 6.20m (-1.11m to -2.31m OD). This deposit consists of context 3789015, a yellow silt becoming a sandy-silt towards the base. Molluscs were noted towards the base of the unit.

3789-B, 4.70/4.80m to 5.0m (-0.81/-0.91m to -1.11m OD): These deposits consist of contexts 3789013 and 3789014 consisting of brownish-yellow silt with frequent small sub-angular flint clasts overlying pinkish-brown sandy silt. Both contexts contain root canals filled with carbonate precipitate and the lower unit breaks with a blocky structure. The upper context dips steeply across the logged profile to the south-east. Molluscs were noted in both units.

3789-C, 3.20m–4.70/4.80m (0.69m to -0.81/-0.91m OD): This deposit consists of context 3789012. This deposit is a yellowish-brown sandy-silt with small rounded flint clasts. The upper part of the sequence is laminated.

3789-D, 1.80m to 3.20m (2.09m to 0.69m OD): These deposits consist of contexts 3789010 and 3789011. The sediments are predominantly silts and sands with some angular flint clasts. Carbonate-rich lenses which appeared to dip north to south occurred in the lower unit and molluscs were noted.

3789-E, 0.00m–1.80m (3.89m to 2.09m OD): These deposits consist of contexts 3789001, 3789002, 3789008 and 3789009, a complex of clay-silt dominated sediments with variable flint content. Flint content increases towards base and colour becomes a strong yellowish-red at base.

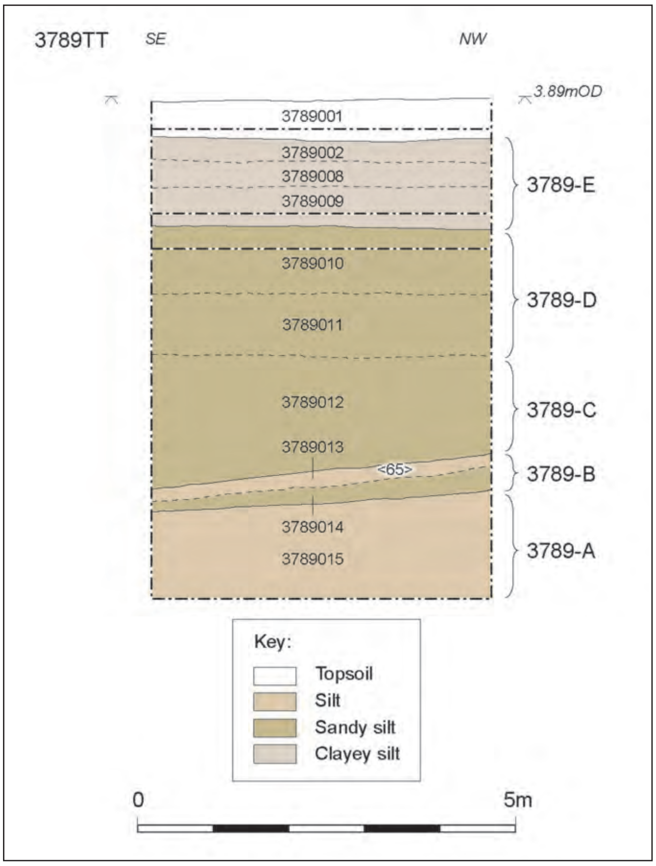


Figure 7.6 3789TT stratigraphic sequence and initial sampling

The interpretation of the sequences is based on the observations made during the field excavations. The overall trend of the sequences indicates fluvial sand deposition at the base of the sequence (3789-A) becoming finer upwards. The basal sands probably suggest deposition within an active floodplain system dominated by sand bar and channel sequences may give

Table 7.7 Stratigraphic sequence, phasing and distribution of environmental and amino acid dating evidence, 3789TT

Lithological phase	Context	Lithology	Inferred environments of deposition	Palaeo-environmental data	Dating (AA)
3789-E	3789001 3789002 3789008 3789009	Clay-silts with flint gravel clasts	Colluvial slopewash resulting from soil erosion under temperate conditions	–	–
3789-D	3789010 3789011	Sands and silt with angular flint clasts. Bedded in places with dipping beds	Colluvial slopewash during cool to cold climate	–	–
3789-C	3789012	Sandy-silt with rounded flint clasts, laminated towards the top	Colluvial slopewash during cool to cold climate	–	–
3789-B	3789013 3789014	Silts with blocky structure, rooting and carbonate precipitates	Floodplain surface with phases of emergence and weathering and pedogenesis	<65> Molluscs, small vertebrates	✓
3789-A	3789015	Silt becoming sandy-silt towards base	Fluvial sand bar and channel deposition on active floodplain	–	–

Table 7.8 Molluscs from 3789TT

	Phase 3789-B, context 3789013				
	65		65b		Total 65
	SV	M	SV	M	
Aquatic					
Valvata cristata	–	59	–	28	87
Valvata piscinalis	–	28	–	13	41
Bithynia tentculata	–	217	–	98	315
Bithynia tentculata opercula	–	751	–	9	760
Belgrandia marginata	–	15	–	–	15
Galba truncatula	–	122	–	47	169
Radix balthica	–	25	–	11	36
Stagnicola palustris agg.	–	9	–	–	9
Planorbis planorbis	–	21	–	–	21
Anisus leucostoma	–	40	–	13	53
Gyraulus laevis	–	2	–	–	2
Gyraulus crista	–	5	–	3	8
Segmetina nitida	–	5	–	–	5
Sphaerium sp.	–	1	–	–	1
Pisidium henslowanum	–	6	–	–	6
Pisidium moitessierianum	–	3	–	1	4
Pisidium milium	–	1	–	–	1
Pisidium spp.	–	5	–	1	6
Total Aquatic	–	**564**	–	**215**	**779**
Land					
Carychium minimum	2	10	–	–	10
Carychium tridentatum	1	27	–	29	56
Succineidae	–	6	–	11	17
Cochlicopa sp.	1	7	–	18	25
Truncatellina sp.	–	–	–	1	1
Vertigo antivertigo	–	2	–	2	4
Vertigo sp.	–		–	2	2
Pupilla muscorum	–	3	–	1	4
Vallonia pulchella	–	1	–	–	1
Vallonia excentrica	–	1	–	–	1
Vallonia pulchella/excentrica	–	6	–	2	8
Vallonia enniensis	–	1	–	–	1
Acanthinula aculeata	–	1	–	–	1
Punctum pygmaeum	–	1	–	–	1
Discus rotundatus	12	29	–	–	29
Vitrea contracta	–	3	–	–	3
Vitrea sp.	–	–	–	1	1
Nesovitrea hammonis	–	–	–	–	–
Aegopinella pura	–	4	–	1	5
Aegopinella nitudula	–	28	–	–	28
Aegopinella spp.	–	–	–	10	10
Oxychilus cf. *cellarius*	–	4	–	–	4
Deroceras/Limax spp.	–	52	–	–	52
Clausilia bidentata	1	–	–	–	–
Clausiliidae	–	3	–	2	5
Cernuella virgata	–	29	–	–	29
Cepaea/Arianta	4	3	–	–	3
Total Land	**21**	**221**	–	**80**	**322**
Total shells	21	**785**	–	**295**	**1101**

KEY: SV – Small vertebrate sample; M – mollusc sample
Note that molluscs extracted from sample residue

way to lower energy floodplain contexts upwards. The shift to finer grained sediment deposition in 3789-B suggests lower energy conditions and the probable establishment of floodplain environments between -1.11m and -0.81m OD (4.70–5.0m depth; Table 7.6; Fig 7.6). Weathering and pedogenesis is also indicated by the blocky structure of the lower context of phase 3789-B and the presence of carbonate precipitation and rooting. Deposits 3789-C and 3789-D are probably slopewash sediments, which may have formed during either temperate or cold climatic conditions. The boundary between phases 3789-D and 3789-E may mark the Pleistocene/Holocene boundary. The uppermost phase 3789-E is also of colluvial character and is probably Holocene in date.

Small Vertebrates

The single bulk sample (65), from context 3789013 yielded two molars of bank vole (*Clethrionomys glareolus*). Today, the bank vole inhabits dense vegetation in woodland and scrub, and during the Pleistocene it probably occupied similar habitats. Elsewhere in the Ebbsfleet Valley, Pleistocene records of *Clethrionomys* are extremely rare. However, *C. glareolus* is abundant in the interglacial (MIS 11) tufaceous channel fill (Phase 6b) at Southfleet Road (Wenban-Smith 2013) and at Site A-TP1, where a single molar was found in bed 2a. At both of these sites, associated environmental evidence suggests fully temperate conditions.

Molluscs

Only one sample from context 3789013 produced molluscan remains, counted as two separate sub-samples (65 and 65b), which could be amalgamated (Table 7.8). The most notable species is *Belgrandia marginata*, a rare species now confined to springs in Catalonia and southern France. The diverse molluscan assemblage suggests a permanent waterbody with aquatic vegetation and possibly one with some flow. The land snails also indicate fully temperate conditions. *Discus rotundatus* (damp shaded conditions) and *Cernuella virgata* (dry, open habitats) are both present. An interglacial environment is indicated, although attribution to MIS 7 or 5e cannot be made purely on this molluscan evidence.

Dating

Three *Bithynia* opercula from sample 65, phase 3789-B, were extracted for amino acid dating under the new protocols of K Penkman at University of York (Penkman, Appendix E). The results (Fig 7.7) suggest a date early in MIS 5e, and also consistently a little earlier than the MIS 5e reference point, based on several sites including Trafalgar Square, Bobbitshole and the East Mersea restaurant site (Penkman *et al* 2011). Also, the results are comparable to those from the calcareous gravel 3972024 (phase 3972-J) the middle of the sequence at the south-east end of 3972TT (see Chap 10).

3789TT Overview

The molluscan evidence indicates, at least for the horizon at which it was found (phase 3789-B), a permanent waterbody during fully temperate interglacial conditions. Both the altitude of the deposits (c -1.00 m OD for the sampled horizon) and amino acid results suggest that this horizon represents part of a Last Interglacial (Ipswichian, MIS 5e) aggradation. The

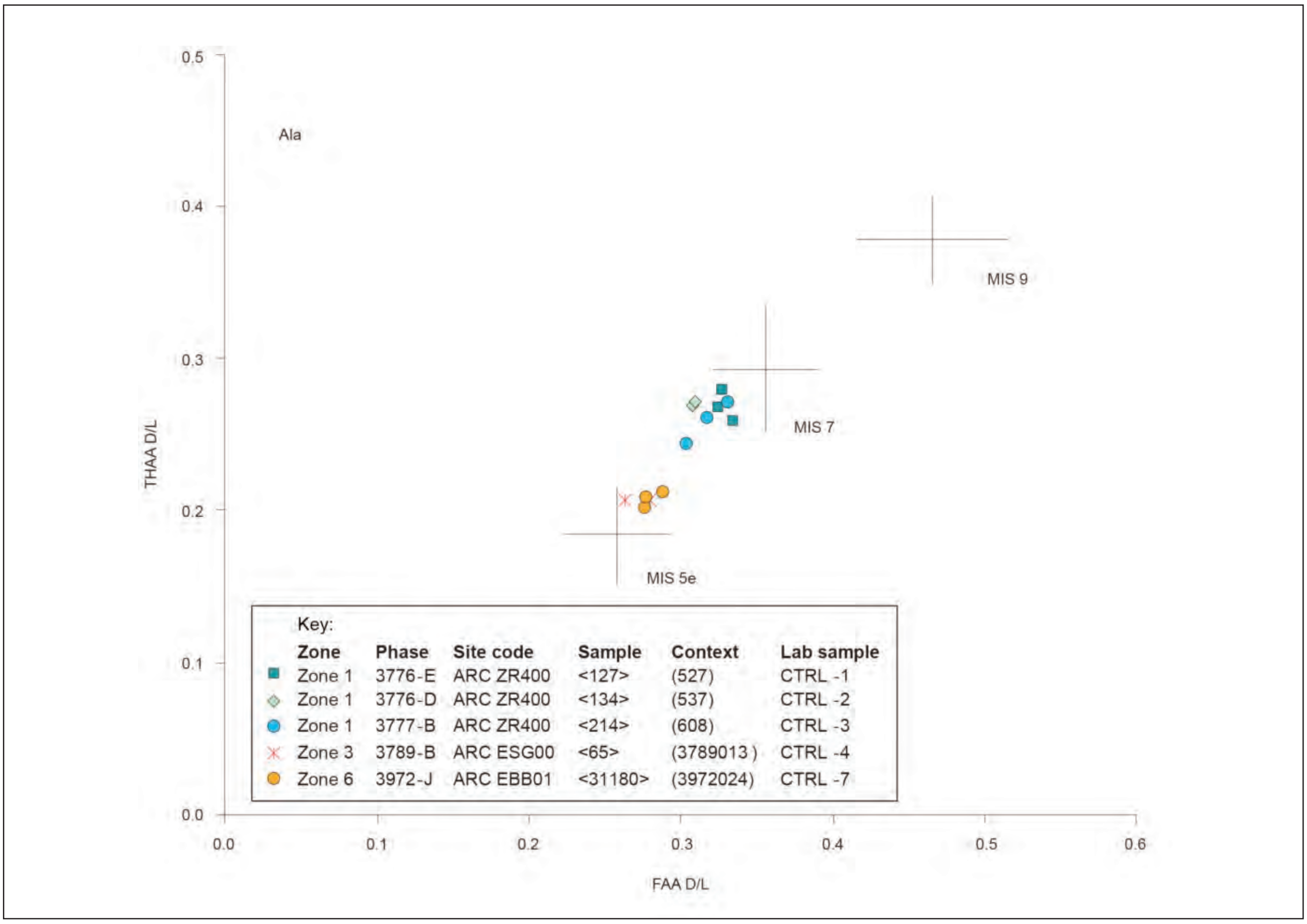


Figure 7.7 D/L Hyd vs D/L Free for alanine in *Bithynia tentaculata* opercula from selected locations: CTRL1 – 3776TP, context 527 (phase 3776-E); CTRL2 – 3776TP, context 537 (phase 3776-D); CTRL3 – 3777TP, context 608 (phase 3777-B); CTRL4 – 3789TT, context 3789013, sample 65; CTRL7 – 3972TT context 3972024, sample 31180. (The error bars represent two standard deviations about the mean for data obtained from opercula from sites correlated with MIS 5e, MIS 7 and MIS 9)

base-depth of the lower part (phase 3789-A) of the sequence is unknown. Its predominantly fine-grained character suggests generally quiet conditions. Higher up the sequence (phase 3789-C to phase 3789-D), it is probable that the fluvial sequence continues with deposits broadly equivalent to those at similar level in nearby Borehole 0021SA (phases 21-D and 21-E). This is discussed more fully in the Zone 3 synthesis below.

3790TT (ARC ESG00)

Introduction

This test pit was mechanically excavated to a depth of 4.4m below ground surface. The surface elevation of the logged profile was 4.15m OD. Bedrock was not encountered in this test pit.

A series of bulk sediment samples was taken from fine grained units throughout the sequence to assess for the presence of small vertebrate and molluscan remains (Table 7.9). Molluscs were noted in the field to be locally present in an isolated calcareous part of one horizon (3790-F) and a vertically contiguous series of 8 samples were taken through it. Specimens of both *Pupilla muscorum* and an operculum of *Bithynia* were also taken for amino acid dating. All results are discussed in turn below.

Lithological Succession

Seven groups of sediments were identified in this test pit (Table 7.9):

3790-A, 4.00m–4.40m (0.15m to -0.25m OD): This body of sediment consisted of context 379008. This was a very pale brown chalk-rich sediment with angular chalk and well rounded (occasionally broken) flint clasts and a chalky paste matrix.

3790-B, 3.95–4.00m (0.20m to 0.15m OD): This body of sediment consisted of context 379007. This was a lens of sub-angular flint gravels.

3790-C, 3.30m–3.95m (0.85m to 0.20m OD). This body of sediment consisted of context 379006. The deposit was a yellowish-brown medium to fine sand with thin sub-horizontal seams of fine to medium flint gravel.

3790-D, 2.95m–3.30m (1.20m to 0.85m OD): This body of sediment consisted of context 379005. The deposit consisted of a yellowish-brown sand with carbonate nodules and some sub-angular flint clasts.

Table 7.9 Stratigraphic sequence, phasing and distribution of environmental and amino acid dating evidence (ground surface at 4.15m OD), 3790TT

Phase	Depth (m)	Contexts	Lithology	Inferred environments of deposition	Samples	Palaeoenvironmental data	Dating (AA)
3790-G	0.25–0.85	3790002	Strong brown sandy and gravelly clay-silt	Colluvial slopewash resulting from soil erosion under temperate conditions	–	–	–
3790-F	0.85–1.65	3790003	Moderately compacted yellowish brown clayey-silty sand with greenish grey mollusc-rich patch, dipping and thickening downslope to east	Colluvial slopewash during cool to cold climate	29–2kg 30–2kg 31–2kg 32–2kg 33–2kg 34–2kg 35–2kg 36–2kg	Abundant molluscs in isolated patch, sampled as vertical series of *c* 2kg samples at *c* 100mm interval	✓ – *Pupilla* ✓ – *Bithynia* (operculum)
3790-E	1.65–2.95	3790004	Moderately soft and friable yellowish brown clayey-silty sand with pinkish grey clayey lenses at base	Colluvial slopewash during cool to cold climate	26–20 litres	None	–
3790-D	2.95–3.30	3790005	Moderately compacted yellowish brown very sandy clay-silt with occasional nodular carbonate concretions	Floodplain surface with phases of emergence and weathering and pedogenesis	21–20 litres 22–20 litres	None	–
3790-C	3.30–3.90	3790006	Moderately compacted to firm gravely sand with sub-parallel laminations of f/m sand towards base and occasional beds 10–20mm thick of fine gravel	Fluvial sand bar and channel deposition on active floodplain	23–20 litres 24–20 litres 25–20 litres 28–20 litres	None	–
3790-B	3.90–4.00	3790007	Loose, moderately well sorted clast-supported f-c flint gravel (clasts generally sub-angular to well-rounded) thickens NE, pinches out to west	Cold climate solifluction deposit or channel lag	100-litre spit sample sieved for lithic artefacts; none found	–	–
3790-A	4.00–4.40 base not seen	3790008	Pale brown Chalk diamict with rounded flint pebbles and occ flint nodules, whole and broken	Cold climate solifluction deposit at base of slope	–	–	–

KEY: vf – very fine; f – fine; m – medium, c – coarse

3790-E, 1.65m–2.95m (2.50m to 1.20m OD): This body of sediment consisted of context 379004. The deposit was a yellowish-brown slightly silty fine to medium sand. Common carbonate nodules were present and the base of the unit contained thin, discontinuous lenses of silt.

3790-F, 0.85m–1.65m (3.30m to 2.50m OD): This body of sediment, context 3790003, comprised a yellowish-brown slightly silty sand containing numerous carbonate nodules. Molluscs were also present within the sequence.

3790-G, 0.00m–0.85m (4.15m to 3.30m OD): This group of sediments consisted of the topsoil and context 3790002, a strong brown sandy clay-silt. This unit thickened across the trench and downslope.

The overall sequence present here commences with a chalk-rich deposit at the base. This is likely to be a solifluction deposit that is overlain by a thin gravel horizon (3790-B). This gravel is probably either a fluvial gravel lag related to the overlying sands or a thin tongue of soliflucted gravel – it is not possible to distinguish between these options in the limited exposure of a test pit. The sands (3790-C) are potentially channel deposits fluvial sands overlain by further sands (3790-D) that may have undergone some post-depositional weathering. Deposits 3790-E and 3790-F were both thought to be Pleistocene slopewash deposits during fieldwork, but subsequent molluscan analysis (see below) suggests an aquatic depositional environment for 3790-F with dry grassland in the wider vicinity. The uppermost unit (3790-G) is probably Holocene colluvium.

Molluscs

A vertical series of mollusc samples was taken at 0.10m intervals through context 3790003, phase 3790-F. It was apparent in the field that decalcification had not taken place in this one small part of this deposit, since abundant molluscs were present. The molluscan assemblages through this sequence are similar and relatively restricted in diversity. Initial examination by RC Preece recorded an aquatic fauna dominated by *Galba truncatula, Radix balthica* and *Anisus leucostoma* suggesting deposition in and around shallow pools, often those liable to drying out in summer. Sample 29, at the top of the sampled sequence, yielded *Bithynia tentaculata* and *Planorbis* cf. *planorbis*, perhaps suggesting a slightly more permanent waterbody. The terrestrial fauna consists of *Vallonia pulchella* and *Trochulus hispidus*, again consistent with a damp open habitat. The surprise is the occurrence of *Cernuella virgata*, a species of dry calcareous grassland and other well-drained habitats. This species does not inhabit marshes, so it must mean that the local environment became extremely dry for much of the time. The assemblages indicate a temperate climate but no indication of the age. *C. virgata* is known from a few interglacial sites in the Lower Thames Valley and also from the very late Holocene (post-Roman) (Preece 1998).

Subsequent examination by T S White led to the additional observations that the molluscan fauna is dominated by *Galba truncatula* and *Anisus leucostoma*, with subordinate *Radix balthica*. This fauna shows similarities to that from phase BMA-C at Site A (Chap 5). A key difference, however, is the abundance of *Cernuella virgata*, which was not recorded at Site A. The presence of modern contaminants, most notably *Candidula intersecta* in three samples from this sequence is a concern, suggesting contamination at the processing stage or perhaps some intrusion of modern material down through the sequence, although there was no sign of this in the sampled section. This species is well-established as a ‘weed’ species in Britain recently introduced from southern Europe. There are no pre-medieval fossils of *C. intersecta* known. It readily colonizes suitable humanly-made habitats on well-drained calcareous soils (Kerney 1999).

Dating

Amino acid dating was carried out on two *Pupilla* shells, which were bulked together as a single sample, and a single *Bithynia* operculum. Both sets of material came from sample 31, towards the middle of the shelly sampled sequence in context 3790003. The new protocols of Penkman (University of York) were used, and full details are provided in Appendix E. The *Pupilla* results are less well understood than those from *Bithynia* opercula, and the range of usual variation is not yet established. However, when plotted against a range of comparator material (Fig 7.8), they consistently suggest a date slightly closer to that of Harnham (an interstadial late in MIS 8, *c* 250,000 BP – see Bates *et al* 2014) than Cassington, thought to date to MIS 5a, *c* 80,000 BP (Maddy *et al* 1998). For the *Bithynia* operculum, the results are more clear-cut (Fig 7.9), with the results closely matching both the standard reference point for MIS 5e, and the data from towards the base of the nearby test pit 3789TT. Taken together, the results support a Last Interglacial, MIS 5e date.

3790TT Overview

The small surviving patch of mollusc-rich sediments, surviving relatively high up in the stratigraphic sequence of 3790TT, at an altitude of *c* 3m OD and only 1m below the ground-surface, provides an intriguing interpretive glimpse into a widespread sediment body otherwise generally lacking in data. The temperate mollusc assemblage includes freshwater and marshland elements, suggesting deposition in shallow pools, prone to drying out in summer and a generally damp open habitat. It also includes *Cernuella virgata*, which is characteristic of dry calcareous grassland and other well-drained habitats. The amino acid results suggest a date

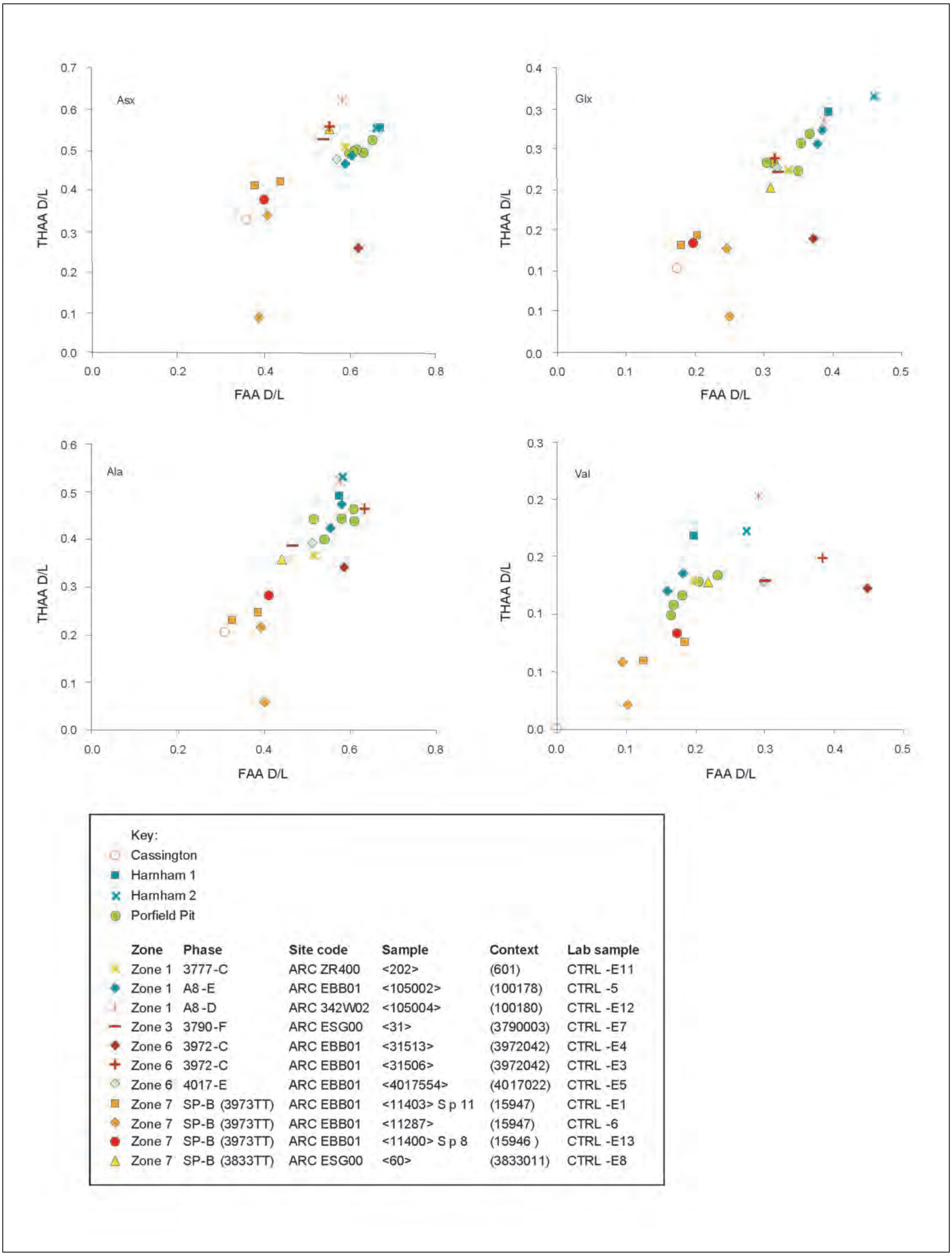


Figure 7.8 Hyd vs Free D/L values of Asx, Glx, Ala and Val for the bleached (intra-crystalline) *Pupilla muscorum* shells from HS1 sites; the specimen from 3790TT, sample 31 is CTRL E7. The data for three other sites (Cassington, Maddy *et al* 1998; Harnham, Bates *et al* 2014 and Portfield Pit, Bates 1998) have also been plotted for comparison

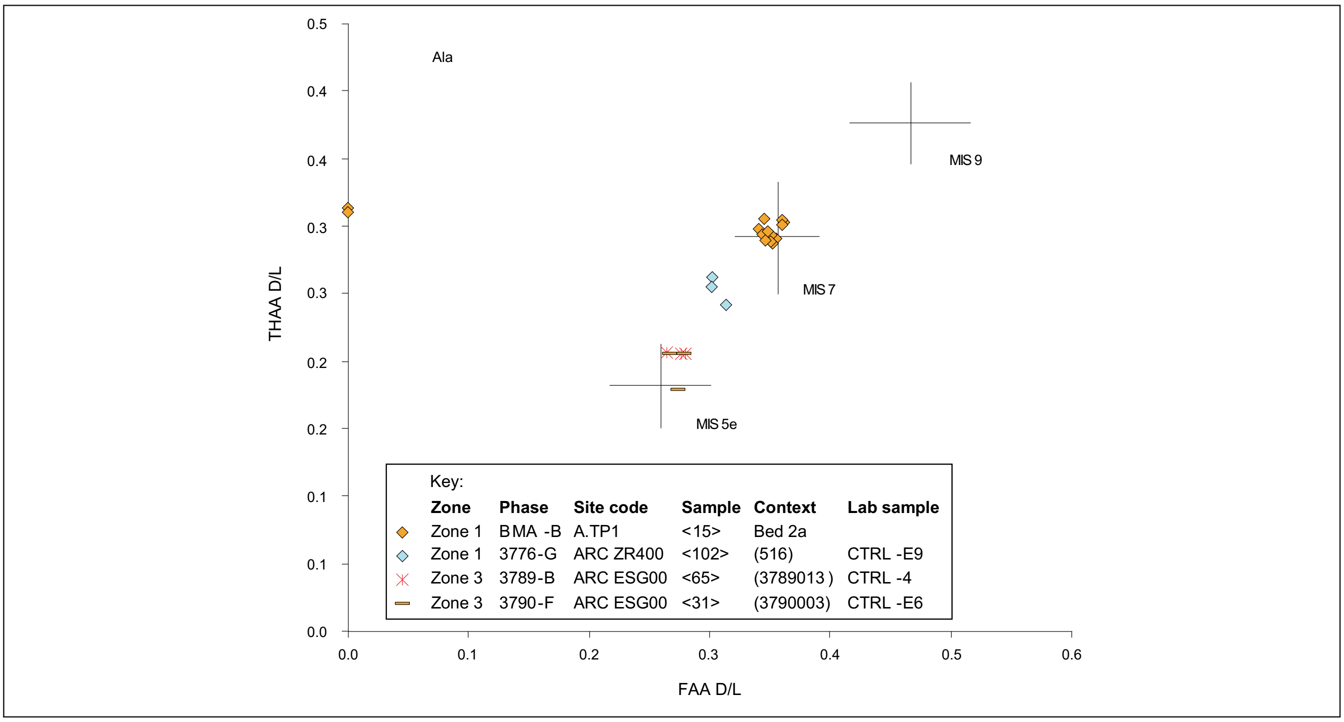


Figure 7.9 Amino acid dating of *Bithynia* opercula from Zones 1 and 3, comparing alanine from 3789TT and 3790TT (Zone 3) with Site A and 3776TP (Zone 1)

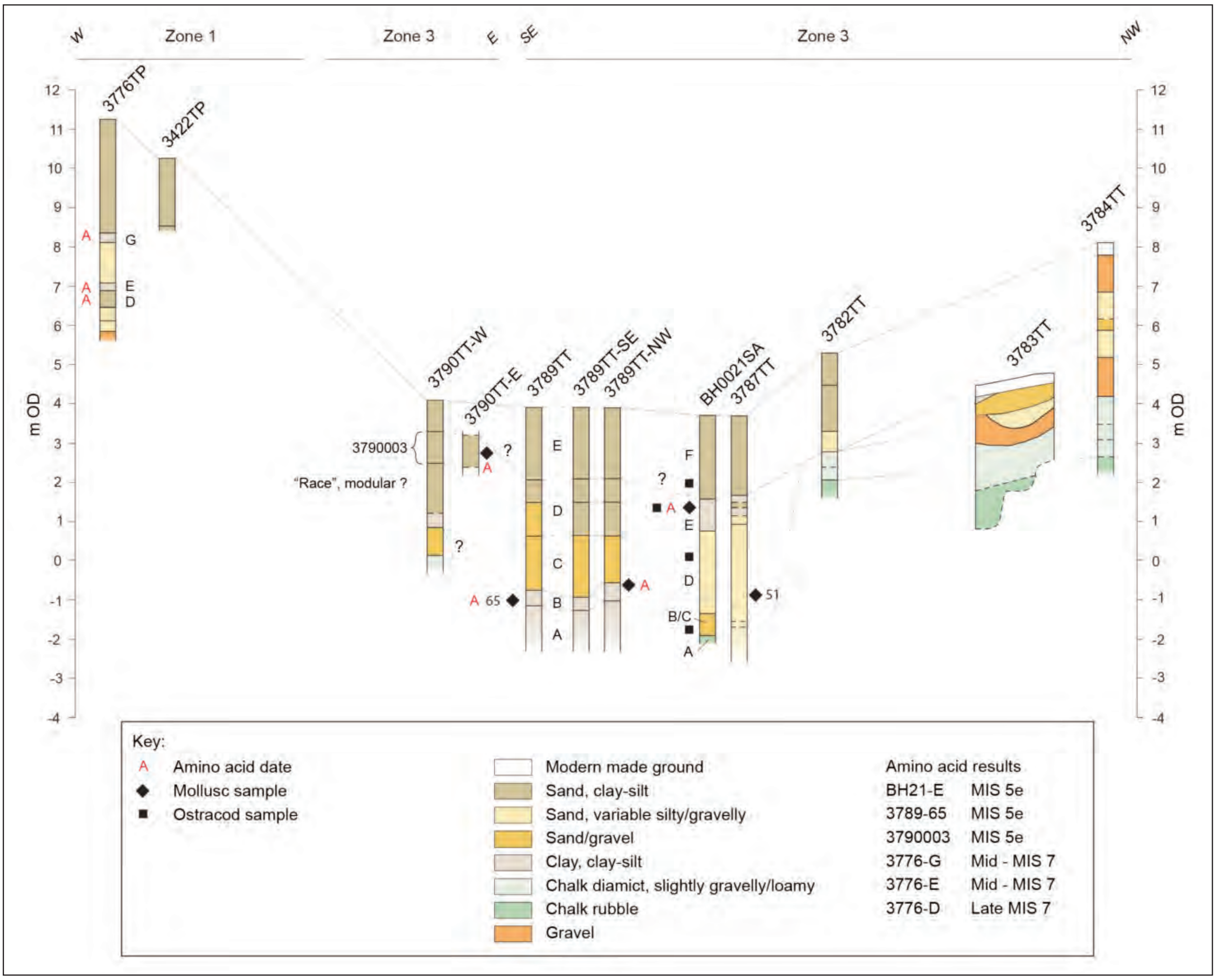


Figure 7.10 Zone 3 stratigraphic overview and relations between different sequences

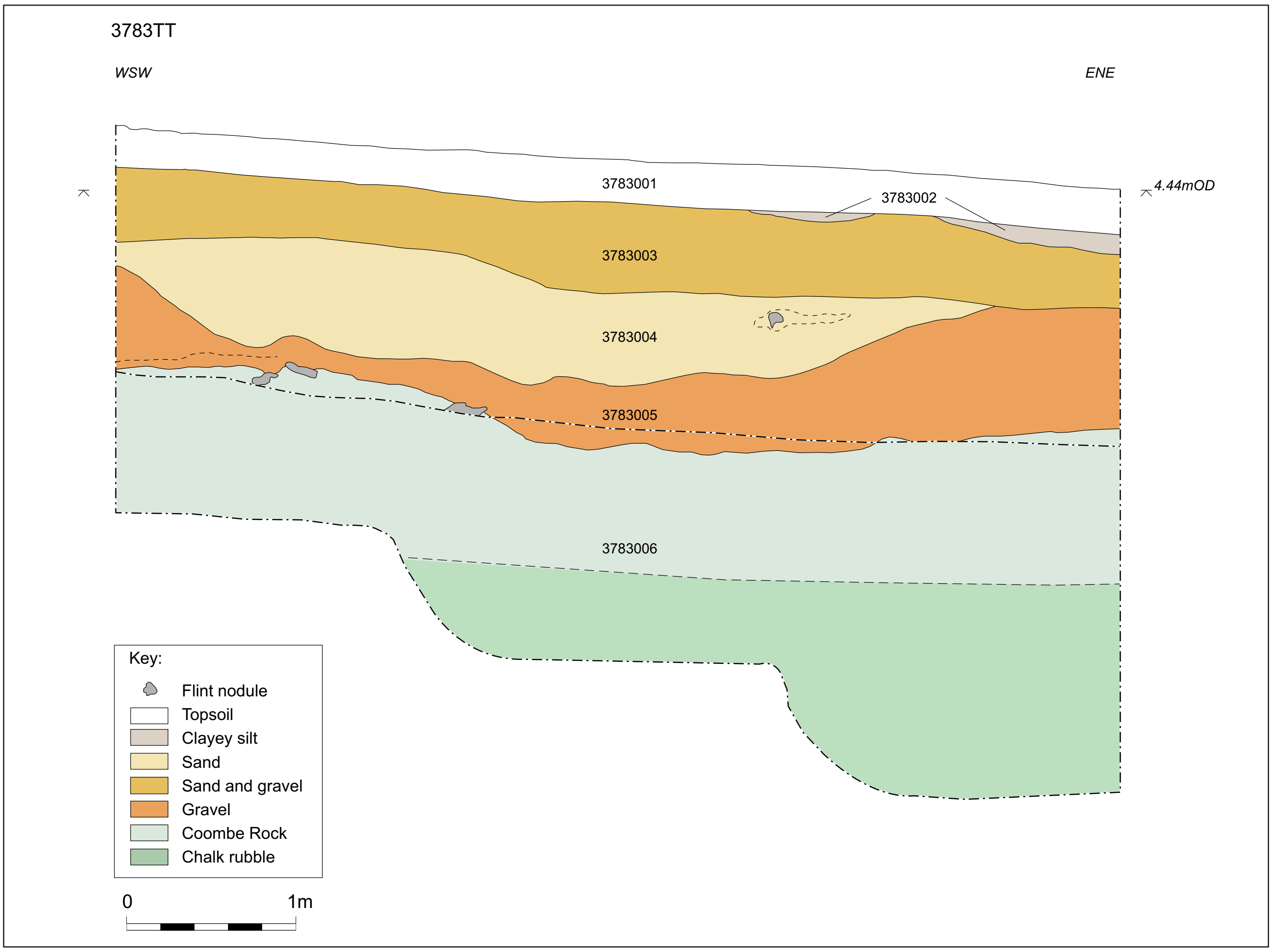


Figure 7.11 3783TT stratigraphic cross-section

of MIS 5e. The physical appearance of the deposits, with numerous fine-grained sand/silt laminae dipping downslope to the east, is characteristic of the colluvial slopewash sediments that predominate in the upper part the Quaternary sequence in the vicinity of Zones 1 and 3. The sequence as a whole seems to represent a similar situation to the sequence in Borehole 0021SA described above. Both sequences show colluvial slopewash deposition interrupted by a period of wetter alluvial/marshland conditions associated with the Last Interglacial MIS 5e.

Zone 3 Synthesis

The central part of Zone 3, in the vicinity of Borehole 0021SA and test pits 3787TT, 3789TT and 3790TT, seems to contain a rare surviving outcrop of a Last Interglacial aggradation in the Ebbsfleet Valley, sandwiched between the MIS 7 terrace of Zone 1 to the west, and the Holocene alluvial floodplain to the east (Fig 7.10). The basal level of this aggradation was not reached, but lies below -2m OD. The parts of the sequence below -1m OD, represented by the mollusc samples from 3789TT (phase 3789-B) and Borehole 0021SA (phase 21-B) show a fully temperate interglacial fauna with woodland elements deposited in a permanent waterbody. Higher up the sequence, between -1m and 3m OD, the molluscan evidence (from Borehole 0021SA phase 21-E, and 3790TT context 3790003) shows continuing temperate conditions, but the general drying up of the local environment, with marshland conditions interspersed with periods of substantial slopewash deposition. These Last Interglacial deposits are then truncated by a younger colluvial slopewash group of sediments that may in their lower parts include Last Glacial elements, but which also included in the upper part significant thicknesses of Holocene sediments. It is uncertain to what extent the Last Interglacial sequence continues east under the present-day Ebbsfleet alluvial floodplain, or was removed by erosion and subsequent deposit emplacement associated with the last glaciation.

The fine-grained Last Interglacial sediments are not recorded in the southern and northern parts of Zone 3, where the sequences at the ZR3A pylon and test pit 3783TT (Fig 7.11) comprise predominantly slopewash sands and gravels at the base, overlain by fine-grained colluvial slopewash deposits of Last Glacial or Holocene age.

Chapter 8
Valley-side Central (Zone 4)

by Martin Bates and Francis Wenban-Smith

Introduction

This zone lies at the western edge of the floodplain of the modern Ebbsfleet (Fig 8.1). The zone was not identified as an area of Palaeolithic/Pleistocene interest in the original assessment of historical and cultural effects (URL 1994). The southern boundary of the zone is marked by the northern edge of a dry valley complex containing Zone 6 while the eastern margin is the approximate edge of the floodplain.

Investigation of the area was undertaken in the main evaluation phase in 2001 (ARC ESG00 URN 2001a) and included 3806TT, 3807TT and 3828TT. In all cases the field investigations involved machine-excavation of a series of large stepped trenches.

3806TT, 3807TT and 3828TT (ARC ESG00)

A series of deep trenches (Fig 8.2) were machine-excavated in a number of phases across the lower parts of the gravel spur projecting towards the floodplain (Fig 8.1). Inspection of the detailed records from these test pits suggested that three (3806TT, 3807TT and 3828TT) record the main stratigraphy and are grouped together. The logs of the sections are presented in Figure 8.2.

Lithological Succession

The deposits present in the three key sequences can be subdivided into two main groups of Pleistocene sediments, all lying between 3.8m and -2.0m OD (at maximum sequence thickness):

A: These consist of gravels and sands. These may be chalk-rich in places. Interbedding with sand units also occurs locally.

B: These are variable in nature and are dominated by sand clay-silts or variants. They consist of multiple units in places. Locally these are replaced by Holocene clay-silts (Phase C) towards the river.

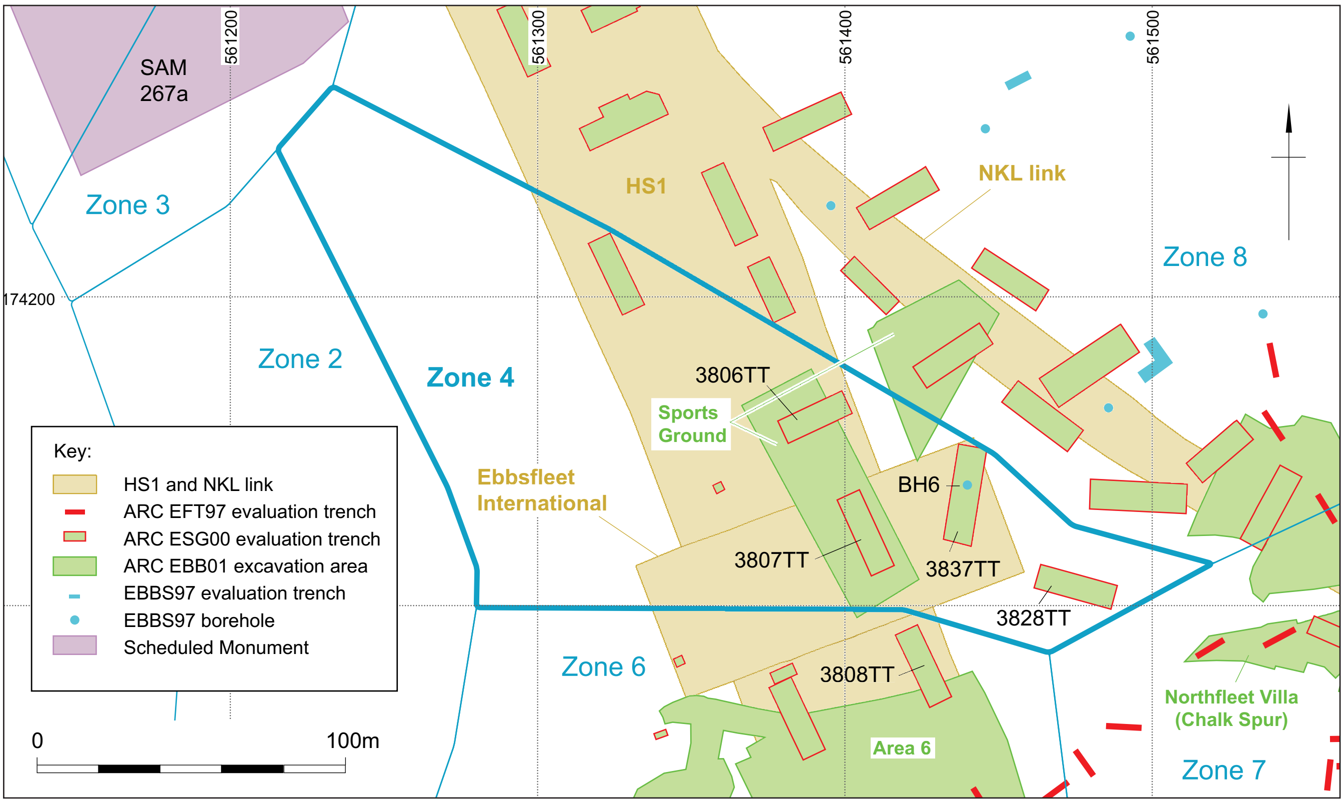


Figure 8.1 Zone 4 layout and key intervention locations

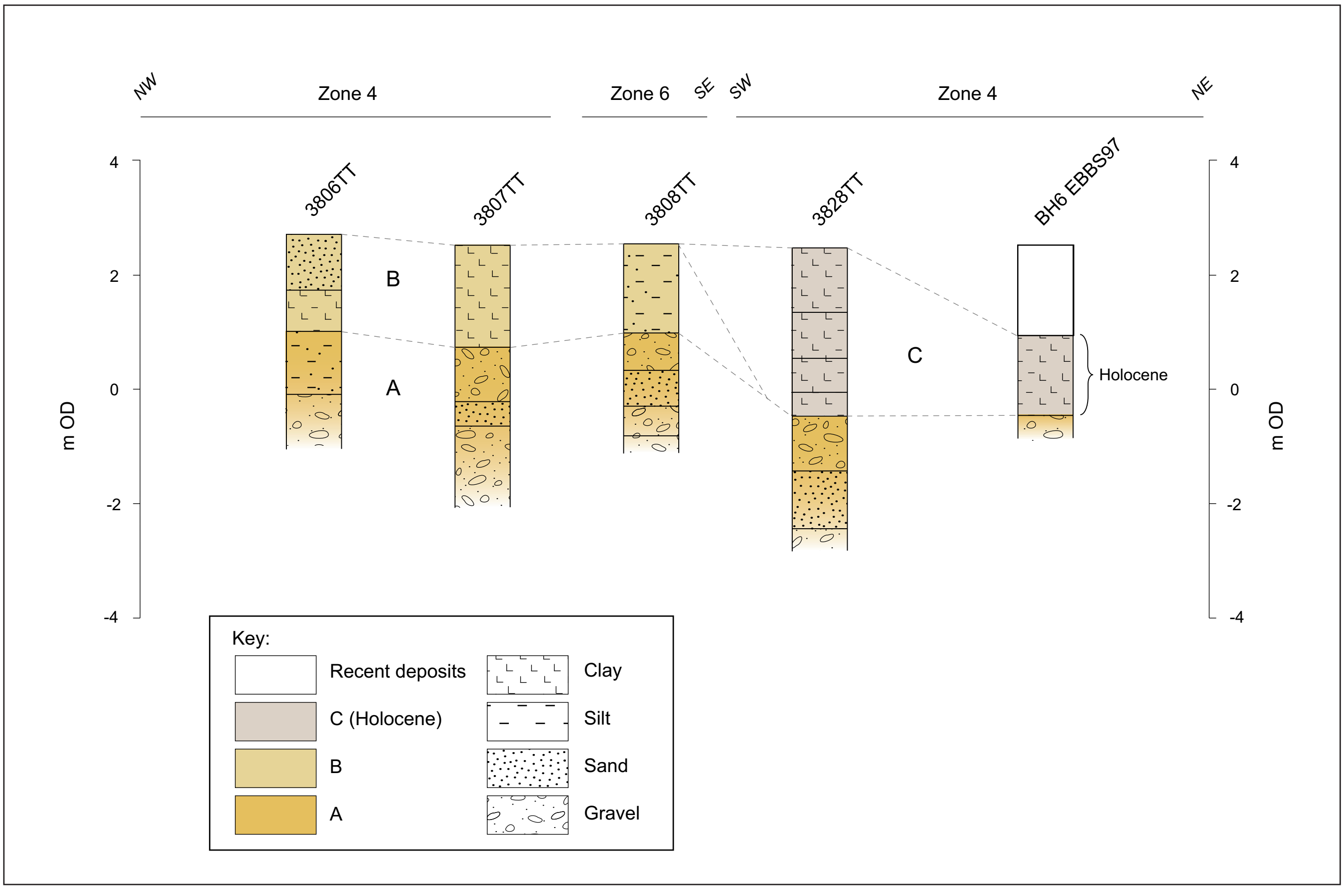


Figure 8.2 Lithology of test pits

The sediments are interpreted as fluvial sands and gravels of a high-energy river system where typically the surface elevation of the sediments lies between 0m and 2m OD. The overlying sediments appear to be dominantly derived from colluvial processes as sheet wash, probably continuous with similar sediments blanketing the valley sides. The sequences present in this zone are limited in number and contain no palaeoenvironmental material or dated samples.

Chapter 9
Chalk Spine (Zone 5)

by Francis Wenban-Smith, Martin Bates, Adrian M Lister and Jean-Luc Schwenninger

Introduction

This zone (Fig 9.1) was of importance, despite being of limited extent and stratigraphic variety. It was the closest surviving remnant of Coombe Rock deposits to those from which RA Smith's seminal "Baker's Hole" Levalloisian lithic artefact collection – the APCM collection, donated to the British Museum in 1914 – was recovered (Chaps 2 and 17; Smith 1911).

The narrow strip of deposits comprising Zone 5 survived within an otherwise desolate quarried expanse (Fig 4.1), having been protected beneath the conveyor belt that carried chalk from Eastern Quarry, *c* 1km to the west, to the APCM washmill by the Ebbsfleet, as shown in Carreck's (1972, 19) site layout diagram (Fig 2.14). In order to understand the deposits at this location, it is important to consider them in their original geomorphological context. Before quarrying, this strip of deposits would have been situated about half-way up the south-eastern flank of a ENE-trending dry valley (Fig 2.16), passing to the west of the spur of chalk, the quarrying of which (as Southfleet Pit) revealed the Baker's Hole Coombe Rock in its "north-west angle". Thus, the Baker's Hole Coombe Rock was dipping and thickening into the same dry valley fill sequence, a tiny remnant of which was preserved as "Site D" (Fig 2.16) or "the Chalk Spine". The Pleistocene sequence at the site was first noticed by Carreck (1972, 59), who described "well-developed, long festoons formed in periglacial frozen ground in the top of the Main Coombe Rock ... [which] sloped, parallel with each other, apparently south-westward". The north-facing side of this strip of deposits was still exposed in the early 1990s, and was recorded by Wenban-Smith as "Site D, section 40" (Fig 9.2), who also excavated a small test pit (D.TP 1) from which a mammoth tooth was recovered (see large vertebrates, below).

Later, for the HS1 investigations, two test pits 2019TP and 2020TP (Fig 9.1) were dug as part of the preliminary evaluation ARC EFT97 (URL 1997a). Both of these produced lithic artefacts from the Coombe Rock (Chap 17). Further investigation proved challenging. Three intended additional, mitigating test pits (3965TP, 3966TP and 3967TP) were started, but not completed, due to: (a) the need to maintain continual use of the Chalk Spine strip as a quarry haul road; and (b) the difficulty of working safely close to the existing quarry edge. Finally, in March 2003, three stepped trenches

Plate 9.1 View of 4018TT, 4019TT and 4020TT, excavated and cleaned

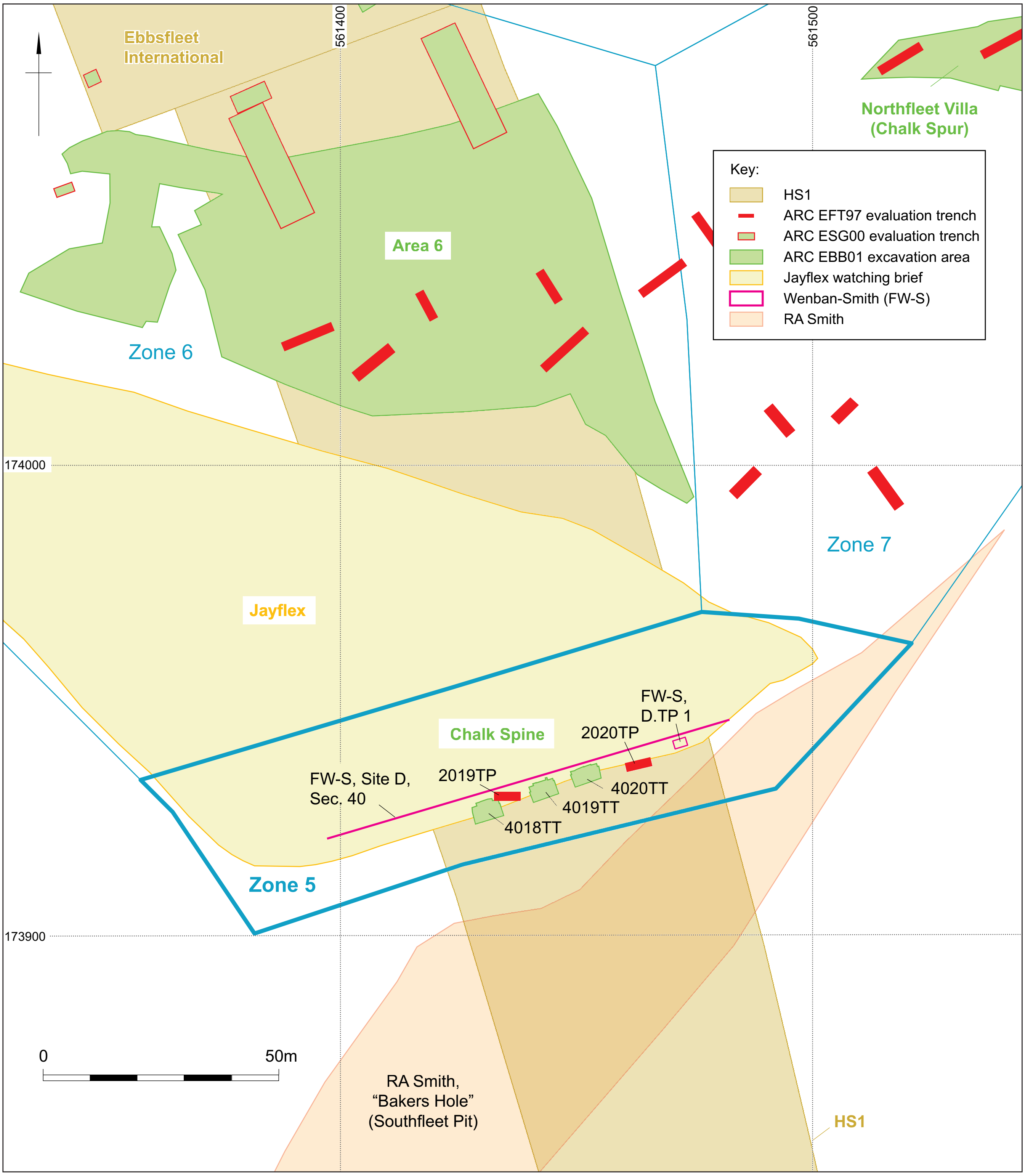


Figure 9.1 Zone 5 layout and key intervention locations

(4018TT, 4019TT and 4020TT) were excavated into the side of the Chalk Spine as part of the ARC EBB01 phase of work (Pl 9.1). Field interventions, past and present, in the vicinity of the Chalk Spine are summarised in the table below, which also shows the key evidence recovered for each intervention (Table 9.1), and their locations are also shown in the zonal layout plan (Fig 9.1). Unfortunately, the watching brief was not carried out in this area as the contractor failed to contact the archaeologist.

Following investigation, deposits of this zone were almost entirely removed in advance of construction of HS1, the main line of which runs directly through the zone. Deposits probably survive to a small degree at the east and west ends of the original Chalk Spine strip, but may be deeply buried by made ground.

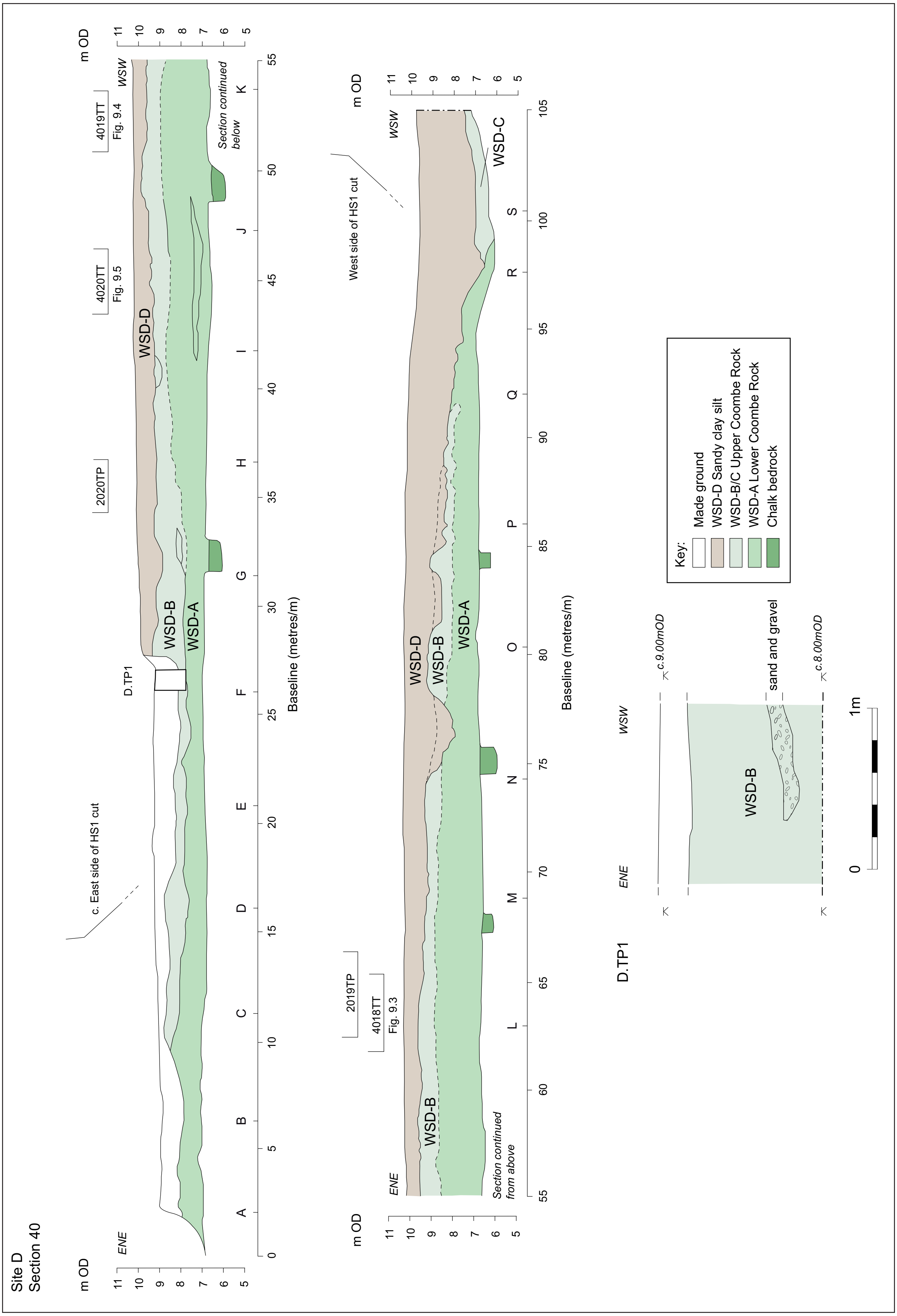


Figure 9.2 Site D, section 40

Site D and Trenches 4018TT, 4019TT and 4020TT (ARC EBB01)

Lithological Succession

The overall lithological succession is best shown in Wenban-Smith's Site D section drawing (Fig 9.2). The three excavated stepped trenches allowed more detailed examination of the deposits (Figs 9.3–5; Pl 9.2), and also exposed sand-rich horizons suitable for OSL dating (see dating, below). Four major deposit phases were recognised, above degraded chalk bedrock. From the base, these are:

WSD-A, Lower Coombe Rock: This was generally a bright white chalk rubble, poorly sorted, in a chalk silt matrix. It contained occasional flint nodules, chaotically distributed, apart from at the base where they were more concentrated, and where there was also an intermittent thin sand bed in places. The chalk-rich deposits of this phase also contained well-developed sand/gravel-filled pockets and, in places, wavy sub-horizontal beds. The smaller pockets were crescent-shaped when seen in cross-section along much of the exposed longer section, reflecting broadly northward-trending downslope channelling which was visible in orthogonal cross-section in the stepped trenches. At the western end of the main Site D section, between 80m and 95m along its base line, there are sloping features probably corresponding with the "apparently south-westward" dipping festoons noted by Carreck. These are probably better understood as north-eastward slumping of the upper part of the body of sediment relative to its lower part, as part of general north-eastward mass movement of deposits down the dry valley. A fine, fresh condition Levallois flake (SF 4018101) was found *in situ* in one of the gravelly involution pockets/channels in 4018TT, as shown in the section drawing (Fig 9.3).

Table 9.1 Zone 5 key interventions and range of specialist and dating studies

Project	Key locations	Secondary locations	Soil micro-morph	Large vertebrates	Small vertebrates	Molluscs	Ostracods	Amino acid	OSL dating	Worked flint
RA Smith (APCM 1914)		"Baker's Hole"	–	X	–	–	–	–	–	X
FW-S PhD	Site D, sec 40		–	x - un-ID	–	–	–	–	–	–
	D.TP 1 (EV 1992)		–	X	–	–	–	–	–	–
ARC EFT97		2019TP	–	–	–	–	–	–	–	X
		2020TP	–	–	–	–	–	–	–	X
ARC EBB01	4018TT		–	–	–	–	–	–	–	X
	4019TT		–	–	–	–	–	–	X	–
	4020TT		–	–	–	–	–	–	X	–

KEY: X – important evidence; x – minor presence

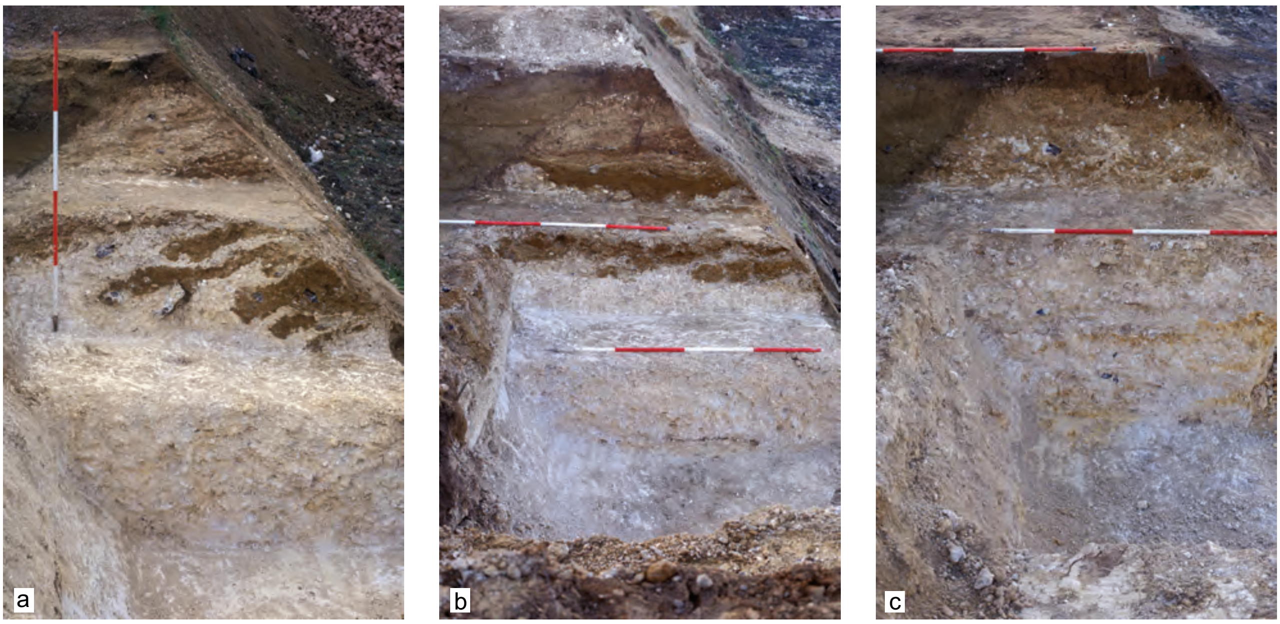


Plate 9.2 Sections from the Chalk Spine test pits (a) 4018TT; (b) 4019TT; (c) 4020TT

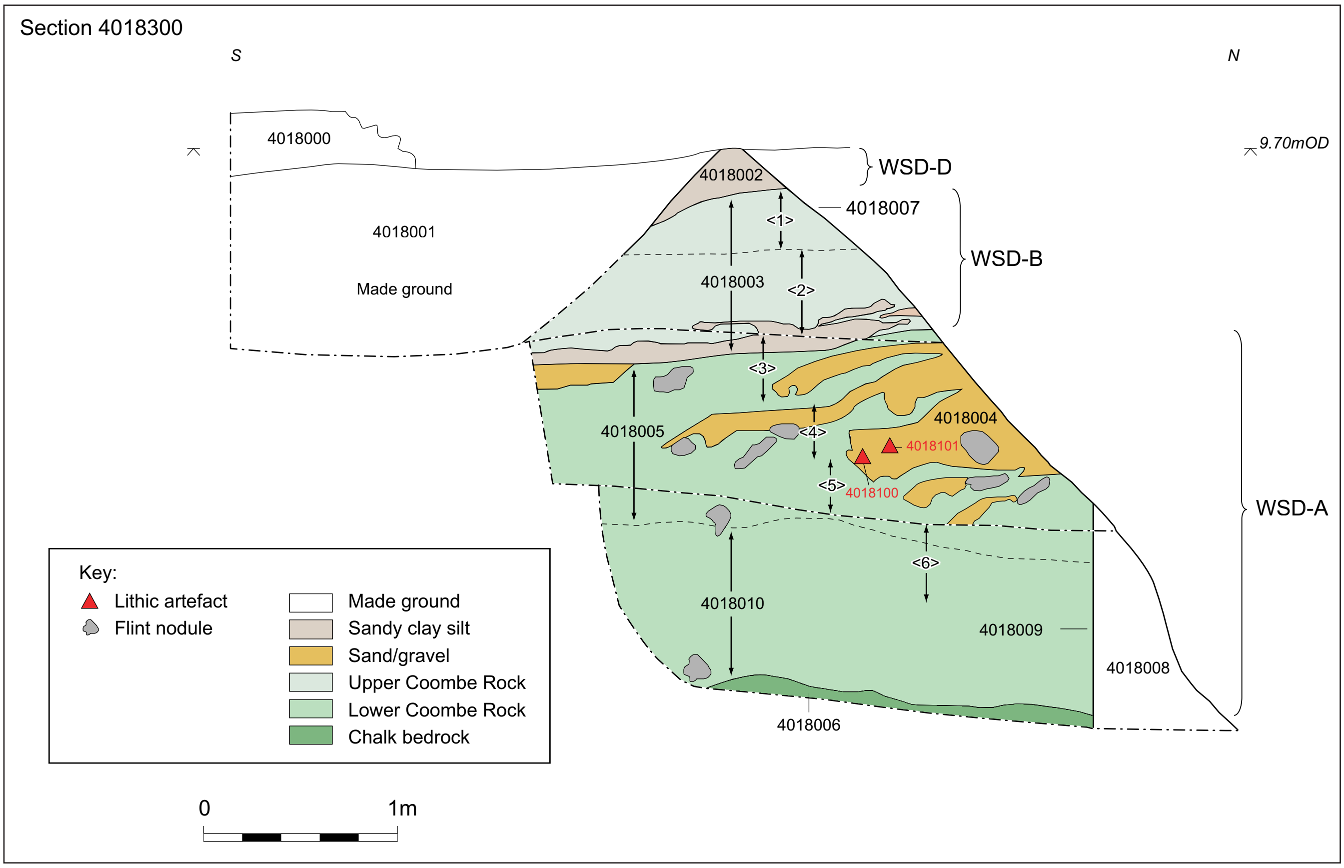


Figure 9.3 4018TT sequence and phasing: note Levallois flake *in situ* (SF 4018101)

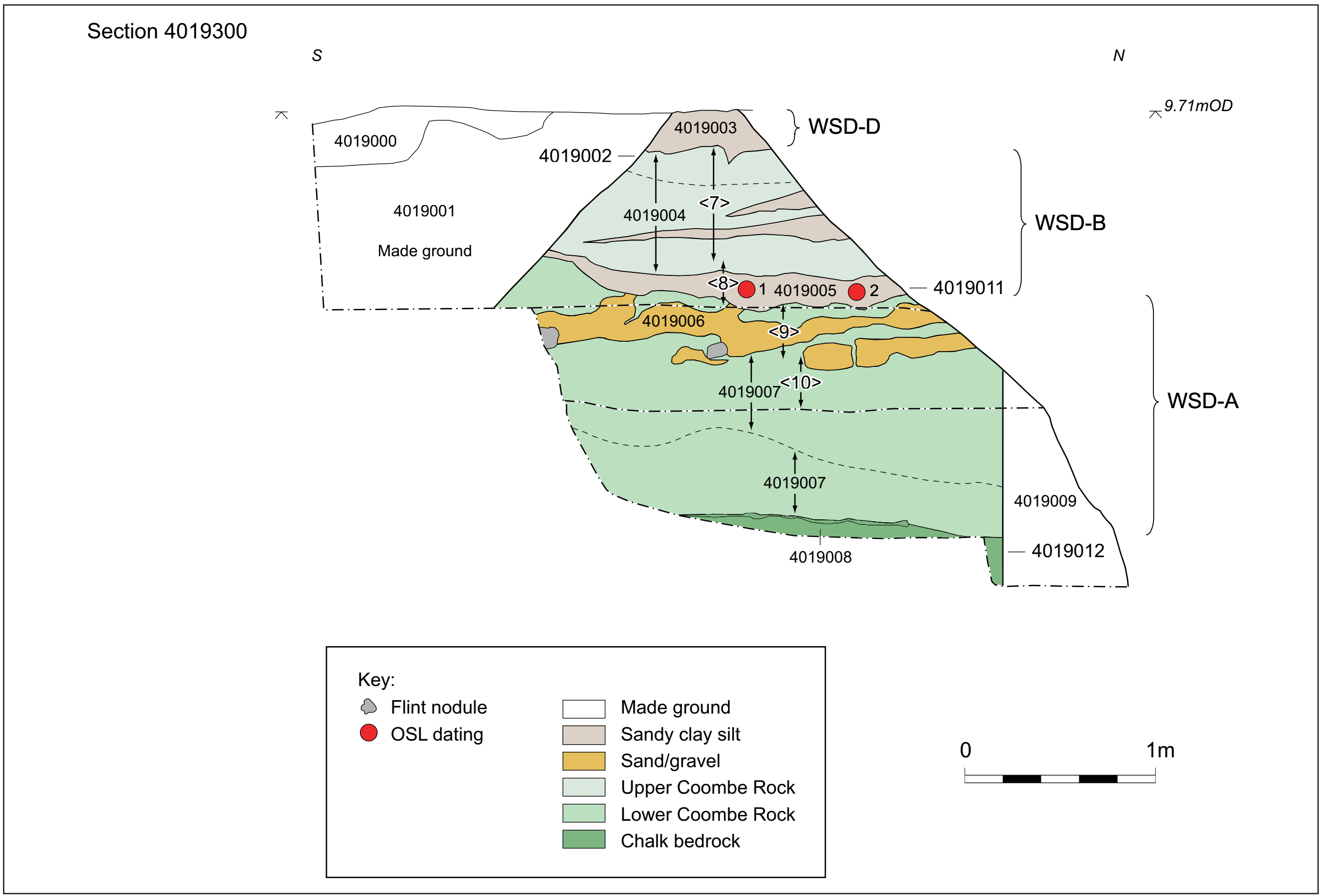


Figure 9.4 4019TT sequence and phasing: note OSL samples in sand/silt at base of upper Coombe Rock (phase WSD-B)

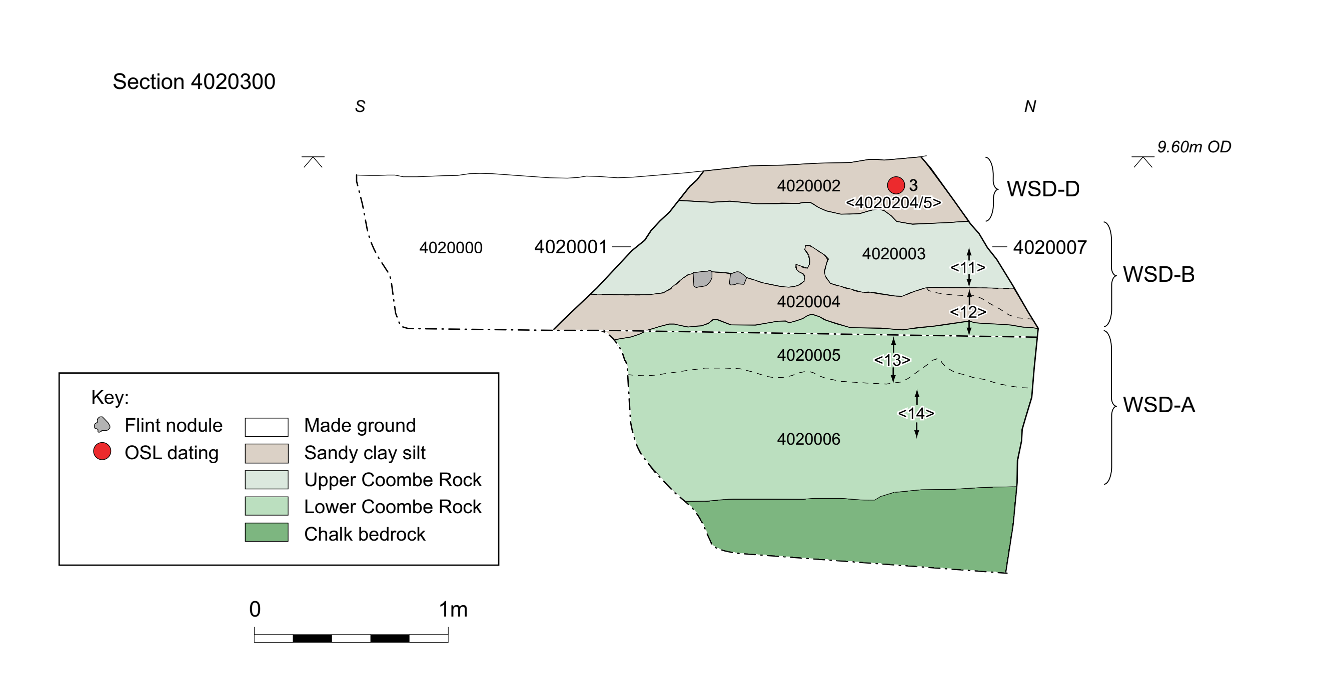


Figure 9.5 4020TT sequence and phasing: note OSL sample in brickearth at top of sequence (phase WSD-D)

WSD-B, Upper Coombe Rock: This deposit was generally very pale brown chalk silt, with common embedded flint and chalk pebbles, and some yellowish-brown sand/silt. As well as sand/gravel-filled channels, which were better developed further east within the exposed section, it contained sub-horizontal lenses of pale brownish-yellow silt and fine sand with fragments of comminuted Tertiary shell. These were increasingly well-developed towards the base of this phase of deposits, allowing OSL dating in 4019TT. No lithic artefacts were found in these deposits during the second phase of fieldwork, although some had previously been found in the initial evaluation phase (Chap 19). The upper part of this deposit was decalcified in places, giving it a strong brown colour, and a very similar appearance to the overlying strong brown sandy clay-silt of phase WSD-D (described below), although with more common flint pebbles.

WSD-C, Upper Coombe Rock: This deposit was identical to that described above as WSD-B, but occurred slightly lower down at the extreme west end of the Site D section, *c* 100–105m along the baseline, and stratigraphically discontinuous from the phase WSD-B sediment body.

WSD-D, Sandy clay-silt, "Brickearth": This phase of deposits capped the sequence, and consisted of a well-consolidated strong brown, sandy clay-silt, with occasional fine-medium flint pebbles. At the western end of the main illustrated section, where it overlay deposits of phase WSD-C, the deposits graded down with a diffuse junction into a basal parallel-bedded fine/very fine sand facies. The main, upper sandy clay-silt part of the deposit was sampled for OSL dating in stepped trench 4020TT (see dating, below).

Large Vertebrates

A mammoth tooth (SF 1097) was found during hand-excavation of test pit D.TP 1 (Fig 9.1), in a sand/gravel pocket within deposits of phase WSD-B, the Upper Coombe Rock. The tooth was poorly preserved, and was damaged by mattocking during the process of discovery. Nonetheless, it was identified as mammoth (*Mammuthus*), although due to incompleteness it cannot be ascertained whether it is woolly mammoth (*M. primigenius*) or 'Ilford type' mammoth (cf. *M. trogontherii*). (Lister, Appendix C3).

Dating

Three sediment samples were dated by OSL. Two were analysed from the relatively thick sand/silt bed (context 4019005) in 4019TT (Fig 9.4), at the basal junction of the Upper Coombe Rock (phase WSD-B) with the Lower Coombe Rock (phase WSD-A). One sample was analysed from the sandy clay-silt (phase WSD-D) capping the Coombe Rock sequence (Fig 9.5), on context 4020002 in 4020TT. The results (Table 9.2) gave a date of *c* 200,000 BP (towards the end of MIS 7) for the sand/silt bed at the base of the Upper Coombe Rock, and *c* 160,000 BP (in the middle of MIS 6) for the brickearth capping the sequence.

Site D and Trenches 4018TT, 4019TT and 4020TT Overview

The sediments of this zone (Fig 9.6) are the surviving remnants of what would once have been a major body of slopewash, solifluction and mass-movement deposits filling the lateral dry valley to the west of Southfleet Pit,

Table 9.2 OSL dating results from 4019TT and 4020TT

Zone	Project	Intervention	Phase	Context	Sample	Lab ID	Depth (m)	OSL date (KBP)	Error range (± KBP)
5	ARC EBB01	4020TT	WSD-D	4020002	4020204	X3010	0.7	160.70	15.50
5	ARC EBB01	4019TT	WSD-B	4019005	4019204	X3011	1.2	199.20	24.10
5	ARC EBB01	4019TT	WSD-B	4019005	4019206	X3012	1.20	199.60	16.79

heading down towards the centre of the Ebbsfleet Valley from the south-west. There seem to have been at least two major phases of chalk-rich solifluction represented. The lower phase has purer, whiter chalk diamict, but with coarser-grained, more sandy and gravelly channels/pockets. This phase of the sequence must reflect upslope denudation and reworking of chalk bedrock, taking place in conjunction with episodic run-off of substantial quantities of surface water bringing sand and gravel from pre-existing Ebbsfleet (or Thames) terrace deposits further up the dry valley. The trend up the sequence in the main Site D section (no. 40) for the sand/gravel channels at the base of the sequence to spread wider in section, and for those higher up to appear as more restricted crescent-shaped pockets, probably reflects changing orientation of channelling as the dry valley filled up.

At the base of the sequence, the clean white chalk diamict and the orientation of sand/gravel channels parallel with the axis of the dry valley probably reflects a more rapid build-up of sediments, and the influx of sediments down the valley from the south-west. Further up the sequence, the crescent-shaped sand/gravel pockets probably reflect channels running down the dry valley sides towards the central axis. Likewise, the different character of the Upper Coombe Rock, with much greater mixing of silt/sand and gravel with the chalk diamict, and more extensive sheets of silt and fine sand, probably reflects reworking of existing chalk diamict and the episodic accumulation of finer-grained sediment either by a combination of colluvial/aeolian processes, or perhaps by more gentle water flow in a flatter and more stable lateral valley. The finer-grained brickearth capping the sequence represents a much more sustained period of probably colluvial deposition, incorporating reworked Thanet Sand from the major bodies of this Palaeocene deposit a short distance to the west.

Both Coombe Rock layers produced lithic artefacts. The artefacts themselves are discussed subsequently (see Chap 19), together with a more detailed consideration of the degree of disturbance and mixing they might have undergone, but it is clear from this discussion of how these deposits formed that the artefacts have been subject to at least some reworking.

The OSL dating results are crucial in establishing both: (a) a *terminus ante quem* for the artefactual evidence from the Coombe Rock; and (b) the likely timescale over which the Coombe Rock sequence built up. The results suggest that the Upper Coombe Rock was in place before MIS 6, and probably accumulated towards the end of MIS 7; it is uncertain how much time is represented by: (a) the deposition of the Lower Coombe Rock; and (b) the transition between Lower

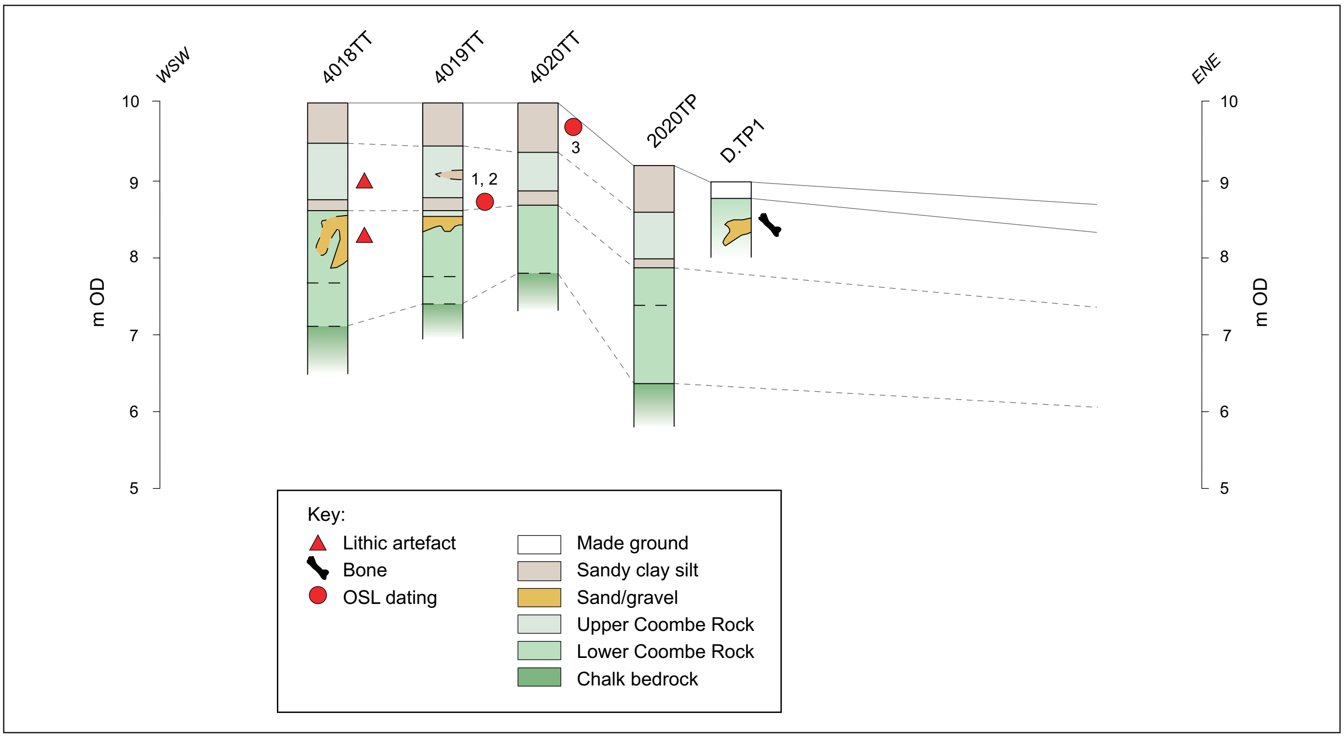


Figure 9.6 Site D, fence diagram of stepped trenches 4018TT, 4019TT and 4020TT

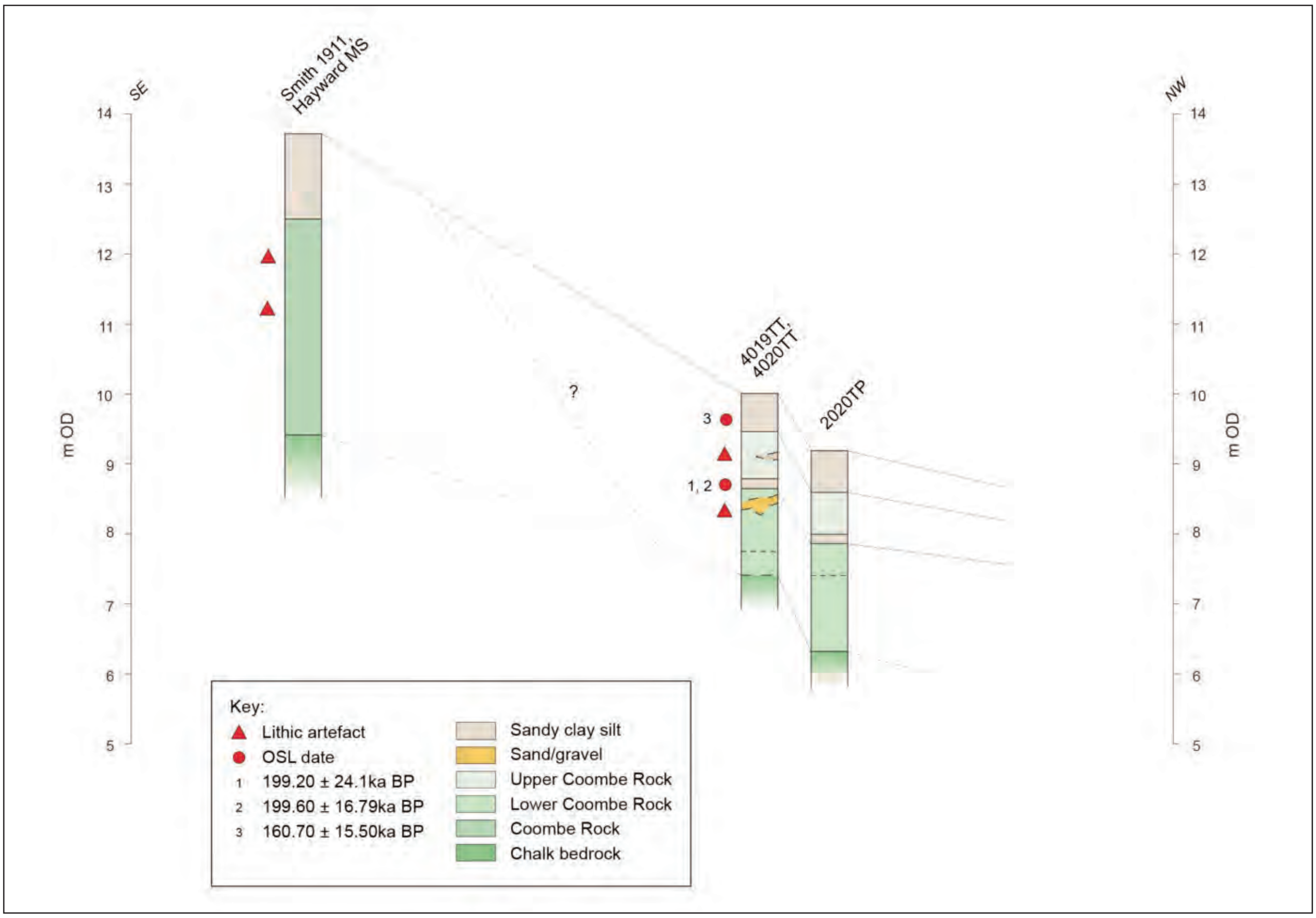


Figure 9.7 Zone 5, fence diagram of Site D sequence in relation to APCM Southfleet Pit Coombe Rock

and Upper phases of Coombe Rock deposition. The Lower Coombe Rock could represent, for instance, MIS 8 or an early cold sub-stage of MIS 7. These results therefore suggest that the contained archaeological evidence at Site D ante-dates MIS 6. Any implications for the much larger APCM flint collection from Coombe Rock at Southfleet Pit, *c* 50 m to the west (see Chap 17) depend upon how the Coombe Rock deposits at these two locations are correlated with each other; this is discussed below.

Zone 5 Synthesis

The important aspect of this zone is its proximity to, and possible stratigraphic relationship with, the Coombe Rock deposit from which a major Levalloisian lithic collection was recovered in *c* 1910 from the quarry known as "Baker's Hole" Smith (1911). The estimated location of Smith's Baker's Hole site – more properly called the Southfleet Pit (see Chap 2) – is shown (Fig 9.1) 50m to the south of the Chalk Spine, based on the information given in Smith's paper. This area corresponds with an expansion of the "north-west angle" of the footprint of Southfleet Pit into the chalk-rich solifluction deposits filling the dry valley to its north-west. When compared with the sequence from the Chalk Spine (Fig 9.7), it can be seen that the Coombe Rock at the edge of the Southfleet Pit occurred at a slightly higher level, as well as 50m away directly up the sloping sides of the dry valley. It is therefore questionable whether the Coombe Rock at the APCM site and either of the Coombe Rock deposits recognised at the Chalk Spine are directly equivalent, or whether there is an additional phase of downslope reworking, as shown in Figure 9.7. The implications of this are that, while we can be sure that the APCM lithic collection is no younger than MIS 7, there is little constraint on how much older it could be, making dates in early MIS 7 or MIS 8 equally likely, or perhaps even older.

It is also necessary to recognise that, while much of the APCM collection may be in fresh condition – and indeed it contains refitting items (Chap 17) – the suggested depositional process for its Coombe Rock context means that it is not necessarily a single assemblage of high integrity. The collection has probably not been transported a great distance, but there may have been mixing of material from chronologically separate phases of activity between MIS 9 and MIS 7 in the same geomorphological situation, on the chalk flanks of the dry valley. This locale may then have repeatedly been subject to similar slopewash/solifluction processes, which may then have led to mixing of lithic material from different periods within the same chalk-rich Coombe Rock deposit.

Chapter 10

South Embayment (Zone 6)

by Martin Bates, Francis Wenban-Smith, Richard I Macphail, Simon A Parfitt, Kirsty Penkman, Richard Preece, Jean-Luc Schwenninger, Tom S White and John E Whittaker

Introduction

This zone lies within the base of a former dry valley running from south to north into the modern Ebbsfleet and broadly corresponds to Palaeolithic DBA Area 6 (Fig 3.1). The southern boundary of the zone is marked by the northern edge of quarrying within the Jayflex remediation area (Fig 10.1). The eastern and western margins are defined by rising ground towards the former chalk spur (east) and a bedrock rise (west) (Fig 9.1).

Initial discoveries in this zone were made by Spurrell (1883, 1884) in the tramway cutting in which Levallois flakes and cores as well as the remains of mammoth ("of great size"), rhinoceros and deer bones. This highlighted the importance of the sequences in this zone and the fact that no quarrying had been undertaken identified it as an area of high potential.

Investigation of the area began during the ARC EFT97 works that included trenches 1021TT–1026TT. This was followed by the main evaluation phase in 2001 (ARC ESG00, URN 2001a) and included test pits 3803, 3805, 3808, 3829A and 3829B. This was followed by mitigation (ARC EBB01) including 3971TT, 3972TT and 4017TT. Finally, the main south-facing section on the north side of the Jayflex remediation area was recorded under the ARC 342W02 project. Key interventions and a summary of specialist studies and dating methods is given in Table 10.1.

In all cases the field investigations involved considerable excavation with machines for the excavation of a series of stepped trenches. The work in the Jayflex remediation area involved the cleaning of the major section across the north-eastern corner of the site.

3971TT (ARC EBB01)

Introduction

This trench was excavated over a length of *c* 90 m parallel with the main path of HS1 (Figs 10.1 and 10.2). Previous work during the ARC ESG00 works had resulted in the excavation of trench 3808TT, which lay at the northern end of 3971TT. The trench cut a gentle slope dipping to the north. Excavation of the trench was undertaken by mechanically digging stepped sections to allow access to the deeper levels of the deposits (Pl 10.1).

Lithological Succession

These deposits can be subdivided into 13 major groups of sediments (Table 10.2):

3971-A: This is represented by contexts 39710006 and 3971045 that consists of weathered Chalk, probably

Table 10.1 Zone 6 key interventions and range of specialist and dating studies

Project	Intervention/s	Soil micro-morph	Large vertebrates	Small vertebrates	Molluscs	Ostracods	Amino acid	OSL dating	Worked flint
ARC ESG 00	3805TT	–	–	–	–	–	–	–	X
	3808TT	–	–	–	–	–	–	–	X
	3829ATT	–	–	–	–	–	–	–	X
	3829BTT	–	–	–	–	–	–	–	X
ARC EBB 01	3971TT	X	–	–	–	–	–	X	X
	3972TT (west – tufa)	–	X	–	X	X	X – *Bithynia* X – *Pupilla*	X	X
	3972TT (south/central)	–	X	X	X	X	X – *Bithynia*	X	X
	4017TT (tufa)	–	–	–	X	X	X – *Pupilla*	–	–
ARC 342W02 (Jayflex)	Sec 50552	–	–	–	–	–	–	X	X
	Sec 50553	–	–	–	–	–	–	X	X
	General area	–	–	–	–	–	–	–	X

KEY: X – important evidence; x – minor presence

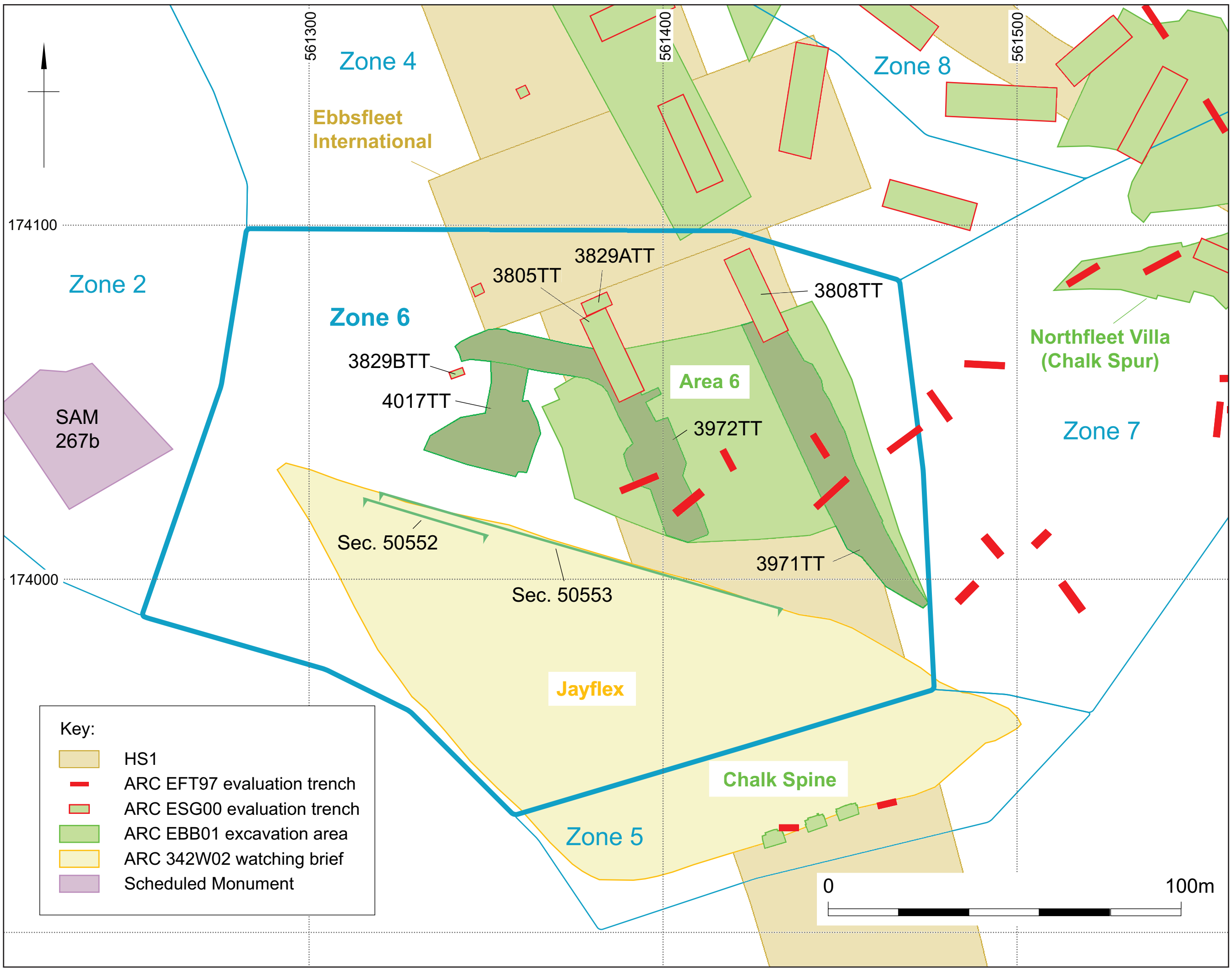


Figure 10.1 Zone 6 layout and key intervention locations

bedrock. This deposit only occurs intermittently at the base of the section.

3971-B: This is represented by contexts 3971023 (lower) and 3971040 consisting of chalk clasts (angular) and chalky silt matrix. This has been described as "Coombe Rock" (locally known as the Lower Coombe Rock) and is probably a cold stage solifluction deposit derived from higher upslope to the south. This deposit occurs as a sheet dipping downslope and tending to thin downslope.

3971-C: This is represented by contexts 3791005 and 3971023 upper consisting of chalk gravels, chalky silt matrix and small, very well-rounded flint clasts. This deposit is similar in distribution to 3971-B dipping downslope and is of variable thickness. The sequence is a local "Coombe Rock" sequence of cold stage slope deposits derived from the south. Locally this has been described as Upper Coombe Rock.

3971-D: Two contexts are assigned to this group (3971083, 3971095) consisting of shelly gravels with sand beds or patches. These appear to infill channel-like features excavated into the underlying chalky sediments of both 3971-B and 3971-C. The sediments infilling these features appear to have been deposited by fluvial action, perhaps resulting from localised erosion and transport of older deposits preserved to the south-west.

3971-E: A single context (3971081) consisting of fine to medium flint gravel clasts occurs as a sheet-like deposit distributed across the lower parts of the trench sealing the channel fill sequences of 3971-D and elements of the older solifluction deposits. This may represent a sheet of gravel deposited down the sides of the valley and in its base under cool climate conditions.

3971-F: A single context (3971039) exists as a sheet of poorly-sorted flint gravel and sand distributed across much of the upper parts of the Upper Coombe Rock (3971-C) and overlaps slightly with the gravel sheet 3971-E. This deposit probably represents deposition by slope wash under cool conditions where erosion of sediments from higher up the slope are providing source material for this body of gravel. Some degree of removal of finer grained material plus possible decalcification under post-depositional conditions may have altered this unit.

3971-G: This deposit (context 3971082) occurs as a thin sheet of medium to coarse sand resting on the middle

Table 10.2 Stratigraphic sequence, phasing and distribution of specialist and dating evidence, 3971TT

Phase	Contexts	Lithology	Lithic artefacts	Palaeoenvironmental data	Dating
3971-K	3971092, 3971093	(cuts and fills of late Holocene activity)	–	–	–
3971-J	3971094, 3971098, 3971099, 3971100, 3971101	(cuts and fills of late Holocene quarrying activity)	–	–	–
3971-I	Remainder	(cuts and fills of late Holocene archaeological features)	–	–	–
3971-H	3971038	Sandy clay-silt with occasional small flint pebbles and chalk flecks	–	Soil micromorphology	–
3971-G	3971082	Parallel bedded sands and silty-sands	–	Soil micromorphology	✓ OSL
3971-F	3971039	Gravelly sand	–	–	–
3971-E	3971081	Silty-sandy flint gravel	–	–	✓ OSL
3971-D	3971083, 3971095	Poorly sorted coarse sandy flint gravel with Tertiary shell fragments and flint nodules	–	–	✓ OSL
3971-C	3971005, 3971023 (upper)	Sub-rounded to sub-angular chalk gravel in chalky silt matrix mixed with silt, sand and flint pebbles	Core SF 30900 Debitage SF 30903 Debitage SF 30904	–	✓ OSL
3971-B	3971023 (lower), 3971040	Sub-angular chalk rubble with chalky silt matrix	–	–	–
3971-A	3971006, 3971045	Chalk bedrock	–	–	–

parts of the slope in the central areas of the section. Slopewash processes are likely to have accounted for its deposition.

3971-H: A single deposit (3971038) consists of dark reddish-brown clay-silt with occasional burnt flint fragments. This deposit caps much of the underlying sequences and forms a sheet dipping downslope and is only interrupted by occasional areas of likely erosion. This layer appears to be a buried soil developed upon the underlying periglacial sediments.

3971-I: This phase contains a complex of units consisting of contexts (3971084, 3971087, 3971088, 3971089, 3971090, 3971072, 3971016, 3971091, 3971026, and 3971095). These sediments consist of variable coloured clay-silts. Two features of particular importance exist at the base of these deposits. A ditch (3971072) and a cut for a sunken building (3971016) dated to the Anglo-Saxon period (see Andrews *et al* 2011a) both cut into the underlying buried soil. The majority of the sediments in this group are considered to be colluvial in origin.

3971-J: Sediments related to contexts 3971094, 3971098, 3971099, 3971100 and 3971101 all infill a pit cutting of late 19th- or early 20th-century date.

3971-K: Two contexts are associated with post-medieval ditches and hedge lines (3971092, 3971093).

3971-L: This context is associated with the modern topsoil (3971036).

3971-M: These contexts are all associated with recent made ground (3971001, 3971002, 3971003, 3971096, 3971097, 3971102, 3971103).

Sediment Micromorphology

Micromorphological investigation was undertaken on slides prepared from two monoliths (31122 and 31132) taken from this trench. Details of the observations made are presented in Appendix B.

Plate 10.1 Excavation of 3971TT

Context 3971038 (3971-H): This is a moderately heterogeneous, burrow-mixed fine silt loamy sand-sandy loam, with a hierarchy of textural pedofeatures. These are, 1) mainly moderately limpid clay grain, with

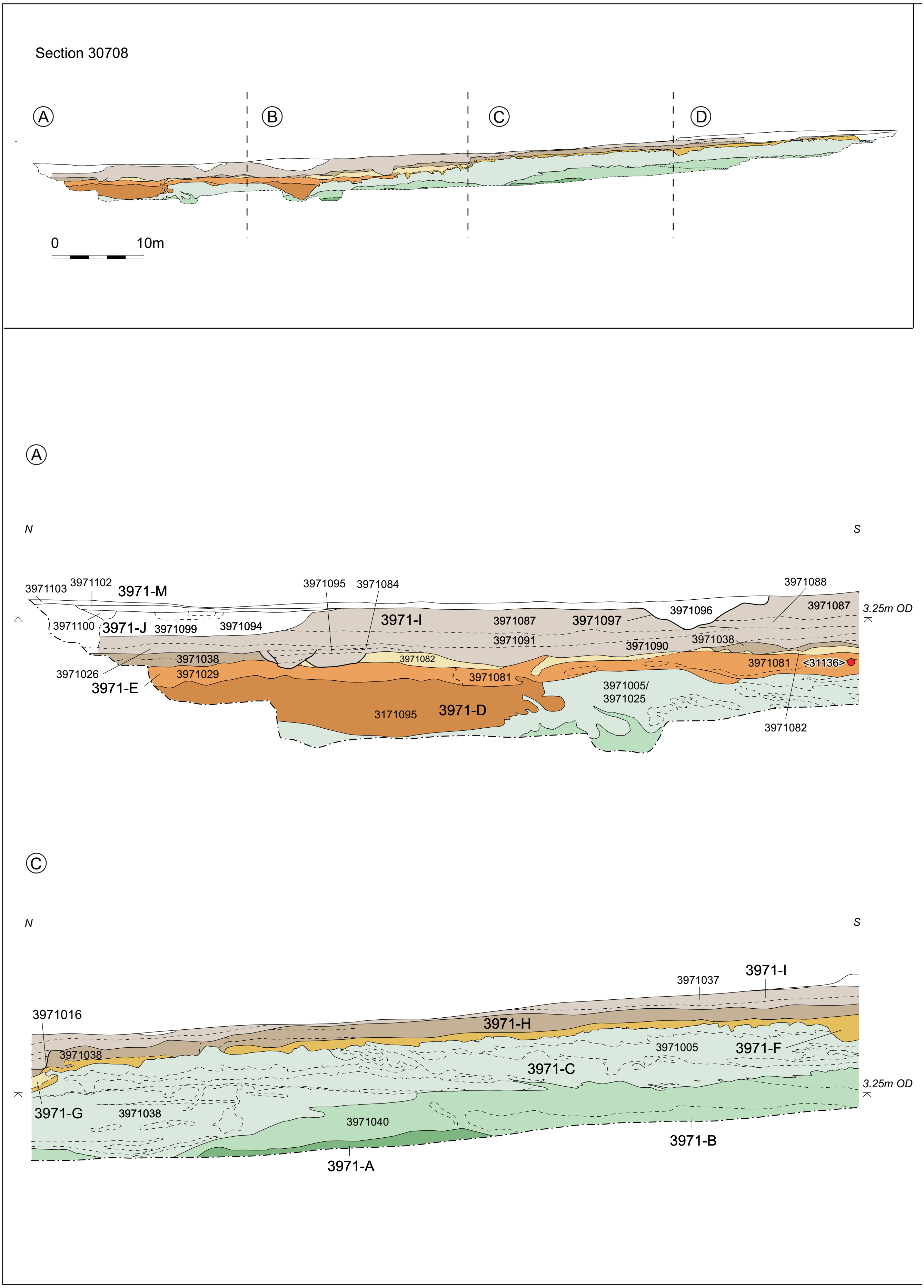
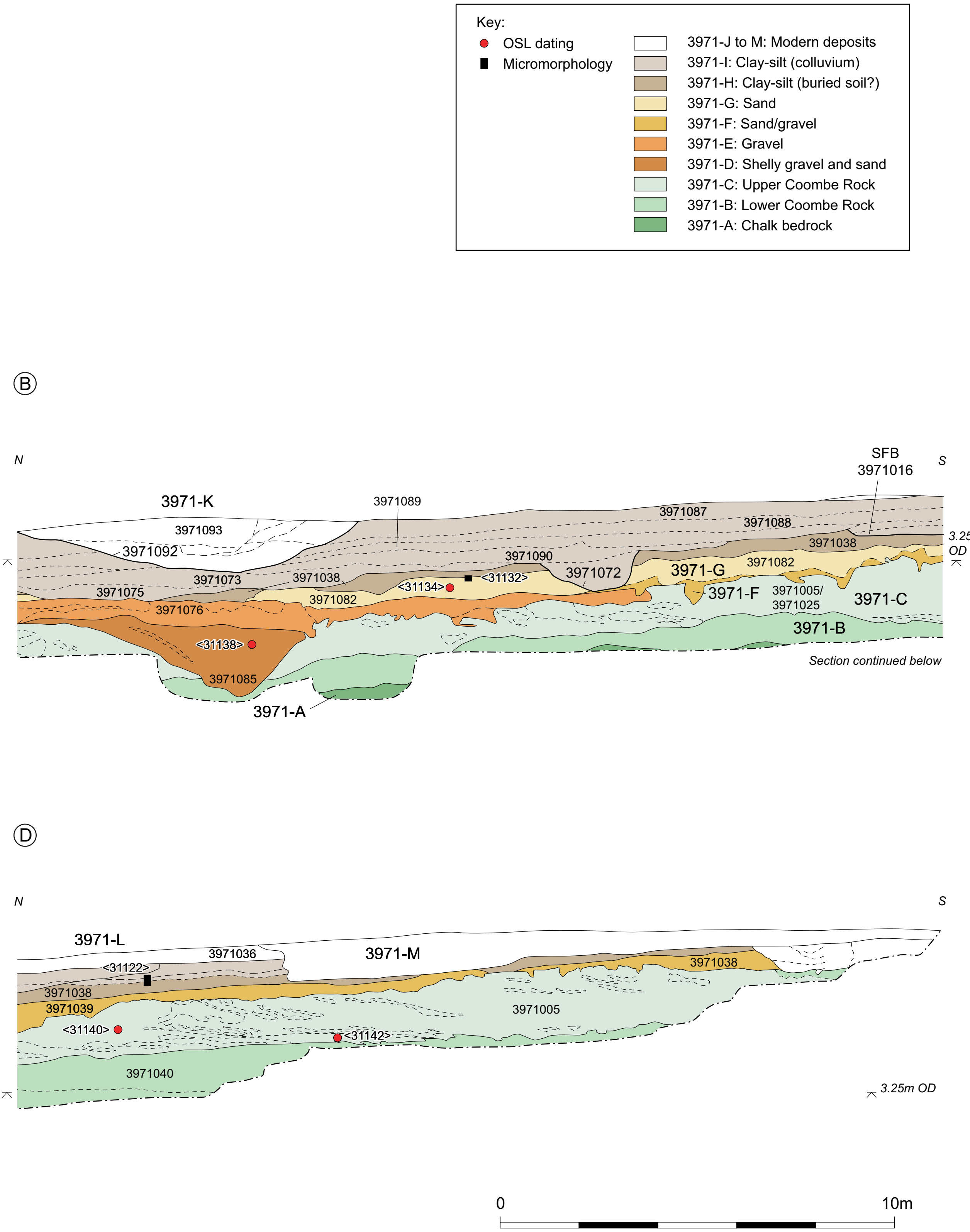


Figure 10.2 3971TT, south-west-facing section 30708 (see Fig 10.5 for location)



Key:
OSL dating
Micromorphology
3971-J to M: Modern deposits
3971-I: Clay-silt (colluvium)
3971-H: Clay-silt (buried soil?)
3971-G: Sand
3971-F: Sand/gravel
3971-E: Gravel
3971-D: Shelly gravel and sand
3971-C: Upper Coombe Rock
3971-B: Lower Coombe Rock
3971-A: Chalk bedrock
B
N
S
SFB
3971016
3971-K
3971089
3971093
3971092
3971087
3971088
3971038
3.25m
OD
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3971-C
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3971-A
D
N
S
3971-L
3971036
3971-M
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3971039
3971005
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3.25m OD
0
10m

Table 10.3 OSL dating results from 3971TT (* poorly constrained result)

Phase	Context	Sample	Lab ID	Depth (m)	OSL date (KBP)	Error range (± KBP)
3971-G	3971082	31134	X893	1.80	18.75	1.39
3971-E	3971081	31136	X895	2.5	25.19	2.20
3971-D	3971083	31138	X897	3.30	24.44	1.74
3971-C	3971005	31142	X901	2.45	*[39.69]**	*10.21*
3971-C	3971005	31140	X899	1.90	29.80	1.80

void coatings within more coarse loamy fine sand (Appendix B: Fig B1, 18); 2) micro-laminated and often dark reddish and iron-stained void clay coatings and infills (Appendix B: Fig B1, 19–20) mainly within burrowed, once-relatively humic, areas; and 3) dusty clay void coatings associated with fine root channels throughout. In addition, there are traces of fine charcoal, rare patches of amorphous organic matter in burrows, rare traces of ferruginised roots, and two channels have gypsum infillings.

There appears to be a junction between an argillic Bt horizon (phase 1) formed in decalcified sandy loam (Appendix B, Fig B1, 19) and overlying sandy loam soil formed by the burrowing of probable earthworms and larger invertebrates, which is relatively more humic, contains rare fragments of amorphous organic matter and is characterised by micro-laminated and often dark reddish and iron-stained clay void coatings and infills (Appendix B, Fig B1, 20) (Btg horizon – phase 2). The formation of a Bt horizon is a slow process and takes millennia (Duchaufour 1982, fig 4.2), with ensuing formation of a gleyic argillic brown earth soil (with 'ferri-argillans', Appendix B, Fig B1, 20) as the soil continues to weather (Bullock 1974; see also review in Duchaufour 1982, 291). The dusty clay void coatings in extant root channels can probably be associated with later plough soil formation and colluviation) – some of which may be relatively recent and associated with relict roots and gypsum (see M31132). This soil records a stable landscape on which an argillic brown soil developed under woodland.

M31132, contexts 3971038 and 3971082: Thin section M31132 records a homogeneous, moderately poorly-sorted fine sandy coarse silt loam, with coarse vertical root channels (with abundant thin organo-mineral excrements) and very abundant broad (2mm) burrowed microfabric. The matrix contains rare traces of coarse charcoal, burned flint, strongly burned slag-like soil material and very fine charcoal in the matrix (Appendix B, Fig B1, 21–4). Very abundant dusty clay and microlaminated dusty clay void coatings and a 4mm long microlaminated micropan is present as part of a possible curved junction between 3971038 and 3971082 at 40mm. This thin section has sampled a typical ploughsoil colluvium formed from decalcified brickearth ('loess') which includes trace amounts of burned anthropogenic inclusions, very fine charcoal and very abundant evidence of plough disturbance and colluviation, ie, very abundant dusty clay textural pedofeatures (Jongerius 1970; 1983; Kwaad and Mücher 1979; Macphail 1992). A typical Devensian decalcified soil formed from the same basic 'brickearth' parent material is present in M54, contexts 1962–1964. A micropan and possible curved junction between 3971038 and 3971082 may represent relict and ephemeral ploughed surface/plough pan.

Dating

Five OSL dates have been obtained from the sediments within the trench (Table 10.3). These dates correspond with stratigraphic order and indicate formation of the phase C (Coombe Rock) deposits prior to the Last Glacial Maximum within the later part of MIS 3. A phase of erosion associated with the phase D/E sediments then occurs at around the MIS 3/2 transition. Finally, deposition of phase G is associated with the Last Glacial Maximum.

3971TT Overview

The evidence obtained from the excavations and analysis of the material from the sequence suggests that a history of slope processes and solifluction dominate within this trench, interspersed with localised channelling and fluvial sedimentation at the lower, northern end. OSL dating of the sediments to the MIS 3/2 transition and Last Glacial Maximum are in agreement with a phase of major landscape instability and transfer downslope of sediment. The ascription of the deposition of the sediment to such a late stage in the Pleistocene is interesting in terms of the development of the decalcified soil identified in the section.

3972TT (ARC EBB01)

Introduction

This trench was excavated over a length of nearly 60m where the southern end of the trench was parallel with HS1 while the northern end swung westwards towards the SAM 267b (Fig 10.1). Previous work during the ARC ESG00 works had resulted in the excavation of trench 3805TT, which intersected 3972TT within the central part of the trench.

Excavation of the trench was undertaken by machine cutting a series of stepped sections to allow access to the deeper levels of the trench (Pl 10.2). A detailed section drawing of the main north/north-east-facing profile is

Plate 10.2 Excavation of 3972TT

reproduced (Fig 10.3), and detail of part of the opposite south-west-facing section in the southern end of the trench is also shown (Fig 10.4).

Lithological Succession

These deposits can be subdivided into 13 main phases (Table 10.4; Pls 10.3–5), all lying between 4m OD and greater than -2m OD (at maximum depth):

3972-A: This phase is represented by a single context (3972050) at the north-western end of the trench. The sediment consists of white, angular chalk rubble that probably consists of shattered bedrock and some mobilised shattered bedrock.

3972-B: Two contexts (3972033, 3972052) are assigned to this phase and this sediment overlies that of 3972-A below. The sediment consists of a pale brown chalky gravel with well rounded chalk clasts in a chalky silt matrix. Locally patches of sand and small gravel filled channels also exist. This sediment probably represents soliflucted chalk derived from upslope mixed with small channels filled with flint gravel and sand deposited by water moving across the surface of the solifluction deposits. It is thought therefore to reflect periglacial conditions.

3972-C: Two contexts (3972041, 3972042) are assigned to this phase that also overlie groups 3972-A and 3972-B. The sediments in this phase consist of occasionally bedded, fine sandy to clayey silts with occasional seams of gravel. The upper parts 3972042 may exhibit features associated with weathering including networks of fine root channels. The origin of these sediments is difficult to ascertain but a possible colluvial origin is suggested from their parallel bedding dipping shallowly downslope and their contained molluscan fauna (discussed below).

3972-D: Sediment belonging to this phase (context 3972043) consists of fine carbonate-rich silt (micritic tufa) with some mottling in places (Pl 10.3). These silts cap 3972-A to C. The sediments appear to have been deposited on the surface of the underlying (possibly weathered) silts as part of a general process of conformable sequence accretion. The carbonate-rich nature of the sediments suggests possible deposition as a precipitate, perhaps within a spring or shallow pond-like feature.

3972-E: Sediments assigned to this phase (contexts 3972020, 3972028) have been noted at the base of the deep sondages cut into the base of the trench. These sediments consist of chalk debris within chalky silt matrix and occasional flint clasts. They are considered to be chalky solifluction deposits formed under cold climate conditions. There is no direct litho-stratigraphic relationship between these solifluction deposits and those of 3972-B.

3972-F: This phase consists of fine to coarse flint gravels with a sandy clay-silt matrix (contexts 3972031, 3972027, 3972019). The deposits exhibit sub-horizontal bedding with iron staining and beds with some chalk gravel clasts. These deposits appear to form a sheet of gravel (mainly traced through the deeper sondages excavated at intervals along the trench) some 1.5m in thickness and of broadly horizontal appearance. This deposit does however thicken slightly to the south

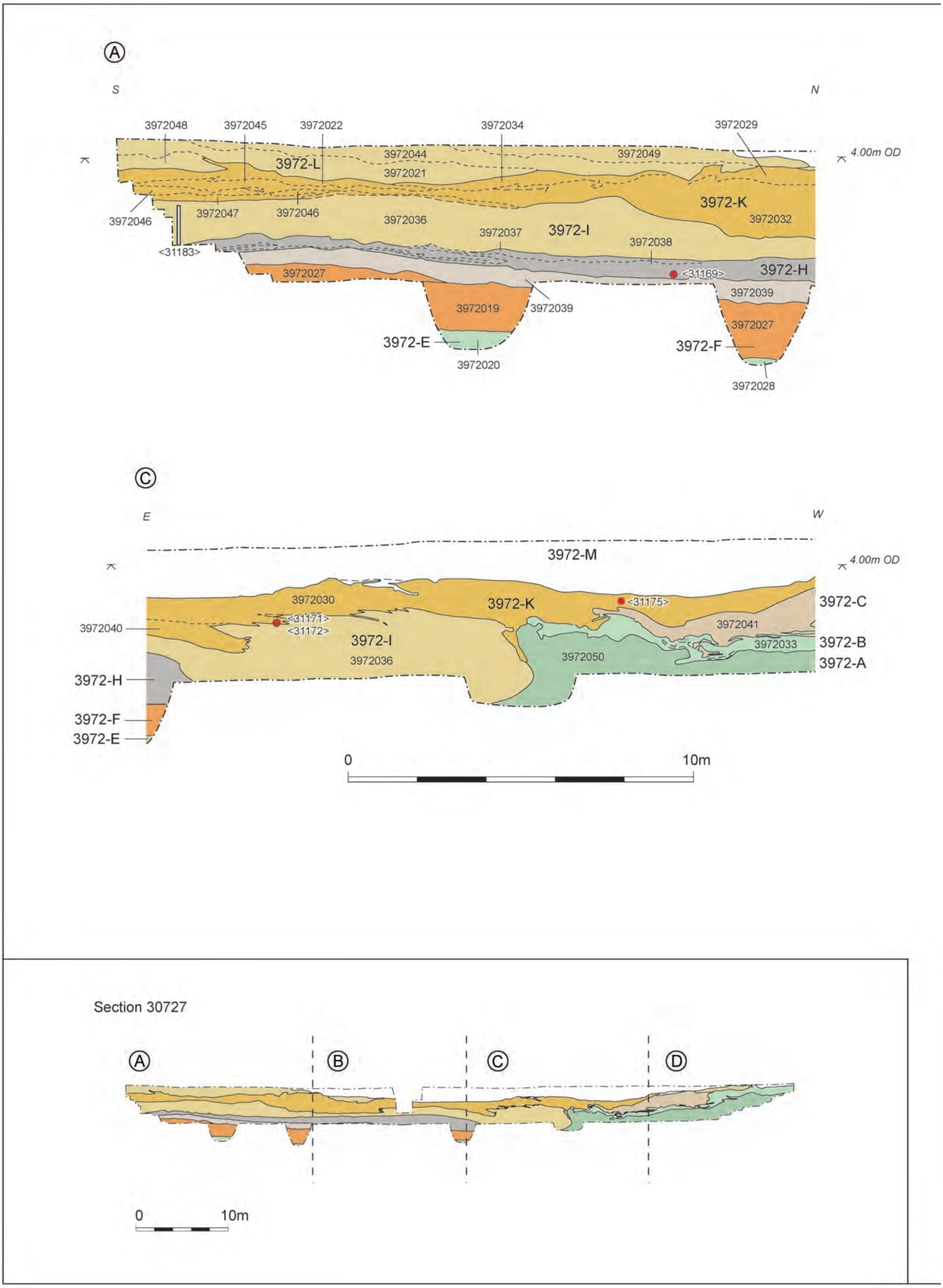
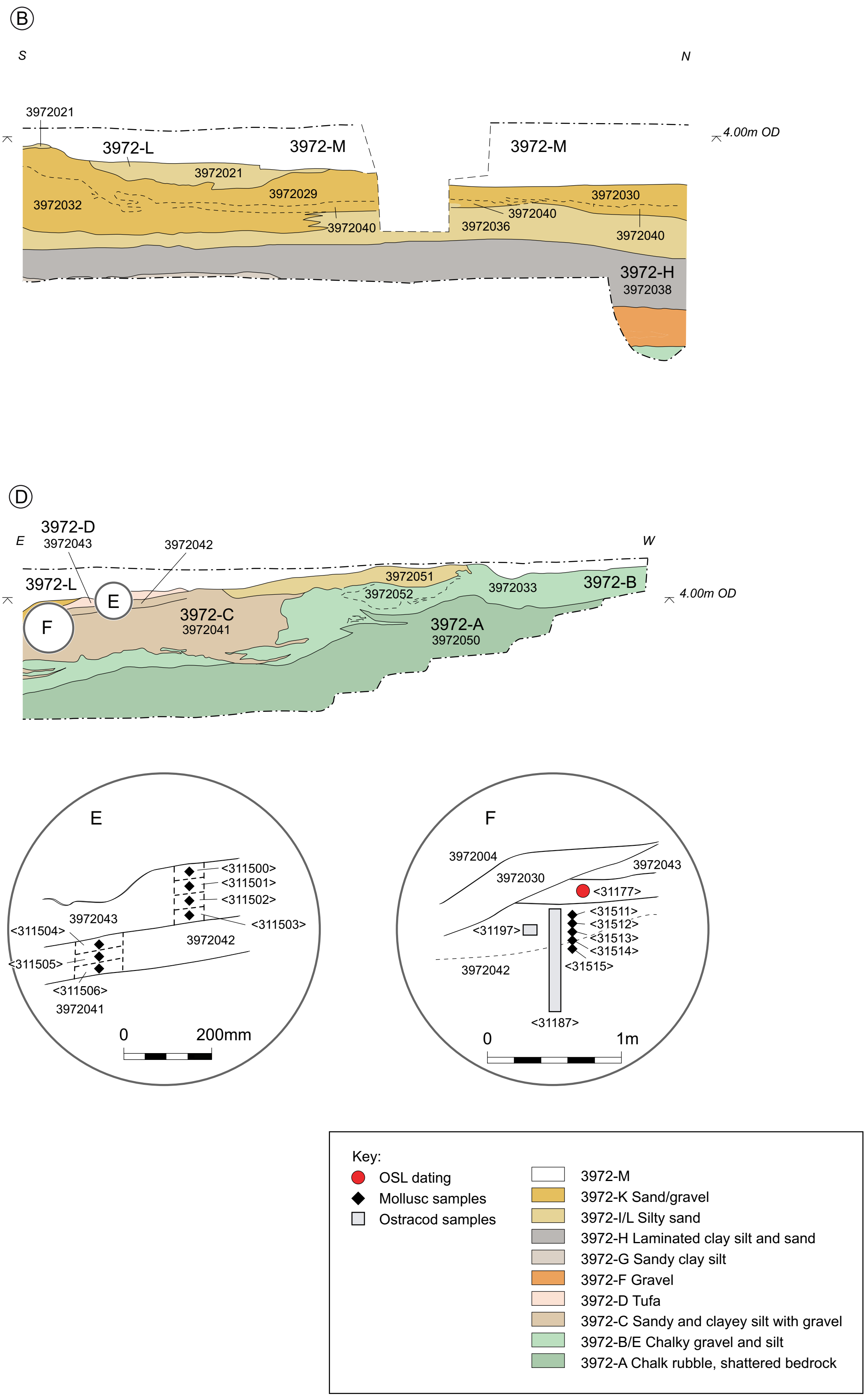


Figure 10.3 3972TT, north/north-east-facing section 30727 (see Fig 10.5 for location)


B
S
N
3972021
3972-L
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0
1m
Key:
OSL dating
Mollusc samples
Ostracod samples
3972-M
3972-K Sand/gravel
3972-I/L Silty sand
3972-H Laminated clay silt and sand
3972-G Sandy clay silt
3972-F Gravel
3972-D Tufa
3972-C Sandy and clayey silt with gravel
3972-B/E Chalky gravel and silt
3972-A Chalk rubble, shattered bedrock

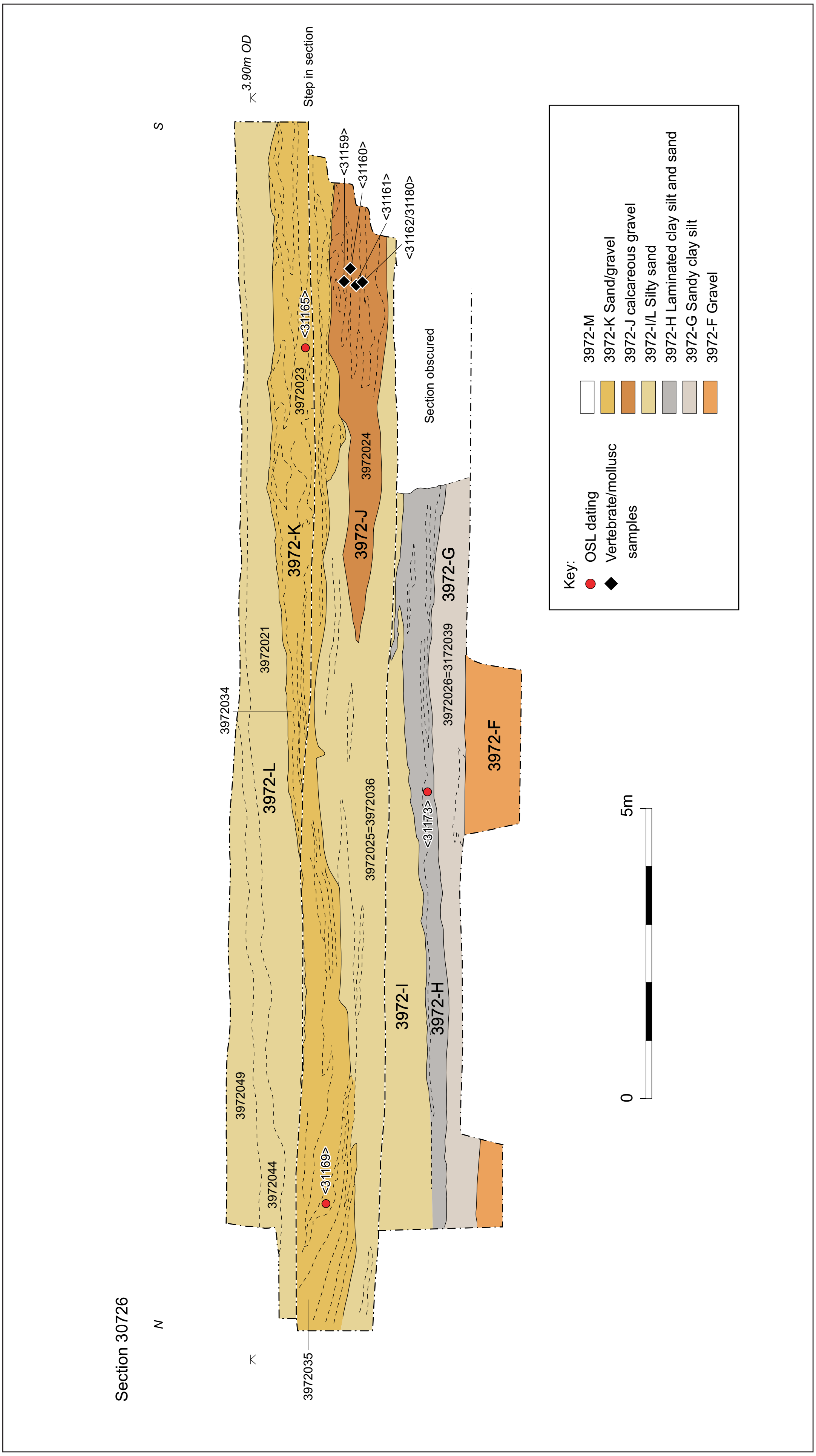


Figure 10.4 3972TT, south-west-facing section 30726 (see Fig 10.5 for location)

Table 10.4 Stratigraphic phasing and distribution of specialist and dating evidence, 3972TT (* poorly constrained date)

Phase	Context	Lithology	Lithic artefacts	Palaeoenvironmental data	OSL date (KBP)
3972-M		Modern deposits related to 19th-century quarrying	–	–	–
3972-L	3972021, 3972044, 3972047, 3972048, 3972049, 3972051	Silty sand	–	–	–
3972-K	3972022, 3972023, 3972029, 3972030, 3972032, 3972034, 3972035, 3972040, 3972045, 3972046, 3972052	Gravelly sand and flint/chalk gravel sheets	3 debitage 1 Levallois flake	–	17.99±2.69 26.20±1.69 38.97±4.59 46.05±2.41
3972-J	3972024	Calcareous sandy flint gravel with sand/silt beds	–	Molluscs, vertebrates	–
3972-I	3972025 (higher), 3972036	Slightly sandy-silt with occasional patches of remnant clay laminations and flint gravel trails	–	–	–
3972-H	3972025 (lower), 3972037, 3972038	Finely-laminated fine sands and clay-silts	–	–	118.83±7.08 130.10±8.80
3972-G	3972026, 3972039	Structureless brownish-grey clay-silt	–	–	–
3972-F	3972031, 3972027, 3982019,	Sandy, clay-silty flint gravel with common Tertiary shell fragments	–	–	–
3972-E	3972020, 3972028	Chalk gravel with flint pebbles in chalky silt matrix	–	–	–
3972-D	3972043	Carbonate-rich silt (micritic tufa)	1 debitage	Molluscs, ostracods	–
3972-C	3972041, 3972042	Parallel-bedded sand/silt		Molluscs	*52.00±4.64**
3972-B	3972033, 3972052	Chalk gravel with flint pebbles in chalky silt matrix with seams of silty sand	1 core	–	–
3972-A	3972050	Chalk rubble and flint nodules with chalky silt matrix	–	–	–

Plate 10.3 3972-D (tufa)

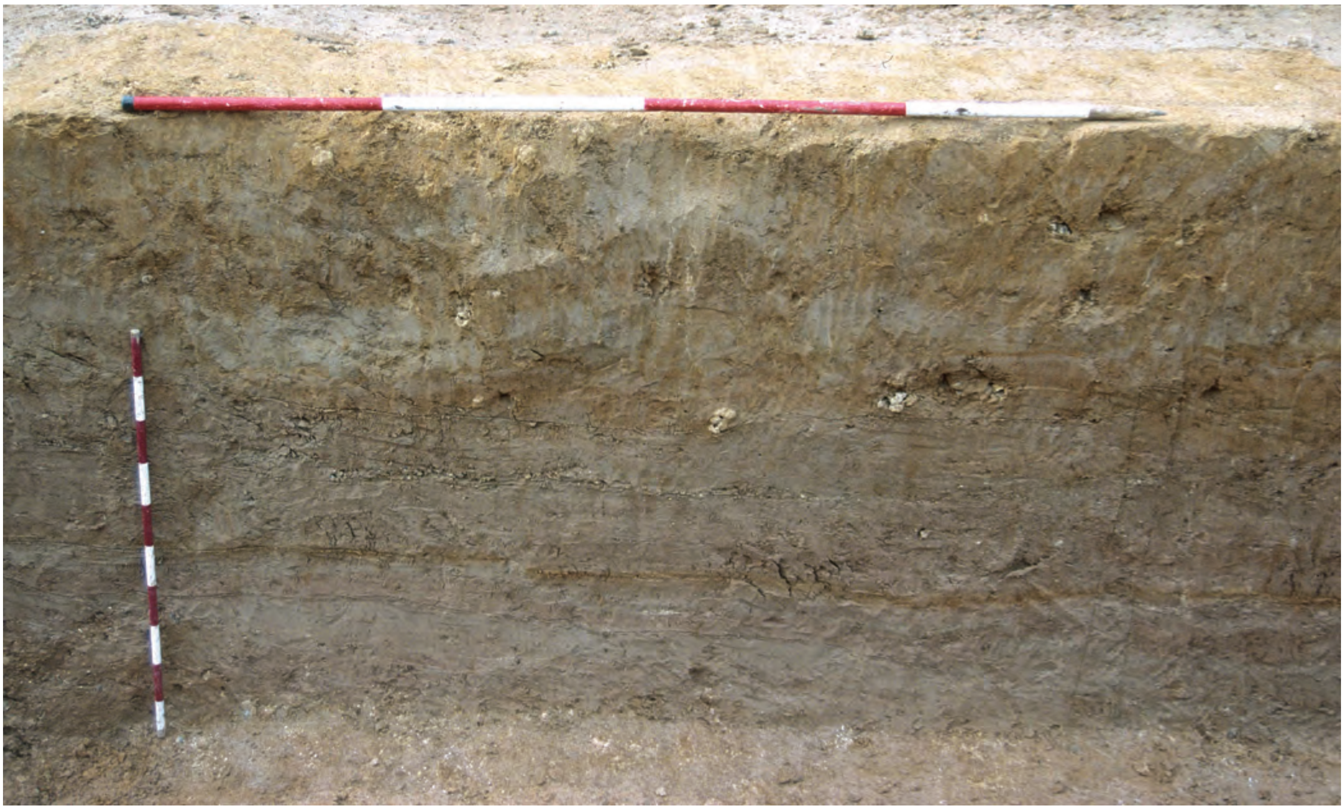


Plate 10.4 3972-E to I (lower sequence showing laminated clays/silts over gravel)

where the upper surface of the gravels rise slightly. The base of this gravel sheet lies at around -2m OD. These gravels appear to be fluvial gravels deposited in a high-energy environment during cold climate conditions.

3972-G: These contexts (3972026, 3972039) consist of brownish-grey sandy clay-silts with occasional carbonate nodules and locally evidence of sub-horizontal laminations 0.10–0.20m thick. Evidence of rooting disrupting the primary sedimentation is also noticeable in places. The sediment is about 1m thick and forms a sheet in the southern part of the trench disappearing towards the middle of the trench. The nature of the remnant bedding suggests possible deposition in wetland situations. Bioturbation (rooting) is noted perhaps associated with the operation of contemporary flora and fauna during sequence accumulation, weathering and associated pedogenesis is also attested to by the presence of the carbonate nodules.

3972-H: These deposits (contexts 3972025 (lower), 3972037, 3972038) consist of finely laminated clay-silts and sand with laminae 2–3mm thick. In places, local traces of cross-bedding were noted. Occasional gravel seams were noted in places. The deposit is up to 1.5m thick in places and is continuous across much of the trench only disappearing towards the northern part of the trench. The upper boundary of this unit is diffuse and difficult to see in places, the lower boundary is clearly defined and lies between -0.5m and -1m OD. These sediments appear to have been deposited under conditions of repetitive sedimentation of the type commonly associated with saltmarsh or tidal/inter-tidal conditions.

3972-I: These deposits (contexts 3972025 (higher), 3972036) consist of silty fine sands with remnant bedding as well as patches of carbonate material and thin trails of flint gravel. The basal contact with the underlying sequence (3972-H) is difficult to define in places and it is likely that continuity in sedimentary process occurred across this junction. The upper surface of this body of sediments exceeds +2m OD in places. Possible changes in sedimentary regime may be indicated by the presence of carbonate nodules implying exposure to weathering and possible pedogenic processes while the presence of gravel bands may suggest local higher energy activity perhaps with small streams introducing fluvial sediments. The possibility that this unit represents a shift from estuarine back to floodplain conditions with associated soil forming processes needs to be considered.

3972-J: This context (3972024) only exists in the southern part of the trench on the eastern section (Pl 10.5). The sediment consists of poorly-sorted flint gravels in a calcareous clay-silt matrix with Pleistocene molluscs and small vertebrate remains. Clear stratification exists within the central part of this body of sediments disappearing towards the north. The distribution and nature of this body of sediments indicates a channel like form that appears to be developed within the 3972-I sequence. The sediments within the channel were probably laid down by moderately high-energy fluvial processes.

Plate 10.5 3972-J (calcareous channel fill)

3972-K: This body of sediment consists of a complex of contexts (3972022, 3972023, 3972029, 3972030, 3972032, 3972034, 3972035, 3972040, 3972045, 3972046, 3972052). The sediments consist of beds of chalk and flint gravel, typically poorly sorted and discontinuous with patches of sand or sandy silt in places. The deposits form a series of sheets appearing to rest on an erosional surface cut into the underlying sediments. The deposits of this phase overlie 3972-I as well as elements of 3972-C and D. They probably represent solifluction deposits laid down under cold conditions, possibly reflecting a series of cold climate events.

3972-L: These deposits (contexts 3972021, 3972044, 3972047, 3972048, 3972049, 3972051) consist of clayey silty-sands varying in colour from grey to reddish-brown. They occur as a series of sheets or lenticular beds mantling the underlying sediments. These appear to be of colluvial origin. It is possible that they are of various ages, from later Pleistocene through to Holocene.

3972-M: These deposits consist of modern made ground.

The body of sediments preserved in this trench are complex and diverse in character; despite the length of the trench, the correlation between different groups of sediments remains problematic in some areas. Basal chalky solifluction deposits are present at the west end of the trench (3972-E) and in its central part (3972-A/B). It is unclear whether these two sets of deposits are contemporary. Within the northern part of the trench a group of sediments consisting of 3972-B, 3972-C and 3972-D appear to form a conformable sequence associated with slope colluvial sediments accreting on the valley margin. The upper part of this sequence (3972-D) may be associated with sedimentation by springs onto a stable, weathered landsurface.

The second group of stratigraphically related sediments consists of 3972-F to 3972-I. These exhibit a sequence of sediments associated with fluvial gravel deposition (3972-F) giving way to lower energy fluvial sedimentation in a wetland context (3972-G). Development of possible estuarine conditions (3972-H) followed before a return to fluvial conditions associated with 3972-I and 3972-J. On the basis of this interpretation this sequence may document the changes associated with changing interglacial conditions associated with sea-level rise into the Ebbsfleet and the subsequent fall towards the end of the interglacial.

Finally, a return to cold climate conditions resulted in the deposition of sheets of soliflucted gravel (3972-K). This is overlain by colluvium much of which may be Holocene in age.

It remains difficult to determine the relationship between the two groups of sediments (3972-A to 3972-D and 3972-E to 3972-I) because of the nature of the contact between them (ie, where 3972-I butts against 3972-A). Both sets of sediments lie beneath 3972-K and therefore predate this solifluction event, however it remains to be demonstrated the precise nature of the relationship between the main interglacial sequence and that culminating in the deposition of the 3972-D sequence.

Table 10.5 Molluscs from 3972TT, phase 3972-C/D

Phase	3972-C								3972-D			
Context	3972041 (upper)	3972042 (lower)				3972042 (upper)			3972043 Tufa			
Sample	31515	31514	31513	31512	31511	31506	31505	31504	31503	31502	31501	31500
Aquatic												
Valvata cristata	–	–	–	–	1	–	–	2	–	–	–	–
Valvata piscinalis	–	–	2	–	–	–	–	–	–	–	1	–
Bithynia tentaculata	–	1	2	6	2	3	1	1	–	1	–	–
Bithynia tentaculata opercula	–	1	1	1	1	2	1	3	1	–	–	–
Galba truncatula	–	25	56	47	23	27	26	37	30	33	41	81
Radix balthica	–	6	4	19	8	5	5	5	4	4	8	5
Stagnicola palustris agg.	–	–	1	–	–	–	1	–	–	–	–	–
Physa fontinalis	–	–	1	–	–	–	–	–	–	–	–	–
Planorbis planorbis	–	–	–	1	–	–	–	1	–	–	–	–
Planorbidae undet.	–	–	–	–	1	–	–	–	–	–	–	–
Anisus leucostoma	–	5	3	13	9	6	4	14	10	14	14	27
Hippeutis complanatus	–	–	1	–	–	–	–	–	–	–	–	–
Gyraulus sp.	–	2	–	–	–	–	–	–	–	–	–	1
Musculium lacustre	–	–	–	–	–	1	–	–	–	–	–	–
Pisidium henslowanum	–	1	–	–	–	–	–	–	–	–	1	1
Pisidium moitessierianum	–	–	–	–	–	–	–	–	–	–	1	–
Pisidium spp.	–	–	–	1	–	–	–	–	–	–	–	1
Total Aquatic	**0**	**41**	**71**	**88**	**45**	**44**	**38**	**63**	**45**	**52**	**66**	**116**
Land												
Succineidae	–	–	–	1	–	–	1	1	1	–	–	1
Truncatalina cylindrica	–	1	1	2	–	–	–	–	–	–	–	–
Vertigo pygmaea	–	–	–	2	–	1	1	1	–	–	–	–
Vertigo sp.	–	–	1	1	–	–	–	–	–	–	–	–
Pupilla muscorum	–	14	9	9	4	8	8	3	–	–	–	–
Vallonia pulchella	–	–	–	–	–	–	–	–	–	–	–	2
Vallonia excentrica	–	2	–	5	5	–	2	4	–	–	–	–
Vallonia pulchella/excentrica	–	11	14	12	7	12	8	3	6		7	14
Vallonia costata	–	2	3	7	1	1	2	3	–	–	–	–
Punctum pygmaeum	–	–	–	–	–	–	–	–	1	2	–	1
Vitrina sp.	–	–	–	–	–	–	1	–	–	–	–	–
Deroceras/Limax spp.	–	1	3	1	1	5	–	2	1	–	–	3
Cernuella virgata	1	3	8	17	10	3	4	6	8	8	10	16
Trochulus hispidus	–	–	–	–	–	–	–	–	–	–	1	–
Cepaea/Arianta	–	–	–	–	–	–	–	–	–	–	1	–
Total Land	**1**	**34**	**39**	**57**	**28**	**30**	**27**	**23**	**17**	**10**	**19**	**37**
Total shells	**1**	**75**	**110**	**145**	**73**	**74**	**65**	**86**	**62**	**62**	**85**	**153**
Cecilioides acicula	–	–	–	–	–	–	–	–	–	–	–	2

Vertebrates

Fragmentary small mammal remains were noted during rapid scanning of samples 31161, 31162 and 31180, from sand and silt layers within the upper part of the calcareous gravel (context 3972024, 3972-J). The only identifiable specimens were recovered during more careful sorting of the residue from sample 31161. This sample yielded several microtine rodent incisor fragments, together with an upper incisor fragment and lower third molar of *Apodemus* sp. Other than noting that *Apodemus* is usually associated with temperate woodland phases (both interglacial and interstadial) in the north-western European Pleistocene, the sample is insufficient for environmental interpretation.

Molluscs

A sequence of 12 mollusc samples was taken from the tufaceous and underlying deposits, phases 3972-D and 3972-C respectively (Table 10.5). The total number of shells was in many cases too small for statistically viable counts throughout the sequence. The aquatic taxa are dominated by the slum species *Galba truncatula, Radix balthica* and *Anisus leucostoma*, which indicate a poor-quality aquatic environment. Some of the other taxa, such as *Bithynia tentaculata, Valvata piscinalis* and *Pisidium henslowanum*, require running water and suggest that a large, flowing waterbody was in existence nearby; these shells possibly entered the sediments during times of flood. The terrestrial taxa are of considerably more interest, as they include *Truncatellina*

Table 10.6 Molluscs from 3972TT, phase 3972-J

Phase	3972-J			
Context	3972024			
Sample	**31179**	**31180**	**31161**	**31159**
Aquatic	M	M	M	M
Valvata cristata		36	36	24
Bithynia tentaculata (shell)	1	91	150	137
Bithynia tentaculata (opercula)	2	187	731	629
Galba truncatula	–	9	19	12
Radix balthica	–	4	5	1
Stagnicola palustris agg.	–	–	16	2
Physa fontinalis	–	–	1	
Anisus leucostoma	–	3	1	1
Gyraulus crista	–	1	2	1
Hippeutis complanatus	–	3	–	–
Segmetina/Hippeutis	–	–	9	7
Planorbis planorbis	–	14	19	14
Sphaerium sp.	–	1	–	–
Aplexa hypnorum	–	–	–	2
Musculium lacustre	–	–	–	1
Acroloxus lacustris	–	1	–	–
Pisidium spp.	–	9	7	8
Total Aquatic	**1**	**172**	**265**	**210**
Land				
Carychium minimum	–	1	–	–
Carychium sp.	–	8	16	19
Succineidae	–	8	20	15
Vertigo antivertigo	–	3	2	–
Vertigo sp.	–	5	3	–
Pupilla muscorum	–	–	–	1
Vallonia enniensis	–	–	–	1
Vallonia sp.	–	1	–	–
Cochlicopa sp.	–	4	3	15
Discus rotundatus	1	11	10	50
Clausilia bidentata	–	–	–	1
Deroceras/Limax spp.	–	12	37	31
Aegopinella pura	–	–	–	4
Aegopinella nitidula	–	1	14	16
Euconulus fulvus	–	–	–	1
Vitrea sp.	–	–	–	2
Oxychilus cellarius	–	1	–	4
Cepaea/Arianta	–	3	11	14
Total Land	**1**	**58**	**116**	**174**
Total shells	**2**	**230**	**381**	**384**

KEY: M – mollusc sample

Table 10.7 Ostracods from 3972TT

Phase	3972-C								3972-I		
Context	3972041				3972042				3972036		
Sample	31187 /14	31187 /12	31187 /9	31187 /7	31187 /5	31197	31187 /3	31187 /1	31183 /18	31183 /12	31183 /4
Depth in monolith (cm)	65–70	55–60	40–45	30–35	20–25		10–15	0–5	95–100	65–70	25–30
Candona neglecta	–	–	–	–	–	xx(j)	xx(j)	xx(j)	–	x(j)	–
Ilyocypris sp.	–	–	–	–	–	–	x	–	–	–	–

KEY: x – a few specimens; xx – common; (j) mainly juveniles

Table 10.8 OSL dating results from 3972TT (*poorly constrained date

Phase	Context	Sample	Lab ID	Depth (m)	OSL date (KBP)	Error range (± KBP)
3972-K	3972035	31167	X927	1.75	17.99	2.69
3972-K	3972023	31165	X925	1.5	26.20	1.69
3972-K	3972030	31175	X935	0.75	38.97	4.59
3972-K	3972030	31171	X931	1.75	46.05	2.41
3972-C	3972042	31177	X937	0.45	*[52.00]**	*4.64*
3972-H	3972038	31169	X929	3.65	118.83	7.08
3972-H	3972025	31173	X933	3.50	130.10	8.80

cylindrica and *Cernuella virgata*, both species of dry, calcareous grasslands. *T. cylindrical* is now extremely rare in Britain. The presence of *Vallonia excentrica, V. costata* and *Pupilla muscorum* also indicate a dry, grassland, probable interglacial, environment.

A further four samples were recovered from sandy and silty beds within a calcareous gravel at the south-eastern end of 3972TT, phase 3972-J (working upwards through the sequence, samples 31179, 31180, 31160 and 31159, all from context 3972024) (Table 10.6). The lowermost sample provided very little shell. However, the upper samples were very shelly and contain a fauna quite different from that recovered from the western end of 3972TT within 3972-C/D. The aquatic taxa are dominated by species typical of well-oxygenated, slowly flowing water, notably *Bithynia tentaculata* and *Valvata cristata*. The latter, along with *Planorbis planorbis* also indicates a well-vegetated aquatic habitat. The presence of *Hippeutis complanatus*, which is commonly found with *Gyraulus crista*, also suggests a permanent calcareous waterbody, since *H. complanatus* is intolerant of soft water and of periods of desiccation.

The terrestrial taxa indicate a wet, wooded interglacial environment. *Carychium* inhabits a variety of moist habitats and is tolerant of periodic flooding. The proportion of *Discus rotundatus* increases up the sequence, which, along with *Aegopinella nitidula* is typical of moist woodland environments. Also notable is the presence of a well-preserved mouth of *Clausilia bidentata*, another inhabitant of moist woodland environments.

Ostracods

The sediments from three sections in 3972TT (contexts 3972041, 3972042 and 3972036) contain some ostracods, albeit sparse (Table 10.7). These are *Candona neglecta* (mostly juveniles) and a few *Ilyocypris* sp. They have no biostratigraphical or climatic significance. Because of their rarity and the fact that the *C. neglecta* is represented almost entirely by juveniles, it may indicate reworking or at least sediment sorting, with specimens over a certain size (and thus the adults) broken or lost.

Dating

Seven samples were selected for OSL dating and the results are presented in Table 10.8. Stratigraphically, the two earliest dates are from phase 3972-H and these suggest an MIS 5e date. The single date from 3972-C is suggestive of an MIS 3 age; however, problems were encountered during analysis of this sample and this is considered an unreliable age estimate. The remaining dates derive from 3972-K and appear to cluster into two discrete groups: one group associated with mid MIS 3 dates; the second with two dates around the Last Glacial Maximum (MIS 2).

Table 10.9 Amino acid dating results from 3972TT

Result	Project	Intervention	Phase	Context	Sample	Lot	Species	No. shells	Lab code	MIS
Below tufa										
CTRL-E3	ARC EBB01	3972TT	3972-C	3972042	31506	1735	*Bithynia* opercula	–	NEaar-4863	5e
CTRL-E3	ARC EBB01	3972TT	3972-C	3972042	31506	1735	*Pupilla*	(4 bulked)	NEaar-4864	5–8
CTRL-E2	ARC EBB01	3972TT	3972-C	3972042	31513	1930	*Bithynia* opercula	–	NEaar-4861-4862	5e
CTRL-E4	ARC EBB01	3972TT	3972-C	3972042	31513	1736	*Bithynia* opercula	–	NEaar-4866	5e
CTRL-E4	ARC EBB01	3972TT	3972-C	3972042	31513	1736	*Pupilla*	(n=1)	NEaar-4865	5–8
Calcareous channel fill										
CTRL-E14	ARC EBB01	3972TT	3972-J	3972024	31162	1924	*Bithynia* opercula	–	NEaar-4903-4905	5e
CTRL-7	ARC EBB01	3972TT	3972-J	3972024	31180	1739	*Bithynia* opercula	–	NEaar-4660-4662	5e

Amino acid dating was carried out on seven molluscan samples (Table 10.9). Predominantly these were *Bithynia* opercula but some *Pupilla* shells were also investigated. The *Bithynia* results cluster within the range of sites dated to MIS 5e. There appears to be little difference in results between those from 3972-C or 3972-J. The *Pupilla* results are less easy to interpret and the spread of data might indicate ages of MIS 5e or older (see Penkman, Appendix E)

3972TT Overview

Development of the sedimentary sequence within this trench appears to span maybe 150,000 years, and commences with deposition of coarse chalk-rich solifluction gravels of MIS 6 age (or older) and associated sediments of phase 3972-A/B. Because of their basal position in the stratigraphic stack the solifluction deposits of 3972-E may also be broadly contemporary with those of 3972-A. Accumulation of fluvial gravels, probably in late MIS 6, is probably represented by the deposition of 3972-F.

Difficulties exist in relating the sequence of deposits associated with 3972-C/D to those of 3972-G/J, because of an intervening unconformity in the sequences at the different ends of the trench. Two OSL dates from 3972-H place this deposit within the Last Interglacial. However, the OSL date from 3972-C was unreliable, and so does not help with correlation. Amino acid data does however suggest that both the 3972-C/D and 3972 G/J deposit sequences are broadly contemporary (within a single interglacial), which would suggest an MIS 5e date for both. This is supported by the presence of fully interglacial mollusc assemblages associated with 3972-C/D and 3972-J. However, the differing ecologies represented in the two sequences suggest accumulation at different times within the interglacial and within different local landscapes.

Sediment accretion under fluvial, or perhaps fluvial-to-estuarine and subsequently fluvial, conditions is attested to by the sedimentology of 3972-G through to 3972-I. The latter phase of this sequence (3972-I) almost certainly was associated with fluvial conditions as the contained channel-fill sediments (3972-J) associated with an aquatic interglacial molluscan fauna (Table 10.6) are indicative of moving water with an associated damp woodland, a finding reinforced by the presence of *Apodemus* within this body of sediment.

A return to cold climate conditions is attested by the solifluction deposits of 3972-K. Although no faunal remains exist in these deposits, OSL dating indicates that accumulation of this body of sediment occurred over a considerable time span with perhaps two main phases of accumulation taking place in MIS 3 and MIS 2.

4017TT (ARC EBB01)

Introduction

Trench 4017TT was excavated to the south of the southern edge of the western arm of the dog-legged trench 3972TT (Fig 10.1). Open area excavation (Fig 10.5) of the carbonate-rich tufaceous silts (3972-D) exposed in the stepped trench 3972TT was then undertaken (Pl 10.6). Six samples squares (1x1m) were excavated (4017001 to 4017006) through the tufaceous deposit and a vertical series of bulk samples were taken for biological remains. The main section at the southern end of the trench (Section 4017001, Fig 10.5) was also recorded (Fig 10.6). This section (Pl 10.7) was orientated parallel with the Jayflex section (see below)

Plate 10.6 Work-in-progress photo of tufa sample squares, 4017TT

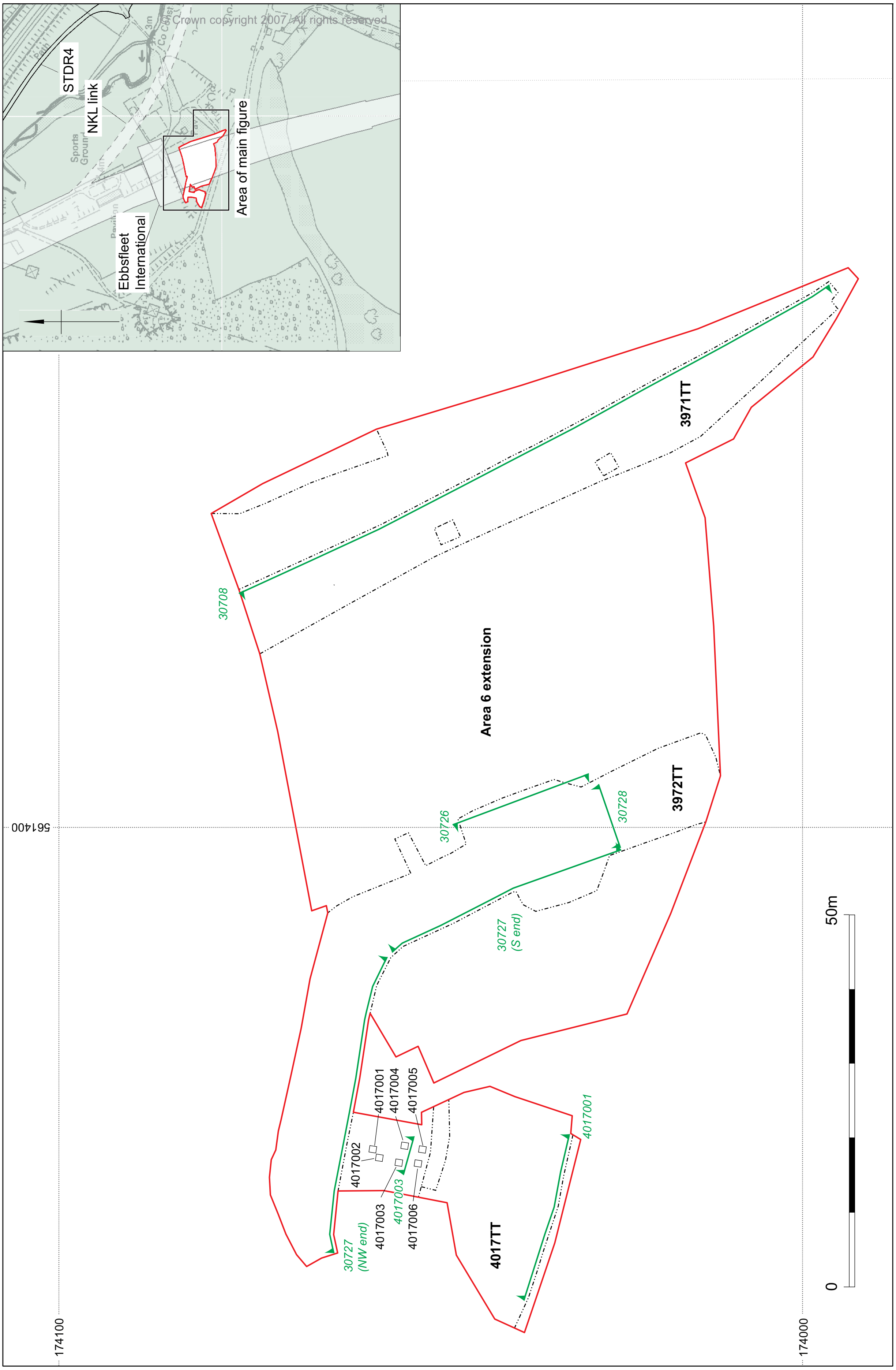


Figure 10.5 Plan of excavation, 4017TT

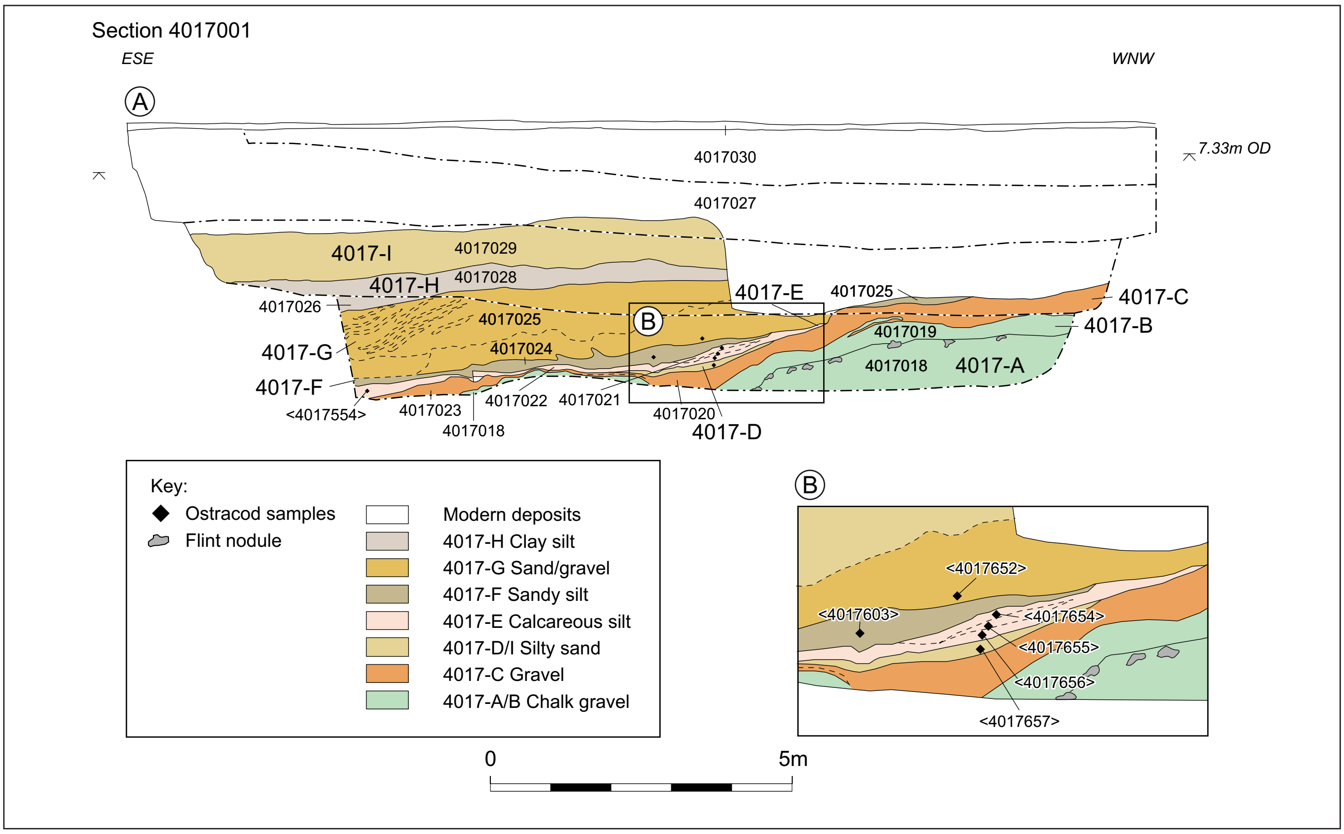


Figure 10.6 4017TT, section 4017001 (see Fig 105 for location)

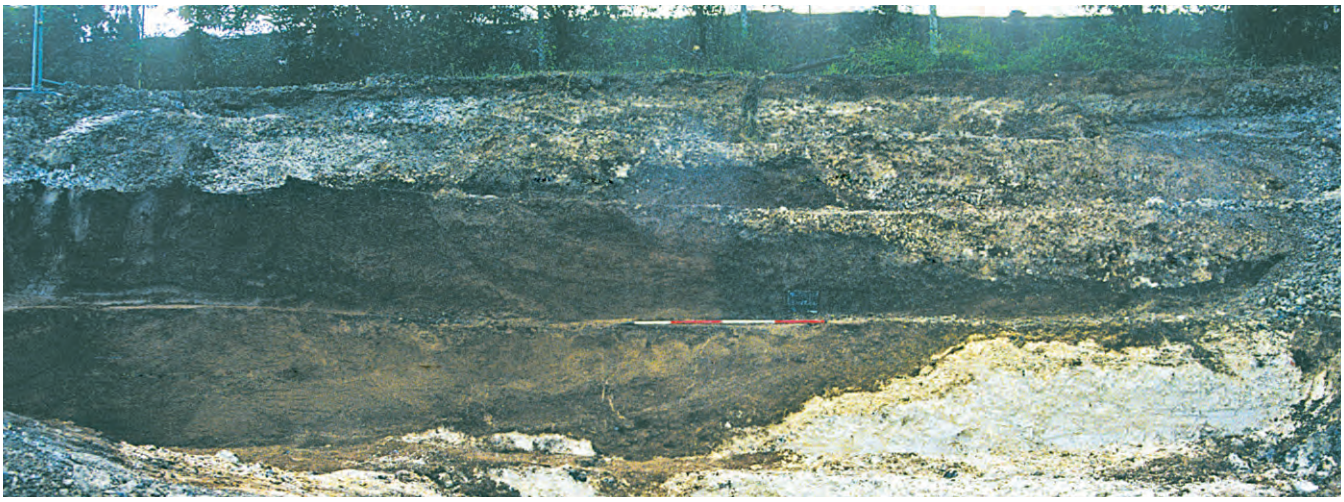


Plate 10.7 4017TT, section 4017001

located further to the south on the opposite side of the surviving sediment ridge beneath the haul road.

Lithological Succession

These deposits can be subdivided into nine major groups of sediments (Table 10.10), all lying between 3.3m OD and 7.8m OD (at maximum sequence thickness):

4017-A: This deposit (context 4017018) consists of white, angular chalk clasts set in a fine chalky silt matrix. The deposit only occurs at the western end of the transect and the upper surface of the deposit dips steeply away to the east. The highest elevation of the deposit is 4.3m OD. This sediment is a cold climate chalky solifluction deposit derived from upslope.

4017-B: This deposit (4017019) consists of partially rounded chalk clasts mixed with rounded flint clasts. It forms a body of sediment resting on the underlying angular chalky deposit at the western end of the trench. The sediment is probably a solifluction deposit generically related to the sediment below.

Table 10.10 Stratigraphic sequence, phasing and distribution of specialist and dating evidence, 4017TT

Phase	Context	Lithology	Palaeoenvironmental data	Dating
4017-I	4017029	Clay silty-sand with common sub-angular to rounded flint pebbles and charcoal	–	–
4017-H	4017026, 4017028	Clay-silt with sub-angular to sub-rounded flint pebbles	–	–
4017-G	4017025	Sand	–	–
4017-F	4017024	Slightly sandy silt	–	–
4017-E	4017022	Calcareous silt	Molluscs, ostracods	MIS 5e
4017-D	4017021	Fine sand	–	–
4017-C	4017020, 4017023	Sandy-silt flint gravel with Tertiary shell fragments	–	–
4017-B	4017019	Chalk gravel with flint pebbles in chalky silt matrix	–	–
4017-A	4017018	Chalk rubble with frequent flint nodules in chalky silt matrix	–	–

4017-C: This deposit (4017020, 4017023) is a poorly-sorted flint gravel with a sandy matrix containing fragments of Tertiary shell. It forms a sheet of deposits dipping to the east from a high of *c* 4.5m OD in the west to *c* 3.30m OD towards the eastern end of the section. The deposit is probably a solifluction deposit laid down the valley side defined by the underlying chalky solifluction deposits under periglacial conditions.

4017-D: This deposit (4017021) is a strong brown fine silty sand of relatively restricted distribution. The sediment may be derived from the gravels beneath or represent slope wash sediments infilling hollows on the valley side through colluvial slopewash of sediments.

4017-E: This is a yellowish-brown calcareous silt (4017022) with some sand. Molluscs are present in quantity. It forms a drape of sediments across the underlying sequence of deposits (4017-A to 4017-D). In places the sediment appears faulted (reverse faulted with throws of *c* 50mm) perhaps indicative of downslope movement of this body of sediment after deposition. The precise nature of the depositional environment is unclear but perhaps precipitation of the calcareous deposits in springs and its secondary movement down slope may have operated.

4017-F: This deposit (4017024) consists of a slightly sandy silt with carbonate precipitate in places. The sediments form a thin sheet along the eastern parts of the section, dipping shallowly east and disturbed in parts by overlying sediments. It may be of colluvial origin on the basis of its downward dip and fine-grained nature.

4017-G: this deposit (4017025) consists of yellowish-brown sands with gravel beds that clearly dip towards the east (ie, downslope). The sediments are clearly of slopewash origin, possibly cold climate solifluction deposits.

4017-H: These deposits (4017026, 4017028) are a strong brown clay-silt with some sand and occasional flint clasts that exhibits a broad sub-horizontal distribution across the section. This is probably colluvial in origin although a degree of weathering and possible pedogenesis may be indicated.

4017-I: This deposit (4017029) is a soft greyish-brown clay-silty sand with common sub-angular and rounded flint clasts as well as charcoal and rooting. This deposit is probably colluvial in origin and probably Holocene in date.

The sequences present are all apparently related to slope processes either through solifluction activity (4017-A-C) or as a result of downslope movement and washing of sediment under milder or temperate conditions. The sediments of Phase 4017-E are thought to be tufaceous spring-wash sediments equivalent to the expanse of carbonate-rich tufaceous sediment excavated as small square test pits in the northern half of trench 4017TT (Fig 10.5), which were in turn a lateral continuation of the tufaceous sediments of phase 3972-D.

Sediments overlying 4017-E all appear to be of colluvial origin, with the possibility that a major stabilisation and weathering horizon occurs in the middle of the section (4017-H).

Molluscs

Shells were recovered from a vertical series of four samples from one of the 1m square test pits – given the context number 4017003 – excavated in the tufaceous deposits of phase 3972-D which extended into the northern part of trench 4017TT, (Table 10.11). The aquatic taxa are dominated by the slum species *Galba truncatula*, *Radix balthica* and *Anisus leucostoma*, suggesting that only low-quality, ephemeral aquatic habitats were present. Occasional shells of species such as *Valvata piscinalis* and *Bithynia tentaculata* suggest flowing water nearby.

The terrestrial taxa are similar in character to those found at the western end of 3972TT described above, being dominated by members of the *Vallonia* family and by *Cernuella virgata,* which indicate dry, calcareous grasslands.

Ostracods

A vertical series of samples through the tufaceous sediment (phase 3972-D) from two excavated squares 4017001 and 4017003 (Fig 10.5) was analysed, as well as a series through the sequence from the main section 4017001 (Fig 10.6), including samples from phase 4017-E that were thought to represent equivalent tufaceous sediments to 3972-D. For the most part the ostracod faunas (Table 10.12) are sparse, which is

Table 10.11 Mollusc counts from vertical series through tufaceous sediments of phase 3972-D in sample square 4017003 (lowest sample 4017553 on left, rising through sequence to sample 4017550), 4017TT

Square	SQ 4017003			
Phase	3972-D			
Sample	4017553 SV	4017552 SV	4017551 M	4017550 M
Aquatic				
Valvata piscinalis	1	3	2	2
Bithynia tentculata	3	–	1	–
Bithynia tentculata opercula	–	2	1	–
Galba truncatula	127	80	82	26
Radix balthica	33	54	11	9
Planorbis planorbis	–	2	–	–
Anisus leucostoma	61	61	34	14
Gyraulus crista	1	–	1	–
Hippeutis complanatus	–	–	1	–
Pisidium spp.	–	1	1	1
Total Aquatic	226	201	133	52
Land				
Succineidae	2	4	4	1
Pupilla muscorum	4	2	3	2
Vallonia pulchella	7	3	–	–
Vallonia excentrica	4	3	3	–
Vallonia pulchella/excentrica	12	5	–	–
Vallonia costata	14	24	6	1
Vallonia sp.	–	–	9	4
Cochlicopa lubrica	–	1	–	–
Cochlicopa sp.	–	–	1	–
Deroceras/Limax spp.	–	–	1	–
Cernuella virgata	13	5	5	–
Trochulus hispidus	12	19	4	–
Cepaea sp.	–	+	–	–
Total Land	68	66	36	8
Total shells	294	269	169	60

Note: SV – Small vertebrate sample, M – Mollusc sample

disappointing as tufa deposits usually contain distinctive spring-dwelling faunas. Here they are absent, apart from a few *Prionocypris zenkeri* which lives in spring-fed pools (Meisch 2000). Instead they are mainly represented (albeit in large numbers) by juveniles of *Candona* (which, where adults are present, appear all to be *Candona neglecta*). There is however, one important species present, namely *Juxilyocypris schwarzbachi*, which is so far, unique within the Ebbsfleet Pleistocene sequences and this occurs in contexts 4017001, 4017003 and 4017022, all representing a thin isolated patch of tufaceous sediment first seen in section at the west end of trench 3972TT (context 3972043). This small but distinctive species became extinct within the Devensian (Whittaker and Horne 2009) – it is, for instance, common at Swalecliffe, Kent (Whittaker 2001), but is known as far back as Cromerian (MIS 15 or older), being found at Little Oakley, Essex (Robinson 1990). It may also be a cold indicator but this is not known for certain. It may also have been missed previously by many Pleistocene ostracods workers on account of its very small size (they were often working from residues coarse-sieved primarily for molluscs), which at the moment rather hinders its full climatic and biostratigraphical potential. As it is rare, even when found, there is the possibility that it could also have been reworked from *in situ* sediments nearby but other deposits (from this and other zones at Ebbsfleet) containing this fossil have not so far become apparent. So, for whatever reason, *J. schwarzbachi* is unique to the upper part of the tufa of ARC EBB01, 4017TT.

Dating

No OSL dates are available from this section. However, one set of amino acid ratios was derived from *Pupilla* from the tufaceous sediment (context 4017022) in Section 4017001 (Table 10.13; Fig 7.8). Unfortunately, it is difficult to ascertain the precise correlation of the data with other *Pupilla* results (Fig 7.8); an age of MIS 5e or slightly older is suggested by the results.

4017TT Overview

The sequence of slope and floodplain marginal related sediments, including the tufa or carbonate-rich silt present is an extension of the similar sequence seen in 3972TT. From the tufa molluscan remains indicate a dry grassland environment of probable interglacial type. Dating of the sediments remains equivocal but a date of MIS 5e is possible; comparison with the well-dated sequence adjacent to 4017 in 3972TT substantiates this conclusion.

Jayflex Remediation Area (ARC 342W02)

Introduction

This area (Fig 10.1) had previously ben quarried for chalk and then infilled with domestic waste. The waste was removed in advance of the HS1 track construction, which exposed the northern face of the quarry preserved to the south of the haul road, revealing a sequence of intact Pleistocene sediments. Recording of the main section face (Fig 10.7; Pl 10.8) was supplemented by detailed recording of the western end of the section (Fig 10.8; Pl 10.9). This section was orientated parallel with the 4017 section (see above, Fig 10.1) recorded on the opposite, northern site of the sediment ridge forming the haul road.

Lithological Succession

These deposits can be subdivided into 11 major phases (Table 10.14), all lying between 1.0m and 7.0m OD (at maximum sequence thickness):

Jayflex-A: These deposits (contexts 500000, 500007) occur towards the base of the section in the west and intermittently across the remainder of the site. They consist of chalky rubble in a chalky silt matrix with common well-rounded flint clasts. They are of cold climate solifluction origin and are associated with

Table 10.12 Ostracods from 4017TT (ARC EBB01)

Phase	**3972-D**							
Context (Tufa square)	**4017001**							
Sample	**4017500**	**4017501**	**4017502**	**4017503**	**4017504**	**4017505**	**4017506**	**4017507**
Depth (m)	0.00–0.10	0.10–0.20	0.20–0.30	0.30–0.40	0.40–0.50	0.50–0.60	0.60–0.70	0.50–0.60
Candona neglecta	xx(j)	xx(j)	xxx(j)	xxx(j)	xx(j)	xxx(j)	xx(j)	x(j)
Ilyocypris sp.	x	x	x	x	–	–	–	–
*Juxilyocypris schwarzbachi**	–	–	x	–	–	–	–	–

Phase	**3972-D**			
Sample	**4017550**	**4017551**	**4017552**	**4017553**
Candona neglecta	xx	xx(j)	xx(j)	xx(j)
Herpetocypris sp.	x	x	x	x
Ilyocypris sp.	x	x	x	x
*Juxilyocypris schwarzbachi**	x	–	–	–
Prionocypris zenkeri	–	x	–	x
Darwinula stevensoni	–	–	x	–

Section 4017001							
Phase	**4017-D**	**4017-E**				**4017-F**	**4017-G**
Context	4017021	4017022				4017024	4017025
Sample	4017657	4017656	4017554	4017603	4017655		
Candona neglecta	–	–	x(j)	x(j)	–	–	–
*Juxilyocypris schwarzbachi**	–	–	–	x	–	–	–

KEY: x – a few specimens; xx– common; xxx – abundant; (j) mainly juveniles; * – species extinct within MIS 5–2;
Shaded blue – extinct species, possible cold/cool indicator

Table 10.13 AAR dating of *Pupilla* from tufaceous sediment in 4017TT

Result	Intervention	Phase	Context	Sample	Lot No.	Species	No. shells	Lab code	MIS
CTRL-E5	Sec 4017001	4017-E	4017022	4017554	1738	*Pupilla*	(4 bulked)	NEaar-4867	5e-8

Table 10.14 Jayflex stratigraphic phasing and distribution of dating evidence (not in stratigraphic order)

Phase	Contexts	Lithology	OSL date (KBP)
Jayflex-K	500014	White chalk rubble with large fresh flint clasts	–
Jayflex-J	500010, 500012	Flint gravel, well-bedded in places but without Tertiary shell and chalky gravel patches. It appears to infill a small channel-like feature in the main section	–
Jayflex-I	500011, 500013	Yellowish-brown medium sands forming a sheet (partially removed by the made ground) resting on the underlying Jayflex-H unit	–
Jayflex-H	500009	Yellowish-brown matrix-supported flint gravel. The gravel is poorly sorted and Tertiary shell fragments are common throughout. The matrix is sand and internally well-bedded. The deposit forms a sheet that is thickest and attains the highest elevations to the east and dips across the section disappearing to the centre of the section	–
Jayflex-G	500008	Reddish-brown medium to fine sand with carbonate material filling root holes within the sediment. Some Tertiary shell fragments are present. The sediment fills much of the central low area in the valley feature	24.09±2.01
Jayflex-F	500005	Dark yellowish-brown silty sand with frequent flint clasts. It infills most of the valley form (where not truncated by recent made ground)	–
Jayflex-E	500004	Strong brown silty sand with common flint clasts becoming sandier into the valley centre. The upper part of this unit appeared weathered and may be associated with a weathering horizon	14.30±1.11
Jayflex-D	500003	Yellowish-brown sandy-silt or silty-sand with flint clasts and angular flint nodules. The deposit becomes finer grained downslope and into the valley feature	–
Jayflex-C	500002	Yellowish-brown laminated sandy-silts and silty sands and small scale vertical faulting. These are only present in the western part of the site	126.34±10.84
Jayflex-B	500001	Sub-horizontally bedded sands and flint/chalk gravels present in the western part of the section. They occupy a shallow channel-like like feature cut into the underlying solifluction deposits	199.45±16.40
Jayflex-A	500000, 500007	Chalky rubble in a chalky silt matrix with common well-rounded flint clasts	

downslope movement through the dry valley associated with the Jayflex site.

Jayflex-B: These deposits (500001) consist of a series of complex sub-horizontally bedded sands and flint/chalk gravels present in the western part of the section. They occupy a shallow channel-like feature cut into the underlying solifluction deposits. They appear to be fluvially deposited, perhaps sheet wash or more active channelling across the underlying solifluction sheet and have been subsequently modified by cold climate frost-heave processes, perhaps reflecting periglacial conditions.

Jayflex-C: This deposit (500002) consists of yellowish-brown laminated sandy-silts and silty sands and small scale vertical faulting. These are only recorded in the western part of the site. These are probably

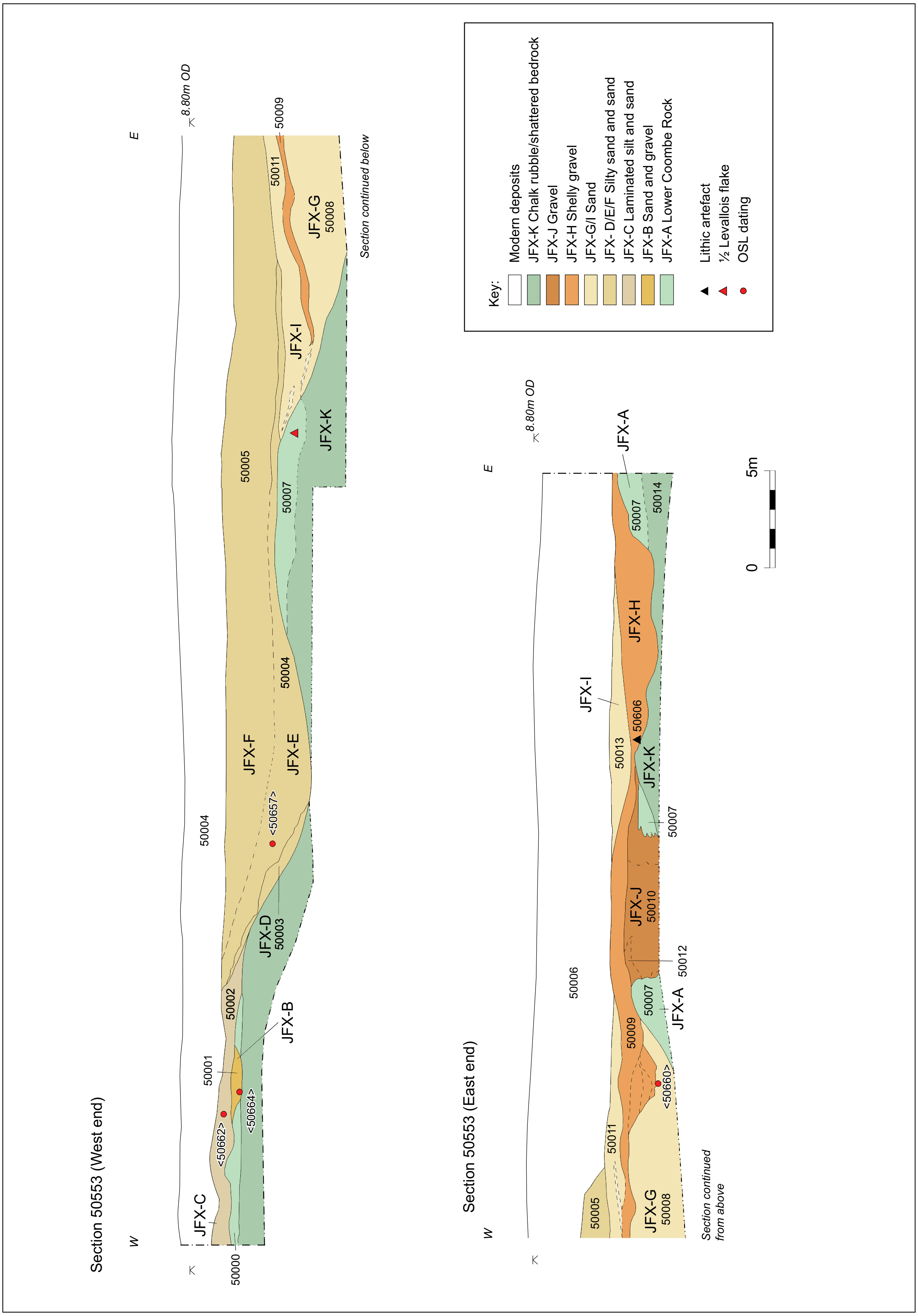


Figure 10.7 Main section in the Jayflex remediation area

Plate 10.8 Main section in the Jayflex remediation area

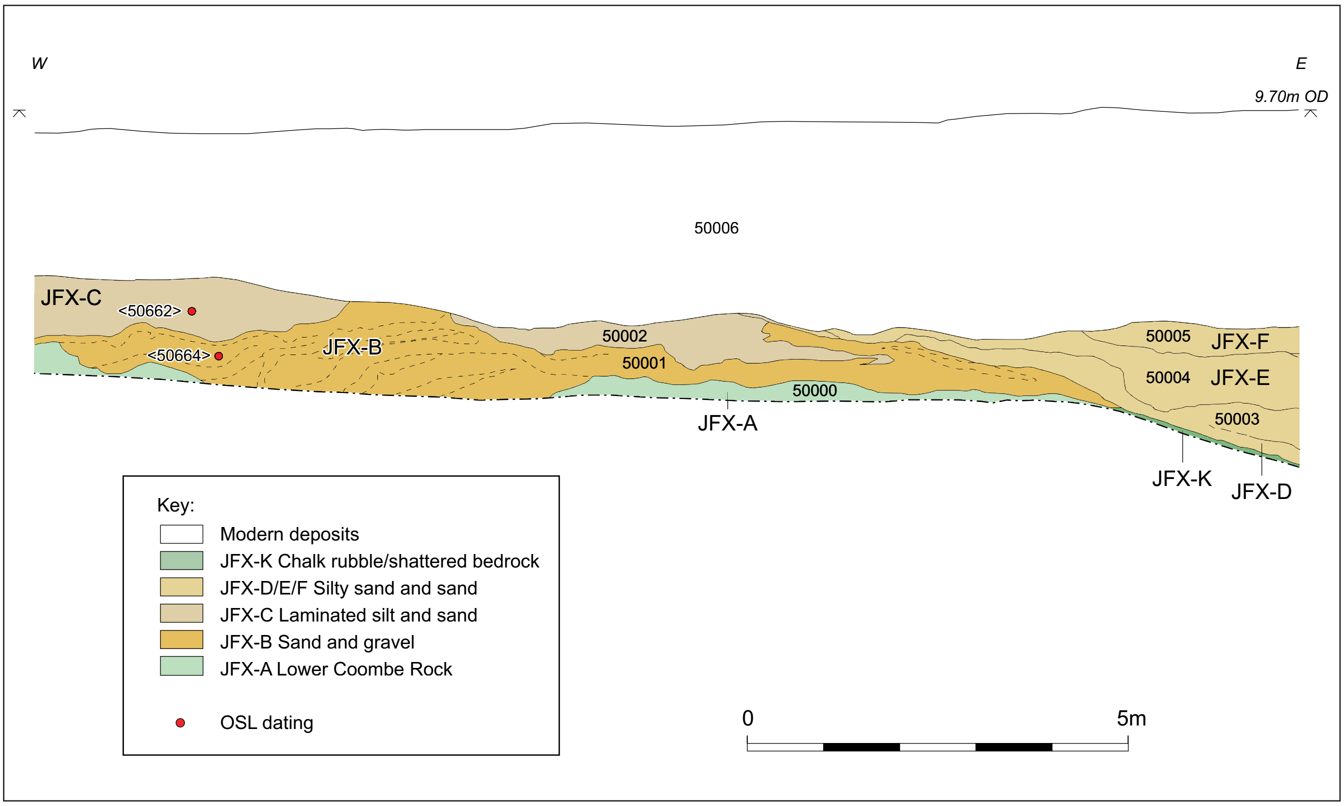


Figure 10.8 Detail of western end of section in the Jayflex remediation area

Plate 10.9 Western end of section in the Jayflex remediation area

slopewash sediments of colluvial origin that have subsequently been impacted by cold climate periglacial processes.

Jayflex-D: This deposit (500003) covers the western side of the major valley form depicted in the main section (Fig 10.7). This deposit consists of yellowish-brown sandy-silt or silty-sand with flint clasts and angular flint nodules. The deposit becomes finer-grained downslope towards the base. These deposits appear to be colluvial slopewash sediments with evidence for sorting resulting in gravel lag deposits forming in places.

Jayflex-E: This unit (500004) is a strong brown silty sand with common flint clasts becoming more sandy into the valley centre. The unit appears to be slope-wash, whether under cold or temperate conditions is uncertain. The upper part of this unit appeared weathered and may be associated with a palaeosol. The distribution of this deposit encompasses much of the western and central parts of the valley feature.

Jayflex-F: This unit (500005) is a dark yellowish-brown silty sand with frequent flint clasts. It infills most of the valley form (where not truncated by recent made ground). This deposit is probably Holocene colluvium based on its high stratigraphic position and its similarity to other colluvial deposits in the Ebbsfleet Valley known to be of Holocene age.

Jayflex-G: This deposit (500008) is a reddish-brown medium to fine sand with carbonate material filling root holes within the sediment. Some Tertiary shell fragments are present. The sediment fills much of the central low area in the valley feature. This sediment body is likely to be a slope-wash sediment perhaps deposited during cool to cold climate conditions and derived from upslope.

Jayflex-H: This deposit (500009) is a yellowish-brown matrix supported flint gravel. The gravel is poorly-sorted and Tertiary shell fragments are common throughout. The matrix is sand and internally well bedded. The deposit forms a sheet that is thickest and attains the highest elevations to the east and dips across the section disappearing to the centre of the section. The deposit was probably deposited in a cold stage by sheet wash and solifluction of gravels from the higher ground where exposed Pleistocene and Tertiary sediments were eroded.

Jayflex-I: These deposits (500011, 500013) are yellowish-brown medium sands forming a sheet (partially removed by the made ground) resting on the underlying Jayflex-H unit. These deposits are probably slope wash sheet deposits laid down during a cold stage.

Jayflex-J: These deposits (500010, 500012) consist of flint gravel, well-bedded in places but without Tertiary shell and calcareous patches. The distribution appears to infill a small channel-like feature in the main section. Cold climate processes associated with solifluction and slope-wash processes are likely to account for these deposits.

Table 10.15 OSL dating results from the Jayflex area

Project	Intervention	Phase	Context	Sample	Lab ID	Depth (m)	OSL date (KBP)	Error range (± KBP)
ARC 342W02	Jayflex Section	Jayflex-C	50002	50662	X907	2.00	126.34	10.84
ARC 342W02	Jayflex Section	Jayflex -B	50001	50664	X909	2.60	199.45	16.40
ARC 342W02	Jayflex Section	Jayflex -E	50004	50657	X902	1.20	14.30	1.11
ARC 342W02	Jayflex Section	Jayflex -G	50008	50660	X905	2.50	24.09	2.01

Jayflex-K: This deposit (500014), present at the base of the section in its deeper parts, is a white block-chalk rubble deposit with large fresh nodular flint clasts. This sediment is interpreted as soliflucted chalk reworked from bedrock or i*n situ* shattered Chalk bedrock.

The sequence of deposits here can be divided into those deposits infilling the major valley feature (Jayflex-D to Jayflex J) and those resting on a shoulder at the edge of the western margin of the valley (Jayflex-B and C). Elements of Jayflex-A and K underlie the full width of the section. Two major types of soliflucted chalk are present including a fresh basal deposit and a mixed upper deposit (Jayflex-A). Sediments at the western end of the section (Jayflex-B and C) appear to have been deposited prior to the cutting of the main valley form, since they appear to have been truncated by the later infill sequence.

The main valley-fill sequences (Jayflex-D to Jayflex-J) consist of a deposit sequence building up within the valley by slope-wash processes. Variable upslope sediment sources are reflected in the differing nature of the preserved sediments. A major weathering horizon (top of Jayflex-E), interpreted in the field to possibly mark the Late Glacial to early Holocene landsurface is present across part of the section.

Dating

Four OSL dates were obtained from sediments in this sequence (Table 10.15). These dates fit into three key time periods: a date at the end of MIS 7 has been obtained from the small gravel filled channel (Jayflex-B) at the western end of the profile (Fig 10.7), while a Last Interglacial date (MIS 5e) has been obtained from the overlying laminated sands (Jayflex-C). Infilling of the main dry valley complex to the east appears to date to the late Devensian on the basis of the two OSL ages from Jayflex-E (post-Last Glacial Maximum) and Jayflex-G (pre-Last Glacial Maximum).

Jayflex Remediation Area Overview

Two discrete bodies of sediment exist within the profile recorded across the site. Towards the west a small body of sediment (Jayflex-A, Jayflex-B and Jayflex-C) rests on a ledge that has been cut through by subsequent downslope movement and gullying (Fig 10.8). This body of sediment records cold stage solifluction activity followed by localised channelling and infilling at the end of MIS 7 according to the OSL date of *c* 200 KBP from Jayflex-B, followed by sand deposition in MIS 5e (Jayflex-C). This body of sediment has subsequently been eroded and cut through by the creation of the dry valley, or its modification, and its subsequent infilling in MIS 2.

Table 10.16 Stratigraphic phasing and correlations in Zone 6, with proposed MIS attributions, where possible

MI Stage	3971 TT phases	3972 TT phases	4017 TT phases	Jayflex phases
1	H–M	L–M		F
2	G F E D	 K		E H G
3	C	K		
4 4a 4b				
5c 5d 5e		 I J D H C G	 E	 C
6				
7				B

Zone 6 Synthesis

The sediments within this zone are dominated by slopewash and solifluction deposits. However, interbedded with these sediments are important fluvial facies that date to both warm and cold stage events. The sediments span a wide range in age from at least the penultimate interglacial (MIS 7) through to the Holocene.

The key dated events identified within this zone are shown in Table 10.16 and Fig 10.9. Elements of early phases of solifluction are noted in the Jayflex area (Jayflex-A) that lie below the dated Jayflex-B horizon of late MIS 7. Whether this early phase of solifluction belongs within a colder phase of MIS 7 or within MIS 8 remains unknown. Minor channelling and infilling of channels is attested to at the western end of Jayflex (Jayflex-B).

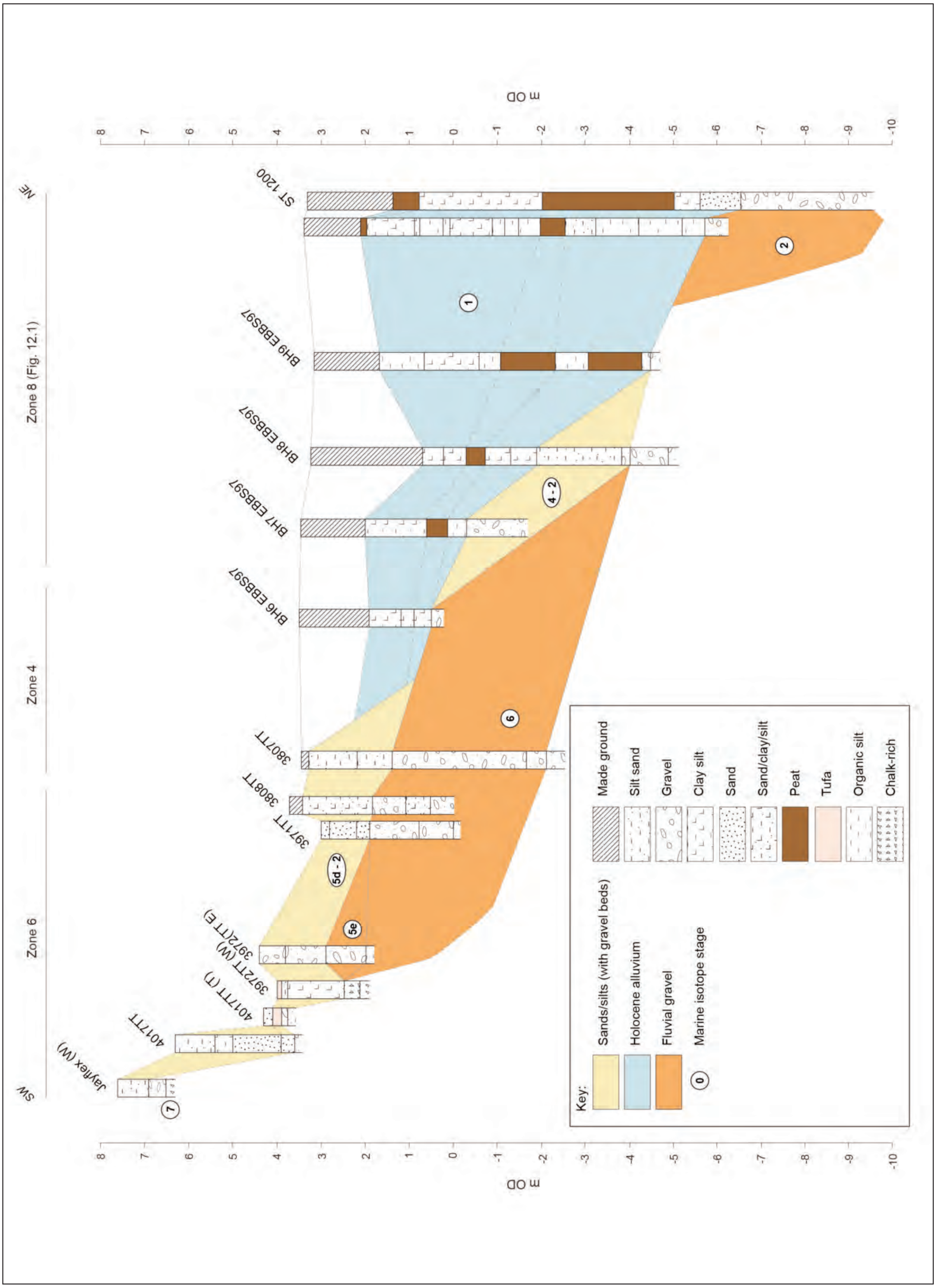


Figure 10.9 Zone 6 stratigraphic profile

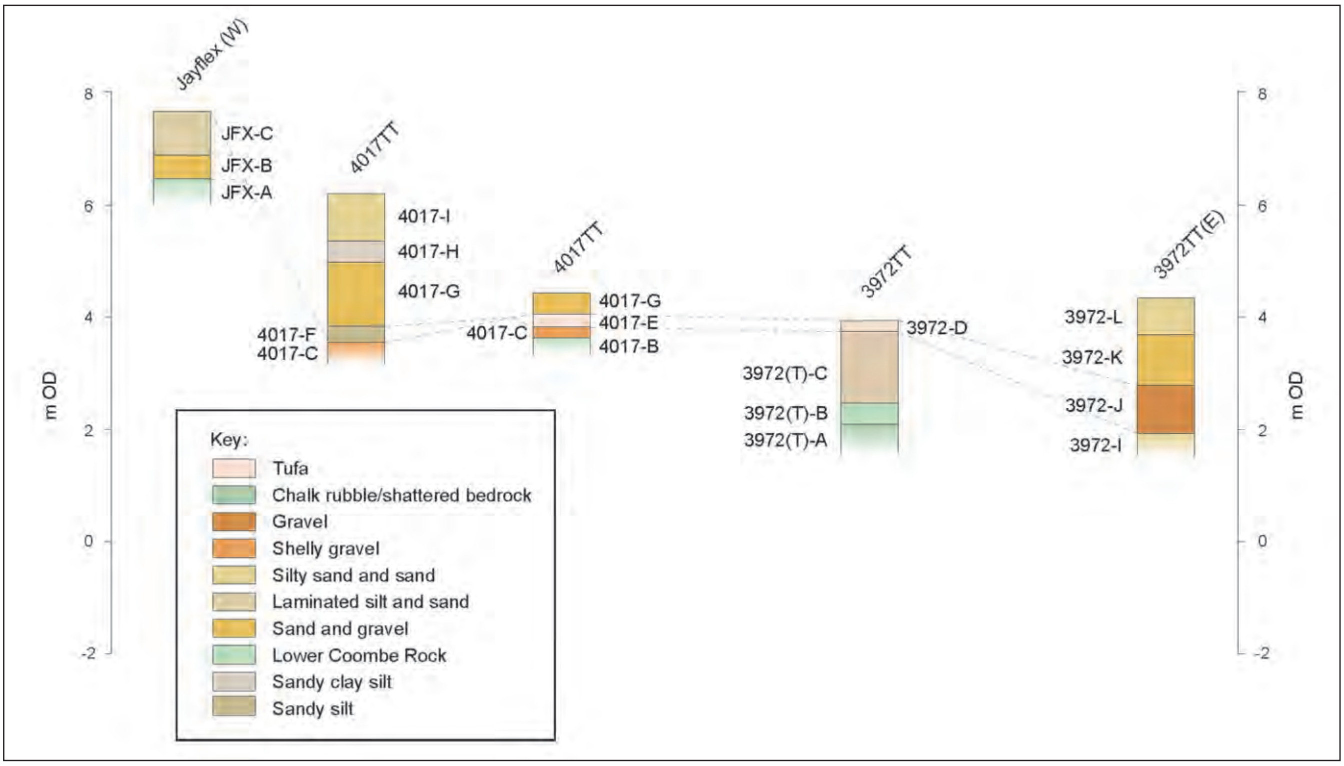


Figure 10.10 Correlation of sequences from Jayflex (central) through 3972TT and 3971TT

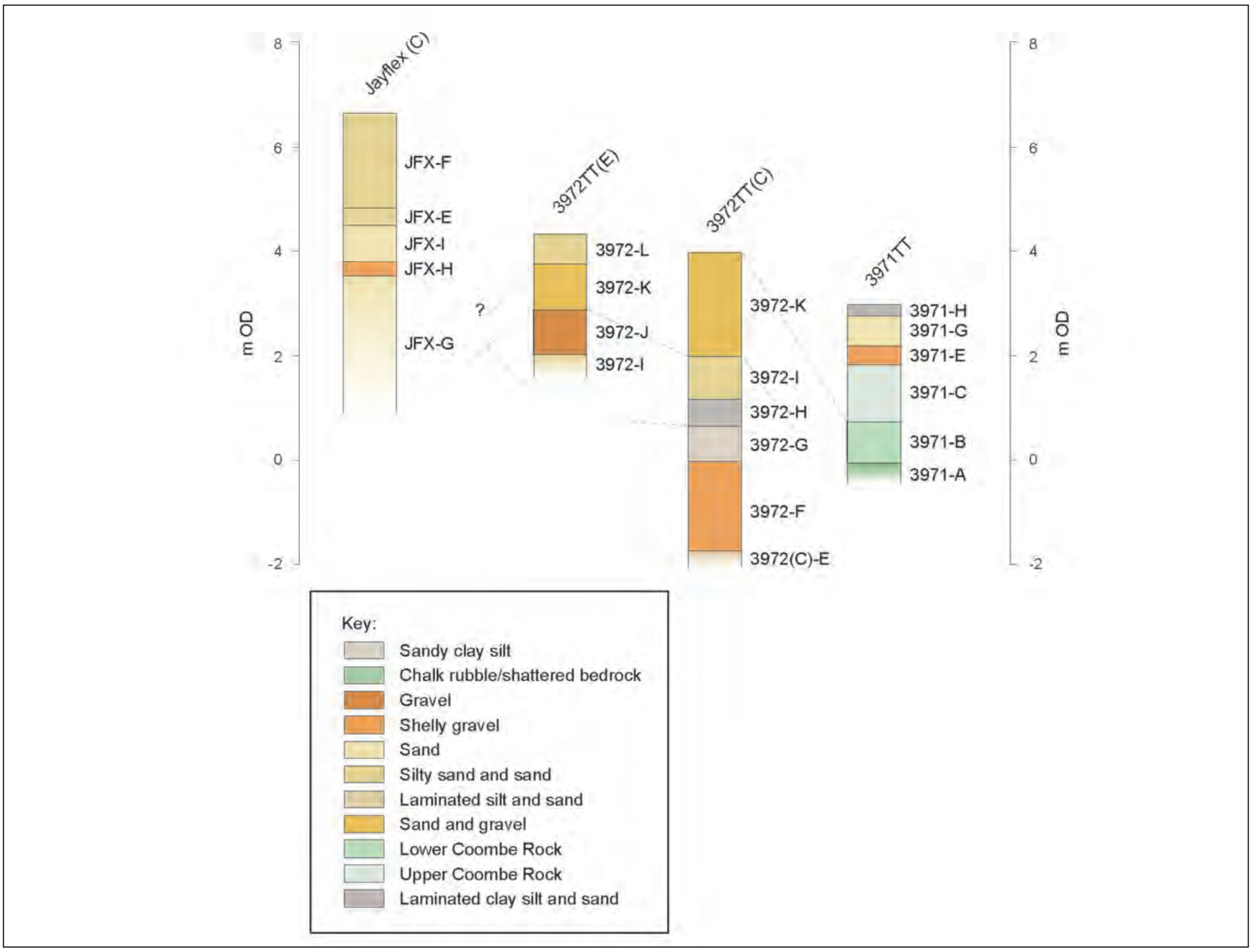


Figure 10.11 Correlation of sequences from Jayflex (W) through 4017TT and 3972TT (W)

Cold stage activity within the zone and correlated with MIS 6 is attested to by the gravels present in 3972 (F) that lie beneath the sands dated to the Last Interglacial at this point (H). It is possible that the solifluction deposits developed in the same section (A) also belong to MIS 6.

A well-dated complex of sediments associated with the Last Interglacial (MIS 5e) is confirmed by both the OSL dates from Jayflex (C) and 3972TT (H) as well as the amino acid geochronology from 3972TT (C and J). Correlation between these two sections is shown in Figure 10.10. The amino acid geochronology from 4017TT (E) is less easy to interpret; however, the fact that 4017TT includes tufaceous deposits that are a direct lateral correlative of 3972-C allows us to infer an age for this deposit. Evidence from the contained biological material in 3972TT and 4017TT suggests that two different phases of the Last Interglacial are represented that include a dry grassland phase as well as a damp woodland phase. The stratigraphic relationship of these two phases is difficult to ascertain without further evidence but it is probable that this open country phase either represents an early phase in the interglacial or a late stage. The significance of the sediments associated with phases G/H/I in 3972TT and the possibility that the preserved sediments are indicative of estuarine or saltmarsh environments should be noted and may be an indication of the flooding of the valley by brackish waters in conjunction with sea-level rise.

Following the deposition of the complex of sediments in the Last Interglacial another complex of colluvial and solifluction deposits have been identified in most trenches. Depositional events in MIS 3 are attested to by group C (3971TT) and at least part of K in 3972TT. A substantial body of sediment has also been dated to MIS 2 (3971-G, 3972-K, Jayflex D/E/G/H/I). Possible correlations are shown in Figure 10.11.

The evidence therefore suggests that a major phase of valley side incision appears to have taken place in the Devensian with the cutting and filling of the dry valley at Jayflex after deposition of the sediments associated with Jayflex-C. This major cut and fill event can also be seen in the dated sections from 3971TT and 3972TT. A complex of landscape elements associated with the Last Interglacial are buried by these Devensian sediments and exist as pockets and remnants of formerly more extensive sheets of deposits.

Chapter 11

Chalk Spur (Zone 7)

by Martin Bates, Francis Wenban-Smith, Richard I Macphail, Simon A Parfitt, Kirsty Penkman, Richard Preece, Jean-Luc Schwenninger, Elizabeth Stafford, Tom S White and John E Whittaker

Introduction

This zone encompasses a spur-like feature projecting north-eastwards into the modern floodplain of the Ebbsfleet on which the Northfleet Roman Villa was constructed (Fig 11.1). Extensive works have been undertaken in this area during the lifespan of the project including test pitting and section cleaning during the ARC EFT97 works, trenching during the ARC ESG00 works and finally additional trenching during the final stages of the project (Table 11.1).

Geomorphologically the zone lies at the tip of a former chalk ridge (now quarried away) (Fig 2.2) running downslope in a north-easterly direction between the dry valley of the Jayflex area and the modern arm of the Ebbsfleet running towards Springhead.

Site E, Section 193 (ARC EFT97)

Introduction

This area of the site (Fig 11.1) was examined in the large open section of the formerly quarried area that survived at its southern side, trending in a south-westerly to north-easterly direction. The drawing of the main section face (Section 193) is provided in Figure 11.2a. Details of the northern end of the section, including sampling and dating points are shown in Figure 11.2b and Plate 11.1.

Lithological Succession

These deposits can be subdivided into 10 major groups of sediments, all lying between *c* 2m and 5m OD at their maximum thickness, at the north-east end of Section 193 (Fig 11.2, Table 11.2).

193-A: This deposit (context 1951) consisted of angular chalk clasts set in a matrix of chalky silt. No rounded flint clasts were present. The sediment underlies much of the section and can be seen dipping and disappearing to the north along the section. The sediment is a chalk solifluction deposit laid down under cold climate conditions.

193-B: This deposit (context 1952 part, SW) is an angular chalk gravel with a chalky silt matrix that contains well rounded flint clasts as well as patches of sand. In places this deposit is semi-cemented. This deposit is restricted to the southern part of the section and cannot be traced towards the northern end. The sediment is interpreted as a cold climate solifluction deposit.

193-C: This group of deposits (context 1955 central NE; 1956 part, central SW; 1971) consists of primarily sandy sediments with gravels mixed and inter-bedded. They occur resting on the surface of phase 193-A as this surface dips sharply to the north. They appear to be mixed slope wash deposits, perhaps with flowing water across these slopes during cold climate conditions.

Table 11.1 Zone 7, key fieldwork locations and recovery of different categories of remains

Project	Key locations	Secondary locations	Soil micromorph	Large vertebrates	Small vertebrates	Molluscs	Ostracods	Amino acid dating	OSL dating	Worked flint
FW-S PhD		Site E, sec 43 (EV 1992–1993)	–	–	–	–	–	–	–	X
ARC EFT97	Sec 193		X	–	–	X	X	X	X	X
		Sec 185	–	–	–	–	–	–	–	X
		2063TP	–	–	–	X	–	–	–	–
ARC ESG00		3830TP	–	–	–	–	–	–	–	–
	3833TT		–	–	–	X	–	X	–	–
	3834TT		–	–	x	X	–	–	–	–
	3835TT		–	–	x	X	–	–	–	–
ARC EBB 1	3973TT		–	–	X	X	X	X	–	–
	Sec 18044		X	–	x	X	X	–	X	–
	Sec 18531		–	X	–	–	–	–	–	–
	Sec 18532		–	X	X	–	–	–	X	–

KEY:X – important evidence; x – minor presence

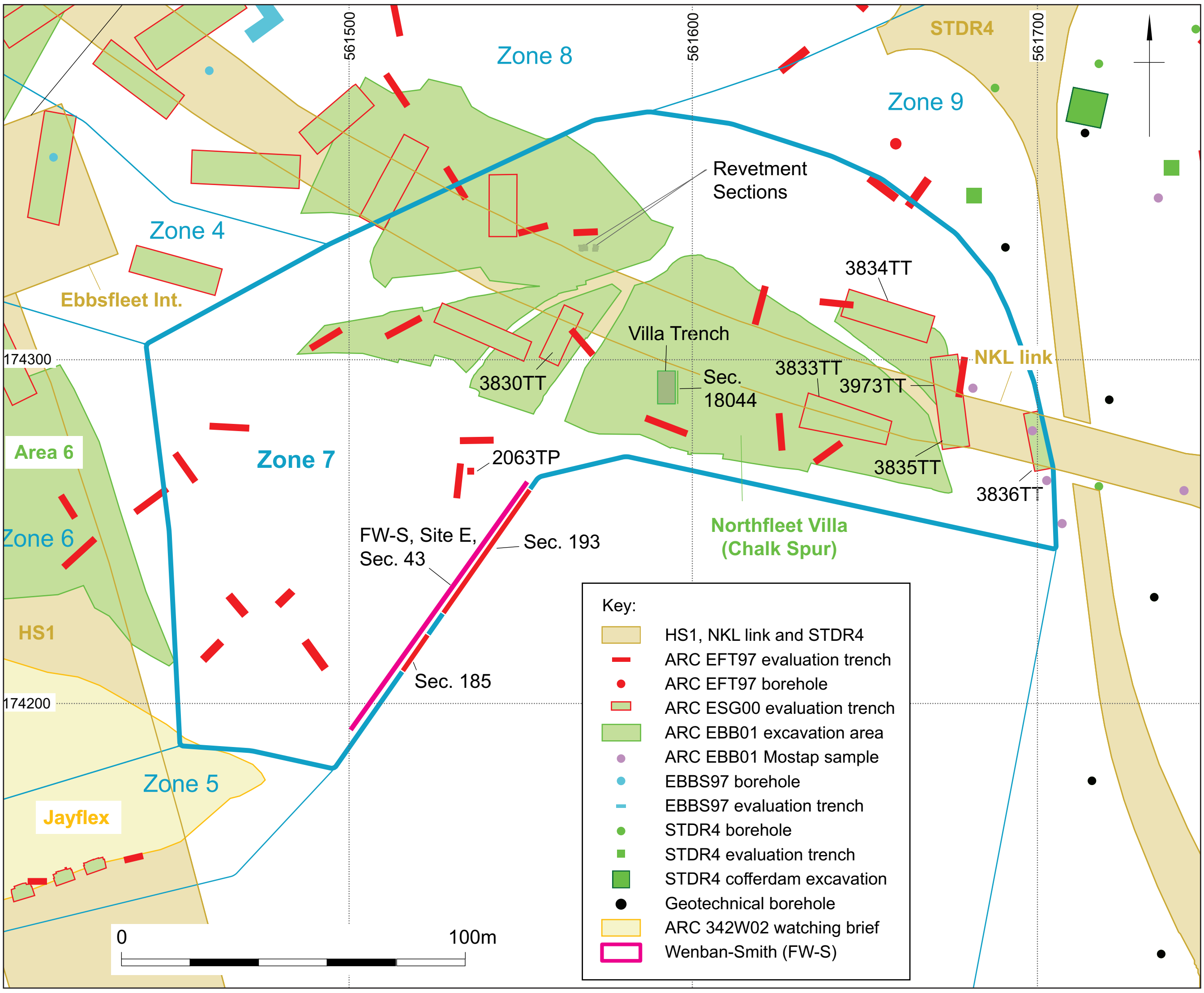


Figure 11.1 Zone 7 layout and key intervention locations

Plate 11.1 Northern end of Section 193

193-D: This group of deposits (contexts 1958, 1959, 1960, 1964, 1968, 1969 and 1970) consists of sand, gravels and silt with a darkened horizon in the centre of the sequence. The deposits are likely to be the result of a combination of slope wash processes, perhaps into small bodies of standing water near the contemporary slope base, interspersed with phases of stability and weathering of the associated sediments.

193-E: These deposits (context 1952, central NW, 1956 central NW), 1957 and 1963) consist of bedded sands, gravels and silts that overlie elements of groups C and D. They probably represent slopewash processes operating during cold stages.

193-F: These deposits (context 1952 centre part, 1955 central part SW) are composed of angular chalk rubble in a chalky silt matrix containing rounded flint clasts and sands. They are interpreted as cold climate solifluction deposits.

193-G: These deposits (contexts 1954, 1961, 1962 and 1973) are sandy-silt dominated sediments that are very well-bedded in places and probably formed as a result of slopewash during cold climate conditions.

193-H: These deposits (context 1952 part central) are composed of angular chalk rubble in a chalky silt matrix containing rounded flint clasts. They are interpreted as cold climate solifluction deposits.

193-I: These deposits (context 1953) are non-chalky flint gravels probably deposited by sheet wash under cold climate conditions.

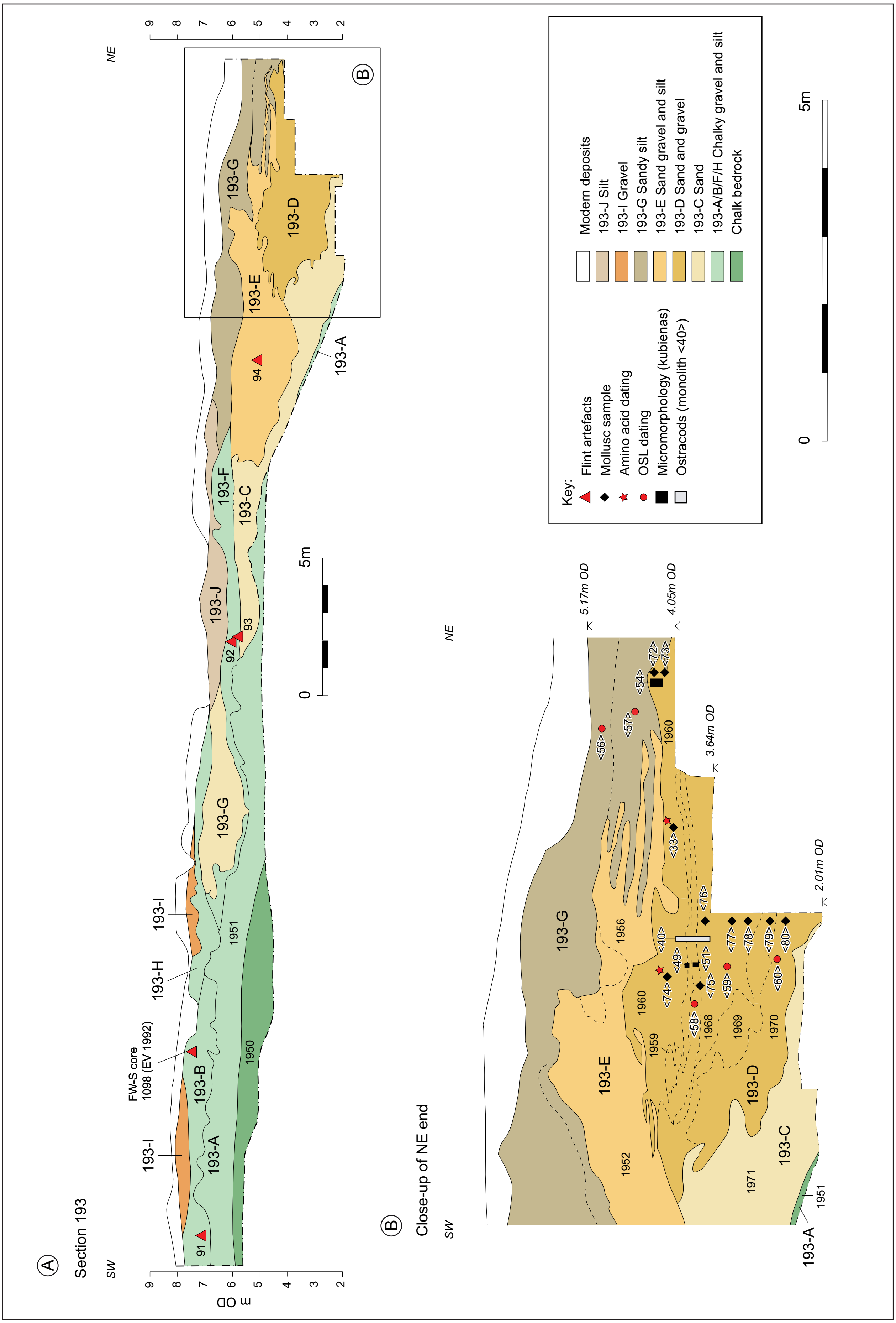


Figure 11.2 Section 193 – (a) Section 193 main profile; (b) detailed drawing of north-east end of Section 193

Table 11.2 Section 193 stratigraphic sequence, phasing and distribution of specialist and dating studies (*poorly constrained date)

Phase	Contexts	Lithology	Palaeoenvironmental data	OSL date (KBP)
193-J	1972	Dark brown silt with blocky structure and small, black, very well rounded "Tertiary" flint clasts		
193-I	1953	Non-chalky flint gravels		
193-H	1952-central part	Angular chalk rubble in chalky silt matrix containing rounded flint clasts		
193-G	1954, 1961, 1962, 1973	Sandy-silt dominated sediments, very well-bedded in places		15.76±1.41 17.92±1.23
193-F	1952-central part, 1955-central SW	Angular chalk rubble in a chalky silt matrix containing rounded flint clasts and sand		
193-E	1952-north-west part, 1956-central NW, 1957, 1963	Bedded sands, gravels and silts that overlie elements of groups C and D		
193-D	1958, 1959, 1960, 1964, 1968, 1969, 1970	Sand, gravels and silt, with a darker horizon in the middle of the sequence	Micromorphology, molluscs, ostracods	97.20±7.75 91.24±8.96 *85.72*±7.01*
193-C	1955-central NE, 1956-central SW, 1971	Sandy sediments with gravels mixed and bedded with the sands, resting on the surface of phase 193-A as this surface dips more steeply to the north	Micromorphology, molluscs, ostracods	
193-B	1952-south-west part	Angular chalk gravel with chalky silt matrix that contains well-rounded flint clasts as well as patches of sand. In places this deposit is semi-cemented. This deposit is restricted to the southern part of the section and cannot be traced towards the northern end		
193-A	1951	Angular chalk clasts set in a matrix of chalky silt. No rounded flint clasts were present. The sediment underlies much of the section and can be seen dipping and disappearing to the north along the section		

193-J: This deposit (context 1972) is a dark brown silt with a blocky structure and small, black, very well-rounded "Tertiary" flint clasts. This probably represents slopewash during cold climate conditions.

The deposits present in this section record a sequence of cool to cold climate episodes during which differing climatic severity or sediment supply resulted in different bodies of sediment being laid down. There is clear evidence from the northern end of the section of downcutting and the build-up of a series of sediment bodies on a slope extending to the north that matches the recent profile of the modern (or relatively recent) geomorphology. These deposits (belonging to 197-D, E and G) all probably represent slopewash sediments, perhaps accumulating on slopes or towards the base of the contemporary slope in small pools or larger bodies of water. Complex histories of mobilisation of chalky solifluction deposits (at different stages in the accumulation of the sediment bodies) mean that superficially similar sediments may have been deposited at different times in the depositional process.

Sediment Micromorphology

Micromorphological thin sections were prepared from three samples: K-49, K-51 and K-54 (see Fig 11.2). Detailed descriptions of the recorded features are presented in Appendix B, but are summarised briefly here:

K-51, context 1968 (193-D): This deposit is a massive moderately well-sorted calcareous coarse silt-fine sand with lenticular (horizontally fissured) microstructure (Appendix B, Fig B1, 5). It is finer and better sorted compared to context 1959 above, with more included non- to poorly calcareous sediment with inclusions of non-calcareous silt loam soil (Appendix B, Fig B1, 6) and clasts (some also as embedded grains). Sedimentary laminae associated with calcitic matrix intercalations sometimes form micropans and these are occasionally weakly fragmented into papules. Some fissures and burrows were affected by secondary micritic (calcite) impregnations and hypocoating formation, and later by very fine rooting (root pseudomorphs). The deposit appears to be formed from both eroded brickearth ('loess') sediments, and soils. The latter include previously formed periglacial calcareous soils (embedded grains formed from eroded link capping microfabrics of cool climate origin) and eroded silt loam soils, some of which had been eroded and integrated into periglacial soils. The brownish colour of 1968 results from interbedding of non- and poorly calcitic sediment formed from silt loam soils (decalcified brickearth?). The deposit has colluvial character, with calcitic intercalations and micropans suggesting muddy deposition into shallow water. The sediment then developed horizontal fissuring (because of its rather 'coarse' texture; Van Vliet 1982) and a lenticular microstructure during ensuing cool conditions, and record probable cool climate seasonal effects.

K-49, context 1959 (193-D) – 35–75mm: context 1959 has a massive with relict laminar and possibly collapsed fine blocky microstructure. It is a moderately poorly-sorted calcareous coarse silt and very fine sand, with medium to very coarse angular sand-size quartz, flint and feldspar (with weathered glauconite, chalk, fossils and shell and soil/clayey fragments). It also contains rare chalk gravel and trace amounts of plant remains and amorphous organic matter. Some shell and flint shows horizontal/sub-horizontal orientation. There are many embedded grains (Appendix B, Fig B1, 7–9), one coarse flint fragment, and a trace of organic remains. Broad burrowing (2mm wide) and relict very fine rooting are recorded, the latter now all infilled with secondary micritic calcium carbonate. The deposit is interpreted as a moderately low energy solifluction deposit developed from calcareous brickearth-like (mixed coarse silt very fine sand, with medium sand) sediments alongside some coarse sand and chalk gravel. Earlier-formed periglacial soils (which had a link-capping microfabric) have been eroded and are now included as embedded grains (*sensu* Bullock and Murphy 1979) – some grains are often highly angular ('frost-shattered') (Appendix B, Fig B1, 7–9). The presence of trace amounts of amorphous organic matter and plant remains also infer soil erosion. This colluvial sediment became burrowed and may have developed fine blocky structure before probably being a little truncated by ensuing/renewed sedimentation caused by the emplacement of overlying context 1960 (the biological and structural fabric of this 'soil' appears to have been truncated). This suggests a period/season of less cool conditions.

K-49, context 1960 (193-D) – 0–35mm: This context is also massive with a relict laminar structure, and has the same mineralogy as 1959 below, but with more (occasional) rounded chalk gravel, and examples of horizontally oriented mollusc shell fragments (Appendix B, Fig B1, 10). Matrix intercalations are associated with laminae and also infillings at the lowermost boundary with 1959. The sediment displays very broad (4mm) and a large (8mm) insect (?) burrows. This context is similar to 1959, but contains a little more chalk gravel and dusty clay papules, it has also retained its laminated structure a little better. It shows a small amount of broad burrowing but no soil structure formation. Locally reworked clayey sediments (colluvium) are included in the sediment. Like 1959 it formed as colluvial/soliflual deposit.

K-54 1962/1964 (193-D, top of): The complexity of the stratigraphic layering in the recovered sample makes it difficult to be certain which contexts are sampled in this section, only that contexts 1962 and 1964 are present. The thin section sampled four distinct layers (Appendix B. Fig B1, 1), and these are described according to depth, from the base upwards.

70–75 mm: Here, a massive micritic marl (with indistinct fine laminae) containing very few fine quartz, clay fragments and papules, is present (Appendix B, Fig B1, 11). It was subsequently affected by fine rooting and the formation of biogenic calcite roots/root cell pseudomorphs. It appears to be a calcareous pond marl formation.

40–70 mm: Above the marl, a chaotic bedded mixture of silty and clayey soil and fragmented clayey textural pedofeatures (papules, *sensu* Mücher 1974) occur (Appendix B, Fig B1, 12). Later sedimentation (from 35–40mm above) resulted in major chalky clay inwash affecting this layer, forming infills and micropans (Appendix B, Fig B1, 13). These included locally fragmented 'soil' from this sub-unit. This layer, which is rather porous was affected by calcitic root pseudomorphs and rare gypsum formation.

This sub-unit probably records the erosive soliflual deposition of silty and clayey soil material, which had eroded from ('older') soils that had probably already formed (earlier) under cool humid conditions (*cf* Boxgrove Unit 11; Macphail 1999a; see also Fedoroff *et al* 1990). There were also subsequent effects of chalk inwash from above (see below). Later rooting and recent gypsum formation occurred, the last possibly the result of local gypsum cement working (F Wenban-Smith pers comm).

35–40 mm: Upwards, there are partially burrowed, fragmented and discontinuous layers of chalky clay containing finely fragmented soil from below, and weakly calcareous coarse silt and fine sands (Appendix B, Fig B1, 13). The layer also contains some coarse sand and traces of possible landsnail fragments. Major secondary gypsum formation and minor calcite root replacement, while partially ferruginised recent (?) roots are visible. This layer probably resulted from erosive intermittent chalky mud and silty-fine sand deposition; chalk muds washed into layer below. Underlying soil-sediments were also eroded presumably from upslope, and fine soil fragments became included in these sediment layer. It appears that there was colluvial erosion and deposition from two different source areas forming intercalated fan deposits. Later fine rooting, and more recent rooting and burrowing occurred after major gypsum formation. The last relates to recent gypsum cement working in this location.

0–35 mm: At the top of thin section M54, a massive non-calcareous silt loam formed of sub-welded rounded aggregates (Appendix B, Fig B1, 14), with few fine (1mm) rounded sharp edge iron and manganese nodules, is present. There are very abundant internal intercalations and exterior intercalations/oriented clay around rounded soil aggregates and nodules. Minor amounts of gypsum occur. This sub-unit records muddy colluvial soil-sediment formation from unstable slope soils that had locally and very recently formed as slurries, then locally reworked downslope (*cf* Boxgrove Unit 11, Macphail 1999, fig 83p). These slope soils probably developed in local decalcified brickearth, with the minor humus content inferring occasionally short-lived vegetated surfaces were present. The literature clearly shows that deposits of different textures react differently to cool climate conditions, here silty clay loams are present (Van Vliet 1982).

Molluscs

Preliminary assessment of material from this section was undertaken by Preece in 1997 (URL 1997a, appendix

Table 11.3 Section 193 molluscs

Sample	Context (Phase D)	*Bithynia tentaculata* opercula	*Valvata piscinalis*	*Galba truncatula*	*Radix balthica*	*Stagnicola palustris* agg.	*Gyraulus crista*	*Anisus leucostoma*	*Musculium lacustre*	*Sphaerium* spp.	*Pisidium henslowanum*	*Pisidium moitessierianum*	*Vallonia pulchella*	*Vallonia* sp.	*Deroceras*/ *Limax* spp.	*Clausilia* sp.	*Cernuella virgata*	*Cecilioides acicula*	**TOTAL**	Notes
72	1960	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	No shells
73a	1960	–	–	4	4	–	–	1	–	–	–	1	–	–	–	–	–	–	10	
73b	1960	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	1	
74a	1960	–	3	16	2	–	1	11	1	–	–	–	–	1	–	–	–	–	35	
74b	1960	1	3	37	16	–	2	19	–	1	1	1	1	1	1	1	2	–	87	*Clausilia* sp. prob. modern
33	1960	–	1	2	6	1	–	12	–	–	–	–	–	–	–	–	–	1	23	*C. acicula* intrusive species
75	1960	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	No shells
76	1968	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	No shells
77	1968	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	No shells
78	1968	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	No shells
79	1969	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	No shells
80	1970	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	No shells
63	1970	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	No shells

Table 11.4 Section 193 ostracods from monolith 40

Context	1960	1959	1968	
Sample	40/1	40/2	40/3	40/7
Depth in monolith	0–70 mm	7–140 mm	140–190 mm	400–500 mm
Candona neglecta	xx (j)	–	–	–
Herpetocypris sp.	x	–	–	–
Ilyocypris sp.	x	–	–	–
Pseudocandona sp.	x	–	–	–
*Leucocythere batesi**	–	–	x	–

KEY: *– species extinct within MIS 5–2;
shaded blue – cold/cool ostracod indicators;
x – a few specimens; xx – common; (j) mainly juveniles

12) and this was augmented more recently by the analysis of a number of additional samples by Preece and White. The initial assessment from contexts 1960 and 1970 (193-D) indicated that *Lymnaea* sp. and *Planorbis* sp. were present in both contexts suggesting an element of waterborne niches. Terrestrial molluscs (*Trochulus hispidus* and *Pupilla muscorum*) were also recovered from context 1960 and suggested possible open grassland conditions perhaps linked to cooler climates.

Processing of additional samples indicated that significant numbers of shells were only present in a few samples. However, several additional species to the four noted by Preece in 1997 were recorded (Table 11.3). The samples are presented in stratigraphical order. Context (1960) was the only context to yield shells; sample 74b is by far the richest, with 87 countable specimens. It is important to note that sample 33 is *c* 1.5m away from the other samples (Fig 11.2), which were otherwise recovered from a roughly vertical sequence through the deposits.

The shelly samples are dominated by aquatic taxa, especially *Galba truncatula* and *Anisus leucostoma*, with *Radix balthica* as a subordinate. These species characterize small stagnant pools, often those prone to drying out in summer; *G. truncatula* in particular is amphibious and can live on damp muddy areas on floodplains and similar situations. Shells of species more characteristic of fluvial situations (eg, *Pisidium henslowanum*, *Pisidium moitessierianum*) were probably washed into these deposits during times of flood. Terrestrial molluscs (*Trochulus hispidus* and *Pupilla muscorum*, both species of open grassland conditions often linked to cool conditions) were also recovered from context 1960.

Ostracods

Assessment of a variety of samples across the full stratigraphic sequence were undertaken (Appendix D) but ostracods were only recovered from contexts 1968 and 1960 from 193-D (Table 11.4). These samples contained very sparse faunas but the presence of *Leucocythere batesi* in context 1968 indicates cold climate conditions at the time of deposition (Whittaker and

Table 11.5 Section 193 OSL dating results (*poorly constrained date)

Phase	Context	Sample	Lab ID	Depth (m)	OSL date (KBP)	Error range (± KBP)
193-G	1961 (L) [=1973 U]	56	X-3001	1.10	15.76	1.41
193-G	1962 (M)	57	X-3002	1.50	17.92	1.23
193-D	1968 (P)	58	X-3003	2.30	97.20	7.75
193-D	1968 (P)	59	X-3004	2.85	91.24	8.96
193-D	1970 (R)	60	X-3005	3.55	*[85.72]**	*7.01*

Table 11.6 Amino acid racemisation dating results from Section 193

Laboratory sample number	Species	HYD	Average/SD HYD	Average/SD HYD BAL 3355
BAL 3355 A	*Trochulus hispidus*	0.066	0.056	0.070
		(0.046)	(0.014)	(0.015)
BAL 3355 B	*Trochulus hispidus*	0.055	0.056	–
		0.057	0.001	–
BAL 3355 C	*Trochulus hispidus*	0.086	0.084	–
		0.085	0.003	–
		0.081	–	–
BAL 3355 D	*Trochulus hispidus*	0.064	0.065	–
		0.071	0.006	–
		0.060	–	–
BAL 3355 E	*Trochulus hispidus*	0.096	0.096	–

Horne 2009). The presence of abundant remains of the ostracod *Candona neglecta* suggests permanent and temporary small waterbodies in open grassland or small, slow moving streams.

Dating

Five samples were dated by OSL (Fig 11.2b; Table 11.5). These samples derived from 193-D (58, 59, 60) and from 193-G (56, 57). The dates suggest that the sediment dated in 193-D are mostly likely to date to MIS 5b while the sediments from 193-G are of MIS 2 age.

Amino acid data from context 1960 are derived from two sources. Initial investigation was undertaken in 1997 by the Bergen Amino Acid Laboratory in Norway on samples of *Trochulus hispidus* from sample 33 (Table 11.6). When compared with data from Bowen *et al* (1989), the results suggested that context 1960 was younger than the grey brickearth at Trafalgar Square but older than Layer G at Halling (Kent) (Table 11.7).

An additional analysis was undertaken on a single *Bithynia* operculum from context 1960 (Table 11.8; Appendix E). The D/L Hyd vs D/L Free values for this operculum from this sample are shown in Figure 7.5, together with values from other Ebbsfleet sites and reference sites in Southern England. The results indicate a date of MIS 5e.

Table 11.7 Comparative amino acid racemisation ratios from key UK sites

Site, unit	Age ascription	Mean/SD
Halling, Layer G	late Last Glacial	0.036 ±0.001
Ebbsfleet HS1, Section 193, context 1960		0.070 ±0.015
Trafalgar Square, grey brickearth	Last Interglacial, MI Stage 5e	0.113 ±0.005
Portland Bill, Head	MI Stage 6?	0.197 ±0.02
Woodston, Basal beds	MI Stage 11	0.236 ±0.027
Bushley Green, Basal beds	MI Stage 11	0.235 ±0.01

Section 193 Overview

The evidence obtained from the field and laboratory investigation of the sediments in this profile suggests accumulation of the stratigraphy during cool to cold climate conditions. This interpretation has been made on the basis of the nature of the sediments themselves (both at the macro-scale in the field and the micro-scale through thin section analysis) and their contained palaeoenvironmental information. Detailed investigation only took place on sediments from the end of Section 193 and in particular phases 193-D and 193-G.

Molluscs recovered from context 1960 (within 193-D) are dominated by aquatic taxa the characteristically occur in small stagnant pools that may be subject to drying in summer. A local river is attested to in the nearby environment by the presence of flowing water species that were probably introduced through flooding and hence a situation marginal to the contemporary floodplain is likely for this context. A similar scenario is indicated by the single sample (from 1960) with abundant remains of ostracods in which *Candona neglecta* occurs. This species frequently occurs in permanent and temporary small waterbodies in open grassland or small, slow moving streams. Evidence in the sediment micromorphology for colluviation and inwash of sediment and soil material under cool conditions is attested to in both K-49 and K-51 from context 1960.

Phase 193-D has been dated by three OSL dates from contexts below context 1960, which indicate deposition with MIS 5, probably 5b. Amino acid results likewise suggest a date in MIS 5. The initial results from the Bergen laboratory suggested that the deposit post-dates MIS 5e. In contrast, the subsequent single ratio from a *Bithynia* opercula suggested an MIS 5e age.

Table 11.8 Amino acid racemisation dating of *Bithynia* operculum from Section 193

Result	Phase	Context	Sample No.	Lot No.	Species	No. shells	Lab code	MIS	Comments
CTRL-E15	193-D	1960	74	1932	*Bithynia* operculum		NEaar-4906	5e	Only a single operculum; may be reworked

However, this should be treated with caution given that the fluvial element in the molluscan assemblage may have been reworked. However, this result at least gives a maximum possible age for this particular sediment body.

This evidence therefore suggests that much of the lower part of the sequence below the dated contexts are either ascribed to the colder parts of MIS 5b or 5d or to a pre-Last Interglacial date. A major hiatus is also inferred between context 1960 and the dated parts of phase 193-G where OSL dates suggest accumulation of this part of the sequence following the Last Glacial Maximum. At this point it is unclear whether phase 193-E belongs to the earlier or later phase of depositional activity, however, given its apparent erosional relationship with 193-D and the inter-fingering of deposits in 193-E and 193-G at the northern end of the trench (Fig 11.2b) it may be associated with the post Last Glacial Maximum event represented by 193-G.

Villa Trench (ARC EBB01)

Introduction

A deep trench within the central part of the Roman Villa site was excavated to sample the underlying Pleistocene stratigraphy (Fig 11.1). The section was stepped to allow access and the exposed section was recorded (Fig 11.3, Pl 11.2).

Lithological Succession

These deposits can be subdivided into five major phases of sediments (Table 11.9), all lying between 4.3m and -0.15m OD (at maximum sequence thickness):

VT-A: This is a loose, stratified (sub-horizontally) sandy gravel (16769) with a bimodal grain size distribution of the gravel. The sediments (although only minimally exposed at the base of the trench) appear to be fluvially deposited by high-energy river systems probably under cold climate conditions.

VT-B: The sediments belonging to this phase (16768) consist of mixed sandy-silts and gravels. The gravels are poorly sorted and include flint and chalk. The sediments appear to dip downslope and are probably coarse soliflucted sheets of gravel derived from higher up slope.

VT-C: This phase of sediments (16767) consist of laminated sandy-silts and silts with occasional carbonate nodules. Laminations are discontinuous and sub-horizontal. The origin of these sediments is difficult to ascertain but deposition either in floodplain marginal situations or shallow slopes through sheet wash and/or gentle colluviation is likely.

VT-D: This phase of contexts (16765, 16766) consists of silty fine sands becoming sandier upwards into 16765. Occasional patches of carbonate nodules as well as poorly-preserved sub-horizontal bedding noted in places. Some gravel stringers noted in 16765. These are probably colluvial slopewash sediments deposited under cool climate conditions. A change in sediment source up-profile is indicated by the increase in grain size.

VT-E: The uppermost sediment (16764) consists of an orange brown silty fine to medium sand. Charcoal flecks are common throughout as is evidence for rooting. This is a colluvial deposit probably of Holocene age.

The sediments record a changing local environment from fluvial deposition within a high-energy river channel at the base (VT-A), becoming generally finer upwards to slopewash deposition of sandy sediments during cold conditions (VT-D). Following fluvial activity solifluction deposits (VT-B) on an active slope seem to have dominated for a while before giving way to a series of finer-grained sediments. The lowermost part of this sequence of finer sediments (VT-C) appears to be a low energy colluvial or floodplain edge sequence. Slopewash processes subsequently dominate sequence accumulation at this point in the site.

Sediment Micromorphology

Thin sections were examined from samples 13105, 13108 and 13106 from this trench.

M13106, context 16767(VT-C): This sample derives from the very top of VT-C just below the contact surface with VT-D. This is a moderately well-sorted coarse silt

Table 11.9 Villa Trench stratigraphic sequence, phasing and distribution of specialist and dating studies

Phase	Contexts	Lithology	Palaeoenvironmental data	OSL date (KBP)
VT-E	16764	Orange-brown silty fine to medium sand. Charcoal flecks are common throughout as is evidence for rooting	Micromorphology	–
VT-D	16765, 16766	Silty fine sands becoming sandier upwards into 16765. Occasional patches of carbonate nodules as well as poorly preserved sub-horizontal bedding noted in places. Some gravel stringers noted in 16765	Micromorphology	15.87±1.65
VT-C	16767	Laminated sandy-silts and silts with occasional carbonate nodules. Laminations are discontinuous and sub-horizontal	Micromorphology, ostracods	121.63±13.29
VT-B	16768	Mixed sandy-silts and gravels. The gravels are poorly sorted and include flint and chalk. The sediments appear to dip downslope	–	–
VT-A	16769	Loose, stratified (sub-horizontally) sandy gravel (16769) with a bimodal grain size distribution of the gravel	–	162.59±30.35

Plate 11.2 Villa Trench section

and fine sand, with laminae of now-ferruginised fine soil clasts, and has a horizontal fine fissured weakly-formed lenticular microstructure. It displays weakly formed link capping (and associated matrix intercalations infilling horizontal voids) and a well developed banded fabric of thin (1mm) 'clean' (elutriated) minerals alternating with thick (4mm) iron-stained laminae containing more fine fabric and soil clasts (Appendix B, Fig B1, 3, 15–16). Many fine root pseudomorphs and associated micritic impregnative hypocoatings occur. The sediment is a colluvium composed of sloping laminated coarse silts and fine sands, which also included concentrations of fine soil clasts. The deposit was subsequently affected by weak freeze-thaw ice fissuring (because it is relatively coarse), localised elutriation and deposition of fine fabric concentrations, and subsequently soil wetness led to iron-staining of these fine fabric-rich layers; hence banded fabric formation and weak lenticular microstructure and localised fragmentation of banded fabric soils (Appendix B, Fig B1, 1, 15–16) (Van Vliet 1982; 1985; 1998). In comparison to context 16766 higher up, for example, perhaps more moist and less intense extreme freezing effects are recorded (Romans and Robertson 1974).

M13106, context 16767 gravel band: This gravel is composed of very poorly-sorted calcareous coarse silt to very coarse sand-size quartz (with shell, embedded grains, flint, ironstone, soil clasts (argillic papules) and chalk), with frequent 2–3mm size chalk and few quartzite gravel (max 7mm) (Appendix B, Fig B1, 1). Matrix micropans and infills are present. This layer represents a moderately high energy and probably erosive, colluvial gravel (fan) spread, perhaps relating to spring melting and soliflual activity.

M13108, context 16766 (VT-D): This is a massive and coarsely fragmented sediment made up of calcareous coarse silt-fine sand and coarse silt-sand with little fine fabric. There are both link cappings and banded fabrics with very abundant intercalations. A fine channel microstructure and calcitic root pseudomorphs is present at the base of the thin section; the sediment becomes more horizontally fissured and less porous upwards (Appendix B, Fig B1.2). Here, cool climate, freeze-thaw (very poorly humic) soils developed in low energy solifluction deposits, with a period of vegetated soil formation being recorded. Ensuing solifluction and renewed freezing and thawing, 'buried' this soil, destroying some soil structures and creating a fragmented and fissured soil. Seasonal cool climate soil formation in active soils on a slope is apparently recorded.

M13108, context 16765: Like the gravel layer at the top of context 16767 (see note above regarding contexts), context 16765 is a poorly-sorted sand and gravel, with soil fragments, coarse chalk and shell, merging and mixed laterally with coarse silt-fine sands (as

Table 11.10 Villa Trench, ostracods from Section 18044

Context	16767										
Sample	**13123**	**13124**	**13125**	**13126**	**13127**	**13128**	**13129**	**13130**	**13131**	**13132**	**13133**
Depth in monolith	**0–5cm**	**5–10cm**	**10–15cm**	**15–20cm**	**20–25cm**	**25–30cm**	**30–35cm**	**35–40cm**	**40–44cm**	**44–47cm**	**47–50cm**
Ilyocypris sp.	–	x	–	x	–	–	–	–	–	–	–
*Leucocythere batesi**	–	–	x	x	–	x	x	–	–	–	–
*Amplocypris tonnensis**	–	–	–	x	x	x	x	–	–	–	–
*Tonnacypris convexa**	–	–	–	–	–	–	x	–	–	–	–

KEY: * – species extinct within MIS 5–2; x – a few specimens
shaded blue – cold/cool ostracod indicators

Table 11.11 OSL dating results from the Villa Trench

Phase	Context	Sample	Lab ID	Depth (m)	OSL date (KBP)	Error range (± KBP)
VT-D	16765	13112	X-3006	0.85	15.87	1.65
VT-C	16767	13114	X-3008	1.80	121.63	13.29
VT-A	16769	13115	X-3009	3.75	162.59	30.35

below). The junction between 16766 and 16765 is marked by a mixed and fragmented (micro-faulted) boundary. This is another moderately high-energy colluvial sands and gravel (fan) sediment, again possibly related to spring melting and soliflual activity.

M13105, context 16765 (VT-D): This is moderately sorted coarse silt-fine sand, that is calcareous and with relict laminae at the base of the thin section (70–75mm); upwards it becomes massive, decalcified and weakly structured. The sediment was also affected by very broad (4–6mm) burrowing-in of once humic soil (iron-replaced humus). In addition, there are examples of wood charcoal (Appendix B, Fig B1, 17), a burned iron nodule and burned (calcined) flint near a burrow. Micromorphology shows decalcification and soil formation in the upper part of once calcareous and laminated and muddy colluvium. The small (2mm) charcoal (Appendix B, Fig B1, 17) and burned flint and iron nodule that are present are near once-humic very broad burrow infills. The relict humic soil is possibly derived from a landsurface that is no longer present, whilst the anomalous presence of charcoal and burned minerals is possibly intrusive from later activities (a Roman ditch is nearby); on the other hand, rare charcoal grains can be found in Pleistocene soils (*cf* Boxgrove; Macphail 1999, fig 83).

M13105, context 16764 (VT-E): This is a decalcified moderately sorted coarse silt-fine sand, which is massive with fine channels, fissures and vughs, and displays rare micritic impregnation. This is a poorly humic decalcified soil formed in once-calcareous and laminated colluvium (base of 16765). The boundary is marked by once-humic, now-ferruginised very broad burrow fills of unknown date/origin, but if Roman these burrows would probably contain mainly non-mineralised organic matter.

Small Vertebrates

Material was extracted from samples 13117–13122. Biological remains were sparse and several samples contained recent contamination in the form of ceramics, glass and mortar. The sparse small mammal remains may be intrusive from the overlying Roman deposits.

Molluscs

Six samples were assessed from the presence of molluscs from the sequences in the Villa Trench but only a single *Pupilla* shell was found in context 16767, sample 13122.

Ostracods

The samples all derive from context 16767 (VT-C) (Appendix D; Table 11.10). Only four species were present in the samples examined. All the samples contained a few individuals including well-known cold ostracod indicators (colour-coded blue), most notably *Leucocythere batesi* as well as *Amplocypris tonnensis* and *Tonnacypris convexa*. The evidence suggests a cold climate associated with a glacial or stadial period, or the very beginning or end of an interglacial.

Dating

Three samples were dated by OSL (Fig 11.3; Table 11.11), from phases VT-A, VT-C and VT-D. The results suggest that the sediment dated in VT-A belongs to MIS 6 while that from VT-C dates to early in MIS 5. The uppermost body of sediment belonging to VT-D dates to MIS 2.

Villa Trench Overview

The basal gravels (VT-A) have been dated to the penultimate cold stage (MIS 6) by OSL and appear to have been fluvially deposited in a high energy, probably braided river system. They are overlain by cold stage solifluction deposits that therefore probably date to the middle or end of MIS 6. The overlying sands, of phase VT-C, are dated by OSL to early in MIS 5 and have yielded cold ostracod faunas. It is therefore most likely that

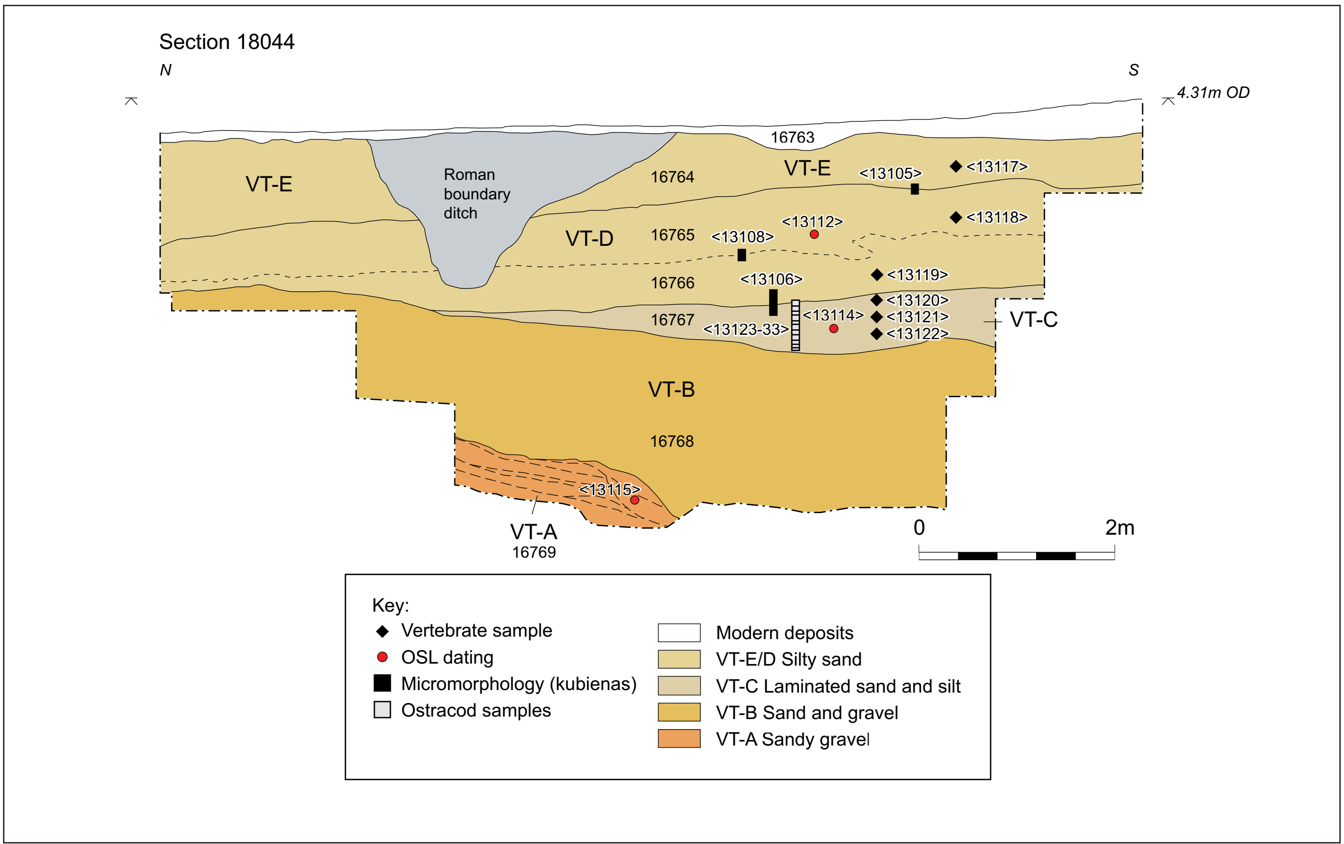


Figure 11.3 Villa Trench, Section 18044

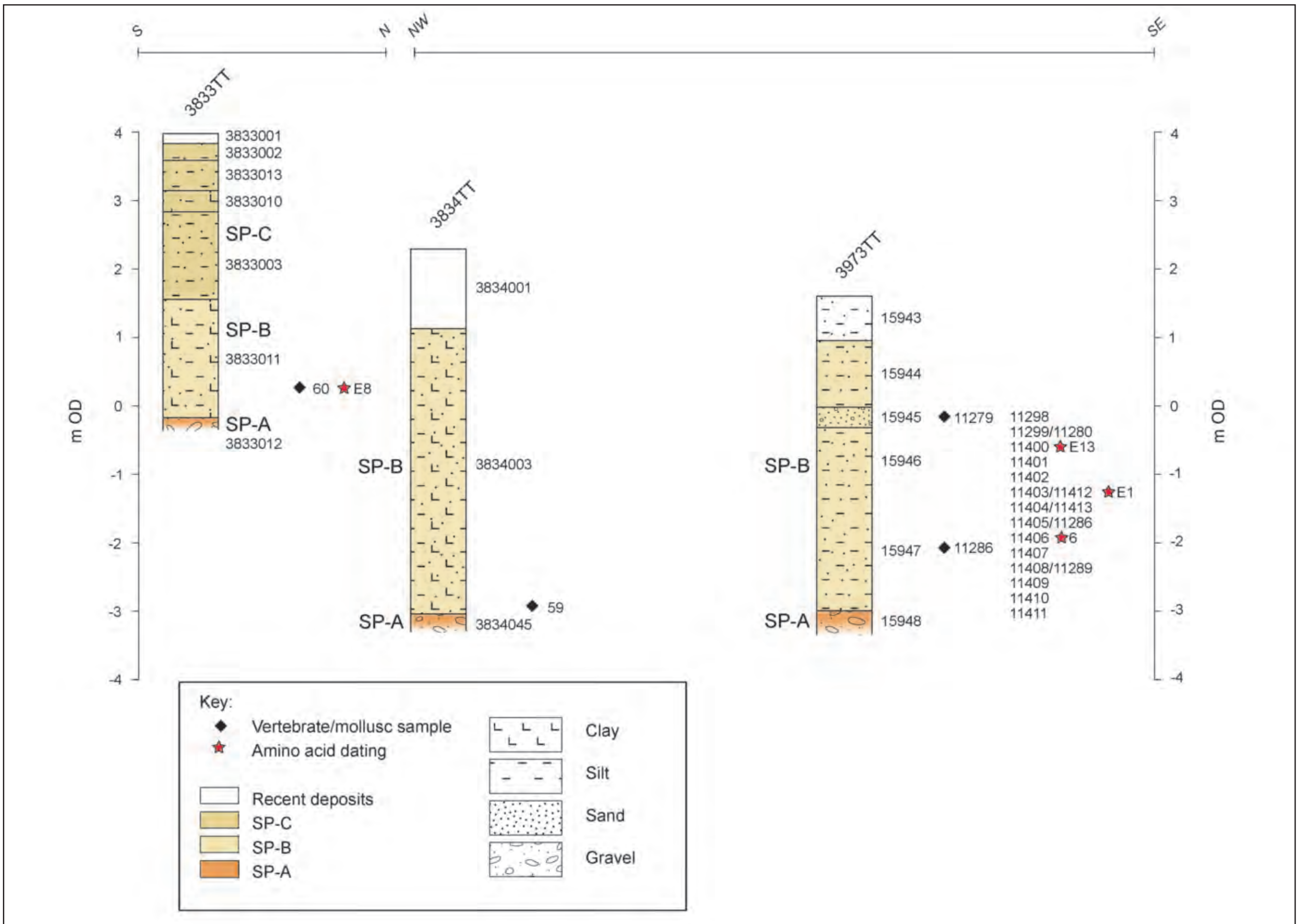


Figure 11.4 Logs of trenches 3833TT, 3834TT, 3835TT and 3973TT

the VT-C sands date to either the very end of MIS 6, or MIS 5d. Both the ostracods and the micromorphological evidence (Appendix B) suggest deposition in small waterbodies, fed perhaps by slope wash activity. Cold climate processes impacted on this sequence.

A major hiatus exists at the top of VT-D and the overlying sands post-date the Last Glacial Maximum. Deposition through slope wash colluvial processes characterise this sequence.

Spur End Trenches (ARC ESG00)

Introduction

A series of deep trenches was excavated in the north-west part of Zone 7, towards the floodplain (Fig 11.1; URN2001a). Inspection of the detailed records from these trenches suggested that one coherent body of sediment had been sampled and consequently four of these (3833TT, 3834TT, 3835TT and 3973TT) are treated as a group the 'Spur End Trenches'. The logs of the sections are presented in Figure 11.4. In each case access to the trenches was prohibited and all recording and sampling was undertaken from the surface. Test pits were excavated by machine.

Lithological Succession

These deposits can be subdivided into three major groups of sediments (Table 11.12; Fig 11.4), all lying between 4.0m and -3.30m OD (at maximum sequence thickness):

SP-A: Deposits belonging to this group are noted in 3830TT (3830011), 3833TT (3833012), 3834TT (3834045) and 3973TT (15948). These deposits consist of poorly-sorted flint gravels with variable quantities of chalk in some places. Because of access difficulties, it was not possibly to examine the sediments closely to determine their origin; either deposition in high-energy fluvial conditions or as periglacial solifluction events is likely.

SP-B: Deposits belonging to this group are noted in 3833TT (3833011), 3834TT (3834003), 3835TT (3835005, 3835015, 3835016, 3835020) and 3973TT (15944, 15945, 15946, 15947). These deposits consist of the main body of sediments in the spur area. Typically, they consist of bedded sandy-silts to silty-sands with occasional diffuse bands of gravel. Local carbonate concretions are noted in places. These sediments appear to be of colluvial origin deposited on low angle slopes, in shallow pools associated with undulating surfaces on the slopes or at the base of the slope where slopes give way to aquatic environments.

SP-C: Deposits belonging to this group are only present in 3833TT (3833010, 3833003). These deposits are dominated by sands and sandy-silts. Accumulation under colluvial conditions is likely. These may be Holocene in age.

This sequence of deposits consists of a major body of sand-dominated sediments (SP-B) accumulating under colluvial conditions where derivation of the sediments is probably from the east or south-east. Deposition of these sediments is likely to have occurred under sub-aerial conditions although local deposition in pools or at the edge of the contemporary floodplain is also likely. The basal part of the sequence (SP-A) remains difficult to ascribe to particular environments of deposition but cold climate conditions are almost certainly associated with their accumulation.

Vertebrates

Several bulk samples were taken from deposits of phase SP-B (Fig 11.4). This batch of samples is characterised by generally low abundance of vertebrate remains. None of the fragmentary large mammal remains was

Table 11.12 Spur End stratigraphic sequence, phasing and distribution of specialist and dating studies

Descriptor	Contexts	Lithology	Palaeoenvironmental data	Dating (AAR)
SP-C	3833003 3833010	Sands and sandy-silts		
SP-B	3833011 3834003 3835005 3835015 3835016 3835016 3835020 15944 15945 15946 15947	Bedded sandy-silts to silty-sands with occasional diffuse bands of gravel. Carbonate concretions are noted in places	Molluscs, ostracods, vertebrates	MIS 5a-6
SP-A	3830011 3833012 3834045 15948	Poorly sorted flint gravels, variably chalk-rich in places		

Table 11.13 Molluscs, 3973TT

Phase	SP-B																
Sample	11289	11287	11285	11411	11410	11409	11408	11407	11406	11405	11404	11403	11402	11401	11400	11299	11298
Aquatic																	
Bithynia tentaculata	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
Galba truncatula	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
Pisidium spp.	–	–	1	–	–	–	–	–	–	2	–	2	–	–	–	–	–
Total aquatic		**1**	**1**							**2**		**2**					**2**
Land																	
Succinella oblonga	3	97	18	–	–	–	–	–	–	5	18	29	–	–	4	1	2
Pupilla muscorum	27	304	218	15	7	17	–	1	1	12	114	41	1	2	34	15	6
Deroceras/Limax spp.	3	22	20	–	–	–	–	–	–	–	6	–	–	–	2	1	2
Total land	**33**	**423**	**256**	**15**	**7**	**17**	–	**1**	**1**	**17**	**138**	**70**	**1**	**2**	**40**	**17**	**10**
Total shells	**33**	**424**	**257**	**15**	**7**	**17**	–	**1**	**1**	**19**	**138**	**70**	**1**	**2**	**40**	**17**	**12**

identifiable, but molars of narrow-skulled vole *Microtus gregalis* and collared lemming *Dicrostonyx* sp. were present in 3973TT in context 15945 (sample 11279) and 15947 (sample 11286) respectively in SP-B. These rodents indicate the coldest conditions of any of the Ebbsfleet small mammal assemblages and suggest local vegetation at the time was dominated by open dry grassland or tundra. In this environmental setting the presence of fire-cracked flint and calcined bone in context 15946 is intriguing. Many of the samples also contained abundant rhizoliths and large (pedogenic) carbonate nodules which, if contemporary with the deposits, would indicate a vegetated land surface.

Molluscs

A series of samples (Table 11.13) from 3973TT (SP-B) are dominated by three terrestrial taxa (*Pupilla muscorum, Succinella oblonga* and *Deroceras/Limax* spp.). This group is characteristic of dry, open environments; the low species diversity is also suggestive of cooler climatic conditions. A minor background component of aquatic taxa (*Galba truncatula* and *Pisidium* spp.) suggest that shells were occasionally introduced by a river in flood; the rarity of such material suggests that the river was not very close and that only the most extensive floods had any impact.

A single sample (60) from context 3833011 (3833TT), was recovered from a silty sand body beneath the villa at *c* 0m OD (Table 11.14). Few molluscs were recovered; only eight specimens of *Pupilla muscorum* and a single slug plate of *Deroceras/Limax* sp. were recorded.

Three further samples, recovered from the same silty sand body beneath the villa, relate to the middle of this deposit between 3834TT and 3833TT (Table 11.14). Three species of terrestrial mollusc were recorded; *Pupilla muscorum, Succinella oblonga* and *Deroceras/Limax* sp. A single valve of *Pisidium* spp. suggests that the area was quite a distance from the nearest waterbody, which might supply aquatic taxa during times of flood.

Table 11.14 Molluscs, 3833TT

Sample	Elevation (m OD)	*Pupilla muscorum*	*Succinella oblonga*	*Deroceras/ Limax* spp.	*Pisidium* sp.	**Total**
60	0	8	–	1	–	**9**
107/108	-0.5 to 1.0	–	–	–	–	–
109	-1.7	80	35	23	1	**139**
59	-3	76	12	20	–	**108**

Ostracods

Two samples (Table 11.15) from 3973TT contained ostracods from the top part of context 15947 (SP-B). The samples both contained cold ostracod indicators (colour-coded blue), most notably *Leucocythere batesi* as well as *Amplocypris tonnensis* and *Tonnacypris convexa*. Sample 11413 was significantly rich with no less than nine cold species in total (representing a most diverse and abundant suite of ostracods). This assemblage is clearly *in situ*. Both samples seem to indicate a cold climate and must relate either to a glacial period, or to the very beginning or end of an interglacial.

Dating

No OSL dates are available from these sections. However, amino acid dating was carried out on *Pupilla* specimens from deposit phase SP-B from 3833TT (CTRL-E8) and 3973TT (CTRL-6, CTRL-E1 and CTRL-E13). The data from 3973 TT (Fig 7.8; Appendix E) show close similarity in values for the hydrated vs free D/L values of Asx, Glx, Ala and Val for the bleached (intra-crystalline) shell fraction with *Pupilla* from Cassington, Oxfordshire (MIS 5a, Maddy *et al* 1998). This contrasts with the values from the *Pupilla* from 3833TT which are statistically higher and cluster closer to the values recorded from the site at Portfield Pit, Westhampnett East in West Sussex (probably MIS 6, Bates 1998).

Table 11.15 Ostracods from context 15947

Context	15947				
Sample	11412	11413	11415	11417	11418
*Amplocypris tonnensis**	x	xx	–	–	–
*Eucypris dulcifons**	x	xx	–	–	–
*Limnocythere falcata**	x	x	–	–	–
*Leucocythere batesi**	x	xxx	–	–	–
Limnocytherina sanctipatricii	x	x	–	–	–
Ilyocypris sp.	x	x	–	–	–
*Eucypris heinrichi**	–	x	–	–	–
Trajancypris laevis	–	x	–	–	–
Candona candida	–	x	–	–	–
*Tonnacypris convexa**	–	x	–	–	–

KEY: * – species extinct within MIS 5–2; x – a few specimens; xx – common; xxx – abundant
shaded blue – cold/cool ostracod indicators

Spur End Trenches Overview

Superficially, the sequences present in the test pits around the end of the spur appear similar and consist of a tripartite sequence of fluvial or solifluction deposits (SP-A) overlain by cold climate slope wash deposits (SP-B) and probable Holocene colluvium (SP-C). A rich ostracod fauna from phase SP-B in trench 3973 TT produced an ostracod fauna indicating cold glacial conditions. Vertebrate faunal material is sparse; where present the rodents indicate the coldest conditions of any of the Ebbsfleet small mammal assemblages and suggest local vegetation at the time was dominated by open dry grassland or tundra. Molluscs indicate similar environments with some aquatics introduced by flooding.

Dating by amino acid geochronology suggests two very different ages for the sediments dated. The samples dated from the three levels within deposit phase SP-B in 3973TT provide consistent values that indicate a date late in MIS 5 (possibly 5a or 5b), probably the former considering the cold ostracod fauna, or perhaps the sediments date to MIS 4. By contrast the single dated sample from 3833TT suggests a significantly older date, probably within MIS 6.

Revetment Sections (ARC EBB01)

Introduction

Two shallow sections (18531 and 18532) exposed behind a revetment of Roman date were recorded (Figs 11.1, 11.5). The logs of the sections are presented in Figure 11.6.

Lithological Succession

These deposits can be subdivided into three major groups of sediments, all lying between *c* 0.5m and –0.90m OD (at maximum sequence thickness):

REV-A: Deposits belonging to this group include context 19364 which is present in both sections. This is a medium sand body with patches of carbonate material. Traces of flint gravel appear in places and the unit is bedded locally. This may be a fluvial sediment laid down under cold climate conditions. Alternatively, the sediment may be a solifluction deposit.

REV-B: Deposits belonging to this group include 19363 from both sections. This is a variably chalky and flint-rich gravel that is poorly sorted. The sediment is crudely sub-horizontally bedded. The deposit is probably a soliflucted gravel.

REV-C: Deposits belonging to this group include 19362 from both sections. This deposit consists of a slightly silty sand that may have been laid down by colluvial processes.

Vertebrates

From Section 18531, only three of the samples from context 19364 yielded vertebrate remains. In addition to the fragmentary large mammal bones from the sieved samples, a bovid humerus shaft fragment and a bison metatarsal were found during the excavation. Measurements of the bison metatarsal (Bp 57.4mm; SD 34.7mm) indicate a small individual, comparable in size to those from the Last Cold Stage in Britain.

Six samples were processed from Section 18532 from context 19364. Identifiable large mammal remains include a bovid horncore fragment from sample 12230 and a fragment of a canid lower carnassial from sample 12231. The canid tooth fragment is probably from a large wolf (*Canis lupus*). Small mammal remains were also present, but these were scarce and mostly unidentifiable. An important exception is the upper second molar of a water vole (*Arvicola* sp.) from sample 12231. This molar has undifferentiated enamel, which is characteristic of most northern European Late Pleistocene (and some late Middle Pleistocene)

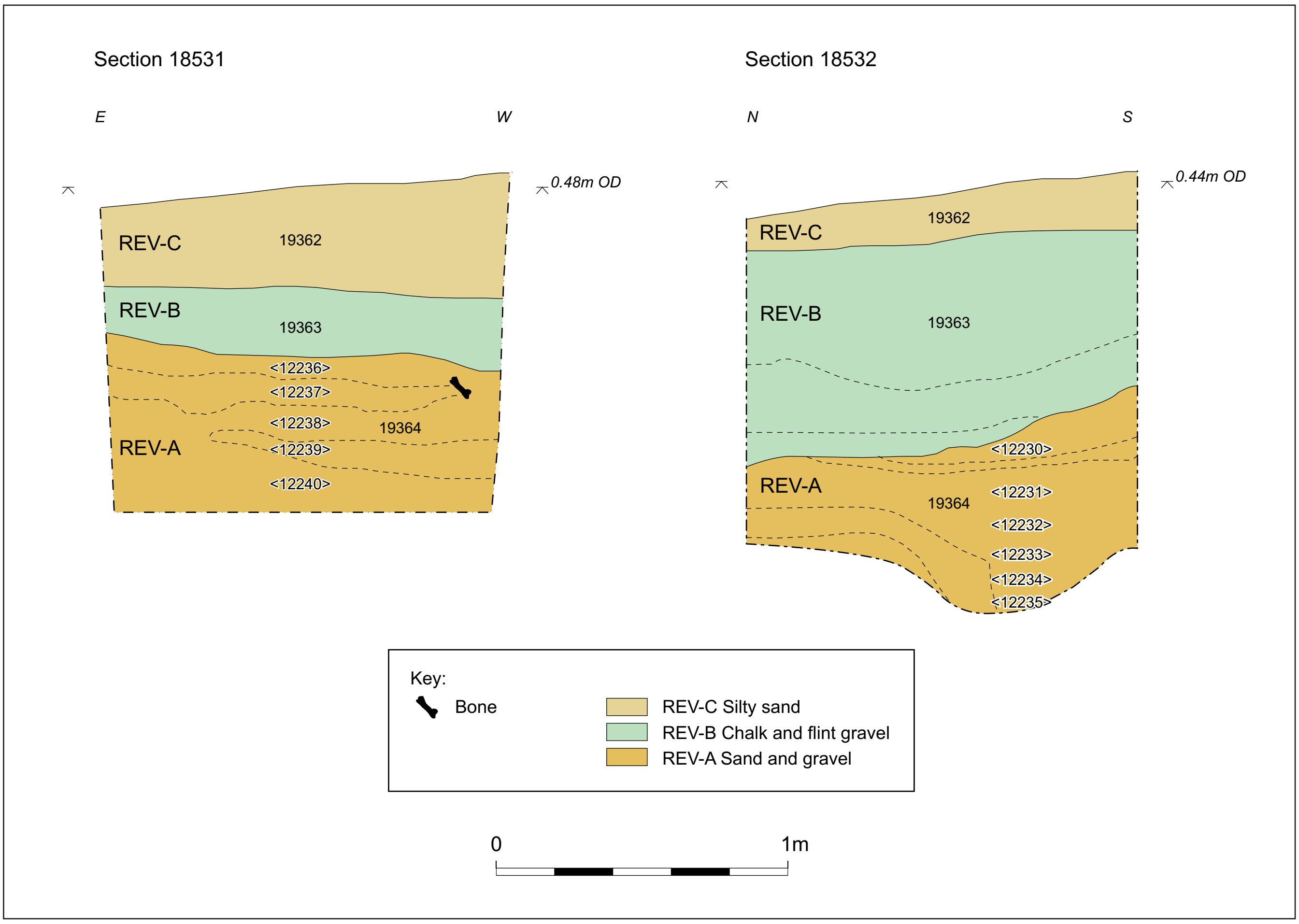


Figure 11.5 Revetment Sections 18531 and 18532

populations (Koenigswald and Kolfschoten 1996; Kolfschoten 1990). The sparse vertebrate assemblage provides scant environmental information, but the water vole suggests grassland.

Revetment Sections Overview

The sedimentary sequence indicates that accumulation of the sediments occurred under cold climate fluvial or solifluction conditions. This interpretation is supported by the vertebrate evidence, which although sparse suggests grassland associated with a cool climate. No chronometric dating evidence is available for these sequences.

Zone 7 Synthesis

The evidence obtained from the field and laboratory investigation of the sediments in the profile (Figs 11.6 and 11.7) suggests that accumulation of the stratigraphy has occurred in a complex fashion over a considerable time period. With the exception of the Villa Trench sediments (Fig 11.3) the sediments within the profiles are typically poorly-sorted solifluction deposits or finely bedded sands where the bedding implies a colluvial origin for the sands. This evidence is supported by the mollusc and ostracod evidence (where available) indicating base of slope, shallow pools and occasional flood events from the river within a predominantly grassland environment. Thus, the majority of the sequences appear to have accumulated as a result of the net movement of sediment downslope under gravity, in minor channels or slurries of sediment during spring thaw events in the colder phases of the Pleistocene. The exception to this is the sediments at the base of the Villa Trench sequence where fluvial gravels were observed beneath the slope wash sediments. Correlation of the main bodies of sediments is attempted in Table 11.16.

The dating evidence for the timing and duration of events of deposition is constrained by the OSL age estimates and the chronological framework supplied by the AAR results. It is clear that four broad phases of dated accumulation of sediments can be defined:

1) MIS 6. The fluvial sediments at the base of the Villa Trench sequence (phase VT-A) have been dated to 162.59±30.35 KBP, in the heart of MIS 6. Likewise, amino acid data from *Pupilla* from the base of phase SP-B in the adjacent trench (3833TT,) suggest correlation with deposits elsewhere in southern England of an MIS 6 age.
2) MIS 5e. A single OSL date from sands in the Villa Trench (phase VT-C) provides an age within the Last Interglacial (MIS 5e).

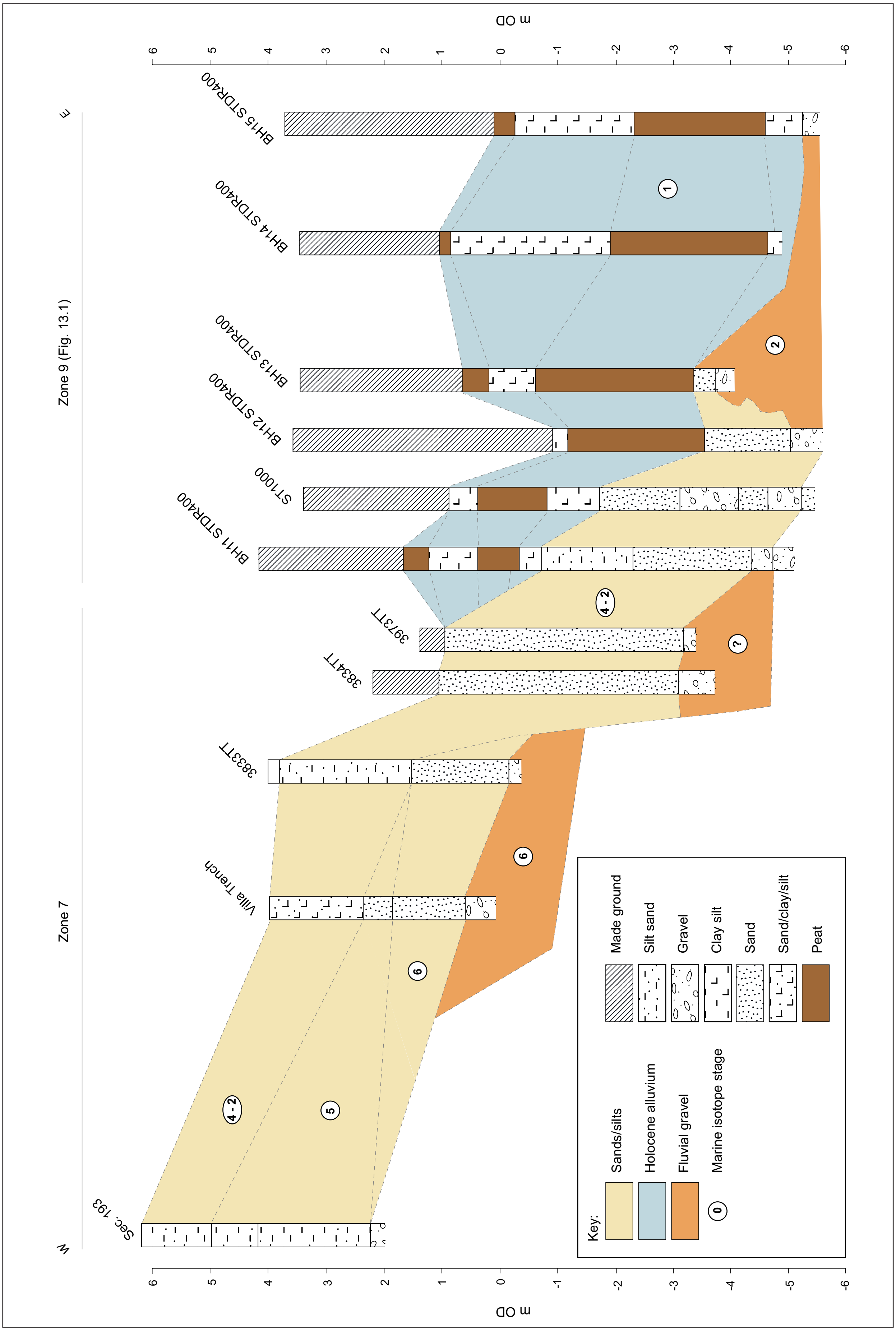


Figure 11.6 Zone 7 long profile

Table 11.16 Stratigraphic phasing and correlations in Zone 7, with proposed MIS attributions

MI Stage	Section 193	Villa Trench	Spur End			Inferred environments and climates of deposition
			3833 TT	3973	REV	
1		E	C			Slopewash, colluvial
2	E?/G	D		C		Cold climate solifluction and colluviation
3						
4						
5a						
5b	D			B/?A		Cold climate solifluction and colluviation
5c						
5d	?A/B/C?					Cold climate solifluction and colluviation
5e		C				Colluvial slopewash under warming or cooling climate
6	?A/B/C?	B	B		?A	Cold climate solifluction and colluviation;
		A	A			high-energy fluvial channel in cold climate with low energy channel-margins

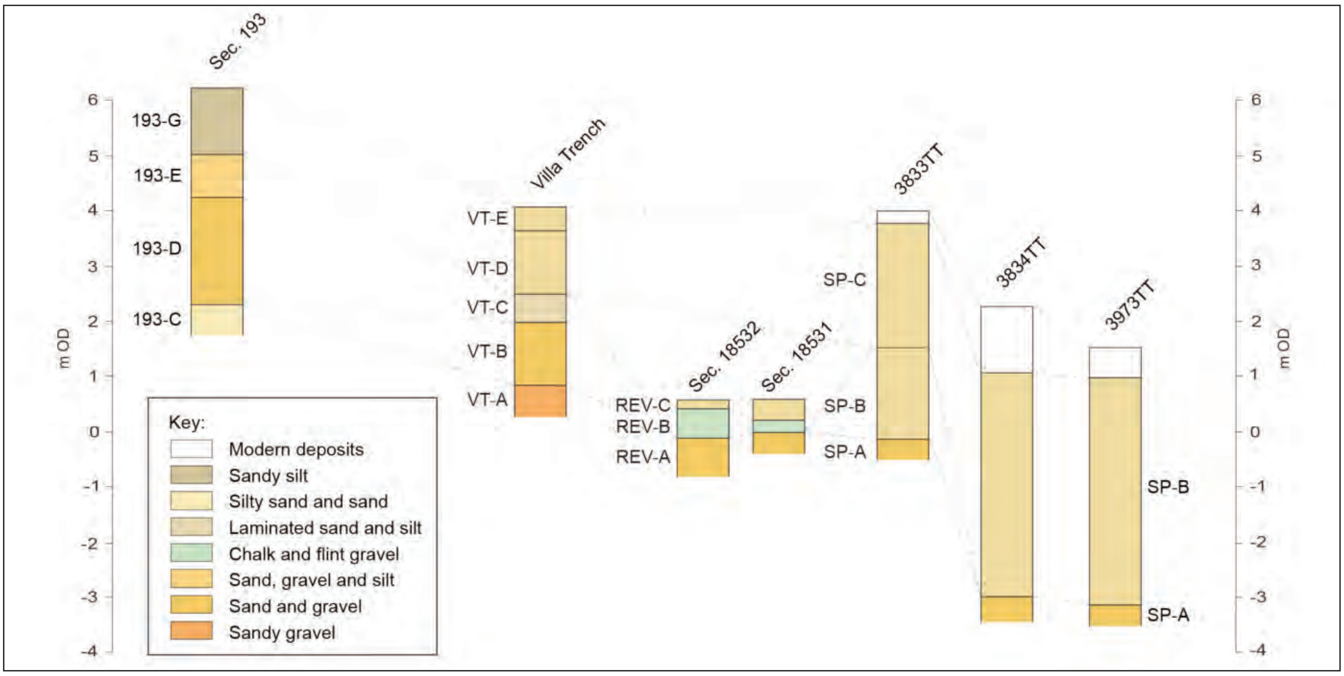


Figure 11.7 Correlation of key sequences

3) MIS 5a/b. OSL ages from Section 193 (phase 193-D) as well as amino acid data from 3973TT (phase SP-B) indicate ages within the later parts of MIS 5 (probably 5a/b).

4) MIS 2. A sheet of sand with ages post-dating the Last Glacial Maximum has been dated in Section 193 (phase 193-G) and the Villa Trench (phase VT-D) to MIS 2.

None of the directly dated sediments (by either OSL or AAR) have provided any indications of sediment accumulation between the end of MIS 5 and MIS 2. Thus, it appears that these climatic stages may have been associated with greater slope instability and downslope movement of sediment than during MIS 3 and MIS 4, when sediment may have been more stable.

The presence of fluvial gravels at the base of the Villa Trench sequence, as well as in trench 3833TT and the revetment Sections 18532, 18531, suggests a substantial episode of fluvial sedimentation with a maximum elevation of *c* 0.7m OD. This was associated with an MIS 6 age in the Villa Trench. Fine-grained sediments, possibly fluvial, dated to MIS 5e are present above the fluvial gravels in the Villa Trench. Subsequently downcutting to datums below -3m OD must therefore have taken place during the following cold stage, the Devensian, from any time after or including MIS 5d. A subsequent phase of gravel aggradation at these lower elevations is attested to in 3834TT and 3973TT. Dating evidence from 3973TT suggests that this later phase of gravel accumulation occurred within MIS 5 (either 5d or 5b) prior to the accumulation of the initial phases of the overlying sandy deposits. Evidence for sediment movement and accumulation between the end of MIS 5 and MIS 2 is absent in this area indicating a degree of slope stability throughout much of the last cold stage in this sector of the landscape.

Chapter 12

Outer Basin (Zone 8)

by Elizabeth Stafford, Martin Bates, Nigel G Cameron, Sylvia Peglar, Ruth Pelling, Rob Scaife and John E Whittaker

Introduction

Zone 8 is located in the low-lying floodplain area in the northern most area of the HS1 land-take (see Chap 4; Figs 4.1, 12.1). Although Pleistocene deposits are present at depth, the focus of the HS1 and STDR4 investigations were the extensive and well-preserved deposits of Holocene age that dominate the upper part of the sequences likely to be affected by construction.

An extensive array of borehole data, recovered during the various evaluation stages of the project (EBBS97, ARC EFT97, ARC ESG00 and STDR400, Chap 3; Table 3.4) revealed deep sequences of Holocene alluvial deposits up to *c* 10m in thickness preserved along the valley central axis, overlying Pleistocene fluvial and soliflucted sands and gravels (Fig 12.2). The Holocene sequences gradually thinned and became vertically conflated against the rise of the underlying Pleistocene deposits at the valley-side margins. Geoarchaeological modeling of the surface of the Pleistocene deposits (ie, the early Holocene topographic template) revealed a deep basin-like feature running along the valley axis, accounting for the greater depths of alluvium in this area (see Chap 16, Fig 16.6). The Holocene deposits infilling this basin comprised a complex sequence of minerogenic sands silts and clays intercalated with more organic units. These organic units include a major peat bed that can be divided in places into a lower wood peat and an upper reed peat. An 'Upper Peat' bed was also noted at a number of locations lying directly beneath deposits of modern made ground.

The key representative sequence from the deepest part of the basin is from Borehole 7 (BH7), recovered during the STDR400 evaluation. BH7 covered one of the longest time spans of all the sequences investigated in this zone and for this reason it was chosen for detailed palaeoenvironmental and dating work (Fig 12.1). Artefactual material, including occasional worked and burnt flint as well as charcoal fragments, was recovered at a number of locations. In Borehole 11 (BH11, EBBS97), within the central part of the basin, this was associated with the early part of the sediment sequence dated to the Late Mesolithic period. However, the majority of direct evidence for human occupation was located within shallower trenches and test-pits distributed along the margins of the Outer Basin and included Area 1 (STDR401) and Trenches 1 and 2 (EBBS97). A summary of each of these sequences is included in Table 12.1 and in the following sections. The results of the radiocarbon dating for this zone are presented in Table 12.2.

Borehole 7 (STDR400)

Introduction

This borehole was drilled during the STDR4 evaluation phase, to a maximum depth of 10.34m. Ground level measured 3.04m OD. A total of 13 U4/U100 cores were retrieved during drilling for detailed sediment description and palaeoenvironmental work. Unfortunately, one of the cores (core 19) within the main peat unit was lost during the assessment and analysis stages of work. Overall nine radiocarbon dates were processed from this borehole and a number of samples examined for a variety of palaeoenvironmental indicators (Fig 12.3; Tables 12.1 and 12.2).

Lithological Succession

The detailed sediment descriptions are presented in Table 12.3 and the location of sub-samples in Figure 12.3. The

Table 12.1 Zone 8 key interventions and range of environmental and dating studies

Project	Key locations	^{14}C	Pollen	Diatoms	Ostracods	Plants	Archaeology
STDR400	BH 7	X	X	X	X	–	–
EBBS97	BH 11	X	–	–	–	x	–
EBBS97	Trench 2	X	–	–	–	x	Worked and burnt flint, charred hazelnuts
STDR401	Area 1	X	x	–	X	–	Late Bronze Age channel revetments, Iron Age artefacts

KEY: X – analysis, x – assessment level only

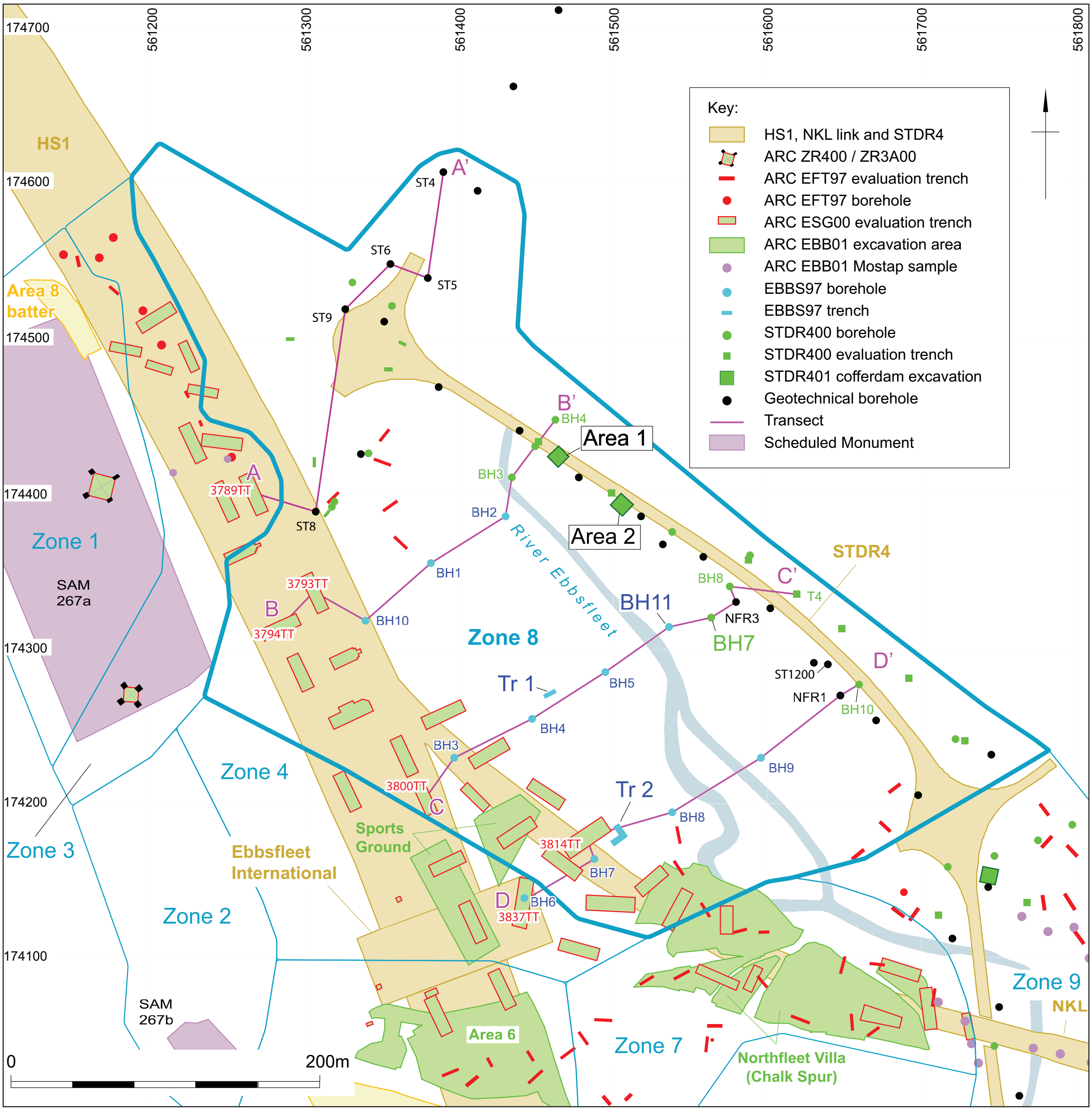


Figure 12.1 Zone 8 layout and key intervention locations

base of the recorded sequence comprised coarse flint gravel of Late Pleistocene age, the surface of which was recorded at -7.19m OD (10.23m depth). This was overlain by a series of intercalated fine grained minerogenic deposits of silty sands and organic silt sandy silts to -6.3m OD (9.35m depth). Above -6.3m OD the deposits became more clayey comprising inorganic silty clays, laminated in places. A major change in lithology occurred at -4.96m OD (8.00m depth) with the commencement of peat accumulation which continued to -2.82m OD (5.86m depth). Initially the peat was quite woody, however from -3.20m OD (6.24m depth) tufa deposits were noted, occurring as both dense lenses and a micritic deposit precipitated within the peat. The peat was sealed by *c* 3.5m of minerogenic silty clays that showed some horizontal bedding structures, and at 0.74m OD (2.30m depth) an upper unit of silty peat. The sequence was capped by 1.75m of modern made ground deposits.

Dating

Overall nine radiocarbon dates were processed from the sediment sequence in BH7 (Fig 12.3; Table 12.2). The purpose of the dating was to provide a broad

Table 12.2 Radiocarbon dates from sediment sequences, Zone 8

Event code	Feature/layer type	Sample	mBGL/mOD	Material dated	Lab code	$\delta^{13}C$ ‰	Result BP	Calibrated date (2 sigma, 94.5%)
STDR400 BH7	Base of upper peat	Core 3	2.16/+0.88	*Sambucus* seeds	NZA-28620	-25.3	1196±30	710–940 cal AD
	Base of upper clay silt	Core 13	5.42/-2.38	*Carduus*/ *Cirsium* sp. seed	NZA-28973	-27.2	3527±30	1940–1750 cal BC
	Top of peat with tufa	Core 15	5.90/-2.86	*Rubus* sp. seed	NZA-28971	-27.0	3836±50	2470–2140 cal BC
	Top of major peat horizon	Core 17	6.40/-3.36	*Alnus glutinosa* twig	NZA-28869	-29.2	4448±30	3340–2940 cal BC
	Within major peat horizon	Core 17	6.83/-3.79	*Alnus glutinosa* mature wood, outer rings	NZA-28867	-23.0	4820±25	3700–3520 cal BC
	Within major peat horizon	Core 21	7.87/-4.68	2 *Alnus glutinosa* seeds	NZA-28972	-27.2	5263±55	4240–3970 cal BC
	Bottom of major peat horizon	Core 21	8.13/-4.94	3 *Alnus glutinosa* seeds	NZA-28974	-26.6	5464±35	4370–4240 cal BC
	Lower organic silt	Core 25	9.35 to 9.44/ -6.30 to -6.39	Bulk sediment	WK-8801	-28.6	6340±80*	5480–5070 cal BC
	Lower organic silt	Core 27	9.77/-6.73	Bulk sediment	NZA-28766	-30.3	9122±55	8540–8240 cal BC
STDR400 BH8	Lower organic silt	–	9.35 to 9.44/ -6.34 to -6.43	Bulk sediment	WK-8802	-	5880±60*	4910–4580 cal BC
STDR400 Area 1	Staked revetment 1071	–	–	Roundwood (cf. *Frangula alnus*)	SUERC-19949	-26.4	2615±30	835–765 cal BC
	Cobbled surface 1012	–	–	Cattle femur	SUERC-19947	-21.8	2385±30	730–390 cal BC
	Coppiced roundwood bundle (faggot) 1062	–	–	Roundwood (*Corylus avellana*)	SUERC-19948	-25.5	2280±30	410–200 cal BC
EBBS97 BH5	Bottom of major peat horizon	–	7.40/-4.37	Roundwood	Beta-108111	-28.3	5770±60	4730–4490 cal BC
EBBS97 BH9	Within major peat horizon	–	5.85/-2.66	Roundwood	Beta-108112	-28.3	5260±60*	4240–3960 cal BC
EBBS97 BH11	Lower organic silt –	–	9.10 to 9.15/ -6.18 to -6.23	Charred *Corylus* nutshell	Beta-108113	-25.5	6420±50	5490–5310 cal BC
EBBS97 Tr. 2	Bottom of major peat horizon 211	–	3.80/0.40	*Corylus* nutshell	Beta-108114	-28.9	4480±40	3350–3020 cal BC

* Bulk radiometric date

Table 12.3 Borehole 7 (STDR400) lithological description

Depth (m)	Description
0.00–1.96	Made ground
1.96–2.03	Cobble
2.03–2.30	Silty peat: 10YR 2/2 very dark brown. Rare clay patches, common fresh root and ligneous fragments. Firm, compact peat with abundant silt running throughout. Massive structure. Clear boundary to:
2.30–2.55	Silty clay: 2.5Y 3/2 very dark greyish-brown. Common poorly degraded root fragments. Rare silt throughout. Firm, compact with fine discontinuous parallel laminae. Merging to:
2.55–2.60	Silty clay: 2.5Y 4/2 dark greyish-brown. Occasional poorly degraded root fragments, very rare fine silt disseminated throughout. Firm, compact clay with patchy discontinuous even, parallel laminae. Diffuse to:
2.60–2.72	Silty clay: 10YR 3/2 very dark greyish-brown. Abundant poorly degraded root fragments and frequent silt throughout. Firm, compact clay, fine parallel discontinuous laminae. Diffuse to:
2.72–2.93	Silty clay 10YR 4/2 dark greyish-brown. Rare ferrous patches. Massive, patchy structure with horizontal cracks. Unknown lower boundary (missing)
2.93–3.28	Silty clay: 5Y 3.2 dark olive grey. Rare silt disseminated throughout. Rare ferrous patches. Massive firm structure. Merging to:
3.28–3.37	Silty clay: 2.5Y 3.2 very dark greyish-brown. Rare sand disseminated throughout. Rare clay patches and ferrous patches with some crystallisation. Massive, firm structure, horizontal cracking. Clear to:
3.37–4.24	Silty clay: 5Y 3/2 dark olive grey clay. Massive firm structure with horizontal and vertical cracks. Discontinuous non-parallel laminae. Unknown lower boundary
4.24–4.87	Silty clay: 5Y 3/1 very dark grey. Common fine silt running throughout. Firm, compacted with horizontal cracks. Parallel discontinuous laminae. Unknown lower boundary
4.87–5.86	Silty clay: 5Y 3/2 dark olive grey. Common silt running throughout. Lenses of fine sand at 5.2–5.21m, 5.38–5.39m & 5.4–5.41m. Firm, compacted with horizontal cracks. Parallel discontinuous laminae. Clear boundary to:
5.86–6.05	Peat with tufa: 2.5Y N2/black well humified, crumbly peat with crumbly tufa disseminated throughout. Moderately compacted. Merging boundary to:
6.05–6.24	Tufa: 2.5Y 7/3 pale yellow. Common root matter throughout. Crumbly, moderately compacted. Unknown lower boundary
6.24–8.00	Peat: 7.5YR N2/black moderately humified crumbly peat. Wood content increasing with depth. Poorly humified wood macrofossil at 6.63–6.75m. Firm, moderately compact
8.00–8.25	Clay with silt: 5Y 3/1 very dark grey. Rare silt running throughout. Rare small wood fragments. Firm, compact. Parallel discontinuous laminae. Clear boundary to:
8.25–8.54	Clay with silt: 2.5Y 4/2 dark greyish-brown. Rare silt and rare root fragments throughout. Compact, firm with discontinuous laminae. Merging to:
8.54–8.70	Clay with silt: 2.5Y 3/2 very dark greyish-brown. As above in all aspects except colour. Common yellowy patches. Merging to:
8.70–8.80	Clay with silt: 2.5Y 4/2 dark greyish-brown. Rare silt and rare root fragments throughout. Compact, firm with discontinuous laminae. (As 8.35–8.54)
8.80–9.35	Clay with silt: 5Y 2.5/1 black. Common silt disseminated throughout. Compact, firm with horizontal cracks. Discontinuous horizontal laminae. Clear to:
9.35–9.55	Organic sandy silt: 10YR 2/1 black. Common root matter throughout. Sand content increases with depth. Firm, compact with faint horizontal continuous laminae
9.55–9.74	Silty sand: 5Y 5/3 olive grey. Rare clay nodules <3mm. Compact. Merging to:
9.74–9.85	Organic sandy silt: 2.5Y 3/2 very dark greyish-brown. Rare clay nodules <3mm. Compact, dense. Merging to:
9.85–10.23	Silty sand: 5Y 5/3 olive grey. Rare clay nodules <3mm. Compact. Cracked (polygonal)
10.23–10.34	Gravel

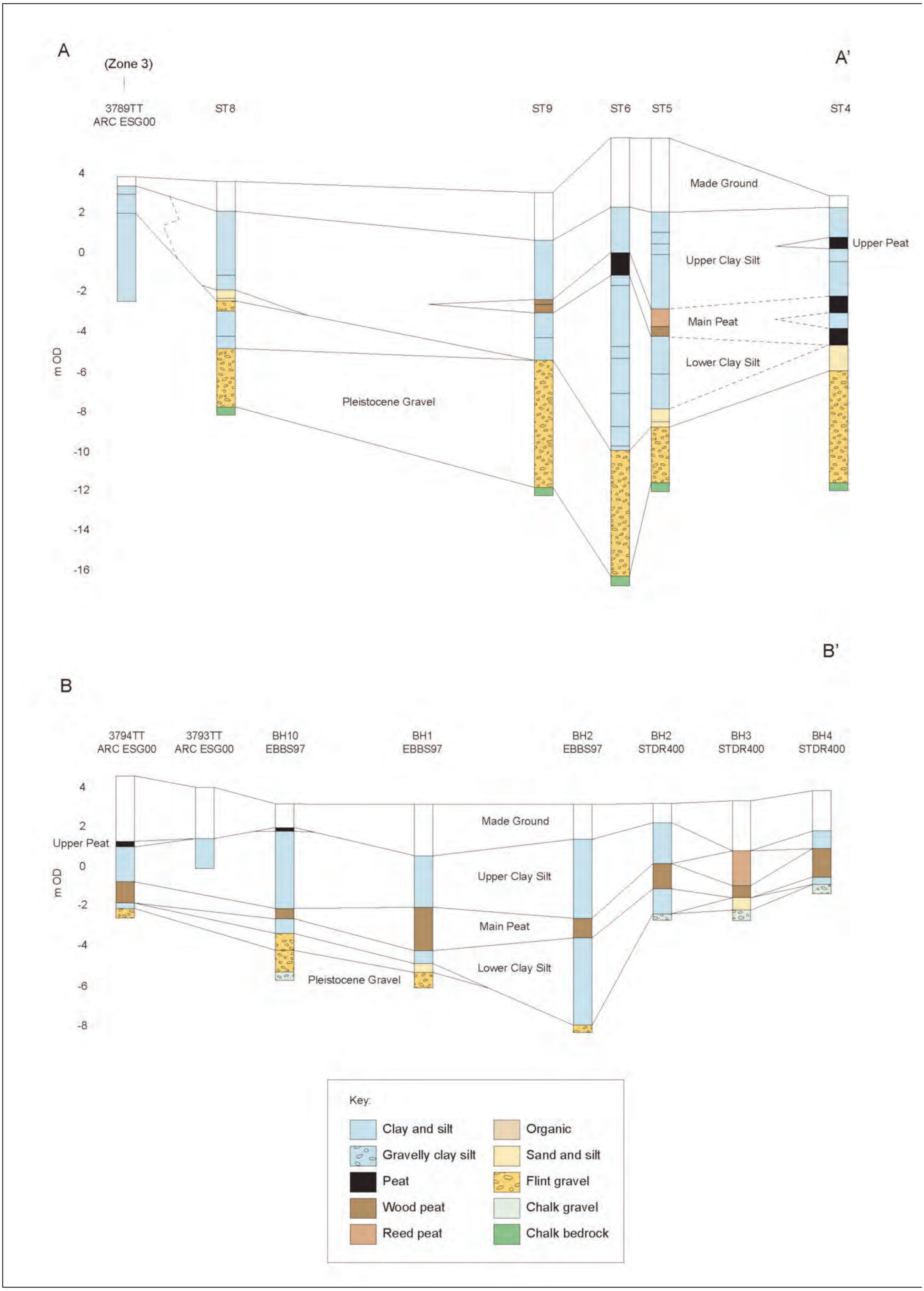
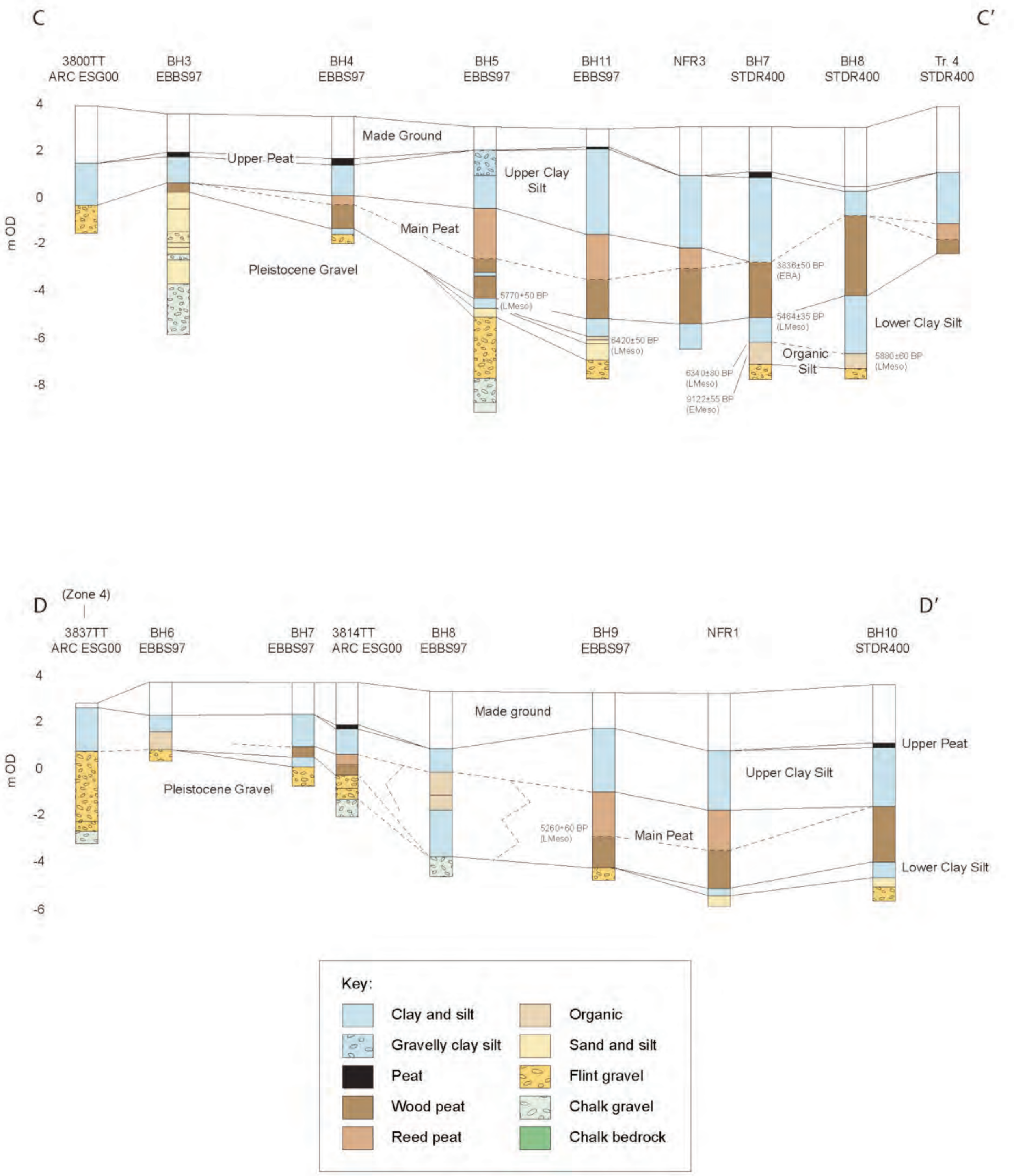


Figure 12.2 Zone 8 long profiles


C
C′
3800TT ARC ESG00
BH3 EBBS97
BH4 EBBS97
BH5 EBBS97
BH11 EBBS97
NFR3
BH7 STDR400
BH8 STDR400
Tr. 4 STDR400
m OD
4
2
0
-2
-4
-6
-8
Made Ground
Upper Peat
Upper Clay Silt
Main Peat
Pleistocene Gravel
Lower Clay Silt
Organic Silt
3836±50 BP (EBA)
5770+50 BP (LMeso)
5464±35 BP (LMeso)
6420±50 BP (LMeso)
5880±60 BP (LMeso)
6340±80 BP (LMeso)
9122±55 BP (EMeso)
D
(Zone 4)
D′
3837TT ARC ESG00
BH6 EBBS97
BH7 EBBS97
3814TT ARC ESG00
BH8 EBBS97
BH9 EBBS97
NFR1
BH10 STDR400
m OD
4
2
0
-2
-4
-6
Made ground
Upper Peat
Upper Clay Silt
Pleistocene Gravel
5260+60 BP (LMeso)
Main Peat
Lower Clay Silt
Key:
Clay and silt
Gravelly clay silt
Peat
Wood peat
Reed peat
Organic
Sand and silt
Flint gravel
Chalk gravel
Chalk bedrock

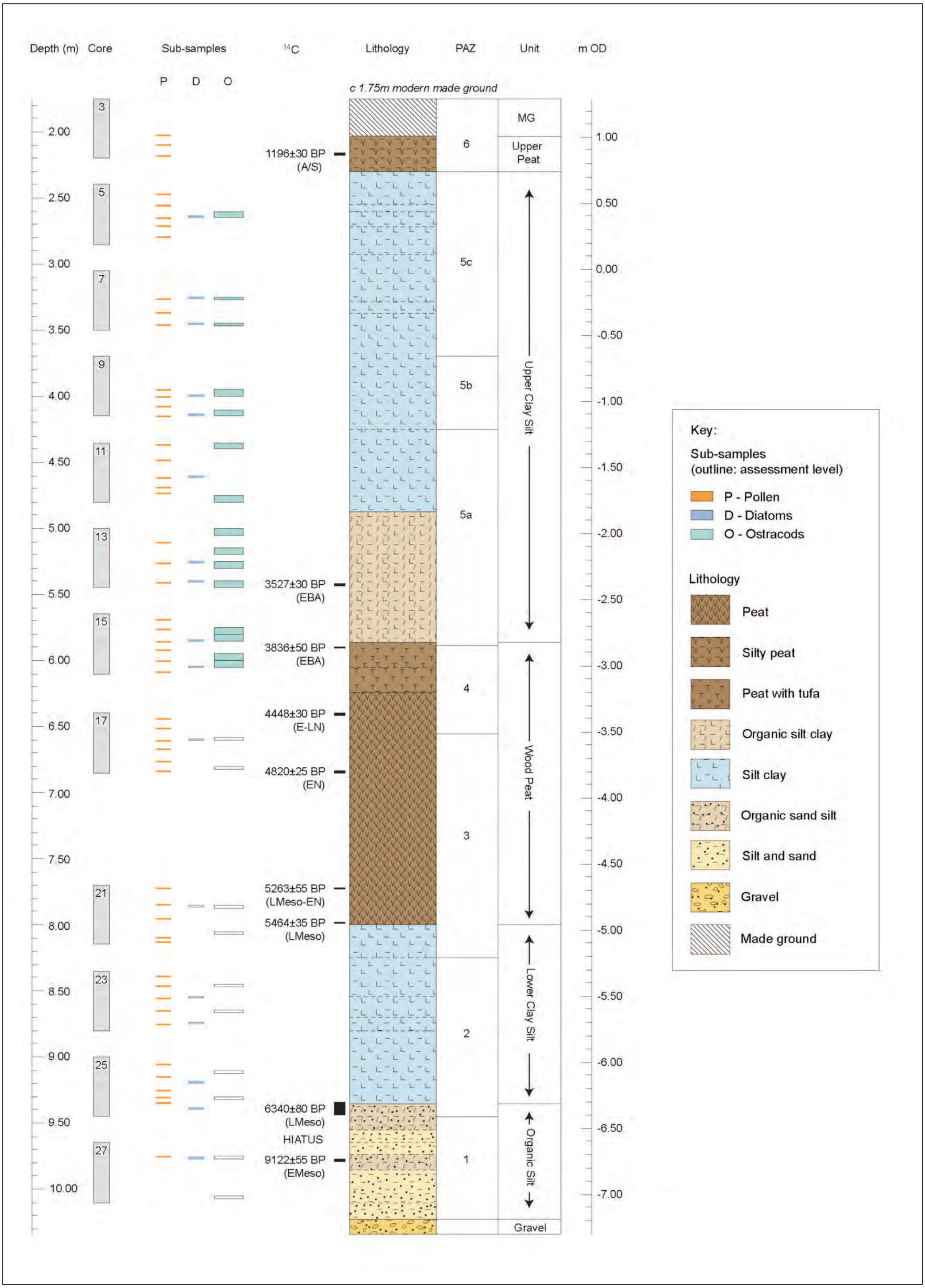


Figure 12.3 Borehole 7 (STDR400) lithology and sample profile

chronological framework for sequence accumulation, as well as to provide dates for key vegetational changes in the pollen spectra.

The earliest date of 9122±55 BP (NZA-28766, 8540–8240 cal BC) derives from the organic sandy silt placing accumulation of the basal part of the sequence within the Early Mesolithic period. Almost immediately above this, however, a Late Mesolithic date of 6340±80 BP (WK8801, 5480–5140 cal BC) from a further unit of organic sandy silt suggests a significant hiatus in the sedimentary sequence between these two units, possibly as a result of erosional processes. The base of the main peat unit was also dated to the Late Mesolithic period at 5464±35 BP (NZA-28974, 4370–4240 cal BC) and accumulation appears to have continued throughout the Neolithic and into the Early Bronze Age period. Tufa formation at the top of the main peat unit, up to -2.86m OD (5.90m depth), appears to have occurred during the Late Neolithic and Early Bronze Age period between 4448±30 BP (NZA-28869, 3340–2940 cal BC) and 3836±50 BP (NZA-28971, 2470–2140 cal BC). The 'Upper Peat' unit at 0.88m OD (2.16m depth) was dated to the middle to late Anglo-Saxon period at 1196±30 BP (NZA-28620, 710–940 cal AD), suggesting a considerable period of accumulation for the intervening clay silt units.

Pollen

by Sylvia Peglar

Samples were analysed from the sequence of sediments in BH7 and six pollen assemblage zones (PAZs) were identified (Figs 12.3 and 12.4; Table 12.4; Huckerby *et al,* Appendix J). This has allowed examination of changes in the local (river valley) and regional (higher drier ground) environments, and variations in sea level from the Mesolithic through to the middle to late Anglo-Saxon period.

Pollen was counted from equally spaced traverses across whole slides at a magnification of x400 (x1000 for critical examinations) until a minimum sum of 450 terrestrial pollen and spores was reached, if possible. Identifications were aided by keys (Moore *et al* 1991; Faegri and Iversen 1989) and a modern reference. Cereal-type grains were defined using the criteria of Andersen (1979). Indeterminate grains were recorded using groups based on those of Birks (1973) as an indication of the state of pollen preservation. Charcoal particles >5 microns were also recorded following the procedures of Peglar (1993). Other identifiable inclusions on the pollen slides (fungal spores, remains of dinoflagellate cysts, foraminfera, turbellarian eggs, pre-Quaternary spores, etc.) were also registered. Plant nomenclature follows Stace (1997).

The results are presented as a pollen and spore diagram (Fig 12.4) with taxa expressed as percentages of the total land pollen and spore sum (sumP). Aquatic taxa and other palynomorphs and charcoal particles are presented as percentages of sumP + sum of the category to which they belong. Calculations and diagrams were made using the programs TILIA and TILIA-GRAPH in TGView (Grimm 1990). The pollen diagram was divided into six pollen assemblage zones (PAZ) using the program CONISS in TGView and by visual examination. The zone boundaries are placed midway between the upper sub-sample of a zone and the basal sub-sample of the zone above.

The Late Glacial and very early Holocene are not represented, but it has been possible to describe the environment and vegetation of the Thames Basin during these periods from sequences found at Bramcote Green, Bermondsey (Thomas and Rackham 1996) and Silvertown, Newham (Wilkinson *et al* 2000). These show that during the Late Glacial there was a treeless landscape with scattered willow bushes with a range of herbs characteristic of arctic/alpine tundra today. At about 10,500 BP birch colonised the land followed by

Table 12.4 Borehole 7 (STDR400) pollen summary

PAZ	Local environment	Regional environment	Human impact
6	Reed/sedge marsh/fen with little evidence of saltwater influx	Very little woodland still extant in area (AP <20%), with further increase in pastures and particularly arable fields	++++
5c	Mid-/upper saltmarsh at base grading into reedswamp with some alder and willow at top. Incursion of salt water greater at base of subzone with freshwater predominating towards the top	Further decrease in deciduous woodland (oak, hazel, ash, birch) with concomitant increase in pastures/meadows. Growth of cereals	+++
5b	Mid-/upper saltmarsh/sedge fen	Further decrease in woodland with evidence for meadows and cereal cultivation	++
5a	Upper saltmarsh/reedswamp with some alder	Grassy meadows/pastures with ribwort plantain and many other herb taxa. Also cereal growth with their attendant weeds. Decrease in deciduous woodland (AP *c* 50%) with the lime decline and a 2nd elm decline at the 4/5 boundary	++
4	Marsh/sedge fen with many ferns Alder carr within river valley	Deciduous woodland of oak, lime, hazel and ash on higher drier ground	+
3	Alder carr	Deciduous woodland of oak, lime, elm and ash on higher drier ground. Primary elm decline probably within missing core	+?
2	Upper saltmarsh/reedswamp with some alder and willow	Deciduous woodland of oak, lime, elm, ash and hazel on higher, drier ground	+?
1	Fast flowing water with scrubby birch and hazel woodland along banks	Deciduous woodland of oak , lime, elm and hazel on drier ground	

KEY: AP – tree and shrub pollen sum; + – negligible; ++ – low; +++ – medium; ++++ – high

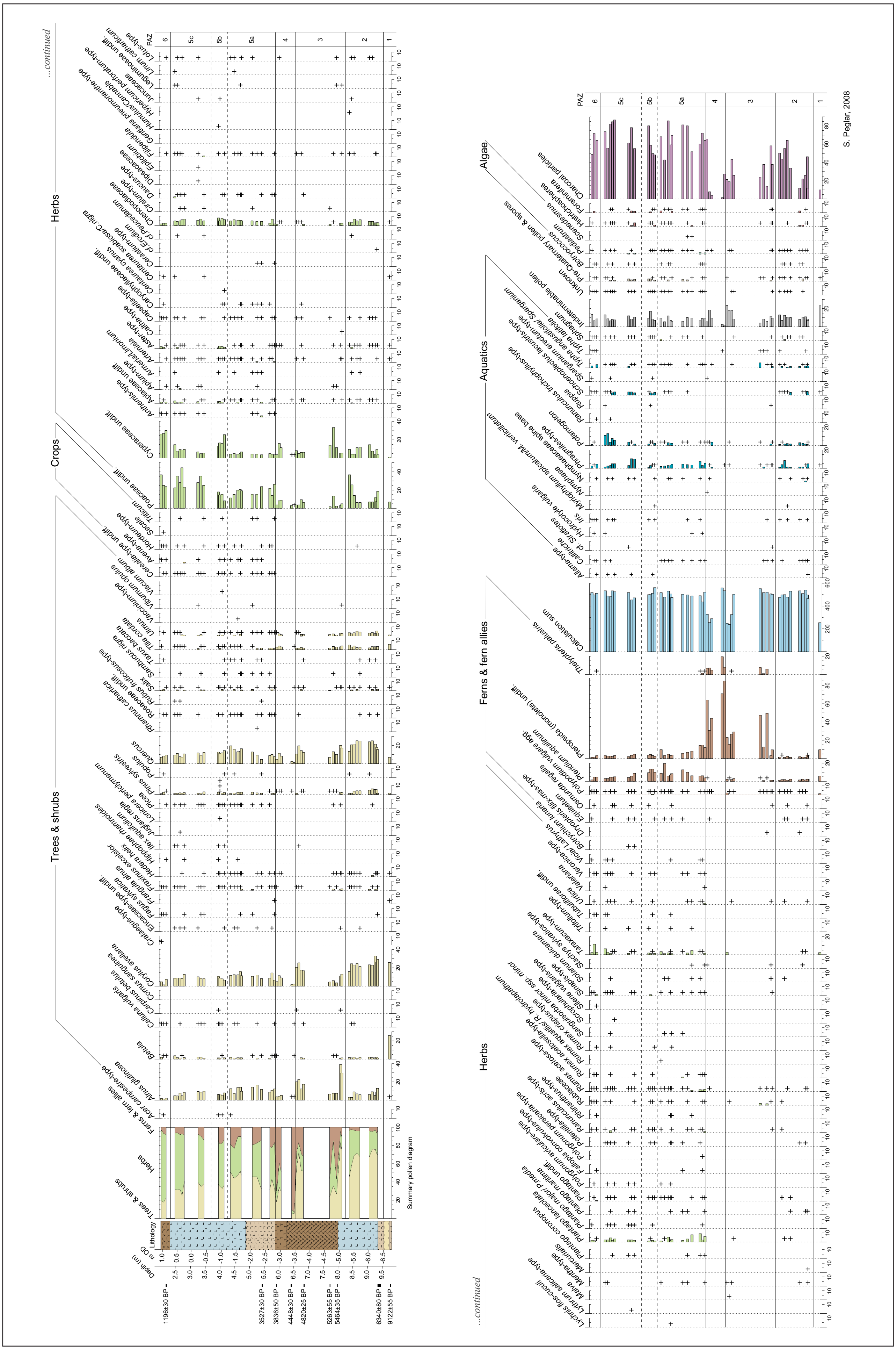


Figure 12.4 Borehole 7 (STDR400) pollen diagram

pine, and, as the climate ameliorated and more temperate trees migrated into the area, mixed deciduous woodland developed.

PAZ 1

Only one sub-sample (-6.71m OD) was analysed from PAZ 1 due to poor preservation. Several other sub-samples were prepared but no countable pollen or spores were preserved. Pollen concentration was extremely low (*c* 5000 grains /cc).

The sub-sample was dominated by tree and shrub pollen (AP) (>70%), particularly that of birch (*Betula*) and hazel (*Corylus avellana*) with a little lime (*Tilia cordata*), oak (*Quercus*) and elm (*Ulmus*). Only one grain of alder (*Alnus glutinosa*) was found. Grasses (Poaceae undifferentiated (undiff.)), ferns (Pteropsida (monolete) undiff.) and bracken (*Pteridium aquilinum*) were also present. The pollen and spores were not very well preserved in this sample, the indeterminable pollen and spore sum was >25%, and this assemblage may therefore be somewhat biased with taxa with robust and easily identifiable grains and spores (eg, dandelion-type (*Taraxacum*-type) and monolete fern spores) being over-represented at the expense of more fragile grains.

The earliest radiocarbon date obtained in BH7 was Early Mesolithic at 9122±55 BP (NZA-28766, 8540–8240 cal BC). However, the basal pollen sample came from 2cm above this and is unlikely to be earlier than *c* 7200 BP (*c* 6000 cal BC) as it contains *Tilia* pollen, known to only have reached the Lower Thames Basin at about this date (Devoy 1979; Huntley and Birks 1983). This suggests that there may be a hiatus in the sediments between the radiocarbon date and the first pollen sample of about 2000 years, possibly caused by channel erosion. The sandy sediments of this zone, together with a lack of aquatic pollen, would suggest that the sediments were laid down by quite strongly flowing water.

The pollen assemblage suggests a rather open scrubby deciduous woodland with birch and hazel and an understorey of grasses and ferns growing on the banks of the river. Clumps of birch pollen were found which suggests that a birch tree(s) was overhanging the site. A clump would probably not survive being washed along in the river, and is therefore good evidence of a very local origin. Further evidence for a river with banks comes from the rarity of pollen taxa associated with reedswamp or marsh. More closed deciduous woodland with a mosaic of lime on the drier soils, and oak, elm and hazel, probably grew further away from the site. Although the sandy silt would have been laid down in an aquatic environment, there is no evidence of any marine influence. This zone correlates with the Mesolithic, but there is very little evidence of any human impact on the landscape at this time. A few microscopic charcoal particles may have come from some distance having been blown or carried into the site by wind or water.

PAZ 2

PAZ 2 is dated to the Late Mesolithic period. There is an abrupt change between the pollen assemblage of PAZ 1 and those of PAZ 2, and a lithological change from sandy sediments to clays and silts, suggesting the development of a gentler sedimentary environment with still or slow flowing water. The pollen concentrations vary greatly throughout the zone, from 5000–111,000 grains/cc, suggesting great variability in the rate of sedimentation from rapid to slow. A greyish-brown organic sandy silt at the base of the zone provided the initial radiometric radiocarbon date of 6340±80 BP (Wk-8801, 5480−5070 cal BC). It is possible that there is a further hiatus in the sediments between pollen PAZ 1 and PAZ 2, particularly given the evidence for strongly flowing water in PAZ 1 which may have scoured the site.

Many telmatic taxa, found growing in the mud/shallow water of reedswamp and marsh, were recorded within this zone – common reed (*Phragmites australis*), common clubrush (*Schoenoplectus lacustris*-type), grasses, sedges (Cyperaceae undiff.), iris, lesser bulrush/bur-reed (*Typha angustifolia*/*Sparganium*), bulrush (*Typha latifolia*), water-plantain (*Alisma*-type), and also floating aquatic taxa such as pondweeds (*Potamogeton*), water starwort (*Callitriche*), water lilies (Nympheaceae leaf spine bases), and the remains of the freshwater green algae Botryococcus and *Pediastrum*. The remains of dinoflagellate cysts and foraminifera could be reworked, but quite high pollen values of the goosefoot family (Chenopodiaceae), a taxon characteristic of saltmarshes and including such genera as glassworts (*Salicornia*), sea-blites (*Sueda*) and saltworts (*Salsola*), suggest that the local environment was being influenced by salt water to some extent, and was probably reedswamp/upper saltmarsh during this period.

Arboreal pollen (AP) averages *c* 70% throughout the zone, mainly oak, hazel, elm, ash (*Fraxinus excelsior*) and lime, with a little pine (*Pinus sylvestris*) and some alder and birch. The pollen assemblages suggest that deciduous woodland with lime, elm, oak, hazel, ash and birch dominated the landscape on drier ground. Alder and willow (*Salix*) values suggest their growth on wetter soils within the river valley. Pine (*Pinus sylvestris*) pollen averages 7% but, as pine produces prodigious amounts of pollen, these low values suggest that it was probably not growing locally but at some distance from the site on more acidic soils. Spruce (*Picea*) pollen is also recorded but this taxon has not been native in Britain during the Holocene. Its presence, together with the spores of *Glomus*, a fungus that grows in soils and is found throughout the sequence, is probably indicative of the erosion of soils into the sediment sequence.

The effects of Mesolithic people on the vegetation are likely to have been were small and ephemeral. Values of microscopic charcoal particles were quite high, particularly towards the top of the zone, where pieces of charred grass were identified from the larger particles sieved off during preparation and are evidence for local (natural or humanly-made) fires. The upper two sub-samples also show some drop in AP and a concomitant increase in herb pollen, especially grasses. One possible cereal-type grain (*Hordeum*-type) was found. However, this pollen taxon also contains some wild grasses including some marine species, and floating sweetgrass (*Glyceria fluitans*) which grows in mud or shallow fresh water.

PAZ 3

At the base of PAZ 3 the sediments are silts-clays with very low concentrations of pollen, suggesting rapid accumulation. There is a large increase in alder pollen shortly followed by that of fern spores, including marsh fern (*Thelypteris palustris*) and sedges (Cyperaceae undiff.). Other herbaceous taxa associated with marshes and fens are present as found in PAZ 2 but at lower values.

A date of 5464±35 BP (NZA-28974, 4370–4240 cal BC) marks a change from clays and silts to wood peat marking the local development of alder carr and marsh/fen with an understorey including ferns and sedges. Clumps of alder and sedge grains and fern spores were found, further evidence for their very local growth on the site. Chenopodiaceae pollen values drop and the remains of dinoflagellate cysts and foraminifera almost disappear suggesting a stronger freshwater influence. Further evidence for a freshwater regime are the Cladoceran (water flea) claws found on the pollen slides, animals which only live in freshwater.

Tree and shrub pollen still dominate the pollen assemblages with oak, lime, elm and ash values suggesting that the regional vegetation was deciduous woodland as in PAZ 2. Unfortunately, one of the cores (core 19) representing the middle of this zone (-4.46m to -4.01m OD) was lost between the assessment and analysis stages. This core may have contained evidence of the primary Neolithic 'elm decline', a more of less synchronous event throughout NW Europe dated to *c* 5000 BP. This decline was probably caused by the interaction of several factors including human interference within the woodland and a pathogenic attack (Peglar 1993). The 'elm decline' has been dated in the area to 4930±110 BP (4000–3500 cal BC) at Stone Marsh, Kent (Devoy 1979) and to 4650±90 BP (3650–3100 cal BC), slightly above the 'elm decline' depth, at Mar Dyke, Essex (Scaife 1988). Three dates were obtained on alder seeds and wood from within PAZ 3 provide further evidence for the 'elm decline' (at *c* 5000 BP) being in the missing core. These dates, 5464±35 BP (NZA-28974, 4370–4240 cal BC) from near the base of PAZ 3, just above the change from clay to peat; 5263±55 BP (NZA-28972, 4240–3970 cal BC); and 4820±25 BP (NZA-28867, 3700–3520 cal BC) towards the top of the zone, suggest that the sediments of PAZ 3 represent the period from the Late Mesolithic to the Early Neolithic.

There is no evidence of cereal growth close to BH7 during the period represented by this zone. However, cereal pollen grains are large and heavy, and do not travel far from their place of origin. Also, the alder fen carr growing on the site at the time would effectively filter them out.

PAZ 4

PAZ 4 correlates with the upper part of the wood peat and tufaceous unit. Two relevant radiocarbon dates were obtained; one from quite near the base of the zone at 4448±30 BP (NZA-28869, 3340–2940 cal BC); and one from the top of the zone at 3836±50 BP (NZA-28971, 2470–2140 cal BC). These would suggest that the zone spans the late Early Neolithic to the Early Bronze Age.

PAZ 4 is dominated by fern spores, probably mostly derived from the marsh fern (*Thelypteris palustris*) including many clumps of spores suggesting their growth directly on the site. Alder pollen values decrease, even when allowance has been made in the percentage data for the very large percentages of fern spores suppressing other pollen values, suggesting that the site was no longer within alder carr although this was still growing quite close by. No clumps of alder pollen were found.

The tufaceous unit indicates a calcium-rich fen with tufa springs growing on the site at this time, dominated by marsh fern. The presence of some obligate aquatic taxa, particularly towards the top of the zone, including pondweeds, white water lily (*Nymphaea*), common reed, bulrushes and/or bur-reed, are evidence of some open freshwater habitats. At the very top of PAZ 4 several herbaceous taxa values slightly increase including those of sedges, daisy-type (*Aster*-type) and goosefoot family, all of which may be associated with saltmarsh, perhaps evidence of saltmarsh growing closer to the site.

On the higher drier ground, mixed deciduous woodland was still widespread. There is still little evidence of human impact on the vegetation within the area, and no evidence of any crop production.

PAZ 5

There is a very large change between the pollen assemblages found in PAZ 4 and those of PAZ 5, and a change from peat with tufa to silty clay at the PAZ 4/5 boundary. It is possible that a further hiatus occurred in the sediment sequence, perhaps caused by flooding from the river and erosion. Quite high values of goosefoot family pollen and other taxa associated with saltmarsh, together with the remains of dinoflagellate cysts and foraminifera, point to the local vegetation being once again upper saltmarsh/reedswamp with common reed and other aquatics such as water starwort, white water lily (*Nymphaea*), bulrushes and bur-reed also well represented. Alder and willow pollen values are also quite high and suggest alder carr was growing within the river valley.

The biggest change, however, is in the vegetation away from the river valley on the higher drier ground. AP drops dramatically and herbaceous pollen rises and accounts for *c* 30% total pollen and spores. At the zone 4/5 boundary elm pollen again drops together with lime pollen. The 'lime decline' is a non-synchronous event associated with human impact and clearance of woodland (Turner 1962). As above, a sample from just below the PAZ 4/5 boundary gave an Early Bronze Age date of 3836±50 BP (NZA-28971, 2470–2140 cal BC). Grass pollen, in particular, increases to *c* 20%, together with taxa indicative of damp meadows/pastures: ribwort plantain (*Plantago lanceolata*), cow parsley family (Apiaceae undiff.), wild carrot-type (*Daucus*-type), meadowsweet (*Filipendula*), bird's-foot trefoil (*Lotus*-type), buttercups (*Ranunculus acris*-type), dandelion-type (*Taraxacum*-type), bedstraws (Rubiaceae), yellow rattle (*Rhinanthus*-type) and daisy-type (*Aster*-type) among others. There is also possible evidence of crop growth with cereals including barley-type (*Hordeum*-type), emmer and/or spelt (*Triticum*) and possibly oats (*Avena*), and weeds which may be associated with arable fields and waste places: including chamomile (*Anthemis*-type), mugwort (*Artemisia*), chickweeds and mouse-ears (*Cerastium*-type), and buck's-horn plantain (*Plantago coronopus*). There is also a large rise in charcoal particles, further evidence for a rise in human impact on the landscape around.

Throughout PAZ 5 AP pollen values decrease. The occurrence of the pollen of taxa such as blackberry (*Rubus fruticosus*-type), other rosaceous taxa such as hawthorn and sloe (Rosaceae undiff.), elderberry (*Sambucus nigra*), holly (*Ilex aquifolia*), guelder rose (*Viburnum opulus*) and ivy (*Hedera helix*), together with trees including elm, oak, ash, hazel and willow, could be indicative of the presence of hedges, or it may be that the woodland was more open and allowed these shrub genera to flower more profusely.

The zone has been divided into three subzones:

Subzone a: this subzone sees the transition from freshwater sedge/reedswamp with the local growth of reeds (*Phragmites australis*), sedges and ferns, and with the occurrence of Cladoceran claws at the base, to more marine influenced upper saltmarsh at the top of the subzone. Quite a lot of woodland was still extant in the area but with open grassland and the cultivation of cereals nearby.

Subzone b: upper saltmarsh with increased pollen values of sedges, goosefoot family and daisy-type, characteristic of saltmarsh, and lower pollen values of grass, common reed, dandelion-type and ribwort plantain – taxa associated with meadows and grazing, suggesting a further influx of saltwater.

Subzone c: similar to subzone a with but with even less tree and shrub pollen and greater pollen values of taxa associated with meadows/pastures, suggesting the retreat of saltmarsh, with evidence of open freshwater towards the top of the subzone with a peak in pondweed (*Potamogeton*) pollen: and the further establishment of meadows and pastures, and the continued cultivation of cereals nearby. An interesting find is a grain of walnut (*Juglans regia*), a species which is thought to have been brought to England by the Romans (Rackham 1986).

The three subzones appear to reflect increasing marine influence through subzone a, inundation by salt water in subzone b, and the subsequent drop in marine influence in subzone c.

PAZ 6

Arboreal pollen (AP) is further reduced in this zone to <20% with non-arboreal pollen (NAP) increasing to >75%, evidence of further clearance of the woodland. The sediments are silty peats with telmatic taxa such as common reed, bulrushes, and iris and sedges, characteristic of reed and sedge swamp. Goosefoot family pollen values decrease as saltmarsh retreats further from the site. Many herb taxa characteristic of meadows and pastures are present including a peak in dandelion-type. However, dandelion-type is also indicative of waste ground/pathways and arable fields together with many other characteristic herb taxa as suggested above (PAZ 5). Cereals, including barley, wheat, possibly oats, and one grain of rye (*Secale*) at 0.95m OD, are also present. Seeds extracted from sediment at 0.88m OD have been dated to 1196±30 BP (NZA-28620, cal AD 710–940) during the middle to late Anglo-Saxon period.

Diatoms

by Nigel G Cameron

Diatom slides were prepared from 17 samples from BH7 (Cameron, Appendix K). An initial assessment showed that diatoms were present in countable numbers in 10 samples (Fig 12.3). Preservation was very good in the 'Upper Clay-Silts', but very poor or absent from the main peat units and 'Lower Clay-Silts'. Consequently, only one sample at -6.15m OD was analysed from the lower alluvial unit and nine from the upper -2.80m to 0.4m OD.

Diatom floras and taxonomic publications were consulted to assist with diatom identification; these include Hartley *et al* (1996) and Krammer and Lange-Bertalot (1986: 1988; 1991). Diatom species' salinity preferences are discussed using the classification data in Denys (1992) and the halobian groups of Hustedt (1953; 1957; 199), these salinity groups are summarised as follows:

Polyhalobian: >30 g l^{-1}
Mesohalobian: 0.2–30 g l^{-1}
Oligohalobian – Halophilous: optimum in slightly brackish water
Oligohalobian – Indifferent: optimum in freshwater but tolerant of slightly brackish water
Halophobous: exclusively freshwater
Unknown: taxa of unknown salinity preference

In summary, in all of the samples analysed the presence of diatoms that inhabit saline environments

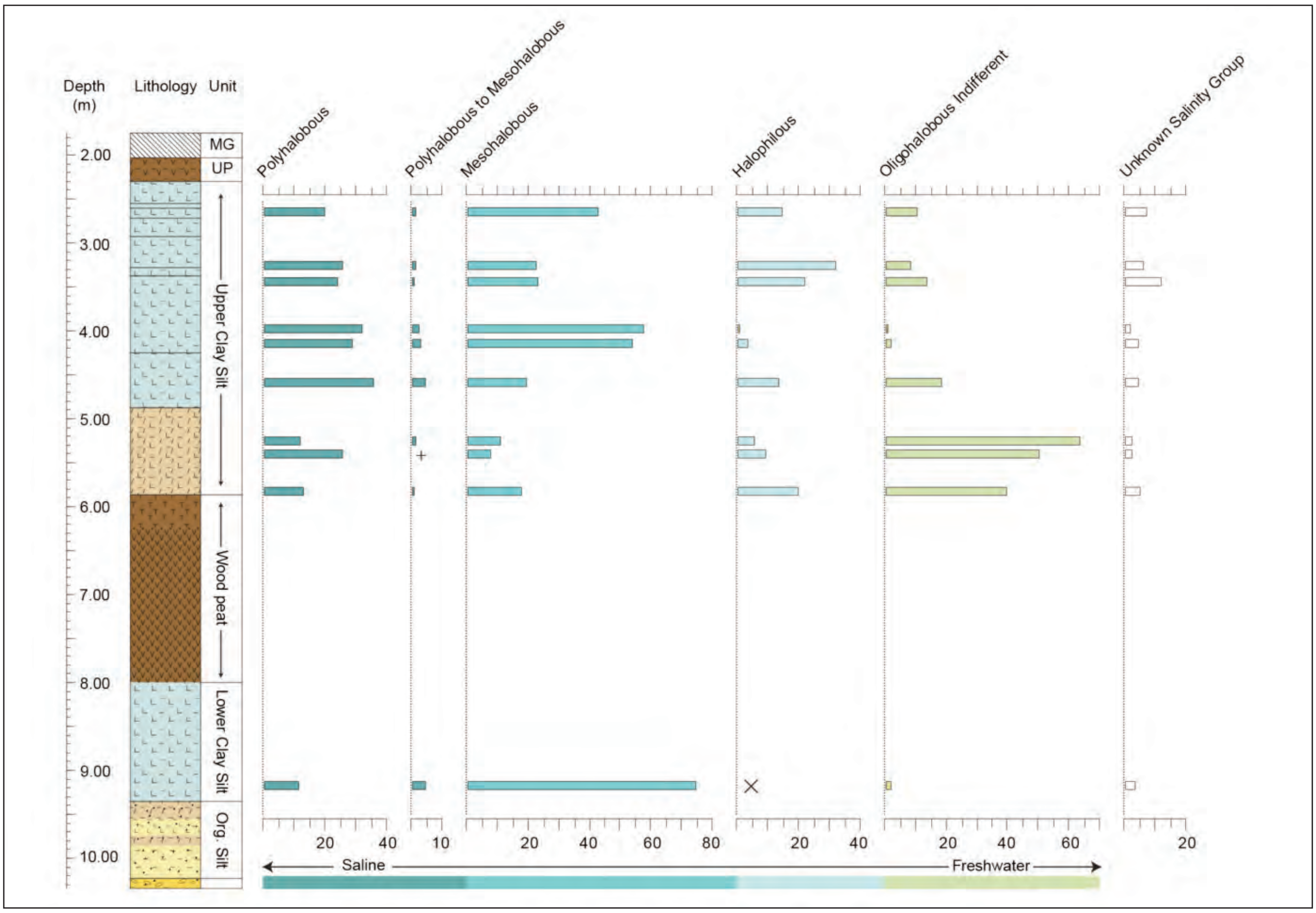


Figure 12.5 Borehole 7 (STDR400) summary of diatoms

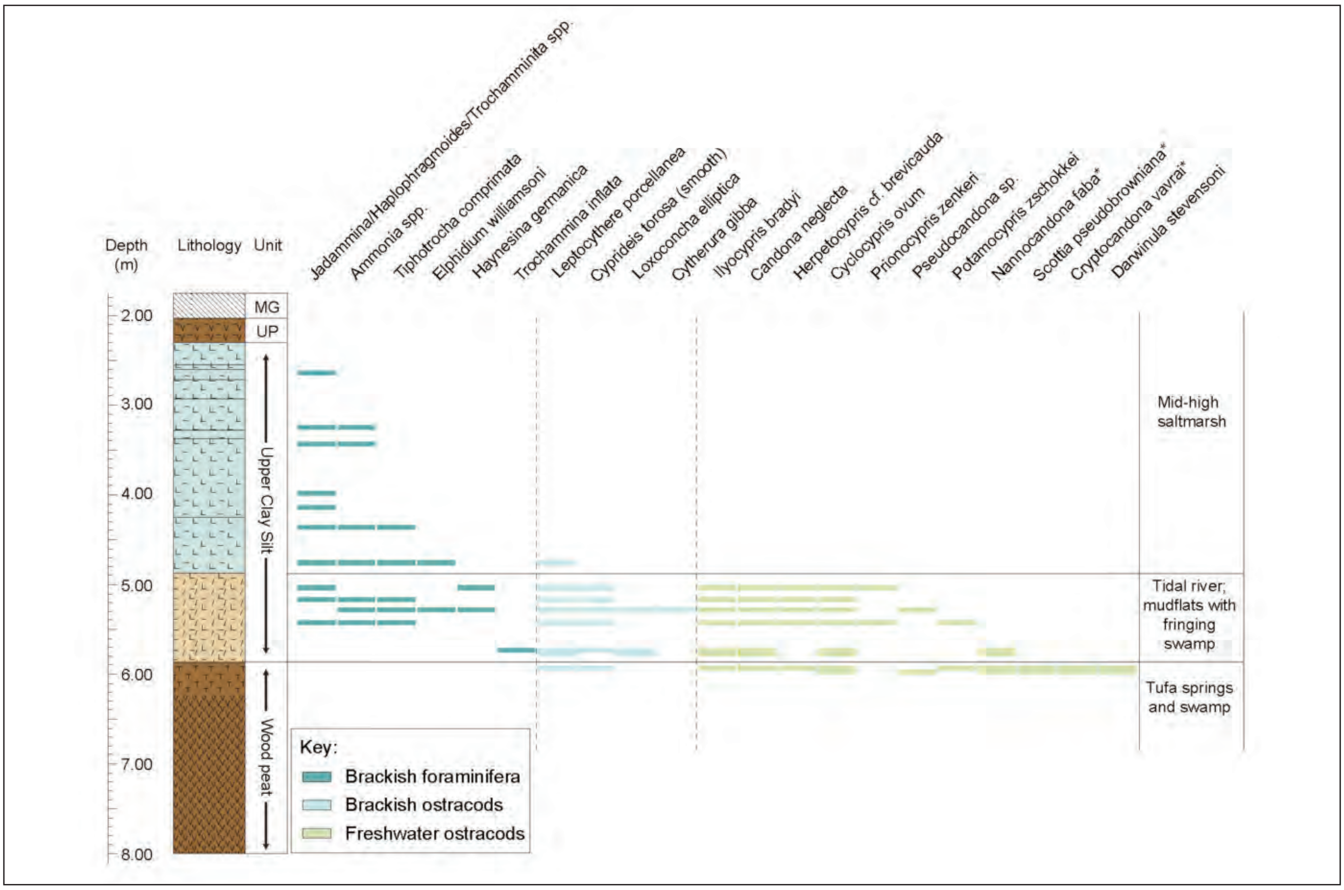


Figure 12.6 Borehole 7 (STDR400) summary of ostracods and foraminifera

reflects the tidal nature of the sedimentary environment (Fig 12.5). At -6.15m OD (9.19m depth) the assemblage represents brackish water conditions where the flora was dominated by diatoms that live in the mud surface, with smaller numbers of estuarine and allochthonous marine plankton, and a rarity of freshwater and halophilous species. Three samples from the upper alluvium, immediately above the main peat bed suggest a mixed freshwater and brackish environment. Samples were dominated by oligohalobous indifferent and halophilous diatoms, but there were also polyhalobous and mesohalobous taxa. The importance of freshwater taxa here reflects a lower mean salinity than the sample from -6.15m OD (9.19m depth), but some of these oligohalobous indifferent diatoms have wide salinity tolerance and the presence of polyhalobous and mesohalobous diatoms shows that the sedimentary environment was periodically tidal. The diatoms from three samples lying in the middle part of the 'Upper Clay-Silt' unit represent an increasingly brackish-marine environment where tidal mudflats or creeks become important habitats. There was a decline of freshwater and halophilous diatoms and high proportion of planktonic marine diatoms transported to the site of deposition. The three uppermost samples contained components from disparate habitats. Oligohalobous indifferent taxa were present, in addition to aerophilous halophilic taxa and a high proportion of allochthonous marine plankton and estuarine plankton.

Ostracods and Foraminifera

by John E Whittaker

Eighteen samples were initially examined from BH7 for ostracods and foraminifera (Figs 12.3 and 12.6; Whittaker, Appendix L). From -3.54m OD (6.58m depth) to the base of the borehole foraminifera and ostracods were absent. Samples from the upper alluvium and the underlying tufaceous unit, however, were more productive. The two samples examined from the tufa contained abundant freshwater ostracods; a mixture of spring and pool-dwelling, and semi-terrestrial forms, the latter living in floating moss, swampy material and leaves (Meisch 2000, eg, *Scottia pseudobrowniana*, *Crytocandona vavrai* and *Nannocandona faba*). However, within the upper tufa sample at -2.91m to -2.96m OD (5.95-6.00m depth) there was also evidence of initiation of tidal access, evidenced by brackish ostracods *Cyprideis torosa* and *Leptocythere porcellanea*. Further up the profile to -1.96m OD (5.00m depth) assemblages were mixed comprising freshwater and brackish ostracods, and brackish foraminifera. The brackish elements are typical of tidal rivers, inhabiting mudflats and creeks. The non-marine ostracods recorded can tolerate low salinities and would probably be living in fringing pools and surrounding swampy vegetation. Above -1.96m OD (5.00m depth) there was evidence of a major shift from tidal rivers and mudflats to mid- to high saltmarsh environments as a result of accretion and perhaps further sea-level change. This is very clearly demonstrated by the overall decline of ostracoda species and increases in foraminifera. The ostracods predominantly crawl in mud or swim on the mud/water interface, whereas the foraminifera mainly cling to vegetation. The former would therefore naturally decline with the disappearance of the tidal flats.

Borehole 11 (EBBS97)

Introduction

This borehole (BH11) was drilled during the Northfleet Rise evaluation (EBBS97) to a maximum depth of 10.10m below ground level, which lay at 2.92m OD. A

Table 12.5 Borehole 11 (EBBS97) lithological description

Depth (m)	Description
0.00–0.80	Topsoil and fill/made ground
0.80–0.85	10YR 3/2 very dark greyish-brown organic silt. Soft and unconsolidated with carbonate patches, molluscs and possible small chalk clasts (<5mm)
0.85–2.55	5GY 4/1 dark greenish-grey clay-silt. Soft and unconsolidated. Common black, reduced organic fragments including *Phragmites* sp. material
2.55–2.60	10YR 3/2 very dark greyish-brown organic silt to peat with black reduced organic material. Firm and compact. Rooting from above noted. Some molluscs and carbonate patches
2.60–2.80	5GY 4/1 dark greenish-grey clay-silt. Soft and unconsolidated. Common black, reduced organic fragments including *Phragmites* sp. material
2.80–3.00	5GY 4/1 dark greenish-grey clay-silt. Soft and unconsolidated. Common black, reduced organic fragments including *Phragmites* sp. material. Common small (2–3mm) angular chalk clasts
3.00–4.05	2.5Y 4/4 olive brown organic-rich silt. Many fine root traces. Soft and unconsolidated. Many reed fragments (in situ). Appears to be interbedded with 5GY 4/1 dark greenish-grey clay-silt with very little organic matter
4.05–4.60	7.5YR 4/2 dark brown organic silt to peat. Strong odour. Network of fine root trances. Soft and unconsolidated. Becomes 10YR 8/4 very pale brown and carbonate rich with depth
4.60–6.60	5YR 3/4 dark reddish-brown peat. Dominated by reed material (*in situ*). No structure, dry and friable. Black organic material lies horizontal in unit. Thin carbonate rich beds present
6.60–8.25	5YR 3/4 dark reddish-brown peat. Very common wood fragments – well preserved. In paces unit is interbedded with carbonate rich units containing molluscs
8.25–8.70	5GY 4/1 dark greenish-grey soft clay-silt with strong odour. Common wood and root fragments. Soft and unconsolidated
8.70–9.00	As above but only occasional roots present. Possibly bedded or fine laminated
9.00–9.07	10YR 5/2 greyish-brown organic silt with fine roots present. Structureless and massive
9.07–9.15	10YR 4/1 dark grey slightly sandy-silt. Structureless. Burnt flint fragments and some possible debitage. Charcoal possibly present
9.15– 0.05	10YR 2/1 black sandy-silt coarsening downwards to silty-sand. Black reduced organic fragments. Becomes 5GY 4/1 dark greenish-grey with depth
10.05	2.5Y N6 grey slightly sandy silt matrix with flint gravel. Clasts (<5mm to >50mm), angular. Dense and compact. With depth becomes slightly better sorted

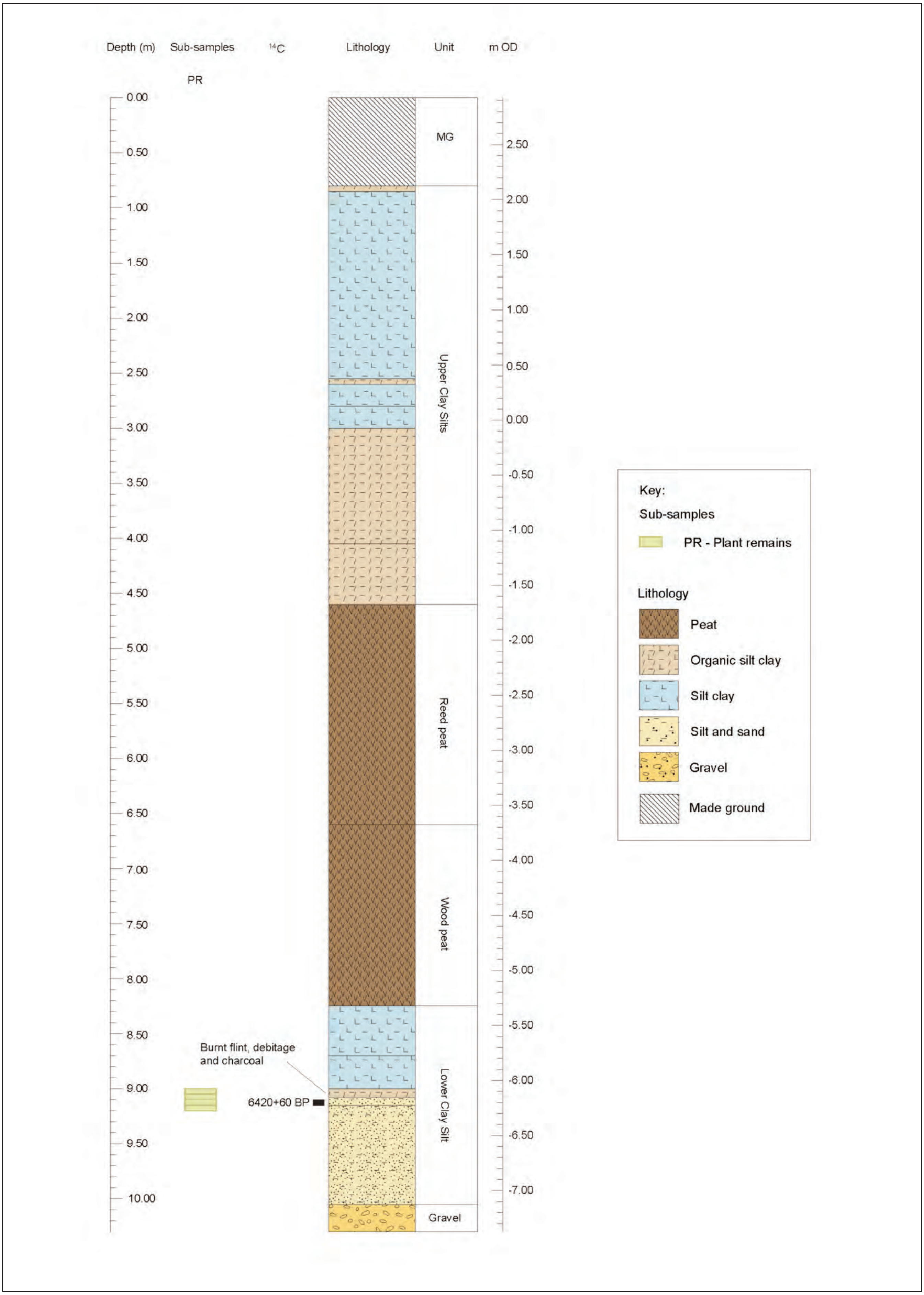


Figure 12.7 Borehole 11 (EBBS97) lithology and sample profile

Table 12.6 Borehole 11 (EBBS97) plant remains

Latin Binomial	Common name	9.15–9.20	9.10–9.15	9.05–9.10	9.00–9.05
	Depth (metres)	9.15–9.20	9.10–9.15	9.05–9.10	9.00–9.05
	Weight processed (kg)	0.2	0.2	0.2	0.2
Waterlogged plant remains					
Ranunculus acris/reprens/bulbosus	buttercup	++	++	+++	+
Ranunculus sceleratus L.	celery leaved crowfoot	–	+	–	–
Prunus spinosa L.	sloe stone	–	–	–	+
Crataegus sp.	hawthorn seed	–	–	–	+
Urtica dioica L.	common nettle	+	–	–	+
Alnus glutinosa (L.) Gaertn.	alder, female catkins	+	–	–	–
Alnus glutinosa (L.) Gaertn.	alder seed	+	–	–	–
Corylus avellana L.	hazel (nutshell frags)	–	+	+	–
Rumex sp.	docks	–	+	++	–
Lycopus europaeus L.	gipsywort	–	+	++	–
Carduus/Cirsium sp.	thistle	–	–	+	–
Charred plant remains					
Corylus avellana L.	hazel (nutshell fragments part charred)	+	+	+	–
Quercus sp.	oak charcoal	+	+	+	–

total of 12 U4/U100 cores and three bulk samples were retrieved during drilling for detailed sediment description and palaeoenvironmental work. One radiocarbon sample was processed (Table 12.2) and a number of samples examined for macroscopic plant remains during the assessment stage (Fig 12.7).

Lithological Succession

The base of the sequence consisted of flint gravel in a sandy silt matrix to -7.13m OD (10.05m depth, Fig 12.7; Table 12.5). Overlying the gravel was a sequence of sandy and clayey silts. A thin sequence of highly organic sediments occurred between 6.08m and -6.23m OD (9.00–9.15m depth). These deposits contained a small amount of burnt flint (17 fragments), worked flint (nine pieces) and charcoal (Chap 20).

Organic sediments lay between -1.68m and -5.33m OD (4.60–8.25m depth). These consisted of a lower wood peat, and an upper reed peat. Carbonate patches were present within both parts of the sequence. The peat was overlain by a complex of organic silts and inorganic clay-silt to 2.12m OD (0.80m depth). The sequence was capped by 0.8m of made ground and topsoil.

Dating

A charred hazelnut shell at -6.18m to 6.23m OD (9.10–9.15m depth), within the organic silt below the main wood peat was dated to 6420±50 BP (Beta-108113, 5490–5310 cal BC) placing it within the latter part of the Mesolithic period (Fig 12.7; Table 12.2).

Waterlogged Plant Remains
by Ruth Pelling

Four samples were assessed in 1997 (OAU 1997) for waterlogged plant remains by Ruth Pelling (then at Oxford Museum of Natural History) from sediments between -6.08m and -6.28m OD (9.0–9.2m depth) in BH11 (Fig 12.7; Table 12.6).

The upper sample contained a single stone of sloe (*Prunus spinosa*) and seeds of hawthorn (*Crataegus* sp.). The lower three samples were dominated by seeds of buttercup (*Rannnculus acris/repens/bulbosus*). Seeds of docks (*Rumex* sp.) were present in the samples taken from -6.13 to -6.23m OD (9.05m to 9.15m). Fragments of charred or semi-charred hazelnut shell (*Corylus avellana*) were present in the lower three samples which may have derived from wild collected food resources. Occasional fragments of charcoal were also present, the larger of which were identified as oak (*Quercus* sp.). The remaining species represented include celery leaved crowfoot (*Ranunculus sceleranis*), characteristic of mineral-rich water, and gipsywort (*Lycopus europaeus*), a species of river or ditch banks and marshes or fens.

Trench 2 (EBBS97)

Introduction

Trench 2 was excavated during the Northfleet Rise evaluation (EBBS97) to a maximum depth of *c* 4m below ground level which lay at 3.36m OD (Pl 12.1). Six monolith samples and six bulk samples were taken from this trench. One radiocarbon date was processed and a number of samples were examined for macroscopic plant remains during the assessment stage (Fig 12.8, Table 12.1).

Lithological Succession

At the base of the sequence lay a dense sandy gravel (Fig 12.8, Table 12.7). The gravel was overlain by a complex of peat units (contexts 211 and 210) that appeared to have rooted into the gravel. The peat consisted of a lower wood peat to and an upper reed dominated peat. Wood remains in the lower peat were well preserved.

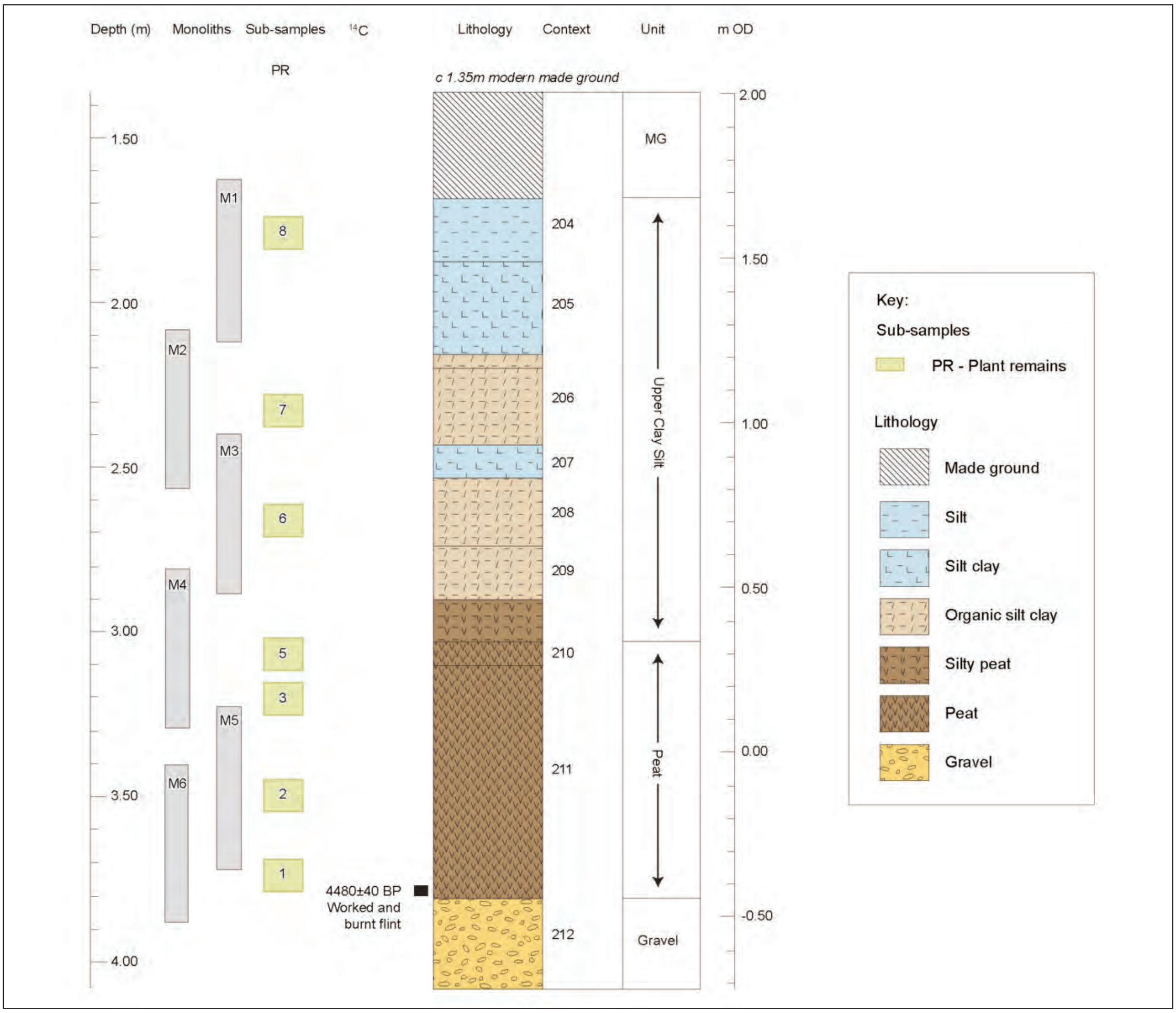


Figure 12.8 Trench 2 (EBBS97) lithology and sample profile

Table 12.7 Trench 2 (EBBS97) lithological description

Depth (m)	Description
0.00–0.20	Topsoil (201). Sharp contact to:
0.20–0.80	Mixed greyish-brown to reddish-brown clay-silt with common gravel clasts of flint and chalk. Poorly sorted 20–>50mm, sub-angular clasts. Structureless and firm. Many modem roots. Dense layer of chalk clasts near base of unit. (202). Sharp contact to:
0.80–1.70	Yellowish-brown clay-silt with occasional chalk clasts (sub-angular). Mottled with grey brown mottles. Clean, structureless and massive (203). Sharp contact to:
1.70–1.95	Dark greyish-brown silt. Structureless with some sand. Small empty red-brown stained root canals present. Occasional small (<15mm) sub-angular, rolled flint clasts. Soft and unconsolidated (204). Sharp contact to:
1.95–2.05	Blue-grey clay-silt with evidence of major root canals penetrating from above (currently empty and red-brown stained). Dense, compact and firm. *Phragmites* sp. Present (205). Sharp contact to:
2.05–2.45	Dark greyish-brown organic silt. Very fibrous in appearance with very common *Phragmites* sp. stem and root material. *In situ* network of roots noted. Some very fine sand grains present. No structure (206). Sharp contact to:
2.45–2.55	Blue-grey clay-silt with evidence of major root canals penetrating from above (currently empty and red-brown stained). Dense, compact and firm. *Phragmites* sp. present (207). Sharp contact to:
2.55–2.75	Dark greyish-brown organic silt. Very fibrous in appearance with very common *Phragmites* sp. stem and root material. *In situ* network of roots noted. Some very fine sand grains present Insect remains noted. No structure (208). Sharp contact to:
2.75–2.90	Dark greyish-brown organic silt. Very fibrous in appearance with very common *Phragmites* sp. stem and root material. *In situ* network of roots noted. Some very fine sand grains present. Some possible indications of thin bedding/laminae noted. No structure (209). Graded contact to:
2.90–3.00	Dark brown reed peat with common well preserved reed fragments and carbonate rich beds. Carbonate particles are firm possibly micritic type. Clear evidence of bedding in places. Contains some woody root material. Loose and unconsolidated (210). One fragment of worked flint recovered. Diffuse contact to:
3.00–3.90	Dark reddish-brown wood peat. Very common fresh wood fragments. Dry and friable. Crisp break to peat. No structure. Strong odour. Towards the base peat is layered with layers of wood resting sub-horizontally in core (211). Sharp contact to:
3.90	Light grey sand with some silt and some gravels clasts. Poorly sorted (<20mm to >100mm), sub-angular and rolled. Common roots fragments penetrate this unit (212). Base of test pit 4.00m

A complex of organic silts and inorganic clay-silt units existed above the peat (contexts 209–204). These units were variably peaty and contained visible reed fragments in the most organic dominated sediment units. The sequence was capped by 1.70m of made ground and topsoil.

Dating

A hazelnut shell from the base of the peat in Trench 2 (context 211) was dated to 4480±40 BP (Beta-108114, 3350–3020 cal BC) placing it within the Early Neolithic period (Fig 12.8; Table 12.2).

Waterlogged Plant Remains

by Ruth Pelling

Four samples from Trench 2 were assessed in 1997 (OAU 1997) for waterlogged plant remains by Ruth Pelling. The samples (Fig 12.8; Table 12.8) can be divided into two groups:

The upper deposits, contexts 210, 208 and 204 (samples 5 to 8), were characterised by very degraded peat and large quantities of *Phragmites* (reed) type rhizomes. Seed remains were characteristic of wet marshy conditions with taxa such as sedges (*Carex* sp.), common spike rush (*Eleocharis palustris*) and crowfoot (*Ranunculus* subgen. *Batrachium*). Celery leaved crowfoot (*Ranunculus sceleratus*), noted in the upper deposit, is characteristic of mineral-rich water.

The lower deposits, context 211 (samples 1 to 3), were characterised by fragments of wood and twigs. The wood fragments were generally poorly preserved, although alder (*Alnus*) wood and occasional seeds of alder (*Alnus glutinosa*) were identified. Remains of other plant species are very infrequent and include occasional seeds of nettle (*Urtica dioica*), buttercup (*Ranunculus acris/repens/bulbous*) and blackberry/bramble (*Rubus* cf. *fruticosus* agg.). Overall the suite of samples suggests alder carr at the base of the sampled sequence gave way to a more open reedswamp environment.

Plate 12.1 Trench 2 (EBBS97)

Table 12.8 Trench 2 (EBBS97) plant remains

Latin Binomial	Common name	1	2	3	5	6	7	8
	Context	211	211	211	210	208	206	204
	Weight processed (kg)	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Waterlogged plant remains								
Ranunculus acris/repens/bulbous	buttercup	–	+	–	–	+	–	–
Ranunculus subgen *Ranunculus*		–	–	–	–	–	+	–
Ranunculus sceleratus L.	celery leaved crowfoot	–	–	–	+	–	–	++
Ranunculus subgen *Batrachium* (DC) A.Gray	crowfoot	–	–	–	–	–	++	++
Rubus cf. *fruticosus* L. agg.	blackberry/bramble	+	–	–	–	+	–	+
Rubus sp.		–	–	–	+	–	–	+
Potentilla anserina L.	silverweed	–	–	–	–	+	–	–
Urtica dioica L.	common nettle	+	+	–	–	–	–	–
Alnus sp.	alder branch wood	+++	+++	++	–	–	–	–
Alnus glutinosa (L.) Gaertn.	alder, female catkins	++	–	–	–	–	–	–
Alnus glutinosa (L.) Gaertn.	alder seed	–	+	+	–	–	–	–
Corylus avellana	hazelnut shell frags.	+	–	–	–	–	–	–
Stellaria media (L.) Vill.	chickweed	+	–	–	–	–	–	–
Sambucus nigra L.	elder	–	–	–	–	–	+	+
Mentha sp.	mint	–	–	–	+	+	–	–
Potamogeton sp.	pondweed	–	–	–	–	–	–	+
Zannichella palustris L.	horned pondweed	–	–	–	–	–	–	++
Juncus sp.	rushes	–	–	–	–	+	–	–
Cyperaceae		–	–	–	–	+	+	–
Eleocharis palustris (L.) Roem. & Schult.	common spike rush	–	–	–	–	++	++	++
Carex sp.	sedges	+	–	–	–	++	++	+++
Phragmites type	reed type rhizomes	–	–	–	+++	++	+++	+

Area 1 (STDR401)

Introduction

Area 1, excavated to mitigate the impact of the STDR4, was located at the north-western margins of the Outer Basin. It was sited adjacent to evaluation Trench 1 (STDR400) where an assemblage of (reworked) animal bone, a sherd of probable Bronze Age pottery and occasional worked flint were retrieved from alluvial channel deposits truncating the main peat bed. The area of subsequent excavation measured 10 x 10m, *c* 5.3m deep, and was supported by a cofferdam of sheet piles (Pl 12.2).

A series of complex channel sequences were recorded through a number of sections. Figure 12.9 presents a composite profile through these sequences and the location of monoliths and sub-samples submitted for assessment. Late Bronze Age and Iron Age archaeological remains included a series of possible timber revetment structures and concentrations of artefactual material associated with the channel sequence. No palaeoenvironmental work was carried out on these sequences beyond the post-excavation assessment stage; however, the assessment results do provide useful data for contextualising the archaeological remains which are discussed further in Chapter 22.

Lithological Succession

The earliest deposit encountered at the base of the trench was a pale greyish-white chalk diamict interpreted as solifluction deposits of late Devensian age. This was overlain by a series of minerogenic greenish-brown and grey clayey sand deposits, which probably represent colluvial deposits and fluvial channel fills of late Devensian and early Holocene age (context 1150). In the western corner of the excavation a layer of peat (context 1214) sealed these deposits, averaging 0.20m in thickness. At the interface between the clayey sand and peat a small number of burnt and worked flint fragments were recovered including a large flake core and a blade. Occasional struck flints were also recovered from equivalent peat context 1102. For a large part of the excavation area, however, the peat appeared to have been either heavily or completely eroded. The overlying deposits comprised a thick sequence of bluish-grey minerogenic silts and clays infilling a series of channels cuts (Fig 12.10). Complex lateral and vertical variation was noted in section which probably represents intermittent shifting of channel positions over time with multiple cut and fill events. Three broad phases of channel incision were identified. The earliest and broadest channel had eroded the eastern extent of the peat body and cut into the underlying Pleistocene and early Holocene deposits.

Plate 12.2 Area 1 under excavation (STDR401)

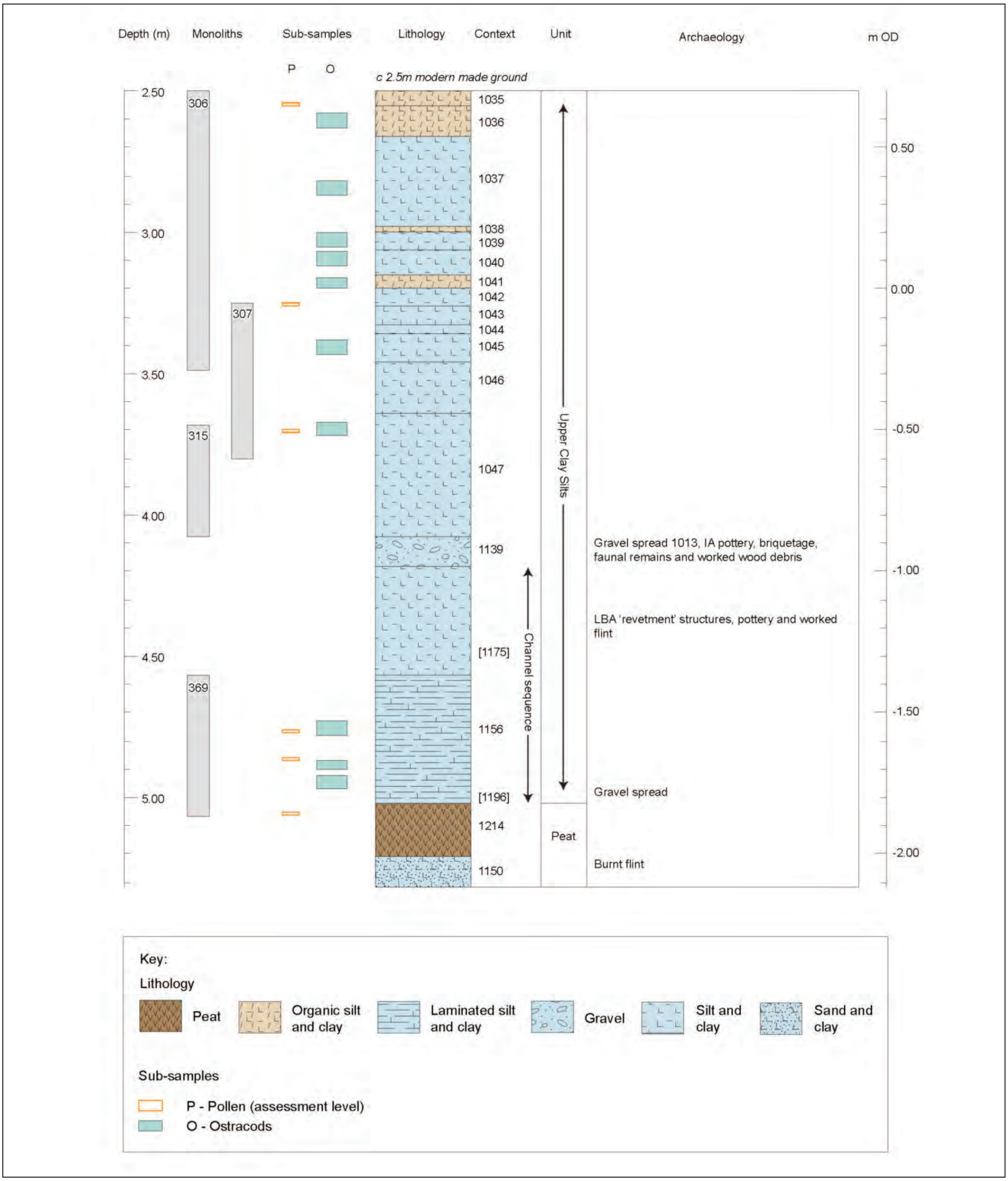


Figure 12.9 Area 1 (STDR401) lithology and sample profile

Gravelly sandy silt deposits infilling the base of this channel indicate deposition within a moderate to high-energy flow regime. The overlying fill exhibited a complex structure of intercalated minerogenic dark greyish-brown and mid-bluish-grey silty clays reaching a maximum thickness of 0.47m. The fine-grained nature and laminated structure of the deposits suggests a significant reduction in flow regime. A further channel recut the earlier channel on the same alignment and to similar dimensions and was infilled with a series of minerogenic silty clays. At the base a further deposit of coarse flint gravel (1153) was recorded that produced a decorated sherd of Late Bronze Age pottery and a small number of animal bone fragments and struck flint. The latest definable channel sequence (1175) was narrower and meandered more than the preceding channels and

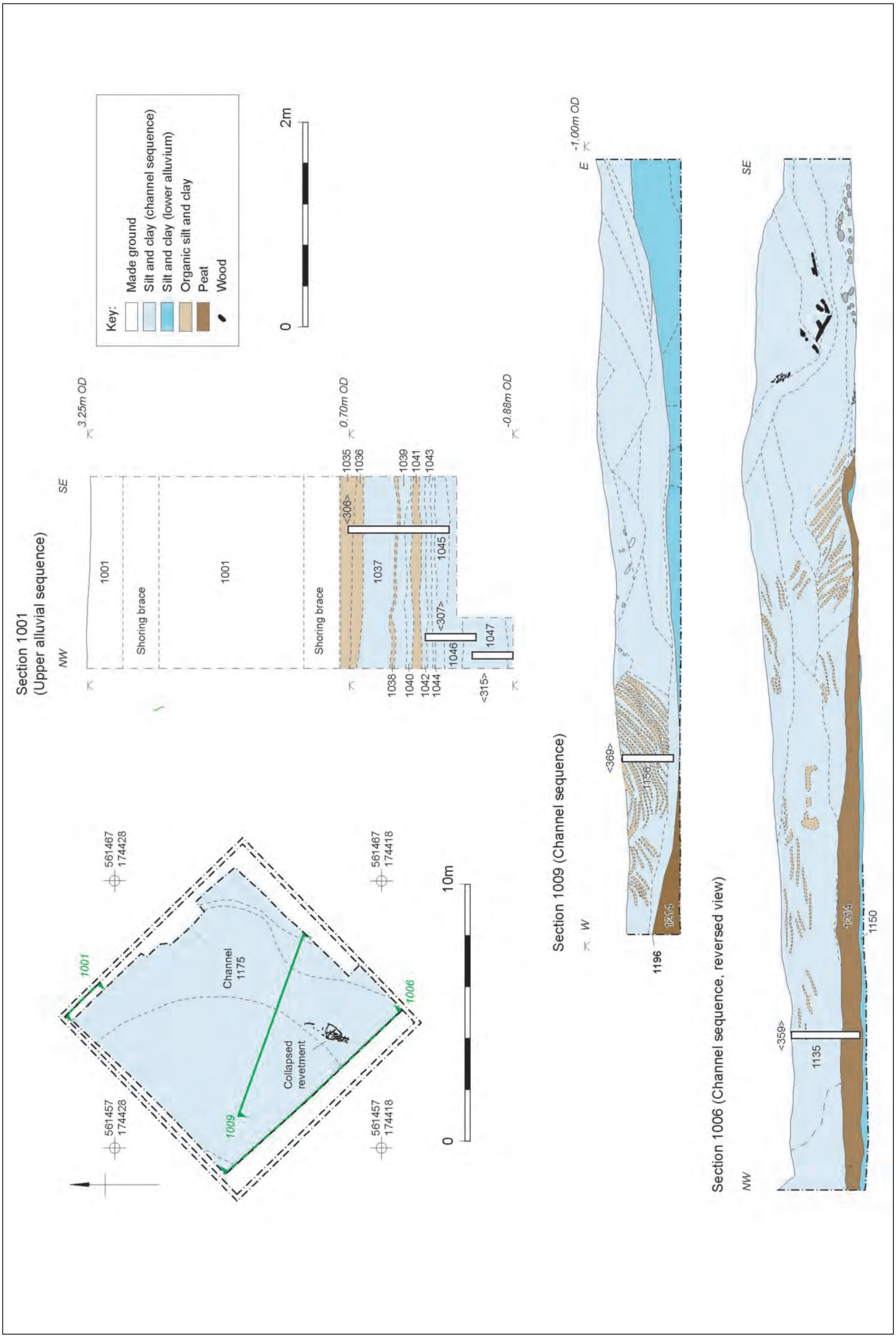


Figure 12.10 Area 1 (STDR401) field sections and plan

was filled with thick deposits of minerogenic bluish-grey clayey silts. Associated with the edges of the later channel sequence was a series of ephemeral wooden stake structures possibly forming a type of revetment. One of these structures was radiocarbon dated to 2615±30 BP (SUERC-19949, 835–765 cal BC, Table 12.2), the Late Bronze Age.

An extensive gravel deposit (1013), possibly of anthropogenic origin and comprising large rounded flint, chalk and chert nodules, 0.10m thick, was identified at the top of the infilled channel sequence Artefactual material associated with this included struck flints, animal bone, Iron Age pottery and wood fragments as well as possible fragments of briquetage.

The channel sequence and gravel deposit was overlain by thick deposits of horizontally laminated brownish blue-grey silt-clays with varying amounts of organic inclusions up to 1.5m deep (contexts 1035–1047 inclusive). Dark grey-green and dark blue-grey clays (1003, 1004 and 1005) completed the alluvial sequence although these were possibly reworked within their upper ranges. A mixed peaty deposit (1002) sealed 1003 and was in turn overlain by made ground comprising mixed chalk frags, flint nodules and modern mixed rubble (ie, bricks and tile frags.) up to 2.5m deep.

Dating

No radiocarbon dates were processed directly from the sediment sequence in Area 1 due to the minerogenic nature of the deposits. However, the stratified artefactual material, some of which was submitted for radiocarbon dating, provides a broad chronology for sequence accumulation (Table 12.2, see also see Chap 22). A sample from one of the wooden structures or 'revetments' associated with the latest channel phase produced a Late Bronze Age date of 2615±30 BP (SUERC-19949, 835–765 cal BC) in addition to a few sherds of Late Bronze Age pottery. The gravel spread which was laid down over the top of the channels once they had silted up contained pottery of Iron Age date and a cattle femur dated to 2385±30 BP (SUERC-19947, 730–390 cal BC). In addition, a bundle of coppiced roundwood found alongside the gravel spread was dated to the Early to Middle Iron Age 2280±30 BP (SUERC-19948, 410–200 cal BC).

Pollen

by Rob Scaife

Pollen preservation was assessed from the sediments from Area 1 by Rob Scaife during the post-excavation stage but the sequences were not taken through to full analysis (Fig 12.9). Three samples were examined from the lower part of the sequence which includes the basal peat and overlying channel fill. The pollen data from the peat (context 1214) suggested a woodland/shrub habitat dominated by hazel (*Corylus avellana*) with some oak (*Quercus*) and alder (*Alnus*). Absence of herbs here also indicated an absence of either open ground in the terrestrial zone or onsite. It is likely that the depositional environment was a dry fen-carr woodland dominated by hazel. Small values of alder were not significant enough to suggest on-site growth, at least in any quantity. Being only a spot sample from this extensive, eroded, peat, it is not possible to be certain about this interpretation.

Compared with the peat the channel fill contained substantially more herbaceous pollen although trees and shrubs remained important. This implies a more open habitat at least on-site. However, oak appeared more important along with hazel. The herb flora indicated that the habitat was perhaps a herb fen on or immediately adjacent to the site with sedges (Cyperaceae), grasses (Poaceae), reed-mace (*Typha angustifolia*) bur reed (*Sparganium*), iris and possibly marginal willow (*Salix*). Goosefoots and oraches (Chenopodiaceae) were present which may indicate saline/brackish water conditions or periodic incursions. *Potamogeton* type may include sea arrow grass (*Triglochin maritima*) although there is also the possibility that these came from freshwater pond-weed (*Potamogeton*).

Table 12.9 Area 1 (STDR401) ostracods and foraminifera

			Foraminifera				**Ostracods**							
							Brackish				**Freshwater**			
Unit	**Sample**	**Context**	*Ammonia limnetes*	*Elphidium williamsoni*	*Jadammina macrescens/ H. wilberti*	*Haynesina germanica*	*Cypridopsis torosa*	*Cytherura gibba*	*Leptocythere porcellanea*	*Loxoconcha elliptica*	*Candona neglecta*	*Cypria ophtalmica*	*Cyclocypris sp.*	*Eucypris pigra*
UCS	306	1036	–	–	–	–	–	–	–	–	–	–	–	–
	306	1037	–	–	–	–	–	–	–	–	–	–	–	–
	306	1039	–	–	–	–	–	–	–	–	–	–	–	–
	306	1040	++	–	–	–	–	–	–	–	–	–	–	–
	306	1041	–	–	–	–	+++	+*	–	–	+	–	–	–
	307	1045	+	+*	–	–	+++	+*	+	–	–	–	–	–
	307	1046	++	+	+	+*	+++	+*	++	+*	+*	+*	–	–
	307	1047	++	–	++	+*	+	+*	++	+*	+	–	–	–
Channel	369	1156	+	–	+++	–	+	–	+	–	+	–	–	–
	369	1156	+	+*	++	–	+	–	++	–	++	+	+	+*
	369	1156	+	–	+++	–	–	+	++	–	+	–	–	–

KEY: UCS – Upper Clay Silt; +* – one specimen; +– present; ++ – common; +++ – abundant

Within the upper alluvial sequence (contexts 1047 and 1035) tree and shrub pollen numbers/percentages were comparable with values for the organic channel fill (above) and again oak and hazel woodland. The uppermost sample had higher values of pond weed/sea arrow grass, sedges and algae (*Pediastrum*) and these taxa suggests that conditions were becoming wetter towards the top of the profile. This sequence also had small numbers of possible cereal pollen gains, which may imply arable activity in the vicinity.

Ostracods and Foraminifera

by John E Whittaker

Samples were examined for ostracods and foraminifera from the upper alluvial sequence and underlying channel fills (Fig. 12.9; Table 12.9; Whittaker, Appendix L). All but the top three samples of the upper alluvial sequence contained a low diversity assemblage of foraminifera and ostracods, as did the underlying channel cut deposits. They all indicated an environment of brackish saltmarsh fringed by intertidal creeks, with some (more minor) freshwater input.

The upper alluvial sequence represents tidal brackish mudflats and creeks (as evidenced by the large numbers of the foraminifera *Ammonia limnetes*, and the ostracods *Cyprideis torosa* and *Leptocythere porcellanea*), whilst the underlying channel fills contained a higher preponderance of the foraminifera *Jadammina macrescens*/*Haplophragmoides wilberti* and some freshwater ostracod species, suggesting influx of more (medium to high) saltmarsh components. As the channel deposits contain both brackish and freshwater microfossils, it is postulated that they may signify the initial onset of tidal access into this part of the Ebbsfleet Valley (and with it a build-up of associated fringing saltmarsh). Initially, scour of the mudflats over a tidal cycle, coupled with the flow from the Ebbsfleet River (at low tide) must have been significant, or at least strong enough to cut these channels.

Chapter 13

Inner Basin (Zone 9)

by Elizabeth Stafford, Martin Bates, Nigel G Cameron, Denise Druce, Elizabeth Huckerby, Sylvia Peglar, Mark Robinson, Wendy Smith, Lucy Verrill and John E Whittaker

Introduction

This zone is located in the low-lying floodplain of the Ebbsfleet, upstream of Zone 8 (Figs 4.1 and 13.1) and similar to Zone 8 the focus of the HS1 and STDR4 investigations were the deposits of Holocene age that dominate the upper part of the sequences.

An extensive array of borehole and trench data recovered during the various evaluation stages of the project (ARC EFT97, ARC ESG00 and STDR400, Chap 3; Table 3.4) revealed sequences of Holocene alluvium preserved along the valley central axis, overlying Pleistocene fluvial and soliflucted sands and gravels. Once again the Holocene sequences markedly thinned and became vertically conflated against the rise of the underlying Pleistocene deposits at the valley-side margins

Geoarchaeological modeling of the surface of the Pleistocene deposits (ie, the early Holocene topographic template) revealed a shallower 'Inner Basin'-like feature existed in this zone, as opposed to the deeper 'Outer Basin' of Zone 8. The Holocene deposits infilling this basin were somewhat shallower but equally comprised a complex sequence of minerogenic sands silts and clays intercalated with more organic units. These sequences also included the major peat bed identified in the Outer Basin as well as the 'Upper Peat' unit. However, the 'Upper Clay-Silts' in this Zone demonstrated much complexity with intercalated organic units reflecting the more marginal nature of these sequences. Once again extensive deposits of modern made ground capped the alluvial and peat sequences (Fig 13.2).

The key representative sequences examined from this zone are Trench 9 (STDR400), Trench 11 (STDR400) and Area 4 (STDR401). Trench 9 covered one of the longest timespans of all the sequences investigated in this zone and for this reason it was chosen for detailed palaeoenvironmental and dating work. Artefactual material, including substantial worked flint scatters and a timber structure, were recorded in Area 4. In Trench 11 part of and Ebbsfleet Ware bowl was recovered from the base of the main peat unit. A summary of each of these sequences is included in Table 13.1 and in the following sections. The results of the radiocarbon dating for this zone are presented in Table 13.2.

Trench 9 (STDR400)

Introduction

Trench 9 was excavated to a maximum depth of *c* 5.3m with ground level at *c* 2.65m OD. Edge support was achieved with the use of sheet piles (Pl 13.1). Although the archaeological record from the trench was poor, the exceptionally well-preserved sequence, containing tufa in places, was thought worthy of further detailed laboratory investigation (Fig 13.3). Analysis included pollen, diatoms, ostracods and foraminifera, plant remains and insects, the full specialist reports of which can be found in the appendices. In total eight radiocarbon dates were obtained on samples from Trench 9 (Table 13.2).

Lithological Succession

The detailed sediment descriptions for Trench 9 are presented in Table 13.3 and the location of sub-samples in Figure 13.3. Trench 9 was unremarkable for its archaeological remains and artefacts. Only two flints and several burnt flint fragments were recovered from a

Table 13.1 Zone 9 key interventions and range of environmental and dating studies

Project	Key locations	^{14}C	Pollen	Diatoms	Ostracods	Plants	Insects	Archaeology
STDR400	Trench 9	X	X	X	X	X	X	
	Trench 11	X	–	–	–	–	–	Ebbsfleet Ware bowl, worked flint and animal bone within main peat deposits
STDR401	Area 4	X	X	X	X	X	X	Artefact scatters associated with main peat deposits: Early Neolithic worked flint, and animal bone at base of peat; Late Neolithic timber structure and Bronze Age worked and burnt flint at top of peat

KEY: X – analysis

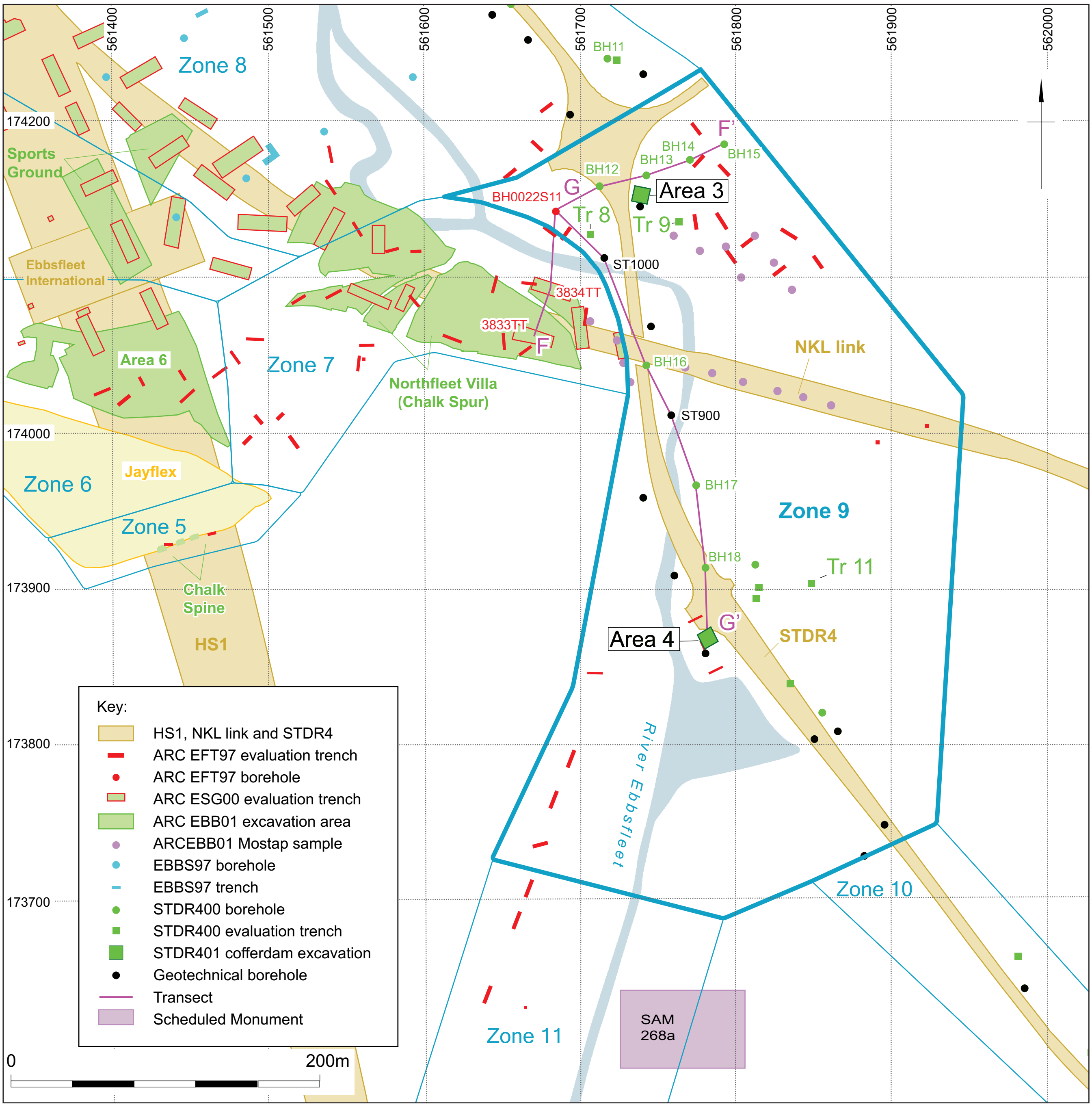


Figure 13.1 Zone 9 layout and key intervention locations

wood and peat layer (context 935) at the base of the trench sitting directly upon the surface of the 'Lower Clay-Silt' (Fig 13.3). The wood layer consisted of interlaced unworked branches of varying circumference and although no evidence of concentrated activity was found in association with it, it cannot be dismissed as entirely insignificant. Although the horizontal timbers may be naturally occurring, possibly water collected and deposited, the slightly unusual appearance of these means its identification as a potential surface/trackway remains.

Woody peat sealed the interlaced wood layer and contained very small fragments of burnt flint throughout. A thick accumulation of amorphous peat deposits above this was interleaved with a complex sequence of thin tufa deposits.

The peat and tufa unit was sealed by the sequence of 'Upper Clay-Silt' which, in turn, was overlain by an 'Upper Peat' unit. This sequence differed from thick elsewhere along the valley in that these deposits were interspersed with brown organic clay silts, rather than entirely the sterile blue/grey of the estuarine deposits and brown/black peats. This suggests the trench was located in a marginal area of the valley side and so may have relevance and implications for the model of sea-level change being more susceptible to water-level function.

Table 13.2 Radiocarbon dates from sediment sequences, Zone 9

Event code	Feature/layer type	Sample	m BGL/ m OD	Material dated	Lab Code	δ¹³C ‰	Result BP	Calibrated date (2 sigma, 94.5%)
STDR400 Tr. 8	Top of major peat horizon 802	73	4.44/-0.09	Juvenile *Quercus* sp.	NZA-29081	-27.0	4495±35	3360–3030 cal BC
	Bottom of sampled peat horizon 805	90	4.73/-0.38	*Sambucus nigra* seeds	NZA-29153	-30.6	4427±35	3330–2920 cal BC
STDR400 Tr. 9	Base of upper peat 910	103	1.98/+0.72	Bulk sediment	SUERC-16657	-28.2	1290±35	650–810 cal AD
	Organic horizon in upper clay silt 912	104	2.37/+0.33	Bulk sediment	SUERC-16658	-28.4	1740±35	220–410 cal AD
	Organic horizon base of upper clay silt 914	104	2.66/+0.04	Bulk sediment	SUERC-16659	-27.2	3840±35	2460–2200 cal BC
	Organic horizon in upper clay silt 916	105	2.73/-0.03	Bulk sediment	SUERC-16660	-28.7	2605±35	840–590 cal BC
	Main peat unit 916	105	3.01/-0.31	Bulk sediment	SUERC-16661	-28.1	2820±35	1120–890 cal BC
	Main peat unit 918	105	3.28/-0.58	Bulk sediment	SUERC-16662	-26.7	3725±35	2280–2020 cal BC
	Main peat unit 934	107	4.59/-1.89	*Alnus glutinosa* roundwood	NZA-29077	-27.7	4663±35	3620–3360 cal BC
	Base of main peat unit 934	107	5.02/-2.32	*Alnus glutinosa* roundwood	NZA-29080	-27.8	4926±35	3780–3640 cal BC
STDR401 Area 3	Main peat unit 3026	469a	5.59/-2.11	*Alnus glutinosa* cone	NZA-29158	-27.5	4752±35	3640–3380 cal BC
	Main peat unit 3029	469b	5.9/-2.42	Bulk sediment	NZA-29083	-28.1	5073±35	3960–3780 cal BC
	Base of main peat unit 3029	469b	6.13/-2.65	Juvenile wood unid due to desiccation (bark removed)	NZA-29084	-26.8	5329±35	4320–4040 cal BC
	Top of lower clay silt 3023	Find 1790	6.2/-2.72	Aurochs bone	NZA-29235	-23.8	5727±35	4690–4480 cal BC
STDR400 Tr. 11	Peat 1119 around Ebbsfleet Ware pot	Ves1		Waterlogged roundwood	WK-8799	-28.4	4730±70 *	3640–3360 cal BC
	Peat 1119 around Ebbsfleet Ware pot	Ves1		Waterlogged *Corylus* nutshell	WK-8800	-28.6	4696±75	3650–3340 cal BC
	Ebbsfleet Ware pot	Ves1		Charred residue	NZA-29079	-26.1	4723±35	3640–3370 cal BC
	Ebbsfleet Ware pot	Ves2		Charred residue	NZA-29155	-28.5	4547±35	3370–3100 cal BC
STDR401 Area 4	Top of main peat 4024	396	4.14/-0.53	Pomoideae roundwood charcoal, 6 years	NZA-29078	-25.2	2841±35	1120–910 cal BC
	Wooden trackway 4027 (context 4033)		4.20/-0.59	*Alnus glutinosa*, waterlogged roundwood	SUERC-19950	-27.9	4120±30	2870–2570 cal BC
	Main peat 4032	445	4.70/-1.09	Bulk sediment	NZA-29082	-29.2	4725±35	3640–3370 cal BC
	Main peat 4041	445	5.36/-1.75	*Sambucus nigra* seed	NZA-29154	-25.9	5078±40	3970–3780 cal BC
	Base of main peat 4049		5.77/-2.16	Butchered sheep rib	NZA-29242	-22.0	4758±35	3640–3380 cal BC
	Base of main peat 4043	432	5.80/-2.19	Waterlogged *Corylus* nutshell	NZA-29247	-23.6	4945±35	3800–3650 cal BC
	Basal peat filled hollow 4053	491	5.85/-2.24	Charred *Corylus* nutshell	NZA-29246	-24.3	5405±35	4350-4070 cal BC

KEY: * Bulk radiometric date

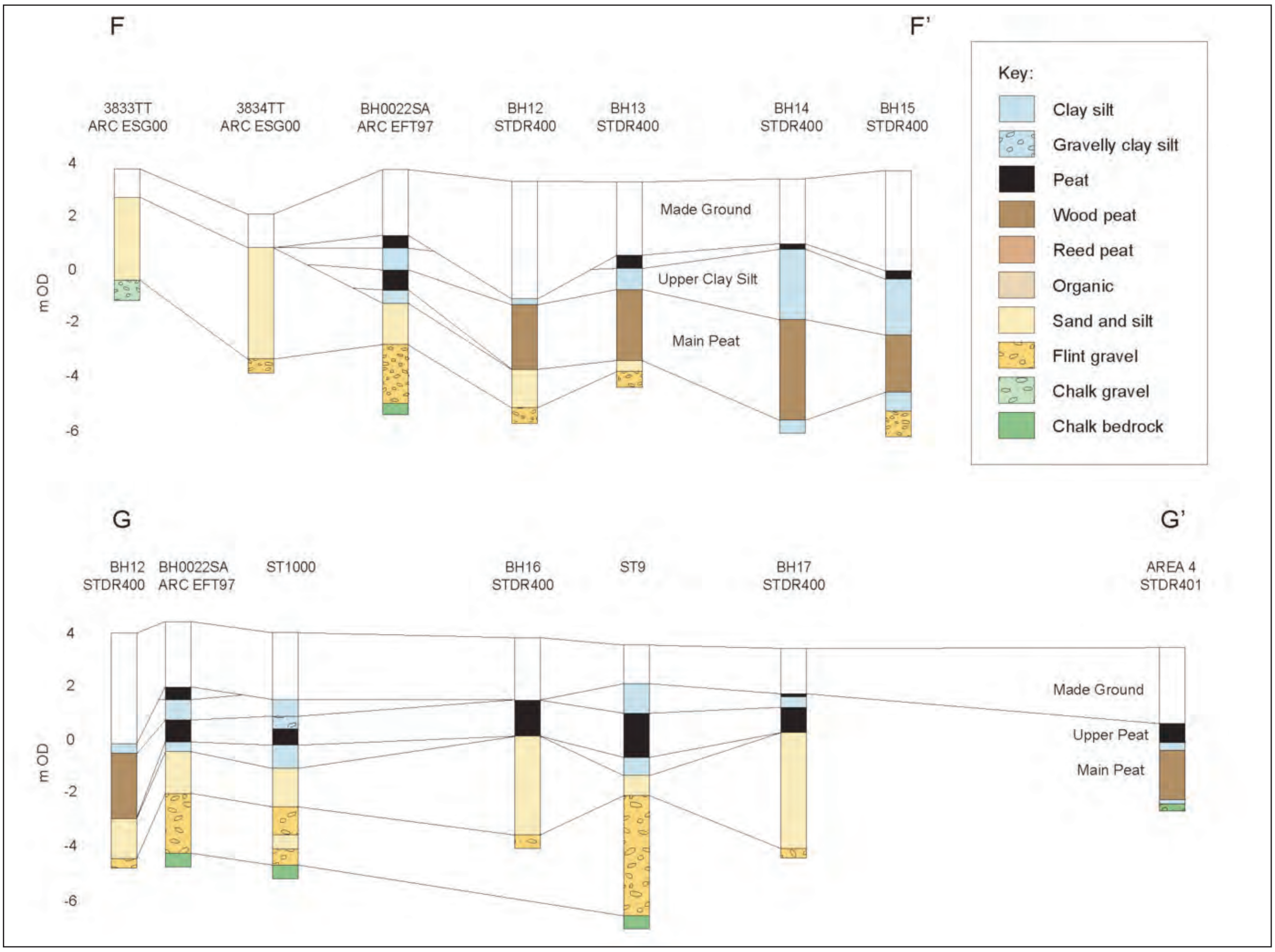


Figure 13.2 Zone 9 long profiles

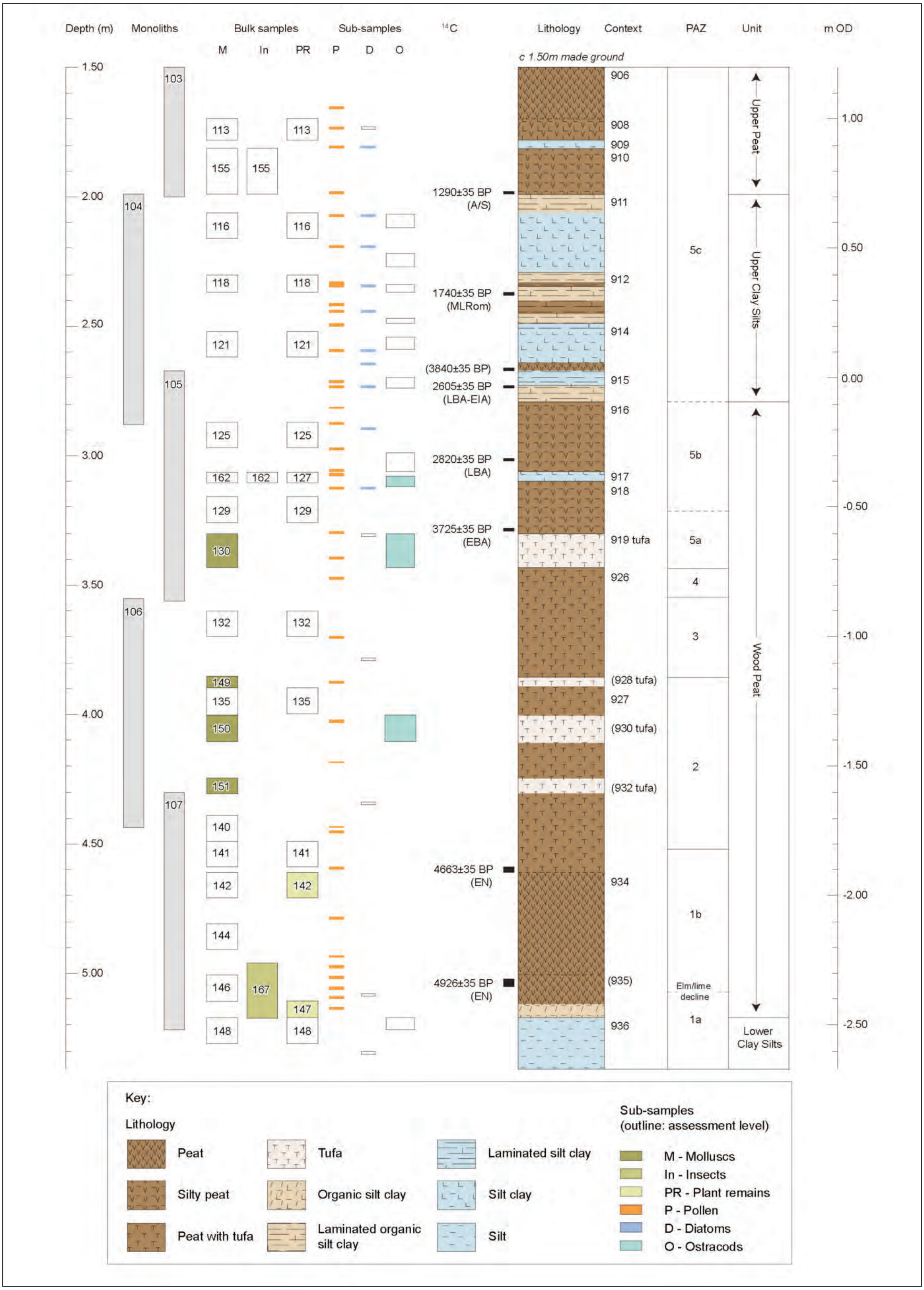


Figure 13.3 Trench 9 (STDR400) lithology and sample profile

Dating

Eight radiocarbon dates were obtained on the sediment sequence in Trench 9 (Fig 13.3; Table 13.2). The purpose of the dating was to provide a broad chronological framework for sequence accumulation, as well as to provide dates for key vegetational changes in the pollen spectra.

The earliest date of 4926±35 BP (NZA-29080, 3780–3640 cal BC) derives from the peat at -2.32m OD, placing accumulation of the basal part of the sequence within the Early Neolithic period. Accumulation appears to have continued throughout the Neolithic and into the Bronze Age period. Tufa formation at the top of the main peat unit appears to have occurred until the Early Bronze Age at 3725±35 BP (SUERC-16662, 2280–2020 cal BC), after which peat formation continued until the Late Bronze Age to Early Iron Age at 2605±35 BP (SUERC-16660, 840–590 cal BC). Organic units within the upper alluvial sequence have been dated to 3840±35 BP (SUERC-16659, 2460–2200 cal BC) and the middle to late Roman period at 1740±35 BP (SUERC-16658, cal AD 220–410). The former anomalous date may well be attributed to contamination of the sample with old carbon. The commencement of the 'Upper Peat' formation has been dated to the middle to late Anglo-Saxon period at 1290±35 BP (SUERC-16657, cal AD 650–810).

Plate 13.1 Trench 9 shored trench excavation

Pollen

by Elizabeth Huckerby, Sylvia Peglar and Lucy Verrill

A total of 36 samples were examined and five pollen assemblage zones (PAZs) identified from the sequence in Trench 9 (Fig 13.3; Huckerby *et al*, Appendix J). The method followed the same procedure outlined by Peglar for Borehole 7 (STDR400, Chap 12). The results are presented as a pollen and spore diagram (Fig 13.4) and summary table (Table 13.4).

Table 13.3 Trench 9 (STDR400) lithological description

Depth (m)	Description
0.00–1.50	Topsoil and fill/made ground
1.50–1.70	7.5YR 2.5/2 very dark brown well-humified peat (906), crumbly. Some mineral input at 1.56–1.70m with a light brown silty clay
1.70–1.78	7.5YR 4/2 mid-brown peat with silt and clay (908), very soft and plastic, mottled with dark organic patches
1.78–1.82	7.5 YR 6/1 grey, soft, plastic silty clay (909)
1.82–1.99	7.5YR 4/2 mid-brown silty peat (910)
1.99–2.29	10YR 3/2 very dark greyish brown, laminated organic silty clay (911). Below 2.06m becoming massive and structureless, 10YR 5/2 greyish brown grading to 2.5Y 5/2, firm, plastic silty clay, mottled with darker grey organics. Frequent Fe oxidation in sub vertical root channels
2.29–2.49	10YR 4/2 dark greyish brown, soft, organic silty clay (912), horizontally laminated. Between 2.34–2.36m and 2.40-2.43m, 3–4mm laminations include 10YR 3/3 very organic/peaty clay
2.49–2.64	10YR 4/1 dark grey silty clay, laminated below 2.62m (914)
2.64–2.79	10YR 3/1 very dark grey peat with some silty clay (915), becoming more minerogenic down profile below 2.67m and finely laminated. Organic at the interface with underlying peat
2.79–3.06	10YR 2/1 black silty peat (916), becoming more reddish brown down profile below 2.97m
3.06–3.10	10YR 4/1 dark grey silty clay (917)
3.10–3.30	7.5YR 2.5/1 black silty peat (918)
3.30–4.61	10YR 2/2 dense, black slightly silty peat (926/927), fibrous but well-humified. Occasional to frequent flecks of micritic tufa. Concentrated tufa lenses at 3.3–3.43m (919), 3.86–3.9m (928), 4.0–4.10m (930), 4.25–4.3m (932)
4.61–5.12	10YR 2/2 dense black, fibrous, slightly silty peat, well-humified with frequent woody fragments including roundwood with bark up to 3mm (934). Very woody below 5.00m (935)
5.12–5.17	10YR 4/1 dark grey brown organic silt, grading to 10YR 4/2. Possibly disturbed with clasts of (936) distributed throughout. Interface deposit with peat and underlying silt
5.17–5.37	2.5Y 6/1 soft, light yellowish grey silt (936). Frequent woody detritus and sub-vertical rooting

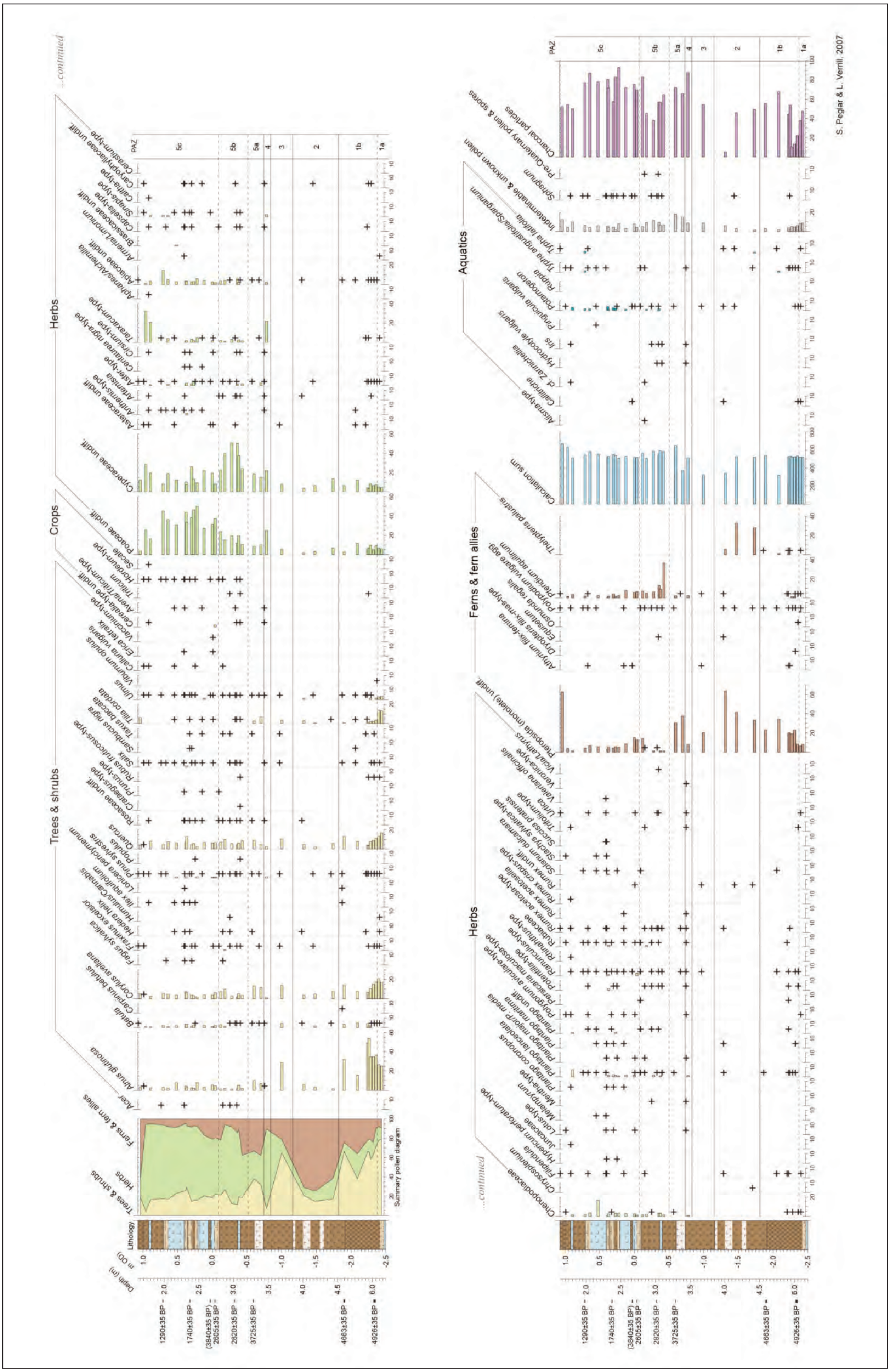


Figure 13.4 Pollen diagram from Trench 9 (STDR400)

Table 13.4 Trench 9 (STDR400) pollen summary

PAZ	Local environment	Regional environment	Human impact
5c	Mid-/upper saltmarsh at base grading into reedswamp. Incursion of salt water greater at base of subzone with freshwater predominating towards the top. Sea-level falls	Very little woodland still extant in area (AP 20–30%), ie, woodland clearance almost complete, with further increase in pastures and particularly arable fields. Arable cultivation throughout (barley) with rye towards the top. A rich herbaceous flora	++++
5b	Reedswamp with freshwater but some incursion of salt water throughout	Deciduous woodland (oak, hazel, ash, birch) continues to fall with concomitant increase in pastures/meadows with a rich herb flora. Bracken growing in woodland clearances or on waste ground. Growth of cereals. Increase in hedgerow/woodland edge shrubs	+++
5a	Alder carr with rich under storey of ferns. Possibly less wet as sea level dropped	Some secondary woodland development?? – increases in lime, oak, hazel.	++
4	Alder carr replaced by sedges with some open water	Possible woodland clearance and development of damp meadows/pastures. Some cereal grains.	++
3	Alder carr	Temporary recovery in deciduous woodland (oak, hazel, ash) on drier ground with some lime and elm	
2	Marsh/sedge fen with many ferns. Alder carr within river valley	Pollen sum is dominated by local taxa and regional environment masked.	
1b	Alder carr with rich under storey of ferns with saltmarsh towards the base	Deciduous woodland (oak, lime, hazel, ash, elm) on drier ground. A *Tilia* decline occurs at the lower boundary of this zone and values of elm are low. 1st appearance of cereal pollen towards the base of the zone	+++
1a	Alder carr with some sedges and saltmarsh	Deciduous woodland of dominated by lime but with some oak, elm, ash and hazel on higher, drier ground with some open ground. 1st elm decline probably already taken place	+

KEY: AP – tree and shrub pollen sum; +– negligible; ++ – low; +++ – medium; ++++ – high

PAZ 1

Subzone 1a: Arboreal pollen taxa are well represented in the opening subzone. Alder (*Alnus glutinosa*) pollen has values of *c* 25% TLP (total land pollen and spores) with *c* 25–30% hazel (*Corylus avellana*-type), and 13% small-leaved lime (*Tilia cordata*) pollen. Oak (*Quercus*), initially well represented at around 16%, declines to *c* 10% over the course of the subzone. Birch (*Betula*), Scots pine (*Pinus sylvestris*), ash (*Fraxinus*) and elm (*Ulmus*) pollen are also represented in low numbers. Grass (Poaceae) pollen is represented at less than 10% TLP, and sedge (Cyperaceae) pollen gradually increases from *c* 5% to *c* 7%. The herbaceous suite is restricted, with occasional pollen grains of daisy type (*Aster*-type) and dandelion type (*Taraxacum*-type), goosefoots (Chenopodiaceae) and buttercup (*Ranunculus*). Indeterminate fern (Pteropsida) spores have values of *c* 10%, bracken (*Pteridium aquilinum*) and polypody (*Polypodium*) spores have values of *c* 10% and some aquatic pollen grains are present in low numbers.

Subzone 1b: At the base of subzone 1b, small-leaved lime pollen decreases dramatically from *c* 15% to <5% TLP together with elm pollen. Just above the base, a single grain of wheat (*Triticum*) was recorded. Alder initially increases to *c* 55% TLP at the base of the subzone. Following this peak, alder, hazel and oak pollen all decline in the middle of the subzone, and increase towards the upper boundary. Mirroring the trend in arboreal pollen, grass and sedge pollen slightly increase mid-subzone and decline towards the upper boundary. Undifferentiated fern spores expand to *c* 35% TLP, and then decline to *c* 25%.

PAZ 2

Arboreal pollen percentages decrease at the PAZ 1/2 boundary, and remain at relatively low values throughout PAZ 2, although there are different trends within this group. Alder pollen slowly increases whilst hazel pollen decreases. Grass and sedge pollen percentages both decline over the course of the zone, and representation of other herbs is only sporadic. Undifferentiated fern spores and marsh fern (*Thelypteris palustris*) spores reach their maxima for the diagram in this zone (*c* 65% and *c* 35% respectively). The latter taxon declines in the upper spectrum of the zone.

PAZ 3

PAZ 3 is represented by a single pollen spectrum with a peak in arboreal pollen taxa including alder, hazel, oak and lime. Indeterminate fern spores decline in value from the previous zone but grass and sedge pollen are present at values similar to those in PAZ 2. Although it is unusual to define a PAZ from a single spectrum the broad sampling interval in the central section of the sequence and the characteristic pollen assemblage was felt to justify this division.

PAZ 4

PAZ 4 is also represented by a single pollen spectrum where arboreal pollen falls to less than 20% of the pollen sum. Grass and sedge pollen each expand to *c* 25% in this zone, and dandelion pollen also peaks at *c* 25%. Two cereal-type pollen grains; one indeterminate, one of *Avena/Triticum*-type, are also recorded with a broad assemblage of herbaceous pollen types.

PAZ 5

Subzone 5a: Increases are seen in the percentage representation of alder, birch, hazel, oak and lime. Grass and sedge pollen remain steady at lower levels than in PAZ 4. Undifferentiated fern spores reach 40% and decline to 35%.

Subzone 5b: Tree pollen percentages decline, reaching very low values in the middle of this subzone. Recovery is only partial and arboreal pollen never reaches substantial proportions of TLP after this point. Sedge pollen increases rapidly, reaching 50% of the sum and declining to 20% by the upper boundary, whereas grass pollen gradually increases from *c* 10 % to *c* 30%. The herbaceous pollen suite is more diverse than previously, with daisy family, goosefoots, plantains (including ribwort plantain *P. lanceolata*), buttercups and dock (*Rumex*) all present. Cereal and cereal-type pollen grains are relatively well represented, with oat/wheat, wheat and barley type (*Hordeum*-type) all present. Bracken spores, initially very high in the subzone, decline to around 10%. Undifferentiated fern spores are poorly represented. Aquatic pollen increases in representation.

Subzone 5c: Tree pollen percentages continue to fluctuate at generally low values. The overall trend for grass pollen is one of expansion, followed by decline in the upper half of the subzone. Sedge pollen fluctuates, but expands in the upper part of the subzone. There is a diverse suite of herbaceous pollen taxa, with dandelions very numerous in the uppermost spectra, and cereal-type and cereal grains, especially barley-type, are present almost continuously. Undifferentiated fern spores initially increase from the low percentages present in subzone 5b, but experience an overall decline until the sharp peak in the uppermost spectrum. The decline in bracken spore representation continues from subzone 5b. An increasingly diverse aquatic pollen spectrum is recorded, with *Potamogeton* the best-represented aquatic pollen taxon.

Overall at the base of the profile arboreal pollen taxa were well represented while the herbaceous suite was restricted. The local environment in PAZ 1a was that of an alder carr with an understorey of sedges with some indeterminate ferns. There were low but consistent values of pollen from the goosefoot family, daisy-type (*Aster*-type, which includes the sea aster), sea plantain (*Plantago maritima*) and a single grain of sea thrift/sea lavender (*Armeria Limonium*), which may suggest some saltmarsh was present in the locality. A deciduous woodland predominantly of lime but with oak, hazel, and some elm and ash would have dominated the landscape on the higher ground. The levels of pollen from herbaceous taxa, which include locally grown sedges, suggest that there may have been a low level of impact by Mesolithic people in the Late Mesolithic, and is confirmed by the presence of microscopic charcoal and the recovery of worked flints at this level Microscopic charcoal particles provide evidence for natural or humanly-made, fires in the catchment.

PAZ1b is dated to the Early Neolithic period. The local environment was of a fen carr with an understorey of ferns and sedges. Bulrushes and/or bur reed early in the zone suggest some open water in the carr.

An elm decline appears to occur at the PAZ 1a/1b boundary and there was also a marked decline in the representation of lime. The lime decline, thought to be caused by anthropogenic activity (Turner 1962), is more normally recorded in the Late Neolithic or Bronze Age from East London (Devoy 1979; 1980; 2000; Scaife 2000; MoLAS 2001; OAU 2006; Wilkinson *et al* 2000) and in the Lower Thames region (Scaife 1988; 2003). However, at this site it appears to date to the Early Neolithic period: much earlier than in many areas. Unfortunately, the segment from the BH7 sequence from the levels that Peglar thought should include the elm decline were lost prior to sub-sampling for analysis, and therefore it is not possible to speculate that this early lime decline was more widespread in the Ebbsfleet Valley (see Peglar, Chap 12). At Sidlings Copse near Oxford a lime decline is recorded together with the primary elm decline and although undated Day (1991) interpreted it as taking place *c* 5000 BP in the Early Neolithic.

There are three possible causes for this very early, apparent lime decline:

1. It may reflect the filtering effects of the local vegetation as changes in percentage pollen data are directly related to changes in other taxa.
2. Lime will not tolerate wet conditions; therefore, a raised water table will cause the death of the trees.
3. It may have an anthropogenic cause as both the declines in elm and lime are associated with an increase in the number of charcoal particles, a record of wheat (*Triticum*) pollen and also pollen from a number of anthropogenic indicator species such as ribwort plantain. These factors are all indicative of a link between the declines in elm and lime and forest clearance. Lime recovers to some extent at the top of PAZ 5a before its decline in the Bronze Age.

In PAZ 2 the local environment was dominated by indetrminate ferns, probably mostly of marsh fern (*Thelypteris palustris*) with some sedges. This PAZ is very similar to the upper part of PAZ 4 in the pollen diagram from BH7 where Peglar (see Chap 12) interprets the local vegetation as a calcium-rich fen with some tufa springs. As in the BH7 some obligate aquatic taxa are recorded including pondweeds and bulrush. The over representation of pollen and spores from the local vegetation has obscured the environment away from the river.

A single pollen spectrum was counted from this PAZ 3 but because it differs significantly from PAZ 2 and PAZ 4 it is placed in a zone of its own. The calcium rich fen is replaced by alder carr again with lesser amounts of ferns. Away from the river a deciduous woodland of oak, hazel, birch and lime was present with some evidence of human impact. Although it is unusual to define a PAZ from a single spectrum the broad sampling interval in the central section of the sequence and the characteristic pollen assemblage was felt to justify this division.

Again, a single pollen spectrum was assigned to PAZ 4 for similar reasons to those mentioned above. Alder carr was replaced by sedge community and the presence of some aquatic taxa suggest areas of open water. Possible woodland clearance took place with the development of damp meadows/pastures, which are

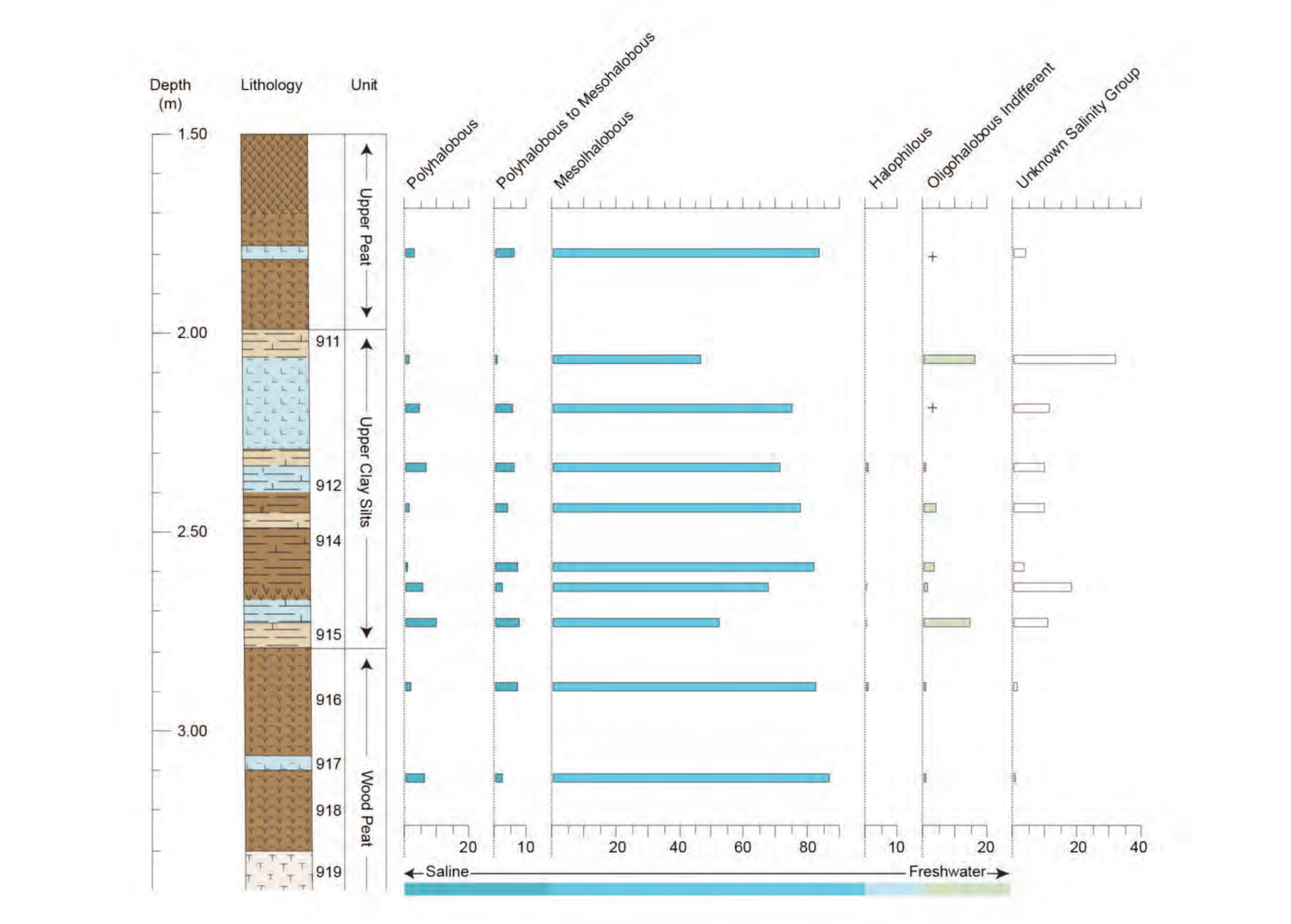


Figure 13.5 Trench 9 (STDR400) diatom summary

shown by increases in the pollen recorded from grasses and dandelion-type pollen (*Taraxacum*-type; Asteraceae sect Lactucoideae). There is no radiocarbon date from this zone but the sequence was dated to 3725±35 BP (SUERC-16662, 2280–2020 cal BC at -0.58m OD in PAZ 5a suggesting that PAZ 4 is likely to be dated to the Early Bronze Age. The pollen record suggests that there were probably some arable fields close to the site in the Early Bronze Age/Late Neolithic. High levels of charcoal were recorded in PAZ.

The upper part of PAZ 5a is dated at -0.58m OD to 3725±35 BP (SUERC-16662, 2280–2020 cal BC) in the Early Bronze Age. The local environment was that of an alder carr with a rich understorey of ferns and sedges, a freshwater community type. On the drier ground, away from the river valley there were still some areas of extant deciduous woodland of oak, hazel and lime but the landscape had largely been cleared for pasture with no indications of arable cultivation close to the site. The increase in the levels of lime pollen during the subzone suggests that the representation of lime in the woodland had recovered following its earlier decline at the lower boundary of PAZ 1b before its final decline in the Late Bronze Age. As discussed above in the interpretation of PAZ 1b, the lime decline in the Thames Valley is thought to have taken place in the Late Neolithic or Bronze Age.

Towards the lower boundary of subzone 5b and of context 916, at a depth the peat is dated to 2820±35 BP (SUERC-16661, 1120–890 cal BC) in the Late Bronze Age. This date is very similar to that of 2841±35 BP (NZA-29078, 1120–910 cal BC) from charcoal associated with flint scatter (4026) and the burnt area in Area 4 (STDR401, see Druce below). The upper part of this subzone is dated at -0.03m OD to 2605±35 BP (SUERC-16660, 840–590 cal BC) placing it in the Late Bronze Age/Early Iron Age. The local environment was probably that of a freshwater reedswamp with some areas of open water. Pollen from halophytes was recorded and increased towards the upper part of the subzone providing increasing evidence marine incursion. On the higher ground woodland continued to decline with pastures, some arable cultivation and extensive areas of bracken in the forest clearances.

The pollen record from the upper part of the sequence, which includes the lower part of the 'Upper Peat' deposit (context 910) and most of the lower clay silts (contexts 911–914 inclusive), is defined as Subzone 5c. The more central part of the subzone is dated at +0.33m OD to 1740±35 BP (SUERC-16658, 220–410 cal AD) in the mid- to late Roman period. Above this at +0.72m OD it is dated to 1290±35 BP (SUERC-16657; 650–810 cal AD) in the Anglo-Saxon period. The earlier part of 5c is therefore likely to be Late Iron Age in date as the upper part of the previous subzone, 5b, was dated to the Late Bronze Age/Early Iron Age. Initially the local environment was saltmarsh, evidenced by the record of pollen from the goosefoot family, daisy-type, sea plantain and occasional grains of thrift/sea lavender. This saltmarsh was replaced by reedswamp with some areas of open water, indicated by an increase in freshwater aquatic pollen, from 220–410 cal AD (the late Roman period) suggesting a decreased marine influence. Away from the river valley the landscape was open grassland with evidence for arable cultivation, represented throughout the subzone, with some stands of oak and hazel woodland. The pollen record suggests that barley and oats/wheat were being cultivated close to the Upper Ebbsfleet Valley from the Iron Age onwards, with rye being grown after 650–810 cal AD. It should be noted that the near continuous presence of pollen from barely (*Hordeum* group) may also be from wild grasses (Andersen 1979) such as couch grass (*Agropyron*), often to be found close to the sea, or from the aquatic taxon *Glyceria* (sweet grasses).

Diatoms

by Nigel G Cameron

Following a brief assessment, a total of 10 samples was analysed in detail for diatoms from the upper part of the deposit sequence in Trench 9. A total of 59 diatom taxa was identified (Figs 13.3 and 13.5; Cameron Appendix K). Methods and terminology follow those outlined for Borehole 7 (Chap 12).

The two samples from the clay-silt lens (context 917) and peat (context 916) provide evidence of a tidal habitat in the vicinity. The dominance of robust (heavily silicified), poorly-preserved benthic diatoms and an aerophilous mesohalobous species suggest a high shore environment where flooding was irregular. The mesohalobous benthic diatom *Diploneis interrupta* made up *c* 70–80% of the diatoms in these samples. This is an epipelic (mud-surface) or epipsammic (on sand grains) diatom and is an aerophilous species, tolerant of desiccation (Vos and de Wolf 1993). Marine-brackish aerophiles such as *Diploneis interrupta* are adapted to irregular flooding and are often indicative of supratidal habitats such as saltmarshes where the component of allochthonous marine plankton might also be high.

In the overlying sample from context 915 the percentage of *Diploneis interrupta* declined to just over 20%, whilst there were small but significant increases in the numbers of oligohalobous indifferent taxa such as *Fragilaria construens* var. *venter* and *Fragilaria pinnata*. At this depth, the lithology is at a transition from the wood peat to the 'Upper Clay-Silt'. The assemblage here reflects a changing environment with perhaps more frequent flooding; evident from the oligohalobous indifferent species with wide salinity tolerance, components of both freshwater and brackish water epiphytes and the marine plankton.

Despite the variation in lithology, the diatom assemblages from the overlying sediments (contexts 914, 912, 911 and 909) were relatively consistent being dominated by mesohalobous benthic diatoms with a single dominant aerophilous component that suggests that this was a high shore environment with infrequent flooding. *Diploneis interrupta* (see discussion above) made up *c* 40–80% of the assemblages. Freshwater, halophilous, mesohalobous plankton and allochthonous marine diatoms formed relatively small components compared with many brackish water sediments. The poor preservation of diatom valves is also consistent with a supratidal environment, in deeper water the preservation of diatom valves would be expected to be better than that found in the assemblages here where many valves are broken and dissolved.

Ostracods

by John E Whittaker

Samples from the upper part of the alluvial profile were far too organic for the recovery of ostracods and foraminifera (Fig 13.3; Whittaker, Appendix L). However, the sample from context 917, a silty clay lens within the upper part of the main peat unit, did contain an abundant but restricted fauna of agglutinating foraminifera. These were poorly preserved, either with collapsed chambers or with only the organic linings of the chambers remaining. Thus, it is difficult to know for certain whether the species in question was *Jadammina macrescens* (a trochospiral form) or *Haplophragmoides wilberti* (which has a planispiral coil), or indeed whether both of them were present. They both have the same niche, however, being found on brackish (high) saltmarshes and can withstand extreme environmental variability (Murray 1979).

The only other samples from Trench 9 which contained microfaunas of ecological significance were the underlying tufa lenses (with the main peat unit). A sample from context 919 contained six species of freshwater ostracods, including the rare *Cypridopsis lusatica* (Pl 13.2). This is only the second record of this species from the British Isles, its first (as *C. bamberi*, a junior synonym) by Henderson (1986), was from a Cornish spring. As the name suggests, this is a southern (Lusitanian) species, widespread in the circum-Mediterranean area, its occasional occurrence in NW and Central Europe being best explained (Meisch 2000) by passive introduction, probably by migrating birds. The ostracods lived either in the spring/seepage itself – *Cypridopsis lusatica*, *Cryptocandona vavrai*, and *Cyclocypris laevis*, or in the vegetation that probably covered the pools that must have formed behind the tufa dams (*Scottia pseudobrowniana* and *Nannocandona faba*) are specialised semi-terrestrial species which live in or burrow into this floating vegetation). In a lower tufa lens (context 930, not illustrated in Fig 13.3) there was much more peat in the sample and only *Nannocandona faba* was present. The one sample from the base of the

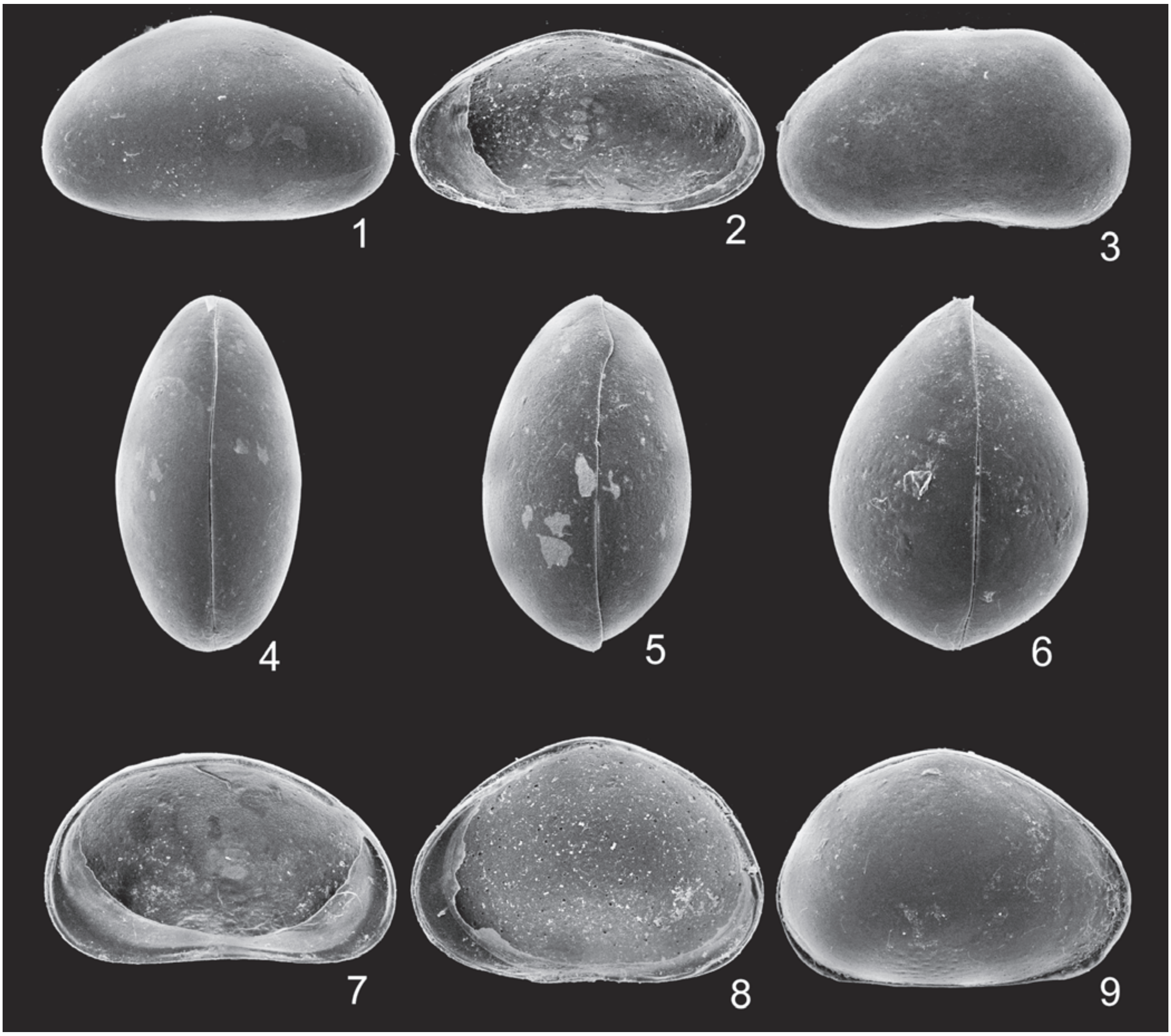


Plate 13.2 Ostracods from tufa deposits, Trench 9 (STDR400) 1. *Cypridopsis lusatica* left valve in external lateral view (x85); 2. *C. lusatica* right valve in internal lateral view (x85); 3. *Nannocandona faba* left valve in external lateral view (x120); 4. *C. lusatica* carapace in dorsal view (x85); 5. *Scottia pseudobrowniana* carapace in dorsal view (x65); 6. *Cyclocypris laevis* carapace in dorsal view (x100); 7. *S. pseudobrowniana* left valve in internal lateral view (x70); 8. *C. laevis* right valve in internal lateral view (x110); 9. *C. laevis* carapace in right lateral view (x100)

sequence (context 936) did not contain any foraminifera or ostracods, but the occurrence of freshwater molluscs, including *Bithynia* opercula, provides an undoubted freshwater signature. It would seem that tidal connection in this sequence first occurred at the end of the main peat event, with a rise in sea level, somewhere between context 919 and 917. This led to deposition of the 'Upper Clay-Silt' and probably to the cessation of all tufa spring/seepage, at least in this lower part of the Ebbsfleet Valley.

Insects

by Mark Robinson

Following the initial plant assessment of 13 small (200g) samples from deposits in Trench 9, three larger (1kg) samples were chosen for were more detailed assessment of insects in 2000 (samples 155, 162 and 167, OAU 2000). Remains were sparse or absent throughout much of the alluvial sequence. The lower part of the main peat unit, however, contained insect remains which are now extinct in Britain and offered potential to provide information on small-scale woodland grazing during the Neolithic. For these reasons sample 167 from context 934 was the subject of detailed analysis (Fig 13.3). The results have been listed in Tables 13.5 and 13.6 along with those from Area 4 from STDR4 (see below), giving the minimum number of individuals represented by the fragments of each species for each sample. The nomenclature follows Kloet and Hincks (1977) for Coleoptera. Along with the identifications is given a short description of the habitat or food of each species. A wide range of sources has been used for ecological

Table 13.5 Trench 9 (STDR400) and Area 4 (STDR401) Coleoptera

	Min. No. Indiv.				
	Area 4		Trench 9		
Context	**4043**	**4042**	**934**		
Sample	**436**	**437**	**167**	**Species**	
Sample volume (litres)	**10**	**10**	**10**	**Group**	**Habitat or food**
Carabus granulatus L.	–	1	1	–	T – often near water, in rotten trees
Nebria brevicollis (F.)	–	1	–	–	WGD
Elaphrus cupreus Duft.	–	1	–	–	MB – at water's edge
Loricera pilicornis (F.)	–	1	*	–	T – usually moist
Dyschirius globosus (Hbst.)	–	–	2	–	T – moist ground, M
Trechus obtusus Er. or *quadristriatus* (Schr.)	–	1	–	–	T
Bembidion doris (Pz.)	–	1	–	–	BM
B. biguttatum (F.)	–	1	–	–	BGW – usually near water
Pterostichus anthracinus (Pz.)	–	1	–	–	MB – shaded
P. gracilis (Dej.)	–	–	1	–	GW – wet, M
P. minor (Gyl.)	1	1	1	–	MB – wooded and open
P. nigrita (Pk.)	–	1	–	–	MB
P. strenuus (Pz.)	–	2	1	–	T – often near water
Abax parallelepipedus (P.&M.)	–	1	–	–	W (GDC)
Agonum thoreyi Dej.	–	5	–	–	MB – inc reed beds
Agonum sp.	–	–	*	–	TM
Acupalpus sp.	–	1	–	–	Mostly wet places
Oodes cf. *helopioides* (F.)	–	1	–	–	M – often amongst reeds and sedges
Haliplus sp.	1	–	–	1	A
Hygrotus inaequalis (F.)	–	–	1	1	A – stagnant or slowly moving
Hydroporus sp.	–	4	–	1	A
Agabus sp. (not *bipustulatus*)	1	2	–	1	A
Acilius sp.	1	–	–	1	A – stagnant
Gyrinus sp.	–	–	1	1	A
Helophorus spp. (*brevipalpis* size)	–	1	1	1	A – but readily leave water
Cercyon sternalis Sharp	–	2	–	7	MB – on damp ground
C. ustulatus (Pres.)	–	1	1	7	V – moist places (F)
Megasternum obscurum (Marsh.)	1	4	2	7	FVC
Cryptopleurum minutum (F.)	–	–	1	7	FVC
Hydrobius fuscipes (L.)	2	3	1	1	A – stagnant
Anacaena globulus (Pk.)	–	1	1	1	GW – wet places, VA
A. bipustulata (Marsh.) or *limbata* (F.)	–	1	–	1	GW K wet places, VA
Laccobius sp.	–	2	–	1	A
Enochrus sp.	–	1	–	1	A – mostly ponds and ditches
Chaetarthria seminulum (Hbst.)	–	1	–	1	B – wet vegetation and mud (A)
Ochthebius cf. *bicolon* Germ.	1	–	–	1	B – mud and decaying vegetation A
O. minimus (F.)	2	1	4	1	A – often stagnant
O. cf. *minimus* (F.)	7	13	9	1	A – often stagnant
Hydraena cf. *riparia* Kug.	1	3	6	1	A
H. testacea Curt.	–	–	*	1	A – usually stagnant
Ptenidium sp.	–	1	1	–	Dung heaps; rotten wood; VM
Ptiliidae indet. (not *Ptenidium* sp.)	–	–	*	–	VM (TF)
Silpha atrata L.	1	1	1	–	mostly under bark of rotten wood
Lesteva sp.	2	5	5	–	B – often at water's edge; M
Platystethus arenarius (Fouc.)	1	–	1	7	FV
Anotylus nitidulus (Grav.)	1	–	–	–	VFC (M)
A. rugosus (F.)	–	–	1	7	FV (C)
Stenus spp.	3	5	8	–	TM
Lathrobium sp. (not *longulum*)	1	–	1	–	TV (C)
Rugilus orbiculatus (Pk.)	1	1	2	–	V (G)
Philonthus sp.	–	1	1	–	FVC (T)
Staphylinus aeneocephalus Deg. or *fortunatarum* (Wol.)	–	2	–	–	WG
Aleocharinae indet.	1	3	2	–	TFVC
Geotrupes sp.	–	1	1	2	F
Aphodius cf. *fimetarius* L.	–	1	1	2	FV
A. cf. *sphacelatus* (Pz.)	2	–	1	2	FVC
Aphodius sp.	–	–	1	2	Mostly F
Copris lunaris (L.)	–	1	–	2	F
Onthophagus taurus (Sch.)	–	–	*	2	F
Serica brunnea (L.)	1	–	–	11	Larvae on grass roots in sandy places
Phyllopertha horticola (L.)	1	1	1	11	Larvae on roots in permanent grassland
cf. *Cyphon* sp.	5	9	3		Larvae A, adults T but close to water M
Dryops sp.	–	–	1	1	BAM – in or close to water (V)
Agrypnus murinus (L.)	–	-	*	11	G
Athous hirtus (Hbst.)	1	–	1	11	WG – larvae on roots of grassland plants
A. haemorrhoidalis (F.)	1	1	–	11	WG – larvae on roots of grassland plants
Actenicerus sjaelandicus (Müll.)	–	–	1	–	MG – wet
Agriotes sp.	–	1	–	11	Larvae mostly on roots of grassland plants
Adrastus rachifer (Fouc.)	1	–	–	–	G
Denticollis linearis (L.)	–	–	1	4	Larvae in rotten wood, adults on flowers
Melasis buprestoides (L.)	–	–	1	4	In rotten hardwood
Gastrallus immarginatus (Müll.)	–	2	–	4	Dead wood of deciduous trees
Anobium cf. *punctatum* (Deg.)	–	2	1	10	Dead wood esp. structural
cf. *Ptinus* sp.	1	–	–	9a	
Aplocnemus nigricornis (F.)	–	1	–	4	Larvae in decaying wood
Malachius sp.	–	1	–	–	Adults often on flowers
Atomaria spp.	–	–	1	–	VT (F)
Olibrus sp.	1	–	–		Adults on Compositae flowers
Cerylon histeroides (F.)	1	–	–	4	In rotten wood and under bark
Corylophus cassidoides (Marsh.)	1	7	6	–	V – esp. decaying reeds
Orthoperus sp.	2	2	5	–	V
Propylea quattuordecimpunctata (L.)	-	1	–	–	T
Enicmus transversus (Ol.)	1	–	–	8	V (GW)
Corticariinae indet.	1	–	–	8	Mostly V

Table 13.5 Continued

	Min. No. Indiv. Area 4		Trench 9		
Context	4043	4042	934		
Sample	436	437	167	Species	
Sample volume (litres)	10	10	10	Group	Habitat or food
Anaspis sp.	1	–	–	4	Larvae dead branches, adults on blossom
Bruchus loti Pk.	1	–	–		*Lotus* and *Lathyrus* spp.
Donacia marginata Hoppe	–	–	1	5	*Sparganium erectum* L.
Plateumaris affinis (Kunze)	2	9	1	5	*Carex* spp.
P. sericea (L.)	1	1	1	5	*Carex* spp. and *Iris pseudacorus* L.
Phaedon sp. (not *tumidulus*)	1	1	1		Various herbs
Prasocuris phellandrii (L.)	1	1	–	5	Aquatic Umbelliferae
Chrysomela aenea L.	–	1	–	4	*Alnus glutinosa* (L.) Gaert.
Phyllodecta sp.	1	–	–	4	*Salix* and *Populus* spp.
Agelastica alni (L.)	1	1	2	4	*Alnus glutinosa* (L.) Gaert.
Crepidodera ferruginea (Scop.)	–	1	–	–	Various herbs
Chaetocnema sp. (not *concinna*)	–	–	1	–	Various herbs
Psylliodes sp.	–	1	–	–	Various herbs
Anthribus fasciatus (Forst.)	1	–	–	4	Larvae on trees and shrubs
Apion craccae (L.)	1	–	–	3	*Vicia* and *Lathyrus* spp.
Apion spp. (not above)	1	2	2	3	Various herbs
Phyllobius or *Polydrusus* sp.	1	–	–	–	Deciduous trees, herbs and herbs
Sciaphilus asperatus (Bons.)	2	1	–	–	Woodland herbs
Tanysphyrus lemnae (Pk.)	1	3	1	5	*Lemna* spp.
Eremotes ater (L.)	–	–	1	4	Dead wood
Rhyncolus sp.	–	–	*	4	Dead hardwood
Acalles turbatus Boh.	–	3	1	4	Dead shrubs esp. in hedges
Thryogenes sp.	1	1	1	5	Cyperaceae and possibly *Phragmites* stems
Ceuthorhynchinae indet.	–	–	1		Various herbs
Limnobaris pilistriata (Step.)	–	–	1	5	esp. *Schoenoplectus* sp.
Mecinus pyraster (Hbst.)	–	1	–		*Plantago lanceolata* L. and *P. media* L.
Rhynchaenus cf. *quercus* (L.)	1	–	1	4	*Quercus* sp. leaves
Rhynchaenus sp. (not *quercus*)	1	1	–	4	Leaves of various trees
Scolytus rugulosus (Müll.)	–	–	1	4	Rosaceous trees and shrubs
Acrantus vittatus (F.)	1	–	–	4	Mainly decaying *Ulmus* spp.
Ernoporus caucasicus Lind.	1	–	–	4	*Tilia cordata* Mill.
Total	**70**	**138**	**100**		

KEY: A – aquatic; B – bankside/water's edge; C – carrion; D – disturbed/bare ground; F – dung; G – grassland; M – marsh; P – pest of stored farinaceous foods; T – terrestrial and occurring in several habitats; V – decaying plant remains; W – woodland or scrub; less normal habitats are given in brackets

Table 13.6 Trench 9 (STDR400) and Area 4 (STDR401) other insects

		Min. No. Indiv. Area 4		Trench 9	
	Context	4043	4042	934	
	Sample	436	437	167	
	Sample volume (litres)	10	10	10	Habitat or food
Dermaptera					
Forficula auricularia L.	adult	1	1	–	T
Hemiptera					
Pentatoma rufipes (L.)	adult	1	–	–	Deciduous trees esp. *Quercus* sp.
Heterogaster urticae (F.)	adult	–	–	2	*Urtica dioica* L.
Drymus brunneus (Sahl.)	adult	–	4	1	Amongst litter and moss
Miridae indet.	adult	–	1	–	T
Saldula S. *Saldula* sp.	adult	–	1	–	MB – at water's edge
Philaenus or *Neophilaenus* sp.	adult	–	1	1	Various plants
Aphidoidea indet.	adult	2	–	2	
Homoptera indet.	adult	1	2	3	
Trichoptera					
Trichoptera indet.	larva	1	3	–	A
Hymenoptera					
Neuroterus numismalis (Geof. in Fourc.)	leaf gall	–	–	1	On *Quercus* sp. leaves
Dolichoderus quadripunctatus (L.)	worker	–	–	5	Nests under bark and in hollow trees
Stenamma debile (Foerst.) or *westwoodii* West.	worker	–	–	1	Nests in shady woodland or hedges
Formica cf. *fusca* L.	worker	–	–	1	Nests under stones and in tree stumps
Hymenoptera indet.	adult	2	3	3	T
Diptera					
Chironomidae indet.	larva	+	+	+	A
Bibionidae indet.	adult	1	–	–	V
Diptera indet.	puparium	1	1	–	
Diptera indet.	adult	1	1	2	

KEY: A – aquatic; B – bankside/water's edge; C – carrion; D – disturbed/bare ground; F – dung; G – grassland; M – marsh; P – pest of stored farinaceous foods; T – terrestrial and occurring in several habitats; V – decaying plant remains; W – woodland or scrub; less normal habitats are given in brackets

Table 13.7 Trench 9 (STDR400) plant remains

	Sample	147	147*	142	142*	141	135	127	125	113
	Context	934	934	934	934	927	927	917	916	908
	Volume processed (litres)	0.2	0.8	0.2	0.8	0.2	0.2	0.2	0.2	0.2
	Proportion of flot analysed (%)		20		10					
Latin Binomial	**Common name**									
Waterlogged plant remains										
Ranunculus acris L./*repens* L./*bulbosus* L.	meadow/creeping/ bulbous buttercup	–	–	–	–	–	–	–	–	–
Ranunculus sceleratus L.	celery-leaved buttercup	+	4	+	25	–	–	–	–	–
Ranunculus ficaria L.	lessser celandine	–	–	–	5	–	–	–	–	–
Ranunculus subg. Batrachium (DC.) A. Gray	crowfoot	–	4	–	27	–	–	–	–	–
Urtica dioica L.	comon nettle	+	13	+	47	+	–	–	–	+
Betula spp.	birch	–	2	–	7	–	–	–	–	–
Alnus glutinosa (L.) Gaertn.	alder	++	–	++	–	++	+	–	–	–
	alder – seed	–	80	–	40	–	–	–	–	–
	alder – female cone	–	5	–	4	–	–	–	–	–
cf. *Alnus glutinosa* (L.) Gaertn.	possible alder seed	–	–	–	–	–	–	–	–	–
	possible alder bud	–	1	–	2	–	–	–	–	–
	possible alder bud-scar	–	16	–	11	–	–	–	–	–
Chenopodium spp.	goosefoots	–	–	–	2	–	–	–	–	–
Moehringia trinervia (L.) Clairv.	three-nerved sandwort	–	–	+	3	–	–	–	–	–
Stellaria media (L.) Vill.	common chickweed	–	–	–	1	–	–	–	–	–
Rorippa sp.	water-cress	–	–	–	1	–	–	–	–	–
Rubus section Rubus	blackberry	–	–	–	3	–	–	–	–	+
Potentilla anserina L.	silverweed	+	–	+	–	–	–	–	–	–
Oxalis acetosella L.	wood-sorrel	–	cf. 1	–	1	–	–	–	–	–
Polygonum hydropiper L.	water pepper	+	–	–	–	–	–	–	–	–
Solanum cf. *dulcamara* L.	bittersweet	–	–	–	cf. 1	–	–	–	–	+
Lycopus europaeus L.	gypsywort	–	–	–	1	–	–	–	–	–
Mentha sp.	mint	–	–	–	–	–	–	+	+	–
Eupatorium cannabinum L.	hemp agrimony	+	–	+	–	–	–	–	–	–
Berula erecta (Hudson) Coville	lesser water parsnip	+	–	–	–	+	+	–	–	–
Lemna spp.	duckweed	–	–	–	1	–	–	–	–	–
Juncus spp.	rush	+	–	–	–	–	–	+	+	–
Scripus sylvaticus L.	wood club-rush	+	–	–	–	–	–	–	–	–
Carex spp.	sedge	–	–	+	–	–	–	–	–	–
Carex spp. – 2-sided	sedge	–	–	–	1	–	–	–	–	–
Carex spp. – 3-sided	sedge	–	–	–	23	–	–	–	–	–
Cladium mariscus L.	great sedge	–	–	–	–	+	+	–	–	–
Poaceae – small caryopsis	small-seeded grass	–	1	–	2	–	–	–	–	–
Poaceae – medium caryopsis	medium-seeded grass	–	2	–	2	–	–	–	–	–
Unidentified	unidentified	–	–	–	10	–	–	–	–	–
Total			**129**		**220**					

KEY: * – samples analysed by Smith 2007; + – present; ++ – many

information about the Coleoptera. Most are given in Robinson (1991, 277–8). In addition, many details on Coleoptera have been gained from Hyman (1992; 1994) and Koch (1989a; 1989b; 1992). Many of the Coleoptera have also been placed into habitat-related species groups following Robinson (1991; 278–81). The particular group into which a species has been placed is given in Table 13.5. The detailed methodology and results for the analysis are presented in Robinson, Appendix N. The following is a summary for Trench 9.

The assemblage from sample 167 indicated the presence of alder carr and included the remains of various water and amphibious beetles which can occur in or close to stagnant water. This suggests that there were pools of water on the peat beneath the trees. Donaciine chrysomelid beetles, particularly *Plateumaris affinis*, suggest that tall sedge vegetation was extensive where sufficient sunlight penetrated the tree canopy.

There was also, however, an element to the assemblage, including some insects from relatively dry habitats, which had probably been derived from the surrounding landscape perhaps up to several hundred metres distant. Many of the non-aquatic insects identified can be found in woodland and the results of analysis from both Trench 9 and Area 4 (see below) suggested tree cover to have been more than 50% and perhaps almost complete.

Host-specific beetles feeding on leaves and bark suggest the presence of alder (eg, *Agelastica alni*) and oak (eg, *Rhynchaenus* cf *quercus*), which most probably predominated in the carr woodland with perhaps a little willow or poplar (eg, *Phyllodecta* sp.) where the canopy was more open. Mixed woodland probably grew on the better drained ground of the valley side. It is possible that there was some thorn scrub at the edge of open areas.

The presence of *Agelastica alni* (alder leaf beetle) is of particular note as it had become extinct in Britain by the late 20th century (Hyman 1992, 170). It is not as obviously an old woodland species as other beetle species identified in Area 4 (see below) but it is possible that on the edge of its climatic range it is only capable of maintaining a viable population in large, undisturbed alder woods. Interestingly, and probably as a result of global warming, *A. alni* has just re-established itself as a breeding member of the British insect fauna (Stenhouse 2006). Five workers of the ant *Dolichoderus quadripunctatus* were found from context 934 suggesting a nest nearby. This ant no longer occurs in Britain although its present range includes France and Belgium (Bondroit 1918, 87). It nests in trees in hollow branches, knots and under bark, especially near the base of the trunk.

There was a small but distinctive component to the assemblage of insects which are dependent upon more open grassland habitats, with well-aerated soil, probably located on the valley sides. Host-specific Coleoptera indicate the presence of bird's foot trefoil, vetchlings, ribwort and hoary plantain and clover. Also present were scarabaeoid dung beetles that feed on the droppings of larger herbivorous mammals and their abundance was such as to imply domestic animals were grazing in the vicinity. It is likely that the grazing extended from the grassland into partly wooded areas. One of them, *Onthophagus taurus*, has been extinct in Britain since the 19th century. There was no evidence from the insects to indicate the proximity of cultivated ground.

Waterlogged Plant Remains

by Mark Robinson and Wendy Smith

An initial assessment of 13 small (200g) samples from deposits in Trench 9 was carried out by Robinson in 2000 (OAU 2000; Fig 13.3; Smith, Appendix O). Subsequently two larger (800g) samples were chosen for more detailed analysis of waterlogged plant remains by Smith from the lower part of the main peat unit (samples 142 and 147, Fig 13.3; Smith Appendix O). Identifications were made in comparison with modern comparative material and/or in comparison with standard identifications keys (eg, Cappers *et al* 2006).

The initial assessment (Table 13.7) noted plant remains were absent from the basal context 936 (sample 148). The lower part of the main peat unit (context 934, samples 147 and 142) contained numerous seeds of alder (*Alnus glutinosa*), with stinging nettle (*Urtica dioica*), hemp agrimony (*Eupatorium cannabinum*) and wood club-rush (*Scirpus sylvaticus*) also present. All are characteristic of alder carr. The only seeds from plants of open habitats were plants of wet mud and shallow water such as water pepper (*Polygonum hydropiper*) and water parsnip (*Berula erecta*).

Preservation was poorer in the middle part of the main peat unit (contexts 927 and 926, samples 141 and 135) but seeds of alder still predominated. Above this level remains were either sparse or absent. However, the occurrence of seeds of silverweed (*Potentilla anserina*), mint (*Mentha* sp.) and rush (*Juncus* sp.) is suggestive of marshy pasture. While these plants can tolerate slightly saline conditions, true halophytes were absent.

The more detailed analysis of samples 142 and 147 from the lower part of the main peat unit unfortunately noted deterioration in the plant assemblages between the assessment carried out in 2000 and analysis in 2008. Notably, Robinson's assessment also includes identifications of water parsnip, water pepper and hemp agrimony. The taxa recovered from the analysis were primarily thick-walled seeds and other plant parts. Similar to the assessment results the deposits were dominated by remains of alder, which included the seeds, female cones, buds and bud scales.

Plate 13.3 Area 4 under excavation (STDR401)

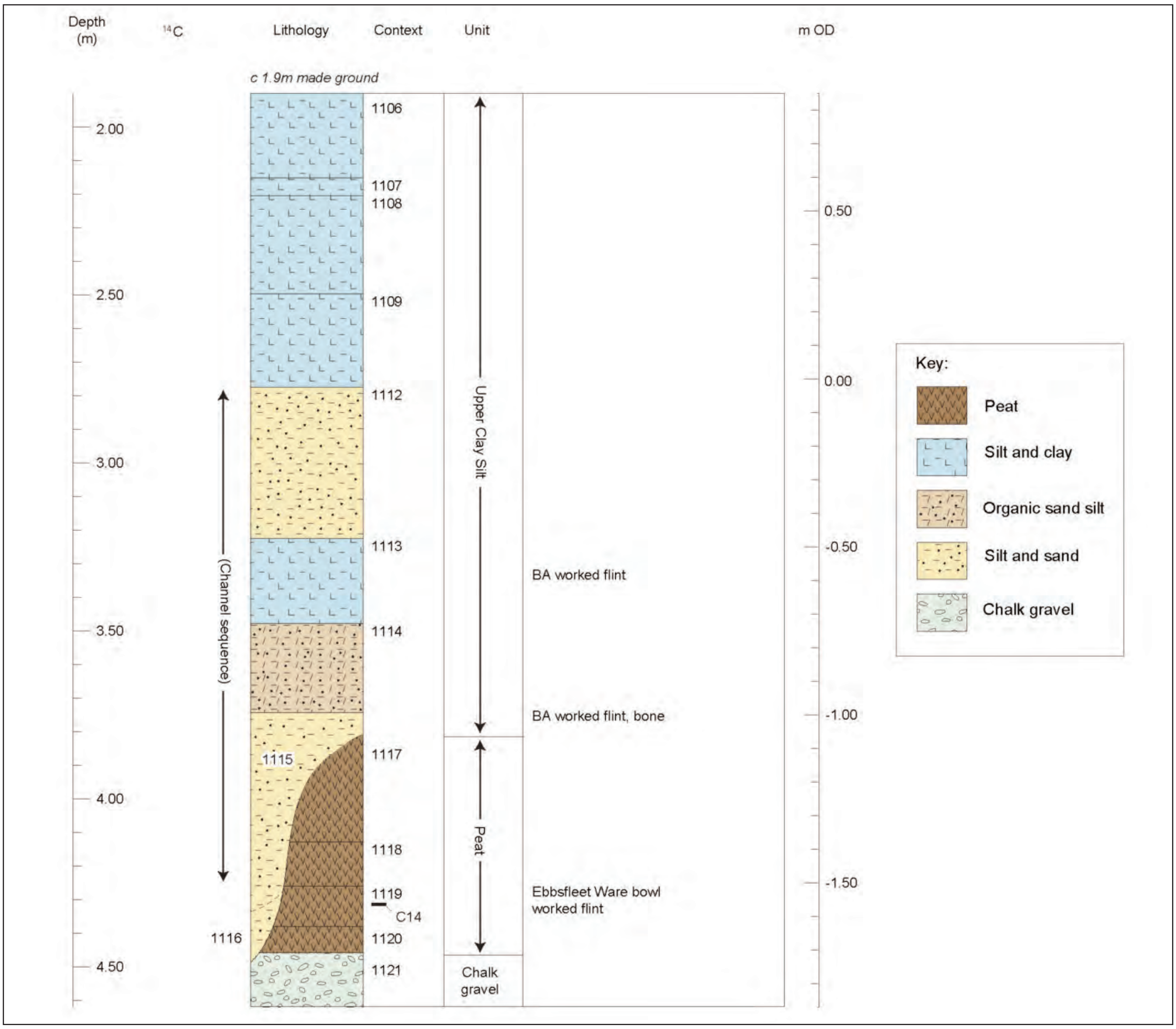


Figure 13.6 Trench 11 (STDR400) lithology and sample profile

Trench 11 (STDR400) and Area 4 (STDR401)

Introduction

Trench 11 and Area 4 excavations for the STDR4 were sited close to each other (Fig 13.1) and are discussed jointly here. Trench 11, which formed part of the evaluation stage of work, was excavated to a depth of *c* 4.65m with edge support achieved with sheet piles. Early Neolithic worked flint and pottery, including part of a fragmented Ebbsfleet Ware bowl, were recorded in this trench associated with the base of the main peat unit (Chap 21). These deposits were, however, truncated by later channel activity and were overlain by a complex series of sandy sediments containing reworked artefacts.

The Area 4 cofferdam excavation, 70m west of Trench 11, measured 10x10m and was excavated to a maximum depth of *c* 6m (Pl 13.3). The peat sequence at this location was preserved to a much greater depth (see Fig 13.7). Once again Early Neolithic artefacts; worked flint animal bone and pottery were found associated with the base of the main peat unit. Remains dating to the Late Neolithic and Bronze Age periods were also found associated with the top of the main peat unit and include a timber trackway structure and concentrations of worked and burnt flint (Chap 21).

Following the assessment stage, palaeo-environmental analysis was carried out on specific horizons in Area 4 associated with the archaeological remains. The work primarily consisted of the analysis of macroscopic remains such as insects and plant remains in order to reconstruct the local environment in which the activity took place. A limited programme of pollen work was carried out on the upper part of the main peat unit to add to the data retrieved from Trench 9. The assessment indicated that ostracods were poorly preserved through much of the sequence and no further work was carried out. In total 11 radiocarbon dates were obtained from samples from Trench 11 and Area 4 (Table 13.2).

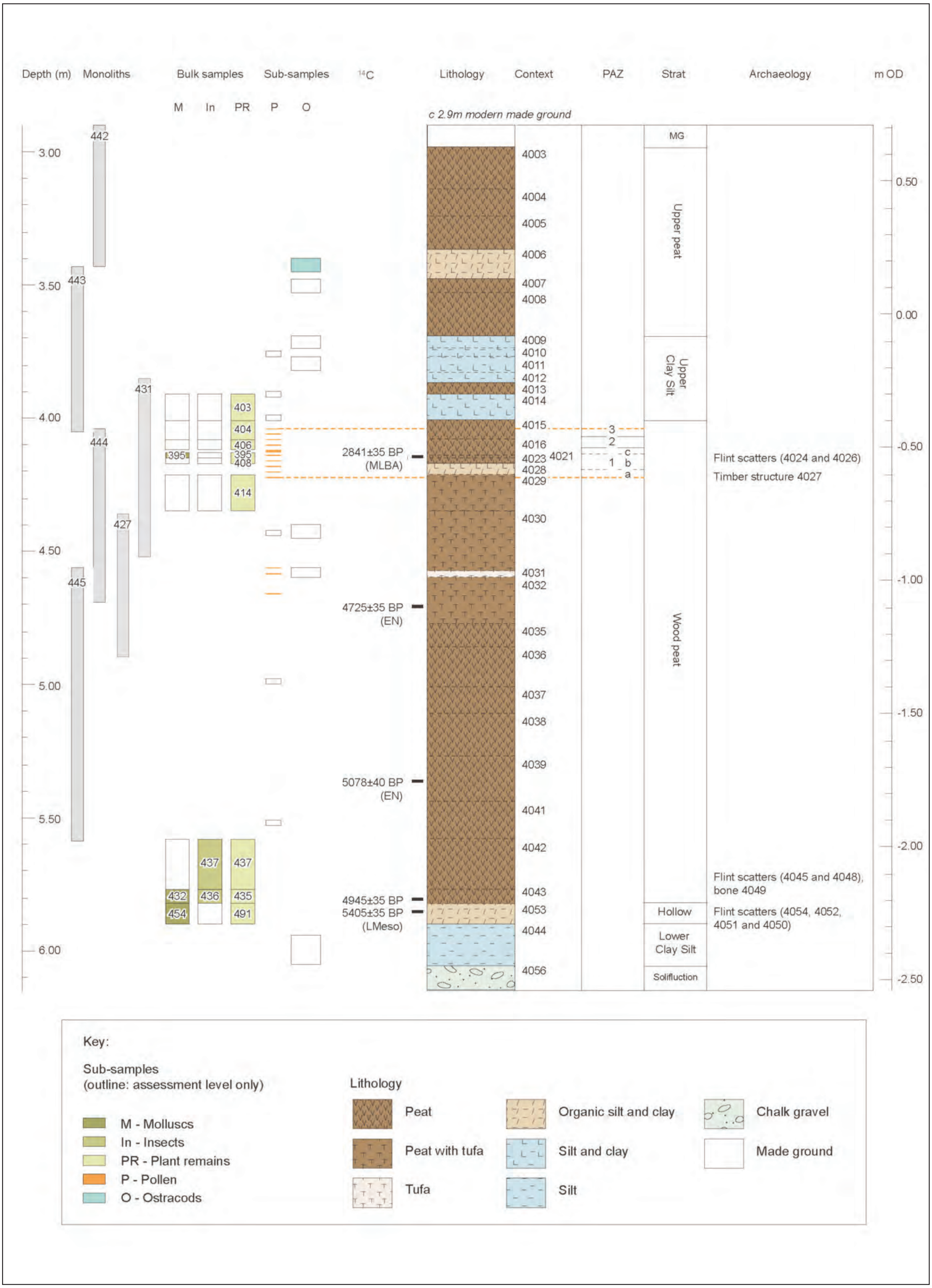


Figure 13.7 Area 4 (STDR401) lithology and sample profile

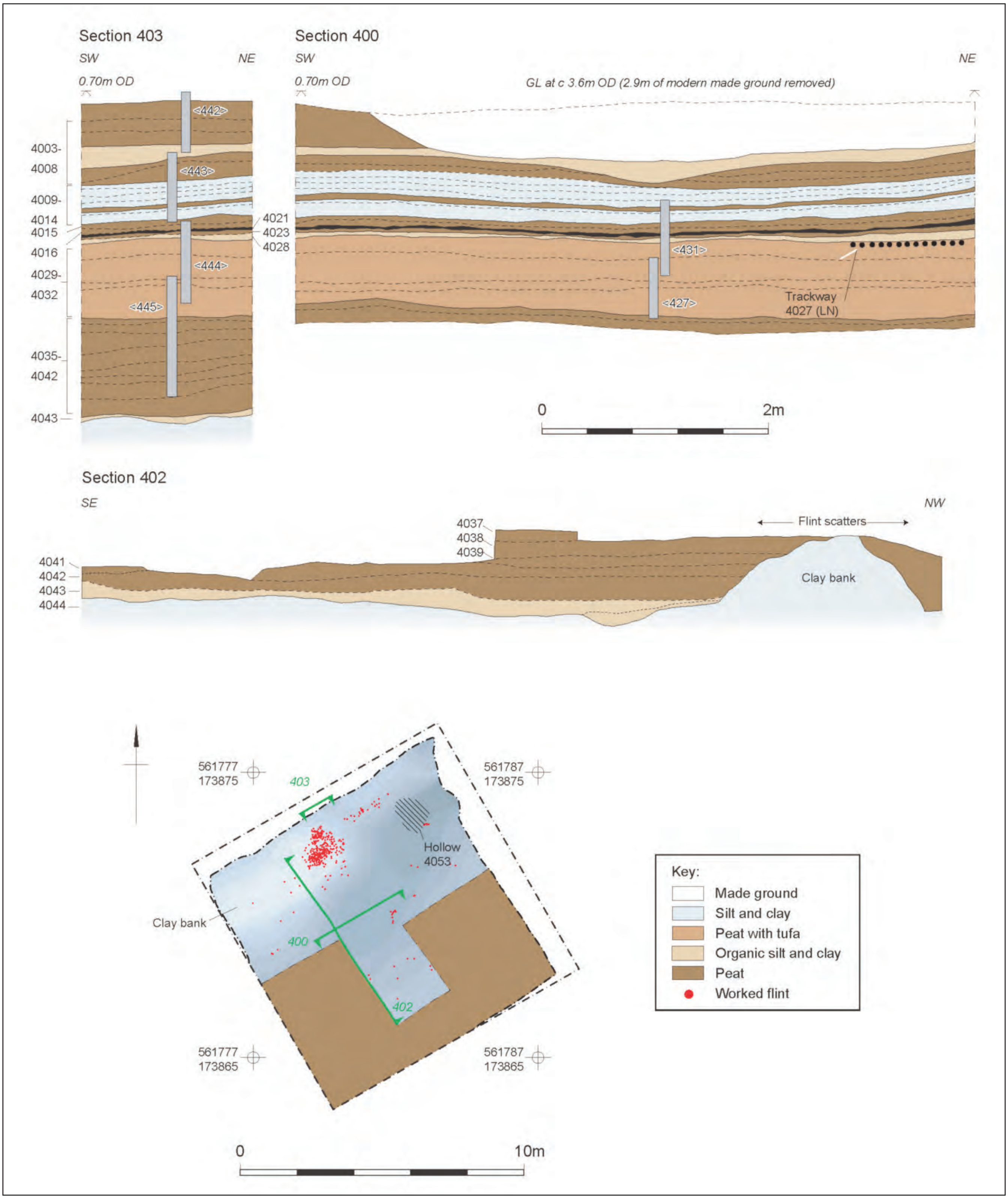


Figure 13.8 Area 4 (STDR401) sections and plan

Lithological Succession

Within Trench 11 chalk solifluction deposits (Fig 13.6) were encountered at the base of the trench (context 1121) demonstrating the full Holocene sequence had been exposed within this location. The main peat unit (contexts 1117–1120) directly overlay this without the intervening 'Lower Clay-Silt' present. Burnt flint fragments, large 'bashed' flint nodules and worked flints were recovered from the two lower peat deposits. Of particular significance was the recovery of part of an Ebbsfleet Ware bowl along with bones of *Gadus* sp. (cod) from the surface of context 1119 (Chap 21; Pls 21.3 and 21.4). This would appear to represent a relatively dry land surface, although the context of deposition of the pot appears without special attention. Truncating the main peat bed was a steeply incised 0.75m deep channel, filled by a sequence of coarse silt and sands (contexts 1116 and 1115). Further flintwork was recovered from these deposits as well as from the overlying clay-silt layer (context 1113). Further fluvial deposits of coarse silt and sand suggest this location may occupy a topographical position followed by water courses prior to levelling by the estuarine clay-silts.

Excavation of the cofferdam (Area 4) revealed soliflucted chalk silt (context 4056) at the base of the trench (Fig 13.7). The surface of this undulated but averaged between -2.3m to -2.4m OD. Overlying this was a sequence of alluvial deposits, possibly defining an early Holocene channel truncating context 4056. The alluvium comprised a lower greenish-grey silt-clay (context 4047) overlain by a bluish clay (context 4044) (Fig 13.8; Pl 13.4). This deposit appeared to bank on an approximate east to west alignment across the northern side of the excavation area, up to 0.4 m higher than the remainder of the deposit. Numerous Early Neolithic struck flints in fresh condition along with burnt flint were recovered from the surface of this layer concentrated in the area of the clay bank (Chap 21; Anderson Whymark, Appendix I).

Layer 4044 was sealed by a sequence of peat deposits (contexts 4043–4029). Abundant micritic tufa inclusions were present in the upper part (contexts 4029–4032). The lowermost peaty deposit, layer 4043, similarly contained numerous flints and burnt unworked flint. Fragments of animal bone were also recovered; occasional cattle and a single fragment of aurochs, in addition to a small stack of articulated sheep ribs showing evidence of butchery (Chap 21; Pl 21.7; Strid, Appendix R). Peat deposit 4042 which overly 4043 also contained struck flint artefacts and fragments of bunt flint throughout, again dated to the earlier Neolithic period, although these were considerably concentrated towards the lower limit of the deposit at the contact with 4043. At the top of the tufaceous peat 4029 a linear accumulation of roundwood (structure 4027) may represent the remains of a structure, perhaps part of a Late Neolithic walkway or trackway (Chap 21; Pl 21.12). Further up-profile, situated upon the surface of the humified peat layer 4021, evidence of Late Bronze Age activity was identified in the form of was a small scatter of struck flints, and burnt flint, pottery sherds and an area of burning (Chap 22; Pl 22.3).

Directly above 4021 the peat and tufa sequence graduated into an alternating sequence of more finely layered organic clay-peat and clay deposits representing in part the 'Upper Clay-Silt' unit. This sequence was largely devoid of artefacts although context 4019 a dark brown reed peat, contained a quantity of Late Bronze Age struck and burnt flints. The sequence was capped by a series of organic/peat deposits correlated with the 'Upper Peat' (contexts, 4008–4003) A shallow rounded hollow, possibly representing a tree root hole cut in to the surface of the uppermost reworked peat layer 4003 below a thick sequence of modern made ground.

Plate 13.4 Sample Section 403, Area 4 (STDR401)

Dating

In Trench 11 four radiocarbon dates were obtained from the basal part of the peat sequence (context 1119) associated with the Ebbsfleet Ware bowl. This included two dates from the charred residue adhering to the pottery itself, as well as two dates on a wood fragment and uncharred hazelnut shell from the surrounding peat. All produced Early Neolithic dates clustering at *c* 3600–3300 cal BC (Table 13.2; Fig 13.6; Chap 21).

Seven radiocarbon dates were obtained from the sediment sequences and associated archaeological remains from Area 4, (Fig 13.7, Table 13.2, Chaps 21 and 22). Two dates came from material at the base of the peat sequence. The first was from charred hazelnut shell (*Corylus*) recovered from peaty organic deposits infilling a shallow hollow, in the surface of the underlying clay at 5405±35 BP (NZA-29246, 4350–4070 cal BC), the second from uncharred hazelnut from context 4043 at 4945±35 BP (NZA-29247, 3800–3650 cal BC). A third date on a butchered sheep rib bone (4049 from context 4043) was dated to 4758±35 BP

Table 13.8 Area 4 (STDR401) pollen results from the tufa deposits 4030, 4031 and 4032

Context	**4032**	**4031**	**4030**
Elevation (m OD)	**-1.05**	**-0.985**	**-0.965**
Trees & Shrubs	**%**	**%**	**%**
Alnus glutinosa	+	1	6
Carpinus betulus	–	–	+
Corylus avellana	+	1.2	2.9
Hedera helix	–	–	+
Quercus	–	+	2.3
Rubus-fruticosus-type	–	–	+
Sambucus nigra	–	–	+
Sorbus-type	–	–	+
Taxus baccata	–	+	–
Tilia cordata	–	1.4	2.1
Ulmus	+	–	+
Total Trees & Shrubs %	**1.7**	**4.3**	**15.6**
Herbs			
Poaceae	+	+	1
Cyperaceae	+	2.8	14.6
Apiaceae undiff.	–	–	+
Aster-type	–	–	+
Fabaceae	+	–	–
Plantago major/P. media	+	+	+
Plantago undiff.	+	–	–
Ranunculus acris-type	–	–	1.2
Total Herbs %	**1.7**	**3.5**	**17.9**
Fern & Fern Allies			
Dryopteris felix-mas-type	+	+	+
Polypodium vulgare agg.	+	+	+
Pteridium aquilinum	+	–	–
Pteropsida (monolete) undiff.	88.8	80.6	51.7
Thelypteris palustris	6.6	10.8	13.8
Fern & Fern Allies %	**96.6**	**92.1**	**66.5**
Calculation Sum	**348**	**509**	**487**
Aquatics			
cf. *Callitriche*	+	–	–
Lemna	+	+	–
Potamogeton	–	+	–
Indeterminate	1.4	8	10
Unknown	–	+	+
Glomus	–	–	+
Ascospores	–	+	–
Pre-Quaternary pollen and spores	+	–	+

KEY: + – rare types count of less than five

(NZA-29242, 3640–3380 cal BC). This confirms a Late Mesolithic to Early Neolithic date for the initiation of peat formation at this location. A date in the lower part of context 4032 suggests the formation of tufa commenced in the Early Neolithic period at 4725±35 BP (NZA-29082, 3640–3370 cal BC) and timber 'trackway' structure 4027 towards the top of the tufaceous peat sequence was dated to the later Neolithic period at 4120±30 BP (SUERC-19950, 2870–2570 cal BC) (Chap 21). Further up-profile fruit wood (Pomoideae) charcoal associated with the burning episode in context 4021 was dated to the later Bronze Age at 2841±35 BP (NZA-29078, 1120–910 cal BC), a date consistent with the associated worked flint and pottery sherds (Chap 22).

Pollen

by Denise Druce

Following assessment (OAU 2006), three samples for pollen analysis were taken from within the tufaceous peat (contexts 4030, 4031 and 4032) and 13 from the upper part of the main peat profile in monoliths 431 and 427 including deposits associated with timber structure 4027 and the Late Bronze Age occupation horizon 4021 (Figs 13.7 and 13.8 Section 400; Druce, Appendix J). The results of the analysis from the tufaceous peat are presented in Table 13.8.

The upper peat (0.425m to 0.62m OD)

The results of the upper part of the main peat profile in which three zones (PAZ 1–3) plus three subzones (PAZ 1a–1c) were identified are presented in a pollen diagram (Fig 13.9) and summary table (Table 13.9). The method follows the same procedure outlined by Peglar for Borehole 7 (STDR400, Chap 12).

The tufaceous peat (-1.05m to -0.965m OD)

The possible over-representation of fern spores within the three samples means that very little other vegetation is represented (Table 13.8). Both arboreal and herbaceous pollen is more or less absent in the lower two samples (-1.05m and -0.985m OD), only rising slightly in the uppermost (-0.965m OD) sample as a consequence of a slight reduction in the levels of fern spores. Alder (*Alnus glutinosa*) and hazel (*Corylus avellana*) pollen is recorded in all three samples and oak (*Quercus*) yew (*Taxus baccata*) and lime (*Tilia cordata*) pollen is recorded in the upper two. Alder pollen is the most dominant tree taxon recorded, followed by low levels of hazel, oak and lime. Rare pollen grains of elm (*Ulmus*), hornbeam (*Carpinus betulus*), ivy (*Hedera helix*), blackberry-type (*Rubus fruticosus*), elderberry (*Sambucus nigra*) and whitebeam (*Sorbus*-type) are also recorded in the uppermost sample.

Table 13.9 Area 4 (STDR401) pollen summary from the upper part of the main peat profile

PAZ	**Local environment**	**Regional environment**	**Human impact**
3	Reedswamp with some saline influence. Conditions wetter	Meadows and pastures with bracken. Woodland now more or less absent apart from occasional scrub	++
2	Drier conditions, possible transition with upper salt-marsh.	Dense cover of bracken in open landscape with possible soil erosion on slopes	++++
1c	Drier conditions with grass and ferns and possible increased salinity	Little woodland with increasing growth of bracken. and areas of disturbed/rough ground. Possible soil erosion on slopes	+++
1b	Fen carr woodland with rich understorey of ferns. Areas of bare ground with possible creeks.	Meadows and pastures with open deciduous woodland of hazel, oak and lime with hornbeam and rosaceous shrubs	++
1a	Fen carr woodland with rich understorey of ferns	Grassy wet meadows and pastures with open deciduous woodland of hazel, oak and lime with hornbeam and rosaceous shrubs	++

KEY: FW – freshwater; B – brackish; B – brackish; + – negligible; ++ – low; +++ – medium; ++++ – high

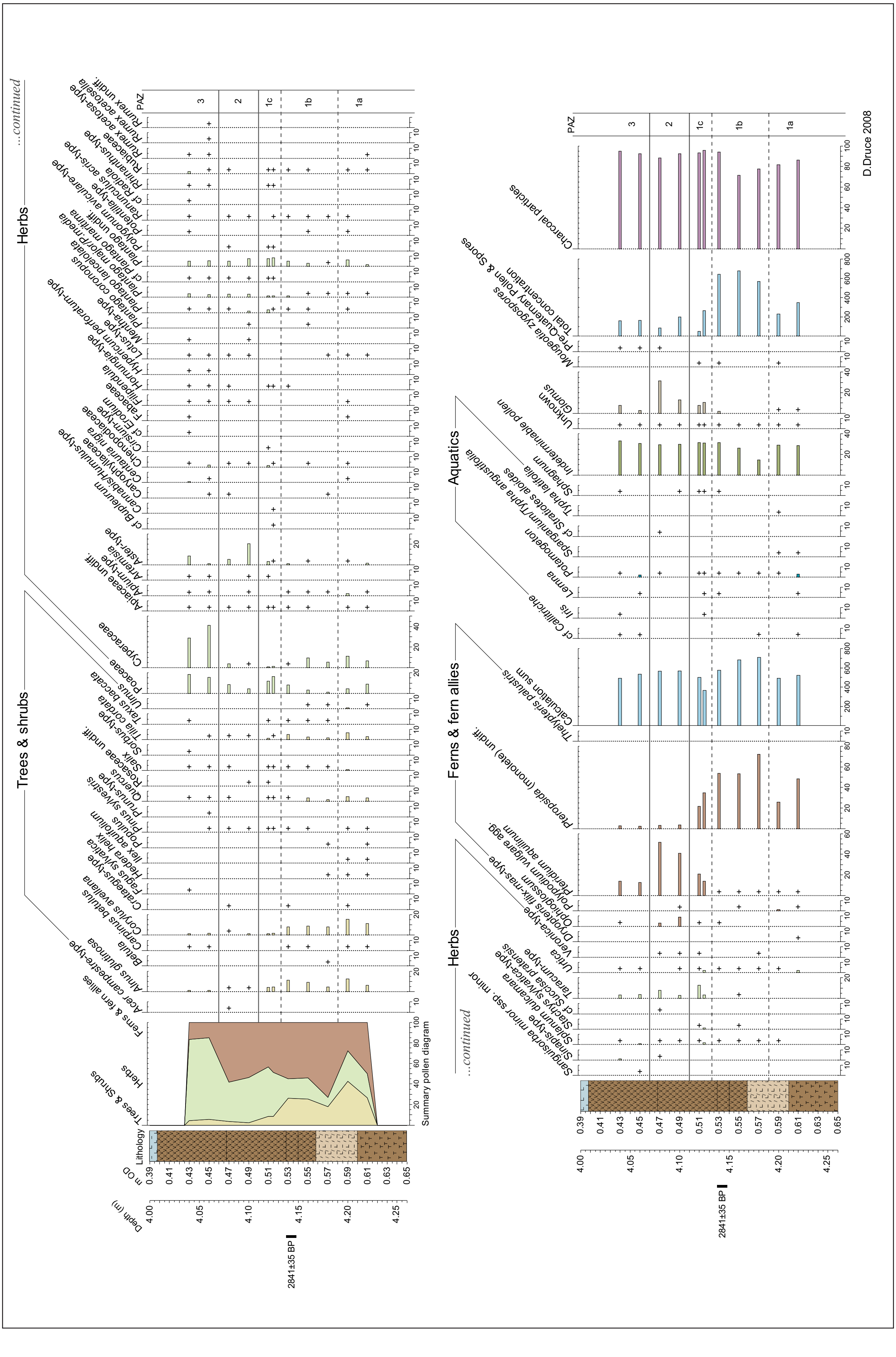


Figure 13.9 Pollen diagram from the upper part of the main peat profile in Area 4 (STDR401)

Sedge (Cyperaceae), grass (Poaceae) and greater/hoary plantain (*Plantago major*/*P. media*) pollen is recorded in all three samples, where sedge dominates the herbaceous assemblage in the uppermost sample. Daisy-type (*Aster*-type) and buttercup (*Ranunculus acris*-type) pollen is also recorded in the latter. Undifferentiated fern (Pteropsida monolete undiff.) spores dominate all three samples, representing between *c* 50% and 90% TLP (total land pollen). Marsh fern (*Thelypteris palustris*) is fairly well represented and male-fern (*Dryopteris-felix-mas*-type) and polypody (*Polypodium vulgare* agg.) spores are also recorded in all three samples.

A few aquatics, such as pondweed (*Potamogeton*), duckweed (*Lemna*) and water-starwort (*Callitriche*) are recorded in the lower two samples, but only as rare types. A few *Glomus* spores and occasional pre-Quaternary pollen grains were recorded on the pollen slides of all three samples. No charcoal fragments were observed.

PAZ 1 (-0.62m to -0.50m OD)

Subzone 1a (-0.62m to -0.58m OD): Arboreal pollen is at its highest in this zone (Fig 13.9), but still represents only 30–40% total land pollen (TLP). Alder and hazel pollen dominates the tree and shrub assemblage. Lime and oak pollen is fairly well represented alongside the occasional grain of pine (*Pinus sylvestris*), elm, poplar (*Populus*), hornbeam and rosaceous pollen (*Crataegus*-type, *Prunus*-type, Rosaceae undiff.). Other taxa recorded in this subzone include ivy and holly (*Ilex aquifolium*). Willow (*Salix*) pollen increases slightly towards the top of the subzone. Herbaceous pollen makes up 25% TLP and is dominated by sedge and grass with occasional ribwort plantain (*Plantago lanceolata*) and greater/hoary plantain, marshwort (*Apium*-type), daisy type, goosefoot (Chenopodiaceae), meadowsweet (*Filipendula*), common knapweed (*Centaurea nigra*), common sorrel (*Rumux acetosa*-type), bird's-foot-trefoils (*Lotus*-type), buttercup, bittersweet (*Solanum dulcamara*), bedstraws (Rubiaceae) and nettle (*Urtica*). Grass pollen decreases at the top of the subzone, which corresponds with a rise in plantain. Fern spores represent up to 50% TLP, which decreases to 30% at the top of the subzone when arboreal pollen peaks. Aquatic taxa are recorded in low numbers and include bulrushes/bur-reed (*Typha latifolia* and *T. angustifolia*/*Sparganium*), pondweed, duckweed and water-starworts, many of which continue to be present in the remainder of this and subsequent zones. Mougeotia algae spores are also recorded in this and the other subzones of PAZ 1.

Subzone 1b (-0.58m to -0.52m OD): This subzone shows a general decline in the arboreal pollen assemblage to 20% TLP, which, in addition to the taxa represented in the previous subzone, includes occasional pollen of yew and birch (*Betula*). Herbaceous pollen of primarily grass, sedge and plantain, also decreases, reaching levels of only 10% TLP, and fern spores increase substantially to 70% TLP. As well as those recorded in the previous subzone, additional herbaceous taxa include woundwort (*Stachys sylvatica*-type), speedwells (*Veronica*-type), dandelions (*Taraxacum*-type), buck's-horn plantain (*Plantago coronopus*), and hutchinsia-type (*Hornungia*-type). This subzone also includes the first appearance of adder's tongue fern (*Ophioglossum*). Higher up the diagram herbaceous pollen increases slightly to 25% TLP, which is matched by a corresponding rise in arboreal pollen to 25% TLP and a decline in other fern spores to 50%.

Subzone 1c (-0.52m to -0.50m OD): A significant change takes place during this subzone, which is represented by a further reduction in arboreal pollen to less than 10% and a corresponding rise in herbaceous pollen, which reaches levels of 50%. All four main arboreal taxa decline, including alder, hazel, oak and lime, and although sedge pollen declines other taxa including grass, plantain, dandelion, daisy-type, goosefoot, bittersweet, woundwort and nettle increase. The diversity of the herbaceous assemblage also increases, with the first appearance of mugworts (*Artemisia*), hare's-ears (*Bupleurum*) (which includes slender hare's-ears *B. tenuissimum*), hemp/hop (*Cannabis*/*Humulus*-type), thistles (*Cirsium-type*), sea plantain (*Plantago maritima*), knotgrass (*Polygonum aviculare*) and yellow-rattles (*Rhinanthus*-type). Although levels of fern spores remain more-or-less unchanged apart from perhaps a small decline, the switch from undifferentiated monolete fern to bracken (*Pteridium aquilinum*), which is a feature of the subsequent zone, is beginning. Low numbers of aquatic pollen persist and iris (*Iris*) is recorded for the first time in this subzone. The number of *Glomus* spores recorded on the pollen slides increases substantially in this subzone.

PAZ 2 (-0.50m to -0.46m OD)

Although maple (*Acer campestre*-type) is recorded for the first time during this zone arboreal pollen levels continue to decline to less than 5% TLP. Herbaceous values fall to *c* 40%, and the assemblage changes from one dominated by grass and dandelion to one dominated by daisy-type. Mint-type (*Mentha*-type), mustard-type (*Sinapis*-type) and devil's bit scabious (*Succisa pratensis*) are also recorded for the first time. Levels of bracken increase substantially reaching 60% TLP, and this is coupled with a peak in adder's-tongue fern spores to 10% TLP. Aquatic pollen continues to be recorded, but in very low numbers and water-soldier (*Stratiotes aloides*) is recorded for the first time. Pre-Quaternary spores are recorded at the top of this zone, plus the amount of *Glomus* recorded on the pollen slide increases. *Mougeotia* algae spores are absent in this and the subsequent zone.

PAZ 3 (-0.46m to -0.425m OD)

Arboreal pollen remains very low during this zone, whereas herbaceous pollen increases to 80% TLP and bracken decreases substantially to 10% TLP. The increase in herbaceous pollen is mainly attributed to a recovery in grass pollen and a significant increase in sedge pollen. At the same time, daisy-type pollen decreases and stork's-bill (*Erodium*), sheep's sorrel (*Rumex acetosella*) and salad burnet (*Sanguisorba minor*) pollen are recorded for the first time. *Glomus* spore levels are significantly reduced in this zone.

Quantities of charcoal fragments are generally very high throughout the sequence. A very slight rise occurs at the top of subzone 1b, when levels increase from 70% to 95% TLP.

Discussion

Overall in the tufaceous peat (contexts 4032, 4031 and 4030) the possible over-representation of fern spores, which may have been growing immediately at the sampling site, makes any interpretation regarding the extent of woodland difficult. However, this said, the evidence indicates a local calcium-rich fen and alder carr with sedges and marsh fern. Lime, hazel, and oak woodland was growing on the drier slopes nearby, and the presence of shrubby/hedgerow taxa such as whitebeam, elder and blackberry suggests the woodland may have been fairly open or marginal. The absence of microscopic charcoal in the three samples suggests that very little burning activity was taking place at this time.

In PAZ 1a in the upper part of the main peat profile the pollen data indicates the presence of fen carr alder and hazel woodland with fairly species-rich damp meadows/pastures. Open woodland of oak and lime, with hornbeam and rosaceous shrubs was likely to have been growing on the drier slopes nearby. Areas of rough grassland were also present. Ferns probably dominated the woodland floor and were possibly encroaching onto the wetter valley bottom, which contained shallow or slow flowing freshwater, as indicated by the presence of aquatics and *Mougeotia* algal spores. The presence of marshworts and goosefoot, which can be associated with brackish/coastal conditions may indicate some marine influence, however the evidence for this is very slight at this stage. Increased disturbance is indicated towards the top of this subzone, represented by a slight increase in plantain. The very high levels of microscopic charcoal in this and subsequent zones indicate relatively intensive burning activity.

An apparent opening-up of the woodland witnessed during PAZ 1b may be attributed to the continued over-representation and increase in fern spores, however, woodland does appear to steadily decline during this and subsequent zones. Fen carr and wet meadows/pastures persisted, plus the presence of buck's-horn plantain may indicate areas of bare ground or creek sides. The continued presence of aquatics and *Mougeotia* algal spores, which are found in shallow or stagnant oxygen-rich pools (Van Geel 2001), indicate freshwater conditions at this stage.

Woodland continues to decline during PAZ 1c and this is matched by a significant decline in fern cover and an increase in taxa indicative of disturbed/rough ground, such as thistles, mugwort and yellow-rattle. It appears that both on-site woodland taxa, such as alder, and that present on the higher ground, such as hazel, oak and lime all decline; oak perhaps declining slightly prior to the other three. A possible increase in salinity is indicated by an increase in daisy-type (which includes sea aster), goosefoot family (which includes saltmarsh taxa such as glasswort, sea-blite and oraches), hare's ears, sea plantain and adder's tongue fern. However, perhaps paradoxically, the decline in sedge and significant increase in bracken spores, which is often associated with dry acid soils, suggests conditions may have been actually becoming drier at the site. Given that many of the taxa often found on higher saltmarshes are also often found in grassland or rough/waste ground, it is difficult to say for certain the exact mechanisms involved here. However, it is possible that the bracken spores, along with the other dryland taxa, originate from vegetation growing on the nearby slopes, which were by now more or less devoid of woodland. High levels of bracken spores were also identified by Scaife (OAU 2006) who suggested their abundance could be due to an increase in material washed in from the surrounding slopes. This is corroborated by the increase in *Glomus* spores in the sediment at this level, which are often related to episodes of soil erosion (Van Geel 2001).

PAZ 2 more or less continues the trend highlighted in PAZ 1c and indicates increased salinity and the possible development of upper saltmarsh conditions dominated by grass and daisy-type. The decline in aquatic pollen in this zone, coupled with the much more humified nature of the peat at this level certainly points to drier conditions. Bracken appears to dominate the immediate landscape; however very abundant *Glomus* spores indicate much soil erosion and thus the possible inwash of material from the surrounding drier slopes.

In PAZ3 although the significant decrease in bracken spores and levels of *Glomus* spores suggests that the surrounding slopes may have stabilised, the area still remained extremely open with very little woodland. A mosaic of species-rich fen reedswamp, wet meadows and pasture, with some brackish influence had developed in the valley bottom.

The changes indicated by the pollen from Area 4 are broadly consistent with those identified in Borehole 7 (Chap 12) and Trench 9 (described above). However, more minor, and perhaps subtle changes in relation to sea level and anthropogenic activity are evident, which is probably due to the level of detail of this study (ie, on average, a pollen sample taken every 0.01m). In essence, the most remarkable feature of the diagram is the quite dramatic changes within just *c* 0.20m of sediment. The pollen data from the tufaceous layers broadly corresponds with PAZ 4 from Borehole 7 and PAZ 2 from Trench 9 and, like these other two locations; indicate wet calcium-rich conditions with tufa springs. Fern spores of probable marsh fern dominate all three pollen sequences, which, in Borehole 7, occurred in clumps, suggesting their growth directly at the site. Like Area 4, the over representation of fern spores in Trench 9, meant that pollen from other vegetation was obscured. However, the data from all three sites indicate a freshwater fen environment dominated by fern, grass and sedge with alder carr growing nearby.

The data from the upper part of the main peat profile from this study broadly correspond with PAZ 5a from Borehole 7 and PAZ 5a and 5b from Trench 9, which both reflect a period of transition between freshwater conditions and increased salinity. Perhaps due to it being closer, Trench 9 especially, appears to mirror the local conditions more closely, which sees a shift from alder carr to reedswamp. The brief period of drier conditions evident in Area 4, however, has been missed. In all three diagrams this period of change appears to be accompanied by an increase in anthropogenic activity and woodland clearance on the surrounding slopes, coupled with a significant increase in bracken at all sites.

Like the sequences in Borehole 7 and Trench 9, a possible Late Bronze Age lime decline is evident, which is coincident with increased evidence of disturbance and soil erosion in Area 4. As Peglar (Chap 12) suggests, the 'lime decline' is a non-synchronous event associated with human impact and clearance of woodland. This event occurred after 3836±50 BP (NZA-28971, 2470–2140 cal BC) in Borehole 7, and a second lime decline, dated to the Late Bronze Age, was evident in Trench 9. Significantly the decline in lime, and woodland generally, the spread of bracken, and the increase in disturbance indicators and possible soil erosion, is almost synchronous with the period of increased activity signified by the archaeological evidence.

Diatoms

by Nigel G Cameron

Diatom samples were initially prepared from four levels in monolith 431 (Figs 13.7 and 13.8). Methods and terminology follow those outlined for Borehole 7 (Chap 12). With the exception of a single valve present at -0.50m OD (a rim fragment probably from the estuarine planktonic diatom *Cyclotella striata*) diatoms were absent from the two samples from the upper part of the main peat profile taken at -0.63m and -0.5m OD. In the two samples examined from the overlying clay silts (-0.37m and -0.26m OD) the concentration of diatom valves, quality of preservation (degree of diatom valve breakage and silica dissolution) and the diversity of taxa was relatively poor. However, it has been possible to make percentage diatom counts for these two samples (Cameron, Appendix K).

The diatom composition of the two samples was similar; both indicate fully tidal conditions with brackish and marine taxa dominating. Mesohalobous diatoms comprised approximately 90% of the total assemblage at -0.26m OD and over 70% at -0.37m OD. The most common mesohalobous diatom was the benthic (epipelic) species *Diploneis interrupta* and there were other mesohalobous, mud surface diatoms such as *Nitzschia navicularis*, *Caloneis westii* and *Navicula peregrina*. The planktonic estuarine species *Cyclotella striata* was present at -0.26m OD. The brackish-marine benthic diatom *Diploneis smithii* was present in both samples and the marine planktonic diatoms *Paralia sulcata* and *Podosira stelligera* were present at -0.37m OD. An aerophilous, freshwater diatom *Pinnularia major* was present in both samples, comprising about 10% of the total diatom count at -0.37m OD (and therefore closer to the wood peat). In addition to its lifetime ability to tolerate periods of desiccation this diatom contains much silica and its sediment record can be preserved in adverse conditions where the valves of other less robust diatom valves do not survive. The presence of *Pinnularia major* may represent upward mixing of earlier sediments from a period of drier conditions before marine inundation or it may be present as the result of inwash from freshwater or terrestrial habitats.

Ostracods

by John E Whittaker

Only one of the samples initially assessed (Fig 13.7; Whittaker, Appendix L) contained foraminifera or ostracods. Context 4006 contained a (medium to high) saltmarsh fauna of agglutinating foraminifera (of either *Jadammina macrescens* and/or *Haplophragmoides wilberti*).

Insects

by Mark Robinson

An initial assessment of 10 litre samples from deposits in Area 4 indicated remains were generally sparse or absent throughout much of the sequence. However, as with Trench 9 (see above), the base of the Early Neolithic peat unit (samples 436 and 437) contained insect remains sufficient for more detailed analysis (Fig 13.7; Tables 13.5 and 13.6; Robinson, Appendix N). The methodology was as outlined for Trench 9, the detailed report for the analysis is presented in Robinson, Appendix N and the following is a summary of the results for Area 4.

The assemblages, similar to those examined from Trench 9, indicated a local environment of alder carr with various water and amphibious beetles suggestive of areas of stagnant water with tall sedges (eg, *Acilius* sp., *Hydrobius fuscipes* and *Ochthebius minimus*, *Plateumaris*

Table 13.10 Area 4 (STDR401) plant remains

Latin Binomial	Common Name	491	435	437	414	408	395	406	404	403
	Sample	**491**	**435**	**437**	**414**	**408**	**395**	**406**	**404**	**403**
	Context	**4053**	**4043**	**4042**	**4029**	**4023**	**4021**	**4019**	**4017**	**4016**
	Volume processed (litres)	**1**	**1**	**1**	**0.7**	**1**	**20**	**1**	**1**	**1**
	Proportion of flot analysed (%)	**100**	**25**	**10**	**50**	**10**	**10**	**100**	**20**	**20**
Waterlogged plant remains										
Ranunculus acris L./*repens* L./ *bulbosus* L.	meadow/creeping/bulbous buttercup	–	1	–	4	–	–	–	–	1
Ranunculus sceleratus L.	celery-leaved buttercup	–	11	–	–	–	–	–	–	1
Ranunculus ficaria L.	lesser celandine	–	4	–	–	–	1	–	–	–
Ranunculus subg. Batrachium (DC.) A. Gray	crowfoot	–	1	–	–	–	–	–	–	–
Urtica dioica L.	common nettle	–	17	–	–	1	–	–	1	1
Betula spp.	birch	–	3	1	–	–	–	–	–	–
Alnus glutinosa (L.) Gaertn.	alder – seed	–	100	15	–	–	2	–	–	–
	alder – female cone	–	11	1	–	–	–	–	–	–
cf. *Alnus glutinosa* (L.) Gaertn.	possible alder – seed	–	2	–	–	–	1	–	–	–
	possible alder – bud	–	3	–	–	–	–	–	–	–
	possible alder – bud-scar	–	–	1	–	–	–	–	–	–
Corylus avellana L.	hazel (nutshell fragments, <1 nut)	–	1	–	–	–	–	–	–	–
Chenopodium spp.	goosefoot	–	–	–	–	–	–	–	–	–
Atriplex spp.	orache	–	–	1	–	–	–	–	–	2
Chenopodiaceae – internal structure	goosefoot family	–	–	–	–	–	–	–	–	1
Chenopodiaceae/ Caryophyllaceae – internal structure	goosefoot/pink family	–	–	–	1	–	1	–	–	–
Moehringia trinervia (L.) Clairv	three-nerved sandwort	–	–	–	–	6	–	–	–	–
Cerastium spp.	mouse-ear	–	2	–	–	–	–	–	–	–
Spergula arvensis L.	corn spurrey	–	–	–	–	–	–	1	–	–
Caryophyllaceae	pink family	–	1	–	–	–	–	–	–	1
Rumex spp.	dock	–	1	–	–	–	–	–	–	–
Viola spp.	violet	–	–	–	–	–	–	–	2	–
Brassicaceae – unidentified fruit – Iberis type	mustard family seed pod	–	–	–	1	–	–	–	3	8
Rubus section Rubus	blackberry	1	2	–	–	–	–	–	2	–
Potentilla spp.	cinquefoil	–	1	–	–	–	–	–	–	–
Prunus spp.	indet. bullace/cherry/damson/plum	1	–	–	–	–	–	–	–	–
Rosaceae	rose family – thorn	–	1	–	–	–	–	–	–	–
cf. *Oxalis acetosella* L. – outer seed coat decayed	possible wood-sorrel	–	–	–	1	–	–	–	2	–
Solanum sp.	nightshade	–	1	–	–	–	–	–	–	–
Viburnum sp.	viburnum	–	1	–	–	–	–	–	–	–
Stachys spp.	woundwort	1	–	–	–	–	–	–	–	–
Ajuga reptans L.	bugle	–	–	–	–	–	–	3	–	–
Lycopus europaeus L.	gypsywort	–	–	–	–	–	–	–	–	2
Mentha spp. indet.	mint	–	–	–	51	–	–	83	11	47
Plantago media L.	hoary plantain	–	–	–	–	–	–	1	–	1
Euphrasia spp./*Odontites* sp.	eyebright/bartsia	–	–	–	–	–	–	–	–	1
Galium spp. – small-seeded	bedstraw	–	–	–	–	–	–	1	–	–
Potamogeton spp.	pondweed	–	–	–	3	–	–	–	9	27
Juncus spp.	rush	–	–	–	1	–	–	–	–	–
Eleocharis palustris (L.) Roem. & Schult./*uniglumis* (Link) Schult	common/slender spike-rush	–	–	–	6	–	–	–	22	46
cf. *Scripus sylvaticus* L. – type	wood club-rush	–	–	–	–	–	–	–	–	10
Carex spp. – 2-sided	sedge	–	3	2	–	–	–	1	24	79
Carex spp. – 3-sided	sedge	13	12	3	13	–	2	34	13	15
cf. *Carex* spp. – 4-sided	possible sedge	–	–	–	1	–	–	–	–	–
Bolboschoenus sp./ *Schoenoplectus* spp.	club-rush	–	–	–	–	–	–	1	1	–
Poaceae – small caryopsis	small-seeded grass	–	2	–	–	–	–	–	–	–
Poaceae – medium caryopsis	medium-seeded grass	1	–	–	–	–	–	1	–	1
Unidentified	unidentified	1	4	1	3	2	1	3	1	5
Total		**18**	**185**	**25**	**85**	**9**	**8**	**129**	**91**	**249**
Charred plant remains		–	–	–	–	–	–	–	–	–
Corylus avellana	hazelnut shell (<1 nut)	4	–	–	–	–	–	–	–	–
Charcoal		–	–	–	+	–	–	+	–	–

KEY: + – present

affinis). Some of insect remains again indicated drier habitats within the surrounding landscape which included woodland. The wood- and tree-dependent Coleoptera of Species Group 4 ranged from 17% of the terrestrial Coleoptera in context 4043 down to 9% of the terrestrial Coleoptera in context 4042. Many of the other non-aquatic insects can be found in woodland and some, such as the large predatory ground beetle *Abax parallelepipedus* and the snail-feeding *Silpha atrata*, mostly occur in woodland. The results suggested tree cover to have been more than 50% and perhaps almost complete.

As with Trench 9 host-specific beetles feeding on leaves and bark suggest the presence of alder (eg, *Agelastica alni* and *Chrysomela aenea*) and oak (eg, *Rhynchaenus* cf *Quercus*), which most probably predominated in the carr woodland with perhaps a little willow or poplar (eg, *Phyllodecta* sp.) where the canopy was more open. Mixed woodland including lime and elm (eg, *Ernoporus caucasicus* and *Acrantus vittatus*) probably grew on the better drained ground of the valley side.

The assemblages included a strong 'old woodland' element of insects which are now rare and associated with over-mature trees and decaying wood. These included the wood-boring beetle *Gastrallus immarginatus* and the lime-bark beetle *Ernoporus caucasicus*, currently listed as 'endangered species' in the 'Red Data Book' (Hyman 1992, 65, 399). As in Trench 9, *Agelastica alni* (alder leaf beetle) was also recorded; a species that became become extinct in Britain by the late 20th century (Hyman 1992, 170). It is not as obviously an old woodland species as the other two beetles but it is possible that on the edge of its climatic range it is only capable of maintaining a viable population in large, undisturbed alder woods. Interestingly, and probably as a result of global warming, *A. alni* has just re-established itself as a breeding member of the British insect fauna (Stenhouse 2006).

Open grassland habitats, probably located on the valley sides, were indicated from a small component of the assemblages and again host-specific Coleoptera indicate the presence of bird's foot trefoil, vetchlings, ribwort and hoary plantain and clover. Scarabaeoid dung beetles were again present that feed on the droppings of larger herbivorous mammals and their abundance was such as to imply domestic animals were grazing in the vicinity. It is likely that the grazing extended from the grassland into partly wooded areas. One of these beetles, *Copris lunaris* from context 4042, has not been captured for over 50 years in Britain (Jessop 1986, 26).

Waterlogged plant remains

by Wendy Smith

Nine samples were analysed from the sequence of deposits in Area 4 (Fig 13.7, Table 13.10). The plant remains, in general, were not particularly well preserved and were biased toward 'woodier' seeds and plant parts.

The lowest sample from a hollow in the basal peat (context 4053, sample 491) was not particularly rich or diverse and sedges were the most abundant taxa recovered. Notably, this sample did produce a few fragments of charred hazelnut shell (*Corylus avellana*). Peat context 4043 contained abundant remains of alder (*Alnus glutinosa*) as well as birch (*Betula* spp.), but the sample from the overlying peat deposit (context 4043, sample 437) was not particularly rich. It seems likely that these deposits represent a phase of alder carr woodland.

Contexts 4021 and 4023 (samples 395 and 408) examined from the upper part of the main peat profile were equally unproductive. However, context 4029 and the contexts spanning the transition to the 'Upper Clay Silt' unit (samples 406, 404 and 403) contained many wetland taxa such as club-rush, sedge and spike-rush with mint. Water taxa such as pondweed were also present. In general, this suggests areas of standing water surrounded by waterside taxa.

Chapter 14

Brook Vale (Zone 10)

by Martin Bates, Elizabeth Stafford and Mark Robinson

Introduction

This area lies along the eastern reach of the Ebbsfleet along Brook Vale (Fig 14.1) and was investigated through a series of five trenches (Trenches 13–17) as part of the STDR4 evaluation phase (Table 14.1). Trenches 13–15 were located at the south-eastern end of the STDR4 route on a narrow surviving spit of land between the 'Blue Lake' quarry and the current Blue Circle access road off Springhead Road. Two extant sections (Trenches 16 and 17) recorded from the face of the former quarry were also located nearby to the north-west. The trenches and sections were located in the largely dry valley tributary of the Ebbsfleet and, as such, demonstrated dry colluvial sequences throughout. No made ground was encountered in any of these trenches.

Trenches 13–17 (STDR400)

Lithological Succession

Trenches 13 and 16 (Fig 14.2) possessed the deepest and most complete sequence of colluvial deposits as well as a possible soil horizon. Soliflucted chalk with flint nodules, contexts 1322 and 1617, was encountered at the base of each of these. A series of sterile eroded chalk silts, contexts 1321–1308, were then deposited within Trench 13. However, the lower sequence of Trench 16 was well preserved with a reddish silt, context 1616, defining a probable early Holocene soil horizon resting directly on the soliflucted chalk. Eroded chalk silt, context 1615, and further potential early soils, context 1614, were located directly above. A sequence of sterile eroded chalk silts, contexts 1613–1609, similar to those

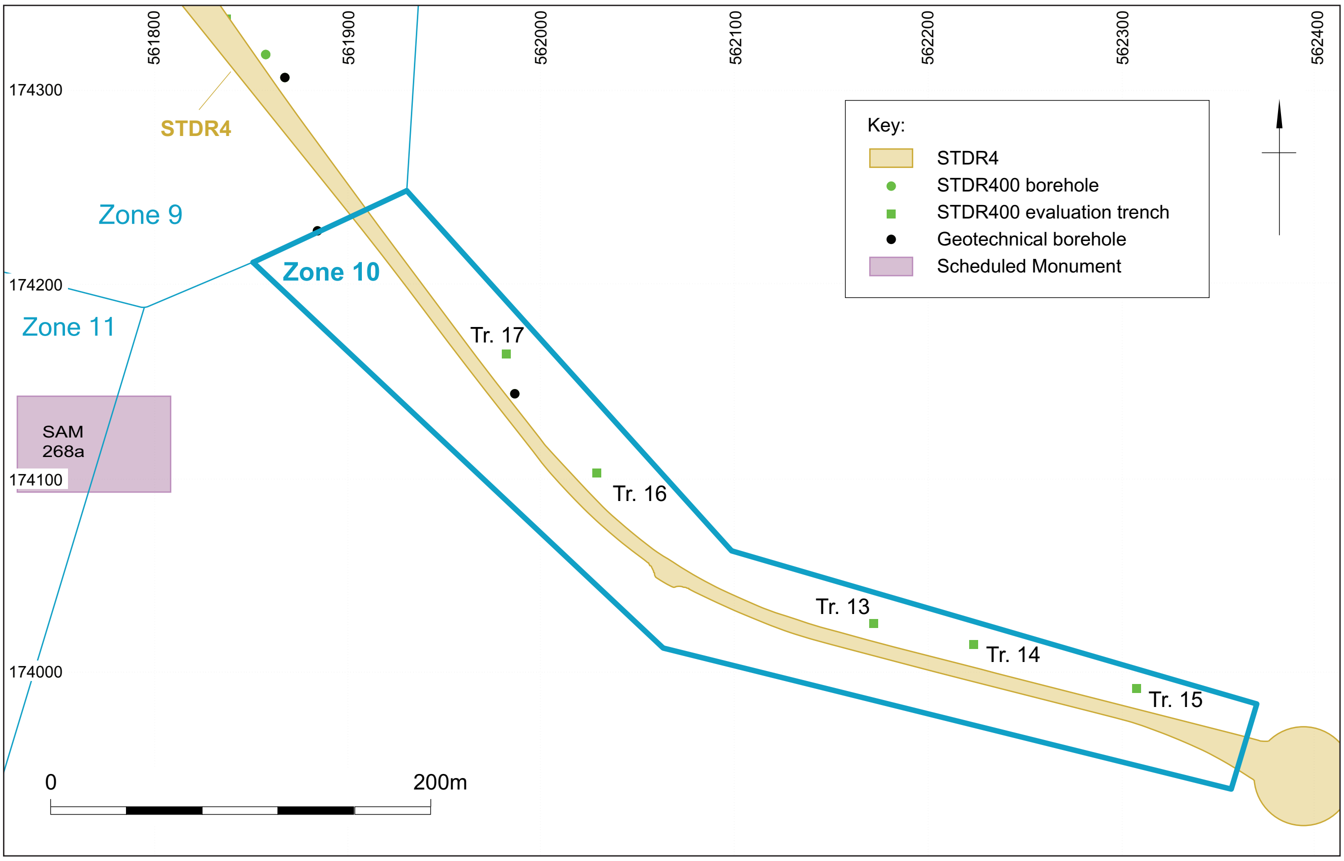


Figure 14.1 Zone 10 layout and key intervention locations

Table 14.1 Zone 10 key interventions and range of environmental studies

Project	Key locations	Molluscs	Archaeology
STDR400	Trench 13	–	Occ. worked flint, burnt flint
	Trench 14	–	–
	Trench 15	–	–
	Trench 16	x	Occ. worked flint
	Trench 17	–	–

KEY: x – Assessment level only

in Trench 13 were located above the possible soil horizons. No artefactual material was discovered from the lower colluvial and soil units.

Darker brown silty possible soil horizons, contexts 1307 and 1608–1606, with flint nodule inclusions were located within both of the trenches defining the boundary between the lower chalk silts and the upper unit of colluvial soils described below. Worked flint was recovered in small quantities (three items) from these deposits which were otherwise unremarkable. An unusual 0.1m thick layer of burnt flint sealed context 1307 across the full extent of the trench, representing a substantial quantity of raw material. This was comprehensively investigated *in situ* but no worked flint was evident within the layer. Charcoal or other signs of burning were similarly absent showing the layer was either deposited purposefully from another location or, more likely, had been eroded into the catchment area of the subsidiary dry side valley from a nearby location.

A consistent sequence of upper colluvial deposits and soils was encountered across the area. Three of the trenches (14, 15 and 17; Fig 14.2) demonstrated a comparatively shallow sequence of the upper colluvial brown/grey silty soil with rounded chalk inclusions directly overlying relatively thin soliflucted chalk. Trenches 14 and 15 were particularly shallow demonstrating that they were located upon or near the top of the valley side with the solifluction deposits slumping down further towards the valley base. The sharp contact between the lowest colluvial soil in these trenches and the surface of the soliflucted layers, combined with the composition of the soils, clearly demonstrates a very eroded interface which has removed

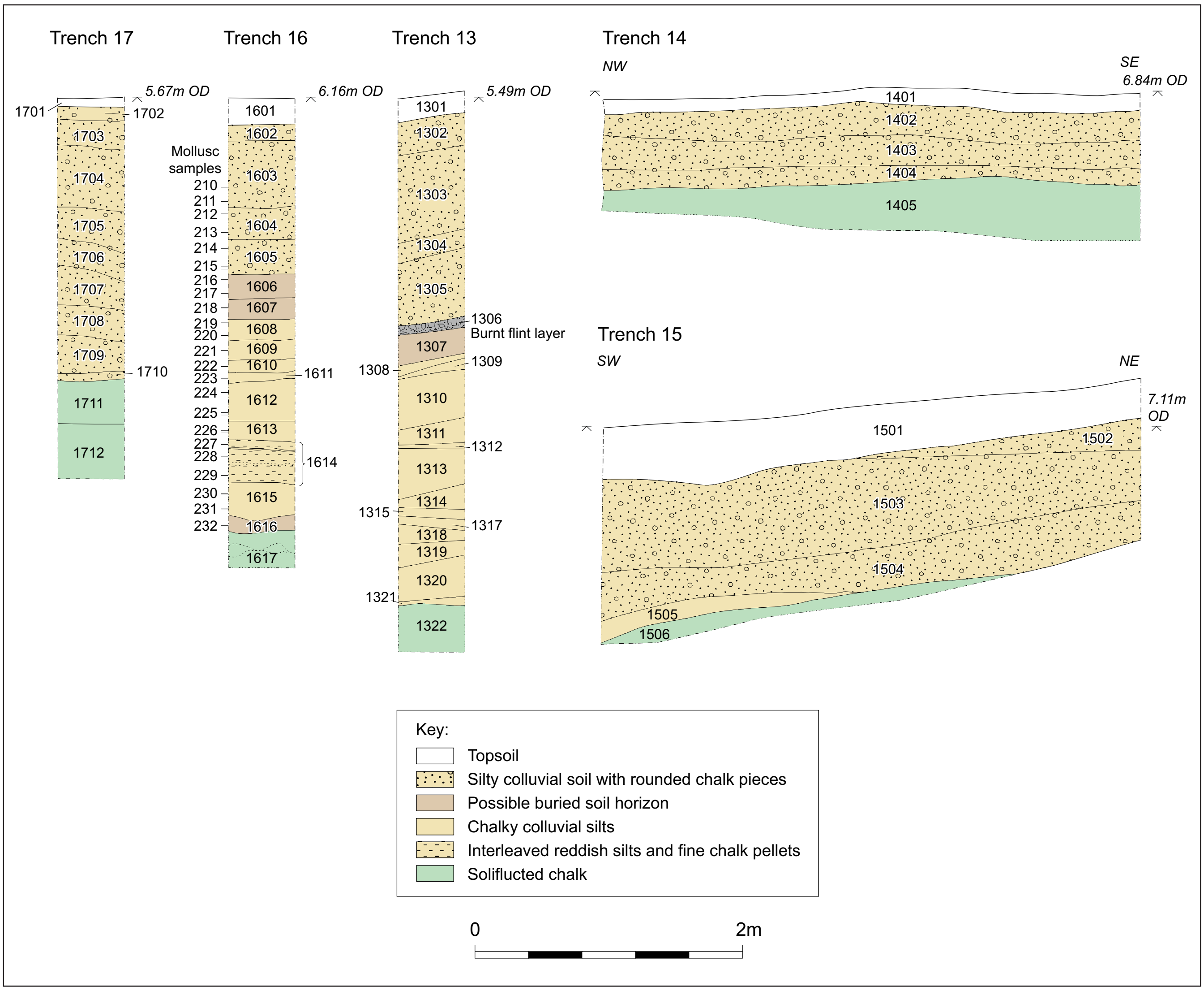


Figure 14.2 Brook Vale field sections (STDR400)

Table 14.2 Molluscs from Trench 16 (STDR400)

Context	1611	1610	1609	1608	1607	1606	1605	1604	1608
Sample	223	222	221	220	218	217	215	213	211
Pomatias elegans	–	+	++	++	–	–	–	–	–
Acicula fusca	–	–	–	–	+	–	–	–	–
Carychium sp.	+	++	++	++	++	+	–	–	–
Cochlicopa sp.	–	–	+	–	+	+	–	–	–
Truncatellina cylindrica	–	–	–	–	+	–	–	–	–
Vertigo pusilla	+	+	–	–	–	–	–	–	–
Pupilla muscorum	–	–	+	+	++	++	++	–	–
Vallonia costata	–	+	+	+	+	++	++	+	+
V. excentrica	–	–	–	–	++	++	++	+	+
Vallonia sp.	+	+	+	+	+	++	++	+	+
Acanthinula aculeata	–	–	+	+	+	+	–	–	–
Ena obscura	–	+	–	–	–	–	–	–	–
Punctum pygmaeum	–	–	+	–	–	–	–	–	–
Discus rotundatus	+	++	++	++	+	++	–	–	–
Vitrea sp.	–	–	+	+	–	–	–	–	–
Aegopinella pura	–	+	+	+	+	–	–	–	–
A. nitidula	–	–	+	+	–	–	+	+	–
Oxychilus cellarius	–	–	–	+	–	–	–	–	–
Clausilia bidentata	–	–	+	+	–	–	–	–	–
Candidula/Cernuella sp.	–	–	–	–	–	–	+	+	+
Helicella itala	–	–	–	+	+	+	+	+	+
Trochulus hispidus gp.	–	–	+	+	+	+	++	++	+
Cepaea spp.	–	–	+	–	–	–	–	+	–

any traces of earlier soil horizons within these trenches. The upper 1.2–1.6m of Trenches 13 and 16 were also occupied by the same sequence of colluvial soils.

The composition and character of the upper unit was consistent with more recent ploughsoils with medieval or post-medieval tile recovered from contexts 1303, 1403 and 1503. Small coke-like inclusions were also note in these deposits. However, this colluvial unit also proved rich in flint artefacts. Several scrapers, multi-platform cores, denticulate, notched, retouched flakes and a single backed knife were recovered across this spectrum of deposits. No features were encountered in any of the trenches and inspection of the visible length of the extant section similarly failed to identify potential features. It remains possible that the lowest deposits within this unit are of prehistoric date although this seems unlikely in Trenches 14 and 15.

Molluscs

by Mark Robinson

Only in Trench 16 were shells recovered (Table 14.2). Shells are absent from the lower part of the colluvial sequence (samples 232, 231, 228, 226, 225), which possibly represents Late Glacial solifluction debris or early Holocene deposits. Shells of woodland snails, particularly *Carychium* sp. and *Discus rotundatus*, predominate in samples 223, 222, 221 and 220. They include the rare snail *Vertigo pusilla*, which no longer occurs in Kent, in samples 223 and 222. Open-country species are not entirely absent, but it is unclear whether they are residual from Late Glacial and Early post-glacial presence or related to prehistoric human activity. The occurrence of many shells of *Pomatias elegans* in samples 221 and 220 could be a reflection of clearance-related surface instability. Open-country species predominate in samples 218 and 217, particularly *Pupilla muscorum* and *Vallonia excentrica*, but shells of woodland species are by no means absent. They were from deposits that were perhaps derived by colluviation from the ploughing of woodland soil. Shells of woodland molluscs are largely absent from samples 215, 213 and 211 while the presence of *Candidula* or *Cernuella* sp. would suggest the upper colluvial sediments to be medieval or more recent in origin.

Chapter 15

Springhead (Zone 11)

by Catherine Barnett, Elizabeth Stafford, John Crowther, Richard I Macphail, David Norcott, Rob Scaife and Sarah F Wyles

Introduction

Zone 11 is located in the upper part of the Ebbsfleet Valley and incorporates the results of the area excavations carried out by Wessex Archaeology in the vicinity of Springhead. The Springhead group of sites occupy the slopes and valley bottom on both sides of the current River Ebbsfleet (Fig 15.1). The modern topography of this area is variable. On the eastern side of the river the north-eastern part of the excavations at Springhead Sanctuary (Springhead Roman Town; ARC SPH00) was situated on a relatively flat plateau area at an elevation of approximately *c* +27m OD. Adjacent to this plateau, the ground fell away steeply to the south-west descending to +6.1m OD to the valley bottom. The Ebbsfleet River Crossing excavation (ARC ERC01) was situated a little further downstream on the eastern bank of the river at elevations between +8m and +4m OD. On the western side of the river the excavations at Springhead Roadside settlement (Springhead Nursery; ARC SHN02) occupied a gentler slope with elevations reaching up to +13m OD in the north-west.

Prior to excavation, the modern Ebbsfleet Channel was very narrow, lying centrally within a clearly defined floodplain which predominantly comprised *Phragmites* reedbeds with drowned trees visible. A steep river cliff up to 1.5m high defined each side of the floodplain. It appears that both the floodplain and the river channel at this location were, at least during some periods, managed.

The geology of the area around Springhead is mapped as Upper Chalk overlain by a complex of Pleistocene and Holocene fluvial terrace and floodplain deposits (BGS Sheet 272). Gravels capping the higher elevations are recorded by the BGS as plateau gravels and Woolwich Beds. However, Drs Michael J Allen and Richard I Macphail noted during a site visit that the gravels exposed in this area contained disturbed 'Blackheath pebble beds', pebbles and stained flints, and therefore were more likely to be associated with the Pleistocene terrace gravels. The recovery of an ovate Palaeolithic axe from these deposits strongly indicates that all the gravels are the basement bed of the Boyn Hill gravels associated with the Swanscombe sequence. The lower part of this unit is a clay-rich deposit over Thanet Sands. The Thanet Sands form the majority of the hill overlooking the main excavations. At the top, they are largely loose unconsolidated medium 'beach' sands, although the silt and clay content increases with depth, at one point forming a mixed sandy loam with a strong aeolian component akin to brickearth. At extreme depth, they are green and glauconitic. The Thanet Sand overlies Bullhead flints over chalk. These are contorted flints, which represent the base of deep, weathered tropical soils lying on old land surfaces, during phases of temporary terrestrial land. These deposits are discontinuous across the chalk surface. The chalk occurs under Thanet Sands or Bullhead beds, and dips strongly northwards. In valley bottom locations, it is mantled with periglacial solifluction or coombe deposits, and recent (Holocene) alluvium and colluvium.

The area around Springhead has been the subject of numerous previous archaeological investigations, largely focused on Roman and later remains (see Andrews *et al* 2011a–b; Barnett *et al* 2011). However, investigations by Burchell in the 1930s identified prehistoric remains described as two 'Mesolithic floors' in the vicinity of the Ebbsfleet River Crossing (Burchell 1938, SAM 268b). The site was reinvestigated by Sieveking in the 1960s (Sieveking 1960). The lower of Burchell's 'floors' was apparently stratified between a white calcareous silt and a lower ferruginous gravel and included flint artefacts now identified as belonging to the long blade industry of the Final Upper Palaeolithic. The upper 'floor' was contained within the upper part of the silt and was latterly identified by Sieveking as Neolithic in date producing items of worked flint and pottery sherds.

The Ebbsfleet River Crossing (ARC ERC01)

Introduction

Initial evaluation trenching in the area of the Ebbsfleet River Crossing was carried out in 1997 (URL 1997b) and revealed a deposit of burnt flint and charcoal sealed beneath colluvium at a depth of approximately 2.2 metres below ground level at the southern end of trial trench 1161TT. This was interpreted as a putative burnt mound feature of possible Bronze Age date.

In 2001 a borehole survey was carried out both to the east and west of the current channel (URN 2001b). Forty-eight locations were drilled by window sampling and sleeved cores were retrieved at two further locations for more detailed examination of the sequence (Fig 15.2a). In the area to the west of the current Ebbsfleet Channel much of the works area was a former landfill

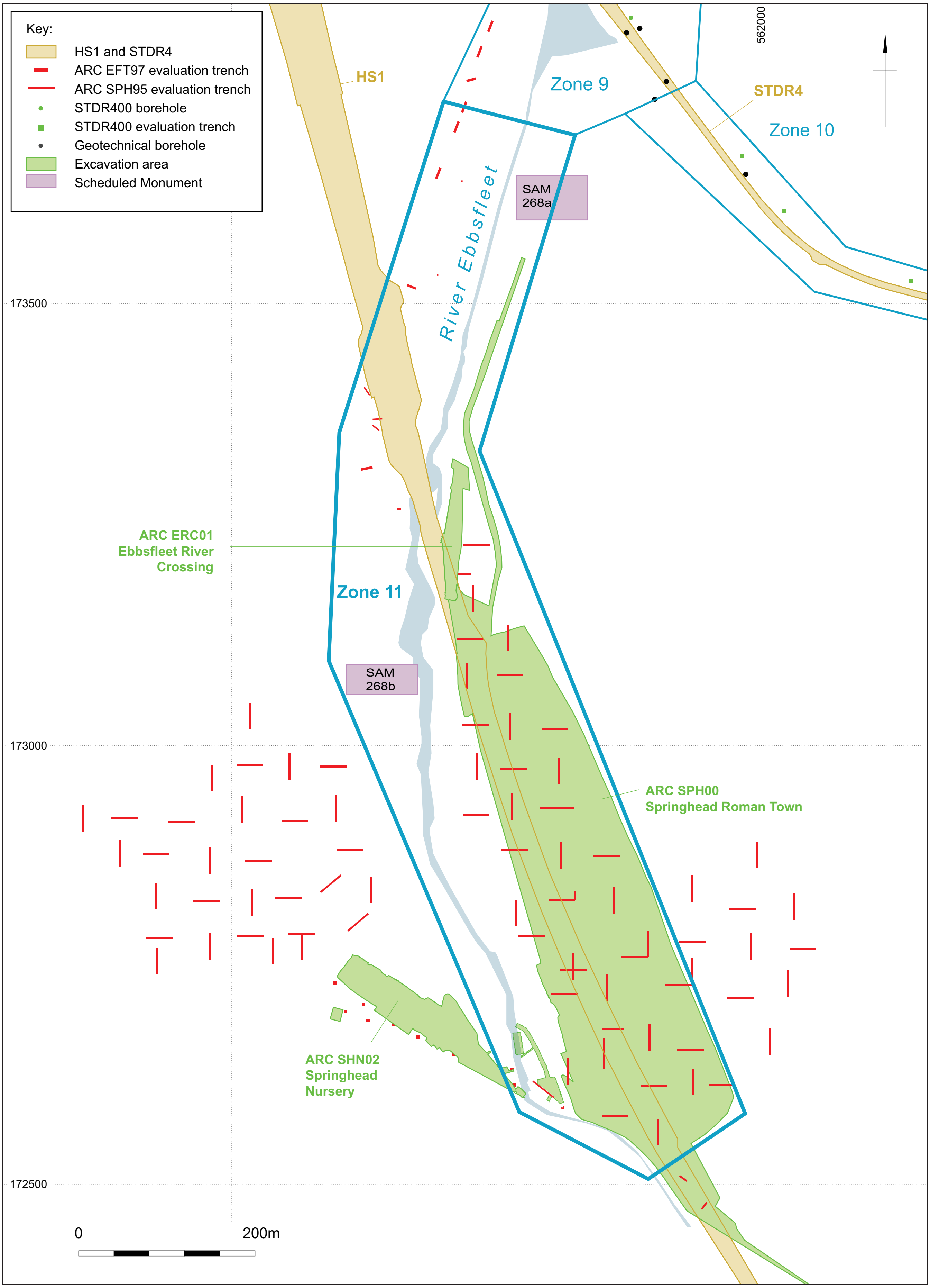


Figure 15.1 Zone 11 layout and key intervention locations

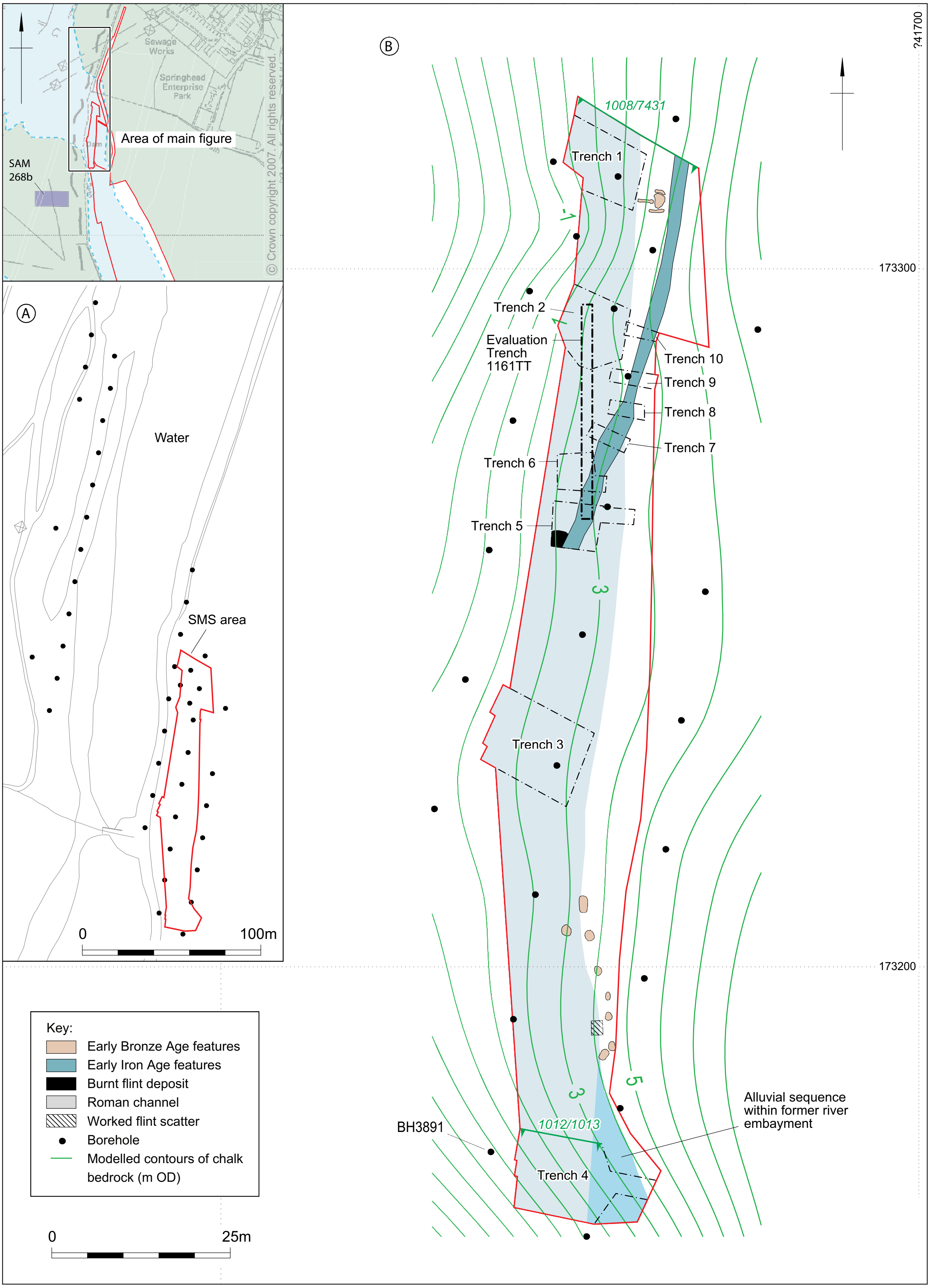


Figure 15.2 Site plan, Ebbsfleet River Crossing (ARC ERC01); (a) location plan; (b) detailed plan of strip, map and sample (SMS) area

Plate 15.1 Trench 4 (ARC ERC01)

site. A narrow strip of undisturbed ground between the landfill and the river cliff was examined by the borehole survey but no alluvial deposits were recorded. Colluvial deposits here were found to overlie gravels and sands. No further investigation was carried out at this location due to difficult ground conditions associated with the flooded reedbed zone, although a watching brief was maintained during construction. In the area to the east of the current Ebbsfleet Channel, the borehole survey demonstrated the underlying chalk sloped steeply to the south-west in the southern area of the site (Fig 15.2b). Dips in the chalk topography indicated small embayments at channel edge locations in the north central and southern area of investigation where the depth of overlying alluvium and colluvium increased.

Plate 15.2 Trench 1 (ARC ERC01)

Increasingly thick deposits of alluvium with substantial peat units were noted to be present westwards towards the Ebbsfleet Channel. The excavation of a small trial trench confirmed the presence of an alluvium-filled channel or embayment in the central part of the site along with a small feature cut into the chalk bedrock. The feature was very shallow but contained charcoal and burnt unworked flint. A quantity of worked flint was also found associated with a buried soil overlying the feature and in the upper part of the alluvium within the channel.

The borehole survey was immediately followed by a second stage of fieldwork east of the Ebbsfleet Channel (URN 2001b). This comprised a strip, map and sample (SMS) excavation covering an area of *c* 150m long by 15–20m wide (Fig 15.2b). The area was machine stripped of topsoil and colluvium and all discrete archaeological features were fully excavated. At the western edge of the SMS area, four deeper trenches (Trenches 1–4) were machine-excavated to investigate the deeper alluvial sequences within the embayments identified by the preceding borehole survey. One additional deeper trench (Trench 5) was targeted on the south end of the archaeological evaluation trench 1161TT to investigate the potential burnt mound recorded there previously. Four further deep trenches (Trenches 6–10) were machine-excavated to determine the presence and alignment extent of a substantial Iron Age ditch which was noted during the SMS excavation.

Prehistoric remains recorded during the SMS exercise include a number of pits and spreads of burnt and worked flint distributed along the edge of the

Table 15.1 Zone 11 key interventions and range of environmental specialist and dating studies

Project	Key locations	^{14}C	Pollen	Micro-morphology	Molluscs	Archaeology
ARC ERC01	Trench 4	X	X	–	–	Neolithic artefact scatters and Bronze Age features on adjacent higher ground
	Trench 1	–	–	–	X	
ARC SPH00	Spring-side (Sections 7486/7, 7630)	X	–	X	X	Middle Bronze Age barrows and burnt flint spreads

KEY: X – Analysis

Table 15.2 Radiocarbon dates from sediment sequences, ARC ERC01, Zone 11 (see Appendix G for calibration methods)

Event code	Feature/layer type	Sample	mBGL	Material dated	Lab code	δ^{13}C ‰	Result BP	Calibrated date (2 sigma, 94.5%)
ARC ERC01 Tr. 4	Layer, top of 493	160–1	0.65–0.66	Herbaceous stem (*Phragmites*)	NZA-28868	-26.5	1501±25	460–640 cal AD
	Layer, base of 493	160–2	0.92–0.93	Twig wood	NZA-28866	-26.6	1318±25	650–770 cal AD
	Peat 494	160–2	1.07–1.08	Bulk sediment	NZA-28795	-30.4	2625±30	835–770 cal BC
	Peat 546	161	0.34–0.35	Bulk sediment	NZA-28773	-28.8	4519±45	3370–3080 cal BC

alluvial zone which dated to the Late Neolithic to Early Bronze Age period. The key sediment sequences described here derive from Trenches 1 and 4 (Pls 15.1 and 15.2). In addition to several incremental mollusc columns, a number of undisturbed monolith samples were retrieved that allowed detailed recording, pollen analysis and radiocarbon dating (Table 15.1). The results of the radiocarbon dating are presented in Table 15.2.

Lithological Succession

by Catherine Barnett, David Norcott and Elizabeth Stafford

At the Ebbsfleet River Crossing, weathered chalk bedrock and chalk solifluction gravels were encountered at the base of the sequences sloping towards the south-western part of the site. Alluvial deposits overlying the chalk in this area indicate the presence of relict channels and associated edge deposits, running broadly north-south, associated with former river activity. The earliest Holocene deposits comprised alluvium, recorded in detail at the south-western edge of the excavation (Trench 4, Fig 15.3a). These deposits extended northwards and thinned against the rise of the chalk to the west, although they were found to be entirely absent at the northern edge of excavation (Trench 1, Fig 15.3b). The deposits comprised fine-grained minerogenic silts, clays and sands, often with chalk fragments, and most likely derive from colluvial deposits reworked by alluvial processes. Stratigraphic analysis suggests that these deposits are of prehistoric date with the basal sequence most likely deposited some time in the Early to Mid-Holocene.

In Trench 4, an organic horizon (monolith 161, context 546, Table 15.3) overlying a basal alluvium, represents a former marshy land surface. This layer was radiocarbon dated to the Early Neolithic period (see below). A further thick unit of minerogenic sandy silt colluvium (context 545) was recorded overlying the organic horizon. This unit was deposited under rapid downslope movement, as indicated by the disturbance and mixing-in of the underlying peat. The presence of this colluvium indicates instability, with hillwash being a feature of the area prior to the Late Bronze Age, probably relating to early agriculture upslope. This unit most probably correlates with similar units recorded in the area excavations in the higher eastern parts of the site, the surface of which was cut by a series of Early Bronze Age features.

In Trench 4, this early sequence of deposits was cut by later channelling, followed by the deposition of a series of intercalated minerogenic and organic alluvial deposits (monolith 160, Table 15.3). The inclusion of small stones and chalk fragments indicate the layers included reworked colluvium. The lowest organic horizon here has been dated to the Late Bronze Age/Early Iron Age (see below) which suggests a significant hiatus in the sedimentary record between the lower part of this sequence and the truncated earlier edge sequence to the east (represented in monolith 161). The upper organic channel fills and fully stabilised peat horizon (context 493) in this profile formed during the early to middle Anglo-Saxon period (see below), indicating a second hiatus between the peat and underlying alluvial and organic layers, perhaps due to increased erosive channel activity during the Roman period.

The later channel sequence can be traced northwards to Trench 1 (Fig 15.3b) where the channel truncates late prehistoric features and a Bronze Age soil horizon (context 405) that formed on chalky colluvial deposits. The channel fills at this location can be correlated with the upper part of the sequence in Trench 4. Here, however, the basal deposits within the channel comprised coarse flint gravels which have been interpreted as a deliberate Roman consolidation layer (context 413). Sealing the channel fills and the archaeological features to the west were further thick deposits of colluvium. It is likely that the lower part of

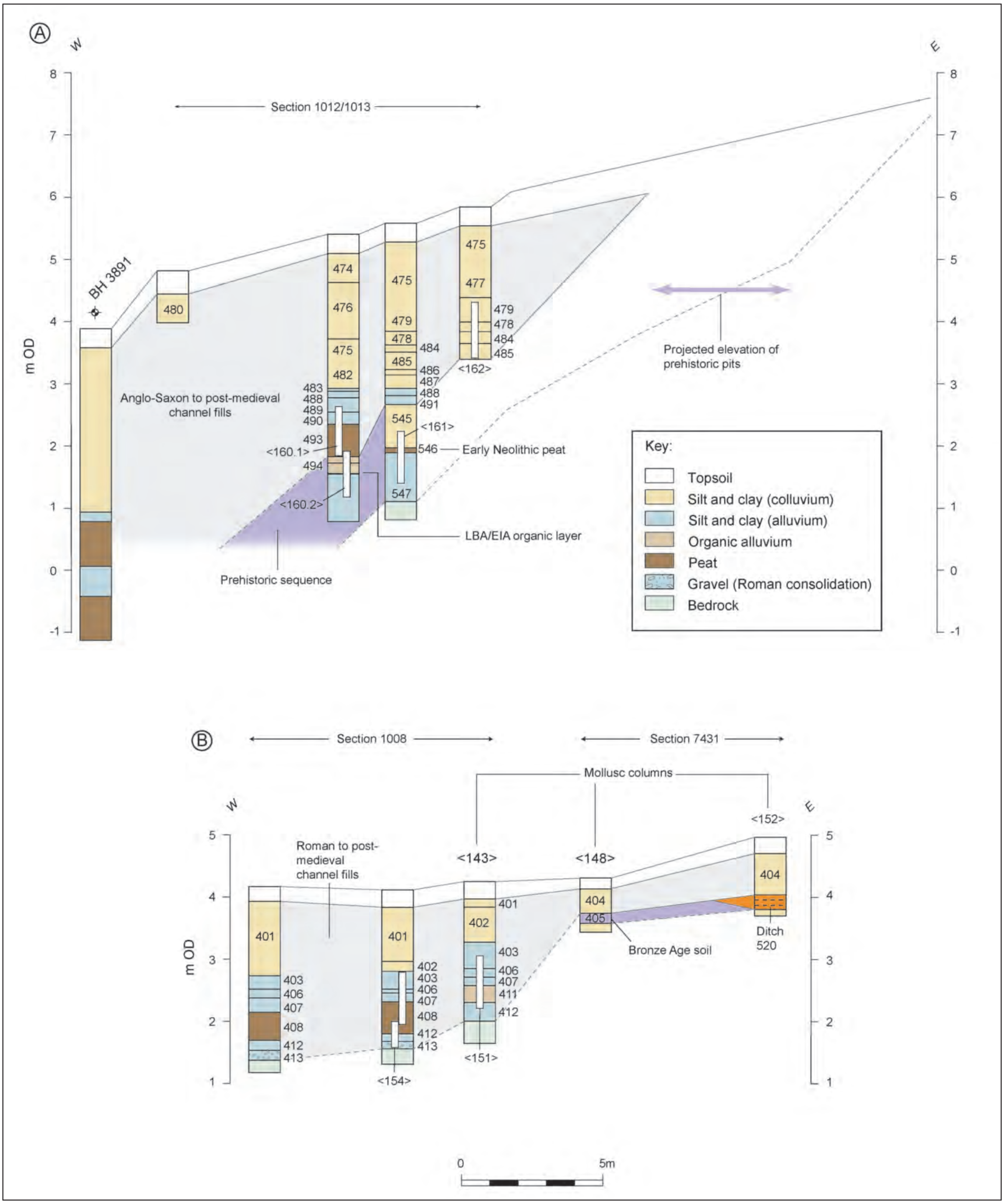


Figure 15.3 Composite sample sections, Ebbsfleet River Crossing (ARC ERC01)

this colluvium dates to the later Anglo-Saxon or medieval period and the upper part to the post-medieval, artefactual material providing a *terminus post quem* for deposition.

Overall these sequences demonstrate the complex interplay and intercalation of colluvial and alluvial deposition at the edge of the valley and base of the slope from prehistory onwards. Alluvium dominated the edge environment but its silty nature and inclusion of small chalk fragments suggest that this was commonly formed of reworked colluvium. Early on (pre-Early Neolithic) the alluvium was highly calcareous and indicates the presence of the calcium-charged waters of the spring(s) but this input decreased over time, and the channel

Table 15.3 Trench 4 (ARC ERC01) lithological description

Sample	Context	Depth (m)	Description	Interpretation
160.1	489	0.00–0.22	Mottled 10YR 3/2 very dark greyish-brown and coarse lenses and mottles of 10YR 4/4 dark yellowish-brown humic silt loam. Very rare small rounded stones and degraded herbaceous stems and wood charcoal 2mm	Humic alluvium (?colluvium relain in water)
160.1	490	0.22–0.42	10YR 4/2 dark greyish-brown massive compact silt loam faint sedimentary laminations. Rare coarse strong Fe mottles 7.5YR 3/4 dark brown. Burnt flint at 0.32m	Alluvium (?colluvium redeposited in water)
160.1	493	0.42–0.64	10YR 2/2 very dark brown highly organic silt, no visible inclusions, faint sedimentary laminations *c* 1mm with increased silt content/decreased organic content	Peaty alluvium
160.1 and 160.2	493	0.64–0.93	10YR 2/1 black well humified compact silty peat. Few recognisable plant remains and wood. Burnt flint at 0.78m	Peat "the upper peat"
160.2	493	0.93–0.98	10YR 2/1 black greasy massive peaty clay, no visible inclusions	Highly organic alluvium/gyttja
160.2	494	0.98–1.07	Fine horizontal laminations of 10YR 3/2 very dark greyish brown slightly humic and 10YR 4/3 brown soft silt. No inclusions	Alluvium
160.2	–	1.07–1.08	Wedge of 10YR 2/1 black peaty silt with ?fine comminuted charcoal	Organic silt
160.2	–	1.08–1.29	10YR 5/2 greyish-brown soft friable clean silt. Rare small herbaceous plant remains and small rounded stones	Alluvium
160.2	–	1.29–1.45	Mottled 10YR 4/3 brown silty clay with coarse strong Fe mottles (10YR 3/4 dark yellowish-brown) 100mm diameter pocket of 7.5 YR 3/4 dark brown stiff clay at 1.43m. No visible inclusions	Alluvium (with colluvial input?)
161	545	0.00–0.29	10YR 4/4 dark yellowish-brown soft friable fine sandy silt. Angular – sub-rounded small chalk fragments. Strong Fe staining along few vertical root voids in upper 0.05m. Weak blocky structure to top. Organic staining to base where underlying peat mixed in	Colluvium (some water resorting)
161	546	0.29–0.35	10YR 2/1 black crumbly well humified fine sandy silty peat. Few vertical root voids small fragment burnt flint at 0.33m	Peaty land surface
161	547	0.35–0.75	10YR 4/2 dark greyish-brown highly calcareous silt. Very abundant molluscs. No clear inclusions. Abundant long vertical Fe stained root voids traceable to overlying layer (ie, well rooted)	Alluvium (highly calcareous)
161	–	0.75–0.81	No sediment collected	–
162	479 + 478	0.00–0.47	10YR 4/6 dark yellowish-brown compact homogeneous calcareous silt clay. Abundant macropores, well-developed large blocky prismatic structure. Redeposition of $CaCO_3$ along inter-ped faces and few vertical root voids	Colluvium
162	484 + 485	0.47–0.77	(As above) 10 YR 4/6 dark yellowish-brown compact homogeneous calcareous clay silt. Moderately well developed large blocky structure. Redeposition of $CaCO_3$ along rare vertical root voids. Common coarse strong black Mn staining and Fe staining (7.5 YR 4/6 strong brown) No visible inclusions	Colluvium
162	485– 486?	0.77–0.89	10YR 4/4 dark yellowish-brown slightly humic calcareous clay silt. Weak medium blocky structure few small rounded stones, few coarse strong Fe mottles (7.5YR 4/6 strong brown)	Colluvium

shifted or water levels dropped to enable gyttja-like (fine, black, humic, waterlain) layers and peats to form.

Dating
by Catherine Barnett

The chronological framework for sequence deposition is provided by the presence of stratified archaeological finds and features supported by a programme of radiocarbon dating (Table 15.2). The full details of the latter are provided in Appendix G. The basal peat recorded in Trench 4 (context 546) was dated to the Early Neolithic period at 4519±45 BP (NZA-28773, 3370–3080 cal BC). This layer had been tentatively correlated with the thin lower peat in monolith 160.2, but radiocarbon dating of the latter shows this to be of Late Bronze Age to Early Iron Age date at 2625±30 BP (NZA-28795, 835–770 cal BC). It is apparent, therefore, that a later channel cut the (Neolithic) peaty landsurface. The 'Upper Peat' (context 493) recorded in the later channel has proved to be significantly later in date, with the base dated to the middle Anglo-Saxon period at 1318±25 BP (NZA-28866, 650–770 cal AD) and the top dated to 1501±25 BP (NZA-28868, 460–640 cal AD).

Pollen
by Rob Scaife

The two separate pollen sequences (Trench 4, monolith samples 161 and 160, Fig 15.4) obtained from this part of the River Ebbsfleet Valley margin have provided information on the late prehistoric and historic environments of this area. The following is a summary of the full report by Rob Scaife which is included in Appendix J.

The earliest sediments of context 494 (monolith 161) are of Neolithic date and show a predominantly wooded habitat (Figs 15.3a and 15.5). This was dominated by lime (*Tilia*), oak (*Quercus*) and hazel (*Corylus*) on drier areas with alder (*Alnus*) carr along the fringes of the Ebbsfleet Valley. There is also some evidence for open areas, probably localised woodland clearances. These were of a pastoral/grassland nature, although it is possible that any arable components are not fully represented in the pollen assemblages. The valley bottom at this time (prehistoric) was fen with alder and an understorey of reedswamp taxa. A closer sampling interval was adopted for the upper part of the 'lower' peat horizon. Overall, there were only minor stratigraphical variations in the pollen spectra and no local pollen assemblage zones have been defined for this

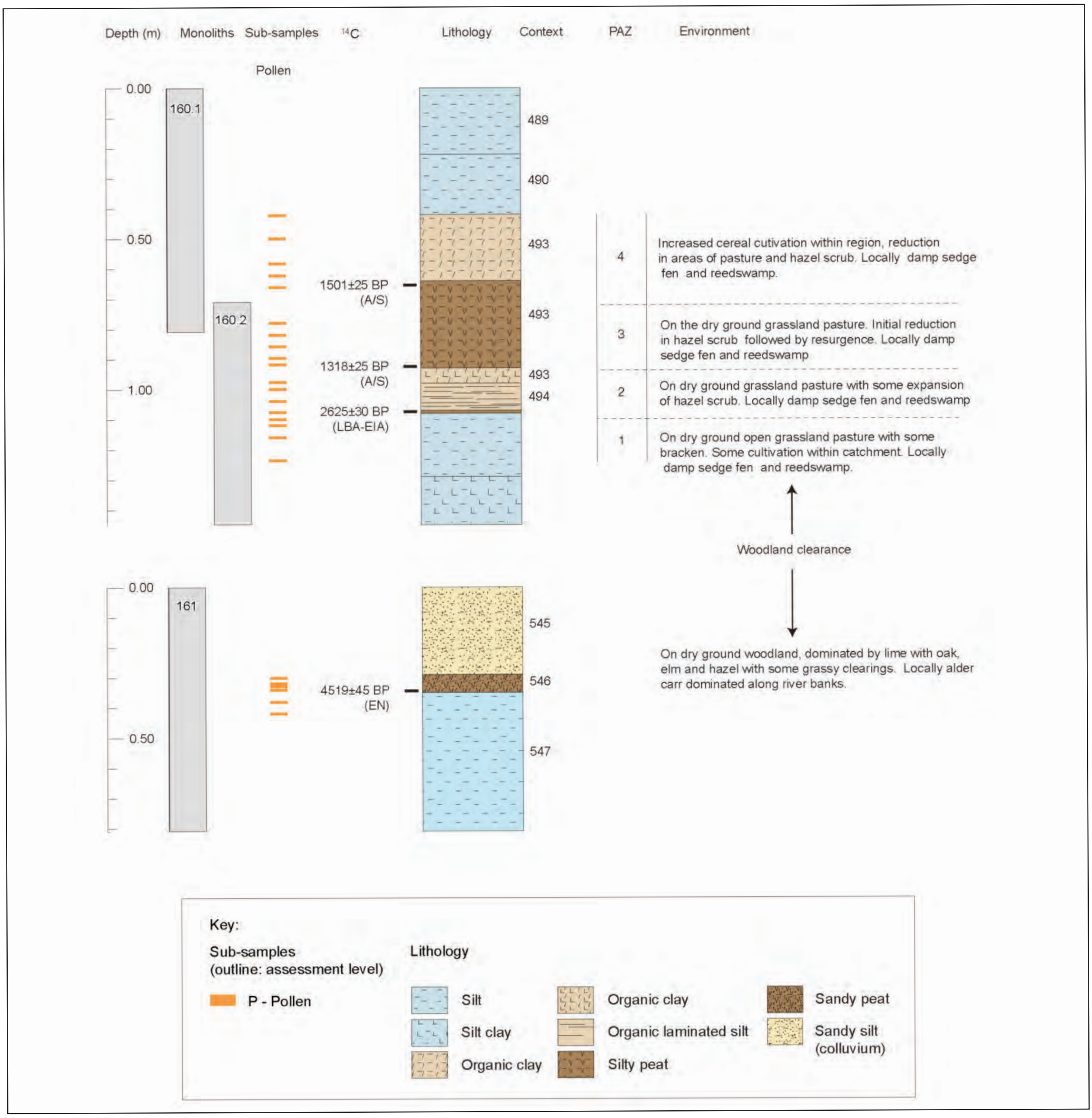


Figure 15.4 Pollen summary, Ebbsfleet River Crossing (ARC ERC01)

profile. A phase of colluviation (context 545) occurred, probably as a result of woodland clearance and destabilisation of the soils. This effectively sealed the lowest peat accumulation (context 546).

The later peat and sediments (monolith 160) have a completely contrasting pollen flora showing a largely open, deforested, environment. Four local pollen assemblage zones (PAZs) were recognised in the *c* 1.2m of sediments examined (Figs 15.3b and 15.6). A phase of predominantly grassland/pasture is evidenced for the later prehistoric period (PAZ 1) at the base of monolith 160.1. Occasional cereal pollen was present suggesting localised arable activity in the catchment. An expansion of hazel scrub occurred (PAZ 2 and PAZ 4), which may be a taphonomic phenomenon caused by changing sediment regime, but is more probably due to colonisation of areas of grassland and bracken. Grassland (with some evidence of arable activity) remained. The uppermost PAZ 4 had clear evidence for an increase of arable activity in the local region during the middle Anglo-Saxon period. The only other possible cultigen apart from cereals was a single and inconclusive record of hemp or hop (*Cannabis*/*Humulus*-type). Contrasting with the alder herb fen environment of the earlier prehistoric period, the Ebbsfleet Valley at this point became one of much more open, fen herb character. Grasses, sedges and a range of other taxa were indicated.

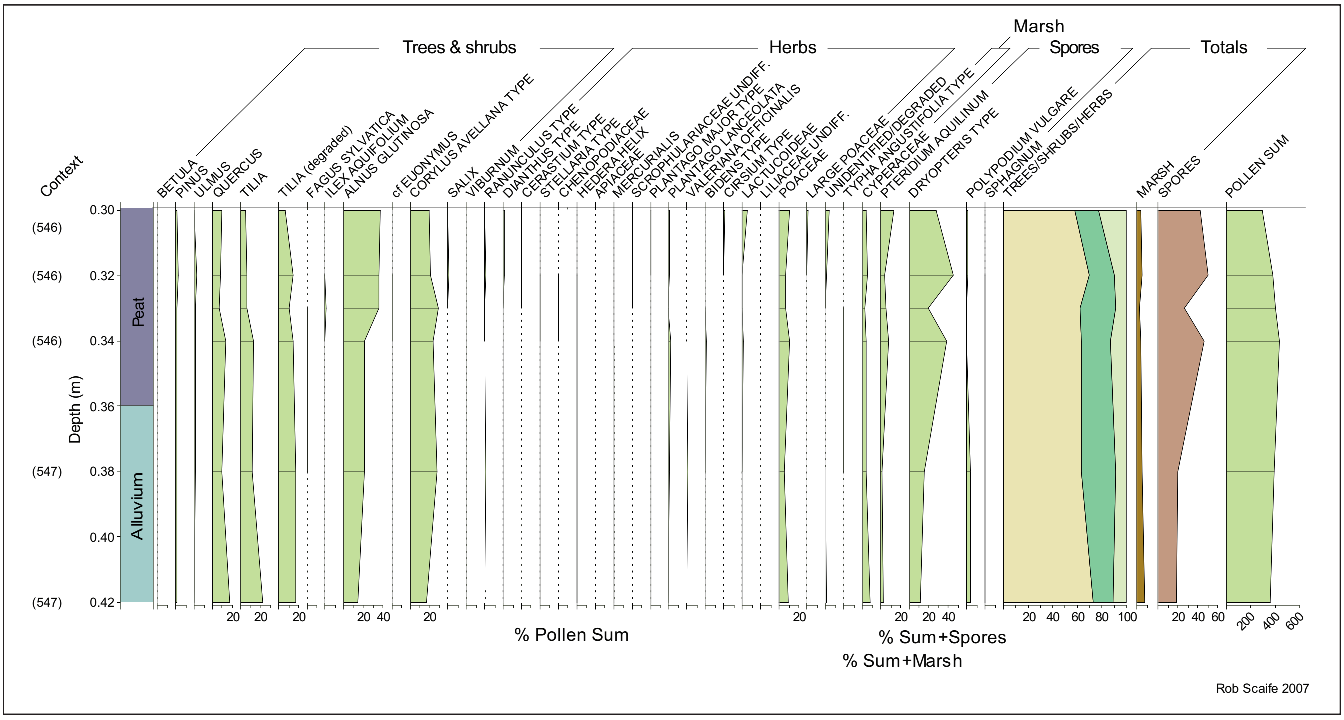


Figure 15.5 Pollen diagram from the Early Neolithic peat in Trench 4 at the Ebbsfleet River Crossing (ARC ERC01)

Molluscs

by Sarah F Wyles

Six samples from incremental columns 148 and 152 containing molluscs in countable numbers were analysed from Trench 1 at the northern edge of the excavations (Fig 15.3b). This included a Bronze Age buried soil (context 405), ditch 520 and post-Roman colluvium (context 404). A further five samples were analysed from incremental column 143, although these derive entirely from Roman and post-Roman channel fills and are not therefore considered in detail here. The detailed report on the molluscs is included in Appendix M.

To summarise, the sequence from columns 148 and 152, the changes in the snail assemblages were such that four molluscan assemblage zones (MAZs) could be differentiated (Fig 15.7). The chalky colluvium (MAZ 1) underlying the Middle Bronze Age buried soil, produced an assemblage dominated by intermediate species with a smaller shady element. *Pomatias elegans* was quite numerous, a species fond of broken ground and is therefore sometimes used as an indicator of interference with the soil such as the onset of clearance (Evans 1972). The presence of Clausiliidae and *Discus rotundatus* is indicative of the presence of woodland or scrub nearby. Clearance is likely to have been secondary rather than primary, given that no taxa indicative of full undisturbed cover were present.

Open country taxa were much more frequent in the samples examined from the Bronze Age buried soil (MAZ2, context 405). Here *Vallonia* sp. dominate and *Pupilla muscorum* was also frequent indicating an environment of short-turfed grassland, perhaps with areas bare of vegetation. The presence of the rare obligatory xerophile (lover of extremely dry conditions) *Truncatellina cylindrica*, a species that favours short dry calcareous grassland, supports this interpretation

The samples from the colluvial ditch fill and subsequent inwash of colluvial material (MAZ3) were characterised by a significant increase in shade-loving species although this decreases within the zone. The species composition (zonatids, *Aegopinella pura* and *Aegopinella nitidula,* and *Carychium*), however, suggests this is likely to be indicative of areas long unkempt grassland, as opposed to wooded conditions. In MAZ 4 (Roman and post-Roman colluvium) open-country species again dominated indicating very open, probably short turfed, grazed downland, with perhaps some areas of trampling.

The Prehistoric Spring-Side Sequences (ARC SPH00)

Introduction

Initial evaluation trenching further upstream in the vicinity of Springhead was carried out in 1997 (URL 1997b). This was followed by a series of area excavations in 2000–2 (ARC SPH00). Prehistoric colluvial sequences similar to those at the Ebbsfleet River Crossing were recorded at the head of the springs underlying the Roman Sanctuary complex. Here, however, the sequences were overlain and in places heavily truncated, by a complex series of deposits associated with later channelling and intensive Roman occupation (see Andrews *et al* 2011a; Barnett *et al* 2011). Artefact assemblages recovered from the colluvium included a quantity of worked flint dating from the Final Upper Palaeolithic to Bronze Age

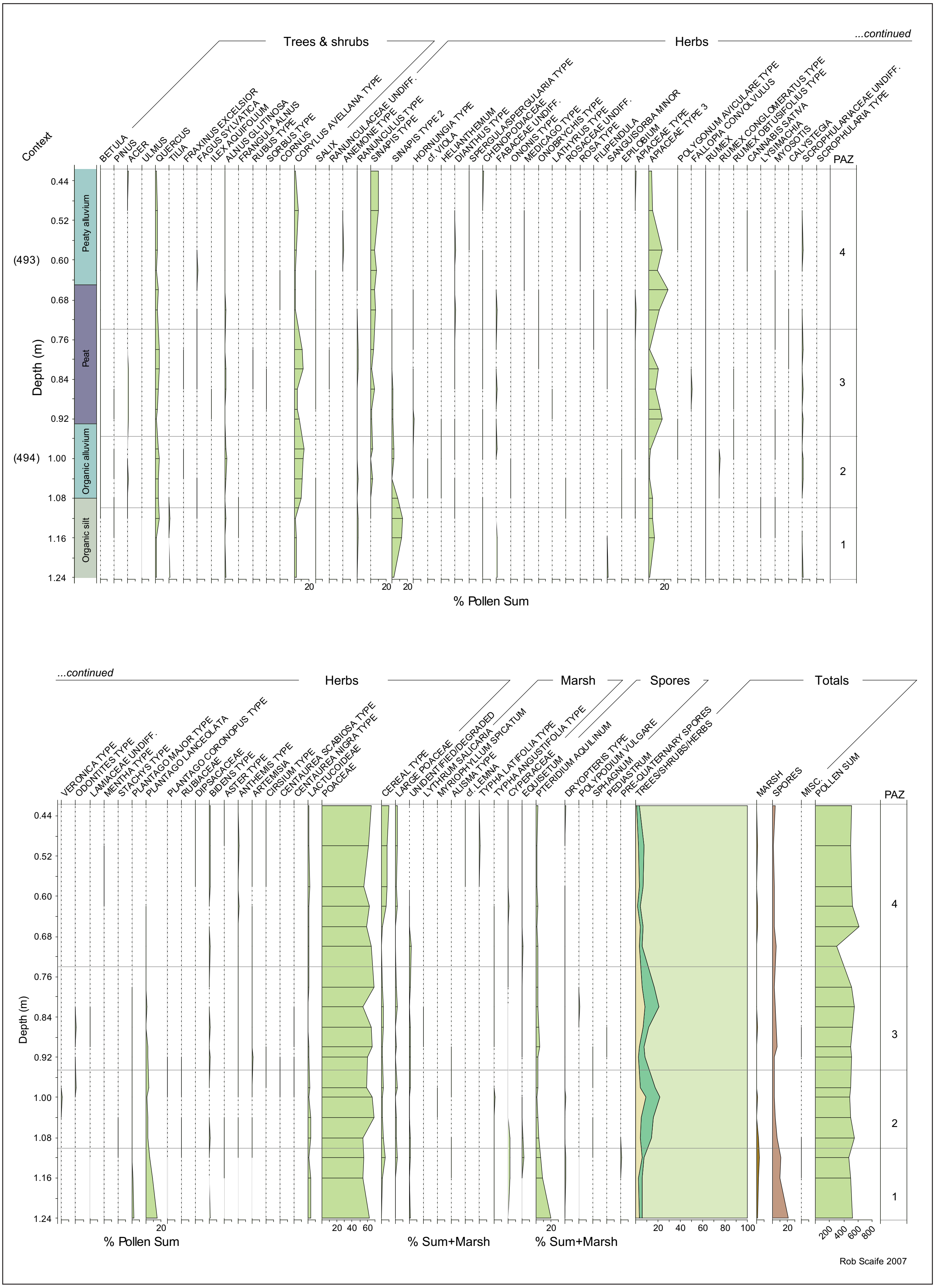


Figure 15.6 Pollen diagram from the channel deposits and later peat in Trench 4 at the Ebbsfleet River Crossing (ARC ERC01)

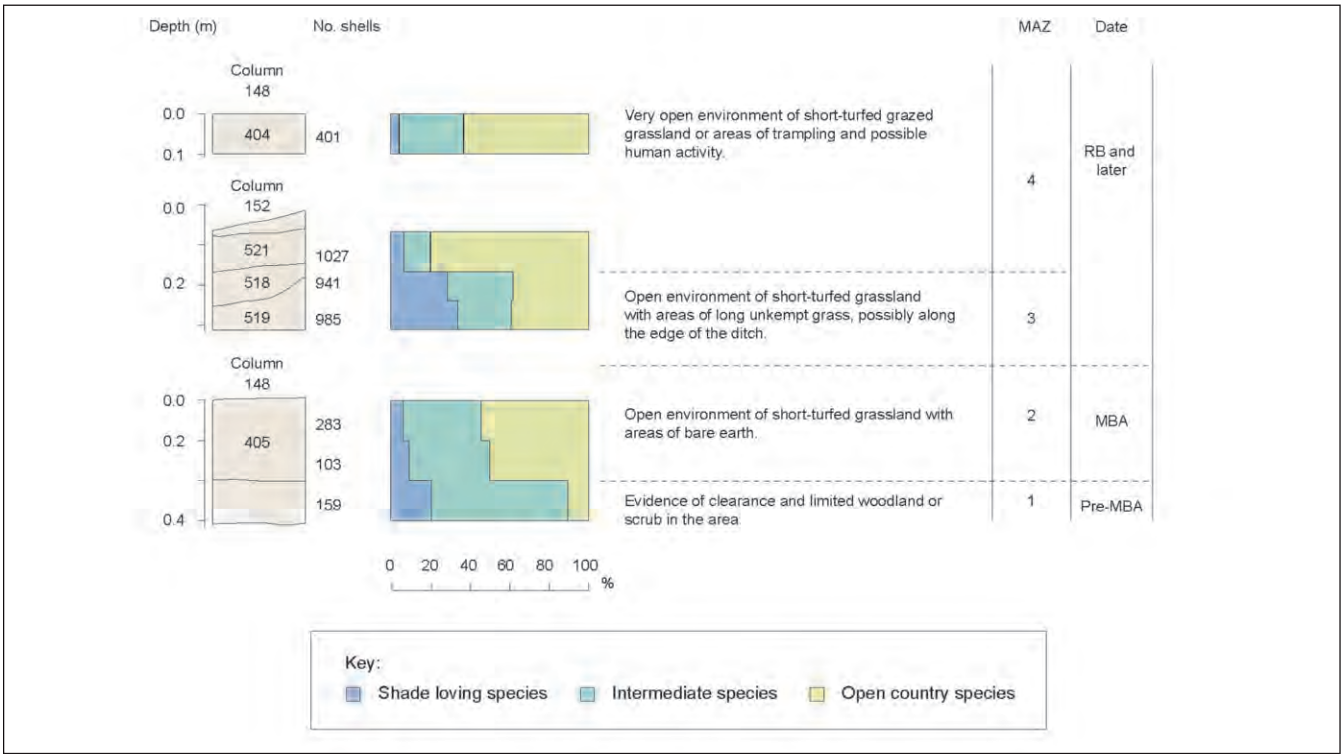


Figure 15.7 Summary of molluscan data, Ebbsfleet River Crossing (ARC ERC01)

periods, as well as a series of stratified Middle Bronze Age features including two truncated ring-ditches (possible barrows) and associated burnt mound deposits (Fig 15.8).

The key sediment sections dating to the prehistoric period are 7486/7 and 7630 (Fig 15.9). In addition to several incremental mollusc columns, a number of undisturbed monolith and kubiena samples were taken from these sections that allowed for more detailed recording. Bulk chemical and micromorphological analysis was also carried out on deposits associated with a Middle Bronze Age buried soil and burnt mound (Fig 15.9).

Lithological Succession

by Catherine Barnett, David Norcott and Elizabeth Stafford

The base of the sequences in the lower lying areas comprised weathered chalk bedrock and chalk solifluction deposits (Coombe Rock) overlain by a series of colluvial deposits (Fig 15.9). The basal parts of the colluvial sequence (beneath the Middle Bronze Age occupation deposits) were probably deposited in the Early to Middle Holocene. A significant amount of worked flint was recovered from these deposits (including items of Final Upper Palaeolithic date), although analysis has revealed the assemblages to be rather mixed, suggesting the reworking of older deposits from further upslope during the Late Neolithic to Early Bronze Age period.

Cut into the surface of these colluvial deposits in the south-western part of the site was a series of Middle Bronze Age features, including two ring-ditches associated with *in situ* contemporary soils and a number of burnt flint spreads. These features were subsequently buried by further colluvium deposits during the Late Bronze Age or Iron Age.

During the Late Iron Age or early Roman period the prehistoric sequences in the area below the Sanctuary Complex were extensively truncated by channel activity. As at the Ebbsfleet River Crossing, the base of the channel in several sections was filled with coarse gravel interpreted as Roman consolidation layers and contained a number of potsherds and other artefacts. In places, these gravels lay directly above chalk or chalk solifluction deposits, suggesting that the channel bed may have been intentionally cleaned out prior to consolidation. Above the gravels, further deposits of colluvial material were recorded infilling the spring area and extending further upslope onto the higher drier ground. Although dating evidence is rather limited for these colluvial deposits it is likely that some of the initial deposits were laid down during the later Roman and Anglo-Saxon periods.

One of the key sequences recorded here (section 7486/7, Fig 15.9a) included deposits of late Devensian to Middle Bronze Age date. It includes a basal soliflunct, calcareous colluvium and a thin soil beneath a burnt mound or midden deposit (context 5103). The colluvial deposits were recorded in monolith 8450 (Table 15.4) and generally comprised brown silty clay loam with occasional sub-angular to rounded flint clasts and frequent secondary carbonate precipitates in rootholes. This unit became increasingly chalky down profile approaching the interface with the underlying chalk. Bedding within these deposits suggests episodic

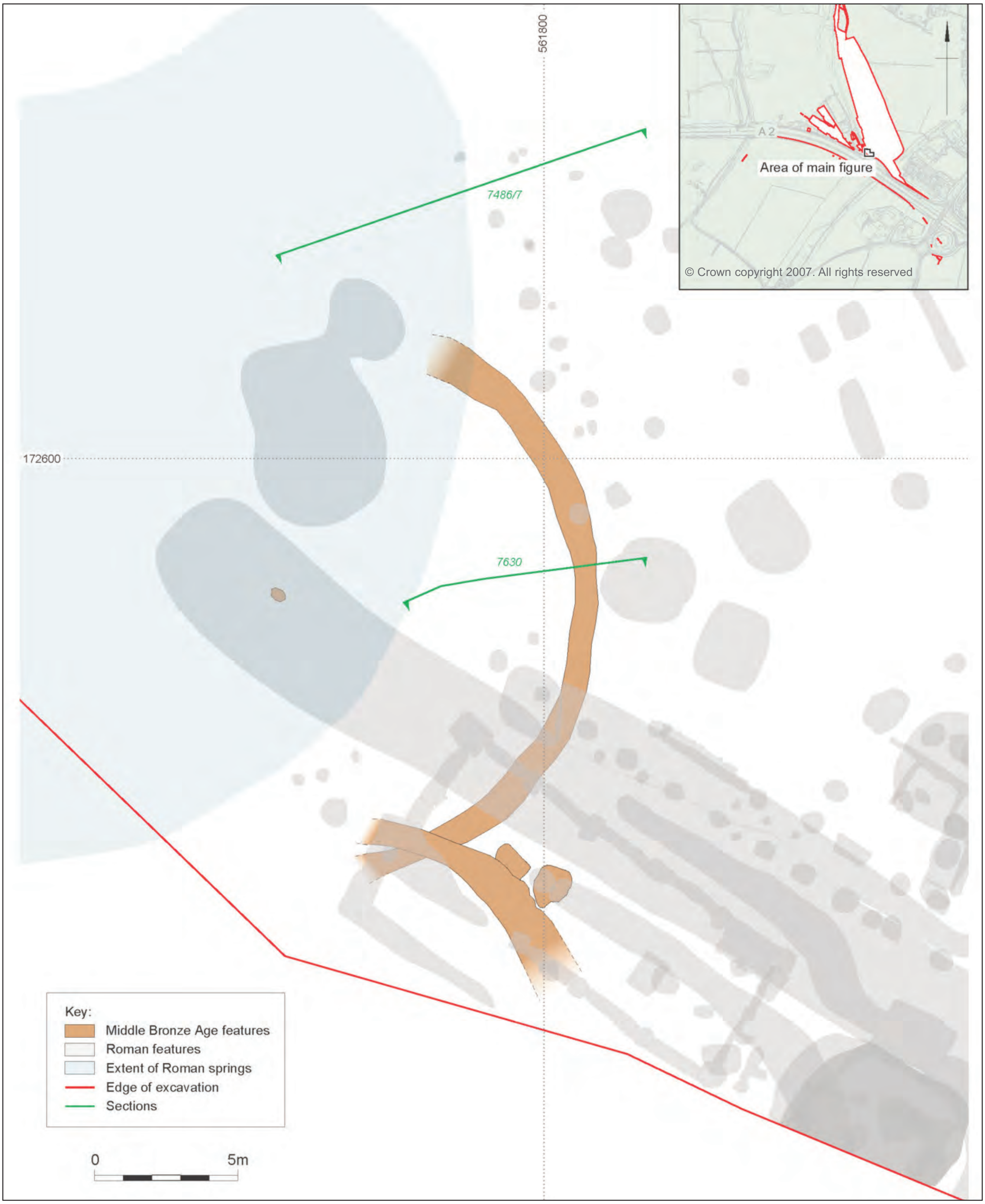


Figure 15.8 Site plan, spring area (ARC SPH00)

deposition and perhaps periods where the rate of sediment accumulation was reduced. The upper part of the prehistoric profile was recorded in kubiena samples 8374–5 which included micromorphological analysis (see below). Context 5102 immediately below the Middle Bronze Age soil (5103) comprised a very dark greyish-brown clay silt with common shell fragments and angular gravel clasts and may represent the remnants of a soil formed within the colluvium prior to the activity associated with context 5103. Context 5103 is interpreted as the remnants of a burnt mound deposit or midden dating to the Middle Bronze Age. The lower

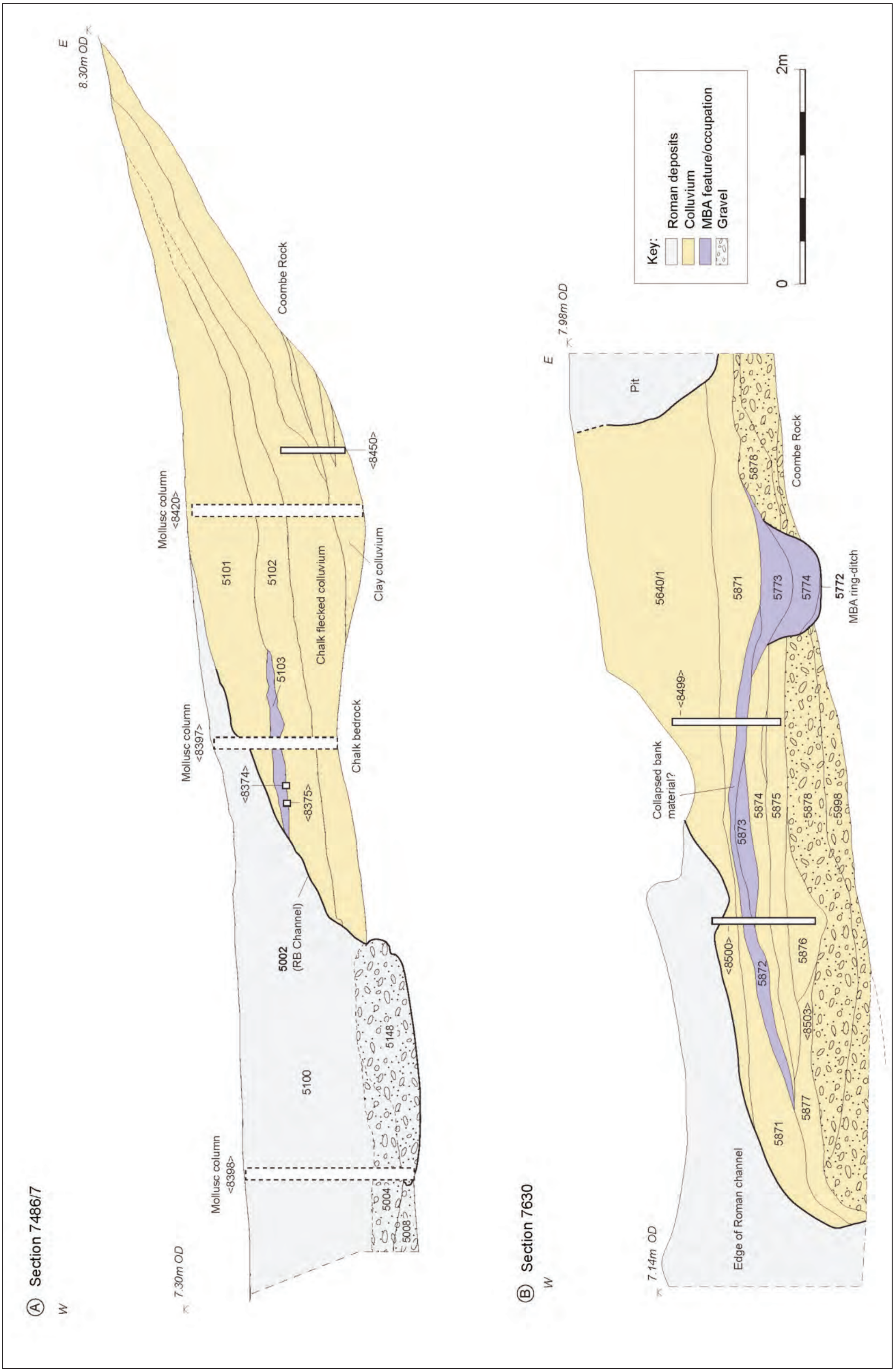


Figure 15.9 Field sample sections, spring area (ARC SPH00)

Table 15.4 Spring-side sequences (ARC SPH00) lithological description

Sample	Context	Depth (m)	Description	Interpretation
8450	–	0.00–0.39	10YR 4/4 dark greyish-brown silty clay loam. Darkens somewhat down profile from nearer 5/4 at top. Some sub-rounded flint gravel at 0.19–0.23m, also few small chalk pieces. ?weak ?medium ?blocky structure. Macropores. No roots observed	Colluvium
8450	–	0.39–0.49	10YR 4/3 brown silty clay loam. Quite common calcareous or silicate precipitates in small voids/rootholes. ?large crumb/?small – med ?blocky structure, weakly developed. Occ small flints <10mm, sub-angular. NB worked flint recovered at 0.42m	Weakly developed stasis horizon
8450	–	0.49–0.58	10YR 4/3 brown silty clay loam – same Munsell as above but actually slightly darker than above. Occasional sub-angular to rounded flints <20mm. Precipitates in rootholes again, ?small to medium ?blocky structure again, but quite well developed. NB very chalky at base, coming down onto chalk or periglacial chalk	Weakly developed stasis horizon
8374	5103	0.00–0.05	10YR 3/2 very dark greyish-brown friable clay silt loam with common coarse pockets of comminuted charcoal. Few angular medium gravel, molluscs	MBA soil formed in colluvium and spread from burnt mound
8374 and 8375	5103	0.05–0.12	10YR 2/1 black stiff clay silt very abundant comminuted and macroscopic charcoal common molluscs. No other visible inclusions Possible struck flint at 0.115m	MBA soil formed in colluvium and spread from burnt mound
8375	5102	0.12–0.22	10YR 3/2 very dark greyish-brown friable clay silt. Abundant large macropores ?medium blocky structure common molluscs and angular gravel <4mm	MBA soil formed in colluvium and spread from burnt mound.
8499	5641	0.00–0.41	10YR 5/4 yellowish-brown soft friable silt with common rounded chalk <4mm, rare small sub-angular – rounded stones. Well developed medium blocky structure	Colluvium
8499	5871	0.41–0.60	10YR 4/3 brown slightly organic silt loam. Few angular-rounded small stones and chalk fragments <4mm. Common macropores. Weak granular and small blocky structure	Immature soil/stasis having formed in colluvium. LBA/EIA?
8499	5872	0.60–0.67	10YR 4/4 dark yellowish-brown clay silt, weak granular – small blocky structure, common poorly sorted angular – rounded small-medium stones. Few macropores	Colluvium, some post-depositional pedogenesis
8499	5874 + 5875	0.67–0.97	10YR 4/4 dark yellowish-brown clay silt loam, compact and massive, few small specks of charcoal and chalk. No bedding visible	Water-sorted colluvium
8499	Base of 5875	0.97–1.00	10YR 4/4 dark yellowish-brown friable silt loam. Common small rounded chalk fragment, few sub-rounded small stones	Water-sorted colluvium
8500	5638	0.00–0.05	10YR 4/3 brown soft friable and crumbly silt, stone-free, few small chalk and charcoal specks	Primary fill of ditch
8500	5641	0.05–0.21	10YR 4/4 dark yellowish-brown soft friable massive clay silt few macropores, common angular chalk fragments and stones <4mm, common charcoal (including wood charcoal >4mm)	Colluvium
8500	5871	0.21–0.28	10YR 3/3 dark brown soft massive clay silt slightly humic with common specks of charcoal and few small chalk fragments. No structure/evidence of pedogenesis but is likely to be a brief stasis	Colluvium with stasis/ immature soil LBA/EIA?
8500	5872/ 5873 to base	0.28–0.41	10YR 4/4 dark yellowish-brown soft friable calcareous clay silt. Abundant poorly sorted sub-angular to sub-rounded small-large flint gravel, common small chalk fragments, few molluscs and charcoal	Colluvium (part of possible stasis?) Some worm sorting?
8500	5874	0.41–0.54	10YR 4/4 dark yellowish-brown massive soft friable silt loam. Rare chalk flecks. Few vertical voids (worm burrows)	Colluvium
8500	5875/ 5876	0.54–0.89	10YR 4/6 dark yellowish-brown coarsely mottled with 10YR 4/4 dark yellowish brown and faint Mn staining compact silt loam. Few worm burrows. Rare chalk flecks	Colluvium (some water resorting)
8500	Base of 5876	0.89–0.98	10YR 5/4 yellowish-brown highly calcareous fine sandy silt. Abundant small round chalk fragments. Note there are no tufaceous nodules/concretions. No visible structure or stases	Calcareous alluvium (with some soliflucted/colluviated chalk input possible)
–	–	0.98–1.00	Loss of sediment	–

part of context 5103 was recorded as stiff black clay silt with abundant charcoal and shell fragments. This graded upwards into a greyish-brown clay silt loam with frequent pockets of comminuted charcoal. The upper levels of this sequence (recorded on site but not recovered) can be directly correlated with the deposits described for the Ebbsfleet Channel edge sequence (ARC ERC01, Trench 4, see above).

Two monoliths, samples 8499 and 8500 (Table 15.4), were also examined from Section 7630 adjacent to the spring and Middle Bronze Age ring-ditch, with a more complete sequence (*c* 1m) collected in the latter. Section 7630 is located very close to where an assemblage of flint, including that dated to the Final Upper Palaeolithic period were recovered. The lowermost deposit examined in monolith 8500 (context 5876) contained some possible soliflucted chalk, reworked into a highly calcareous alluvium related to the spring which post-dates the Final Upper Palaeolithic material.

Dating

The chronological framework for sequence deposition is provided primarily by the presence of stratified artefacts and archaeological features. The lower portion of colluvium beneath the Middle Bronze Age occupation deposits is likely to have formed during the Late Neolithic to Early Bronze Age period, although it did contain residual worked flint from earlier periods, including items of Final Upper Palaeolithic date. Radiocarbon dates were obtained from the Middle Bronze Age occupation levels that confirm the evidence provided by the artefacts such as pottery and worked flint (Appendix G). This includes a date of 2969±35 BP (NZA-28804, 1310–1050 cal BC) from charcoal from the burnt mound feature (context 5103).

Micromorphology and Sediment Chemistry

by Richard I Macphail and John Crowther

Two kubiena samples and two bulk samples from the Middle Bronze Age soil and colluvium immediately underlying it were submitted for soil micromorphological, chemical and magnetic susceptibility analysis. These studies were carried out to provide geoarchaeological information on site formation processes related to the soil and landscape prior to this occupation deposit, the character of the burnt mound itself and post-depositional processes affecting the site as a whole. The detailed report is included in Appendix T.

In summary, the results of the bulk analysis revealed context 5102 to be largely minerogenic and showed no evidence of magnetic susceptibility enhancement. It had a moderate phosphate content, with a high proportion of the phosphate in an inorganic form. The phosphate concentration recorded may simply be attributable to natural enrichment in the topsoil on the slope from which the colluvium was initially derived, but could also reflect the inclusion through bioturbation and/or leaching of some anthropogenic-related material from the overlying midden spread. Thin section analysis of context 5102 showed it to be a biologically worked moderately humic topsoil formed in a weakly calcareous fine sandy silt loam colluvium. Both faunal homogenization and rooting were recorded. This colluvium is probably of arable origin as it is generally well sorted and includes much fine charcoal and organic fragments, the last possibly a relict of manuring (*cf* Iron Age colluvium at White Horse Stone, Kent; Crowther and Macphail 2006; see Macphail 1992). A fragment of bone that is poorly autofluorescent under blue light may be another weathered inclusion.

The presence of slightly weathered earthworm granules and slug plate fragments also testifies to their exposure and transport, in comparison with 'fresh' earthworm granules present in context 5103 above.

Just below context 5103, a slightly compacted and slightly more humic topsoil was present. Also, included in context 5102, were coarse mollusc shell, burned land snail shell and a 2mm-size iron-stained coprolitic bone fragment, which although associated with burrows appear to slightly pre-date the burnt mound spread. These may be associated with preliminary activity at the site or a bioworked part of an earlier spread. Low intensity burning (camp fires) of Neolithic date at Windmill Hill, Wiltshire on humic calcareous topsoils produced similar burned land snail shell (Macphail 1999b).

Colluvium in and over the burnt mound deposits also contained burned land snail shell, perhaps reflecting (along with the fine charcoal) the use of fire in Middle Bronze Age arable management. The coprolitic bone fragment could possibly result from the working of the burnt mound by scavengers (Goldberg and Byrd 1999; Goldberg and Guy 1996; Goldberg and Macphail 2006a; in prep), but no burnt bone was found actually in the mound deposit, *sensu stricto*, only one small (1mm) leached bone fragment. The shell and coprolitic bone may therefore also be regarded as possible inclusions resulting from manuring (Bell 1981; Goldberg and Macphail 2006b, 207–9; Crowther and Macphail 2006). Lastly, the occurrence in burrows of dusty clay coatings that contain fine charcoal, is indicative of continuing waterlain colluvial wash across the site (Farres *et al* 1992), as recorded for example as context '5103 upper' (see below), while weathering of the calcareous content of the burnt mound (see below) has resulted in small amounts of secondary micrite formation in context 5102, for example as hypocoatings.

Bulk analysis of context 5103 demonstrated a much higher organic matter content than the underlying colluvium, which could be attributable to the dumping of organic-rich waste materials. It also showed stronger signs of magnetic susceptibility enhancement and phosphate enrichment. While these results are clearly indicative of anthropogenic activity, as might be associated with a midden-type deposit (eg, phosphate enrichment through accumulation of domestic wastes and susceptibility enhancement through hearth-related deposits), it should be noted that neither the phosphate-P nor χ_{conv} were especially high – ie, the material seems unlikely to be purely midden material. One possibility is that the spread of midden deposit has become mixed with the surrounding soil/colluvial matrix, thereby 'diluting' the strength of its anthropogenic signal.

Thin section analysis indicated context 5103 occurred as a single layer over the buried colluvial soil in sample 8375. Sample 8374, however, records the burnt mound occurring in two concentrations separated, and buried by, dominantly colluvial deposits ('5103 upper') that include rounded flint, chalk and earthworm granules. Abundant broad burrowing by earthworms had mixed burned material into colluvium, and colluvium into burnt mound layers. Rooting through the burnt mound and buried soil was visible as rare traces of calcitic root pseudomorphs, some cell pseudomorphs being fragmented by burrowing mesofauna.

The burnt mound material itself was strongly heterogeneous burrow-mixed concentrations of coarse burned flint (mainly whitened with some others rubefied), wood charcoal, with a few ash residues in places. Other inclusions were rare traces of burned soil, pottery, and an example of leached bone. Ash was present as scattered remains and as rare aggregates, but best preserved as ash residues adhering to burned and fire-cracked flint. This type of ash preservation is typical of biologically worked combustion zones in open air sites (Goldberg and Byrd 1999; Goldberg and Macphail 2006a; in prep). The presence of aggregated ash testifies to *in situ* weathering of the burnt mound prior to its fragmentation and spread. Open channels containing very thin organo-mineral and rare traces of organic excrements indicate biological activity by fauna other than earthworms.

Context '5103 upper' is a rather pure, weakly calcareous fine sandy silt loam that was more compact than the burnt mound layer below, and although there has been burrowing, dusty clay burrow fills and intercalatory textural pedofeatures are indicative of unstable soil surfaces probably related to colluviation.

Clearly overall this is a charcoal and fire-cracked flint-rich burnt mound that includes calcitic ash residues mixed with arable (?) colluvium related to continuing colluvial activity. The possibility that some of the spread of the burnt mound material is interbedded with colluvial soil, that is still apparent despite biomixing, may suggest that agricultural activity (colluviation) had been a continuous phenomenon at this site, and that the burnt mound and associated

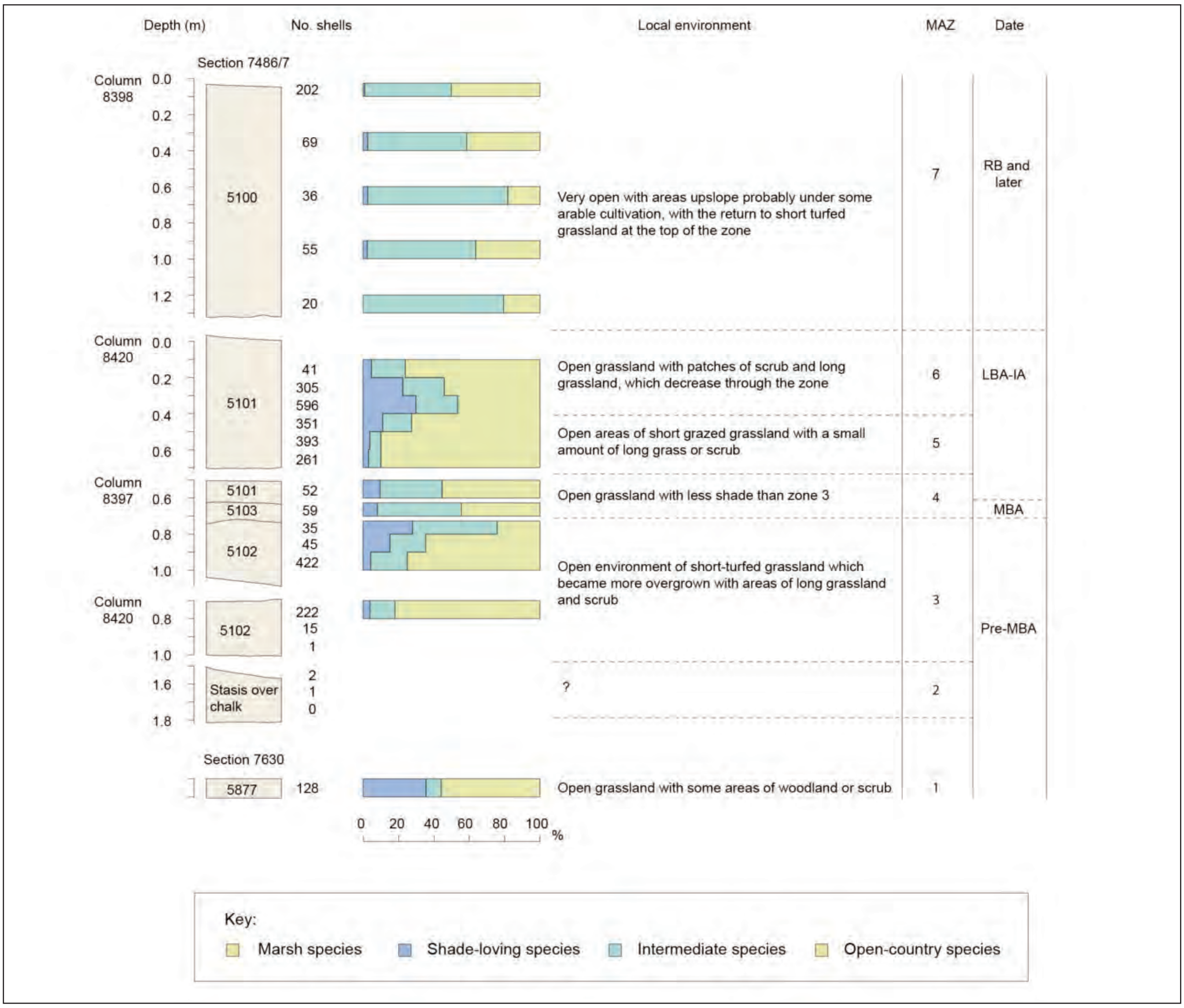


Figure 15.10 Summary of molluscan data, spring area (ARC SPH00)

anthropogenic materials were formed by several occupation episodes.

Overall, the burnt mound and likely associated deposition of occupation materials was probably not a single event, and the spreads more likely record a series of middening occurrences contemporary with and occurring alongside continuing arable activity and the deposition of colluvium.

Molluscs

by Sarah F Wyles

A series of 22 samples from the three mollusc columns from the spring-side sequence (Section 7486/7) and a single sample from beneath the Middle Bronze Age barrow ditch (Section 7630) were analysed. The detailed report on the molluscs is included in Appendix M. The changes in the snail assemblages were such that seven molluscan assemblage zones (MAZs) could be differentiated (Fig 15.10) spanning pre-Middle Bronze Age to post-Roman colluvial deposits, as well as the Middle Bronze Age soil (context 5103). Overall the assemblages examined were dominated by open country species suggesting a largely cleared landscape, mainly short grassland, but with with local variation. Prior to the Middle Bronze Age, the area appears to have been open, short grassland with some open woodland or scrub and long grass; by the Middle Bronze Age this seems to be an area of open grassland. During the Late Bronze Age/Early Iron Age period the snails indicate open, short grazed grassland with some areas of scrub and long grass. There is a variety of environments and land-uses indicated by the assemblages during the Roman period. There were areas of short-turfed grassland, long unkempt grassland, some open woodland and scrub, together with areas of marsh, and also some areas under cultivation.

Chapter 16

Landscape, Environment and Dating Framework

by Francis Wenban-Smith, Martin Bates, Elizabeth Stafford and Simon A Parfitt

Introduction

The key to understanding the origin and landscape development of the Ebbsfleet Valley, and its particularly rich preservation of Palaeolithic remains, lies in its Middle Pleistocene geological history. Although this itself has, of course, deeper structural roots, a useful starting point for understanding the deposits that form the focus of this volume is MIS 11 (Fig 2.1). At the start of MIS 11, the Thames (as represented in the phase 1 deposits of Lower Gravel and Lower Loam at Barnfield Pit, Swanscombe – Bridgland 1994) was flowing eastward past the northern end of the palaeo-Ebbsfleet, with a base level of *c* 20m OD, and with the probable point of confluence with the Ebbsfleet near the location of the British Museum's Site A excavation. At this time (Fig 16.1a), the Ebbsfleet (as represented in the clay-laminated sands of Phase 5 at the Southfleet Road elephant site – Wenban-Smith 2013) was flowing northward towards the Thames, to the west of the north-south chalk spur that was later quarried as Southfleet Pit (Fig 16.3).

At some point early in MIS 11, the reason for which is uncertain, there seems to have been a major (and perhaps locally catastrophic) re-arrangement of the landscape in the Swanscombe area. Giant masses of clay-rich reworked Tertiary sediments (Phase 7 of the Southfleet Road elephant site – Wenban-Smith 2013), originally from high ground to the west, slipped down eastward into the Ebbsfleet Valley, plugging the channel ("Ebbsfleet 1" in Fig 16.1a) that was passing to the west of the Southfleet Pit spur (Fig 16.1b). This was followed by another phase of Thames deposition (represented by phase II deposits – the Lower Middle Gravel and Upper Middle Gravel). A widespread gravel terrace formed in the Swanscombe area, with a base level of *c* 26.5m OD, and a southern loop extending significantly further south than currently mapped (British Geological Survey 1998), beyond the dry valley that in the present-day enters the Ebbsfleet from the west from Eastern Quarry (Wenban-Smith 2013, 57–110; Fig 16.1c). The Ebbsfleet then over-rode the slipped clayey plug of its western channel, depositing a fluvial gravel (Phase 8 of the Southfleet Road elephant site – Wenban-Smith 2013), which truncated the slipped clayey mass, heading north-west towards the nearby confluence with the Thames.

These events provide the critical backdrop to the post-MIS 11 development of the Ebbsfleet Valley. After MIS 11, there was significant downcutting of the Thames during MIS 10 to a much lower base-level of *c* 5m OD (as reflected at Purfleet – Bridgland *et al* 2013). The main Thames channel migrated north, leaving the MIS 11 deposits as a terrace. The northward-draining Ebbsfleet must now have passed to the east of the Southfleet Pit Chalk Spur, due to obstruction of the previous western channel by the slipped clayey mass. This new MIS 10 channel ("Ebbsfleet 2" in Fig 16.1d) then must have joined with the Brook Vale, flowing first westward and then curving north, incising through the Swanscombe terrace, before entering the Thames.

Thus was formed a relatively quiet backwater embayment of the Ebbsfleet, with a steep bank to the west and south but, crucially, no major drainage from the south, from where the previous route of the Ebbsfleet was blocked. This sheltered backwater area thus became in effect a sump in the landscape within which deposits seem to have periodically accumulated from MIS 8 onwards, although with only vestigial traces recorded from the period MIS 9–10. There are amino acid results suggesting an MIS 9 date for deposits attributed by Burchell to "Lower Loam" at Site B, in Zone 2 (Chap 6). There is no record of where exactly the source deposit for this material was. The dated opercula may have been reworked, or it is possible that heating of the specimens prior to their recent rediscovery may have compromised their chemistry, leading to a misleadingly old date. Four major post-MIS 11 phases of deposition have been recognised, clustering at different levels down the valley side to the present Ebbsfleet floodplain and its underlying late Devensian gravels. A representative transect down the valley side is shown (Fig 16.2), with the presence of archaeological evidence shown at appropriate horizons.

Phase 1: MIS 8–7

There are numerous deposits in Zones 1 and 2 reliably dated to the MIS 7 interglacial by biostratigraphy and amino acid dating, with supporting indications from their geomorphological situation and OSL dating. In many places, these deposits overlie chalk-rich deposits

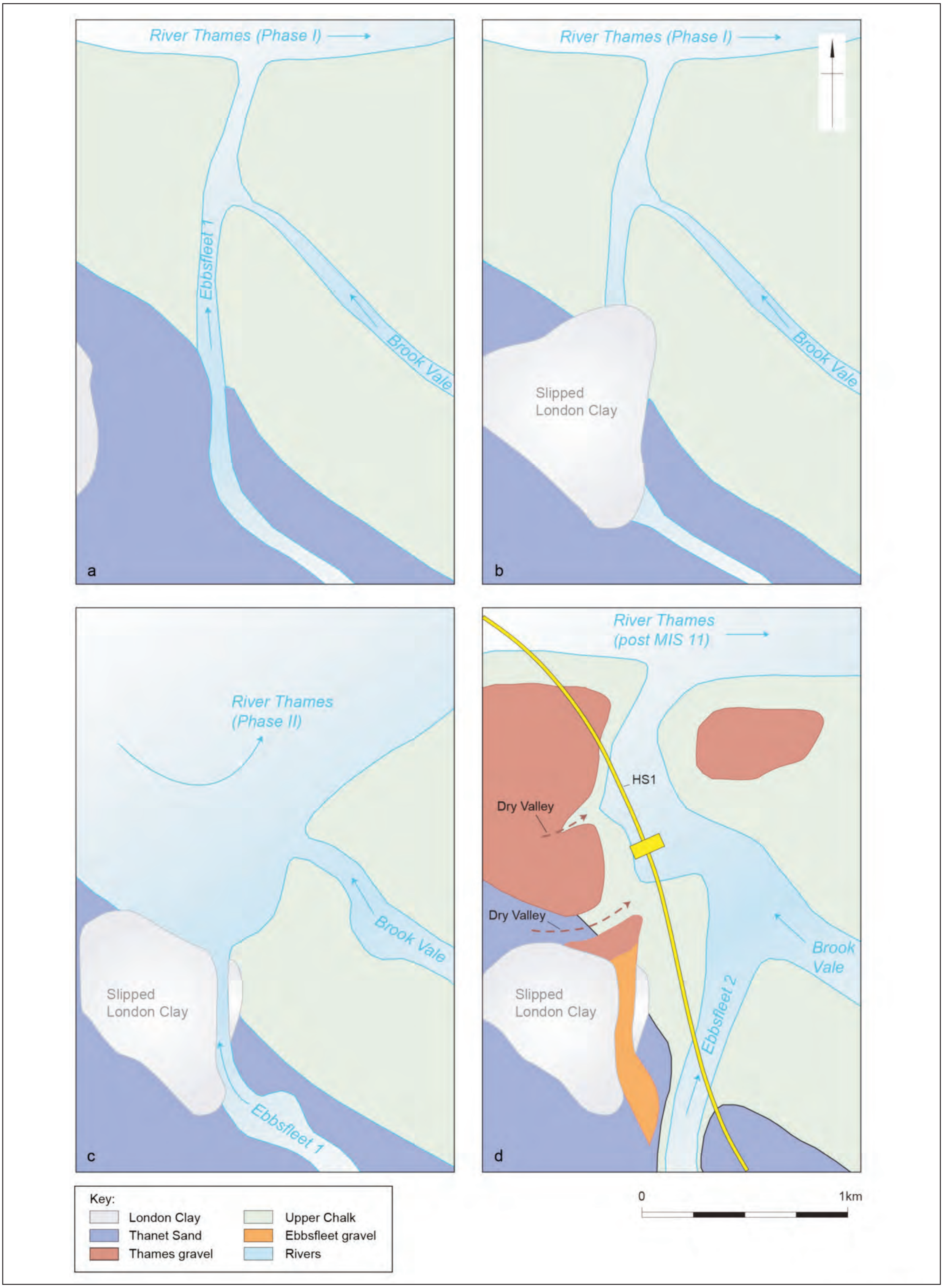


Figure 16.1 MIS 11–10 evolution of the Ebbsfleet Valley: (a) Early MIS 11, equivalent to Phase I of Barnfield Pit sequence; (b) slippage of clay mass; (c) later MIS 11, equivalent to the Lower Middle Gravel of Barnfield Pit sequence; (d) MIS 10, blocking of western Ebbsfleet Channel

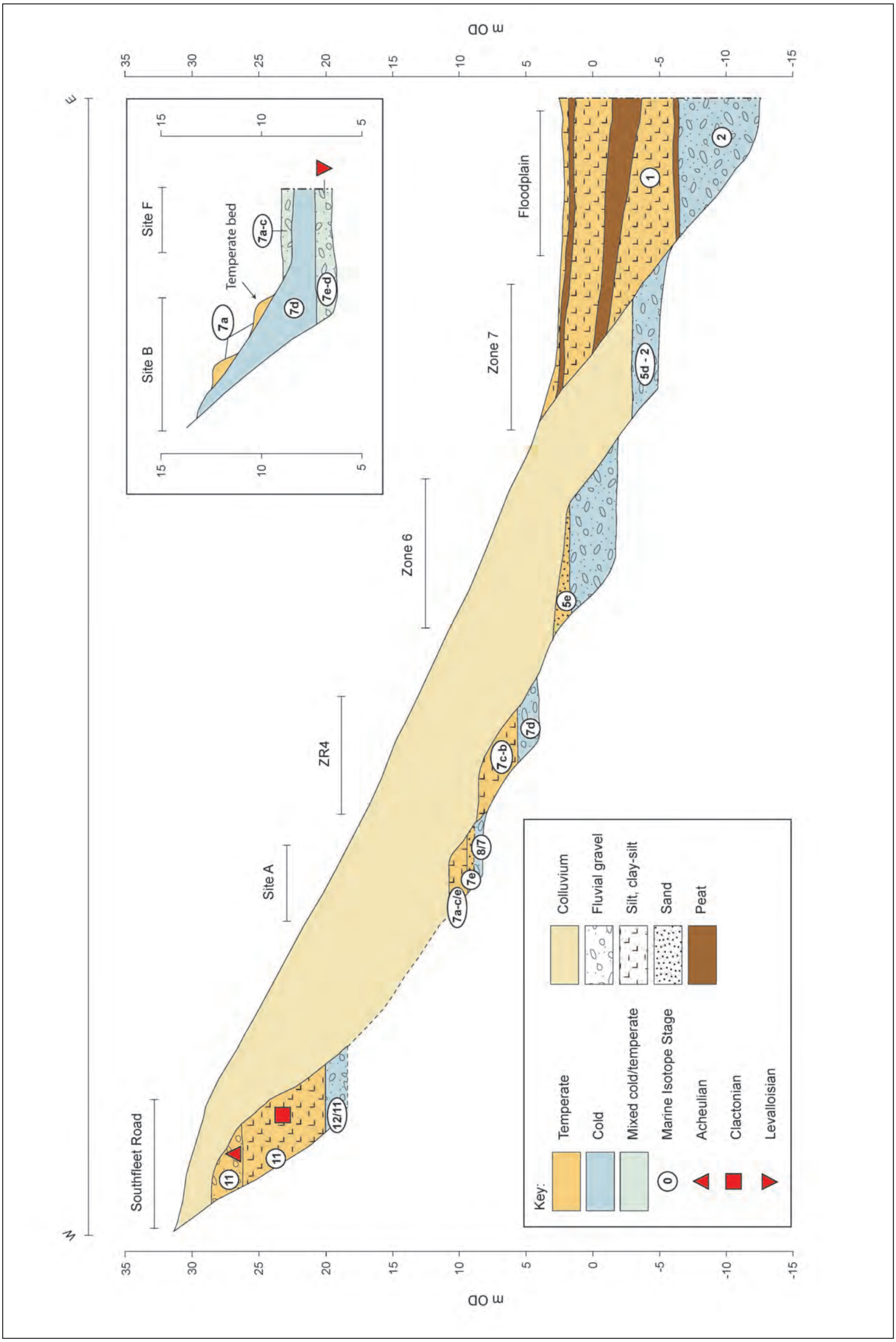


Figure 16.2 Representative transverse cross-section through Ebbsfleet Valley, showing fluvial deposits from MIS 11 through to the present day and reliably established horizons of occupation

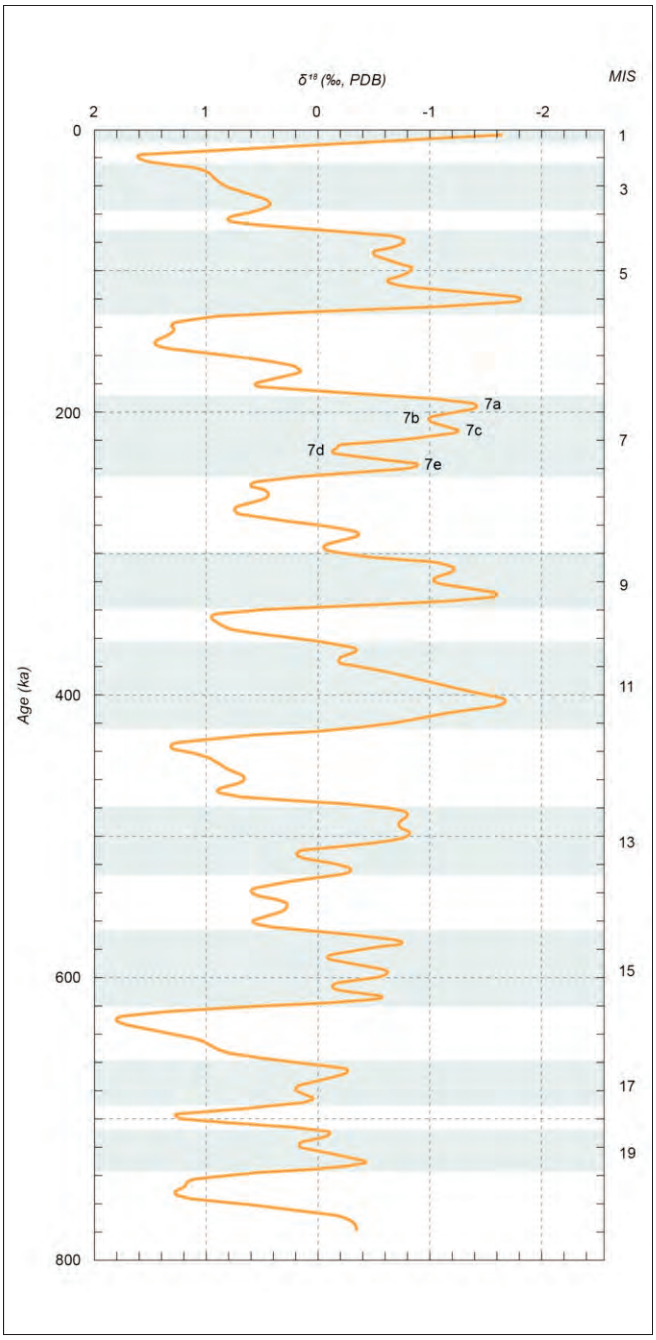


Figure 16.3 Smoothed Specmap MIS stack, with MIS 7 sub-stages marked (Imbrie *et al* 1984)

(Coombe Rock) that are probably cold-climate deposits formed by solifluction. These latter can therefore be ascribed either to MIS 8, or to one of the cold sub-stages 7b or 7d within MIS 7.

In Zone 1, deposits that can be attributed to MIS 7 are present at both Site A and the ZR4 pylon footing trench 3776TP (Chap 5). The sequences at these sites contain evidence of at least two distinct fully temperate peak interglacial episodes: an earlier episode represented by the basal gravel bed 2a at Site A, and a later episode represented by phases 3776-D/E at 3776TP. Both these episodes indicate deciduous woodland development, yet they are clearly differentiated by both faunal biostratigraphy and amino acid dating evidence. The small, but diverse, small mammal assemblage from bed 2a contains species that are entirely absent from the huge assemblage from phases 3776-D/E, making it inconceivable that they represent the same episode. The amino acid dating results from these two horizons form two distinct clusters (Fig 5.8), with the cluster from bed 2a clearly older.

In Zone 2 (Chap 6), there likewise seem to be two distinct fully temperate MIS 7 episodes represented at Site B. There is an older episode, associated with the Lowermost Loam towards the base of the sequence; and there is a younger episode, represented by the Temperate Bed at the top of the sequence. These episodes are divided by a thick sediment sequence that includes Burchell's Levalloisian "floors" at its base (in stratified gravel beds under the Middle Loam) and a stratigraphic hiatus at the top of the Middle Loam, under the Temperate Bed (Chap 6, Site B).

The Lowermost Loam produced a fully-temperate small mammal fauna including bank vole *Clethrionomys* (Chap 6, *Vertebrates*). Amino acid dating of *Bithynia* opercula from Burchell's "Lowermost Brickearth" (synonymous with Lowermost Loam) produced results indicating a date early within MIS 7 similar to the date of Bed 2a at Site A (Chap 6, *Dating*; Fig 6.8). Further up the sequence, although the specimens are currently missing, there are reports of the microtine fauna associated with Burchell's Levallois "floors" in the gravel directly above the Lowermost Loam. Burchell (1935a) and Carreck (1972, 35, quoting Hinton) list a range of voles (*M. anglicus, M. arvalis* and *M. nivalis*) that suggest an assemblage dominated by what we would today recognise as the distinctive large form of

the northern vole *M. oeconomus* that is characteristic of MIS 7 and 6 (Parfitt *et al*, Appendix C1).

At the top of the sequence, the Temperate Bed contains a rich fully interglacial mollusc fauna in its lower parts with several woodland indicators, although the upper parts of the Temperate Bed are associated with more open grassland conditions. The Temperate Bed is marked by a remarkably restricted rodent fauna, with nothing but abundant *Microtus oeconomus* known from the upper part of the sequence, and only *Microtus oeconomus* and rare *Neomys* (water shrew) in its lower parts. It is attributable to MIS 7 on the basis of both amino acid dating (Fig 6.8) and also from the distinctive form of *Microtus oeconomus* that is abundantly present (Fig 6.5). Two OSL dates of *c* 188 KBP and *c* 196 KBP (Table 6.14) from its upper part likewise suggest a date towards the end of MIS 7. The Temperate Bed is thought to be the upper part of the same aggradation that has at its base the gravel (Bed C) that occurs within Carreck's Channel D sequence at the southern end of Site F, at location F.3a (Chap 6, *Zone 2 Synthesis*).

In Zone 5, there is also a late-MIS 7 date of *c* 200 KBP, based on OSL dating (Table 9.2) but not corroborated in any other way, from a sand/silt lens within the bottom part of phase WSD-B at test pit 4019TT at Site D (Chap 9). If this sand/silt lens is accepted as broadly contemporary with the overlying

Upper Coombe Rock, as seems likely given the presence of similar lenses throughout this deposit, this provides a *terminus ante quem* for the Levalloisian material of the APCM lithic collection, found in Coombe Rock of similar, or earlier, age in Southfleet Pit, *c* 50m to the south of the dated location. This cold-climate deposit, situated between 8m and 10m OD on the flank of a dry valley, is unlikely to be contemporary with any of the fluvial interglacial deposits at Site A, 3776TP or Site B. It may represent a cold episode within MIS 7, such as MIS 7d or 7b; or it could have been laid down earlier in MIS 8.

The important questions, both for integrating the deposits in different parts of the Ebbsfleet Valley with each other and for placing the archaeological evidence of Palaeolithic occupation within an integrated framework, are: can these more-reliably dated horizons be related to each other and can they be correlated with the MIS framework at a sub-stage level? The Lowermost Loam immediately underlies the horizons at which Burchell recovered mint condition, refitting lithic material from Levalloisian "floors" (see Chap 18), so dating this horizon is crucial for putting this horizon of confirmed Levalloisian occupation in its chrono-stratigraphic context.

MIS 7, the penultimate interglacial, is increasingly becoming a focus for research, part of a general trend of increasing recognition of the complexity of the terrestrial counterpart of the marine isotopic record (eg, Candy and Schreve 2007; Roucoux *et al* 2008; Kleinmann *et al* 2011). The standard smoothed model of the isotopic curve for MIS 7 (Fig 16.3) shows a distinctive pattern of a sharp initial peak (MIS 7e) followed by a major cold stadial (MIS 7d). This in turn is followed by a double warm-peak (MIS 7c and 7a) interrupted by a relatively minor cool stadial (MIS 7b).

It remains unclear how the British MIS 7 terrestrial and faunal assemblage archive reflect the sub-stage climatic oscillations known to have occurred from the continuous marine and ice-core isotopic records. Candy and Schreve (2007) have suggested that more-open grassland faunas without woodland development (eg, Sandy Lane MAZ at Aveley, Essex, and the lower channel assemblage at Marsworth, Buckinghamshire) can be related to sub-stage MIS 7a. However, the evidence presented here from two different later-MIS 7 deposits – the Temperate Bed at Site B, and phases 3776-D/E at the ZR4 pylon – suggests that, at both these locations, an early peak interglacial woodland episode was followed by more-open grassland. As explained in more detail below, one of these sequences must represent MIS 7a.

Furthermore, it has also now been separately shown that the last warm sub-stage MIS 7a does in fact show development of deciduous woodland and associated fauna, contra the suggestion of Candy and Schreve (*ibid.*). As demonstrated by Kleinmann *et al* (2011) in north-west Germany and Roucoux *et al* (2008) in northern Greece, there is a woodland phase in the interglacial peak (MIS 7e) at the start of MIS 7, followed by a prolonged phase of grassland during MIS 7d. Then the later parts of MIS 7 are dominated by a prolonged spell of woodland development (during both MIS 7c and 7a) with only a relatively minor interruption and reversion to grassland for MIS 7b. This pattern also better matches most models of the MIS curve for this period (Fig 16.3), which show sub-stage MIS 7a reaching a warmer peak than the others, as well as following a relatively minor stadial interlude for MIS 7b – making it highly unlikely that this final sub-stage would be uniquely characterised by an open grassland fauna. Here, it is proposed that all the warm sub-stages MIS 7e, 7c and 7a would have been accompanied by deciduous woodland in southern Britain, with each followed by a grassland phase, and that all three warm sub-stages are represented in the Ebbsfleet Valley. The severity of the stadial of MIS 7d would certainly have had a major impact upon depositional regimes and environments, and would have led to a substantial period of cold, dry and open grassland conditions, as well as probably fostering a substantial faunal turnover between the woodland episodes of MIS 7e and 7c. Sub-stage MIS 7b, in contrast, was a relatively minor stadial and may well be represented in the terrestrial archive by cool temperate grassland conditions, prior to a revival of woodland conditions in MIS 7a, which may well therefore have a similar vertebrate fauna to MIS 7c/7b without major turnover by new colonisation from continental refugia.

Proposed correlations between the sub-stages of the continuous marine/ice-core record for MIS 7 and the deposits investigated at different locations in the Ebbsfleet Valley are presented here (Table 16.1) and discussed in more detail below.

Table 16.1 Possible framework for sub-stage correlation of Ebbsfleet Valley MIS 7 deposits at different localities; Option 1 is preferred

	Option 2			Option 1		
Sub-stage	**Site A**	**3776TP**	**Site B**	**Site A**	**3776TP**	**Site B**
7a-late	Bed 3??	3776-F/G	–	Bed 3??	–	Calcareous Loam? Temp. Bed (upper)?
7a-peak	–	3776-D/E	–	–	–	Temp. Bed (lower)
7b	Bed 3?	–	Calcareous Loam? Temp. Bed (upper)??	Bed 3?	3776-F/G??	–
7c-late	Bed 3?	–	Temp. Bed (upper)?	Bed 3?	3776-F/G?	–
7c-peak	–	–	Temp. Bed (lower)	–	3776-D/E	–
7d	–	–	Middle Loam	–	–	Middle Loam
7e-d	–	–	Lower Gravel – "Levallois floors"	–	–	Lower Gravel – "Levallois floors"
7e-late	Bed 3??	–	Lowermost Loam?	Bed 3??	–	Lowermost Loam?
7e-peak	Bed 2a	–	Lowermost Loam	Bed 2a	–	Lowermost Loam

There are three main sets of deposits (below) associated with peak interglacial woodland episodes and attributed to MIS 7:

– Site A, phase BMA-B (bed 2a)
– 3776TP, phases 3776-D/E
– Site B, phase BMB-E (Temperate Bed, lower part)

At these locations, the peak woodland episodes are overlain by deposits with faunal assemblages reflecting more open conditions. At Site A, there may be a hiatus between the lower woodland phase (bed 2a) and the upper more-open phase (bed 3), but the other sequences appear more-continuous, particularly within the Temperate Bed where there is no stratigraphic junction between its upper and lower its parts.

The peak woodland interglacial episodes at Site A and 3776TP cannot be the same, as the small vertebrate assemblages are so different, with the absence of both *Clethrionomys* and *Crocidura* from the rich 3776-D/E assemblage. Furthermore, Site A occupies a higher position in the terrace staircase within the Ebbsfleet Valley (see Fig 16.2), and has a well-differentiated cluster of amino acid dating results indicating a date early within MIS 7 (Fig 5.8). This evidence therefore indicates that bed 2a at Site A represents a different, and earlier, sub-stage within MIS 7 than phases 3776-D/E at 3776TP.

It is then necessary to consider how the Temperate Bed might relate to these two sets of deposit, in conjunction with the separate piece of information that it is underlain by the Lowermost Loam, which also represents a warm episode of MIS 7. The amino acid results from the Temperate Bed (Fig 6.8) strongly suggest a date in the later part of MIS 7, and are clearly differentiated from the results from bed 2a (Fig 5.8) that suggest a date for this latter horizon early in MIS 7. This conclusion is supported by the lack of small mammal diversity in the Temperate Bed, likewise suggesting that it represents a different, and younger sub-stage than Bed 2a at Site A.

The hardest problem to resolve is the relationship of the Temperate Bed woodland episode to the peak interglacial episode of phase 3776-D/E, disregarding for the moment the existence of the underlying Lowermost Loam temperate episode, which is less robustly established. The amino acid dating results for both horizons are broadly similar (compare Figures 5.8 and 6.8), and suggest a date late in MIS 7. The Temperate Bed is marked by a remarkably restricted rodent fauna, with nothing but *Microtus oeconomus* known from the upper part of the sequence, and only *Microtus oeconomus* and *Neomys* (water shrew) in lower parts. At 3776TP, the small mammal fauna is reasonably diverse in the peak interglacial levels (although lacking *Crocidura* and *Clethrionomys*), but becomes less diverse upwards with only *Microtus oeconomus* and *Arvicola cantianus* in phases 3776-E through 3776-G; the former becomes increasingly predominant upward through the sequence (albeit with very low counts in the uppermost horizons).

Unfortunately, one critical piece of information is missing. We do not know how Kerney's mollusc sequence through the Temperate Bed (which includes the peak interglacial woodland phase at its base) relates to Wenban-Smith's sampled sequence. Therefore, we cannot reliably establish the small vertebrate assemblage associated with the peak interglacial woodland phase of the Temperate Bed sequence. If, as is likely given the very limited extent of survival of the Temperate Bed, broadly the same sequence was investigated, then the lack of small mammal diversity in the Temperate Bed would rule out correlation with the peak woodland phase of 3776-D/E. It remains possible that the surviving Temperate Bed deposits sampled by Wenban-Smith and rich in *M. oeconomus* are higher within the overall Temperate Bed sequence than the warm peak identified by mollusc analysis, and could perhaps be considered as equivalent to the higher parts of the 3776 sequence, such as 3776-F/G. However, and most importantly, the assemblage of *Microtus oeconomus* from the Temperate Bed shows sufficient distinctive features to indicate that it represents a different population, and therefore a different MIS 7 sub-stage, than that from the fully temperate woodland episode in phases 3776-D/E (see cluster analysis, Parfitt *et al,* Appendix C1, Fig C6).

In summary therefore, we know from a combination of amino acid dating and biostratigraphy that bed 2a at Site A is different from, and earlier than, both the Temperate Bed at Site B and phases 3776-D/E at the ZR4 pylon. We also know on biostratigraphic grounds that the Temperate Bed and phases 3776-D/E represent different fully temperate episodes. Reinforced by the knowledge that the Temperate Bed is at the top of a sequence that has the separate temperate episode of the Lowermost Loam at its base, it then becomes certain that bed 2a at Site A must represent the earliest sub-stage MIS 7e.

It then still remains to consider (a) whether the Temperate Bed is younger than 3776-D/E, or vice-versa and (b) whether the Lowermost Loam relates to MIS 7e or MIS 7c. There are strong grounds for correlating the Lowermost Loam with MIS 7e. Firstly, the amino acid dating results are very similar to those from bed 2a at Site A (compare Figures 5.8 and 6.8), suggesting these deposits may be the same age. Secondly, the Lowermost Loam small mammal fauna included the bank vole *Clethrionomys*. This means that it must represent a different warm sub-stage than that represented in phases 3776-D/E at the ZR4 pylon site where this species is absent in the very rich assemblage. Therefore, whatever the relative order of the Temperate Bed and phase 3776-D/E woodland episodes, the Lowermost Loam must be older than them both, and must therefore be correlated with MIS 7e.

The overlying Middle Loam is formed of a substantial thickness of colluvial slopewash sediments, perhaps with some aeolian input. It has a very restricted mollusc fauna throughout, dominated by *Pupilla muscorum* and indicative of a prolonged period of cool, dry conditions. This phase of the sequence must represent one of the two cold sub-stages of MIS 7. The earlier and colder sub-stage MIS 7d seems most likely, in light of its greater intensity and length. This would suggest that the Levalloisian floors found by Burchell between the Lowermost and Middle loams date to the 7e–7d transition or early in MIS 7d, and that the major build-up of the Middle Loam also relates to MIS 7d. The weathering horizon and soil development at the top of the Middle Loam reflects a depositional hiatus that could therefore perhaps be associated with the other cool stage MIS 7b.

It is hard to strongly justify one or other option for the relative order of the Temperate Bed and the 3776-D/E woodland episodes; on balance, we prefer to place the 3776-D/E episode in MIS 7c and the Temperate Bed episode in MIS 7a (Option 1 in Table 16.1). There is a faint hint from amino acid data (compare Figures 5.8 and 6.8) that the 3776-D/E episode may be older than the Temperate Bed. There are also OSL dates from the Temperate Bed of *c* 190 KBP, at the end of MIS 7 (Chap 6, Site B, Table 6.14). However, the strongest line of evidence is the very restricted small vertebrate fauna from the Temperate Bed. This limited fauna dominated by *Microtus oeconomus* would probably follow on more naturally from MIS 7b than 7d, due to the climatic deterioration and sea-level drop in MIS 7b being insufficient to lead to local faunal extinction and colonisation by a new range of fauna. Therefore, our preferred model for these younger MIS 7 woodland episodes (Table 16.1 – Option 1) is that the Temperate Bed relates to MIS 7a, that 3776-D/E relates to MIS 7c, and that 3776-F/G relates to the tail end of MIS 7c and perhaps also MIS 7b. However, it is also feasible (Table 16.1 – Option 2) that the Temperate Bed sequence relates to 7c, or a combination of 7c and 7b, and that the 3776 sequence relates to 7a. Bed 3 at Site A, could fit almost anywhere into this framework; the only secure fact on its position is that it is younger than bed 2a, from which it is divided by a thick sequence including at least one major stratigraphic hiatus. Therefore, it probably represents MIS 7c or 7a, rather than a later part of MIS 7e. The former is probably most likely (following the aggradational model of Figure 5.21b); if it were the latter there would have to be an additional phase of aggradation representing earlier parts of 7a in the area of Zone 1 between Site A and the ZR4 pylon, and there is no evidence of this.

Phase 2: MIS 6–5e

Deposits attributable to MIS 6 fall into two groups. Firstly, there are massive bodies of predominantly fine-grained sand/silt deposits that unconformably overlie MIS 7 deposits in Zone 1, dipping down north-eastward towards the floodplain of the Ebbsfleet Valley. Secondly, there are coarser, gravel-dominated deposits that underlie MIS 5e deposits, and which are mostly present in Zones 3, 6 and 7. In Zone 1 the MIS 7 deposits at Site A, 3776TP, 3777TP and the Area 8 batter (*cf* Chap 5) are overlain by slopewash sediments, interpreted as having formed under post-MIS 7 cold conditions. At Site A, OSL dating results from bed 5a, capping the interglacial sequence, gave results in the range *c* 120–150 KBP. At 3777TP, the cold ostracod fauna from the top of phase 3777-B is taken to indicate post-MIS 7 deposition (Chap 5, *3777TP Overview*). Most of the molluscan and small vertebrate remains for this horizon are interpreted as reworked; however, amino acid dating was nonetheless carried out on *Pupilla* from context 601, from sediments of phase 3777-B that sedimentologically appeared be of colluvial origin, with fine sand/silt/gravel laminations dipping downwards. The exclusivity of *Pupilla* in this horizon suggested they were more likely to be associated with deposition of the sediment, rather than derived earlier deposits; the results indicated a date in the period MIS 7–5 (Fig 5.18). These sediments dipped towards the exposure at the Area 8 batter, a short distance (*c* 50m) downslope to the north-east (*cf* Chap 5, *Area 8 batter*). At this location, molluscan and ostracod remains indicating cold conditions were present towards the base of what appeared to be a major build-up of slopewash sediment (phase A8-E). Amino acid dating of *Pupilla* from this horizon gave results very similar to those from context 601 at 3777TP (Fig 5.18), suggesting a similar age, probably *c* MIS 6.

In Zones 3, 6 and 7, the basal gravel deposits of the sequence in, respectively, Borehole BH0021SA (phase 21-B), 3972TT (phase 3972-F), and in the Villa Trench (phases VT-A/B) are all either attributed to MIS 6, or underlie deposits dated to MIS 5. These gravel bodies have base levels of, where known, between *c* -1m and -2m OD. They are overlain by fine-grained clay-silt/sand sediments, between *c* -2m and +1m OD, which contain molluscan evidence of warm, temperate conditions in Borehole BH0021SA and 3789TP (Chap 7, *Zone 3 Synthesis*). Further up the sequences where these deposits are present between *c* +1m and +3m OD – especially at: both ends at 3972TT (phase 3973-C and 3972-J); the upper part of Borehole BH210021SA (phase 21-E); and 3970TP (context 3970003) – there seem to be alternating phases of slopewash deposition (some, at least, associated with cool climate based on ostracod and molluscan fauna) with temperate alluvial deposition. Dating evidence from these deposits indicates an attribution to MIS 5e, and these sequences are interpreted as representing initial fluvial deposition early in MIS 5e, with a change up the sequence towards a combination of alluvial and slopewash deposition on the margins of the floodplain through the MIS 5e aggradation.

Phase 3: MIS 5d–2

The bodies of sediment attributed to MIS 5e are then unconformably capped by a variety of slope-wash deposits comprising silts, sands and thin gravel bands. OSL dating has indicated a range of dates through the Devensian from MIS 5d through to MIS 2, with the

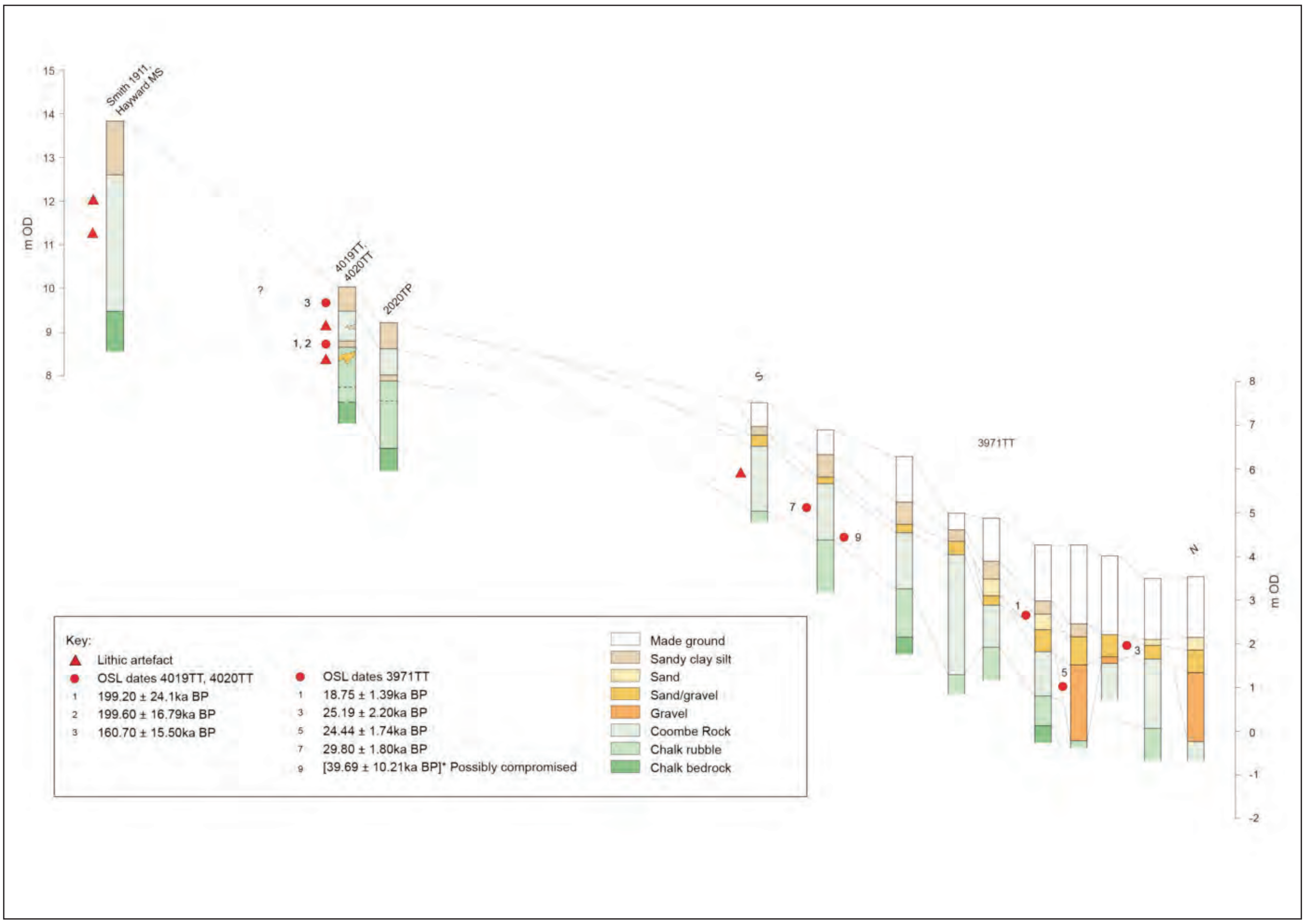


Figure 16.4 Progressive build-up of chalk-rich (Coombe Rock) solifluction deposits down valley-side slope from the APCM Southfleet Pit through the Chalk Spine to 3971TT

MIS 2 sediments mostly representing slope mobilisation during the Last Glacial Maximum. In Zone 6, at 3972TT, gravelly slope-wash/solifluction deposits (phase 3972-K) dated to *c* 40 KBP directly overlie fine-grained laminated sands/silts (phase 3972-I) that are thought to relate to MIS 5e deposition. The slope-wash sands/gravels contain relatively abundant and fresh condition Levalloisian lithic material. This is without doubt reworked from pre-existing deposits probably dating to MIS 7 and equivalent to Burchell's "floors", known to have existed upslope to the south-east of 3972TT, in the Jayflex remediation area.

At 3971TT, a short distance to the east of 3972TT, the sequence is dominated by chalk-rich solifluction deposits (phase 3971-C) that dip down to the north/north-west, down the side of the dry valley that enters the Ebbsfleet from the south-west. At the time of excavation, these were considered to be a direct continuation of the similar chalk-rich (Coombe Rock) deposits of the Chalk Spine (see *Phase 1: MIS 8–7*, above), themselves thought to be a continuation of the original Southfleet Pit deposit that produced the APCM flint collection. However, OSL dating of the 3971TT sequence (Chap 10, *3971TT*) has demonstrated a late Devensian date of *c* 30–40 KBP for the Coombe Rock in 3971TT. Besides demonstrating the age of this deposit, and the continuing formation of chalk-rich solifluction deposits in the later Devensian, this result also exemplifies a wider model for the progressive build-up of slopewash/solifluction sediments in dry chalk landscapes, whereby older material upslope is progressively reworked downslope as the landscape evolves (Fig 16.4).

The later Devensian is also associated with deeper downcutting of the central Ebbsfleet Channel, and its migration north-east towards its current position. Slopewash sediments from the later Devensian are present in the Spur End Group of test pits (3834TT, 3835TT, 3836TT, 3973TT) in Zone 7, where they are associated with distinctly faunal remains indicative of distinctly cold conditions, and where they reach lower levels of *c* -5m OD (Fig 16.5).

Phase 4: The Late Glacial and Holocene

The Lower Ebbsfleet Valley

The surface of the Pleistocene deposits in the Lower Ebbsfleet Valley formed the early Holocene topography that dictated patterns of later sediment accumulation. Reconstruction of this surface using borehole and trench data has revealed a deep Outer Basin (Zone 8), downstream of the Chalk Spur (Zone 7), infilled with

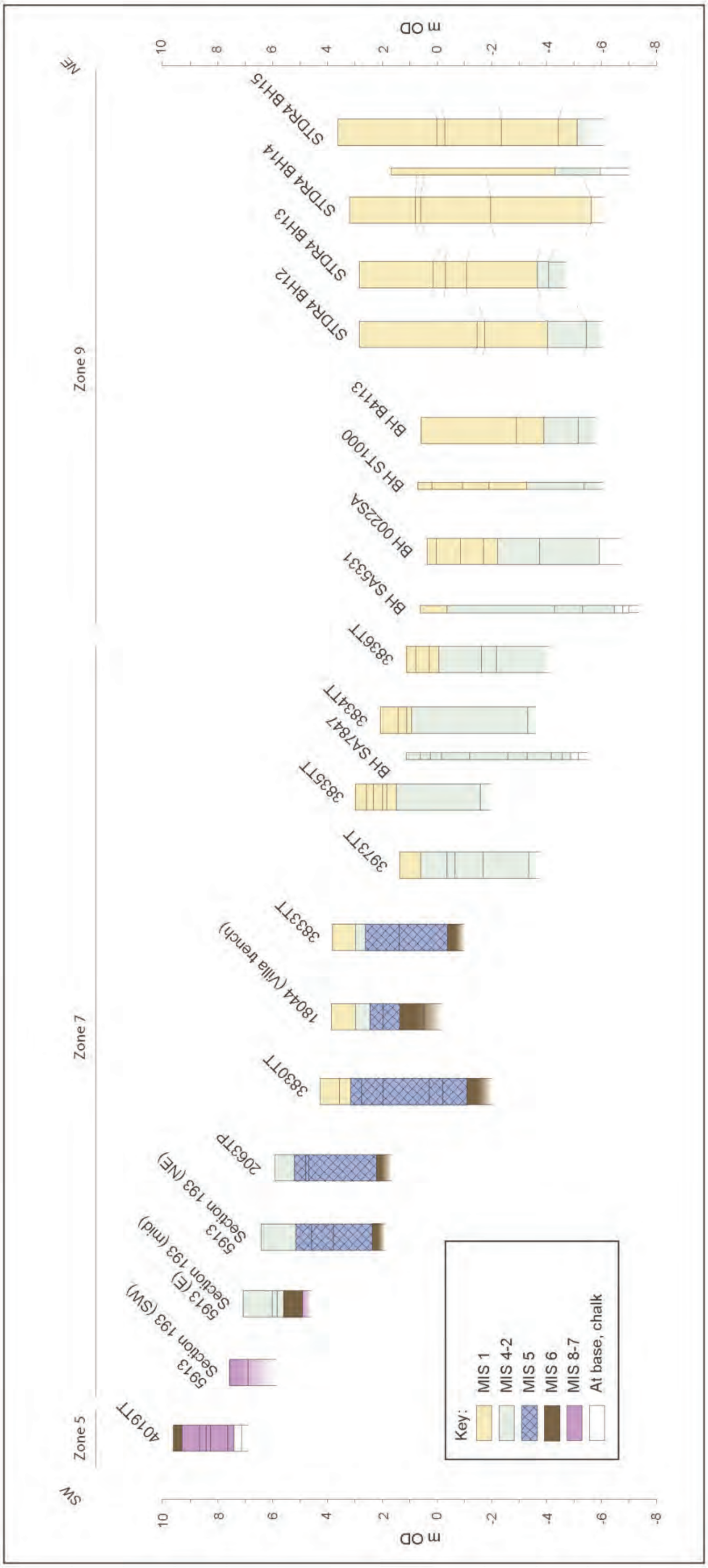


Figure 16.5 Transect from MIS 8–7 deposits of Chalk Spine through Section 193 to MIS 2 deposits of Spur End Trenches and Holocene alluvium

more then 10m of fine-grained Holocene estuarine and freshwater sediments. A shallower Inner Basin (Zone 9) is located upstream of the Chalk Spur, which itself would have formed a promontory extending from the western slopes of the valley. This promontory would have remained an area of higher drier ground throughout much of the Holocene, so much so it was chosen as the site for the Roman Villa (Fig 16.6).

Prior to the investigations associated with HS1 and the STDR4 the only published data on the Holocene floodplain sediments derived from the limited 1930s excavation undertaken by Burchell (Burchell and Piggott 1939), which included analysis of the pollen from a 'peaty alluvium' containing Neolithic artefacts. Therefore, as part of the post excavation work two master palaeoenvironmental sequences have been analysed in detail; Borehole 7 (STDR400) is located in the Outer Basin approximately 160m north of the Chalk Spur (Chap 12) and Trench 9 (STDR400) is located in the Inner Basin 60m to the north-west (Chap 13). Detailed palaeoenvironmental analysis has also been carried out on the sequence from Area 4 (STDR401) further upstream to the south-west (Chap 13).

Development of the prehistoric wetlands

The broad sequence of Holocene sedimentary units identified in the Lower Ebbsfleet Valley is summarised in Table 16.2. The results of the topographic modelling, detailed palaeoenvironmental work and radiocarbon dating have allowed a number of landscape stages to be identified for this part of the valley. Mapping of the position of the dry ground/wet ground interface during the various landscape stages is intended to assist in the contextualisation and interpretation of the archaeological evidence (discussed in Part III) within its topographical and environmental context (Fig 16.6). These projections are based on time/depth estimates for the onset of organic sedimentation onto the topographic template (*sensu* Bates and Stafford 2013). The projections show the gradual expansion of the wetland zone and the loss of dry ground habitats.

Landscape Stage 1a: Late glacial

This stage, during a sea-level low-stand, is generally characterised by cold climate periglacial activity and coarse gravel/sand aggradation in the valley bottom. Within the area of investigation, a deeply incised valley would have existed flanked by the higher ground that was capped by older fluvial sediments and major bodies of slope wash deposits derived from earlier episodes of sand and gravel aggradation. Exposed bedrock surfaces may also have existed on the valley sides. Areas of higher ground bedrock, possibly capped by older fluvial sediments, may also have existed within the floodplain area.

Sedimentation in the valley bottom would have been characterised by fluvially deposited coarse gravels and sands with soliflucted sands, gravels and silts at the margins of the floodplain blanketing the valley sides. These deposits would have consisted of bedrock mixed with older Pleistocene sediments and possibly aeolian inputs.

Table 16.2 Holocene sedimentary units identified in the Lower Ebbsfleet Valley floodplain area

Phase 4: The Late Glacial and Holocene (Lower Ebbsfleet Valley floodplain)		
Stage	**Unit**	**Inferred environment of deposition**
	Made ground	Recent dumping/landfill
4b	Upper peat	Reedswamp
4a	Upper clay-silt	Inter-tidal/estuarine mudflats
3	Reed peat	Reedswamp
	Wood peat	Alder carr wetland
2	Lower clay-silt	Inter-tidal/estuarine mudflats
1b	Organic silts	Freshwater infilled creeks
	Sand	Fluvial channel
1a	Sandy flint gravel	Braided fluvial channel
	Chalky gravel	Cold climate slope (solifluction) deposits
	Chalk	Bedrock

Landscape Stage 1b: The early Holocene freshwater river

During this stage, following climatic amelioration associated with MIS 1, but prior to significant sea-level rise, the area would have been characterised by relict Late Glacial features with a stable channel within the old Late Glacial main channel. The floodplain of the river adjacent to the main channel would have stabilized with the development of Holocene vegetation and probably formed a relatively dry ground area. Higher gravel areas existed as 'islands' of isolated older Thames gravels in the floodplain and on the valley sides. A key ecotonal area probably existed adjacent to the main channel and any floodplain tributaries. Higher ground would have provided additional landscape resources for both humans and animals within different environments (Fig 16.6a).

Deposits relating to this period are represented in places by fluvial sands and a discontinuous unit of organic sandy silt identified in a number of boreholes and deep trench excavations across the valley bottom. These deposits represent freshwater infilled creeks, radiocarbon dated in Borehole 7 (BH7, STDR400) to 9122±55 BP (NZA-28766, 8540–8240 cal BC, see Chap 12; Fig 12.3). Pollen assemblages were dominated by tree and shrub pollen and suggest rather open scrubby deciduous woodland with birch, hazel, and an understorey of grasses and ferns, growing on the banks of the river. More closed deciduous woodland probably grew further away from the site. There was very little evidence of any human impact on the landscape at this time. A few microscopic charcoal particles noted during the pollen analysis may have come from some distance, having been blown or carried into the site by wind or water.

Landscape Stage 2: The early to mid-Holocene marine incursion

During this stage, sea-level rise probably began to influence sedimentation and fluvial dynamics within the valley floor area. As water levels rose channel stability decreased and flooding of low-lying areas began due to backing-up of fluvial water behind the landward migrating estuarine front. The floodplain surface became unstable due to widespread flooding and rapid minerogenic sedimentation ensued. During this period

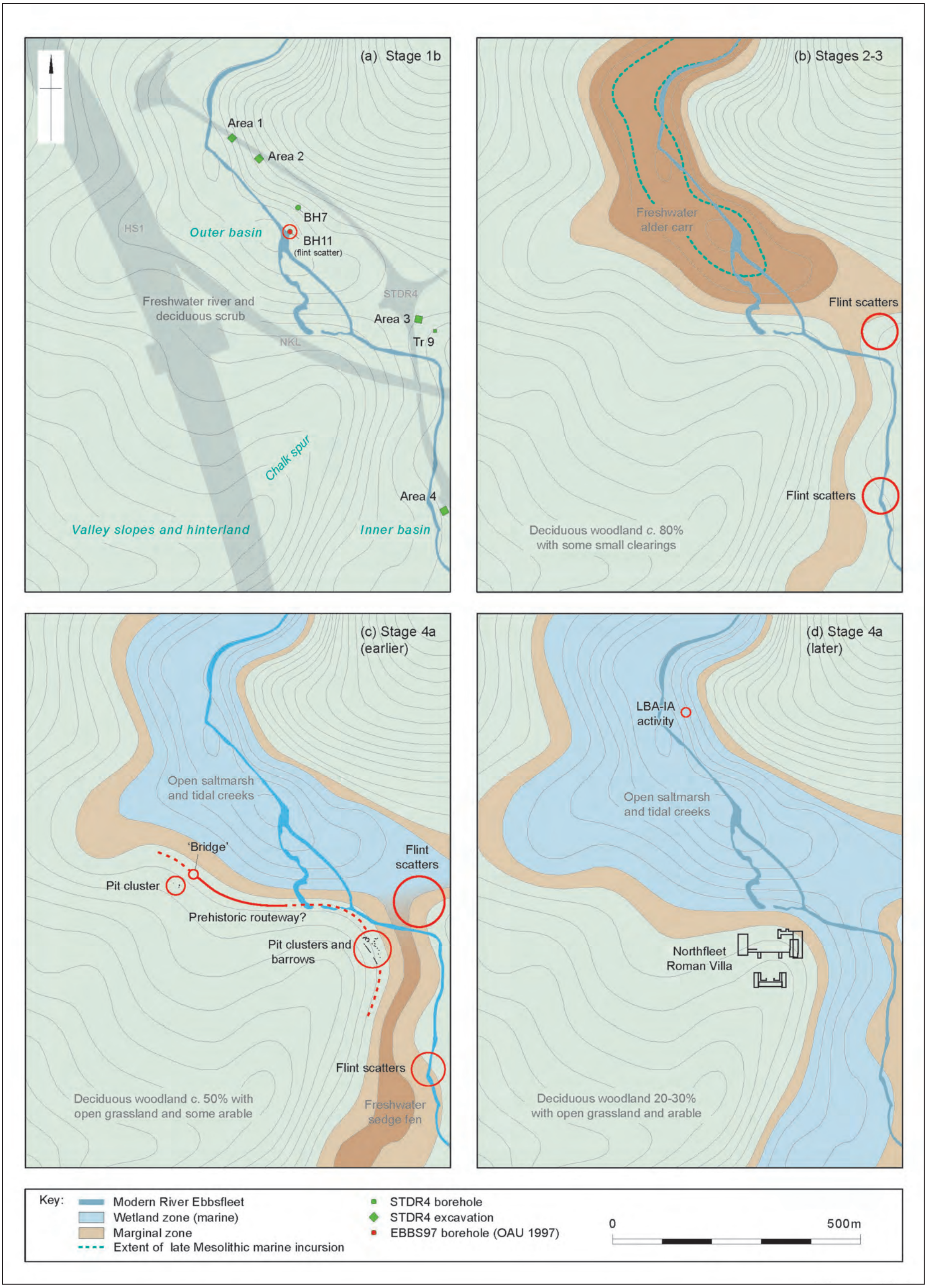


Figure 16.6 Summary of Holocene Landscape Stages in the Lower Ebbsfleet Valley

the ecotonal zone between wet and dry ground migrated inland and rose in datum. Thus, wetland environments began to expand at the expense of dry ground areas. Temporary landsurfaces may have existed within flooded areas but these are likely to have been local, ephemeral and of short duration. Dry ground areas remained as 'islands' within the wetland and at the margin of the wetland zone.

Evidence of an early influx of brackish waters (the 'Lower Clay-Silts') during the Late Mesolithic period was found in a number of sequences examined from the Outer Basin (Zone 8). Deposition in Borehole 7 (BH7, STDR400) occurred between 6340±80 BP (WK-8801, 5480–5070 cal BC) and 5464±35 BP (NZA-28974, 4370–4240 cal BC) (Fig 16.6b; see also Chap 12, Fig 12.3). Pollen and diatom evidence suggests the local development of saltmarsh and reedswamp environments with some alder and willow, and on the higher ground deciduous woodland of oak, lime and hazel. Values of microscopic charcoal particles were quite high, including pieces of charred grass, possibly evidence for local humanly-made fires. In a regional context, this early marine transgression into the Lower Ebbsfleet Valley can be broadly correlated with the first phase of estuary expansion on the Thames floodplain (see Long *et al* 2000) and Devoy's Thames II transgression (Devoy 1979).

Landscape Stage 3: The mid-Holocene peatlands

This stage is characterised by fluctuating water-levels in which alterations between organic and inorganic sedimentation dominated the area. Temporary emergence of surfaces at or above flooding level stimulated the growth of organic sediments and lead to peat growth. Peat growth expanded as channel stability was regained after initial flooding. The ecotonal zone between wetland and dryland continued to move inland and topographic variation was lost. During times of peat accumulation complex boundaries between peat and non-peat wetland ecosystems emerged. Wetland now dominated in the floodplain area as dry ground zones shrank rapidly.

Towards the end of the 5th millennium BC minerogenic sedimentation was replaced by peat formation in the Outer Basin (Zone 8), which commenced in Borehole 7 (BH7, STDR400) at 5464±35 BP (NZA28974, 4370–4240 cal BC, Chap 12, Fig 12.3). Initially the Inner Basin remained comparatively dry, and it is here that significant evidence of human activity in the form of *in situ* Early Neolithic flint scatters were identified during the investigations associated with the STDR4 (Fig 16.6b, see also Chaps 13 and 21). These occupation horizons were however rapidly inundated as the wetland front expanded into more marginal areas at slightly higher elevations. In Trench 9 (STDR400) the base of the peat was dated to 4926±35 BP (NZA-29080, 3780–3640 cal BC, Fig 13.3) and in Area 4 4945±35 BP (NZA-29247, 3800–3650 cal BC, Fig 13.7). Pollen, macroscopic plant remains, diatoms and coleoptera from the peat indicate locally freshwater alder carr environments predominated in the valley bottom during the Neolithic period, along with marsh/fen and an understorey of ferns and sedges. Trees and shrubs continued to dominate the pollen assemblages with oak, lime, elm, ash and hazel values suggesting that the regional vegetation was deciduous woodland during the period of peat formation. There was however, some indication of small clearances, possibly for domestic animals, on areas of drier ground. A temporary decline in values of lime pollen noted in the lower part of the peat sequence from Trench 9, and commensurate with the first appearance of cereal pollen, may be related to human activity within the catchment.

In a number of sequences, particularly within the more marginal Inner Basin, deposits of micritic tufa, containing rich assemblages of ostracods, were noted within the upper part of the peat suggesting the presence locally of freshwater springs. Rich assemblages of freshwater ostracods were preserved in the tufa from Trench 9 (STDR400; Chap 13), including the rare *Cypridopsis lusatica,* only the second record of this species from the British Isles. This period of tufa formation, dated in Borehole 7 (STDR400), Trench 9 (STDR400) and Area 4 (STDR401) (see Chaps 12 and 13), appears to have been a relatively synchronous event across the valley bottom, occurring at some point between the Early Neolithic and Early Bronze Age periods (*c* 3600–2000 cal BC). It is unclear why tufa formation started at this time rather than when peat formation commenced, as it is widespread in valley bottom contexts in many chalk valley systems throughout much of the early Holocene. However, the proximity to brackish water systems (even during periods of freshwater dominance) may have influenced tufa formation.

Within the wider context the main body of peat in the Lower Ebbsfleet Valley generally occurs at a similar stratigraphic position and date to Devoy's Tilbury III peat on the Thames floodplain (Devoy 1979). The dates are also consistent with Long's proposed phase of mid-Holocene estuary contraction (Long *et al* 2000).

Landscape Stage 4a: The mid- to late Holocene marine incursion

This stage is characterised by the final submergence of the former floodplain topography and the loss of much of the floodplain diversity (Fig 16.6c). Typically, organic sediment growth appears to cease after topographic elevation is buried.

The cessation of tufa formation is probably related here to the onset of a further phase of marine incursion into this part of the valley, which eventually caused the cessation of peat formation and the deposition of the 'Upper Clay-Silts'. However, tufa formation commonly ceases in the Bronze Age in many places in southern England as a result of both climatic and anthropogenic factors and consequently these factors may also be important in the Ebbsfleet system. Towards the top of the peat profile, there is evidence locally for an increase in marsh/sedge fen environments with abundant ferns, indicating increased wetness in the valley bottom.

The change to minerogenic sedimentation is dated in Borehole 7 (BH7, STDR400, Fig 12.3) in the Outer Basin at -2.38m OD to the Early Bronze Age at 3836±50 BP (NZA-28971, 2470–2140 cal BC) and 3527±30 BP (NZA-28973, 1940–1750 cal BC). Here, the Upper Clay-Silts are largely minerogenic and rather homogenous, although some faint horizontal bedding was noted in Borehole 7. Ostracod, foraminifera, diatom and pollen evidence suggests the presence of a tidal river with mudflats and fringing saltmarsh, fen and reedswamp environments. On the drier ground pollen evidence suggests grassy meadows and pasture with some cereal cultivation (Chap 12).

Further upstream the brackish incursion occurred a little later. Here, in the more marginal Inner Basin the 'Upper Clay-Silts' are more heterogeneous, characterised by intercalated beds of minerogenic silt clays and more organic, sometimes peaty, deposits. The first indication of brackish water actually occurs within the underlying peat facies, sometime during the Late Bronze Age. The onset of major estuarine sedimentation at -0.03m OD was dated in Trench 9 (STDR400, Fig 13.3) to the Late Bronze Age or Early Iron Age at 2605±35 BP (SUERC-16660, 840–590 cal BC). Accumulation appears to have continued throughout the later prehistoric and into the historic period (Fig 16.6d). An organic lens in Trench 9 at 0.33m OD produced a middle to late Roman date of 1740±35BP (SUERC-16658, 220–410 cal AD). The pollen assemblages at this level contained a rich herbaceous flora and, similar to Borehole 7, suggest local environments of middle and upper saltmarsh existed (Chap 13).

The regional pollen assemblages suggest away from the valley bottom a much more open environment developed during the later prehistoric period. Woodland cover decreased significantly at the beginning of the Bronze Age and is undoubtedly related to human activity in the catchment. The landscape is likely to have comprised open grassland with arable cultivation and some stands of oak and hazel woodland. Barley, oats and wheat appear to have been cultivated from the Iron Age onwards. By the late Roman period arboreal pollen values were as little as 20–30%, as recorded in the sequence from Trench 9 (STDR400; Chaps 12 and 13).

This phase of marine transgression into the Ebbsfleet Valley in the later prehistoric and historic periods is mirrored at many sites previously investigated up and down the Lower Thames. It can be broadly correlated with the second phase of estuary expansion on the Thames floodplain (see Long *et al* 2000), and Devoy's Thames III-V transgressions (Devoy 1979).

Landscape Stage 4b: The late Holocene regression

The Upper Clay-Silts are generally overlain by a laterally extensive freshwater peat. This unit was identified in numerous profiles in both the Outer and Inner Basins. Radiocarbon dating suggests accumulation commenced during the Middle or Late Saxon period. The base of this unit was dated in Borehole 7 (STDR400), at 0.88m OD, to 1196±30 BP (NZA-28620, 710–940 cal AD), and in Trench 9 (STDR400), at 0.72m OD, to 1290±35 BP (SUERC-16657, 650–810 cal AD). Pollen evidence from these levels in both Borehole 7 and Trench 9 suggests the presence of freshwater marsh and sedge fen environments, with open pasture and arable on the drier ground. Very little woodland was present in the area at this time (Chaps 12 and 13).

The evidence for a possible regression in the Ebbsfleet Valley contrasts somewhat with the evidence presented for changing river levels on the Thames floodplain at this time. In the Outer Estuary, Greensmith and Tucker (1973) present evidence of marine transgression between AD 800 and AD 1000. In central and east London, the River Thames appears to rise in the post-Roman and medieval periods (Sidell *et al* 2000, 17), although a brief period of regression has been suggested between the mid-10th and late 12th century at Thames Court in central London (*ibid*).

Relating the patterns of sedimentation in the Ebbsfleet Valley to those elsewhere in the Thames is not, however, easy. The sump-like nature of the Ebbsfleet indicates that local factors may be of considerable importance in controlling sedimentation and as such may not be entirely comparable to the sequences from the Thames floodplain. In the absence of a major river system draining through the Ebbsfleet and flushing sediment out of the system accretionary processes have tended to dominate. It is probable that accumulation of the Upper Clay-Silts filled the available space to a point where the valley was simply choked with sediment, inhibiting the flow of tidal waters into the upper reaches thereby promoting the growth of reedswamp. The pollen profiles provide supporting evidence for this notion whereby an increase in arable activity during this period has been noted that may have resulted in significant increase in the amount of colluviation and sediment run-off into the channel system further enhancing the infilling of the basin. Although the impact of human interference related to the building of sea-walls and land reclamation cannot be entirely ruled out as a mechanism for environmental change, there is no archaeological evidence of this in the Ebbsfleet Valley during this period. Historical records suggest marshland in the Thames Estuary was being embanked and drained immediately after the Norman Conquest and it possible sea banks downstream of Gravesend, at Sittingbourne and on the Cliffe Marshes date to this period (Spurrell 1885).

Colluvial deposits of the 'dryland' zone

Slope deposits have been mapped extensively across the margins of the Lower Valley, both of Pleistocene and Holocene age, and episodes of erosion and aggradation have played an important role in modifying the landscape. Within the HS1 land-take, Holocene colluvial deposits were located predominantly on the western slopes of the valley (although it should be noted that the eastern parts of the valley saw little impact from the scheme and much of the eastern part of the valley had previously been quarried out). These deposits were recorded during the evaluation stages of the project; however, much this area was not the subject of later, detailed excavation and sampling.

The taphonomic processes associated with colluviation are complex. Artefacts, and other evidence of human activity such as charcoal often reside in sediments for long periods of time. Episodes of erosion and redeposition through downslope processes may occur repeatedly. Consequently, pottery sherds, or other datable artefacts may only provide a *terminus post quem* for the date of deposition. A more reliable indicator for the date of deposition can be provided where well-dated archaeological features are found stratified within colluvial deposits, (as at Springhead, see below). In the Lower Ebbsfleet Valley, archaeological trenching identified only small mixed assemblages of worked flint and pottery sherds within these deposits along with a small number of undated features. As a result stratigraphic analysis of the sequences has proved problematic.

The slope deposits in the Lower Ebbsfleet Valley often show a twofold division between material of Pleistocene date forming the lower part of the sequences, and later deposits of Holocene Age, although the boundary between the Holocene and Pleistocene was not always easily identified. Holocene colluvial deposits generally comprised reddish- or yellowish-brown sandy silts and clayey silts with varying quantities of chalk and flint clasts. Occasional zones of rooting suggest periods of slope stabilisation and soil formation. Assessment of samples identified occasional charcoal fragments but mollusc shell was often either absent or very poorly preserved.

As opposed to climatically induced processes inferred from Pleistocene sediments, the Holocene colluvial deposits are likely to have formed largely as a result of anthropogenic activities. This includes episodes of forest clearance and cultivation, which increase the susceptibility of soils to erosion through the breakdown of structure and loss of nutrients (see Bell and Boardman 1992).

In the north-western area (Zones 1 and Zone 3) deposits reached up to *c* 1.7m in thickness, and analysis of the elevation of the surface of the Pleistocene deposits in this area suggest the deposits infill a small valley feature. A small amount of charcoal, worked and burnt flint was recorded from colluvium in a number of interventions (3782TT, 3789TT, ARC EFT97 2005TP, 2006TP, 2018TP and 2064TP), although much of this material is likely to be reworked. In 2006TP for example the worked flint was associated with Anglo-Saxon pottery suggesting at least part of the colluvial sequence in this area is of historical date. In 2018TP, deposits were notably sandier and probably derive from the reworking of older, fluvial sediments recorded higher on the slope. Artefactual material in this test pit appeared less mixed. The lowermost unit, a chalky silt with angular flint and chalk clasts, may represent a solifluction deposit. Rooting was noted in places within the overlying silty sands, suggesting the possible presence of stable surfaces during accumulation. At 2.6m to 2.8m, a dark greyish-brown sandy silt deposit contained frequent burnt flint fragments and was associated with Late Bronze Age pottery and charcoal fragments. Late Iron Age or early Roman pottery was recovered from a dark yellowish-brown silty sand higher in the profile between 1.20 and 1.50m.

Further south, Holocene colluvial deposits were recorded in a number of evaluation trenches reaching up to 1.6m in thickness. Much of this, however, appeared to be of medieval or later date. Mixed assemblages of Late Bronze Age, Roman, Anglo-Saxon and medieval pottery along with worked and burnt flint was recovered from these deposits in five interventions (ARC EFT97, 1015-16TT, 1019-20TT, 1023TT). In the open area excavations in Zone 6, thick deposits sealed features of Saxon date that, in turn, truncated Pleistocene deposits. In the area excavations in Zone 4 features of Early and Middle Bronze Age date were sealed by a thin layer of sandy silt colluvium which was, in turn, cut by features associated with the western Roman complex. A further 1m of colluvium, containing medieval pottery, was deposited after the period of Roman activity.

In Zone 7 beneath the main Northfleet Villa complex relatively thick deposits of fine grained sands, silts and clayey silts overlay chalk and flint solifluction gravels. The majority of these deposits relate to the Pleistocene sequences. The upper part of the profiles, however, may represent reworked material deposited as sheet wash sometime during the Holocene. Prehistoric features cut into these deposits, suggest deposition may have occurred prior to the Middle Bronze Age. The majority of these features were recorded at a similar level to the Roman archaeology, suggesting little sedimentation at this location during the later prehistoric period. Where the Holocene sequence remained untouched by previous excavations or truncated by modern disturbance, the Roman features were sealed by further deposits of colluvium containing medieval pottery.

Further deposits were examined infilling the dry valley at Brook Vale (Zone 10, Chap 14). Here, the basal sequence in evaluation Trenches 13 and 16 (STDR400) recorded a series of possible Early to mid-Holocene buried soils within colluvium, but no artefactual material was retrieved from these. The upper part of the sequence contained medieval pottery along with numerous residual worked flints. In Trench 16 shells of woodland snails, particularly *Carychium* sp. and *Discus rotundatus*, predominated in parts of the lower colluvial sequence and included the rare snail *Vertigo pusilla*, which no longer occurs in Kent. Open-country species are not entirely absent, but it is unclear whether they are residual from Late Glacial and early post-glacial deposits. The occurrence of many shells of *Pomatias elegans* could be a reflection of clearance-related surface instability.

Overall it appears colluviation may have been occurring in places around the slopes of the Lower

Ebbsfleet Valley from at least the Early Bronze Age as evidenced from the sequence in Zone 7. This is in agreement with other evidence such as the pollen sequences from the valley bottom, which provide evidence of increased woodland clearance and cultivation from this period onwards

The Upper Ebbsfleet Valley at Springhead

Useful information on the nature of the prehistoric landscape in the Upper Ebbsfleet Valley (Zone 11) comes from the channel edge sequences at the Ebbsfleet River Crossing (ARC ERC01, Trench 4, see Chap 15) Here, an Early Neolithic (4519±45 BP, NZA-28773, 3370–3080 cal BC) peaty landsurface (context 546) overlay calcareous alluvium. Both contained well-preserved pollen that demonstrates a predominantly wooded habitat. This was dominated by lime, oak and hazel on drier areas with alder carr and reedswamp on the floodplain. Clearance was slight at this time, with only small open areas in the woodland indicated in the local area.

A number of pre-Middle Bronze Age colluvial and alluvial layers were analysed for molluscs at both the Ebbsfleet River Crossing (ARC ERC01) and further upstream at the head of the springs (ARC SPH00). These broadly show the presence of short-turfed chalk grassland and limited open scrub/woodland, with secondary woodland clearance indicated by this time. The pollen evidence also indicates that an increase in clearance and arable activity occurred in the Late Neolithic to Early Bronze Age, which caused sufficient destabilisation of the soils to enable colluviation. Bodies of such early (pre-Middle Bronze Age) colluvium were exposed at the River Crossing (context 545) and underlying a Middle Bronze Age burnt mound at the springs (context 5102). The molluscs from the Middle Bronze Age soil at the River Crossing (MAZ 2, context 405) were of open ground and include the rarely found *Truncatellina cylindrica*, which favours extremely dry conditions, normally short dry calcareous grassland.

Subsequent channel activity cut the earlier prehistoric sediments at the River Crossing site. The channel fills, including a peat dated to the Late Bronze Age to Early Iron Age at 835–770 cal BC (NZA-28795, 2625±30 BP), contained a pollen spectrum that indicates substantial clearance had occurred by this time, creating an open landscape dominated by grassland/pasture with some localised arable activity. Further layers of colluvium were laid down over a burnt mound at the springs (ARC SPH00, context 5101) at the same time, which supports an interpretation of continuing clearance and resulting instability. By the Late Bronze Age to Early Iron Age the molluscs indicate that the environment near the springs comprised open short-grazed grassland with small areas of scrub and long grassland.

Part III

Occupation and Activity

Chapter 17

Palaeolithic – The APCM "Baker's Hole" Lithic Collection

by Francis Wenban-Smith

Introduction

The current status of "Baker's Hole" as Britain's foremost Levalloisian site arises from the substantial lithic collection donated to the British Museum by the Associated Portland Cement Manufacturers (APCM) in 1914, which formed the basis of Smith's (1911) seminal publication on the site. The collection was recovered from a chalk solifluction deposit ("Coombe Rock") in the north-west angle of the Southfleet Pit (Fig 2.8), erroneously known to many at the time as "Baker's Hole", by which name the collection is still generally discussed – although within the British Museum the site was mostly documented as "Northfleet". It is now well-established (Wenban-Smith 1990b; 1995) that the original Baker's Hole was the first main chalk quarry between the Ebbsfleet and Swanscombe, shown on the 1895 OS survey (Fig 2.5). Southfleet Pit was the long north-south quarry immediately to the west of the Ebbsfleet, shown at its completed extent on the 1938 survey, but the start of which was just caught by the 1907 survey (Chap 2, *Archaeological Background and Previous Investigations*).

As discussed in Chapter 2, the collection was accumulated by the quarry workmen in 1909 under a cash incentive scheme, rather than by controlled archaeological excavation. The collection is therefore unlikely to have been biased by academic preconceptions as to more desirable and representative artefacts and, at least originally, was likely to have included all recognisable artefacts. However, there must therefore be some question marks over its integrity. Besides there having been no attention to stratigraphic detail in the main Coombe Rock deposit, the cash incentive may have encouraged the inclusion of some material from other deposits; we know from the work of Spurrell, Stopes (see Wenban-Smith 2004b; 2009) and Burchell, amongst others, that the Ebbsfleet quarry complex of the early 20th century was rich in Palaeolithic artefacts protruding from all manner of quarry faces and pit rail cuttings, not to mention the rich pickings from the nearby Swanscombe '100-ft terrace' deposits.

The geomorphological situation of the APCM collection, and the OSL date of *c* 200 KBP for the nearest surviving remnant of the same (or a closely related) Coombe Rock deposit at the Chalk Spine, suggest that the latest possible date for the APCM collection is MIS 7, and that it more likely originates from MIS 8, or perhaps even earlier (Chap 9, *Zone 5 Synthesis*). The evidence from the HS1 investigations for multiple-phased development of chalk-rich "Coombe-Rock" deposits on dry valley slopes in chalk landscapes (Chap 10, 3971TT) also suggests that the APCM collection is by no means certain to represent a single phase of Palaeolithic activity; it may contain mixed evidence from chronologically separate phases of activity in the same landscape situation.

Shortly after its presentation to the British Museum in 1914, a significant part of the APCM collection was dispersed to provincial museums, as well as further afield throughout the British Empire, so that they could obtain representative selections of the artefacts. The majority was however retained by the British Museum. Many of the artefacts in the APCM collection have distinctive labels stuck on them with numbers written on. These labels are mostly either rectangular and white with a blue margin with a tiny dagger motif in the corners, or round and white, occasionally with a blue margin. These labels and their sequence of unique numbers provide a useful key to recognising the APCM collection.

An attempt was made in the early 1990s by Wenban-Smith (1996) to locate and re-examine as much as possible of the collection. Its numbering sequence goes beyond 2,500, suggesting that the original flint assemblage contained well over 2,000 artefacts after allowing for over 150 faunal remains (as reported by E T Newton in Smith's 1911 paper).

In total 935 artefacts were relocated in various museums, of which a sample of 777 were re-examined (Table 17.1). This is a significant reduction from the apparent quantity originally recovered. Several representative sets of artefacts were retained by the directors of APCM and some were lost in World War II; the loss of the remainder is a mystery. Further parts of the collection may yet come to light in museums which acquired them, but which have no records linking them to the site. It is also possible that the original collection made by the quarry workmen included natural material that was labelled and marked with a number, but was then discarded by Smith.

Smith interpreted the collection as the remains of a Palaeolithic (Mousterian) factory-site where tortoise-shaped cores, radially prepared on their top surface, had been used to produce large flakes as blanks for flake-

Table 17.1 Relocated lithics from the APCM collection

Museum	Located	Studied
Sheffield	30	30
Plymouth	24	–
Cardiff	28	28
Rochdale	20	20
Reading	15	15
Salford (Ordsall Hall)	20	20
Lincoln	20	–
Saffron Walden	19	19
Hastings	23	23
Bradford (Ilkley)	24	24
Glasgow (Hunterian)	25	–
Leicester	20	–
Leeds	23	23
Austin, USA (Texas Memorial)	19	–
Bolton	23	23
Derby	22	22
Perth, Scotland	14	–
Carlisle	4	–
Warrington	26	26
Worcester	4	–
Cheltenham	21	21
Horniman	16	16
Ipswich	14	14
Maidstone	28	28
Oxford (Pitt Rivers)	31	31
Ontario, Canada	28	–
Cambridge University	84	84
Birmingham	17	17
British Museum: R A Smith	64	64
British Museum: APCM	216	216
British Museum: Geological Survey	13	13
Total	**935**	**777**

tools. He recognised the similarity of these products and their means of production with material from the site of Levallois in France. He also recognised the presence of elongated flakes amongst the debitage, but regarded these as part of the general variety of waste debitage produced from the tortoise cores and unsuitable for flake-tool manufacture, rather than associating them with a different knapping technique. He also noted the presence of numerous handaxes in the collection from so-called "Chelles and St Acheul periods" (Smith 1911, 521), regarding them as derived from the nearby Swanscombe '100-ft terrace' outcrop. However, he also regarded at least some handaxes as part of the main Mousterian assemblage, identifying one sub-cordate handaxe (*ibid*, 524 and pl 73: fig 2) as "the perfect implement" representative of the site's tool production.

As discussed subsequently (*Discussion and Conclusions*), Smith was particularly keen to draw parallels between the APCM collection and the French Mousterian, to demonstrate the similar cultural succession in Britain and France during what were thought to be the same climatic stages. Subsequent discussions of the collection continued to emphasise its classic – ie, based on radial preparation of the top surface of tortoise cores – Levalloisian nature (eg, Wymer 1968, 354–8; Roe 1981, 81; Robinson 1986). Wymer noted the presence of some elongated blade-like flakes in the assemblage whose parallel dorsal scars suggested production from simple prismatic or more evolved two-platform cores; he also noted at least 16 handaxes in similar condition to the Levalloisian material and thus probably associated with it. In contrast, Roe and Robinson (*ibid*) regarded all the handaxes as almost certainly derived and do not note the presence of any blade-like knapping approaches; although Robinson also draws attention to a large bifacially worked Levalloisian flake that she classifies as a flake-cleaver.

More recently (Wenban-Smith 1992b; 1995; 1996) and Scott (2010; 2011) have both re-examined the APCM collection. These workers take divergent approaches to the association of handaxes with the Levalloisian elements of the APCM collection, the former recognising the presence of several derived handaxes but regarding at least some as genuinely associated, whereas Scott regards the entire handaxe element as intrusive and reworked from earlier deposits. However, both agree that the Levalloisian approaches represented are more complex than merely the production of single flakes from radially prepared tortoise cores, and that there is evidence of unipolar and bipolar blade production as well as the recurrent production from some tortoise cores of more than one radially prepared Levallois flake-tool. The technology, typology and integrity of the APCM collection is re-assessed here, and then reconsidered in light of the new HS1 work that has provided a firmer basis for its age and provenance.

Methods and Classificatory Framework

The condition of the artefacts was systematically recorded to try and establish the integrity of the collection. The aims of the lithic analysis were to establish the knapping strategies present and the lithic technological *chaîne opératoires*, and to investigate the organisation of lithic production, stretching from procurement and exploitation to tool manufacture, use and discard. The lithic material was first grouped into technological categories (Table 17.2).

Core-tools (Handaxes)

Core-tools were classified into groups following Wymer's (1968, 60) handaxe typology (Table 17.3).

Cores: Four Main Knapping Strategies

Cores were classified following a bi-partite scheme, which identified knapping strategies by firstly (T1) the general concept and secondly (T2) the specific reduction method (Table 17.4). Four primary over-arching knapping strategies were considered – Clactonian, Mousterian, Classic Levalloisian and Broad-blade – and then for each of these strategies a number of more specific tactics/techniques were identified. Use of terms such as Clactonian, Mousterian and Levalloisian is not intended to necessarily imply

Table 17.2 Technological categories for lithic artefacts

Core	Remnant part of flint raw material from which flakes have been removed; flake removals generally reasonably large and not distributed to create core-tool (qv) or regular sharp edge suitable for use
Core-tool	Remnant part of flint nodule, usually bifacially shaped/thinned to create symmetrical lenticular bifacial core-tool (or handaxe) with removal of numerous small shaping flakes of no use in themselves
Flake	Usual product of knapping, with features such as a striking platform and conchoidal ripples
Chunk	Lump, fragment or shatter; piece of knapped flint bigger than 20mm but not otherwise classifiable; often resulting from knapping frost-fractured pieces
Chip	Small flakes, with a maximum length along the axis of percussion of less than 20mm
Flake-flake	Debitage struck from flakes rather than cores, usually interpreted as secondary working to form a flake-tool (qv)
Flake-tool	Flake from which secondary debitage has been removed, with the apparent intention of regular shaping or modification for use as a tool (sometimes a handaxe on a large flake blank)

Table 17.3 Broad groups for handaxe classification, based upon Wymer (1968, 60)

Wymer type letter	Type name	Description
Proto	Simple	Simple bifacial or unifacial edges opposed to natural handles. Includes McNabb and Ashton's (1994) "non-classic" handaxes
D, E and F	Pointed	Pointed/sub-pointed biface, including smaller, cruder and thicker forms with more wavy edges, and thinner more finely-worked forms with straight edges; generally thicker and heavier at butt, which can variably worked
G	Sub-cordate	Progression from pointed form, with convex sides, often more rounded point, thick/heavy butt, widest part of handaxe well towards butt; butt can be worked, although usually crudely worked or unworked
GK and K	Ovate, sub-ovate	Cutting edge and thinning/shaping all round; tip is smoothly rounded without any well-defined point, widest part of handaxe is nearer middle of long axis, clear working to shape/thin butt and sides as convex curve
H	Cleaver	Key characteristic is straight cutting edge at tip end, transverse to main longitudinal orientation of tool
L	Side-chopper	Segmental chopping tool, one knapped bifacial edge or sharper edge opposed by flat edge or natural backing; crucial distinction with cleaver is that business edge is parallel with main longitudinal axis rather than transverse

cultural links with other industries given these names in the north-west European Palaeolithic, for instance the Clactonian of MIS 11 in southern England or the Mousterian of south-west France. They are merely descriptors of a knapping strategy, as summarised in Table 17.4. More detailed discussion of the distinction and definitions of these techniques is given in Wenban-Smith, Appendix F.

Debitage: Classification of Flaking Products

Flakes were classified using a bipartite scheme in the same way as cores, with the addition of the possibility that they were from handaxe-making. The first part of the classification (T1) represented the general concept of the knapping strategy, and the second part (T2) represented the role of the flake within this concept (Table 17.5). However, as demonstrated by Wenban-Smith's experimental work (1996), most flakes from even well-structured Levalloisian or handaxe-making reduction sequences are not specifically recognisable on their own, and some flakes can on their own give misleading indications.

Flake-tools

These are flakes from which further debitage has been removed by secondary working, interpreted as with the intention of forming a tool; usually regular retouch of an edge, or shaping the flake into a symmetrical form. A continual problem in the analysis of the lithic material from the Ebbsfleet Valley was the distinction of deliberate secondary working from natural damage. Many of the artefacts examined are heavily abraded or notched. In many instances the damage affects the whole circumference of the flake and is accompanied by smoothing of the dorsal ridges and numerous incipient cones suggesting natural damage by a very active post-depositional history. In other cases, damage is more localised, often being restricted to distinct notches in otherwise quite sharp material. This type of damage was also regarded as natural due to frequent cases where the lack of patination of the apparent notch contrasted with the patination of the rest of the flake surface, indicating that the notch was formed long after the flake was struck. Deliberate working was distinguished by the criteria of: i) invasiveness; ii) regularity; and iii) consistency of condition of the retouched and unretouched flint surfaces.

The flake-tool blank was classified according to its knapping strategy as for unworked flakes, but no attempt was made to assign specific tool-types, as: (a) they were a small element of the collection; and, more importantly, (b) it is questionable whether there is a usable typological framework for British flake-tools of the Lower/Middle Palaeolithic. Bordes' (1961; 1979) widely applied flake-tool typology for the French Mousterian is increasingly being challenged at both theoretical and practical levels (Kolpakov and Vishnyatsky 1989; Dibble and Rolland 1992), and may not be useful for sparse flake-tool assemblages from the British Lower/Middle Palaeolithic.

Refitting

One widely used approach to confirming the high integrity and lack of disturbance of a lithic assemblage is refitting it back together (Cahen 1987). Burchell recorded fine-grained "loams" within gravel deposits, and claimed to have found "floors" of artefacts, a term which usually refers to undisturbed assemblages. The

Table 17.4 Bipartite scheme of core classification

T1 – General strategy	General description	T1–T2 – More specific method	Method details
Unspecific/testing	No apparent flaking strategy, for broken core pieces or flint pieces with very few removals	–	–
2 – Clactonian	An umbrella term for loosely structured *ad hoc* approaches to core reduction, incorporating migrating platforms, alternating platforms and flakes off the same surface from opposed platforms (McNabb 1992; Ashton and McNabb 1996)	2–0 – Clactonian, typical	Migrating and alternating platforms, globular cores
		2–1 – Clactonian, fixed-platform	Fixed-platform cores and cores with flakes off a main face from different directions
		2–2 – Clactonian, combination	Combination of above
3 – Mousterian	Initially trimming around the sides of a core as for Levalloisian (qv); then radial flaking from the upper surface, or sometimes from both the upper and the reverse surfaces, leaving a discoidal core that is either unifacially or bifacially flaked (Bordes 1979, 17)	3–1 – Mousterian, unifacial	Radial flake removals from one, upper surface of a core, without any suggestion of special preparation to privilege or deliberately shape any preferential removal
		3–2 – Mousterian, bifacial	Radial flaking as above on two opposing faces of a broadly bifacial core
4 – Classic Levalloisian	Production of "privileged" flakes from prepared cores, the form of the flake having been predetermined by special preparation of the upper/front surface of the core. The cycle of knapping can cease after the first privileged flake removal ("linear"), or be repeated ("recurrent") so that additional privileged flakes are struck from the same core surface with intervening stages of re-preparation (Bordes 1961; Boëda 1988a; Boëda 1988b; 1995)	4–1 – Levalloisian, classic flake production	Radial preparation of core's distinct front/upper surface, leading to privileged flake of circular or oval shape with centripetal dorsal scar pattern
		4–2 – Levalloisian, blade	Radial preparation of core's front/upper surface, leading to privileged flake of markedly elongated shape, but retaining centripetal dorsal scars
5 – Broad-blade	The front/upper surface of the core is prepared with parallel flaking, from either just one end or from opposite ends of the core (Fig. 17.1); there may also be some preparatory surface trimming from the sides. Once initially prepared, a series of blade-like flakes are removed, struck from one end (unipolar), or opposing ends of the core (bipolar), with only minor lateral core surface maintenance, if any. The blades produced therefore show strong parallel dorsal scars and occasional minor lateral scars. The technique is exemplified at the site of Crayford (Spurrell 1880a; Spurrell 1880b; Scott 2011), as well as in the APCM and Burchell collections from the Ebbsfleet Valley	5–2 – Broad-blade, parallel	Solely uni/bi-polar dorsal scars surviving on core's front surface
		5–3 – Broad-blade, radial	Primarily uni/bi-polar dorsal scars surviving on core's front surface, but with some signs of radial/lateral trimming before or during main flaking series of uni/bi-polar blades

Table 17.5 Bipartite scheme of flake classification

T1 – General strategy	T1–T2 – Specific reduction task
Unspecific/unknown	0–0 – Unspecific/unknown
2 – Clactonian, fixed-platform	2–0 – Unspecific/unknown
3 – Mousterian	3–2 – Upper surface
4 – Classic Levalloisian	4–20 – Preparing front/upper surface
	4–21 – Re-preparing front/upper surface
	4–3 – Privileged (Levalloisian) flake
	4–4 – Privileged (Levalloisian) blade
5 – Broad-blade	5–2 – Parallel uni/bi-polar flaking from core front/upper surface
	5–3 – Ditto with some radial trimming
6 – Handaxe manufacture ("Acheulian")	6–0 – Bifacial thinning/shaping, including recognisable tranchet-sharpening flakes

sharp condition of many artefacts in both the APCM and Burchell's collections (Chap 18) suggested minimal disturbance, and some refitting was attempted to investigate this.

Condition of Artefacts

An important factor affecting the interpretation of the lithic collection was the extent to which it might have suffered post-depositional disturbance and mixing. The condition of the artefacts provides a useful pointer to the degree of disturbance and the possible extent of mixing. Four categories were used for recording condition (Table 17.6), based upon those suggested by Wymer (in Singer *et al* 1973, 27), but with the amalgamation of Wymer's mint and sharp categories. Patination was not recorded, as this was highly variable, even on single artefacts, so was not considered to have any interpretive potential.

Technology and Typology

Overview and Integrity

In order to examine the integrity of the APCM collection its condition was assessed in relation to artefact category. Because of its dispersal, a refitting study was impractical, yet one pair of refitting artefacts was found, suggesting that more could be present if the collection was ever combined for a systematic study. A core from the National Museum of Wales at Cardiff (14-239/1) refits with a flake from the Cheltenham Art Gallery and Museum (1914: 103:B:4) (Pl 17.1). Both artefacts are in fresh condition, although there is no record of their original locations. The remainder of the fresh portion of the collection may therefore represent a

Table 17.6 Categories of condition for artefacts

Category	Characteristics
1 – Mint (Mt)	Artefacts which look as if recently knapped, having crisply visible fissures, sharp dorsal ridges, and sharp edges with no macroscopic damage apart from the occasional nicks which are also found in freshly knapped experimental material
2 – Fresh (Fr)	Artefacts which are definitely sharp, but which are not quite mint. The sharp edges have slight macroscopic damage visible along 50–100%, but this damage is not invasive by more than 1–2mm. The dorsal ridges are still crisply defined
3 – Slightly abraded (SR)	Artefacts which have battering/damage easily visible on all edges. Overall shape of flake's outline not affected but about 30% of edges have scars which invade by 3–5mm. Occasional damage invades 6–7mm. Dorsal ridges are slightly rounded
4 – Very abraded (VR)	Artefacts have heavy damage on all edges. The shape has been modified by the removal of projections and weak points. Damage invades 3–5 mm around 100% of outline, with several invasions in 10–20mm range. Dorsal ridges are also well-rounded and/or macroscopically damaged

collection of higher integrity than might be expected from a Coombe Rock context, perhaps having been either gently buried, or rafted *en masse* downhill. Prior to a more systematic refitting study, it remains to be seen whether more abraded material also has refitting potential.

The varying condition of different technological categories of artefacts is tabulated (Table 17.7) and shown graphically for the more abundant technological categories as percentages for each category of condition (Fig 17.1). The cores and debitage tell an opposite story, with a higher proportion of flakes being more abraded and a higher proportion of cores being less abraded. Flake-tools show a similar profile to cores, which is surprising considering that morphologically they are more like flakes, with a relatively high proportion in fresh condition (as well as a few in mint condition); the diagnostic traces of deliberate working may have been obscured in more abraded material. Core-tools show a profile halfway between the extremes of flakes and cores, with a slight increase in their proportion among the fresh artefacts.

Table 17.7 Condition of artefact categories for APCM collection (see Table 17.6 for condition criteria)

Condition	**Mint**	**Fresh**	**Slightly abraded**	**Very abraded**	**Total**
Cores	–	19	16	8	**43**
Core-tools	–	10	10	10	**30**
Flakes	–	129	263	264	**656**
Chunks	–	–	–	–	–
Chips	–	–	–	–	–
Flakes	–	1	1	–	**2**
Flake-tools	3	22	14	7	**46**
Total	**3**	**181**	**304**	**289**	777

Interpretation of the varying condition of different elements of the collection depends upon how the Coombe Rock is thought to have been formed. If one regards condition as a direct proxy for degree of transport and varying depositional history, then one could consider grouping the assemblage by condition for further analysis. However, it is more likely that artefacts of similar provenance have ended up in different

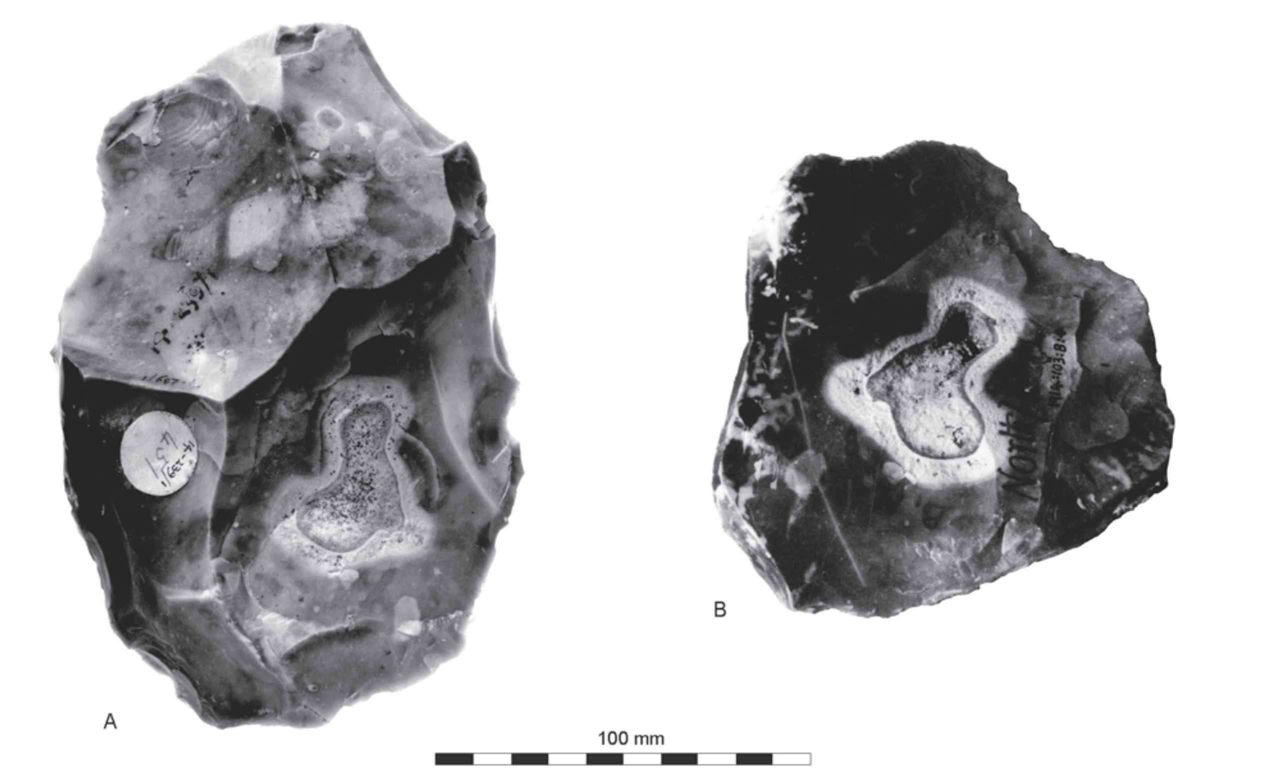


Plate 17.1 Refitting Levalloisian core (a) National Museum of Wales, Cardiff and flake (b) Cheltenham Art Gallery and Museum

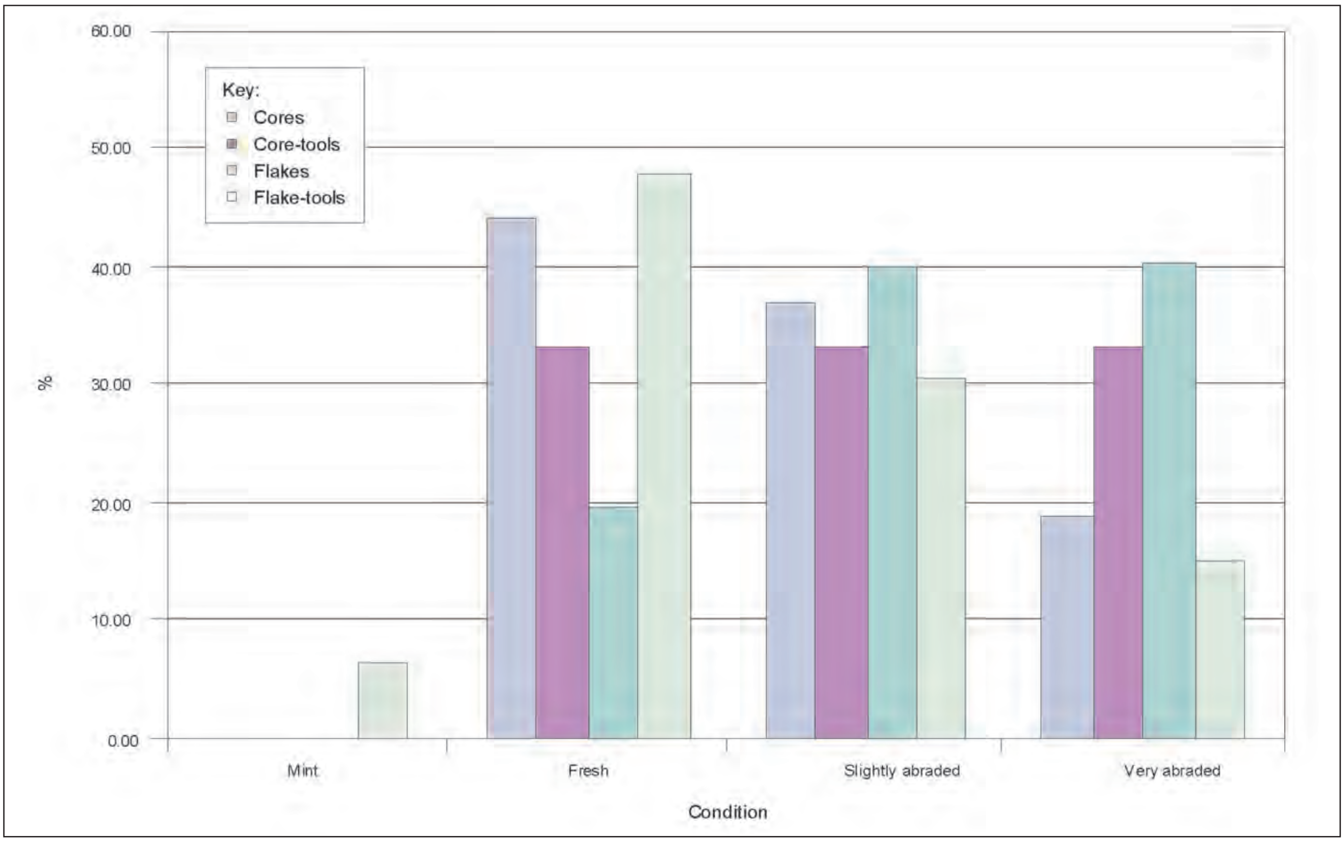


Figure 17.1 Categories of artefact in different conditions

conditions due to either mere chance (perhaps due to localised concentrations of material abrading against each other or against other concentrations of flint clasts), or to other factors such as artefact size and shape.

The absence of chunks and chips, and the minimal presence of flake-flakes, is probably a reflection of their small size and the difficulty for the workmen of distinguishing them from natural flints. Overall, the APCM collection displays a significant absence of smaller-sized debitage (as also noted by Robinson 1986), when compared with experimental models (Wenban-Smith 1996). The mean length of debitage in the collection sample is 115mm, with an interquartile range of 98–135mm. This compares with a mean length of 57mm for experimental debitage from a mixture of Acheulian (n=210), Clactonian (n=148), Mousterian (n=115) and Classic Levalloisian (n=176) reduction, with an interquartile range of 37–75mm. Overall the assemblage contains material of mixed condition, and there is certainly no significant distinction between the core-tool, core and the other elements of the assemblage, all of which contain reasonably high proportions of fresh and slightly abraded material. The significant size-bias in terms of the absence of smaller debitage from the assemblage has implications for the recognition of flaking strategies; handaxe-manufacture in particular (see Fig 17.6) would be disproportionately represented in smaller debitage, as discussed below.

Table 17.8 Knapping strategies of cores in APCM collection (see Table 17.6 for condition criteria)

	Fresh	Slightly abraded	Very abraded	Total
Mousterian, unifacial	3	4	–	7
Mousterian, bifacial	3	2	2	7
Classic Levalloisian	10	8	5	**23**
Broad-blade, non-radial	–	1	1	**2**
Broad-blade, radial	3	1	–	**4**

Cores

There were 43 cores in the sample of the APCM collection studied. The knapping strategies reflected in these are tabulated here (Table 17.8). There are no differences between the range of knapping strategies for different condition cores. Classic Levalloisian cores are the most common, comprising 53% of the assemblage (Fig 17.2.i), followed by Mousterian cores (Fig 17.2.ii) and Broad-blade cores (Fig 17.2.iii), which comprise 33% and 14% respectively. Thus, although the core assemblage is dominated by classic Levalloisian approaches, there is a significant co-occurring element of other knapping strategies. There are however no Clactonian cores.

There is occasional evidence of the continuing exploitation of Classic Levalloisian cores after successful removal of a privileged flake, with the top surfaces of some cores having scars from later flake removals intersecting the scar of an earlier main Levalloisian removal. However, most Classic Levalloisian cores were

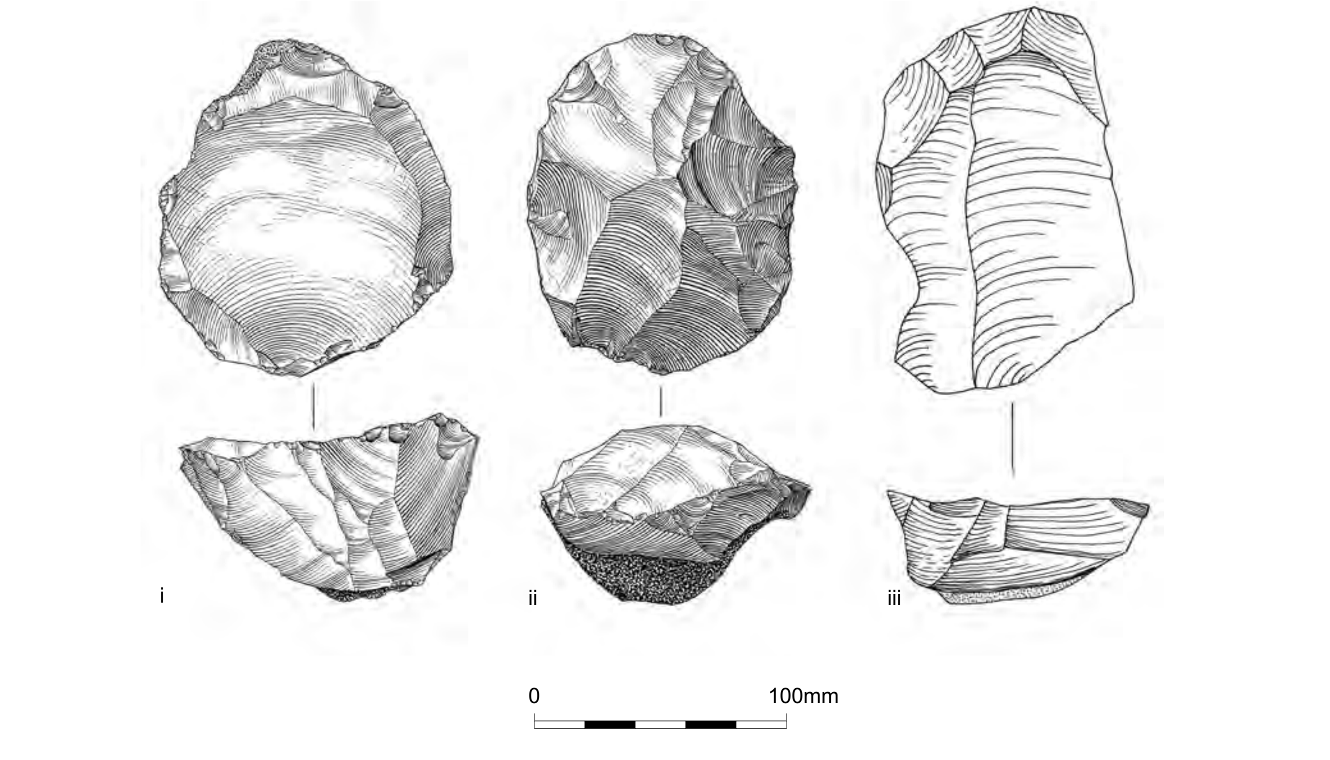


Figure 17.2 Cores from APCM collection: (i) classic Levalloisian; (ii) Mousterian; (iii) Broad-blade

abandoned with a prominent negative scar displaying a single successful privileged removal. This is curious, as, if the efficient production of sizeable sharp-edged flake-blanks was the main knapping objective, then one would expect knapping to continue to remove the flakes either side of the privileged scar. These would have produced flakes with long sharp edges and a naturally blunted back, which one would expect to have been a desirable form of flake-blank. Cessation of the reduction sequence appears, therefore, to reflect a deliberate decision in the face of better functional options. We should perhaps pay more attention to the large size and even shape of the classic Levalloisian removal as being a prime functional objective, or start to consider the social factors behind this ostentatious display of knapping prowess and raw material extravagance.

Handaxes

The handaxe element of the APCM collection has often been regarded as all or mostly derived (eg Smith 1911; Roe 1981; Robinson 1986; Scott 2010). However, the range of condition of the handaxes is not differentiable from the cores and flakes (Fig 17.2), so there is no reason *a priori* to exclude even the more battered specimens from analysis as part of the same assemblage. Some of these do however exhibit strong staining, a pointed shape and a higher level of battering that suggest they are derived from MIS 11 terrace deposits that are widespread in the vicinity, as recognised by Smith (1911). However, others are likely to belong with the Levalloisian parts of the assemblage, as recognised by Wymer (1968, 355). Support for the association between the bifacial and Levalloisian elements of the collection is given by at least two flake-tools that show bifacial working of the products of Levalloisian reduction: (1) For a slightly abraded sub-cordate handaxe held at Leeds City Museum (catalogue D.77/1964A), the back, pyramidal face of a classic Levalloisian flake core has been flaked away at the distal end, and the resulting flake-blank trimmed bifacially and tranchet-sharpened to make a sub-cordate handaxe; (2) Robinson (1986) illustrates a large bifacially flaked cleaver on a Levallois flake.

The sample of the APCM collection studied included 30 handaxes (Table 17.9). The complete assemblage is very diverse (Fig 17.3), with an emphasis on pointed and sub-cordate forms. Distinctive technological features such as tranchet-sharpening and twisting occur in low proportions on all types (except simple). The typological range and technological features of the pointed forms are indistinguishable from those from assemblages from the Lower Middle Gravel of the nearby Swanscombe '100-ft terrace' (or equivalent deposits of the coeval Ebbsfleet, as

Table 17.9 Handaxes in APCM collection (see Table 17.6 for condition criteria)

	Fresh	**Slightly abraded**	**Very abraded**	**Total**
Simple	2	2	–	**4**
Pointed	–	2	5	**7**
Sub-cordate	6	2	3	**11**
Ovate, sub-ovate	–	3	2	**5**
Cleaver	1	1	–	**2**
Side-chopper	1	–	–	**1**

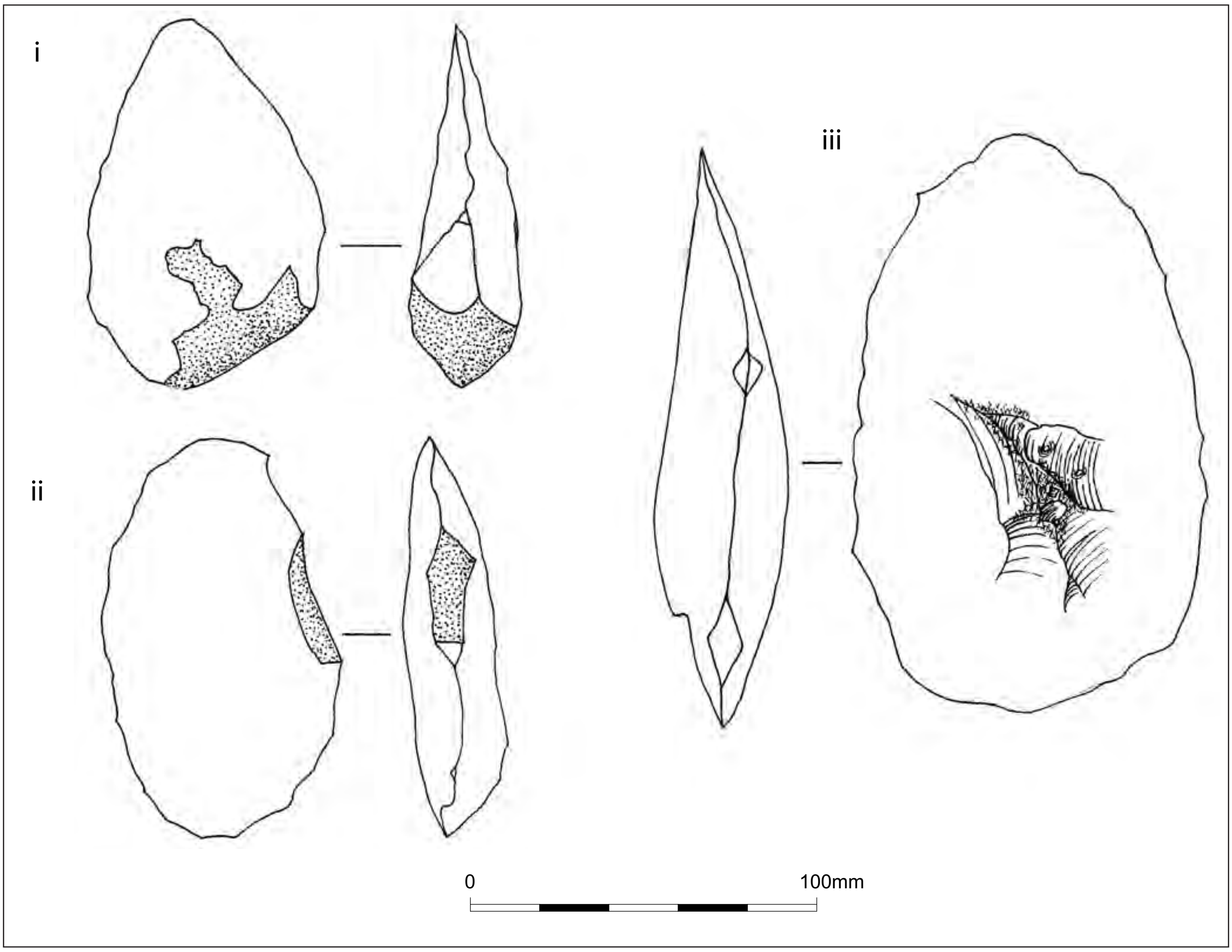


Figure 17.3 Handaxes from APCM collection: (i) sub-cordate; (ii) sub-ovate; (iii) ovate, with battering and percussive impact marks on crown of one face

represented by the Phase 8 gravel at the Southfleet Road elephant site – Wenban-Smith 2013). Since these pointed forms are all in abraded condition, with most of them very abraded, this element of the collection is likely to be intrusive and derived. The same could be said for the ovate and sub-ovate group, although they show more equal quantities in slightly and very abraded conditions. In contrast, for the sub-cordate group (and also for both cleavers and the side-chopper) there is a much stronger prevalence of fresh condition. This suggests that, while there may be a derived element of the core-tool component of the APCM collection, there is also a sub-cordate handaxe and cleaver element that needs to be considered along with the Levalloisian elements as part of the same overall lithic industrial tradition.

Debitage

The sample studied included 658 pieces of unworked debitage, comprising 656 flakes and two flake-flakes. One flake-flake is in fresh condition and represents the removal of the bulb of percussion of a large flake-blank. The other is slightly rolled and represents a large notch taken out of one side of the ventral surface of a flake-blank. Their size is much larger than the small chips that would be produced by retouching one edge of a flake into a side-scraper, which suggests that large flake-blanks were being modified to a major degree (eg, for the cleaver illustrated by Robinson 1986, 21), rather than just having the profile and edge-angle of selected edges trimmed. The lack of flake-flakes in the assemblage does not necessarily reflect their true prevalence. The demonstrable bias in the assemblage in favour of larger debitage would reduce their representation.

The technological attribution of the flakes in different conditions is summarised graphically (Fig 17.4). The technological profiles of the fresh (n=129), slightly abraded (n=263) and very abraded (n=264) flake-groups are very similar, suggesting that these groups are all part of a single assemblage despite their varying condition. Three main knapping strategies are represented: Mousterian, Classic Levalloisian and Broad-blade (Fig 17.5). Broad-blade is most common with 42% of the flakes being attributable to it, followed by Classic Levalloisian with 15% of flakes being attributable (most of which are privileged Levalloisian flakes), and finally, Mousterian is least common with

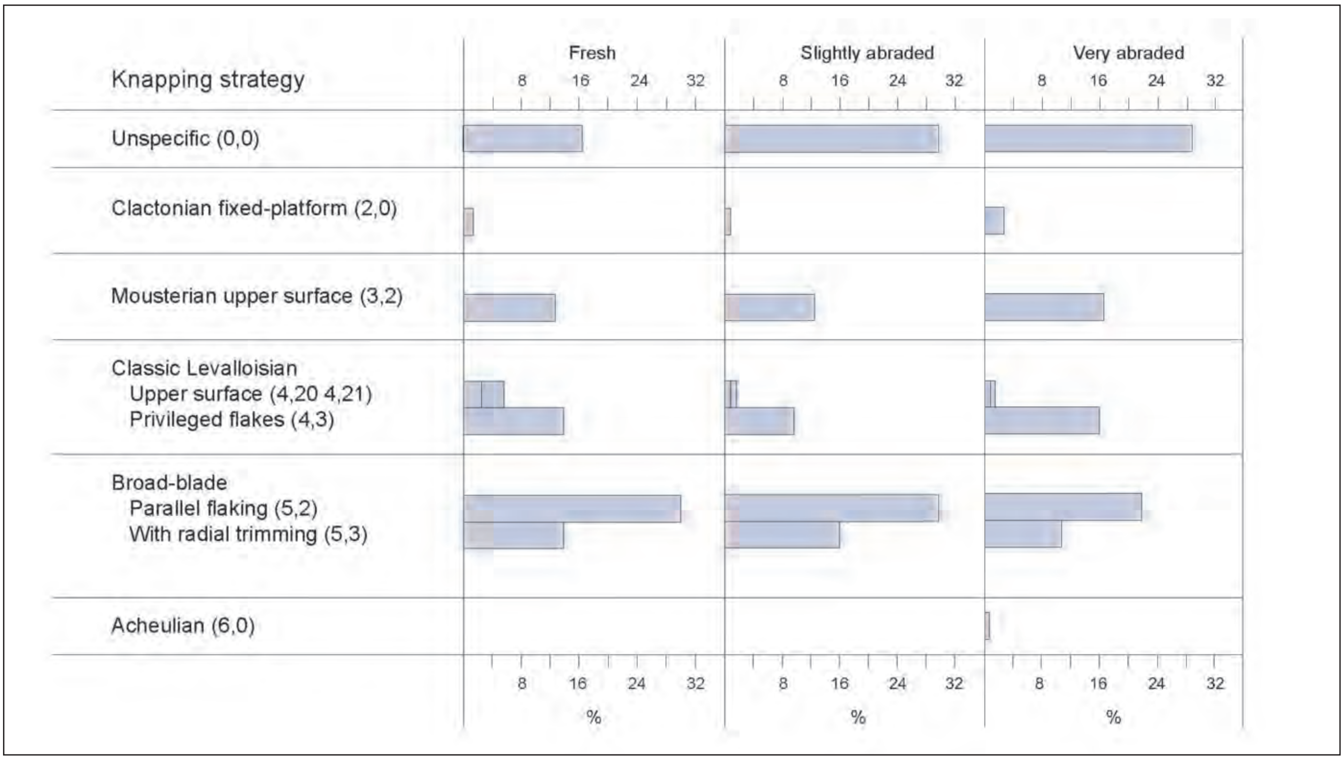


Figure 17.4 Distribution of knapping strategies in debitage from the APCM collection

14.5% of flakes being attributable. Half of the flakes from trimming the upper surface of Classic Levalloisian cores are recognisable as from recurrent Levalloisian production, suggesting that this was commonly carried out. A small proportion (1.5%) of flakes seemed to represent a Clactonian fixed-platform strategy, although these could have been incidentally produced in the early stages of any reduction strategy, particularly Broad-blade reduction, and a single very abraded flake was interpreted as from handaxe manufacture. Around a quarter (26%) of the flakes were unattributable to a specific reduction strategy.

These results probably broadly reflect the variety of knapping strategies being applied, although there is a marked absence of debitage from handaxe manufacture. However, whether they represent accurately the relative prevalence of the different knapping strategies needs to be considered in the light of the extent to which different knapping strategies produce different proportions of identifiable debitage.

Bearing in mind the lack of smaller debitage, the proportion of unspecific flakes (between *c* 15% and 30%) is around what would be expected from the experimental results of the attempted attribution of the experimental debitage (Fig 17.6). The almost complete absence of Acheulian debitage can be explained as due to the missing smaller debitage, which includes most identifiable Acheulian flakes, and to the fact that many of the handaxes are regarded as derived, so handaxe manufacture is thought to have been a small element of the lithic production carried out.

Taken at face value, the raw figures indicate almost three times as much Broad-blade as Classic Levalloisian knapping. However, Broad-blade knapping episodes produce a far higher proportion of technologically attributable debitage than classic Levalloisian episodes (Wenban-Smith 1996). While there was clearly a significant amount of Broad-blade knapping, it was probably practised (in terms of number of core-reduction episodes) a little less often than Classic Levalloisian knapping. Mousterian debitage was almost as frequent as Levalloisian debitage, but also produces a high proportion of recognisable debitage in the size-range represented. Mousterian knapping was therefore probably less frequently practised than both Classic Levalloisian and Broad-blade, particularly bearing in mind the possible overlap of attribution between Mousterian and Classic Levalloisian.

The overall picture mirrors that from the cores, with a variety of flake/core knapping strategies being applied which all follow Boëda's (1988a; b; 1995) fundamental Levalloisian concept involving the volumetric conception of a core and removal of individual privileged flakes, or privileged series of flakes, from its front flaking surface. Classic Levalloisian strategy is most dominantly represented in the debitage, followed by Broad-blade and then Mousterian. Broad-blade production is better represented in the debitage than the cores, which reflects the higher quantities of diagnostic Broad-blade debitage produced.

Flake-tools

The APCM sample studied included 46 flake-tools; three of them were in mint condition, 22 were fresh, 14 were slightly abraded and seven very abraded. The size-distributions of these sub-groups are shown, alongside

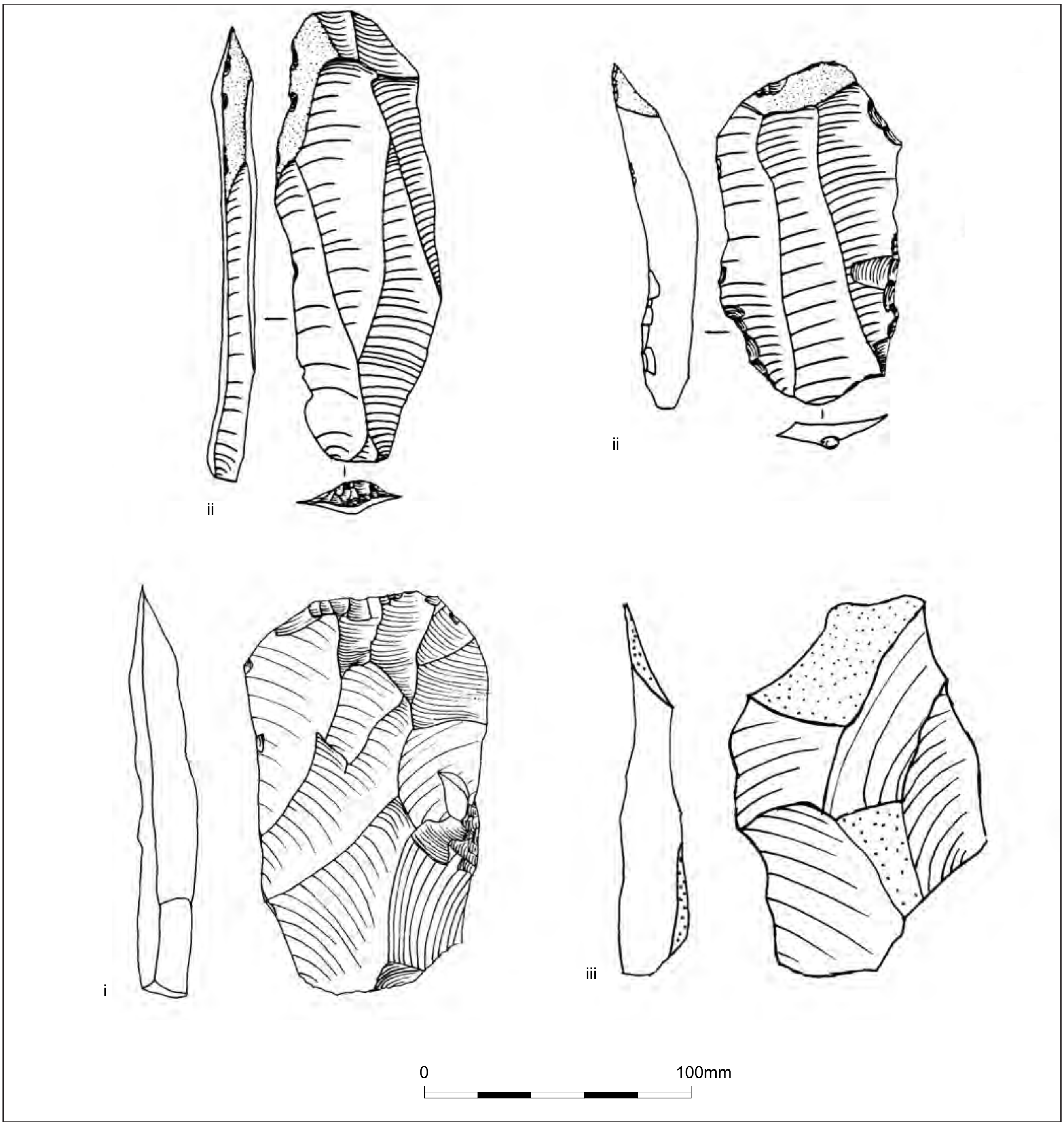


Figure 17.5 Examples of different knapping strategies in debitage from the APCM collection: (i) classic Levalloisian; (ii) Broad-blade; (iii) Mousterian

those for all flake-tools combined and all the unworked flakes (Fig 17.7). The peak for flake-tools occurs at 13–4cm maximum length in contrast to 10–12cm for unworked flakes. Likewise, the distributions of the size-profiles for flake-tools and flakes do not correspond. There are roughly equal quantities of flake-tools in each 1cm size-bracket between 10 and 17cm, and very few outside this range, whereas the distribution for the unworked flakes tails off smoothly above and below the 10–12cm peak. These data suggest a preference for substantially larger than average flakes as the blanks for working into flake-tools.

The proportions of flake-tools made from blanks of different knapping strategies are also summarised graphically (Fig 17.8), alongside the proportions for unworked flakes. It can be seen that there is a clear preference for Classic Levalloisian flakes as the blanks for working, with over half of the worked-flakes retaining the evidence of having been made on such flakes. Over a fifth (22%) of the blanks for the worked-flakes are from the upper surface of Mousterian cores, and the same number were from Broad-blade debitage. A small number (3%) of the blanks are from unspecific debitage. Some of the blanks identified as having been unspecific

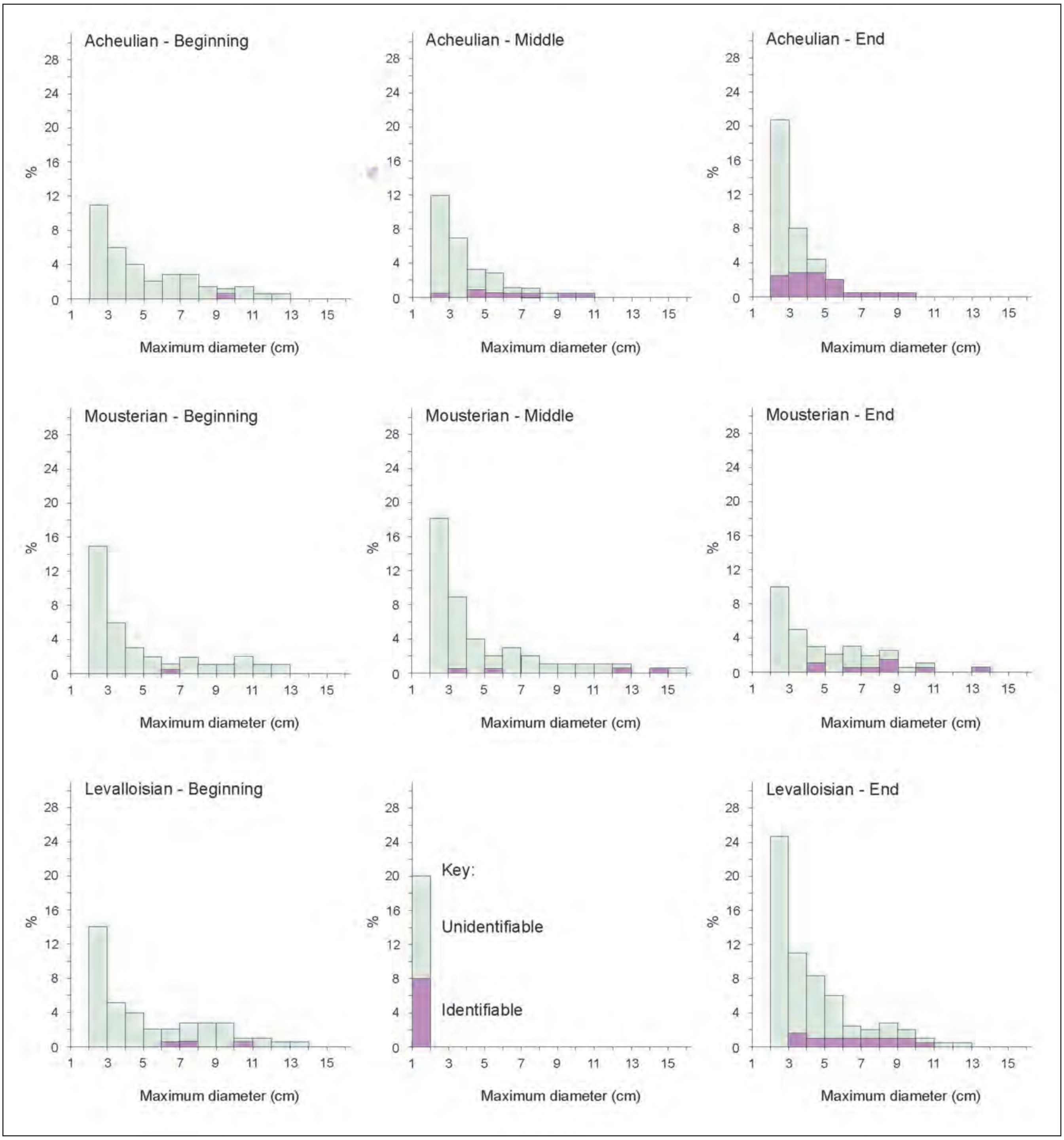


Figure 17.6 Identifiability of experimental debitage from different knapping strategies in different size-ranges

or Mousterian may originally have been Broad-blade or Classic Levalloisian flakes as the working might have obscured their characteristic dorsal scar pattern.

There is a striking discrepancy between the proportion of Levalloisian flakes remaining unworked in the debitage and the proportion used as blanks for working. The large flakes from the upper surface of Mousterian cores were also favoured as blanks. In contrast, a lower proportion of Broad-blade debitage was used as blanks, and only a very small number of unspecific flakes. These data suggest that the Levalloisian and Mousterian flaking strategies were aimed at the production of flake blanks for working into tools, rather than as end-products in themselves.

A selection of the flake-tool assemblage is illustrated (Fig 17.9). It includes one common form, with unifacial or part-bifacial working around the perimeter of an oval flake to leave a bluntly pointed form with the striking platform left unretouched (Fig 17.9, iii-iv). Larger blanks were often retouched opposite a sharp edge, probably to make a "knife" with an opposing blunt edge for a handle (Fig 17.9, i), and there were a variety of one-off forms with localised working (Fig 17.9, ii). Working (of the blank) seems to be used both to shape

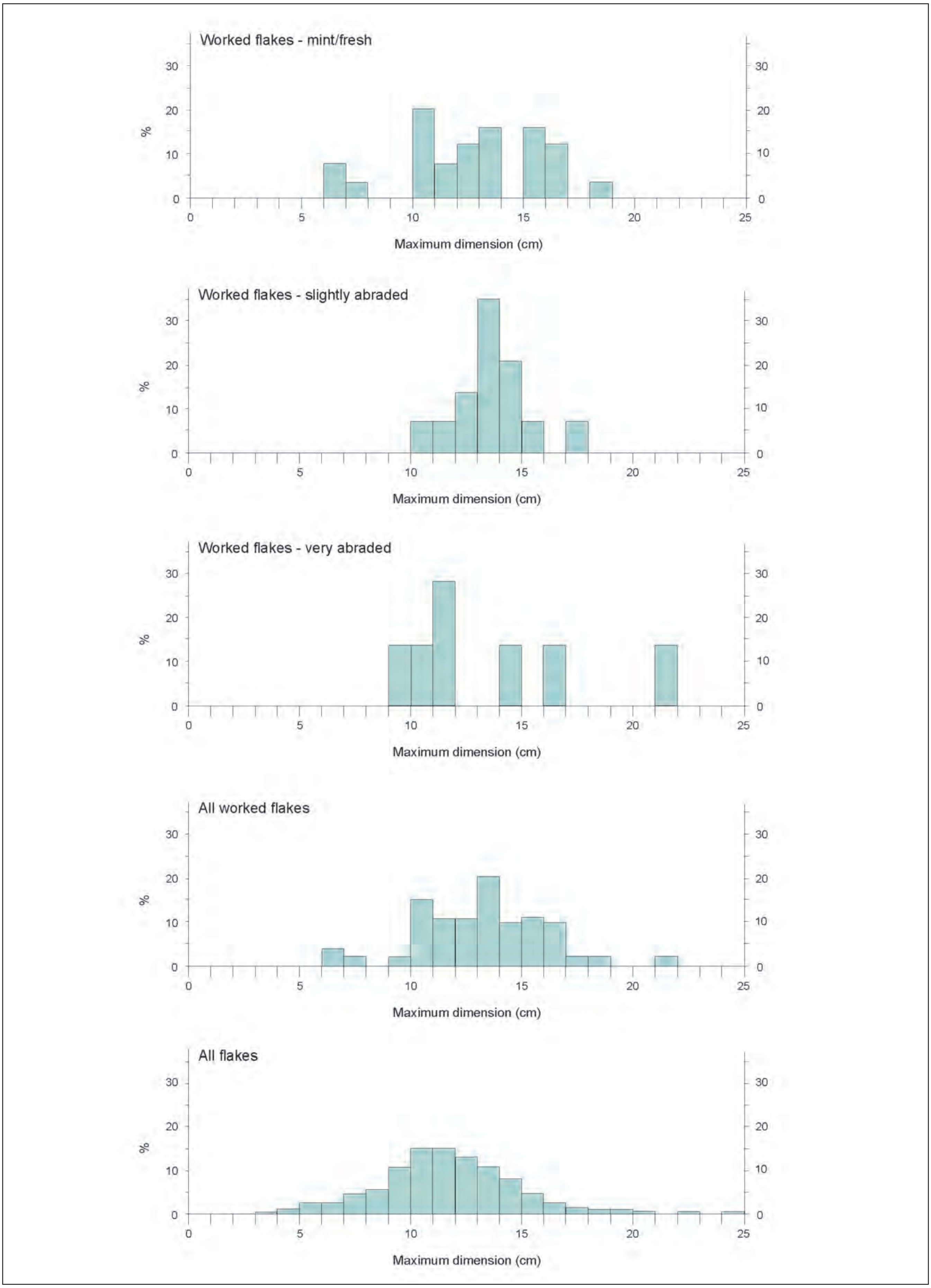


Figure 17.7 Size distributions of flake-tools in the APCM collection

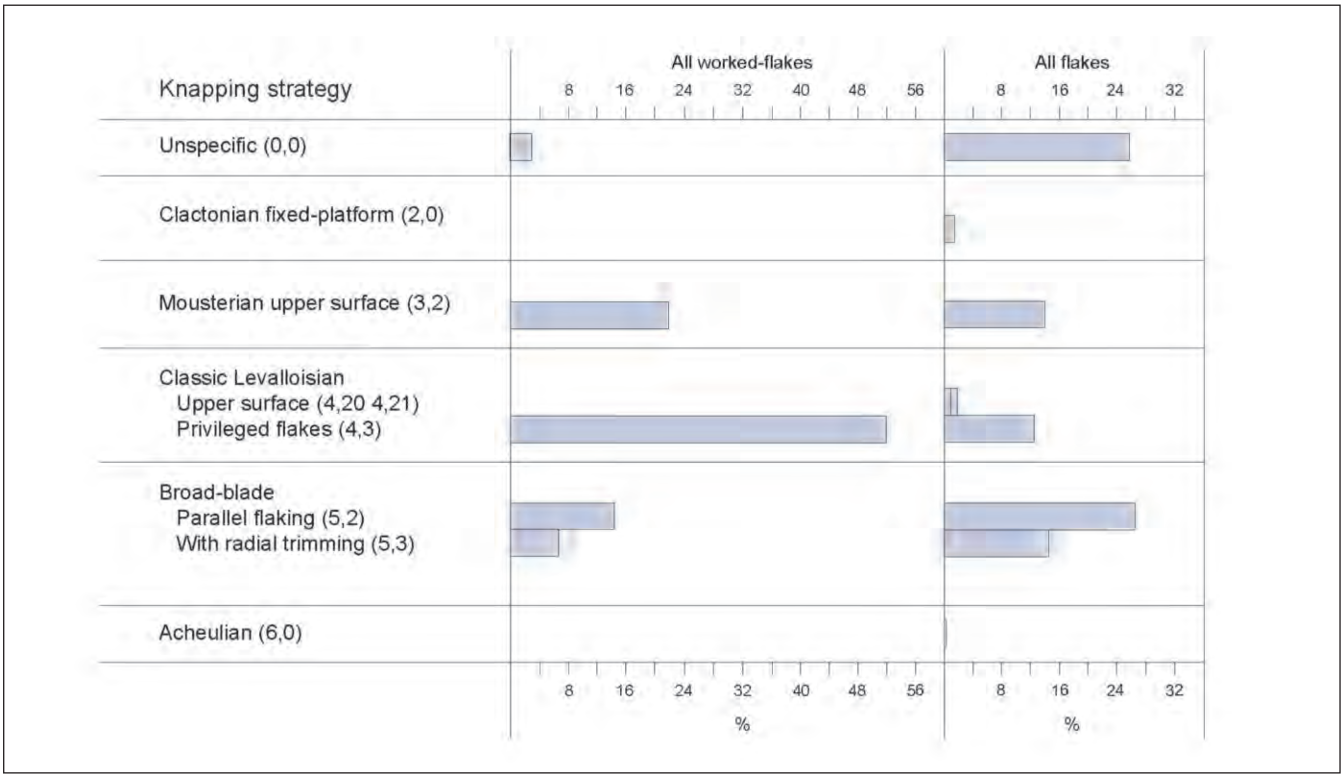


Figure 17.8 Knapping strategies for flake-tool blanks in the APCM collection

an edge for use, and also to blunt parts of a blank to serve as a handle opposite an unretouched sharp edge. As discussed above, the predominant shape of the core-tools was sub-cordate, with a bluntly rounded point with a thick butt, and the condition profile of the sub-cordates in particular closely matches the Levalloisian component of the assemblage. These sub-cordates were generally similar size and shape as the main type of flake-tool recognised here. Thus, the same morphological end-point was evidently being reached by very different pathways, either reduction of a nodule directly to a tool, or production of flake-blanks from a nodule, and then reduction of a blank into a tool.

Organisation of Production and the *Chaîne Opératoire*

Introduction and Methods

Wenban-Smith (1996) carried out a number of analyses to investigate the organisation of the lithic production represented in the APCM archaeological collection, particularly: (a) whether there was a balanced correspondence between the quantities of cores, debitage and Levalloisian end-products; and (b) whether there was any evidence for transport of cores into or away from the site in partly-worked states, represented by a differential representation of debitage from different stages of core reduction. Experimental knapping work was used to develop a comparative model for the quantity and characteristics of flakes from different stages of the different knapping strategies represented in the APCM collection. This was then adjusted to reflect the size profile of the APCM collection, and the model was then compared with the archaeological flake assemblage.

Three different approaches were used: (i) analysis of the absolute quantity of debitage in relation to the cores; (ii) analysis of the ratio of volume of debitage (VD) to its cortical surface area (CA); and (iii) using Canonical Correlation Analysis (CCA) to combine several flake attributes to derive a single canonical function that correlates with reduction order, and therefore can be used to investigate stages of reduction in a debitage assemblage. These different approaches provide a multiple set of independent solutions to investigate the organisational structure of an assemblage.

Debitage Quantities

Table 17.10 compares the ratios of cores (and handaxes) to identifiable debitage in the APCM collection and the experimental model. There are several major discrepancies. Firstly, there should be far more recognisable Acheulian flakes. The observed ratio is

Table 17.10 Comparison of key technological ratios for archaeological case and experimental model

Strategy	Technological ratio	Experimental model	APCM collection
Levalloisian	Classic flakes:cores	2	3.7
	Classic flakes:surf. prep.	3	6.5
	Classic cores:surf. prep.	1.5	1.8
Mousterian	Mousterian flakes:cores	4	6.9
Broad-blade	Broad-blades:cores	15	45.7
Acheulian	Thinning flakes:bifaces	4	0.03

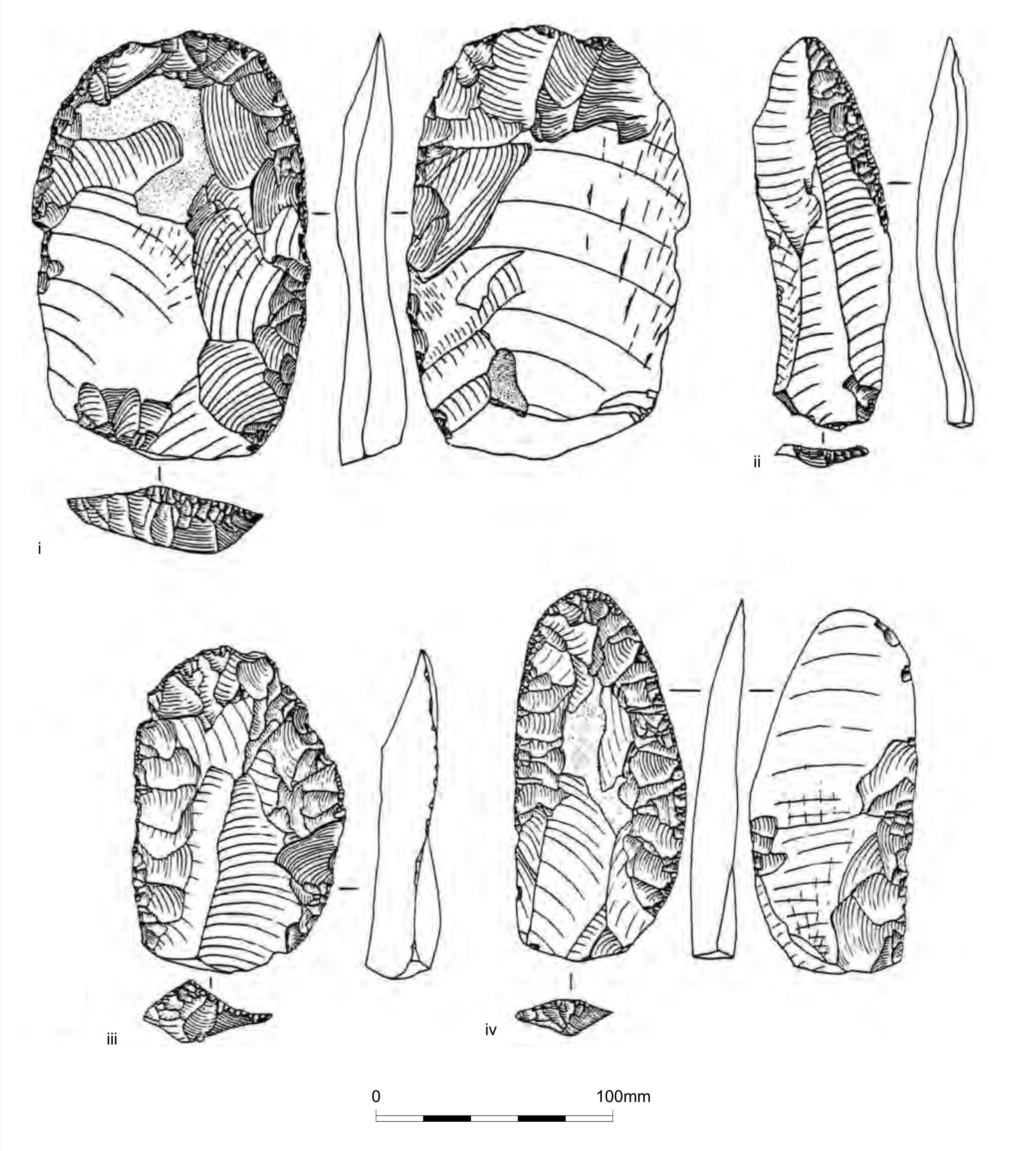


Figure 17.9 The APCM collection: selection of flake-tools: (i) "knife"; (ii) example of localised working: (iii) oval flake with unifacial working; (iv) oval flake with part-bifacial working

roughly 130 times lower than expected which is well beyond the probable range of inaccuracy in the experimental model. This suggests that bifacial manufacture, apart from possibly early stages, was not carried out at the site, and the sub-cordate handaxes regarded as part of the assemblage must have been imported ready-made.

Secondly, there are more Broad-blades than might be expected from the numbers of cores found, with a ratio of almost 46:1. The observed ratio in the APCM collection is triple the prediction of the experimental model. However, the low number of Broad-blade cores in the collection (six) makes the significance of their quantity in relation to the numbers of flakes vulnerable to incomplete sampling. It is also questionable whether sufficient experimental mastery of Broad-blade technique was achieved for this part of the model to be reliable. Long sequences from Crayford, Kent (Scott 2010) suggest that single cores can produce numerous broad-blades. Overall, there is an indication that Broad-blades may be over-represented in relation to the number of cores, but the result is questionable.

The ratio of Mousterian flakes to cores is also higher (at 6.9) for the APCM material than in the experimental model. One possible factor influencing this result is that the experimental study concentrated on unifacial Mousterian cores, whereas half of the ones in the APCM collection were bifacial. The bifacial Mousterian technique would probably produce a higher number of recognisable Mousterian flakes although the same amount of flint would be involved. The ratio of Mousterian flakes to cores therefore looks compatible with the presence of complete reduction episodes.

For Levalloisian production, there are three ratios to examine. The proportion of cores to surface preparation flakes is 1.8, which is similar to the experimental prediction of 1.5. However, the archaeological proportion of Levalloisian flakes to cores is 3.7, which rises to 4.7 when the Levalloisian flakes used as tool-blanks are taken into account. The proportion of archaeological Levalloisian flakes to surface preparation flakes is 6.5, rising to 8.4 when the tool-blanks are included. There appears to be an excess of unworked Levallois flakes in relation to the amount of Levalloisian production at the site, as represented by cores and surface preparation. This could be explained by a high frequency of unrecognised recurrent sequences with 3–4 cycles of Levalloisian production. However, this is unlikely considering the limitations of the size of the flint nodules available, the difficulty of working very large nodules and the size of the Levalloisian flakes themselves (average dimensions: 137 x 84 x 25mm worked, and 127 x 90 x 23mm unworked). The excess of Levalloisian flakes in relation to Levalloisian production is even more marked when the worked Levallois tool-blanks are taken into account. These results suggest that the APCM collection includes unworked Levalloisian flakes and tools made on Levalloisian flakes which have been brought into the site having been made elsewhere.

Debitage Volume in Relation to Cortical Surface Area

There are 43 cores (Mousterian, Levalloisian and Broad-blade) in the APCM collection. The average size of flint nodule collected from the site area for the experimental replication of these knapping strategies was 1650cm³ (with a standard deviation of 216). Using

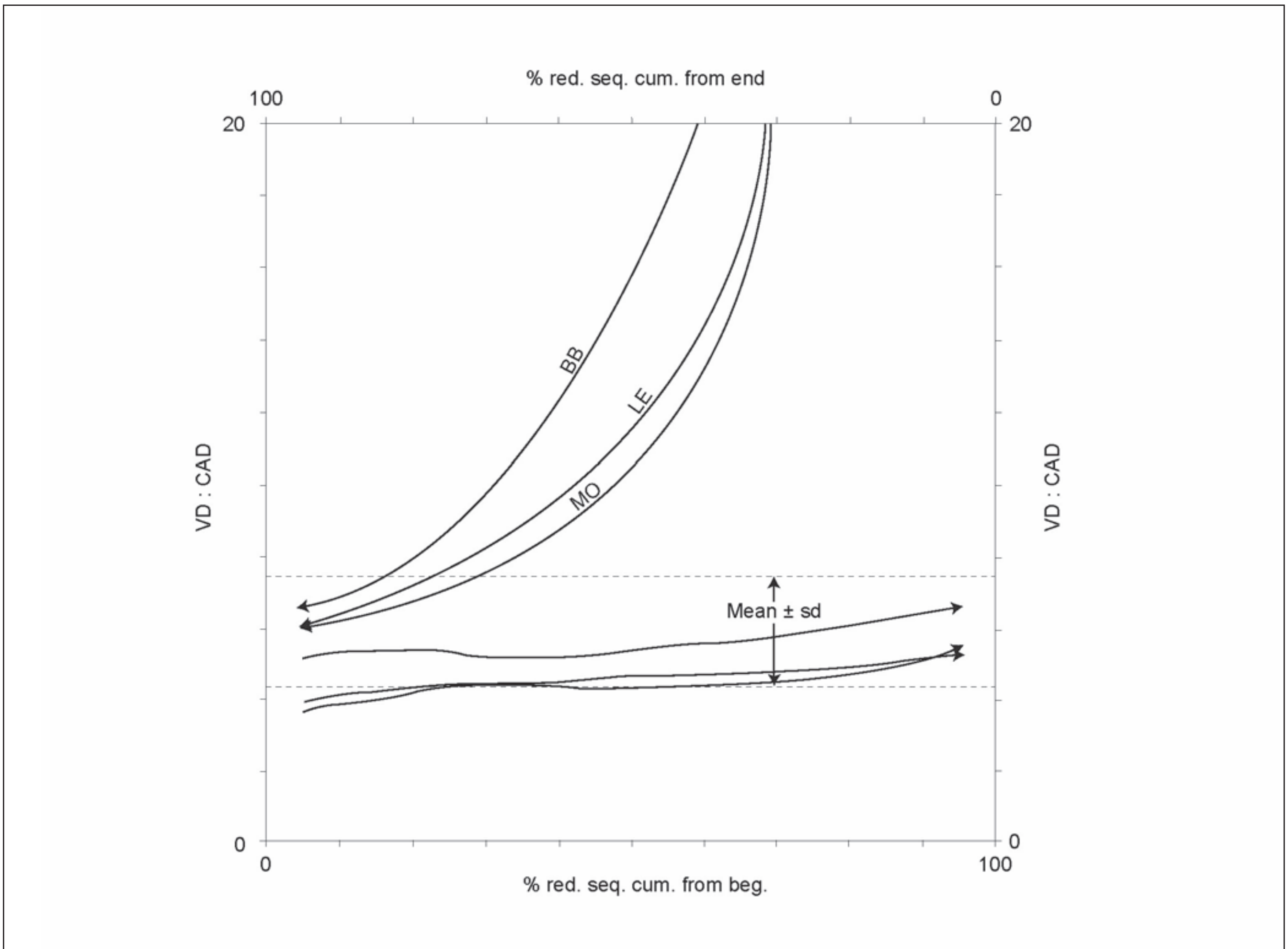


Figure 17.10 Changing ratios of debitage volume (VD) to cortical surface area (CAD) for experimental model of APCM collection; lines represent separate models for Broad-blade production (BB), Levalloisian production (LE) and Mousterian production (MO)

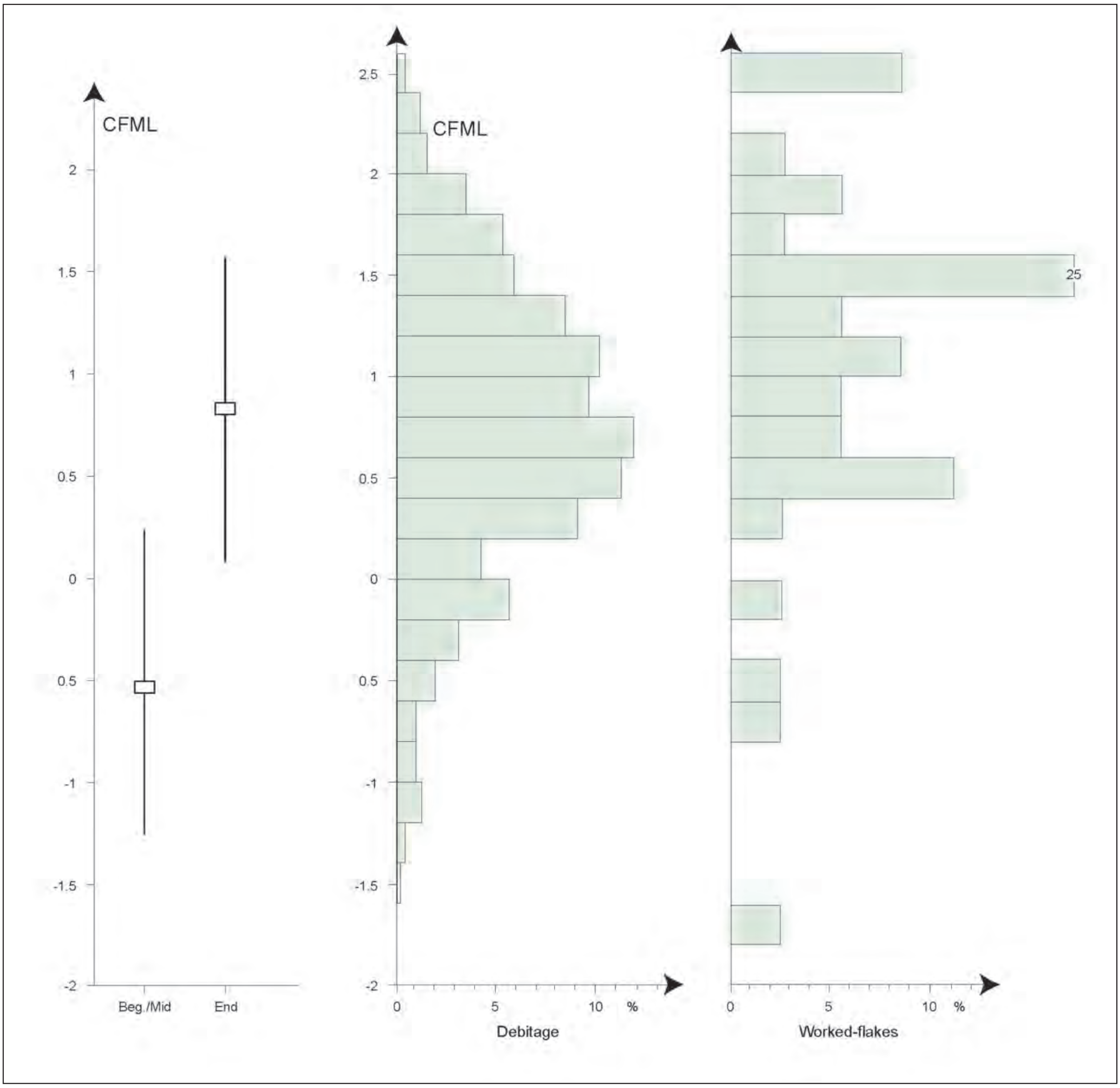


Figure 17.11 Distribution of APCM debitage along canonical function for reduction stage

the figures from the experimental model a total debitage estimated volume (VD) of between 158,000 and 205,000cm³ would be expected if the complete debitage from reduction of these cores was represented in the collection. However, the actual total of VD is 122,792cm³ for the unworked flakes, and 135,173cm³ for worked and unworked flakes combined. This is beneath the expected range, suggesting that the collection does not represent their complete reduction.

The average amount of cortical surface area on the experimental nodules was 756cm² (with a standard deviation of 140), leading to an expected range for estimated cortical debitage area (CAD) for the complete debitage recovery from the 43 cores of the ACPM collection of between 25,000cm² and 36,000cm². However, the actual CAD in the APCM collection is 5136cm² for the unworked flakes, and 5438cm² for worked and unworked flakes combined. This is well beneath the expected range for a complete assemblage, again suggesting: (a) that the associated debitage assemblage does not represent the complete reduction of the cores; and (b) that the debitage is dominated by material from the later stages of reduction, as these have been shown to be more lacking in cortex.

Experimental work (Wenban-Smith 1996, 129, fig 3.27) has shown that the ratio VD:CAD for an assemblage of debitage behaves predictably in relation to the stages of reduction represented. In the APCM collection, the ratio VD:CAD for the unworked flakes is 23.9, for the worked flakes is 40.9, and for the worked and unworked flakes combined is 24.9. These ratios are well above the average range of 4–8 for a complete assemblage (Fig 17.10), confirming that the collection is dominated by the later stages of reduction, and suggesting an assemblage dominated by debitage from the last 25–30% of reduction. Robinson (1986, 20) also pointed out that 'cortical flakes are notable by their near absence'. The key question (discussed further below): is this absence an organisational property of the assemblage reflecting hominin behaviour, or is it due to taphonomic or collection biases?

Distribution Along Canonical Function

The final analytical technique developed for interpreting the stage of reduction of the debitage assemblage was the derivation of a tailor-made canonical function for the knapping strategies represented. This canonical function (CF-ML) excluded Broad-blade debitage as there was no suitable experimental material to work from. Therefore, the Broad-blade element of the APCM assemblage was excluded from this part of the analysis. Details of the derivation of the canonical function are given in Wenban-Smith (1996). In summary, it was demonstrated by experimental work that three flake attributes "TEN" (no. dorsal scars >10mm), "PERCOR" (percentage of dorsal surface area covered by cortex, estimated to nearest 5%) and "TPA" (TEN/surface area) all contributed to development of a function that could reasonably reliably distinguish between debitage from beginning/middle and end stages of reduction.

Figure 17.11 shows the distributions for the APCM flakes (unworked and worked) compared with beginning/middle and end stage ranges for the experimental model. It can be seen that the peak of the APCM distributions occurs within the domain of the later stages of reduction, suggesting a strong over-representation of debitage from the end stage of reduction. When the Broad-blades (261 of them unworked, and 10 worked) are taken account of, this imbalance is even more marked.

Organisational Results

Overall, the different approaches to investigating technological organisation show a consistent picture of an assemblage disproportionately dominated by the end-products of Levalloisian, Broad-blade and Mousterian reduction, most of which are unworked but a sizeable number of which are worked into flake-tools. In contrast, there was minimal evidence for the manufacture of handaxes or for the working of flakes into tools, despite the high frequency of large flake-tools and handaxes themselves.

The presence of some minimally worked cores and debitage from early stages of knapping show that some reduction sequences were started at the site, but the marked over-representation of flakes from the end-stages of Levalloisian, Mousterian and Broad-blade production suggests that these were usually imported into the site, with the actual knapping having been done elsewhere. The small amount of evidence for handaxe and flake-tool manufacture at the site suggests that these tools were usually made away from the site and were then imported, although the absence of smaller debitage in the collection would affect these elements disproportionately. The very marked over-representation of later stages of reduction is probably the reflection of a pattern of behaviour in which these elements were accumulating in a small way, whose effect has been magnified by stability over a long period of time.

The APCM Collection: Discussion and Conclusions

The technological analysis of Smith's Baker's Hole assemblage confirmed the prevalence of the Classic Levalloisian knapping strategy, accompanied by numerous flake-tools made on Levallois flakes. There was also a significant presence of Broad-blade knapping technology, and a minor presence of handaxes. The presence of handaxes has been noted before but they have usually been regarded as derived. While several are no doubt of derived origin, it is suggested here that the more sub-cordate forms in particular should be regarded as associated with the Levalloisian production. The similarity between the most common shape of the flake-tools and the most common shape of the handaxes also suggests they are both the product of the same cultural group, implementing contrasting core-tool and flake-based knapping strategies to arrive at the same tool outcome. The reason for this variety is not clear, but the Levalloisian approach may have developed as a strategy for dealing with large globular flint nodules that are common in the Chalk bedrock of the Ebbsfleet Valley, and which are very difficult to flake bifacially into a core tool.

The prevalence of Broad-blade technology is mostly represented in the debitage although there are some previously unrecognised typical Broad-blade cores in the APCM collection. The presence of Broad-blade technology in the late Middle Pleistocene of Britain has been known since the 19th century as a result of Spurrell's work at Crayford, Kent (Spurrell 1880a; b). It has subsequently become recognised as common in this period across NW Europe (Révillion and Tuffreau 1994), and the evidence from the Ebbsfleet Valley fits in with this pan-NW European pattern. Long-standing culture-historical frameworks that pigeon-hole assemblages into one of a restricted number of industrial variants, such as Acheulian or Levalloisian, have therefore served to obscure the variety and complexity of "Archaic" lithic technology.

The organisational analyses of this assemblage show a strong and consistent trend for the over-representation, in relation to the amounts of debitage and cores, of: (a) tools, including both handaxes and worked-flakes; and (b) Levallois flakes. There is virtually no evidence of handaxe-manufacture or of secondary flake-working. There is some evidence of debitage from the early stages of reduction, but in general there is a strong over-representation of debitage from later stages of production. These apparent patterns may, however, be influenced by selective collection of larger and presumed-more-informative pieces, or by subsequent discard of pieces deemed uninformative at the analytical stage.

The organisational evidence apparently suggests Archaic hominins foraging across the surrounding landscape, making flake-blanks and working them into tools at certain locations, and then carrying the blanks and tools around with them until they were discarded at sites such as the Chalk Spur that was later quarried as Southfleet Pit. The APCM collection thus, although including cores and some debitage from early stages of reduction, seems to represent the site as a focus of tool-use and resource exploitation that was repeatedly provisioned with an influx of tools and flake-blanks. Ironically this is the reverse interpretation to that offered by Smith in 1911, who saw the site as a factory site from which tools were usually exported. The local topography would have made the site a natural choice for a local base. It was on a chalk promontory overlooking the alluvial floodplain of the Thames Valley, within a loop of the ancient Ebbsfleet. Flint raw material would have been locally available if required, although the lithic evidence from the site suggests that lithic provisioning was usually embedded in foraging further afield. A corollary of this model for behavioural organisation would be smaller sites scattered in the surrounding landscape dominated by the early stages of reduction and cores. A few such sites dating to the late Middle Pleistocene have been found, for instance in southern England (Lion Pit Tramway Cutting – Bridgland 1994) and northern France (Hermies – Masson and Vallin 1993).

Chapter 18

Palaeolithic – Burchell's "Ebbsfleet Channel" Lithic Collection

by Francis Wenban-Smith

Introduction

As previously discussed (Chaps 2 and 6), Burchell collected artefacts from various sites in the Ebbsfleet Valley, the location of only one of which is known in the present day (Site B in this synthesis). The artefacts were mostly collected in the 1930s and given to various museums between 1932 and 1961. Most of them are now in the British Museum (Franks House), although others are at the Cambridge University Museum of Archaeology, Maidstone Museum and Ipswich Museum. Most of the surviving artefacts are provenanced to one of the horizons identified by Burchell in his work, although the reliability of these provenance attributions needs careful consideration (Chap 6). In total, 947 provenanced artefacts were relocated and studied, and Burchell's myriad of provenances were conflated into a simplified stratigraphic scheme, with nine assemblages forming the Burchell (BUR) collection (Table 18.1). The richest assemblages were Group 7 ("Upper Solifluction"), Group 5 ("Temperate Bed") and Group 2 (Lower Gravel, including all material attributed to "floors" between the Lower and Lowermost loams at his Ebbsfleet Channel sites A and B).

The amino acid dating and faunal analyses (Chap 16) have combined to suggest that the main horizons associated with the Group 2 assemblage probably date to early in MIS 7, probably in the period MIS 7e/7d, and that the Temperate Bed relates to a later sub-stage in MIS 7, probably MIS 7a. It is however questionable whether the archaeological material linked to the Temperate Bed is contemporary with its formation, or whether it is reworked from earlier deposits.

The same classificatory methods and framework were applied as for the APCM collection (Chap 17).

Overview and Integrity

The quantities of artefacts of different technological categories in each of the main stratigraphic groups are tabulated (Table 18.2). Most are unworked flakes, although the large assemblages from Groups 2 and 5 include several cores, core-tools and worked-flakes. The conditions of the artefacts from each category in each group are also summarised (Table 18.3). The integrity of the assemblage from each group has been assessed by reference to its condition and size-profile, and by use of refitting. The assemblages from all groups are dominated by abraded artefacts, although the larger assemblages from Groups 2 and 5 have higher proportions of fresh and mint condition artefacts than the other groups; in particular, a higher proportion of flakes and cores from Group 2 are in mint condition.

Table 18.1 Stratigraphic provenance of BUR collection

Group	Group name	Burchell horizon name	No. artefacts
8	Modern	–	–
7	Upper Solifluction	Upper Trail/Coombe Rock Uppermost Loam Cailloutis Lower Trail/Coombe Rock	59
6	Calcareous Loam	Calcareous Loam	–
5	Temperate Bed	Temperate Bed	156
4	Middle Loam	Upper Middle Loam	17
4c	Orange Band	Middle Coombe Rock	
4b	Upper Middle Loam	Lower Middle Loam	
4a	Lower Middle Loam		
3	Solifluction Gravel	Meltwater gravels (above bank of Ebbsfleet channel)	–
2	Lower Gravel – "floors"	Lowermost Loam (surface) Lower Gravels Gravel between Lower and Lowermost Loams Mid. Moustier floor Lowermost Loam Lowermost Loam (base)	693
1b	Meltwater gravels	Meltwater gravels (in base of Ebbsfleet channel)	13
1a	Coombe Rock	Coombe Rock	9
		Total	**947**

Table 18.2 BUR collection, technological categories by stratigraphic group

Category	Group 1	Group 1b	Group 2	Group 4	Group 5	Group 7	Total
Core	1	–	19	–	3	–	**23**
Core-tool	–	–	4	–	5	3	**12**
Flake	8	13	663	16	142	56	**898**
Flake-flake	–	–	1	–	–	–	**1**
Worked-flake	–	–	6	1	6	–	**13**
Total	**9**	**13**	**693**	**17**	**156**	**59**	**947**

Table 18.3 BUR collection, conditions of artefacts from main stratigraphic groups; percentages are given for groups 2 and 5 as proportions of artefacts in particular conditions (see Table 17.6 for condition criteria)

Group	Category	Mint	Fresh	Slightly abraded	Very abraded
7	Core-tool	1	1	1	–
	Flake	1	4	26	25
5	Core	–	–	2	1
	Core-tool	–	1	4	–
	Flake	4	27	62	49
	Worked-flake	–	4	1	1
4	Flake	1	6	4	5
	Worked-flake	–	1	–	–
2	Core	5	1	10	3
	Core-tool	–	1	3	–
	Flake	50	158	238	217
	Flake-flake	1	–	–	–
	Worked-flake	–	4	1	1
1b	Flake	–	1	9	3
1a	Flake	–	2	3	3
	Core	–	–	1	–

Table 18.4 Refitting groups, BUR collection (* actual refits; + core; other artefacts listed have such similar cortex and raw material that it is suggested they belong with the respective sets of refitting material)

Refitting Group	Museum Registration	Condition	Burchell's detailed provenance
RG 1	1961,7-5:667 *	1	2 yellow dots, "A"
	1961,7-5:662 *	1	2 yellow dots, "B"
	1961,7-5:415	2	–
	1961,7-5:251	1	"L. Gvl. E. Ch."
RG 2	1961,7-5:236 *	1	Lower Gravel Ebbsfleet Channel
	1961,7-5:673 *	1	2 yellow dots, "A"
	1961,7-5:427 +	1	Lower Gravel Ebbs. Ch.
	1961,7-5:141	1	–
	1961,7-5:671	1	2 yellow dots, "A"
	1961,7-5:137	1	–
RG 3	1961,7-5:247 *	1	–
	1936,7-9:26 *	1	–
	1961,7-5:322	1	Lower Gravel Ebbs. Ch.

Group 1

The flakes from Group 1a (Coombe Rock) need not have been moved far from their original place of manufacture despite their mostly abraded condition as the chalk rubble constituting the Coombe Rock probably originated nearby. However, the small size of the assemblage makes it unhelpful for investigating the organisation of production. The flakes from Group 1b (Meltwater gravel) are also mostly in abraded condition. They are likely to have been derived from the Coombe Rock.

Group 2

The assemblage from Group 2 is large enough, and includes enough mint and fresh material, to justify organisational as well as technological and typological investigation. However, it is necessary to consider what depositional processes are involved, and whether the more-abraded material can be amalgamated with the fresher material. Although the reported presence of *Bithynia* suggests a fluviatile origin for the loams above and below the gravel that contained the "floors" of lithic material, we have no data for the floors themselves apart from the presence of mint and fresh condition lithic material, which suggest a low energy depositional environment and a minimum of disturbance. However, the presence of more-abraded artefacts, in a gravel also reported by Burchell as including larger nodules, suggests periods of high-energy deposition during which material could have been gathered from further afield or the formation of gravels by other means such as slopewash. The degree of disturbance of the material was investigated by attempting to refit it, and by comparative analysis of the size-profiles.

Three groups of refitting artefacts were found, each group consisting of a pair of flakes, and each representing different flint nodules (Fig 18.1). As well as the actual refits, each group could be linked with other artefacts showing distinctive raw material characteristics allowing them to be identified as likely from the same reduction sequence. The condition, registration numbers and detailed stratigraphic provenance of these groups of artefacts are summarised below (Table 18.4). Burchell stuck either one or two yellow paper dots on various artefacts from his "floors", although there is no record of what he meant by them. Artefacts with two dots are generally inked in Burchell's writing as from "Between lowermost and lower loams", and those with single dots as from the "Middle Moustier floor". He also labelled many of the double-dotted flints with "A" or "B". This likewise is nowhere explained, but one could reasonably postulate that these designations corresponded with his "Channel A" and "Channel B" sites, as labelled in his stratigraphic diagram (Fig 2.12). Finally, Burchell wrote context details on some of his flints – eg, "Lower Gravel Ebbsfleet Channel"; "Lower Gravel Ebb. Ch."; and "L. Gvl. E. Ch." – which are self-explanatory, although utterly dependent upon Burchell's field interpretation, or subsequent revisions thereof.

The first refitting group (Fig 18.1, RG 1) has two artefacts, both in mint condition, and both with double dots, but one labelled A and the other B. The two extra artefacts thought to be associated are flakes in mint and fresh condition respectively, with the mint flake labelled "L. Gvl. E. Ch.". The two refitting artefacts for the second refitting group (Fig 18.1, RG 2) are also both in mint condition, one with a double dot and labelled A, and the other just inked with "Lower Gravel Ebbsfleet Channel". The four additional artefacts thought to be associated, including one core, are all in mint condition; two of them are unlabelled, and the other two have the same info as the two refitting pieces. The two refitting artefacts for the third group (Fig 18.1, RG 3) are also both in mint condition. Neither is otherwise labelled, although both are in the part of the collection generally attributed to Burchell's "Lower Gravel", presumably following information directly received from Burchell when the material was donated. The additional artefact thought to be associated with RG 3 is also in mint condition, and inked by Burchell with "Lower Gravel Ebbs. Channel".

The positive results of the refitting study confirm that the mint material represents undisturbed knapping debris, and suggest that this may also be the case for much of the fresh material, as one fresh condition artefact is related with a refitting group. The small number of refitting groups discovered, and the low number of refitting pieces in each, is easily explained by the piecemeal nature of Burchell's collecting and the fact that the material studied (comprising only the collection held at the British Museum) only represents a sample of what he collected. The diversity of provenances within the refitting groups confirms that the double dot A and B material can (a) be grouped together and (b) can be grouped with more generally provenanced "Lower Gravel" material. Therefore, there is no benefit in sub-dividing the Lower Gravel assemblage into smaller sub-assemblages following Burchell's more specific provenances. Since there were no refitting links with abraded artefacts, the only evidence to assess their depositional provenance in relation to the fresher material was their size-profile.

The size-distributions for flakes in each of mint, fresh, slightly abraded and very abraded conditions are compared here (Fig 18.2). Even the mint material does not have the characteristic profile of complete undisturbed debitage (Wenban-Smith 1996, section 3.9) but this is probably due to incomplete collection. It can be seen that material in each condition covers a similar range. The wide range of debitage sizes suggests a little-moved assemblage. The damage on individual artefacts need not reflect movement downstream of that artefact, but could reflect internal movement of the deposit during the 200,000+ years of burial leading to artefacts grating against other or other gravel clasts.

Overall, given the likely small size of the Ebbsfleet in the past, and the location of the site in an embayment formed within an abandoned channel (Chap 16) it is not likely that any elements of the Group 2 assemblage have come very far. It could include some material derived from the underlying Coombe Rock. If these were numerous, they would distort the organisational analysis as evidence of two sets of behaviour at the same place but associated with a different climatic, topographic and geographic environment would be mixed. This material would most likely be in worse condition. Therefore, in the following organisational analysis the mint and fresh material is taken as one group (U2I), and the slightly and very abraded material is taken as another group (U2II). Group U2I is therefore securely associated with

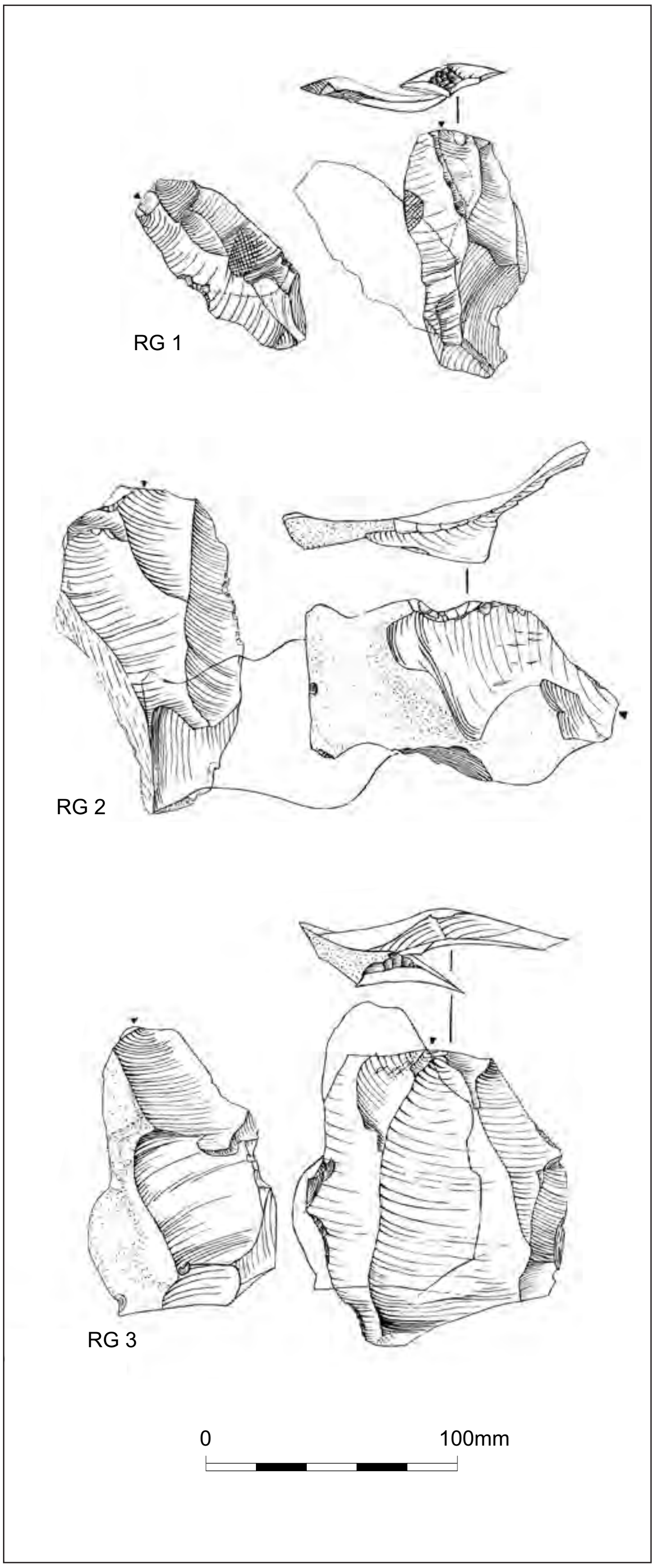


Figure 18.1 Refitting artefact groups RG1–RG3 from Burchell's lower gravel "floors"

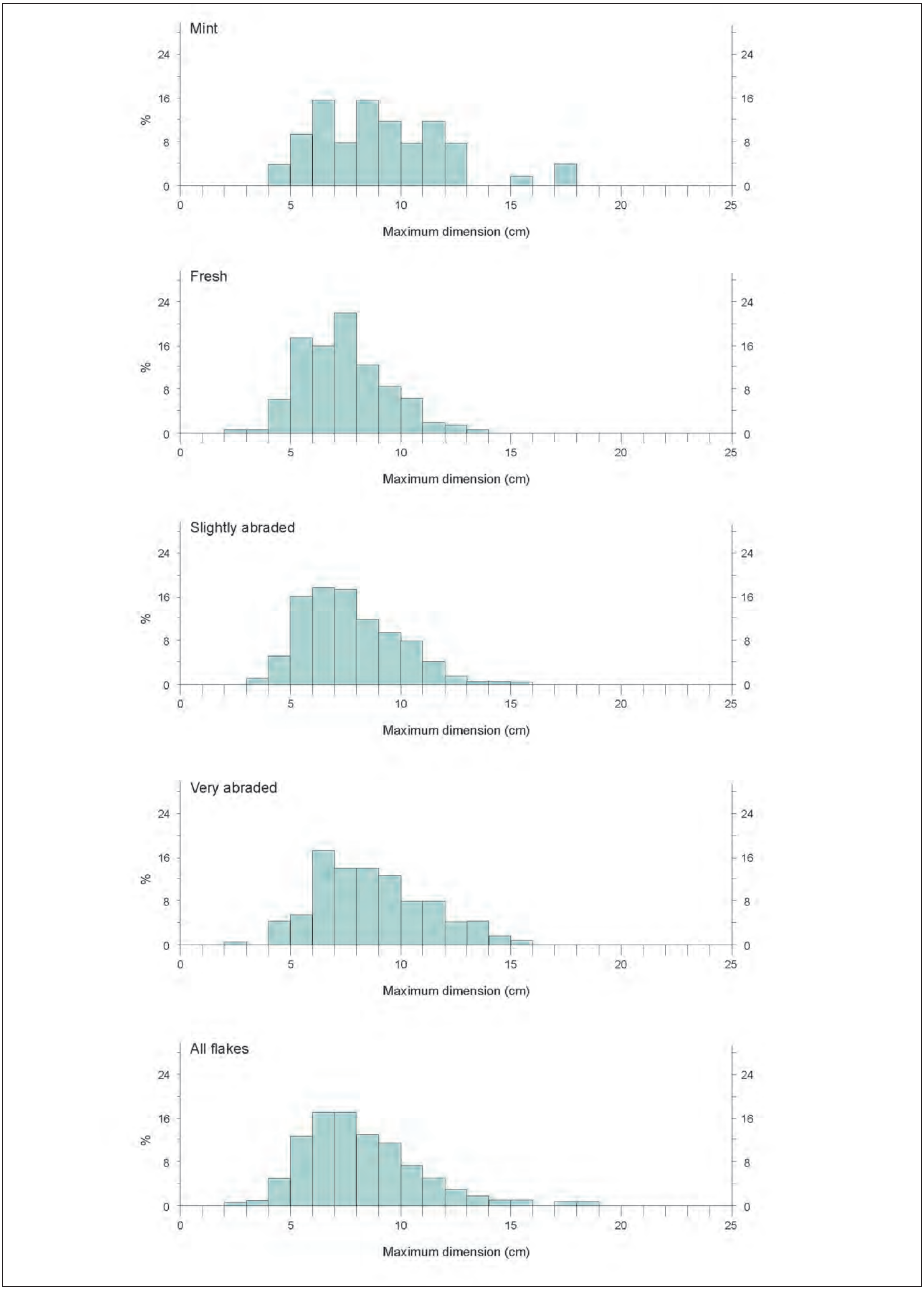


Figure 18.2 Size distributions of Group 2 flakes in different conditions

Table 18.5 Knapping strategies of cores in BUR collection for group 2 (lower gravel, including "floors") and group 5 (Temperate Bed) (see Table 17.6 for condition criteria)

Group	Knapping strategy	Mint	Fresh	Slightly abraded	Very abraded	Total
5	Unspecific	–	–	1	1	**2**
	Broad-blade, non-radial	–	–	1	–	**1**
2	Unspecific	–	–	1	–	**1**
	Clactonian, fixed-platform	1	–	–	–	**1**
	Mousterian, unifacial	1	–	2	–	**3**
	Classic Levalloisian	–	–	1	2	**3**
	Broad-blade, non-radial	3	1	5	1	**10**
	Broad-blade, radial	–	–	1	–	**1**
1a	Mousterian, unifacial	–	1	–	–	**1**

the deposition of the Lower Gravel and Burchell's Levalloisian floors, whereas Group U2II may include material derived from further afield and from the underlying Coombe Rock.

Group 4

The assemblage from Group 4 (Middle Loam) is unlikely to be undisturbed, else it would all still be in mint condition. The condition of the artefacts suggests they have been derived from the Coombe Rock or Solifluction Gravel above the bank down which the Middle Loam was slipping/washing before accumulating in the Ebbsfleet Channel. The small size of the assemblage precludes organisational analysis, and the material is all likely to be derived from pre-existing deposits.

Group 5

Refitting was attempted for the assemblage of 156 artefacts from Group 5 but no refits were found. In contrast to Group 2, Group 5 has originated from the homogenous sandy silt of the Temperate Bed, reflecting (in conjunction with its faunal evidence) a stable low-energy fluvial depositional regime. The deposit also contains occasional horizons of larger chalk and flint clasts showing evidence of frost-fracture, abrasion and patination indicating exposure to the elements over a long period of time. The most likely explanation for these is that they have slid down into the river over its banks. Combined with the low number of artefacts in mint condition and the lack of refitting, Group 5 is taken as a mixed assemblage of uncertain integrity. Therefore, an organisational analysis was not carried out. However, the assemblage was sufficiently large for it to seem worth splitting into two conditional groups for technological analysis of the debitage, Group U5I for mint and fresh debitage and Group U5II for slightly and very abraded debitage.

Group 7

The assemblage from Group 7 (Upper Solifluction) has 59 artefacts. However, this group is an amalgamation of four different deposits recorded at different times and different sites by Burchell during the 1930s: the Upper Trail and Coombe Rock, the Uppermost Loam, the Cailloutis, and the Lower Trail and Coombe Rock. Burchell failed to record enough information for these deposits to unravel their possible correlations with each other. As a group, they represent material from slopewash deposits capping the Temperate Bed. It is uncertain, however, whether they represent occupational evidence subsequent to formation of the Temperate Bed, or reworked material from earlier times. The generally abraded condition and small quantities of artefacts in each deposit make the assemblage unsuitable for organisational analysis.

Technology and Typology

Cores

Burchell's collection included 23 cores, one from Group 1a and the rest from Groups 2 and 5 (Table 18.5). The core from Group 1a is a typical unifacially worked Mousterian disc core. Group 2 is dominated by neat Broad-blade cores (Fig 18.3, 1947 5-2 92 and 94) including one showing some radial trimming (Fig 18.3, 1947 5-2 93); they are in a variety of conditions including three in mint condition, and comprise more than half the total. The next commonest type of core is unifacial Mousterian of which there are three, including one mint example, which probably represents the same nodule as the two flakes of Refitting Group 2. There are two very abraded classic Levalloisian cores, which may be derived from the underlying Coombe Rock as Burchell specifies that they were found at the base of the lowest part of the gravel filling the Ebbsfleet Channel, which was cut into the Coombe Rock, and the APCM collection made from similar Coombe Rock has shown that it is rich in classic Levalloisian material. There is also one slightly abraded core classified as Levalloisian on the basis of its large central negative flake scar (Fig 18.3, 1948 12-2 1). There are also single examples of a globular core of no particular strategy, and a small crude uni-pyramidal core flaked from a fixed platform.

Group 5 has only three cores: two unspecific and one Broad-blade. One of the unspecific cores is a very abraded and frost-fractured piece of a nodule from which only a single flake has been removed. This probably represents its testing and rejection, and it is

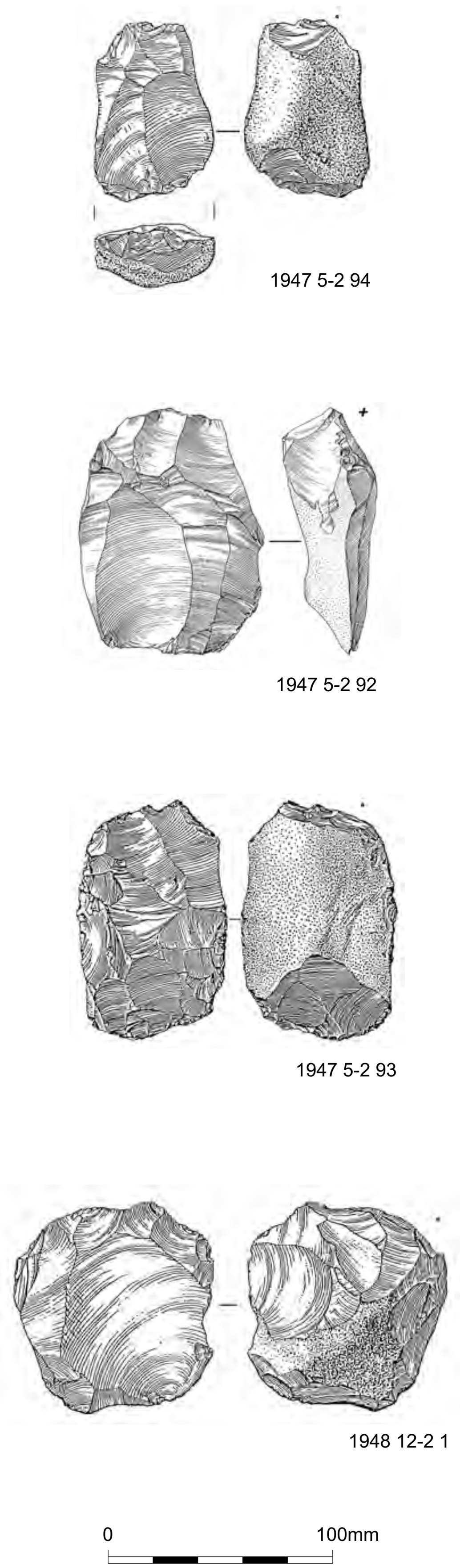


Figure 18.3 Selection of cores from Burchell's Ebbsfleet Channel collection (1947 5-2 92 is a drawing by Waterhouse in the British Museum; the other drawings are from Coulson 1990)

Table 18.6 Handaxes in BUR collection for group 2 (lower gravel, including "floors"), group 5 (Temperate Bed) and group 7 (Upper solifluction) (see Table 17.6 for condition criteria)

Unit	Handaxe type	Mint	Fresh	Slightly abraded	Very abraded	Total
7	Pointed biface	–	1	1	–	**2**
	Cleaver	1	–	–	–	**1**
5	Non-classic biface	–	–	3	–	**3**
	Pointed biface	–	1	1	–	**2**
2	Non-classic biface	–	1	2	–	**3**
	Pointed biface	–	–	1	–	**1**

also probably derived from older deposits. The other unspecific core is a broken piece too small for a knapping strategy to be identified. However, the third core is a slightly crude and abraded example of non-radial Broad-blade production.

Core-tools (Handaxes)

There were 12 core-tools, or handaxes in Burchell's collection, from three different stratigraphic groups (Table 18.6). The handaxes from Group 2 (Fig 18.4) are mostly asymmetric enough in both plan and cross-section to be labelled as non-classic, although one of them is quite large and could alternatively be construed as a large bifacial Mousterian core. The handaxes from Group 5 are a similar mix of non-classic and sharp-pointed forms (Fig 18.5). The pointed forms were probably the basis for Burchell's (1957) recognition of a Micoquian floor at the base of the Temperate Bed, these broadly corresponding with the typical Micoquian shape as understood at that time (see Roe 1981, 129). Group 7 has two more tiny and neatly symmetrical pointed handaxes, as well as a bifacial object attributed as a cleaver (Fig 18.5, 1947.5-2.114). Overall there is a small but persistent bifacial element in Groups 2 and 5, mostly asymmetric forms over which little care was taken, with the exception of some very small handaxes and neatly pointing examples. The fresh or mint condition of several would seem to suggest they are not derived. Their low numbers suggest that their absence from the other groups may well be a factor of sampling, and does not mean that they were not part of the technological repertoire. Some of the more abraded material may, however, be reworked from the older, MIS 11 deposits that proliferate in the Swanscombe area.

Debitage

Burchell's collection contained 899 unworked pieces of debitage, comprising 898 flakes and one flake-flake. The flake-flake came from Group 2 and is quite large, in mint condition, and shows scars from the removal of other flake-flakes. It appears to represent the working of a large flake into a bifacial flake-tool. The large flake-assemblages from Groups 2 and 5 were both sub-divided into two groups for analysis, I (mint/fresh) and II (slightly/very abraded). The flake-assemblages from the other groups were mostly abraded and were too

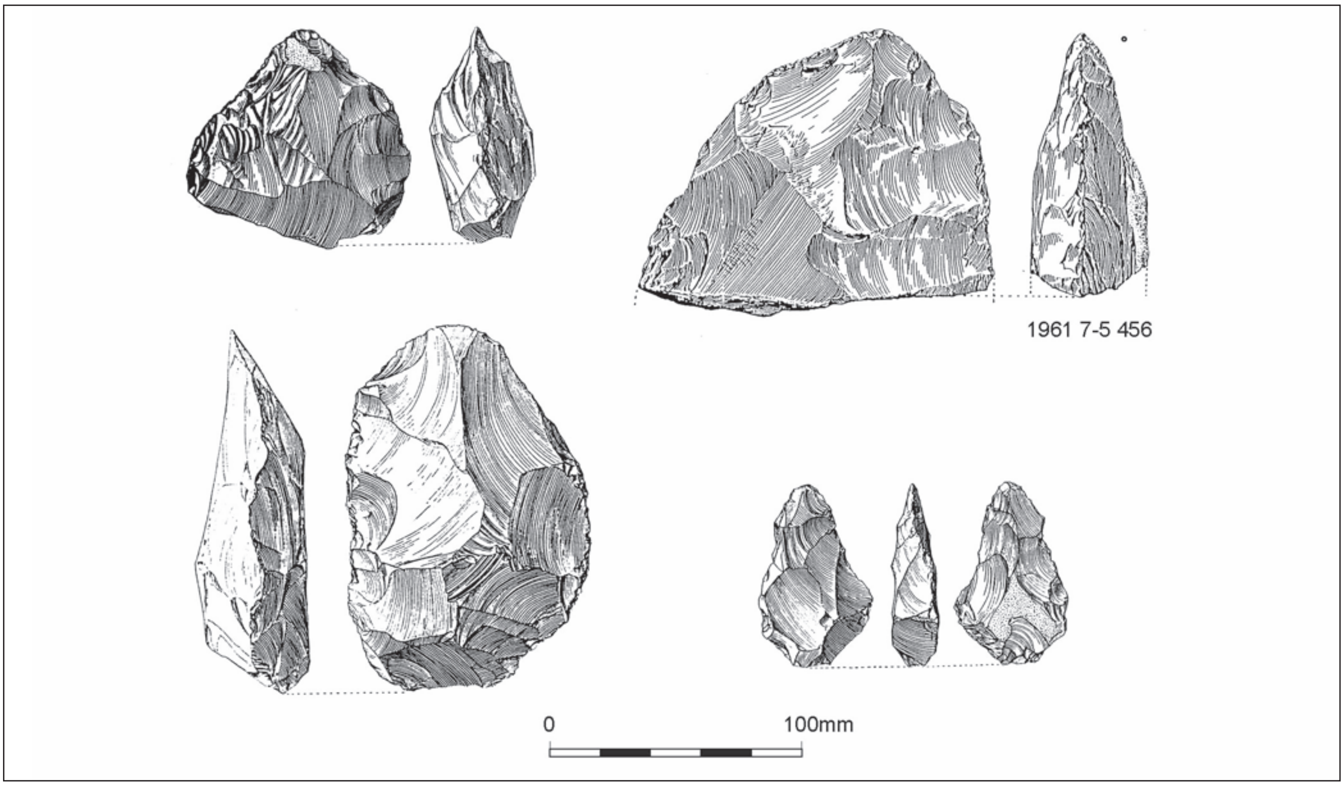


Figure 18.4 Handaxes from Group 2 (lower gravel, including "floors")

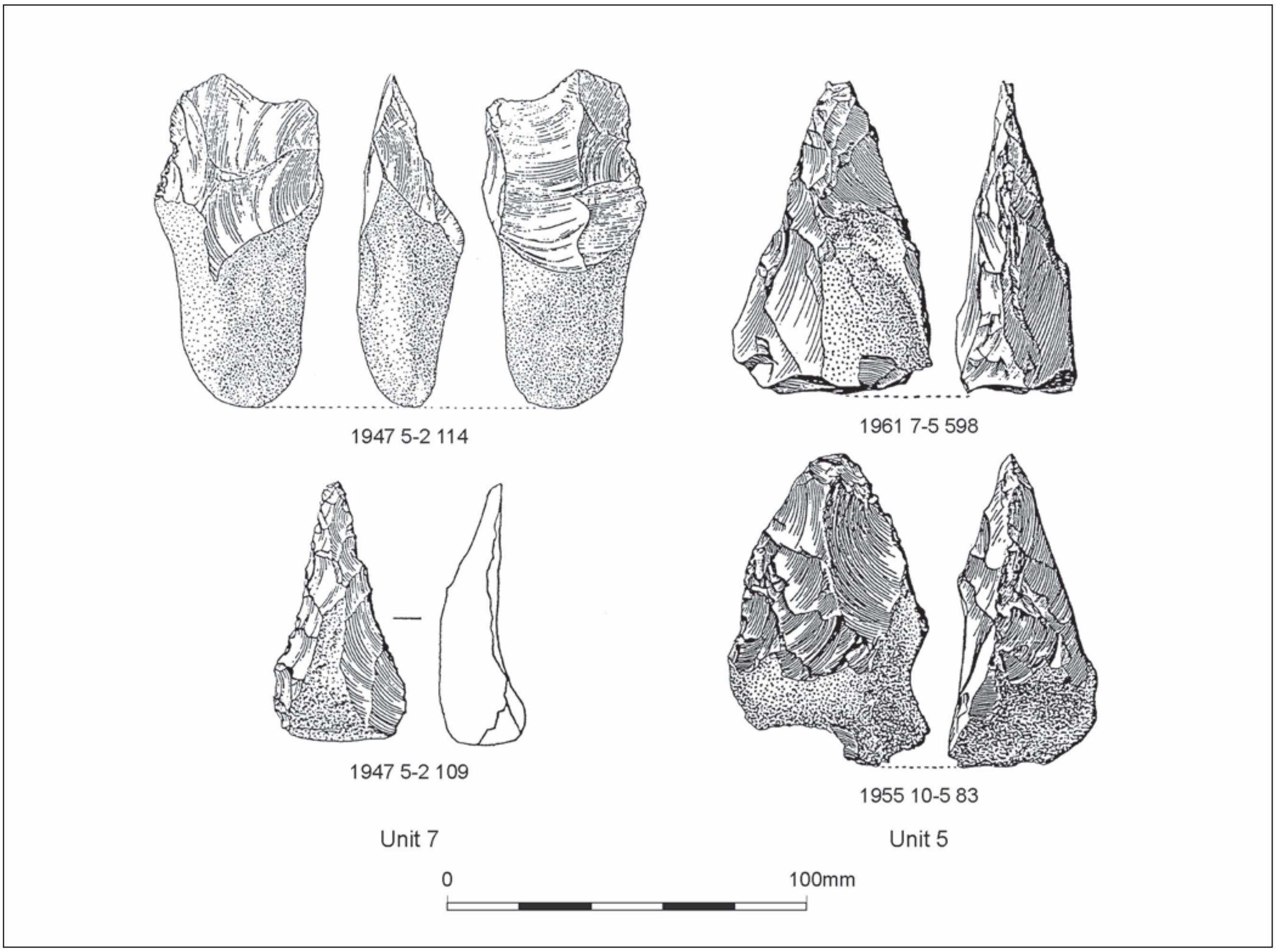


Figure 18.5 Handaxes from Groups 5 and 7

Table 18.7 BUR collection, technological attribution of flakes from Groups 1 (Coombe Rock), 4 (Middle Loam) and 7 (Upper solifluction)

Knapping strategy	Group 1a	Group 1b	Group 4	Group 7
Unspecific	1	11	13	50
Clactonian				
mixed-platform	–	–	2	5
Mousterian				
upper surface	1	–	–	–
Classic Levalloisian				
upper surface (4,20/21)	–	–	–	–
privileged flake	2	–	v	–
Broad-blade				
parallel flaking	2	2	1	1
radially trimmed	2	–	–	–

small for any finer sub-division by condition to be useful, so they were studied as a whole (Table 18.7).

The small assemblage from Group 1a contains evidence of Mousterian, classic Levalloisian and Broad-blade strategies. This is in line with the material RA Smith collected from a nearby deposit of Coombe Rock (see Chaps 2 and 17), and the exact technological parallels support the idea that the Coombe Rock at Burchell's site is a lateral equivalent of that investigated by Smith. The flakes from Group 1b were mostly technologically undiagnostic, although included two flakes with parallel dorsal scars suggesting they were from Broad-blade reduction sequences. The assemblage from Group 4 is almost all undiagnostic as to knapping strategy, although contains two flakes attributed to fixed-platform Clactonian strategy and one to a Broad-blade strategy. There is a strong overlap between the fixed-platform Clactonian concept and the Broad-blade concept and one might expect similar characteristics in many of the flakes produced. Without refitting evidence, it is not possible to be sure that flakes attributed to fixed-platform Clactonian strategy are not poorly-formed or early debitage from a Broad-blade strategy. The assemblage from Group 7 shows the same technological characteristics as that from Group 4, being dominated by unspecific flakes with a few flakes attributable to fixed-platform Clactonian and Broad-blade strategies.

The proportions of flakes from different knapping strategies in the larger sub-group I and II assemblages from Groups 2 and 5 are summarised graphically (Fig 18.6). For Group 2, both sub-groups U.2I and U.2II have a very similar profile of technological attribution. Most of the flakes are unspecific (63–64%), with far less flakes (around 10% for each) attributable to fixed-platform Clactonian, Mousterian and Broad-blade strategies. And there is a small element of classic Levalloisian material, including evidence of both linear and recurrent modes of core preparation as well as privileged flakes themselves.

The refitting groups (RG 1–3) provide more detailed information on the technological strategies being practised (Fig 18.1). RG 1 shows reduction on a single surface of a core, dominated by crudely laminar removals from one quadrant, with evidence of a few removals from the opposite quadrant. This flaking strategy is closer to Broad-blade than Mousterian despite its lack of success in producing parallel-sided debitage. The number of medium-sized removals does not suggest preparation of the surface of a classic Levalloisian core as a lot of useful flint is being wasted if this was the objective. RG 2 shows the initial cortical trimming of the surface of a core from one side, followed by a sequence of at least four laminar flakes from an orthogonal quadrant. This is a typical Broad-blade strategy and the size of flakes produced and their generally parallel sides reflects its successful accomplishment. RG 3 shows the same as RG 2, although with the added factor of laminar debitage having been struck from both ends of the core after its initial radial trimming.

The overall picture in Group 2 is of a predominance of Broad-blade and Mousterian knapping strategies, with the occasional effort being made to produce a more privileged, classic Levalloisian flake from the upper surface of a core. The quantity of attributable Broad-blade debitage is lower than might be expected, considering the prevalence of Broad-blade cores, which outnumber Mousterian/Levalloisian cores by 2:1. One explanation for this could be that Broad-blade strategy being practised seems to begin with radial reduction of a core with a later focus on more laminar removals, leading to the production of both Mousterian and Broad-blade flakes from the same core.

For Group 5, the sub-group U.5I and U.5II assemblages also have a similar profile to each other, although they contrast strongly with the Group 2 assemblages. There is a strong dominance of unspecific material (87–98%). Fixed-platform Clactonian flakes are the next most frequent group (9% in sub-group I and 2% in sub-group II). Then Mousterian, classic Levalloisian and Broad-blade strategies are each represented by one or two flakes for sub-group I and not at all for sub-group II. Given the potential for individual flakes to be misleading, particularly for Mousterian and classic Levalloisian (which is represented only by a single surface preparation flake), and given the likely cross-over between Broad-blade and fixed-platform Clactonian strategies, there is no reliable evidence for any specific flaking strategy in Group 5 other than Broad-blade, which is also represented by a core.

Flake-tools

Burchell's collection included 13 worked-flakes, six from Group 2, one from Group 4 and six from Group 5, made on blanks from a range of knapping strategies (Table 18.8). The majority (4/6) of the worked-flakes from Group 2 were made on either privileged Levalloisian flakes or on Broad-blades. This suggests that such flakes were deliberately chosen as tool blanks since the unworked material is dominated by unspecific flakes. However, in Group 4 the only worked-flake is made on an unspecific flake and in Group 5 all six of the worked-flakes are made on unspecific blanks. In both these cases this is in keeping with the characteristics of the unworked material, which is almost entirely

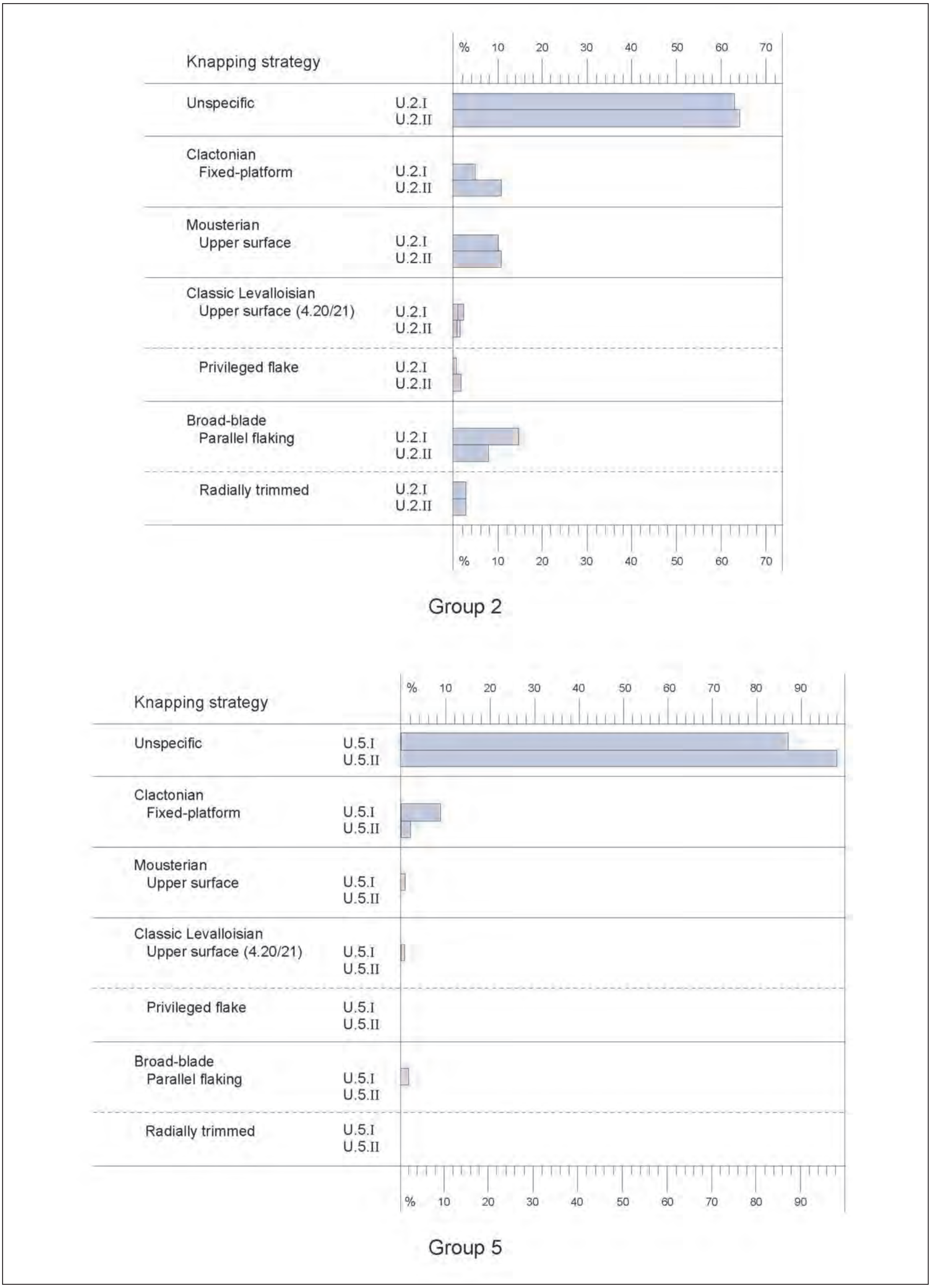


Figure 18.6 Knapping strategies in flakes from Groups 2 and 5

Table 18.8 BUR collection, flake-blanks chosen for working into flake-tools, technological attribution of flakes from Groups 2 (Gravel, lower), 4 (Middle Loam) and 5 (Temperate Bed)

Group	Flake-blank	Sub-group I	Sub-group II	All
5	Unspecific	5	1	**6**
4	Unspecific	–	–	**1**
2	Unspecific	1	1	**2**
	Levalloisian (priv.)	1	1	**2**
	Broad-blade (parallel)	1	–	**1**
	Broad-blade (radial)	1	–	**1**

unspecific. There is no difference between the sizes of the worked-flakes from Groups 2 and 5, although the unworked material is generally larger in Group 2. This suggests that the less structured knapping strategies of Group 5, although producing smaller flakes, still produced an adequate number of suitable flakes for making into tools.

The four worked-flakes from sub-group U.2.I are all unifacially worked along one edge. The two worked-flakes from U.2.II include one large bifacially worked flake and one broken piece whose original form cannot be identified. The worked-flake from Group 4 is a pointed tool similar in size and shape to the pointed bifaces recovered from the overlying Group 5. The five worked flakes from U.5.I are bifacially or unifacially retouched to form scrapers, bluntly backed knives and points. There is also one chunk of flint that has been bifacially worked, possibly to form a robust scraping edge. The worked flake from U.5.II has been unifacially retouched along one edge to form a typical Mousterian side-scraper (*sensu* Bordes 1979).

Organisation of Production and the *Chaîne Opératoire*

Introduction and Methods

Only Group 2 contained enough artefacts for an organisational study to be worthwhile. The assemblage was split into two groups (U2I and U2II) on the basis of condition as discussed above. The knapping strategies represented in Group 2 are mostly Broad-blade and Mousterian, with some Levalloisian; these occur to a similar degree in both groups U2I and U2II. Therefore, an experimental model was developed for Group 2 – as described for the APCM collection (Chap 17) – that included Broad-blade, Mousterian and Classic Levalloisian material. Acheulian material was excluded because there was no recognisable Acheulian debitage in the assemblage, and the core-tools from Group 2 were either abraded (suggesting derivation) or non-classic handaxes (suggesting a reduction sequence more similar to a flake/core technique than a typical Acheulian technique). The experimental model (BURXD2 – Wenban-Smith 1996) was size-sorted to simulate the characteristics of the archaeological material, and comparative models were produced for i) the expected ratios of cores/core-tools:flakes, ii) the volumes (VD) and cortical surface areas (CAD) of the debitage and iii) a canonical function reflecting progression of reduction. These models were then used as controls to investigate the stages of reduction represented in the archaeological assemblages U2I and U2II.

Table 18.9 BUR collection Group 2, comparison of key technological ratios with experimental model (* The fixed-platform Clactonian core and flakes are included with the Broad-blade cores and flakes)

Technological strategy	Experimental model	U2I	U2II
Levalloisian flakes: cores	2	3/0	4
Levalloisian flakes: surf. prep.	3	0.5	1.3
Levalloisian cores: surf. prep.	1.5	0/6	0.3
Mousterian flakes: cores	4	21	25
Broad-blades: cores *	15	9.4	15

Archaeological Comparison

The recognisable Mousterian flakes, Broad-blades and Levalloisian flakes from assemblages U2I and U2II reflect the later stages of these knapping strategies. However, as desired end-products, these artefacts might have been imported having been made elsewhere. The absence of Levalloisian cores from U2I supports this possibility, although the presence of several flakes from preparing the upper surface of Levalloisian cores suggests the later stages of some Levalloisian sequences were carried out at the site as these are unlikely to have been deliberately imported.

Debitage Quantities in Relation to Cores

To investigate whether the whole of the reduction sequence is represented in the debitage, it is necessary to consider the numbers of attributable and unattributable flakes and their ratios in relation to cores (Table 18.9). The results give a conflicting picture, probably influenced by the low numbers of cores which means small variations in their numbers have a large effect on the technological ratios. For Levalloisian production in both U2I and U2II, the amount of surface preparation is higher than would be expected for the numbers of cores and flakes found; and the number of flakes found is higher than would be expected for the number of cores found. The blanks used for worked-flakes also include two Levalloisian flakes (one from U2I and one from U2II) which further increases the over-representation of Levallois flakes. The number of Mousterian flakes is also higher, although to a much greater degree, than would be expected from the number of Mousterian cores found. The ratio of Broad-blade debitage:cores corresponds well with the predictions of the model for the preservation on-site of the complete reduction sequence, although they are slightly under-represented in U2I. The two Broad-blades from U2I used as blanks for worked-flakes do not significantly affect the overall ratio.

Ratios of Debitage Volume to Cortical Surface Area

The average size of nodule collected from the Ebbsfleet Valley for flake/core experimental work was 1650cm³, with a standard deviation of 216 (Wenban-Smith 1996). Using the figures discussed above for VD:V0 it is possible to estimate ranges for the expected total VD of an assemblage in relation to the number of cores, and then to compare this with the actual VD. The estimated and actual VDs for U2I-II are summarised below (Table 18.10). The contribution of worked-flakes is also included although their low number makes its effect on the overall results negligible. The actual VD for U2I is well below the estimated range, which would suggest that the assemblage does not represent the complete on-the-spot reduction of cores, but represents either the importation of cores or the exportation of debitage. In contrast, the actual VD for U2II is only slightly below the estimated range, which suggests that the total volume of debitage is at least compatible with the possibility that an accumulation of complete reduction sequences are represented in conjunction with their cores.

Cortical surface area can be investigated in the same way. The average cortical area of the experimental nodules was 756cm² with a standard deviation of 140. Using the figures discussed above for the total cortical surface area of debitage for each nodule (CAD:C0) it is possible to estimate ranges and actual totals of cortical surface area (CAD) for the Unit 2 assemblage groups (Table 18.11). Again, the contribution of worked-flakes to the overall results is negligible. The results mirror the VD analysis, with U2I seeming quite significantly lacking in total CAD, and with U2II slightly lacking in total CAD. These results suggest that the debitage represents the reduction of less cores than were found, suggesting that the cores may have been brought to the site having been partly knapped elsewhere, or that a significant export of debitage from the site has taken place.

The two options suggested for the imbalances of VAD and CAD in Unit 2 would leave different stages of reduction represented in the debitage studied. If cores had been imported having been partly knapped elsewhere, the associated debitage would represent the end stage of reduction, and if selected debitage had been exported the cores left behind would be associated with debitage from the beginning of reduction. Two approaches have been found experimentally which can establish the reduction stage of collections of debitage, i) the ratio of VD:CAD and ii) the application of a canonical function derived from a comparative experimental assemblage. The ratios of VD:CAD are summarised below (Table 18.12), and the related figure (Fig 17.10) shows how the value of the VD:CAD ratio relates to reduction stage of the debitage. The number of worked flakes in Groups U2I and U2II are too low to affect the outcomes, although the higher ratios give an indication that flakes from later in the reduction sequence were selected as tool-blanks. For the unworked flakes (and also in combination with worked flakes), the ratios for both U2I and U2II are a little higher than the estimated range (4.5–7.5) for a balanced assemblage, suggesting that U2I and U2II both have a slightly disproportionate quantity of debitage from the later stages of production.

Table 18.10 BUR collection Group 2, estimated and actual VDs (cm³)

Assemblage	Cores	Estimated VD	Actual VD	W-flakes	Total
U2I	6	22,300–29,000	13,591	393	**13,984**
U2II	12	44,600–58,000	42,764	798	**43,562**

Table 18.11 BUR collection Group 2, estimated and actual CADs

Assemblage	Cores	Estimated CAD	Actual CAD	W-flakes	Total
U2I	6	3510–5110	1612	48	1660
U2II	12	7020–10,210	5015	47	5062

Table 18.12 VD:CAD ratios assemblages U2I-II

Assemblage	Flakes	W-flakes	Combined
U2I	8.43	8.18	8.42
U2II	8.53	16.98	8.61

Table 18.13 Estimated number of b/m and e flakes in U2I-II using CFBU

Assemblage	Stage	Estimate	B/M:E
U2I	B/M	49	0.35
	E	141	
U2II	B/M	162	0.57
	E	282	

Distribution Along Canonical Function

The other approach to determining the stage of reduction of the flake-assemblage is the use of a canonical function (Wenban-Smith 1996, 49–54 and 351–356). The function CFBU was derived for application to Burchell's Group 2 assemblage and the results of its application to U2I-II are shown (Fig 18.7). The Broad-blades were excluded from the analysis as (a) the canonical function was not designed to deal with them and (b) they are already known to be from the later stages of reduction. The experimental figures were used to estimate the actual numbers of debitage from Beginning/Middle (B/M) and End (E) stages, and then the numbers of Broad-blades in each assemblage were added back in to produce a final estimate of the numbers of flakes from each stage (Table 18.13). The experimental model (Wenban-Smith 1996) indicated that for complete reduction episodes the expected B/M:E ratios would range between 0.5:1 and 2.6:1 according to the mix of Mousterian, Classic Levalloisian and Broad-blade debitage. An even mix would produce a ratio of approximately 1:1. The low values of the ratio B/M:E for U2I-II suggests that U2I and U2II have an over-representation of debitage from the later stages of

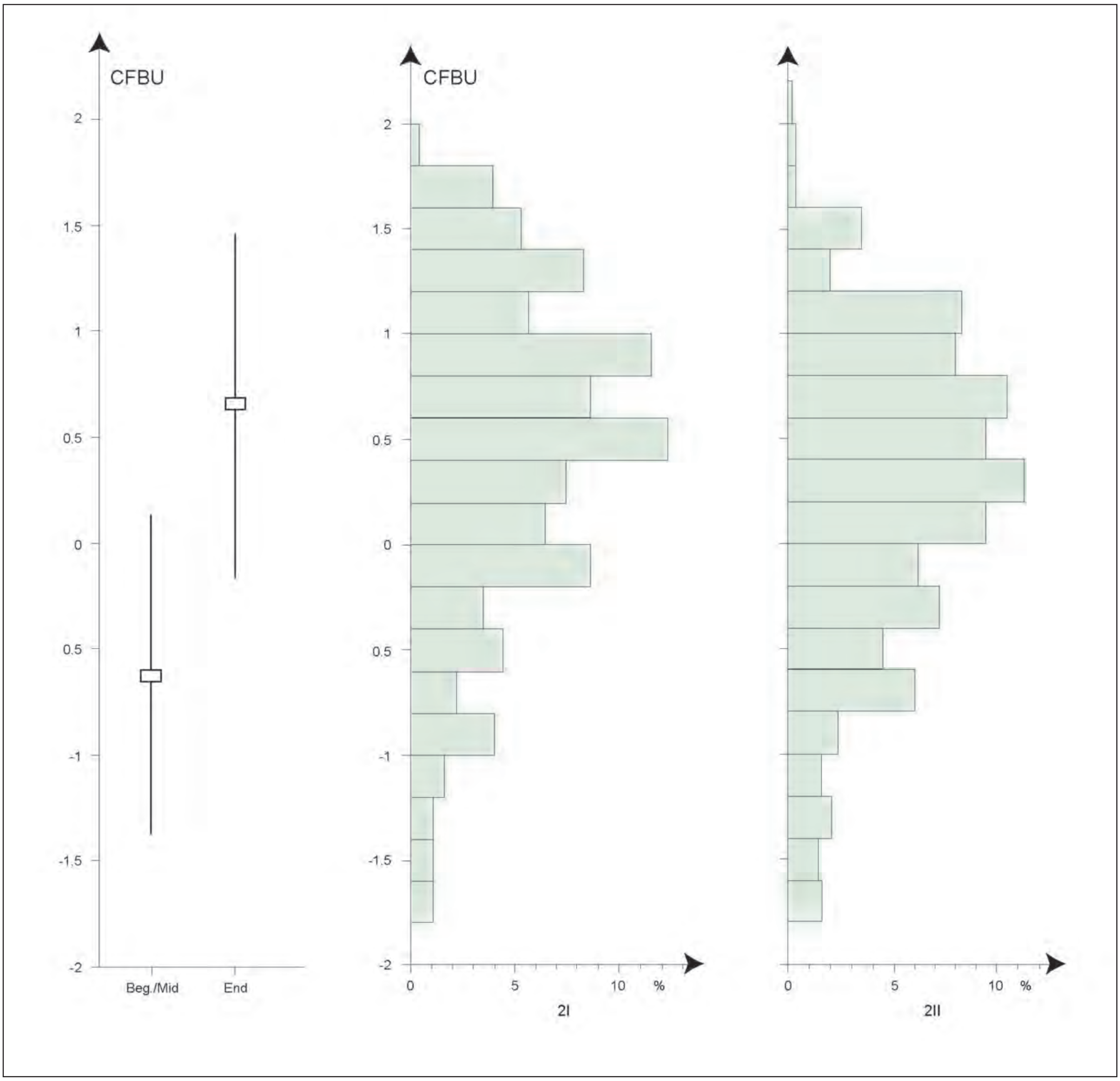


Figure 18.7 Distribution along CFBU for Group 2 debitage

reduction, particularly as the majority of the assemblage is known not to be from Broad-blade reduction.

Organisational Results

Overall, the above analyses present a consistent picture of an over-representation of debitage from the later stages of production in both sub-groups U2I and U2II. Once this factor has been recognised the numbers of cores broadly correspond with the amount of debitage, apart from the lack of Levalloisian cores (which could be explained by their desirability for collectors and hence their absence from current museum collections). It is also possible that the more-cortical and technologically undiagnostic waste flakes that would represent early stages of reduction were less appealing to Burchell, so he failed to collect them and his collection is distorted by their absence.

Burchell's Ebbsfleet Channel Collection: Discussion and Conclusions

There is a contrast between the nature and prevalence of classic Levalloisian flake production in the APCM (n=43) and Burchell (n=23) collections. In the former (Table 17.8), the majority of cores (53%) are of classic Levalloisian form, with remnant scars from the removal of single large privileged flakes, with 33% being from a non-privileged Mousterian strategy (or being un-struck classic Levalloisian cores) and 14% being from Broad-blade production. In the latter, although their quantity is lower, there are only three classic Levalloisian cores

(13%), two of which are very abraded suggesting derivation. Approximately 50% of the cores represent Broad-blade reduction, of which several are in mint or fresh condition, and only one in a very abraded condition (Table 18.5).

The mint/fresh assemblage included three groups of refitting material, which gave extra support to the presumption based on condition that the assemblage was of reasonably high integrity and little disturbed/transported. Both the mint/fresh and the abraded parts of the assemblage had identical organisational structures, with a disproportionate representation of debitage from the later stages of reduction compared to debitage, and a very low representation of actual tools, whether flake-tools or handaxes.

There are various possible explanations for this pattern (discounting bias in collection): (i) partly knapped cores were imported, knapped and then abandoned along with the undesired proportion of the debitage, (ii) some cores were knapped locally from start to finish, but several cores were knapped elsewhere and selected debitage from the end stage of reduction brought to the site and then abandoned, or (iii) debitage from the early stages of reduction was selectively exported. None of these scenarios is very convincing. The first two involve the transport of undesired material (cores or debitage) over some distance (beyond the catchment area of the site) to a fixed point in the landscape, from which desired material is then exported for use and abandonment elsewhere. And the third involves the problem of why knapping would have been continued after the desired debitage had been produced, and what happened to the cores, which would have been left behind in disproportionately large numbers relative to the flakes left behind.

A more intuitive and conventional interpretation of the site, without considering the organisational evidence, would be one where initial reduction was carried out near a raw material source, before the export of partly-worked cores and/or selected flake-blanks. For this to be the case both the canonical function and the ratio VD:CAD have to be providing misleading results. However, the experimental work has shown VD:CAD to be a very robust statistic relying on minimal assumptions for its use in identifying stage of reduction. If the nodules knapped in the archaeological assemblage were consistently much larger than the experimental ones, then the VD:CAD ratio would tend to be higher for an evenly-balanced assemblage. However, it was difficult to find large enough nodules for the experimental work from the same source as that exploited by the Archaic knappers. The canonical function approach depends upon more assumptions, including a more-accurate replication of the Archaic knapping strategies, and so is less robust. However, it was consistently effective in the analysis of experimental material. Furthermore, the congruence of the results from both approaches supports their accuracy.

The apparent pattern of behaviour reflected in the structure of the organisation of lithic production in Burchell's Group 2 collection remains to be understood. The results appear to suggest the regular import of debitage from the later stages of reduction to a specific point in a landscape, and then its use in an unmodified form or the export of a selection of the imported blanks for use/modification elsewhere. If so, this pattern is one in which the landscape appears culturally-structured independently of environmental context with a fixed location acting as a focus for one part of the lithic product. However, it is unfortunately perhaps more likely that this attempt at an organisational analysis has been confounded by Burchell's collecting bias, and the consequent disproportionate absence of more cortical and technologically undiagnostic debitage in the collection resulting from his work in the Ebbsfleet Valley.

Chapter 19

Palaeolithic Worked flints from HS1 Investigations

by Francis Wenban-Smith

Introduction

Palaeolithic worked flints are a relatively sparse element of the HS1 archive compared to the wealth of palaeoenvironmental material. Nonetheless they are of high importance as the main direct evidence of hominin presence and activity, and provide an important link to the far larger collections previously recovered at the site (see Chaps 17 and 18); conventions for categorising different levels of abrasion and for technological and typological classification follow these previous two chapters. This chapter covers worked flint artefacts from the earlier part of the Palaeolithic, covering the periods generally labelled as Lower and Middle Palaeolithic (see Table 2.1); Upper Palaeolithic and post-Palaeolithic flint artefacts from the HS1 project are considered separately (see Chaps 20–22 and Anderson-Whymark, Appendix I).

Quantification

In total 60 Lower/Middle Palaeolithic flints were found in the various projects associated with the HS1 investigations (Table 19.1). A full listing is provided in Appendix F, which also gives specific details for each artefact of its condition, appearance and any technological interpretation.

Provenance, Stratigraphic Integrity and Site Phasing

The Palaeolithic worked flint collection can be divided into six main assemblage groups (A, B, C, D, F and U), with material from different groups usually spread between several zones (Table 19.2). Most of the Palaeolithic flints were found *in situ* in Pleistocene sediments, or on freshly-revealed exposures of Pleistocene sediments, so for these there is no doubt over their stratigraphic provenance. They were divided into four assemblages, A to D, reflecting different phases of the site's build-up of Pleistocene sediments, in broad chronological order from A through to D.

The integrity of these assemblages is slightly uncertain, but no more so than for most Lower/Middle Palaeolithic material, and less than most as we have good information on the originating context. Assemblage A is the earliest artefact-bearing phase, and comes from Coombe Rock, similar (and nearby) to that from which RA Smith collected numerous Levalloisian artefacts in the early 20th century (Smith 1911; Wenban-Smith 1995 and 1996). As previously discussed (Chap 9), the HS1 work has shown that "the Coombe Rock" is not a single, laterally equivalent deposit, even when similar exposures are found in reasonably close proximity. In contrast, Coombe Rock deposits are liable to migrate downslope in conjunction with repeated phases of reworking, potentially blending pre-existing archaeological contents with newer material. The oldest Coombe Rock deposit that produced lithic artefacts for the HS1 work was that at the Chalk Spine and the western end of Section 193, dated to MIS 7 or earlier, and thought most likely to be slightly younger than the APCM Coombe Rock. The artefacts comprising Assemblage "A" were further divided into three sub-groups A1-A3, reflecting the likelihood of progressively increasing degrees of reworking (see below, and Appendix F).

Assemblage B comes from gravel-rich deposits that cut into and overlie various Coombe Rock deposits in different parts of the site; the artefacts are most-likely derived from the Coombe Rock by river action, and so they can probably mostly be regarded as a reworked

Table 19.1 Ebbsfleet prehistoric Palaeolithic worked flint collection, by project

Project	Handaxes	Cores	Debitage (inc Lev)	F-tools	Total	Notes
EFT 97	0	2	5	0	7	
ESG 00	0	1	15	0	16	One flake missing, but it is described in excavation notes
EBB 01	0	4	12	0	16	Two flakes missing, but notes from excavation
ZR4 00	1	0	0	0	1	Not *in situ*, found on ground-surface
342 W 02	0	1	6	0	7	
SPH 00	3	0	3	1	7	All handaxes are surface finds; others in recent (Holocene) feature contexts
SHN 02	1	0	1	1	3	All in recent features
342 E 02	0	0	1	2	3	All in recent features
Total	**5**	**8**	**43**	**4**	**60**	

Table 19.2 Main assemblage groups for Ebbsfleet prehistoric Palaeolithic worked flints, by zone

Assemblage group	Stratigraphic provenance	Site zone	Handaxes	Cores	Debitage (inc Lev)	Flake-tools	Sub-total	Total
A	Coombe Rock – chalk-rich solifluction deposits	5	–	1	4	–	5	–
A	Coombe Rock – chalk-rich solifluction deposits	6	–	3	8	–	11	–
A	Coombe Rock – chalk-rich solifluction deposits	7	–	1	4	–	5	**21**
B	Fluvial gravel over CR	3	–	–	2	–	2	–
B	Fluvial gravel over CR	4	–	–	3	–	3	–
B	Fluvial gravel over CR	6	–	1	2	–	3	**8**
C	Tufa	6	–	1	–	–	1	**1**
D	Slopewash sand/gravel capping A, B and C	6	–	–	12	–	12	**12**
F	Holocene features	?	–	1	3	2	6	–
F	Holocene features	NA	2	–	4	2	8	**14**
U	Unstratified surface finds	1	1	–	–	–	1	–
U	Unstratified surface finds	6	–	1	–	–	1	–
U	Unstratified surface finds	NA	2	–	–	–	2	**4**
Total			**5**	**8**	**43**	**4**	**60**	**60**

element from Assemblage A. Assemblage B may, however, also incorporate reworked material from later activity any time from MIS 7 through to the late Devensian. It has been divided into two sub-groups: B1 from the slopewash gravel in test pit 3783TT; and B2 from a variety of, probably younger, fluvial/solifluction gravels lower down the valley slope.

Assemblage C has just one artefact, a large well-abraded and heavily-stained flake found *in situ* in the fine-grained tufaceous context 3972043 at the south end of trench 3972TT, which was attributed to MIS 5e (see Chaps 10 and 16). It has clearly suffered heavy post-depositional action since its manufacture, so its presence within the tufa is a mystery – but it is clearly not representing an *in situ* occupation surface. It is probably a residual clast, left in position during formation of the tufaceous spring deposits around it.

Assemblage D is, like Assemblage B, thought to be derived from earlier deposits. It has been separated because all of its constituent artefacts (n=12) come from a particular stratigraphic horizon in Zone 6, namely silt, sand and gravel layers that slope shallowly down from the higher ground to the south, and are dated to *c* 40,000 to 30,000 BP, in the middle of the Devensian prior to the Last Glacial Maximum.

The other two phases (F and U) represent flints, from Holocene features and unstratified surface finds respectively, that are thought by their appearance, condition and technological/typological characteristics to be Palaeolithic. Flints in these groups have low integrity and cannot be related to any of the site archaeological phases A to D, so most are not considered further. However, one particular core, unfortunately found unstratified, was a particularly instructive example of the Levalloisian approach to what has here been called Broad-blade production, so is illustrated and discussed below.

Lithic Analysis

Assemblage A: Coombe Rock (Zones 5, 6 and 7)

Assemblage A1

This sub-group (n=9) of Assemblage A comes from the oldest body of Coombe Rock investigated, which underlies deposits dated by OSL to *c* 200 KBP in 4019TT. This older "Lower Coombe Rock" is represented in the lower levels of the Chalk Spine test pits (phase WSD-A) and the Coombe Rock exposed at the base of the sequence at the Jayflex remediation area (JFX-A) (Figs 19.1 and 19.2). It is the nearest deposit to the Coombe Rock that produced the APCM lithic collection in *c* 1910, but as discussed in Chapter 9, it is uncertain whether these Coombe Rock bodies are directly equivalent, or whether there is a phase of reworking between the APCM and the WSD-A/JFX-A sediments.

The lithic artefacts are in a variety of conditions; most are pale blue-grey patinated, but two are unpatinated, one of which was found *in situ*, establishing that degree of patination is not a reliable guide to Coombe Rock provenance. All, bar one flake, are moderately heavily abraded, with slightly smoothed ridges between flake scars. The exceptional artefact is in very fresh condition. This artefact is also exceptional technologically, as it appears to be a thick blade from a medium-sized blade core. It was found on the freshly stripped surface of the Coombe Rock in the Jayflex remediation area, and there was no reason to suspect it as being intrusive from later horizons – it is also, incidentally, blue-grey patinated.

Despite its small size, the lithic assemblage is technologically very coherent, with a high incidence of large, and quite crude, Levalloisian flake production. It includes quite a large core (130mm long) with a failed central flake-scar, and two moderately large classic sub-oval Levalloisian flakes, both broken in half across the middle and with evidence of radial trimming prior to detachment. The remainder of the material comprises two chunky, technologically undiagnostic flakes.

Assemblage A2

This sub-group (n=9) comes from the upper part of the Coombe Rock at the Chalk Spine (phase WSD-B), and its presumed westward equivalent (phase 193-B) at Section 193 (Fig 19.2). The flint artefacts are mostly moderately well abraded (Appendix F), and are mostly pale blueish-grey patinated – although there are some exceptions.

The assemblages include three cores, all broken by frost-action, all looking like parts of classic Levalloisian flake cores and all moderately-heavily abraded. The debitage component of this assemblage is more varied,

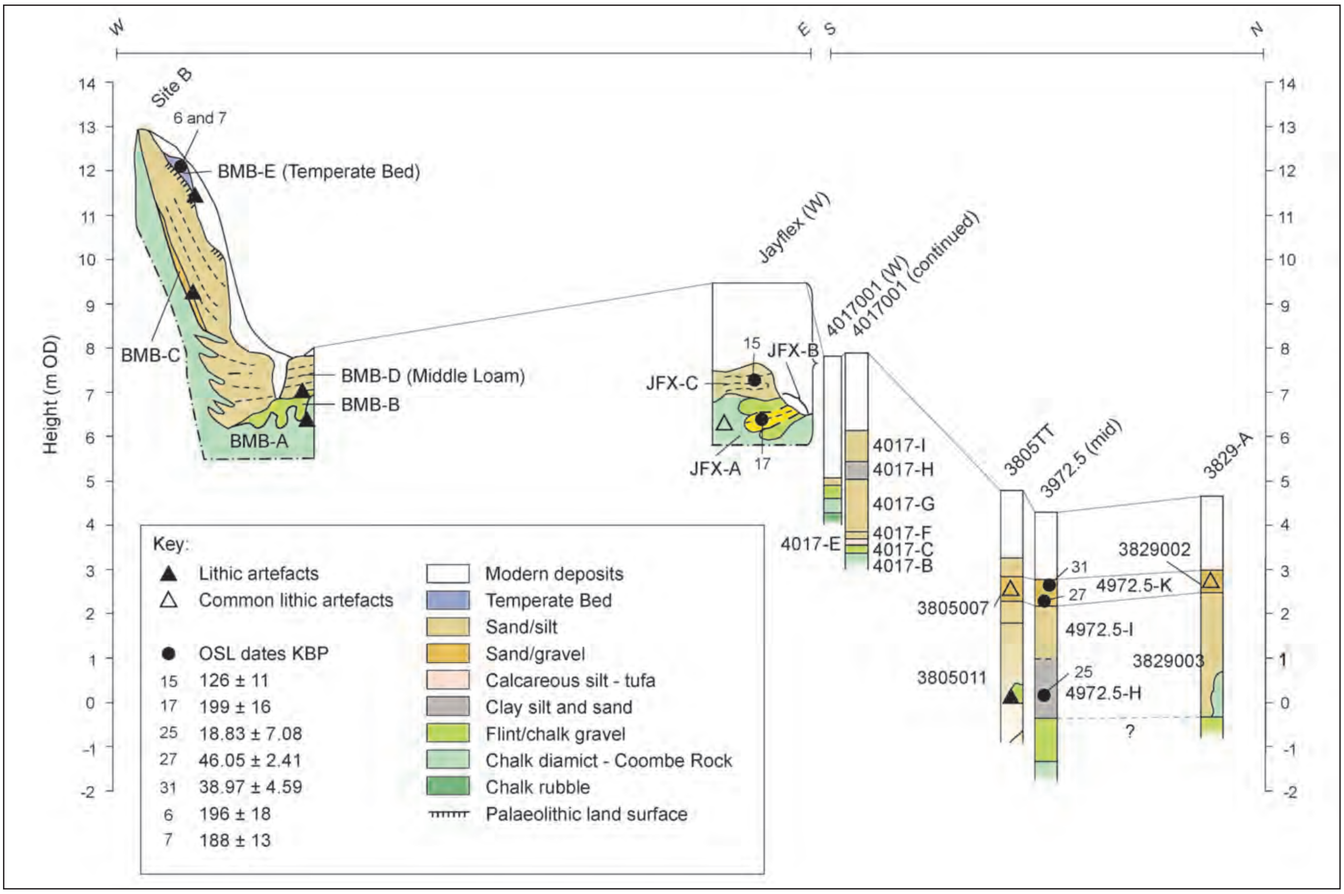


Figure 19.1 Correlation and phasing of lithic-bearing horizons from Zones 2 and 6: Site B, Jayflex, 3972TT, 3805TT and 3829TP

being in a range of conditions from very fresh to well abraded, and including evidence of blade production, as well as chunky undiagnostic flakes with hints of being from either classic Levalloisian or Broad-blade Levalloisian production.

Assemblage A3

This sub-group (n=3) comes from the much younger Coombe Rock of 3971TT, dated by OSL to *c* 30–40 KBP (Fig 16.4). One of its three artefacts is missing: a small, very fresh condition and unpatinated cortical flake. It may be a modern intrusion, perhaps caused by the bucket of the mechanical excavator, although its subsequent loss means this cannot now be re-assessed. The other two artefacts are both moderately heavily abraded, and are both broken across the middle by frost-action. One of them is a core, of typical Levalloisian form with radial trimming and the remains of a central, privileged flake scar. The other is the pointed end of a very large flake, with a wide curving and faceted striking platform, probably a mis-struck Levalloisian flake.

Assemblage B: post-Coombe Rock Fluvial, Slopewash and Solifluction Gravels (Zones 3, 4 and 6)

Assemblage B1

This sub-group has only two artefacts, both from the slopewash/solifluction gravel 3783005 at the northern end of Zone 3, in the section of stepped trench 3783TT. Both are technologically undiagnostic waste flakes, unstained and unpatinated from primary decortication. Their abraded condition suggests substantial depositional transport, but the lack of staining and patination belies reworking from older deposits, so they may well represent occupation contemporary with formation of the gravel, which is of uncertain age, but is thought to post-date MIS 7.

Assemblage B2

This sub-group (n=6) comes from a range of younger gravel deposits, generally thought to date between MIS 6 and the late Devensian. One of the artefacts is missing. The remaining artefacts are all at least moderately abraded, with two of them well abraded, suggesting a history of transport and reworking. As a group, they seem to represent derived elements from the Levalloisian material that was relatively abundant in the various MIS 8-7 deposits previously prevalent in the Ebbsfleet Valley.

Assemblage D: Slopewash Sands and Gravels Capping 3972TT Sequence (Zone 6)

This group of material (n=12) comes from sands and gravels (phase 3972-K) capping the Last Interglacial deposits of Zone 6, mostly from sieved samples from test pit 3829-A TP or individual finds from trench 3972TT

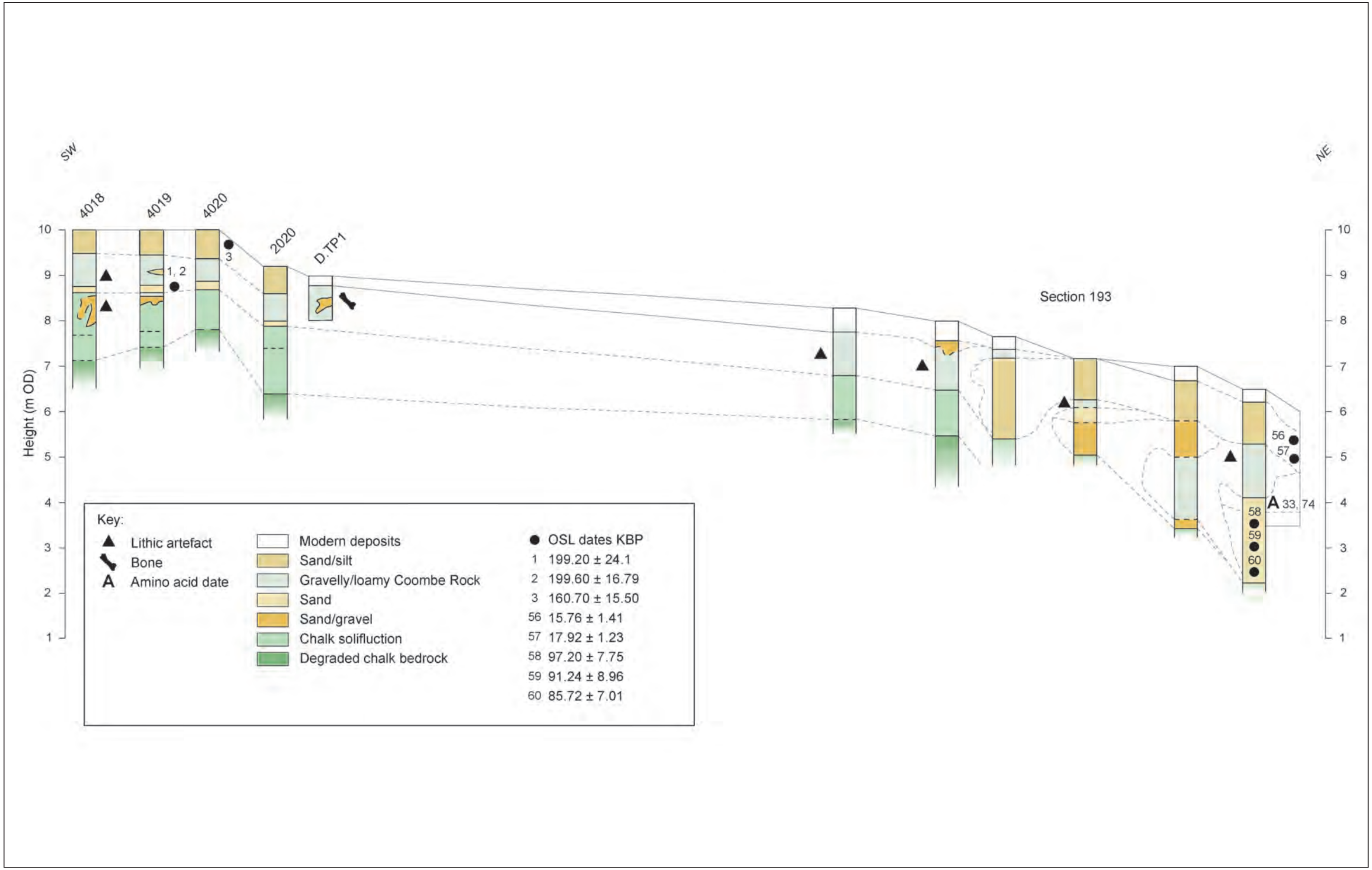


Figure 19.2 Correlation and phasing of artefact-bearing Coombe Rock between Chalk Spine and Section 193

(Fig 19.1). These sands and gravels have been OSL-dated to *c* 30 to 40 KBP, but, as reinforced by the abraded condition of the artefacts (Appendix F) it is presumed that they are derived from the MIS 8–7 deposits that are known to previously have existed in the upslope areas to the south and west of where they were found. Therefore, while the assemblage lacks stratigraphic integrity, it includes a range of elements typifying the Levalloisian range of the Ebbsfleet Valley's pre-MIS 6 deposits.

Three artefacts are illustrated (Fig 19.3). Find 30913 is a typical, radially prepared sub-oval Levallois flake (Fig 19.3, 2). Find 115 is a very large, elongated blade-like flake (Fig 19.3, 3). While it does not have previous parallel flake scars that would define it as part of a deliberately laminar reduction sequence, it does have deliberate transverse trimming of its dorsal ridge, to straighten it and ensure its elongation once struck; it is therefore interpreted as the start of a deliberate laminar reduction sequence. The third illustrated flake shows the scars from at least two previous large removals from opposite directions, together with preparatory trimming from one side of the core (Fig 19.3, 4). It thus represents evidence of a recurrent, bipolar laminar Levalloisian approach, whereby the prepared core surface is exploited for a sequence of large laminar removals from opposite directions.

Core SF 30910: Levalloisian Broad-blade Chaîne Opératoire

Although not found *in situ*, and therefore of uncertain provenance, this core is such a magnificently instructive example of one of the Levalloisian *chaînes opératoires* in use in the Ebbsfleet Valley that it is worth discussion in detail. It was found on the ground surface in the western part of Zone 6, in an area of remnant Pleistocene deposits disturbed by construction traffic to the west of the dog-leg trench 3972TT. Thus, it was found in an area where deposits of MIS 8–7 are known to still be present at the western end of the Jayflex section (see Chap 10) in the vicinity of Sites B and F. This is also the same general area as where Burchell recovered undisturbed material from "Levalloisian floors" towards the base of the sequences at his Ebbsfleet Channel "A" and "B" sites. Therefore, it seems likely that this core is part of the same general assemblage as represented by the material from these "floors", and indeed its technological characteristics perfectly match those of the assemblage from Burchell's Lower Gravel group of horizons (see Chap 18).

The core (Fig 19.3, 1, SF 30910) clearly represents a strand of the Levalloisian group of reduction strategies here labelled as "Broad-blade", dominated by either unipolar or bipolar laminar reduction from the upper/front, privileged surface. What is important about this particular core is that its reduction has been interrupted due to a combination of knapper error and (perhaps) internal flaws in the flint. This arrested production therefore preserves the evidence of prior preparation of the privileged flaking surface, that would have been otherwise lost by the ensuing blade production.

The core exemplifies Boëda's (1995) fundamental Levalloisian concept of an opposed volumetric organisation between: (a) a "privileged" upper/front surface, which is managed to a particular shape and dorsal scar pattern to support removal of flakes that are not necessarily desired to be of similar or standardised form, but which nonetheless are of controlled or broadly anticipated form; and (b) a "reverse" face that is managed to create appropriate striking platforms for both preparatory surface-shaping flakes of the privileged face, and the privileged flakes themselves.

The sequence of reduction preserved in the flake scars reveals the *chaîne opératoire* as being a highly routinised flow of a nested hierarchy of knapping objectives. Early stages of de-cortication are lacking, these scars being replaced by those that are present, so it is unclear what, if any, routines or hierarchies were brought to the initial shaping of the core.

The first flaking routines are two similar series of what are here termed "Surface Management" flakes that progress alternately down each side of the core (Fig 19.4), labelled as "SML" and "SMR" for the left and right sides respectively as viewed from the front. Both these routines (SMR.1–4 and SML.1–3) start at the same end of the core, which also is the same end (the "top") from which the first privileged flakes (P.1–P.3) are later struck. The reduction order of one flake (SMR.3, at the bottom of the right side of the core) is uncertain in relation to SMR.1–2, but it definitely precedes SMR.4. Flakes from these routines are directed to: (a) keeping the back surface quite flat; and (b) preserving a bulging front surface of the core, containing flint raw material that is later exploited for the privileged flake production. A particular feature of the surface management series on both sides is that the last flake of each sequence to be struck (SML.3 and SMR.4) is a preparatory flake of the front surface, struck about halfway down the side of the core, and directed slightly towards its "bottom" end. This would have had the effect of facilitating the successful removal of the first group of privileged flakes (P.1–P.3) from the opposing "top" end of the core.

There is also evidence of a routine for preparation of the striking platform at the core's top end for the forthcoming privileged removals, involving at least two striking platform preparation flakes (SP.1a and SP.1b). It can be interpreted from the intersection of surface management flake SMR.1 by the striking platform preparation flake SP.1a that initial preparation of the primary striking platform area at the top of the core followed flake SMR.1, but it is uncertain how its order (and that of the other initial striking platform preparation flake SP.1b) relates to the rest of the lateral surface management series. It seems intuitively reasonable that preparation of the striking platform

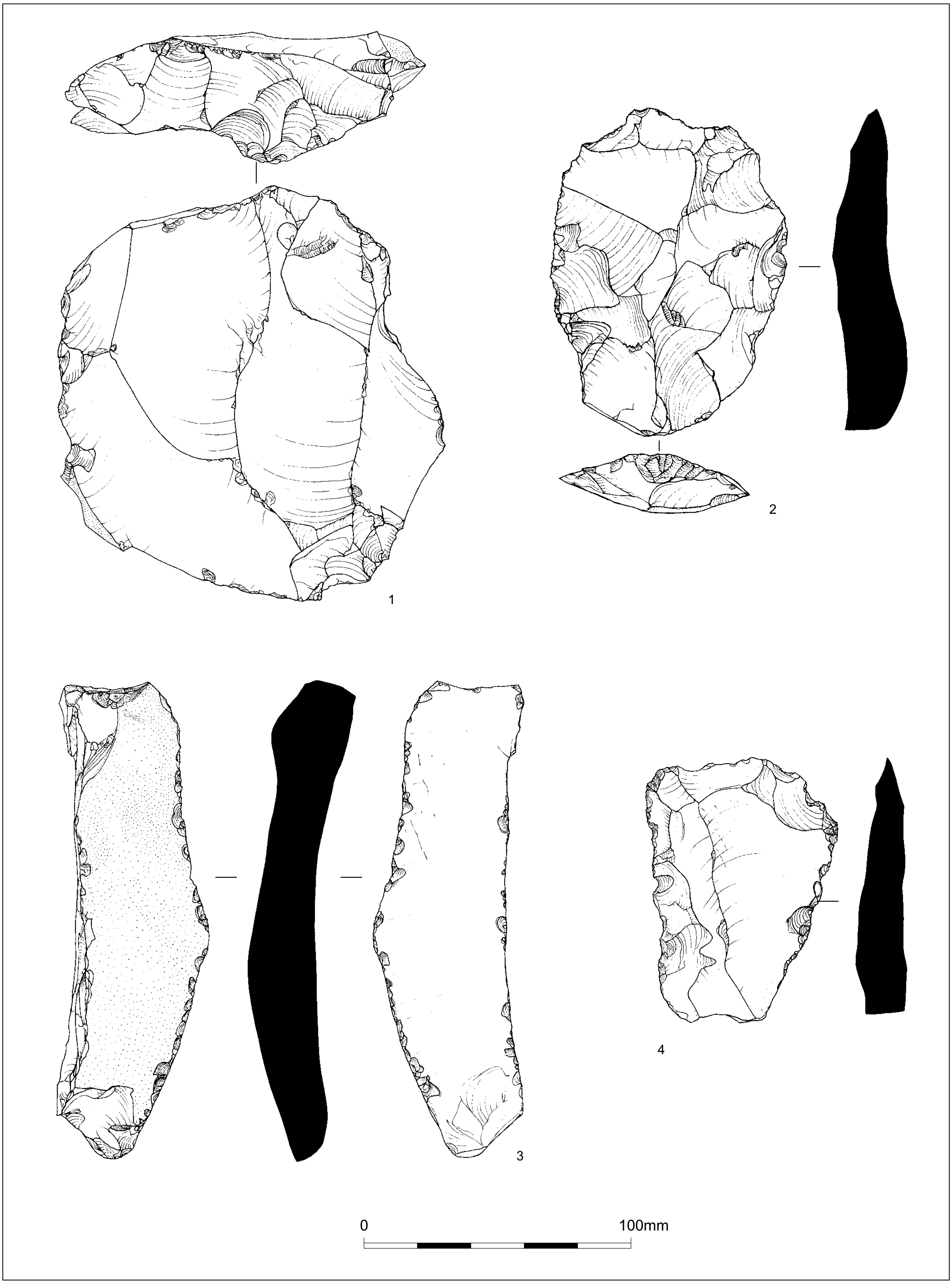


Figure 19.3 Lithic artefacts from HS1 excavations. 1. Levallois Broad-blade core (unstratified) (ARC EBB01, SF 30910); 2. Classic radial Levallois flake (phase 3972-K, context 3972030, SF 30913, ARC EBB01); 3. Large blade-like flake (phase 3972-K, context 3805007, SF 115 ARC ESG00); 4. Levalloisian surface trimming/rejuvenation (phase 3972-K, context 3829002, 3829TT, sieved spit 1, ARC ESG00)

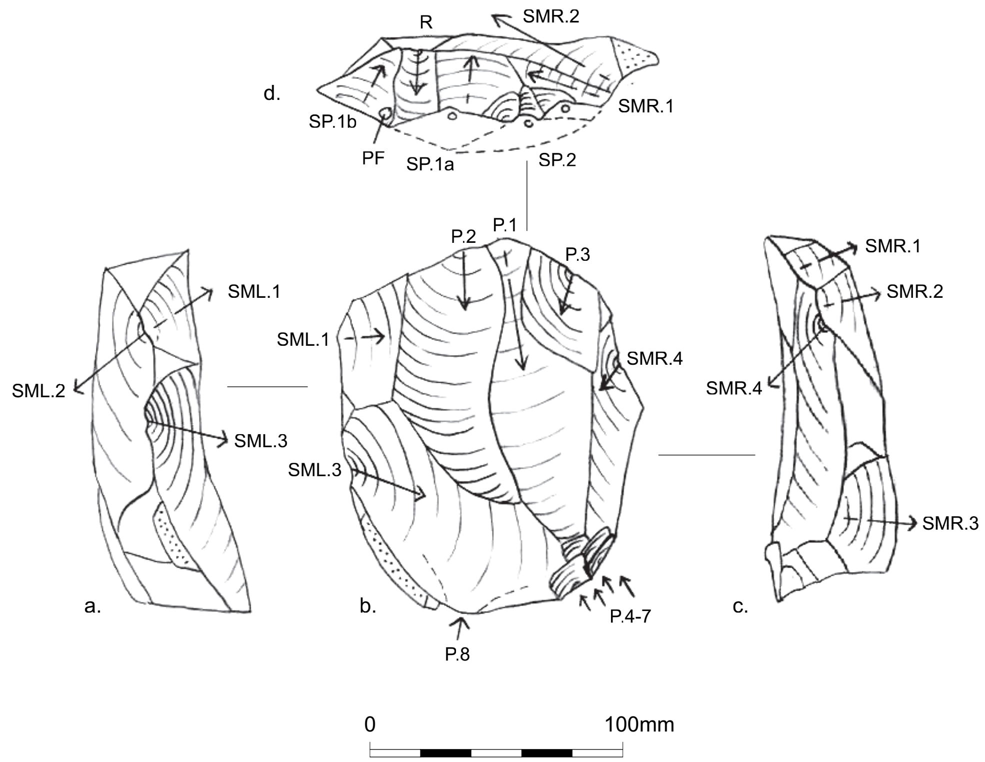


Figure 19.4 Levalloisian Broad-blade core from HS1 excavations (SF 30910, ARC EBB01)

would follow the lateral surface management series as a distinct conceptual stage, and directly precede the removal of privileged flakes.

After preparation of the striking platform, which was shaped to a shallow convex form in both profile and plan view, the first series of privileged flakes to be struck were P.1–P.3. Besides corresponding with every aspect of the core's prior preparation, the longer scar of the first removal P.1 is intercepted at its distal end by one of the scar-group P.4–P.7, confirming its relative striking order. The first removal P.1 extends most of the way down the core's front face. This was followed by a second removal, almost certainly P.2, the striking point of which was offset to the side of the first flake, corresponding with where a prominent ridge would have been left down the centre of the core. Again, a reasonable size flake was produced, but then things began to go wrong. Two further sequences take place at the top end of the core, the order of which is uncertain. Firstly, the third attempted privileged flake P.3 was mis-struck, and a pitifully small flake was produced that travelled only a short distance before ending in a step-fracture. Secondly, there is a failed attempt (PF) to remove a fourth flake from the left side of the core, the point of percussion for which is visible. It was then attempted to rescue the viability of the original striking platform by (rarely a good idea in this knapper's experience) striking a small flake (R) in the "wrong" direction, towards the notional "hinge" of Boëda (1995) that separates the privileged flaking "front" surface from the primary striking area. This hooks around the front face, rendering further striking from this end futile.

Attention was then turned to the opposite end of the core. Little, or no, attention was given to preparation of a striking platform at this end, which was a curving, naturally broken and weathered flint surface with a *c* 90° angle with the bottom end of the privileged front surface. The thickness of this end of the core does not appear to support the possibility of successful trimming for a striking platform, and this was evidently also the instinct of the Palaeolithic knapper. There are no less than four failed attempts (P.4–7) to remove a flake from opposite the fattest part of the front face, opposite the distal end of flake P.1. This was then followed (or possibly preceded) by an attempted removal of flake P.8, which fails to detach, leaving a fracture through the flint radiating from the point of percussive impact. At this point the core was abandoned, presumably in disgust.

Amongst the interesting aspects of this core are not just what was done, but what was not. It is still a very substantial piece of flint, *c* 150 x 130 x 65mm in size, and weighing 1.8kg. Although the striking platforms at both ends were ruined, the weight of flint left in the core and its morphology still seem to support the possibility of further knapping to re-prepare the core's surfaces and striking platforms, and to produce further, albeit smaller, privileged flakes; yet no attempt was made to do so. Two possibilities present themselves. Firstly, that only large flakes were wanted, and even the slight reduction in size was unacceptable. Secondly, and more likely, the pounding the core had taken and the development of a number of incipient fractures within it, had ruined its potential for production of even reasonably large further privileged flakes. It is also possible that some of the incipient fractures now present in the core, probably caused by freeze-thawing, were already present and becoming apparent to the knapper, rather than being due to post-depositional processes.

The core represents a good example of the start of a linear Broad-blade Levalloisian reduction sequence. It exemplifies Boëda's (1995) Levalloisian volumetric concept, with a clear and maintained dichotomy between a front face prepared for removal of privileged flakes and a back face managed to provide striking platforms for removal of both front-face preparation flakes and then a series of privileged flakes. Although initial stages of the core's reduction are not preserved, there is evidence of at least three distinct stages of a Levalloisian *chaîne opératoire*: (a) preparation of the front face; (b) preparation of a primary striking platform prior to removal of any privileged flakes; and (c) removal of a series of privileged flakes struck from the primary striking platform, interspersed with further minor management of the main striking platform. After the primary striking platform failed, the knapper attempted to remove flakes from the opposite end, and after this failed, the core was abandoned. The fact that it failed early in the sequence of privileged removal has preserved better evidence than usual of the preparatory management of the core's front surface prior to initiation of the privileged flaking part of the *chaîne opératoire*, demonstrating a highly routinised approach to this task with a similar migration down both sides of the core, progressing from top to bottom.

Comments and Conclusions

The more blade-focused strategies present in the historic APCM and Burchell collections from the Ebbsfleet Valley are well-exemplified by the core SF 30910, described in detail above. The HS1 material from Assemblages A–D generally represents reworked material from either the same Coombe Rock as produced the APCM collection, or from the suite of late MIS 8 and early MIS 7 deposits present in the vicinity of Sites B, F and the Jayflex remediation area – the "Burchell triangle" (Chap 6).

The artefacts from the Coombe Rock group, Assemblage A, show very similar characteristics to those from the APCM Southfleet Pit collection. Tellingly, the larger classic Levalloisian flakes and cores are mostly broken in half by frost action, and are all moderately heavily abraded. This must reflect their depositional history, which probably includes at least one cycle, and probably often more, of reworking as chalk-rich solifluction deposits remobilise and migrate downslope during repeated cycles of climatic change. Some of the pieces – again tellingly, always those with more blade-like characteristics – are in fresher condition, probably reflecting a lesser history of reworking. This is a strand of evidence supporting the suggestion that classic radial Levallois flake production was an earlier practice, and that a drift towards more blade-focused reduction strategies was a later development in the Ebbsfleet Valley (see Chap 23 for further discussion).

Chapter 20

Final Upper Palaeolithic and Mesolithic

by Hugo Anderson-Whymark, Elizabeth Stafford and Chris Hayden

Final Upper Palaeolithic and 'Long Blade' Industries (*c* 12,000–8500 BC)

Final Upper Palaeolithic activity within the Ebbsfleet Valley, straddling the Pleistocene–Holocene transition, falls within 'Holocene' Landscape Stages 1a and 1b as outlined in Chapter 16. To summarise, the Late Glacial is a period marked by rapid climatic oscillations and landscape instability (Fig 20.1). During the colder periods of the Dimlington and Loch Lomond stadials the environment of the Ebbsfleet Valley was probably quite harsh periglacial tundra. The landscape was subject to rapid physical weathering and erosion with solifluction processes depositing head deposits on the slopes and valley bottom. During the brief interlude of the warmer Windermere interstadial, and indeed the beginning of the Holocene, immature soils probably developed supporting open grassland and scrub with pine and birch woodland. A high-energy braided river deposited coarse sandy gravel in the valley bottom. The river probably comprised a network of small channels, and between the channels temporary islands or eyots existed. The River Thames during this period was a freshwater river; a tributary of the River Rhine that flowed out through the Straits of Dover into the Atlantic.

Swanscombe Marsh

No evidence of human activity during the earlier part of the Late Glacial period was identified in the Ebbsfleet Valley proper during the construction of HS1. However, a moderate assemblage of worked flint recovered during the cutting of the Thames Tunnel Portal on the Swanscombe Marshes immediately to the north was recently analysed by Anderson-Whymark (see Bates and Stafford 2013, chap 11). This assemblage was recovered from the upper 0.1m of an alluvial silt, sealed by peat, and included refitting debitage from blade production, several short end scrapers on flakes, burins and a curve backed blade. The industry was orientated at the production of blades up to 100mm in length, generally removed from bipolar blade cores maintained by tablet rejuvenation. Although lacking certain elements, such as penknife points, the assemblage was thought to be characteristic of the Final Upper Palaeolithic. Only a few dates are available for comparable assemblages, but they indicate a date probably in the Windermere interstadial. These include assemblages from a number of cave sites in Devon (Broken Cave, Pixie's Hole, and Mother Grundy's Parlour: Barton 1999, 25), as well as the open sites at Hengistbury Head, Dorset and Brockhill, Surrey (Barton 1992).

Springhead (Zone 11)

Worked flint from Springhead colluvial sequence (ARC SPH00)

by Hugo Anderson-Whymark

Evidence of activity spanning the very end of the Late Glacial to the early post-glacial period (*c* 10,000–8500 BC) was identified in the Upper Ebbsfleet Valley at Springhead Roman Town (ARC SPH00, Zone 11). This comprised residual worked flints within Early Bronze Age colluvial deposits and a Middle Bronze Age ring-ditch (Figs 15.9 and 20.2; Pl 20.1; Anderson-Whymark Appendix I).

The assemblage comprises 176 pieces (Table 20.1) and diagnostic elements include four bruised flakes and blades, and a long blade core. The deposits also contained a quantity of debitage, apparently contemporary with the diagnostic elements, intermixed with Neolithic and Bronze Age flintwork. The earlier flint is distinguished on the basis of the degree of cortication in relation to other artefacts in the assemblage as well as technological attributes. The flints exhibited a heavy to very heavy white surface cortication,

Table 20.1 Quantification of the Final Upper Palaeolithic worked flint from Springhead (ARC SPH00)

Category type		Total
Flake		**102**
Blade		**32**
Bladelet		**1**
Blade-like		**15**
Irregular waste		**2**
Chip		**4**
Rejuvenation flake core face/edge		**2**
Rejuvenation flake tablet		**1**
Rejuvenation flake other		**7**
Bruised blade/flake		**4**
Core single platform blade core		**1**
Bipolar (opposed platform) blade core		**3**
Retouched flake		**2**
	Total	**176**
No. Burnt worked flints (%)*		**15 (8.7)**
No. Broken worked flints (%)*		**96 (55.8)**
No. Retouched flints (%)*		**2 (1.2)**

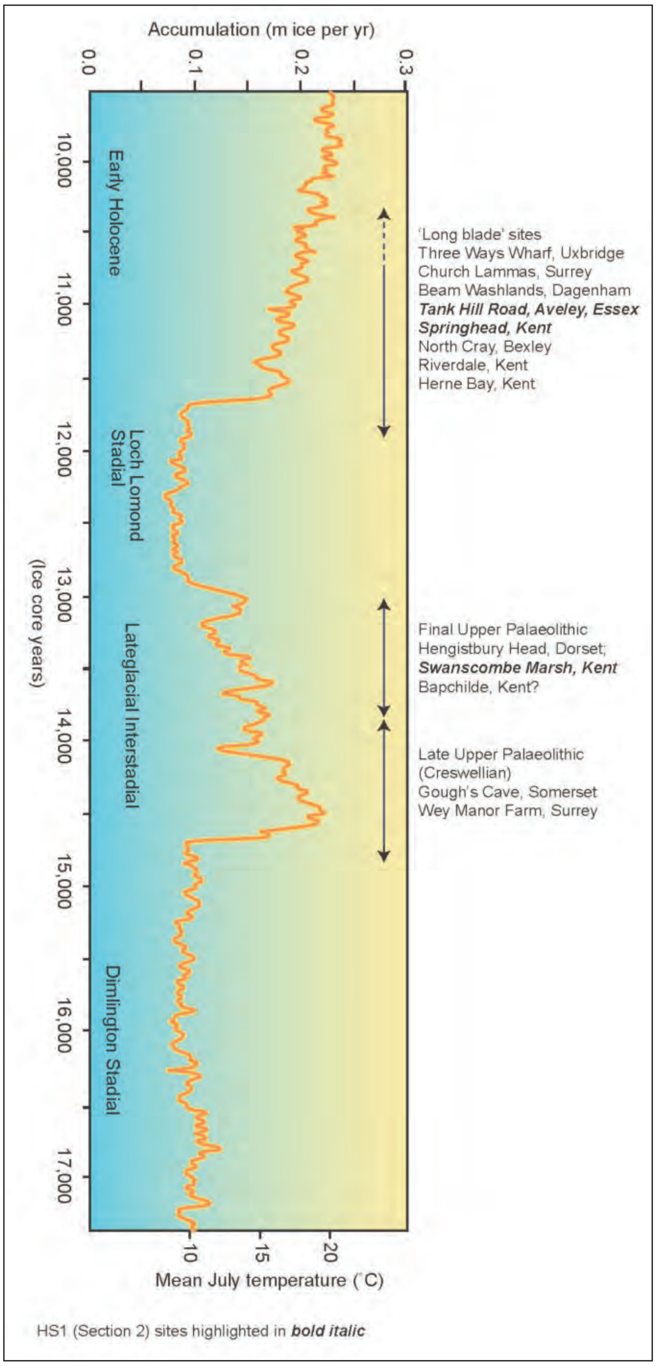


Figure 20.1 Late Glacial and early Holocene transition; climatic variation and archaeology (after Morigi *et al* 2011, 138, fig. 7.1)

measuring approximately 1mm thick. Overall the flints were recovered from 23 contexts, the majority of which were in a limited area close to the spring-head. Comparatively few possible early flints were located away from this concentration, but two possible flakes were also found at Springhead Nursery site (ARC SPN00).

Raw material and condition

The raw material is relatively uniform and it is possible much of the debitage results from the reduction of a single large flint nodule. All diagnostic artefacts and refitting flints exhibit this cortex. The nodule was of good quality, but occasional small thermal fractures were present towards the cortical surface. The nodules cortex is particularly distinctive. The cortex is thin and abraded and is light buff in colour with mottled mid-grey patches. The cortical surface and thermal fractures suggest the flint nodule has been selected from a secondary gravel source. The nodule must have been of substantial proportions as the largest blade measures 152mm, and one core was abandoned at 120mm. Large nodules are readily available from the local gravels, but it is notable that no similar cortical surfaces were observed among the raw materials for later industries. The raw material for the later industries is also heavily frost shattered. This may indicate the careful selection of raw materials for the production of long blades or the exploitation of a source not used in later periods.

The condition of the flint varies between archaeological contexts, but is generally in relatively fresh condition with limited post-depositional edge-damage. A blade (context 5876) was refitted to the long blade core (5873, Fig 20.2, 1) and a flake (context 5875) refitted to a bruised flake (context 5899, Fig 20.2, 4); conjoins were also made between a burnt spall and a bruised flake (context 6553, Fig 20.2, 3) and also between two halves of a blade with an ancient break (context 5874). The condition of these flints and the presence of refits and conjoins indicate the flints, although redeposited, have moved a very limited distance from their original place of deposition.

The diagnostic flints exhibit a heavy to very heavy white surface cortication, measuring *c* 1mm thick, where recent breaks allow examination. Several flints also exhibit speckled black manganese staining. Cortication is notoriously unreliable as a dating indicator, but can in certain circumstances assist in distinguishing admixed assemblages (Brown 1995). The proportion of blades to flakes in relation to the degree of cortication is presented in Table 20.2. This clearly indicates corticated assemblages include a higher proportion of blades more typical of earlier industries (Pitts and Jacobi 1979; Ford 1987). The very heavily corticated flints, and the majority of heavily corticated flints, were present in contexts associated with diagnostic flints. All the very

Table 20.2 The degree of cortication recorded on flints from Springhead (ARC SPH00)

	Degree of cortication				
	None	Light bluish/ speckled white	Medium white	Heavy white	Very heavy white
Flakes	3303	869	144	99	56
Blades	51	45	20	18	18
Bladelets	23	11	1	3	
Blade-like flakes	59	32	10	12	5
% Blades/bladelet/blade-like flakes vs. Flakes	3.9%	9.2%	17.7%	25%	29.1%

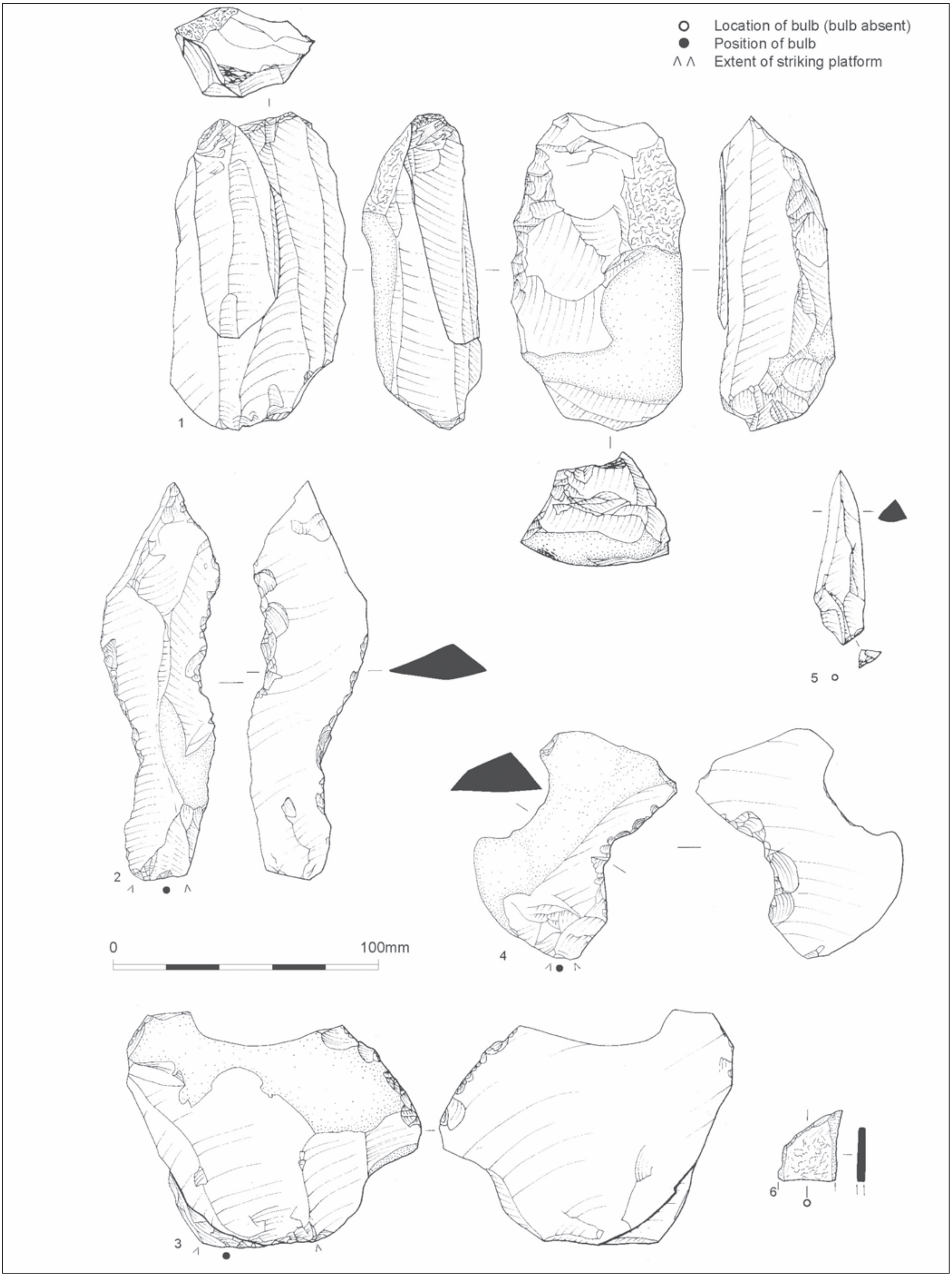


Figure 20.2 Final Upper Palaeolithic worked flint from HS1 investigations at Springhead. 1. Long blade bipolar core with refitting blade (ARC SPH00, 5873 and 5876); 2. Long blade, 152mm long, with two areas of bruising (ARC SPH00, 5875); 3. Bruised flake with a conjoining fragment, broken by burning (ARC SPH00, 6553); 4. Bruised flake (ARC SPH00, 5899); 5. Blade with basal retouch removing bulb (ARC SPH00, 6553; 6. Obliquely retouched flake, burnt and broken (ARC SPH00, 6553)

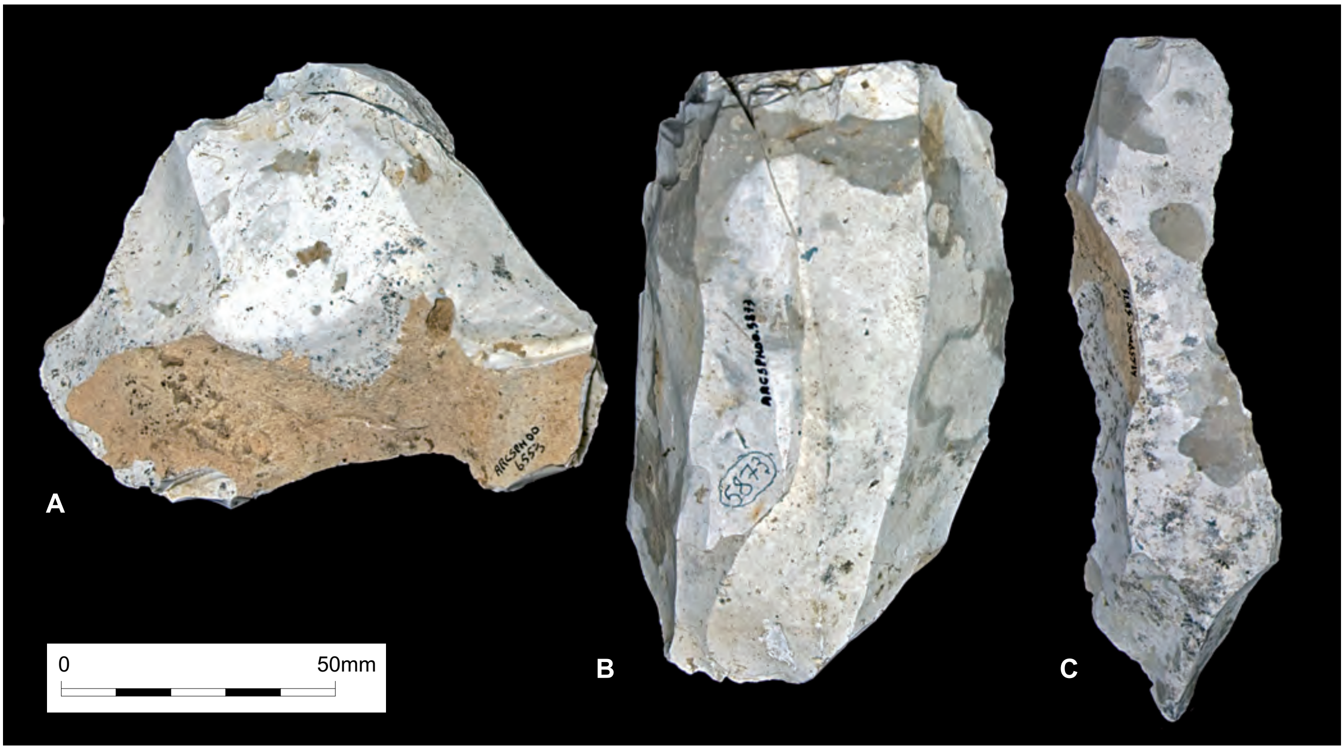


Plate 20.1 Final Upper Palaeolithic worked flint from Springhead (ARC SPH00); (a) context 6553 bruised flake with con-joining fragment of flake broken by burning; (b) context 5876 long blade core with refitting blade; (c) context 5875 long blade

heavily corticated flints and heavily corticated flint associated with diagnostic artefacts have been considered as potentially contemporary and form the sample considered for technological attribute analysis below.

Fifteen (8.7%) of the flints are burnt and 96 (55.8%) are broken. The burnt pieces include a long blade core (Fig 20.2, 1) and a bruised flake; a burnt spall was con-joined to the latter (Fig 20.2, 3). The presence of burnt artefacts is unusual for long blade assemblages, but considering that the burnt flints exhibit a heavy white cortication comparable to the other early flints in the assemblage there is no reason to suspect the burning occurred in a later period. The proportion of breakage is also relatively high. The breaks on several flakes are not corticated indicating they result from post-depositional damage, but this does not account for all the breakage. It is apparent that several breaks occurred during knapping; a common occurrence when producing long blades (pers obs). Other blades, however, may have been intentionally snapped into segments for use or further adaptation.

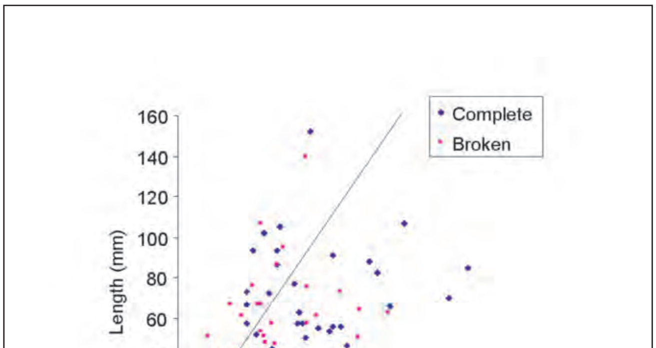


Figure 20.3 Length to breadth scatter diagram for Final Upper Palaeolithic worked flint flakes from Springhead (ARC SPH00)

Debitage

The debitage recovered was orientated to the production of substantial blades and 22% of the flake debitage was of blade proportions (>2:1 length to breadth ratio). In total, five blades exceeded 100mm, but only two exceeded 120mm; the largest measures 152 x 48 x 13mm (Fig 20.3 and Fig 20.2, 2). The average length of a complete blade is, however, only 77mm (sample = 13). A significant proportion of the flake debitage (31%) bore some of the original cortical surface indicating early elements of the nodule's reduction sequence are present in the assemblage. A number of large side and distal trimming flakes suggest the preparation of the core at this location, but large entirely cortical flakes are absent suggesting initial core preparation may have been performed elsewhere.

The three cores in the assemblage each exhibit a different reduction strategy. The core from context 5876 is typical of long blade industries (Fig 20.2, 1). The core has one main relatively flat working face and a rear surface with minimal preparation. The platforms are opposed and removals were made alternately from each platform. The core was abandoned at 120mm length, although it would have been possible to rejuvenate the

Table 20.3 Technological attributes of Final Upper Palaeolithic worked flint from Springhead (ARC SPH00)

Termination type				
Hinge	**Step**	**Plunging**	**Feather**	**Other**
21 (18.3%)	0	12 (10.4%)	79 (68.7%)	3 (2.6%)

Butt type						
Cortical	**Plain**	**>1 Removal**	**Facetted**	**Linear**	**Punctiform**	**Other**
6 (7%)	47 (54.7%)	10 (11.6%)	2 (2.3%)	6 (7%)	7 (8.1%)	8 (9.3%)

Dorsal extent of cortex					
0	**1–25%**	**26–50%**	**51–75%**	**76–99%**	**100%**
104 (67.1%)	26 (16.8%)	7 (4.5%)	7 (4.5%)	5 (3.2%)	6 (3.9%)

Flake type					
Preparation	**Side trim.**	**Distal trim.**	**Misc. trim.**	**Non-cortical**	**Rejuvenation**
10 (6.3%)	25 (15.8%)	7 (4.4%)	7 (4.4%)	98 (62%)	11 (7%)

Proportion of blades, presence of platform-edge abrasion and dorsal blade scars		
% flakes >2:1 L:B ratio	**% flakes with platform edge abrasion**	**% flakes with dorsal blade scars**
21.5%	37%	28.5%

Hammer mode		
Hard	**Soft**	**Indeterminate**
29 (34.9%)	18 (21.7%)	36 (43.4%)

core and make further removals. The bipolar core from context 5898 opportunistically exploits the ridge along the side of a thermally fractured flake, to facilitate blade removals. A plain platform was established at each end of the core, but few flakes were removed prior to abandonment. A single platform blade core from 5877 may have once formed part of significantly larger core, but the final removal plunged leaving the core measuring only 60mm in length. The core platforms are generally simple with 54.7% of flakes exhibiting plain butts (Table 20.3). These platforms were maintained through frequent rejuvenation (7% of flake debitage) with further minor adjustments reflected by a few small flakes with facetted butts. The abrasion of platform edges was frequently undertaken, with 37% of flakes exhibiting some edge-abrasion; the platform-edges of large blades were frequently heavily abraded.

It is likely that the flakes and blades were detached using direct percussion, but it is difficult to determine the tool used for percussion. A consideration of the bulb morphology, following Onhuma and Bergman (1982), suggested 35% of flakes were produced by a soft hammer and 22% by a hard hammer, but 43% of flake were indeterminate. The large number of indeterminate bulbs reflects the presence of mixed attributes. The point of percussion was frequently broad and exhibited a lip, but the bulb was prominent. These attributes may suggest the use of a soft stone hammer for percussion, although antler percussion can produce similar attributes (Barton 1998).

The flake debitage reflects a complete reduction sequence, although it is only partially represented due the loss of flints during redeposition. A partly dressed nodule was brought to the springs, where it was prepared into cores that were worked, with numerous modifications to the platform angle, until exhausted. The presence of retouched tools and bruised flakes, considered below, including one that refits to another flake, indicates that tools were also used and abandoned at this location.

Retouched and utilised flakes

Retouched tools were poorly represented with only two flints, equating to 1.1% of the assemblage, exhibiting secondary working. One flake exhibited oblique distal retouch (context 6553, Fig 20.2, 6). The proximal end of this flake was broken in antiquity and the dorsal surface was burnt and had subsequently broken. The second retouched flint was a thick blade that converged to a distal point (context 6553, Fig 20.2, 5). The proximal end of the blade exhibited a limited area of abrupt retouch removing part of the striking platform. The retouch may have served as backing, but no obvious traces of use were present on the point.

A further three flakes and a blade exhibited heavy edge-damage from use and are considered to be bruised flakes/blades. The bruised blade (context 5875, Fig 20.2, 2) is the largest blade recovered, measuring 152mm, and exhibited heavy edge-damage on the middle of both the left- and right-hand sides. The three bruised flakes (see Fig 20.2, 3 and 4) were all substantial side trimming flakes and exhibited heavy damage along one side. The use-wear was pronounced with numerous step fractures and scars extending up to 10mm into the flake surface. This damage suggests use against a hard material and experimental work has shown similar damage can be produced chopping bone or antler (Barton 1986).

Discussion of the assemblage

The flint fulfils the criteria established by Barton (1998) for a long blade assemblage in that it contains blades in excess of 120mm, with evidence of a complete reduction and use sequence. The assemblage also has a low incident of retouch, but includes heavily utilised 'bruised' flakes and blades. A number of long blade find spots have been identified along the Thames corridor including Burchell's excavations in the Ebbsfleet Valley (Burchell 1938, SAM Kent 268b) where a 'Mesolithic floor' produced blades considered by Barton to represent a long blade industry. An *in situ* long blade

Table 20.4 Quantification of Mesolithic worked flint from colluvial contexts 6317, 6318 and 6326 at Springhead (ARC SPH00)

Context	6317	6318	6326
Flake	62	209 (1)	186 (2)
Blade	2	22	21
Bladelet	–	6	11
Blade-like	–	6	17
Irregular waste	–	–	1
Chip		134	64
Micro burin	–	–	1
Rejuvenation flake core face/edge	–	1	–
Rejuvenation flake tablet	–	1	–
Rejuvenation flake other	–	1	1
Tested nodule/bashed lump	–	1	1
Single platform flake core	2	–	1
Multiplatform flake core	2	–	1
Burin	–	1	–
Total	**68**	**382 (1)**	**305 (2)**
No. Broken worked flints (%)*	11 (16.2)	89 (35.7)	64 (26.3)
No. Retouched flints (%)*	–	1 (0.4)	–

scatter has also been discovered adjacent to the River Darent at Lullingstone Country Park, near Eynsford, some 13km to the south-west (Anderson-Whymark *et al* 2016). Associated dating of technologically similar assemblages, for example at Three Ways Wharf, Uxbridge (Lewis 1991; Lewis with Rackham 2011) and Avington VI (Barton *et al* 1998), suggest long blade industries date from the very end of the Late Glacial period and the beginning of the post-glacial. The function of long blade sites is subject to some debate, but it has been argued that they represent short term sites associated with the processing and butchery of large herbivores, such as red deer and horse (Barton 1995, 64). The low incidence of burning and absence of hearths has previously been used to support this interpretation of short term activity. The presence of a significant number of burnt artefacts at Springhead, however, reflects the presence of a fire associated with the flint scatter. This need not indicate longer term activity, indeed the suggestion of tool production, limited retouch, specific use-wear patterns and abandonment continue to support the suggestion of brief task-specific activities.

Mesolithic (c 8500–4000 BC)

The majority of the Mesolithic period falls within Holocene Landscape Stage 1b (Chap 16). This is a period of relative landscape stability. The surface of the gravel and head deposits that accumulated during the preceding period essentially formed the early Holocene topography of the valley. Reconstruction of this surface in the Lower Valley has revealed a deep Outer Basin close to the confluence with the Thames and a shallower Inner Basin upstream. A promontory or 'spur' extended from the western slopes of the valley at the junction of the two basins which would have existed as an area of higher ground overlooking the floodplain (Fig 16.6). The Ebbsfleet during this period was a meandering freshwater river depositing in-channel fluvial sands and organic sandy silts in the more sheltered locations. The vegetation comprised rather open scrubby deciduous woodland with birch (*Betula*), hazel (*Corylus*), and an understorey of grasses and ferns, growing on the banks of the river. More closed deciduous woodland probably grew further away from the site.

There is very little evidence of any human impact on the environment at this time; a few microscopic charcoal particles noted during the pollen analysis (eg, BH7, Chap12; Huckerby *et al*, Appendix J) may have come from some distance, having been blown or carried into the site by wind or water. Although this could be interpreted as evidence of human activity in the catchment, for example the use of fire to create woodland clearings for grazing (Mellars 1976; Simmons and Innes 1997; Simmons 1996), it could equally be the result of natural events such as forest fires.

Direct evidence of human activity during this phase was generally sparse, and again consisted almost entirely of worked flint as residual finds in later archaeological features and layers (Anderson-Whymark, Appendix I). The majority of diagnostic flint artefacts, and several blades and flakes can be broadly attributed to the Mesolithic period on the basis of technological attributes and reflects a general background scatter of activity during this period.

Springhead (Zone 11)

In the Upper Ebbsfleet Valley (Zone 11) finds include a fabricator and an awl from the Ebbsfleet River Crossing (ARC ERC01), two micro-burins and a burin from Springhead Nursery (ARC SHN02) and a second burin from Springhead Roman Town (ARC SPH00). In addition, at the Ebbsfleet River Crossing the fill of a gully associated with Early Bronze Age structure 551 (context 472) also produced a micro-burin, two bladelets and three chips. A coherent assemblage of 755 Mesolithic flints was, however, recovered from the lower portion of the colluvial sequence containing the redeposited Final Upper Palaeolithic flint described above at Springhead (ARC SPH00, contexts 6326, 6318 and 6317, Table 20.4).

Worked flint from Springhead colluvial sequence (ARC SPH00)

by Hugo Anderson-Whymark

Overall these contexts contained debitage resulting from blade production, including several refitting flakes, but the only diagnostic artefacts were a burin and a distal micro-burin. A metrical and technological attribute analysis was undertaken on flint from contexts 6326 and 6318 to characterise reduction strategies and refine dating (Table 20.5).

Raw material and condition

The debitage indicates the exploitation of locally available cobbles of flint from the river gravels. The nodules are generally irregular in form and exhibit a thin white to beige cortex. Refitting sequences suggest nodules in excess of 120mm were exploited. The flint

Table 20.5 Technological attributes of Mesolithic worked flint from colluvial contexts 6318 and 6326 at Springhead (ARC SPH00)

	Termination type				
Context	**Hinge**	**Step**	**Plunging**	**Feather**	**Other**
6318	18	1	9	71	1
6326	13	2	9	56	1
6326/6318 combined	31 (17.1%)	3 (1.7%)	18 (10%)	127 (70.2%)	2 (1.1%)

	Butt type						
Context	**Cortical**	**Plain**	**>1 Removal**	**Facetted**	**Linear**	**Punctiform**	**Other**
6318	4	30	14	6	22	18	3
6326	7	38	6	3	9	11	10
6326/6318 combined	11 (6.1%)	68 (37.6)	20 (11.1%)	9 (5%)	31 (17.1%)	29 (16%)	13 (7.2%)

Context	Dorsal extent of cortex					
6318	0	1–25%	26–50%	51–75%	76–99%	100%
6326	51	28	9	4	4	4
6326/6318 combined	43	19	2	5	11	1
	94 (52%)	47 (26%)	11 (6.1%)	9 (5%)	15 (8.3%)	5 (2.8%)

	Flake type					
Context	**Preparation**	**Side trim.**	**Distal trim.**	**Misc. trim.**	**Non-cortical**	**Rejuvenation**
6318	7	25	7	10	48	3
6326	9	12	5	10	43	2
6326/6318 combined	16 (8.8%)	37 (20.4%)	12 (6.6%)	20 (11.1%)	91 (50.3%)	5 (2.8%)

	Proportion of blades, presence of platform-edge abrasion and dorsal blade scars		
Context	**% flakes >2:1 L:B ratio**	**% flakes with platform edge abrasion**	**% flakes with dorsal blade scars**
6318	17%	50%	11%
6326	19.7%	43%	14.8%
6326/6318 combined	18.2%	47%	12.7%

	Hammer mode		
Context	**Hard**	**Soft**	**Indeterminate**
6318	16	50	34
6326	14	28	39
6326/6318 combined	30 (16.6%)	78 (43.1%)	73 (40.3%)

contains occasional thermal fractures, but in general was of good quality for flaking. The flint was in fresh condition and bore a light to moderate white surface cortication.

Debitage

The debitage present represents testing, preparation and reduction of several nodules for flake and blade production. Knapping refits are present between flints in layers 6318 and 6326 indicating the flints in the contexts result from the same event or series of events. A refit between a tested nodule and a cortical flake in context 6326 indicates that the earliest stages of reduction are present in the deposits. Another refitting sequence in 6317 reflects an unsuccessful attempt to establish a blade core. A simple platform of two flake removals had been established and a series of flakes struck to remove cortex, one of which was refitted. A ridge was then exploited to remove a plunging blade, establishing ridges to facilitate further blade removal. The following removal exploiting one of the ridges was unsuccessful and resulted in a stepped flake, and the next removal, along the other ridge, split the core in two pieces along a thermal fracture and the flint was abandoned (Pl 20.2).

A significant proportion of the refitting debitage appears to result from the preparation of a single nodule as a blade core. Several refitting groups of large plunging flakes in both 6318 and 6326 represent the careful dressing of a nodule. In a similar flint, two halves of a snapped crested blade, measuring 96mm, was conjoined and a small earlier opposed removal was also refitted. A sequence of seven refitting blade and blade-like side and distal trimming flakes also appear to belong to this group. The core and refitting non-cortical blades are notably absent from the assemblage. This may suggest that the dressed core was removed to another location for knapping, or that the core was partially worked and the core and successful non-cortical blades were removed from the assemblage for use or further adaptation elsewhere. The analysis of metrical and technological attributes of flakes in the assemblages complements this observation. The assemblage contained a large proportion of cortical or partly cortical flakes (48%) indicating the presence of numerous pieces associated with the early stages of core reduction. The cores were carefully reduced, predominately with a soft hammer, and 47% of flakes exhibit platform-edge abrasion. The flakes also frequently exhibited linear and punctiform butts (17.1% and 16% respectively), a trait commonly associated with blade production. However, blades only form 18.2% of the flake assemblage; a low percentage for a Mesolithic industry (Ford 1987). Rejuvenation flakes are also poorly represented at only 2.8% of the flake assemblage. The low proportion of blades and rejuvenation flakes reflects the limited reduction cores for blades, following their preparation, and suggests that only the early stages of reduction were undertaken at Springhead.

In addition to the blade production, flakes were struck from small thermally fractured pieces of flint. Flakes were refitted to a single-platform flake core and a multi-platform flake core. These flakes were more expediently removed than in the blade production and exhibit no platform-edge abrasion prior to striking. Indeed, the flakes struck from the single-platform flake

Plate 20.2 Early Mesolithic refitting flakes, demonstrating an unsuccessful attempt to initiate a blade core (context 6317, ARC SPH00)

core were struck from a frost shattered platform using a hard hammer (context 6326, Pl 20.3). This reduction strategy is more typical of the later Neolithic or Bronze Age, but given the context of these flints they may be considered as an expedient Mesolithic product.

Retouch

The only tool recovered from contexts 6317, 3318 and 6326 was a dihedral burin struck on the end of a blade. In addition, the micro-burin technique was used to snap the distal end from a broad, 20mm wide, double-ridged blade. The virtual absence of retouched tools from the assemblage at Springhead adds further weight to the suggestion of a knapping site away from areas of tool production or use.

Discussion of the assemblage

The assemblage reflects the exploitation of local deposits for flint nodules and their primary preparation as blade cores. It is likely these cores were removed for further working and presumably tool production and use elsewhere. Dating of this assemblage from the colluvial deposits is problematic due to the absence of diagnostic artefacts. The use of the micro-burin technique suggests a Mesolithic date; a date also appropriate for the burin. The presence of a large crested blade, measuring 96mm long, suggests the production of relatively substantial blades characteristic of the earlier Mesolithic. The small numbers of flints present in the wider landscape at Springhead are also problematic to date and no more than a broad Mesolithic date can be suggested. The flints are sparsely distributed and, apart from indicating occasional microlith production, tool use and discard, reveal little of the character of Mesolithic activity.

The Lower Valley (Zones 1–9)

In the Lower Ebbsfleet Valley, on the valley slopes and 'spur', a micro-burin from the upper fill of a ditch (ARC EBB01, context 20718) represents the only diagnostic artefact. A further two single platform bladelet cores, and a small number of true blades, may be assigned a broad Mesolithic to Early Neolithic date. The evaluation phase (ARC ESG00) yielded a rod microlith and the watching brief (ARC 342W02) produced a well worked bipolar blade core.

Holocene Landscape Stage 2 as outlined in Chapter 16 occurred during the Late Mesolithic period. This stage is represented in the sedimentary sequences by the deposition of the Lower Clay-Silt unit which marks an early influx of estuarine waters into the Lower Ebbsfleet Valley and the progressive backing-up of freshwater channels with flooding. The floodplain surface during this period would have become increasingly unstable and wetland environments began to expand at the expense of dry ground areas. Temporary land surfaces may have existed within the floodplain but are likely to have been ephemeral. Pollen and diatom evidence suggests the local development of saltmarsh and reedswamp environments in the tidally affected Outer Basin. Further upstream the river remained freshwater.

Deciduous woodland with lime, elm, oak, hazel, ash and birch dominated the landscape on drier ground with alder and willow on wetter soils. Values of microscopic charcoal particles were quite high, including pieces of charred grass, and are evidence for local, possibly humanly-made, fires in the catchment.

A small assemblage of 26 pieces of flint was retrieved from an organic silt in Borehole 11 (EBBS97) at a depth of *c* 9m on the floodplain of the Lower Valley (Zone 8; Figs 12.1 and 12.7). The assemblage included nine reasonably fresh flakes and chips along with 17 burnt fragments; a large assemblage considering the small dimensions of the borehole. The flakes were cortical and trimming flakes, apart from one inner flake, and two of the flakes were thin and struck with a soft hammer (OAU 1997, 52). Radiocarbon dating of the organic sediment produced a date of 6420±50 BP (Beta-108113, 5478–5318 cal BC, Table 12.2). In addition, two complete Late Mesolithic microliths and a third broken example were recovered from Area 4 (STDR401, Fig 20.4), at the interface of the minerogenic alluvial silt (Zone 9; contexts 4044, 4053 and 4054, Figs 13.7, 13.8) and the main overlying peat body. A radiocarbon date of 5405±35 BP (NZA-29246, 4350–4070 cal BC, Table 13.2) was obtained on a charred hazelnut shell from context 4053, from which one of the microliths was recovered, and may date the Mesolithic activity. However, the microliths and hazelnut shell were mixed with Early Neolithic flint scatters that were deposited on the same extant land surface.

Catalogue of illustrated flint
(Fig 20.4)

1. Microlith comparable to Jacobi's type 5 (1978). Abruptly retouched along the left-hand side, but with addition abrupt retouch on the proximal right-hand side from production using the micro-burin technique (context 4044)
2. Rod-like backed bladelet abruptly retouched along the right-hand side, comparable to Jacobi's type 5 (1978), but with slight additional retouch on the left-hand side at the proximal and distal ends to enhance to points (contex 4054, SF 2018)

Plate 20.3 Early Mesolithic flake core with refitting flakes (context 6326, ARC SPH00)

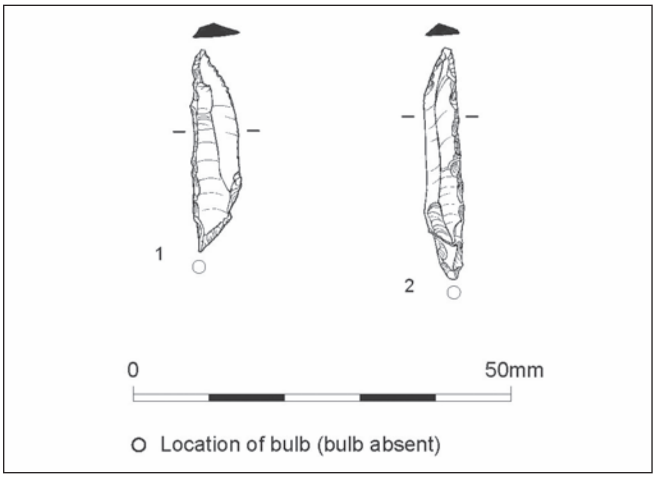


Figure 20.4 Late Mesolithic microliths from Area 4 (STDR401)

Wider Overview

by Chris Hayden

The Mesolithic flint recovered from the excavations has characteristics generally similar to that recovered from other projects in the area. Like the Mesolithic flint recovered from the A2 excavations (Allen *et al* 2012), for example, much of it was residual, in clearly much later contexts. On most sites the number of pieces recovered was small, although there were also noticeably larger and denser concentrations.

That the direct evidence for activity in the Mesolithic is, like that of the surrounding sites, limited to worked flint is perhaps sufficient to indicate that the potential to draw significant inferences about Mesolithic activity is limited. The extent to which this kind of evidence can be interpreted is constrained by a number of significant issues. Of these the most important is the fact that the relationship between the exploitation of the landscape (to say nothing of the social relationships involved) and the patterns in the deposition of flint is likely to have been complex. As Yellen's (1977; Clarkson 2008) work with the Dobe !Kung suggests, unless flint working was entirely expedient (ie, tools were made as they were needed, used on the spot, and then discarded), the pattern of deposition of lithics is likely to reflect the points at which tools wear out and where new tools were made rather than the other activities which occurred at a site.

One important implication of this is that the total number of pieces of worked flint on a site may not give a good indication of the size of the occupying group, of the length of time a site was occupied, or of the fact that a site was repeatedly visited. Sites where the lithic elements of tools were produced are likely to be characterised by much larger assemblages than those where lithic production did not take place – although clearly it would be expected that assemblages from production sites would be characterised by relatively large proportions of knapping debris. (This complexity is an addition to that posed by the fact that Mesolithic flint is often mixed with later material from which only the most chronologically diagnostic pieces can be singled out as Mesolithic. The overall size of the Mesolithic assemblage thus often remains unknown.)

The extent to which discard and production themselves map on to other activities may, then, depend upon the degree to which tools with lithic elements were made expediently. Unfortunately, the composite tools (eg, Grace 1992; David 1998) which seem to be characteristic of the Mesolithic suggest that much tool production in that period was far from expedient. Indeed, it seems more likely that much tool production may have been quite separate from tool use, and some of the evidence from Ebbsfleet may reflect the fact that trips were made to specific locations to acquire flint and carry out the first stages of lithic production.

Despite these problems, a few limited avenues of interpretation remain open. It still seems likely, for example, that many tools would have been broken or worn out whilst they were in use, and thus certain categories of flint may still provide an index – albeit perhaps a very partial one – of the kinds of activities occurring on a site (although the exact use to which the tools were put usually remains unknown). Furthermore, as has already been suggested, it may still be possible to examine the way in which tool production itself was organised.

The evidence from Ebbsfleet, from nearby sites, and from Kent more widely, provides good illustrations of these points. The possibly Early Mesolithic assemblage of 755 flints from Springhead, for example, includes evidence for the primary production of blade cores, which, however, were taken away from the site, and used for tool production elsewhere. In large part, the lithics appear to have been related to the exploitation of local flint cobbles. Only one retouched tool – a dihedral burin – was found. This site, then, appears to have been the location of a specific part – the initial stages – of the process of producing flint tools, and could be seen as having been occupied as part of a logistic pattern of movement (ie, a pattern of movement intended to exploit specific, known resources; *cf* Binford 1980; Kelly 1992; Eder 1984).

It is perhaps worth noting that some of the assemblages recovered along HS1, although they belong to the Late Mesolithic and lie at some distance from the Ebbsfleet Valley, could be seen as representing complementary stages in the process of lithic production. For example, the assemblages from Sandway Road (Trevarthen 2006; Harding 2005) and Beechbrook Wood (Brady 2006a; Cramp 2005) – contained little evidence for core preparation, suggesting that the cores were prepared elsewhere and brought to these sites to be worked into tools (Harding 2006, 12).

Much of the flint from the Late Glacial–early post-glacial assemblage at Springhead also consists of debitage which seems to have been related to the preparation of cores (ibid, 18–19). In this case, however, a larger number of retouched tools and bruised flakes were present which could be taken as an indication that other activities – alongside core preparation – were also taking place on the site.

Although in comparison to the more sporadic finds which were made elsewhere in the Ebbsfleet Valley, and, for example, along the A2 and HS1, the assemblage recovered at Springhead might be regarded as reasonably large, it is small compared to those recovered at the other sites mentioned above. Anderson-Whymark (see Appendix I) notes that much of the debitage appears to have been related to preparation of a single blade core. The quantity of flint need not, therefore, be seen as reflecting a relatively large population or a relatively long occupation. Indeed, if it is correct to view the site as having been exploited logistically, it would perhaps be more plausible to see it as perhaps having been visited, perhaps relatively briefly, on a number of occasions, to acquire and prepare cores. Although refits were found, suggesting that the assemblage had retained some integrity, it was not *in situ,* and it is impossible now to clearly evaluate the extent to which it may have been produced by repeated visits.

The large assemblage of over 11,000 pieces of worked flint from Sandway Road (Harding 2005) makes the point that the size of an assemblage may reflect more the extent to which a site was involved in lithic production, rather than the size of the occupying population, the length of time the site was occupied, or the number of times it was revisited. Like the Springhead assemblage, the Sandway Road assemblage also contained a large proportion of debitage, but, apart from a group of 223 microliths, relatively few retouched tools. The lithics from Beechbrook Wood (Harding 2006, 19; Cramp 2005; Brady 2006a) also contained a large number of chips, as well as cores, and a number of microliths. In this case, the number of micro-burins, outnumbered the number of microliths by a ratio of about 2 to 1, suggesting that the site was involved in the production of microliths which were used and discarded elsewhere.

Sites elsewhere in the region around the Ebbsfleet Valley may exemplify further elements of the overall system of lithic production. At Bronze Age Way, Erith (Bennell 1998), for example, in what seems to have been a Late Mesolithic assemblage, there were apparently few tools, but much evidence for the production of tranchet axes. At Purfleet (Leivers *et al* 2007), again of Late Mesolithic date, further evidence for the production and maintenance of tranchet axes was found. In the main scatter at Purfleet, however, the lithics were dominated by micro-burins which suggest that microliths were made around a hearth. A similar range of evidence was found at Darenth Court Villa (Woodcock 1984), including tranchet axes and axe sharpening flakes, as well as microliths and micro-burins, but few tools or utilised flakes were recovered. Further evidence for tranchet axe production was found at Darenth Gravel Pit (Philp *et al* 1998). The assemblage there, however, also included a group of nine obliquely truncated blades, suggesting also a specialised form of activity.

In a region where the evidence for Mesolithic activity consists almost entirely of lithics, it is perhaps inevitable that only those parts of the settlement system which involve reasonably large scale or repeated production of lithics will be clearly represented in the archaeological record. Although the evidence remains patchy, and of unfortunately vague or varying dates, it is possible to see how the Springhead site might have formed part of the process of lithic production – involving perhaps logistical trips to acquire flint and to work into cores, which were then taken away to other sites to be worked further into tools. The way in which the activity at Springhead might have been related to, and formed part of, a wider system of movements – reflecting subsistence strategies and social organisation (Wiessner 1982) – remains, however, unclear. The relatively frequent but sporadic Mesolithic finds on other sites in the area (eg, along the A2 and HS1; Allen *et al* 2012; Harding 2006) may reflect widespread movement of small groups, but the evidence is not sufficient to provide the basis for more definite interpretation.

Chapter 21
Neolithic and Early Bronze Age

by Elizabeth Stafford, Hugo Anderson-Whymark and Chris Hayden

Introduction

Neolithic and Early Bronze Age activity falls within Holocene Landscape Stage 3 (Chap 16). This stage is characterised by the accumulation of thick deposits of wood peat in the Lower Valley floodplain. In the 'Outer Basin' (Zone 8; Fig 12.1) the commencement of peat accumulation has been radiocarbon dated in Borehole BH7 (STDR400) to the later part of the 5th millennium BC, but further upstream, in the 'Inner Basin' (Zone 9; Fig 13.1), the base of the wood peat lies at slightly higher elevations and the onset of accumulation here is slightly later, dated to the first half of the 4th millennium in Trench 9 (STDR400) and Area 4 (STDR401). In the Upper Valley (Zone 11; Fig 15.1) at the Ebbsfleet River Crossing (ARC ERC01) a peaty landsurface (context 546) overlies calcareous alluvium and was dated to the latter half of the 4th millennium BC. The peat contained well-preserved pollen that demonstrates a predominantly wooded habitat during the Early Neolithic, dominated by lime, oak and hazel on drier areas with alder carr on and along the fringes of the floodplain, with reedswamp beneath. Evidence of clearance was slight at this time comprising small open areas or clearings that may have been grazed by domesticates. Later in this landscape phase, during the Late Neolithic and Early Bronze Age, the environmental evidence suggests increased woodland clearance on the higher drier ground and arable cultivation. This is consistent with the archaeological evidence during this period suggesting increased human activity in the catchment.

Similar to the Mesolithic period dry-land activity dated to the earlier part of the Neolithic is represented by residual artefacts in later archaeological deposits. This included worked flint (Pl 21.1) and a small, albeit significant, assemblage of pottery from the Ebbsfleet River Crossing (ARC ERC01) and on the Lower Valley slopes. In the Lower Valley floodplain area, however, considerable *in situ* evidence of Early Neolithic activity was identified during evaluation and excavation stages for the STDR4, located at the very base of the peat sequence. The assemblages mostly comprised worked and burnt flint scatters with a small faunal assemblage, although notable finds include the recovery of part of a fragmented Ebbsfleet Ware bowl (Trench 11, STDR400) (Fig 21.3, 8, Pl 21.3), and an articulated sheep rib cage showing butchery marks (Area 4, STDR401) (Fig 21.1, Pl 21.7; Table 21.1).

Late Neolithic to Early Bronze evidence on the dry land is more substantial and is represented by clusters of pits and spreads of burnt flint at the Ebbsfleet River Crossing and on the Lower Valley slopes. The pits were generally characterised by large quantities of burnt flint but few diagnostic artefacts. All, however, appear to be located adjacent to the former course of the River Ebbsfleet. In addition to the pit clusters, at the Ebbsfleet River Crossing an interesting group of features (Structure 551) were excavated comprising a central pit, with associated gullies and postholes, suggesting some form of structure possibly related to the heating of water. Radiocarbon dating of charcoal fragments from the feature fills consistently produced Early Bronze Age

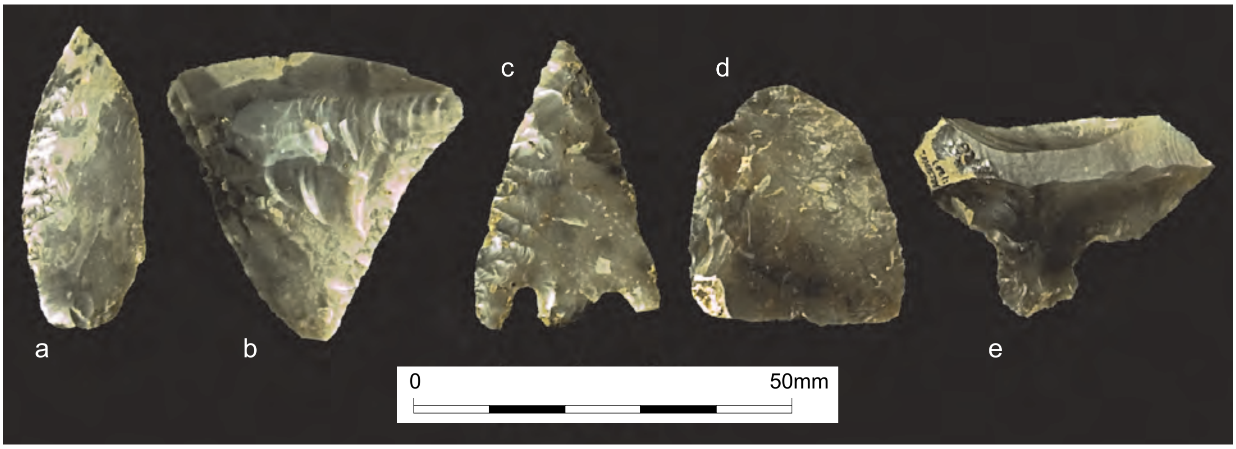


Plate 21.1 Neolithic to Early Bronze Age worked flint from the Upper Valley at Springhead and the Lower Valley Slopes for HS1 (see catalogue for details)

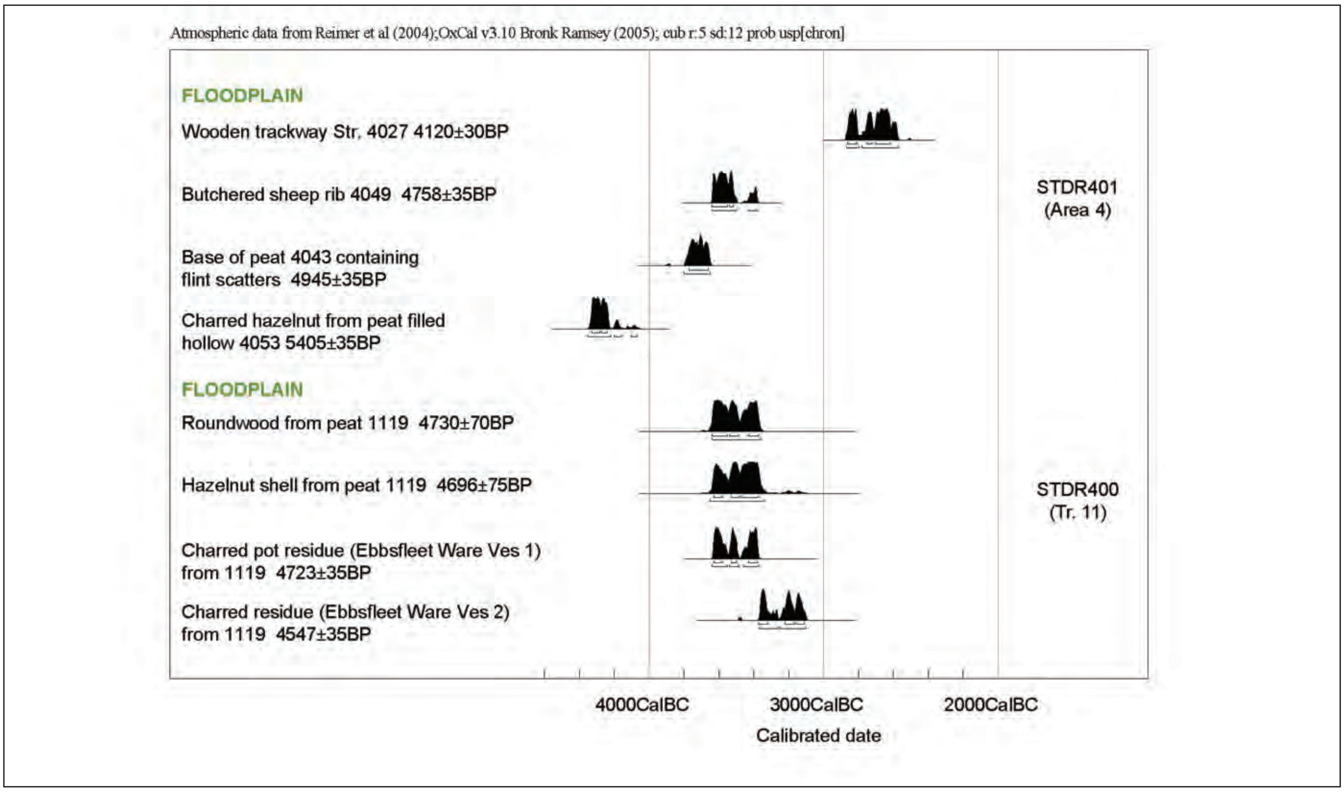


Figure 21.1 Plot of calibrated radiocarbon date ranges associated with Neolithic activity in the Lower Valley floodplain area; Area 4 (STDR401) and Trench 11 (STDR400)

Table 21.1 Radiocarbon dates associated with Neolithic activity in the Lower Valley floodplain area; Area 4 (STDR401) and Trench 11 (STDR400)

Event code	Feature/ layer type	Context	Sample	Material dated	Lab code	$\delta^{13}C$ ‰	Result BP	Calibrated date (2 sigma, 94.5%)
STDR401 Area 4	Wooden trackway Str 4027	4033	–	*Alnus glutinosa*, waterlogged roundwood	SUERC-19950	-27.9	4120±30	2870–2570 cal BC
	Base of main peat	4049	–	Butchered sheep rib bone	NZA- 29242	-22.0	4758±35	3640–3380 cal BC
	Base of main peat	4043	432	Waterlogged *Corylus* nutshell	NZA-29247	-23.6	4945±35	3800–3650 cal BC
	Basal peat filled hollow	4053	491	Charred *Corylus* nutshell	NZA-29246	-24.3	5405±35	4350–4070 cal BC
STDR400 Tr. 11	Peat around Ebbsfleet Ware pot	1119	Ves1	Waterlogged roundwood	WK-8799	-28.4	4730±70 *	3640–3360 cal BC
	Peat around Ebbsfleet Ware pot	1119	Ves1	Waterlogged *Corylus* nutshell	WK-8800	-28.6	4696±75	3650–3340 cal BC
	Ebbsfleet Ware pot	1119	Ves1	Charred residue	NZA- 29079	-26.1	4723±35	3640–3370 cal BC
	Ebbsfleet Ware pot	1119	Ves2	Charred residue	NZA- 29155	-28.5	4547±35	3370–3100 cal BC

KEY: * Bulk radiometric date

Table 21.2 Radiocarbon dates from Early Bronze Age features in the Upper Valley (ARC ERC01) and on the Lower Valley slopes (ARC EBB01)

Event code	Feature/ layer type	Context	Sample	Material dated	Lab code	$\delta^{13}C$ ‰	Result BP	Calibrated date (2 sigma, 94.5%)
ARC ERC01	Burnt flint spread	536	159	Pomoideae. charcoal	NZA-28608	-26.5	3930±30	2560–2290 cal BC
ARC ERC01	Pit 453, Gp.552	460	138	Charred *Corylus* nutshell	NZA-28443	-24.4	3844±35	2460–2200 cal BC
ARC ERC01	Pit 453, Gp.552	460	138	*Betula* sp. charcoal	NZA-28450	-22.9	3808±35	2460–2130 cal BC
ARC ERC01	Pit 435, Gp.552	437	118	*Betula* sp. charcoal	NZA-28615	-26.4	3386±30	1760–1600 cal BC
ARC ERC01	Pit 465, Gp.551	466	134	*Prunus* sp. roundwood charcoal	NZA-28445	-25.8	3379±35	1760–1530 cal BC
ARC SPH00	Burnt flint spread	2963	8311	Pomoideae roundwood charcoal	NZA-28410	-25.9	3354±30	1740–1530 cal BC
ARC ERC01	Pit 430, Gp.552	432	127	*Alnus glutinosa* charcoal	NZA-28618	-27.6	3316±30	1690–1520 cal BC
ARC EBB01	Pit 15818, Gp. 16634	15816	11264	Pomoideae roundwood charcoal	NZA-28400	-25.5	3404±30	1770–1620 cal BC
ARC EBB01	Pit 20726	20724	21162	*Salix/ Populus* sp. roundwood charcoal	NZA-28398	-24.1	3394±30	1770–1610 cal BC
ARC EBB01	Pit 20685, Gp.20750	20684	21150	Pomoideae 5 yr roundwood charcoal	NZA-28250	-26.6	3313±30	1690–1510 cal BC
ARC EBB01	Pit 20682, Gp.20750	20681	21160	*Prunus* sp. charcoal (max 50yrs)	NZA-28249	-23.1	3293±30	1670–1490 cal BC

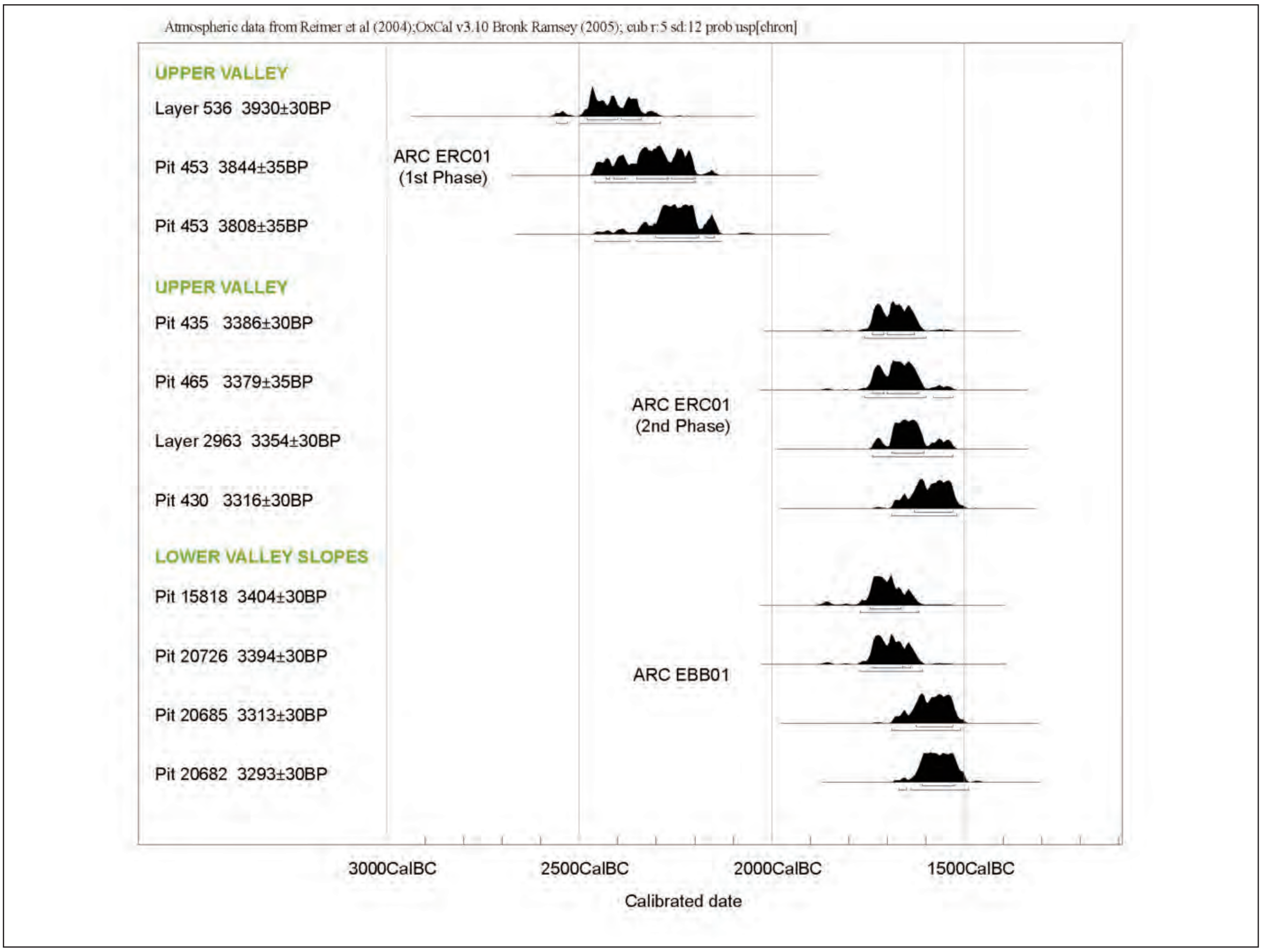


Figure 21.2 Plot of calibrated radiocarbon date ranges from Early Bronze Age features in the Upper Valley (ARC ERC01) and on the Lower Valley slopes (ARC EBB01)

dates, although the range of dates suggest at least two distinct phases of activity at the Ebbsfleet River Crossing (Fig 21.2, Table 21.2). The first phase falls within the latter half of the 3rd millennium BC (2560–2130 cal BC), and the second phase, including Structure 551, in the middle 2nd millennium BC, that is, at the very end of Early Bronze Age (1760–1520 cal BC). On the Lower Valley slopes only one phase was identified (1770–1490 cal BC), although the range suggests the activity may be contemporary with the latter phase at the Ebbsfleet River Crossing.

Evidence of Late Neolithic to Early Bronze Age activity in the floodplain zone is slight, although a section of a log and pole 'trackway' dated to the Late Neolithic period was identified further up the peat sequence in Area 4 (STDR401) (Fig 21.1; Table 21.1).

Catalogue of illustrated flint
(Pl 21.1)

a. Early Neolithic leaf-shaped arrowhead (context 300042, SF 340000, ARC EBB01)
b. Early or Middle Neolithic chisel arrowhead (context 11071, SF 15283, ARC SHN02)
c. Late Neolithic or Early Bronze Age barbed and tanged arrowhead, Sutton type B (context 11739, SF 15275, ARC SHN02)
d. Late Neolithic or Early Bronze Age roughout of barbed and tanged arrowhead (context 16238, ARC EBB01)
e. Early or Middle Neolithic chisel arrowhead? (context 11207, ARC SHN02)

Early to Middle Neolithic (*c* 4000–3350 BC)

Springhead (Zone 11)

An Early to Middle Neolithic pottery assemblage from the Ebbsfleet River Crossing (ARC ERC01, Fig 15.1) comprises 107 sherds, and a further three sherds could be of this date (Barclay and Seager Smith, Appendix H). All of the sherds occur in principally flint-tempered fabrics and were primarily recovered as residual material from the fills of Early Bronze Age pits or natural hollows containing later material. Most notable were the 62 sherds recovered from pit 453, including two incised decorated sherds; one from the neck of a bowl with a

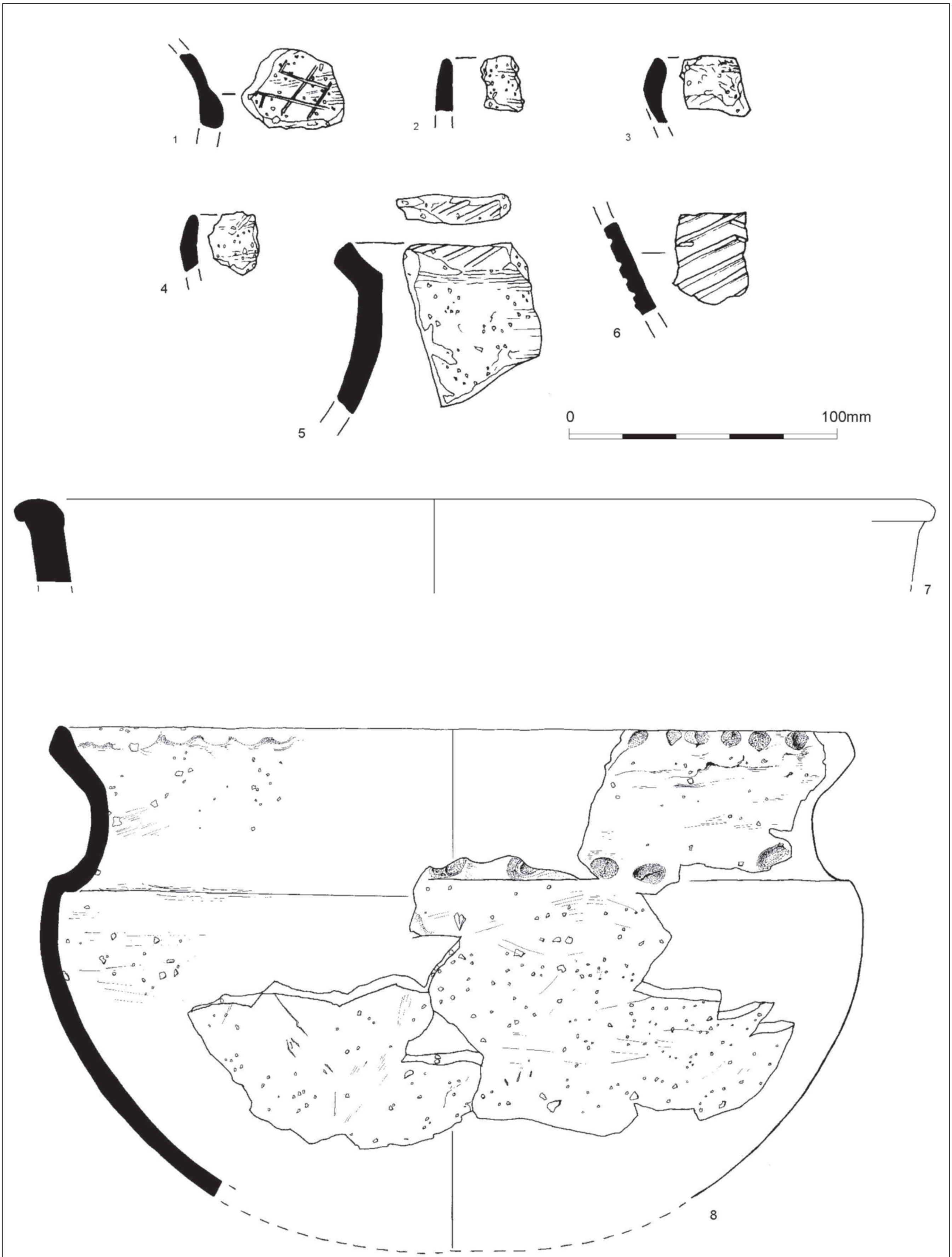


Figure 21.3 Neolithic pottery from HS1 investigations (see catalogue for details)

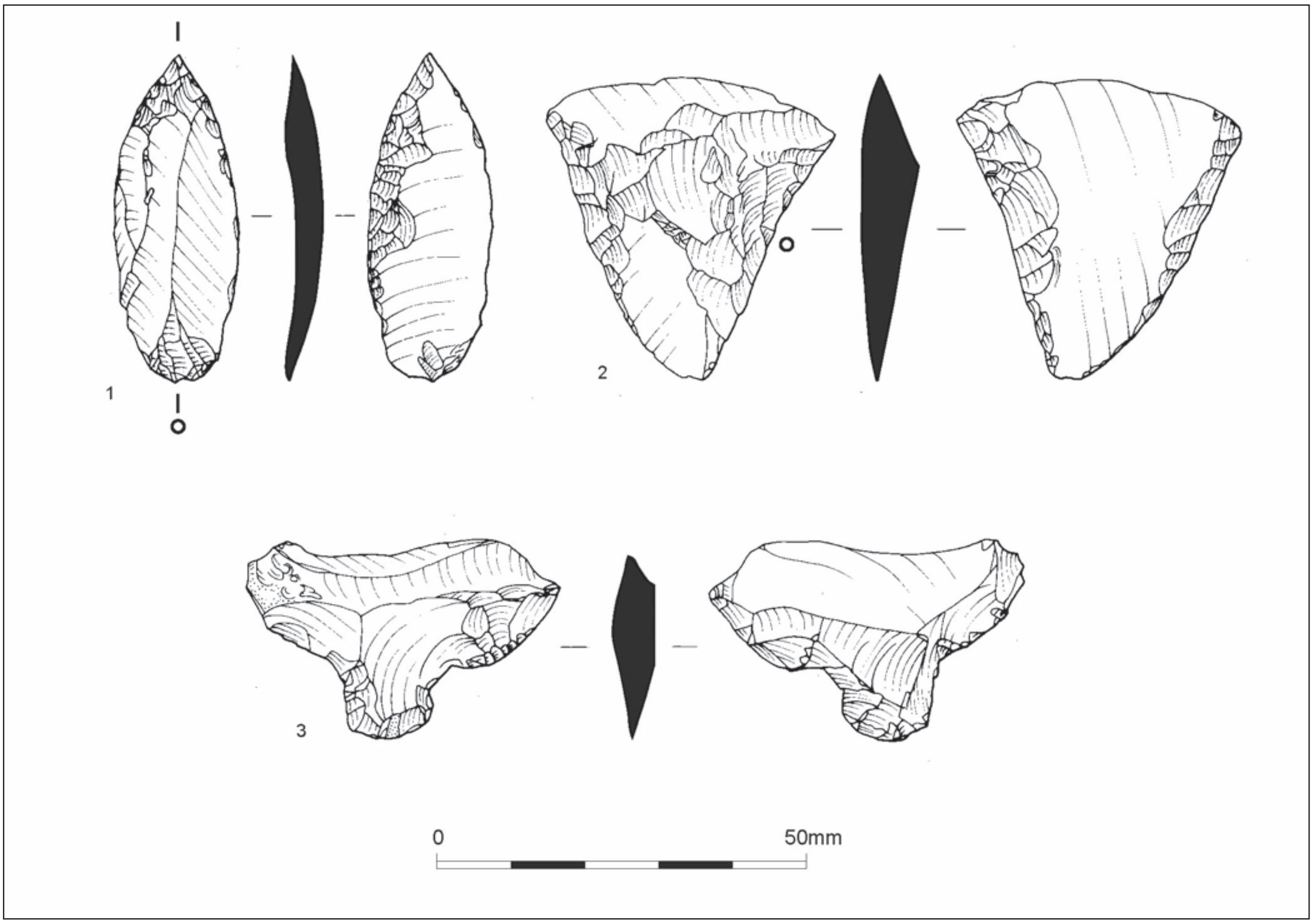


Figure 21.4 Early Neolithic worked flint from HS1 investigations (see catalogue for details)

lattice pattern (Fig 21.3, 1) similar to motifs on vessels previously recovered from the Ebbsfleet Valley (Burchell and Piggott 1939). A sizeable assemblage of 41 sherds was also recovered from the fill of a shallow hollow mixed with Late Neolithic to Early Bronze Age worked flint (layer 457/544, see below). Featured sherds, which include two simple rim fragments, from layer 457, a shoulder sherd from gully 467 and two further worn rims from pit 453 (fill 458), would also fit within the range of illustrated plain vessels (Fig 21.3, 2–4).

Earlier Neolithic flintwork is relatively sparsely represented from the Springhead group of sites (Fig 15.1; Anderson-Whymark, Appendix I). At Springhead Roman Town (ARC SPH00) an assemblage from a colluvial deposit included an extensive refitting sequence suggesting, although reworked, the assemblage had not moved very far (described below). A fragment of a Neolithic polished implement, which had been reworked as a flake core, was also recovered as an unstratified find. At Springhead Nursery (ARC SHN02) a group of three axe-thinning flakes of a broad Neolithic date were recovered from the fill of a Roman ditch (context 16656). Few diagnostic artefacts were present and it is probable some of the flake material may date from this period. Excavations also recovered the tip of a probable leaf-shaped arrowhead (context 16022, SF15899) and a finely retouched chisel arrowhead (context 11071, SF15283, Pl 21.1b; Fig 21.4, 2) of Middle Neolithic date. A crude transverse flake tool with a heavily retouched tang is also tentatively considered to represent a chisel arrowhead (context 11207, Pl 21.1e; Fig 21.4, 3).

Catalogue of illustrated pottery

(Fig 21.3)

1. Ebbsfleet Ware neck sherd (9g), fabric FV2 (context 457, ARC ERC01)
2. Ebbsfleet Ware rim sherd (3g), fabric F2, (context 457, ARC ERC01)
3. Ebbsfleet Ware rim sherd (4g), fabric FV2 (context 458, ARC ERC01)
4. Ebbsfleet Ware rim sherd (5g), fabric FA1 (context 458, ARC ERC01)
5. Ebbsfleet Ware, neck and rim sherd (context 3836013, SF 40, ARC ESG00)
6. Late Neolithic Grooved Ware, decorated body sherd (context 5872, ARC SPH00)
7. Early Neolithic, Plain Bowl rim (STDR400, context 804)
8. Early–Middle Neolithic, Ebbsfleet Ware Bowl (STDR400, context 1119)

Catalogue of illustrated flint

(Fig 21.4)

1. Early Neolithic leaf-shaped arrowhead (context 300042, SF 340000, ARC EBB01)
2. Early or Middle Neolithic chisel arrowhead (context 11071, SF 15283, ARC SHN02)

Plate 21.2 Earlier Neolithic refitting Bullhead Bed nodule; (a) the complete refitted sequence; (b) the reduction of the second largest fragment of the nodule; (c) the sequence of reduction at one end of the nodule; (d) the final episode of blade production (5876 ARC SPH00)

3. Early or Middle Neolithic chisel arrowhead (context 11207, ARC SHN02)

Worked flint from Springhead colluvial sequence (ARC SPH00)

by Hugo Anderson-Whymark

Deposit 5876 (Chap 15, Fig 15.9b) was located in the colluvial sequence at Springhead overlying Mesolithic layers 6317, 6318 and 6326 (see Chap 20 for discussion of Mesolithic flint). The deposit is quite irregular and may have been deposited within a natural feature, such as a tree-throw hole. The deposit contained a small assemblage of 107 flints, including two redeposited Final Upper Palaeolithic flints (Table 21.3). The raw material included flint with an abraded cortex typical of the local river gravels, but 37 flints exhibited the distinctive Bullhead Bed cortex; a deep olive green cortex and underlying orange band, the latter being up to 10mm thick. A refitting exercise demonstrated that 28 flints refitted in one sequence from the same Bullhead Bed nodule (Pl 21.2a). A further 20 flakes were of a similar raw material, but could not be refitted. In addition, a broken flake was refitted to a frost shattered piece of gravel flint irregular waste.

The knapping sequence of the Bullhead Bed nodule is complete from the removal of cortical flakes to abandonment of the cores, although elements of the sequence are missing, presumably removed from the scatter. The reduction sequence was initiated by a blow that fractured the nodule into three pieces along internal thermal fractures. The smallest piece is not present in the assemblage. The second piece measured *c* 120 x 70mm by 60+mm deep. The thermally fractured surface was used as a platform and several small blade-like flakes were removed (not present). A core tablet was then removed and flaking continued with two distal trimming flakes and a side trimming flake struck using hard-hammer percussion. Several non-cortical flakes were then removed (not present), before the core was rotated and at least four plunging flakes struck using the core face as a platform. The core from this sequence is absent (Pl 21.2b).

The third and largest piece of flint was boat-shaped and measured 170 x 70mm by 80mm deep. Flaking was initiated by the alternate removal of four flakes from one end, with the intention of establishing a platform and removing blades along the long axis of the core, to exploit the natural ridge between the thermal fracture and cortex created when the nodule split into three fragments. Attempts to remove a fifth and sixth flake in the alternating sequence crushed the platform edge. Rotating the core a plunging platform tablet was struck from the edge of the thermal fracture across the earlier attempt to establish a platform, removing both areas of crushing. Six or more blade-like flakes were removed from the platform, before a hinge fracture occurred in the centre of the face. A further rejuvenation tablet was removed (not present). Two broad flakes were then removed, the second removing the hinge. The core face now lacked the ridges required to facilitate blade removal and a large flake blank was removed. This flake is missing, but judging the flake proportions the gently curving distal end of this flake would have made an ideal blank for a scraper. The next removal produced a large hinge fracture, as did the following removal immediately behind and this platform was abandoned (Pl 21.2c).

The nodule was still substantial, measuring 150 x 50mm by 80mm deep, and the knapper decided to work the other end of the core. Firstly, a large flake was removed at the end of the nodule to create a new core face; this large flake was tested by the removal of two flakes before it was abandoned. A platform was then established at 90° to the original platform by removing a large cortical flake from the new core face. The side of the nodule was also dressed by the removal of a series of large cortical flakes. A series of plunging blade and blade-like flakes were removed from the platform (Pl 21.2d). The majority of these removals exhibit platform-edge abrasion, but appear to have been removed by percussion with a hard hammer. A flint hammerstone weighing 550g and exhibiting three areas of battering was recovered from this context. It is possible this was used to remove larger flakes, but given the tool's size it is unlikely to have been used to detach the smaller blades. The core was abandoned at this point, although no fault had been encountered and further blades could easily have been removed.

The presence of repeated tablet rejuvenation and generally broad-blade and blade-like products suggest this core probably dates from the earlier Neolithic. The flakes, and particularly blade and blade-like flakes were the desired product. None of the flakes in the assemblage displayed edge-damage visible to the naked eye to suggest they had been used, but it is possible evidence of use may be detected under magnification. However, it is possible that the assemblage represents knapping waste, with all the desired flints removed for use or adaptation elsewhere. It is notable that the majority of the flakes absent from the refitting sequence were non-cortical. These flakes may have been intended for use in an unmodified state, but it would have been possibly to manufacture the larger flakes into scrapers and smaller blades into serrated or simple edge retouched tools. The knapping techniques were clearly not intended to produce specialist blanks for the manufacture of arrowheads (Lamdin-Whymark 2001). Beyond the refitting sequence only two retouched flints were recovered. A squat hard-hammer flake exhibited irregular abrupt retouch as an end scraper and a distal fragment of a broken flake exhibited some abrupt retouch along the break. The latter piece bears a marked resemblance to a chisel arrowhead, but the blank is mis-shaped. It is possible that the earlier Neolithic activity at Springhead was focused on the procurement and knapping of flints for use elsewhere. In this respect the activity is comparable to the Mesolithic.

The Lower Valley slopes (Zones 1–7)

On the higher ground in the Lower Ebbsfleet Valley, Early Neolithic activity is similarly restricted to residual pottery and worked flint in later archaeological features or colluvial layers. The flint assemblage from the excavation (ARC EBB01) includes two earlier Neolithic leaf-shaped arrowheads (eg, Pl 21.1a; Fig 21.4, 1). A large part of the debitage recovered from the excavation was orientated towards flake, rather than blade, production. The majority of flakes were detached using a hard-hammer percussor and only a limited number of flakes exhibited platform-edge abrasion. These attributes are most comparable with the Late Neolithic/Early Bronze Age assemblage at Springhead. It should, however, be considered that the assemblage contains flints of mixed date, with some of the blades most probably belonging to a Mesolithic to Early Neolithic industry (Anderson-Whymark, Appendix I). In addition to the excavations, several evaluation trenches and test pits recovered low concentrations of debitage in fairly fresh condition with a few tools which are not culturally diagnostic, but which could well be Neolithic reflecting general occupation on the higher ground on the flanks of the Ebbsfleet Valley from where colluvial deposits have originated. In Zone 3, test pit 2018TP (ARC EFT97, Fig 7.1) produced a larger assemblage of 59 lithic artefacts, fairly evenly distributed throughout the top 3m of the colluvium. At 2.80m depth, a clear horizon of burnt fire-cracked flint was recorded along with a typically Neolithic convex scraper.

Table 21.3 Quantification of Early Neolithic worked flint from colluvial deposit 5876, Springhead (ARC SPH00)

Context	5876
Flake	82 (1)
Blade	2
Blade-like	7
Irregular waste	4
Rejuvenation flake tablet	1
Bipolar (opposed platform) blade core	(1)
Tested nodule/bashed lump	4
Multiplatform flake core	1
Unclassifiable/fragmentary core	1
End scraper	1
Retouched flake	1
Hammerstone	1
Total	**107 (2)**
No. Burnt worked flints (%)*	1 † (0.9)
No. Broken worked flints (%)*	11 (10.3)
No. Retouched flints (%)*	2 (1.9)

KEY: † Burnt Late Glacial flint; * percentage excludes chips; Late Glacial flints in brackets ( )

Plate 21.3 Reconstruction of the Ebbsfleet Ware bowl from peat deposit 1119, Trench 11 (STDR400)

Early Neolithic pottery was also recovered from this test pit to 3.0m depth (see below). The worked flint assemblage was mostly in fresh to slightly rolled condition, compatible with its colluvial transportation (Wenban-Smith, Appendix 3 in URL 1997a).

The pottery assemblage comprises 15 sherds, the majority consisting of very worn flint-tempered body sherds from either Early Neolithic bowls or Ebbsfleet style vessels of Early to Middle Neolithic date (3650–3350 BC). In addition, six pottery sherds were retrieved from pre-Roman sandy silt colluvial deposits (contexts 3836012 and 3836013) in 3836TT during the evaluation (ARC ESG00), located on the eastern margins of the 'Chalk Spur' (Fig 11.1). This included a single decorated rim and neck sherd from an Ebbsfleet Ware bowl (Fig 21.3, 5). The rim is out-turned, angled from the neck and has a slight lip. Typically, it is slightly expanded and its edge has been decorated with oblique slash marks. The vessel form is closed and relatively large. The rim and neck form of this vessel cannot be exactly paralleled at the nearby type site (Burchell and Piggott 1939), although somewhat similar forms occur at the Staines causewayed enclosure (Robertson-Mackay 1987, fig 52: P175–6) and sites in East Yorkshire (Manby 1975 fig 10:2 and 8). Two abraded sherds from colluvial deposits in 2018TP (ARC EFT97; Fig 5.1) are also likely to be from Early–Middle Neolithic vessels (either Bowl or Ebbsfleet Ware) (Barclay and Seager Smith, Appendix H).

The Floodplain (Zones 8 and 9)

Evaluation trenches

In addition to reworked artefactual material, the HS1, STDR4 and Northfleet Rise evaluation trenching encountered small, potentially *in situ*, scatters of flintwork at several locations in the valley bottom, particularly around the margins of the Chalk Spur (Zone 8/7) and Inner Basin (Zone 9/7) (OAU 1997; OAU 2000; URL 1997a; URN 2001a). The assemblages largely comprised concentrations of worked flint and were mostly associated with the base of the main wood peat. However, given the small size of the assemblages, and given no detailed excavation was carried out as part of the HS1 mitigation in these locations, much of the material remains broadly phased to the Neolithic and Bronze Age.

Worthy of note are five pieces of worked flint recovered from the surface of a basal deposit in Trench 1 (EBBS97) equivalent to the sandy gravel in Trench 2 immediately below the basal peat (EBBS97; Figs 12.1 and 12.8, context 212). These comprised one cortical flake of fresh, dark grey, good quality flint with a thin grey cortex, one small piece of waste, two burnt and broken flakes and a burnt chip (OAU 1997, 52). Radiocarbon dating of hazelnut shell from the base of the peat in Trench 2 (context 211) at 4480±40 BP (Beta-108114, 3350–3020 cal BC) places it within the Early Neolithic period (Table 12.2). In Trench 1240TT (ARC EFT97), the basal peat (context 1949) produced 14 worked flints in exceptionally fresh condition, including a well-made Neolithic convex scraper (Wenban-Smith 1997, Appendix 3). The assemblage from the base of the peat in Trench 9 (STDR400, Figs 13.1 and 13.3) radiocarbon dated to 4926±35 BP (NZA-29080, 3780–3640 cal BC, Table 13.2) comprised only two flints and several burnt flint fragments (OAU 2000, 38–40).

Perhaps more significant was the evidence recovered from Trenches 8, and 11 (STDR400, OAU 2000). In Trench 8 (Zone 9, Fig 13.1) a semi-rolled externally thickened rim from a plain bowl manufactured from a sand- and flint-tempered fabric was recovered from the

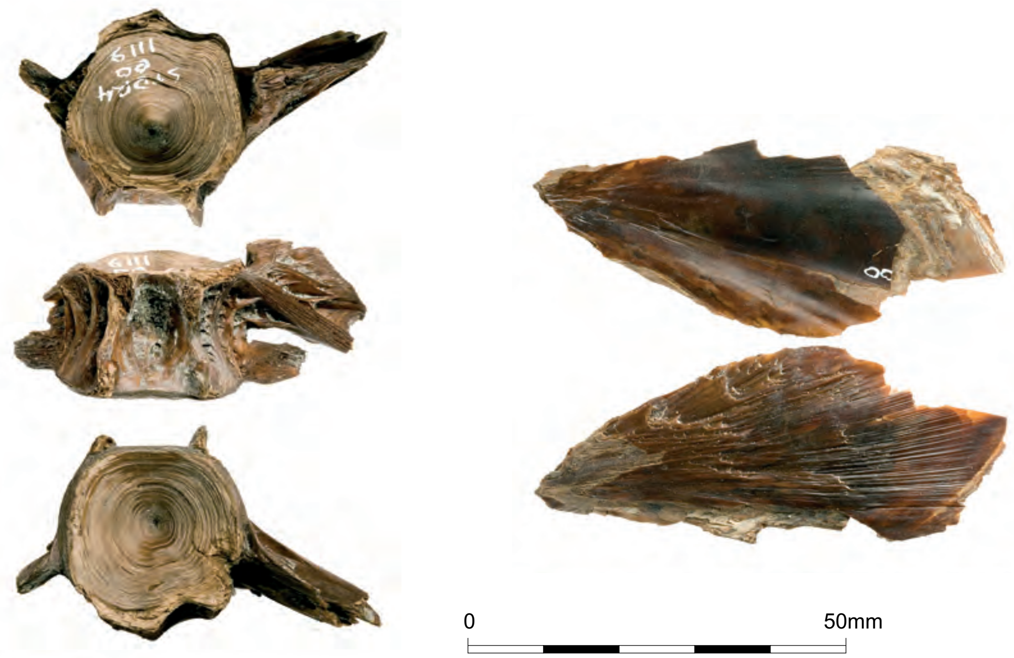


Plate 21.4 Fish bones (*Gadus morhua*) from peat deposit 1119 associated with the Ebbsfleet Ware bowl, Trench 11 (STDR400)

basal peat context 805 (Fig 21.3, 7). Waterlogged elder (*Sambucus nigra*) seeds from the base of peat 805 were radiocarbon dated to 4427±35 BP (NZA-29153 3330–2920 cal BC, Table 13.2). The surfaces, fired to a non-oxidised black, had originally been burnished. A second sherd from this context is likely to derive from the same vessel. Too little of this vessel remains to indicate its precise form, although it appears to have had an upright neck. The rim belongs to the bowl tradition of the earlier Neolithic, which is found throughout Kent and across much of Britain. The rim form is unlikely to be early within the bowl sequence (pre-3700 cal BC Carinated Bowl) and is more likely to be contemporary with the plain and decorated bowl phase of the mid-4th millennium BC when causewayed enclosures and long barrows were in general use (Barclay 2007, table 15.1). The vessel could be earlier than the Ebbsfleet Ware that is discussed below (Barclay and Seager Smith, Appendix H). An assemblage of worked flint (80 pieces) and burnt flint (64 pieces; 1103g) from the peat deposits overlying context 805 was considered to be of probable Neolithic date. The worked flint assemblage was predominantly flake based although a small number of blades and blade-like flakes were identified. Both hard- and soft-hammer percussion was present, and many of the flakes exhibited platform abrasion. A rejuvenation flake from the face of a flake core, and two serrated flakes were identified (OAU 2000, 38–40).

In Trench 11 (Figs 13.1 and 13.6) the main wood peat unit (contexts 1117–1120) directly overlay chalk solifluction deposits (context 1121). Sixteen burnt flint fragments and 21 worked flints were recovered from the two lower peat deposits, along with a small quantity of animal bone. The animal bone was identified as pig and cattle, the latter showing evidence of dog gnawing (OAU 2000, 43). Of particular significance was the recovery of part of a fragmentary Ebbsfleet Ware bowl from peat deposit 1119 (Pl 21.3). The Ebbsfleet Ware bowl consisted of over 50 fragments, although less than a quarter of the original vessel survived. The sherds indicate a relatively large bowl in a flint-tempered fabric with simple decoration of closely spaced finger-tip impressed neck pits and a continuous finger-tip impressed row on the rim. Traces of black residue on the rim and neck could be from cooking. The lower part of the vessel also has signs of heat damage, probably from use as a cooking pot. Two further vessels are represented from context 1119 by single body sherds. One sherd was from a thin-walled vessel manufactured from a flint and sand-tempered fabric and the other was also from a thin-walled vessel made from a flint-tempered fabric. The latter had been relatively well made and had smoothed surfaces. A thin deposit of charred residue was noted on the interior surface indicating that the vessel had been used for cooking. Two radiocarbon measurements were obtained from samples of charred residue that adhered to the interior surfaces of two of the vessels (Fig 21.1; Table 21.1). A sample from the Ebbsfleet Bowl (Vessel 1) was dated to 4723±35 BP (NZA-29079, 3640–3370 cal BC) and one of the plain body sherds (Vessel 2) to 4547±35 BP (NZA-29155, 3370–3100 cal BC). The date on the bowl is as expected and approximates well to the suggested range of 3500/3550 to 3350/3300 cal BC for this style of pottery (Barclay 2007, 343 and table 15.1; Barclay 2002, 90; Cotton 2004, 133; Gibson and Kinnes 1997). The second vessel date is later than expected for this style of pottery, perhaps suggesting that the vessels were not contemporaneous. Two additional radiocarbon dates from hazelnut shell and roundwood fragments from the peat around the Ebbsfleet Ware bowl provided similar dates (Fig 21.1; Table 21.1) (Barclay and Seager Smith, Appendix H).

A single cod (*Gadus morhua*) precaudal vertebra with a possible chop mark and a large gadid (probably cod)

Plate 21.5 Alluvial clay bank and Early Neolithic flint scatter, Area 4 (STDR401)

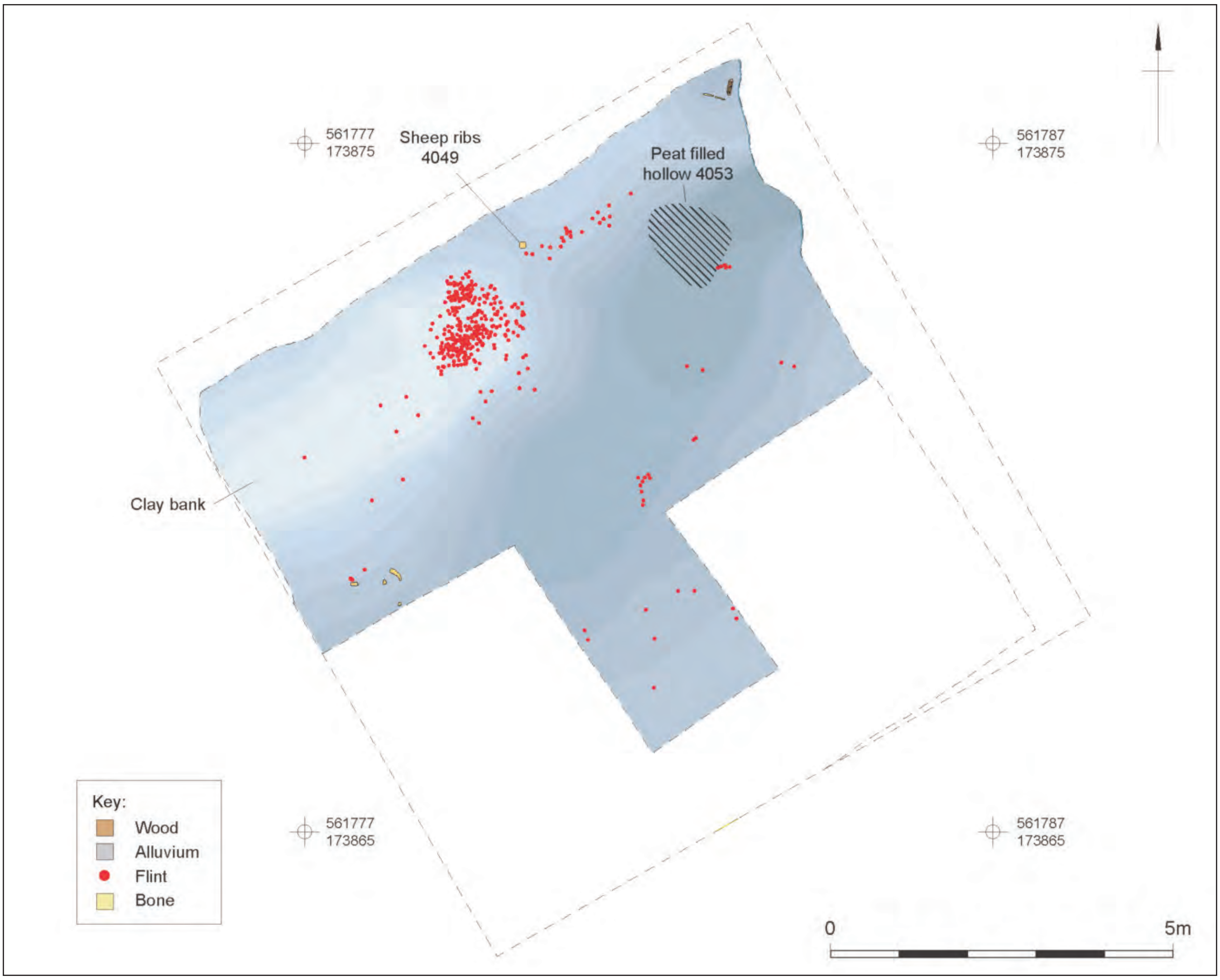


Figure 21.5 Plan of alluvial clay bank and location of artefacts, Area 4 (STDR401)

Plate 21.6 Excavation of the flint scatters and sheep ribs from context 4029, Area 4 (STDR401)

left opercular fragment (Pl 21.4; Strid, Appendix R) were found in the same context as the Ebbsfleet Ware pottery in Trench 11. Although it is impossible to determine whether these bones had been cooked, the association with the pottery is intriguing and they had clearly been brought to the site given they were found in a freshwater peat deposit. The fish represented by these bones would have been well in excess of 1m long, which although large by modern standards would probably not have been unusual in the Neolithic (R Nicholson pers comm). Today these fish are captured in deep, offshore waters, but large cod can occasionally also be caught where deep water occurs close to the shore and may have been more common in the past.

Truncating the main peat bed unit in Trench 11 was a steeply incised channel, 0.75m deep, filled with a sequence of coarse silt and sands. A further 81 worked flints were recovered from these deposits including large irregular flint nodules, which are unlikely to have been transported over a large distance in the channel. The presence of these nodules, along with a number of tested ('bashed') nodules and the indication that some of the flakes derived from the same core, suggest possible knapping close to the water course, although evidence of this was far from conclusive (OAU 2000, 38–40). The channel deposits were overlain by thick deposits of minerogenic silts and clays correlated with the Upper Clay Silts.

Areas 1–4 (STDR401)

Excavation Areas 3 and 4 (STDR401, Zone 9, Fig 13.1, OAU 2006), sited close to evaluation Trenches 8, 9 and 11 described above, yielded *in situ* Early Neolithic flintwork on a preserved land surface at the interface between the base of the main peat body and the underlying alluvial deposits. In Areas 1 and 2 (STDR401, Zone 8, Fig 12.1; OAU 2006) the stratigraphic sequence differed in that the main peat body had been variably eroded by later channel activity, but a smaller number of Early Neolithic flints along with burnt flint representing a low density background scatter were recovered from the silt at the base of the peat in a comparable stratigraphic location to the flint in Areas 3 and 4. The *in situ* Early Neolithic scatters were selected for detailed analysis to characterise the technological and metrical attributes of the assemblage (described below).

Excavation Area 3 was located in close proximity to evaluation Trench 9 (STDR400, Fig 13.1) and contained a similar sedimentary sequence (Fig 13.3). The basal deposit encountered in the trench was a sterile light grey silty sand, (context 3024) overlain by a greenish grey sandy clay (context 3023). Two aurochs bones were retrieved from the surface of this layer along with a concentration of flints in very fresh condition and pieces of burnt unworked flint. One of the aurochs bones was radiocarbon dated to 5727±35 BP (NZA-29235, 4690–4480 cal BC); however a broad Early Neolithic date is suggested for the majority of the flintwork. Sealing the sandy clay (context 3023) was a wood peat (context 3033), which when examined in detail comprised a series of peat, silty peat and organic silty clay layers (contexts 3026–3030).

In Area 4 soliflucted chalk silt (context 4056) was encountered at the base of the trench. Overlying this was a sequence of alluvial deposits, possibly defining an early Holocene channel (context 4044). The alluvium appeared to bank on an approximate east to west alignment across the northern side of the excavation area up to 0.4m higher than the remainder of the deposit and was sealed by a sequence of peat deposits (Figs 13.7 and

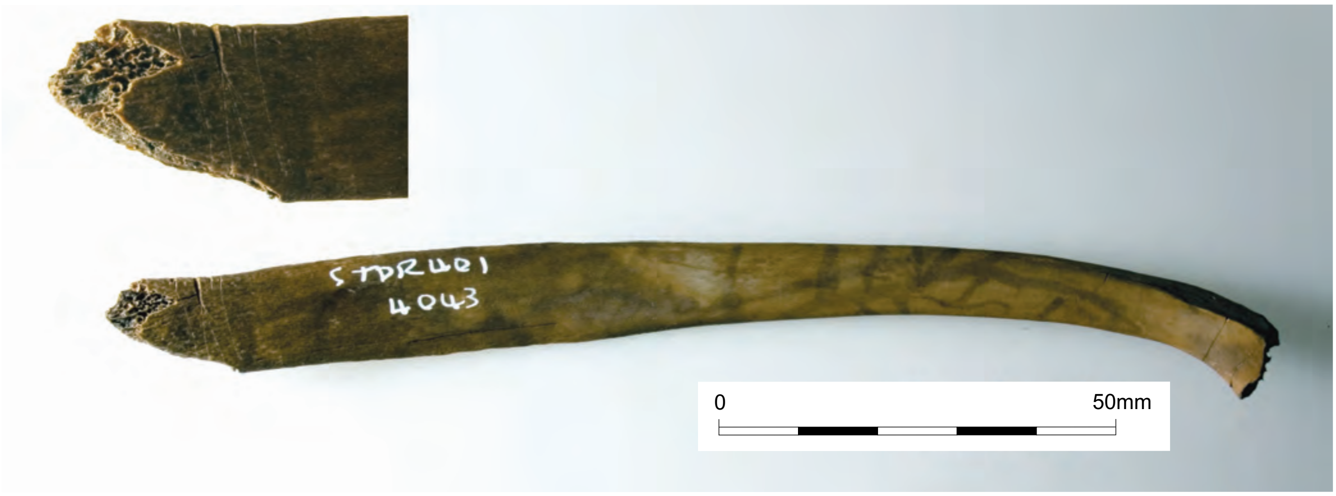


Plate 21.7 Early Neolithic butchery marks on a rib from context 4029, Area 4 (STDR401)

13.8). A considerable quantity of struck flint in fresh condition along with fragments of burnt flint were recovered the interface of alluvial layer 4044 and the basal peat 4043. Much of this material appeared to be concentrated over the alluvial bank (Pl 21.5, Fig 21.5). Fragments of animal bone (Strid, Appendix R) were also recovered; a single bone of red deer, occasional cattle and a single fragment of aurochs. A small stack of articulated sheep ribs (context 4049), from the peat (context 4043), which exhibited butchery marks (Pls 21.6 and 21.7) was radiocarbon dated to 4758±35 BP (NZA-29242, 3640–3380 cal BC; Table 21.1; Fig 21.1). Slightly further up the profile concentrations of worked flint were recorded at the interface of 4043 and overlying peat 4042. Peat deposit 4042 contained a smaller quantity of struck flint and fragments of burnt flint throughout.

Worked flint from Areas 1–4 (STDR401)

by Hugo Anderson-Whymark

Areas 2, 3 and 4 (STDR01) yielded *in situ* Early Neolithic deposits on a preserved land surface and in the lower levels of overlying peat deposits. In Area 1 the stratigraphic sequence differed, but a small number of Early Neolithic flints were recovered from the silt at the base of the peat (1150) in a comparable stratigraphic location to the Early Neolithic flint in Areas 2–4 (Table 21.4). Area 2 yielded 40 Early Neolithic flints and four pieces (113g) of burnt unworked flint representing a low-density background scatter (Table 21.4). Area 3 produced a slightly larger assemblage of 77 Early Neolithic flints including several cores and pieces of irregular waste; these indicate the presence of knapping debris. The only retouched tools were simple edge retouched flakes, although a core on a flake may have

Table 21.4 Quantification of Early Neolithic worked flint from Areas 1–3 (STDR401)

Area	Area 1	Area 2		Area 3			
Context	**1150**	**2013**	**2015**	**2016**	**3023**	**3029**	**3031**
Flake	3	11	2	16	37	11	1
Blade	2	–	–	–	2	–	–
Bladelet	–	1	–	–	1	1	–
Irregular waste	6	3	–	1	4	9	–
Sieved chips 10–4 mm	–	–	–	–	1	–	–
Rejuvenation flake tablet	–	–	–	–	1	–	–
Tested nodule/bashed lump	–	–	–	–	1	1	–
Single platform flake core	1	–	–	–	–	1	–
Multiplatform flake core	–	–	–	–	1	–	–
Core on a flake	–	–	–	–	1	–	–
Awl	–	–	–	1	–	–	–
Serrated flake	–	–	–	1	–	–	–
Denticulate	–	–	–	1	–	–	–
Notch	–	–	–	1	–	–	–
Retouched flake	–	–	–	2	3	1	–
Total	**12**	**15**	**2**	**23**	**52**	**24**	**1**
Burnt unworked flint No./wt. (g)	49/901	1/30	–	3/83	75/1128	68/738	–
No. Burnt worked flints (%)*	7	1	–	1	4 (7.8)	3 (12.5)	–
No. Broken worked flints (%)*	7	5	–	5	10 (19.6)	5 (20.8)	–
No. Retouched flints (%)*	–	–	–	6	3 (5.9)	1 (4.2)	–

Table 21.5 Quantification of Early Neolithic worked flint from Area 4 (STDR401)

	Area 4							
	4042 EN	**4043 EN**	**4044 EN**	**4045 EN**	**4048 EN**	**4052 EN**	**4053 EN**	**4054 EN**
Flake	47	330	143	68	69	143	12	41
Blade	3	55	27	1	8	8	–	18
Bladelet	–	4	–	2	–	1	–	1
Blade-like	6	12	5	10	13	9	–	13
Irregular waste	5	128	14	4	2	22	–	16
Chip	–	20	2	6	22	56	–	6
Sieved chips 10–4 mm	–	–	–	–	–	–	238	–
Rejuvenation flake core face/edge	–	4	1	–	2	3	–	1
Rejuvenation flake tablet	–	1	–	1	v	–	–	–
Core single platform blade core	–	2	–	–	–	–	v	–
Other blade core	–	1	–	–	–	1	–	–
Tested nodule/bashed lump	–	8	5	–	–	2	–	1
Single platform flake core	–	5	1	–	–	–	–	1
Multiplatform flake core	–	5	4	–	–	–	–	1
Unclassifiable/fragmentary core	–	1	–	–	–	1	–	2
Core on a flake	–	2	2	–	1	1	–	–
Microlith	–	–	1	–	–	–	1	1
End and side scraper	–	1	–	–	–	–	–	–
Serrated flake	–	2	–	–	–	–	–	–
Notch	–	2	–	–	1	–	–	–
Retouched flake	–	2	2	1	–	1	–	1
Hammerstone	1	1	–	–	–	–	–	–
Total	**62**	**586**	**207**	**93**	**118**	**248**	**251**	**103**
Burnt unworked flint No./wt. (g)	8/198	303/3769	2/26	1/2	1/15	10/65	123/40	2/86
No. Burnt worked flints (%)*	18 (29)	215 (38)	42 (20.5)	27 (31)	28 (29.2)	116 (60.4)	10 (77)	19 (19.6)
No. Broken worked flints (%)*	13 (21)	233 (41.2)	46 922.4)	31 (35.6)	26 (27.1)	92 (47.9)	10 (77)	28 (28.9)
No. Retouched flints (%)*	0	7 (1.2)	3 (1.5)	1 (1.1)	1(1)	1 (0.5)	1 (7.7)	2 (2.1)

functioned as a denticulated scraper. A quantity of burnt unworked flint (143 pieces/1.866kg) was also recovered (Table 21.4).

The largest flint assemblage was recovered from a series of flint scatters in Area 4, amounting to 1606 flints and 450 pieces (4.201kg) of burnt unworked flint. These scatters varied size, but were broadly similar in composition (Table 21.5). Knapping debris formed a large component of the assemblage. Forty-seven cores were recovered, representing one core per 24 flakes, and numerous pieces of irregular waste and many chips were retrieved; the latter, despite the lack of systematic sieving. Tested nodules were particularly prolific with 16 examples represented. Various core forms were present with multi-platform flake cores most frequently encountered (10 examples, Fig 21.6, 1), followed by single platform flake cores (seven examples, Fig 21.6, 3). Only four blade cores were present in the assemblage, highlighting the comparatively limited production of true blades. Complete cores have an average weight of 143g, whilst tested nodules are slightly larger than cores, with an average weight of 170g. The cores were maintained during reduction by the removal of trimming flakes across the platform or core face. Tablet rejuvenation was infrequently practised with only two examples present in the Early Neolithic assemblage. One of the multi-platform flake cores (89g) and a pebble (77g) were used briefly as hammerstones. Another hammerstone (614g), consisting of a large, battered flint cobble, and a hammerstone reworked as a core (Fig 21.6, 2) are also present.

The flake debitage from Area 4 includes a broad range of trimming flakes indicating the reduction of nodules from an unprepared state. Preparation flakes represent 9.6% of the flake debitage and only 44.5% of flakes are non-cortical (Table 21.6). The average flake measures 38.4mm long, by 29mm wide and 9.5mm thick, but some diversity exists in flake size and morphology (Fig 21.7). In total, 20.3% of complete flakes achieved blade proportions; this figure falls comfortably within Ford's 10–30% bracket for Early Neolithic assemblages (1987, 79). In addition, blade scars were present on the dorsal surfaces of 16.9% of flakes and platform-edge abrasion was noted on 28.3% of flakes (Table 21.6). Hard and soft percussors, such as stone and antler, were both employed in reduction, but hard hammers were used more frequently than soft hammers (Table 21.6).

The retouched component from Area 4 comprises one end and side scraper (Fig 21.6, 6), two serrated flakes, three notched flakes and seven simple edge-retouched flakes. In total, these retouched pieces represent just 0.9% of the entire assemblage, excluding chips. These tool forms are not intrinsically datable and provide little indication of activities performed, except to suggest that some plant-working was undertaken and that scraping activities were comparatively uncommon.

It is particularly notable that the assemblage from Area 4 includes a large number of burnt worked flints, representing 33.1% of the total assemblage, and 4.201 kg of burnt unworked flint. The degree of burning is very uniform, and suggests that the scatter of flint was either burnt *in situ* or has been redeposited from one source (eg, a hearth), as opposed to a midden-style superimposition compiled from various different sources. The levels of burning indicate that fire and the

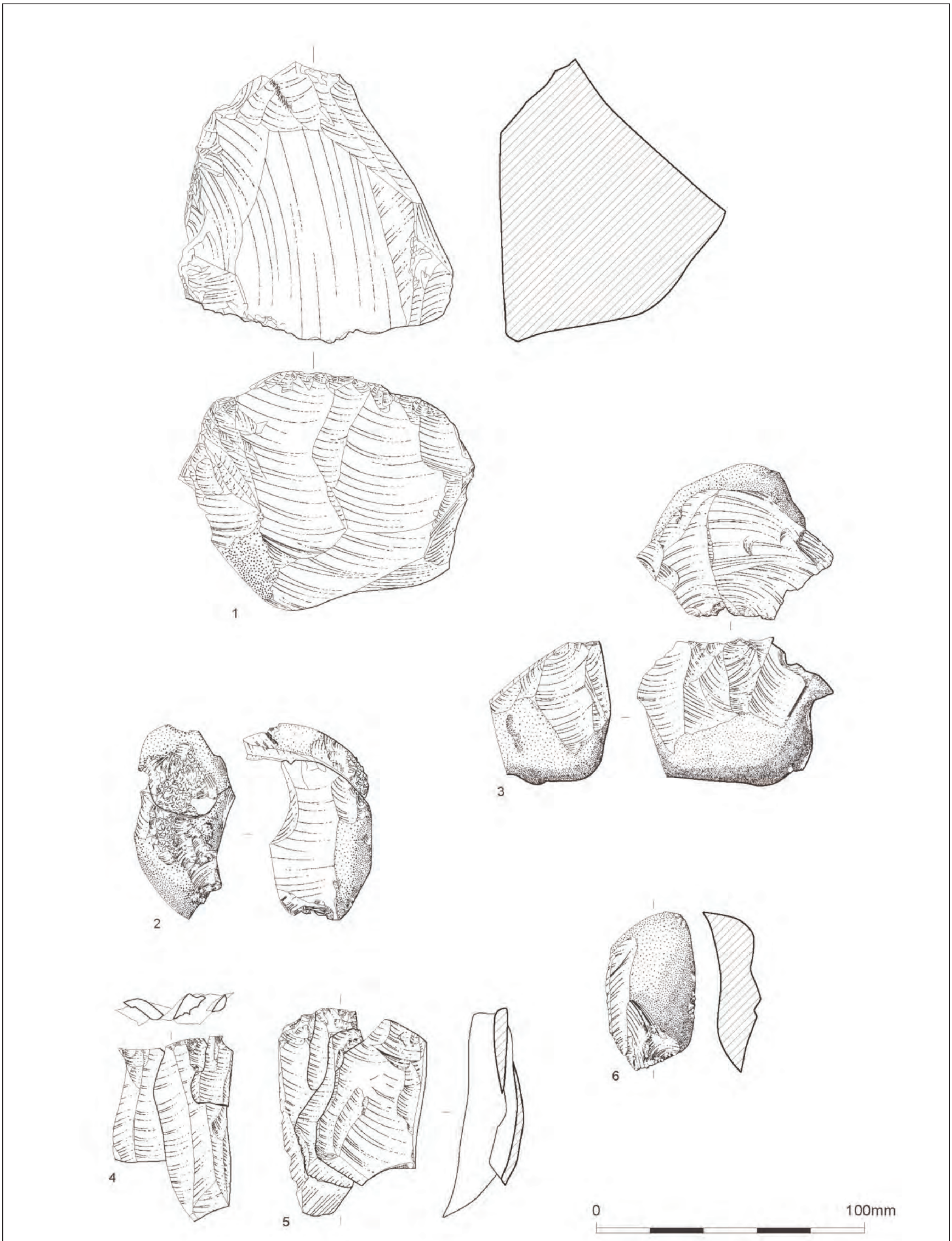


Figure 21.6 Early Neolithic worked flint from Area 4 (STDR401) (see catalogue for details)

heating of flint may have played an important part of activities undertaken in the valley bottom.

Catalogue of illustrated flint

(*Fig 21.6*)

1. Multi-platform flake core (context 4044, SF 1994, STDR401)
2. Refit between a hammerstone reworked as a flake core and flake (context 4042/4044, STDR401)
3. Single platform flake core (context 4044, SF 1755, STDR401)
4. Refit between three utilised flakes (context 4045/4043, SF 1347/1519/1528, STDR401)
5. Refit between four flakes (context 4043/4044, SF1537/1872/1747/1538, STDR401)
6. End and side scraper (context 4043, SF 1984, STDR401)

Evidence from refitting

A refitting exercise on all Early Neolithic flints from Area 4 yielded refits between 30 flakes in 12 sequences; in addition, four fragments of broken flakes conjoined to form two flakes. The refits and conjoins were tentatively assigned to 11 different raw material types (see Appendix I for details). Refits were found in contexts 4042, 4043, 4044 and 4045. Cross-context refits were made between 4043 and 4045, 4043 and 4044, and 4042 and 4044. The refits were generally between flakes, with the longest single sequence being four flakes and blades from contexts 4045 and 4043, but a flake was refitted to a piece of irregular waste in context 4043 and a flake in 4044 was refitted to a core from 4042. Many of the refitting flints had been utilised (see use-wear below) and one was burnt.

The refitting exercise provides little assistance in clarifying reduction sequences, as only short sequences were identified, but provides considerable information on activities undertaken in the scatter and deposition patterns. Firstly, it is clear that many of the flints in the scatter result from a knapping event within, or close to, Area 4. The knapped material has, however, been moved, as demonstrated by cross-context refits and the presence of only short refitting sequences, and was frequently used before discard. The cross-context refits also demonstrate that the distinct scatters in Area 4 are related.

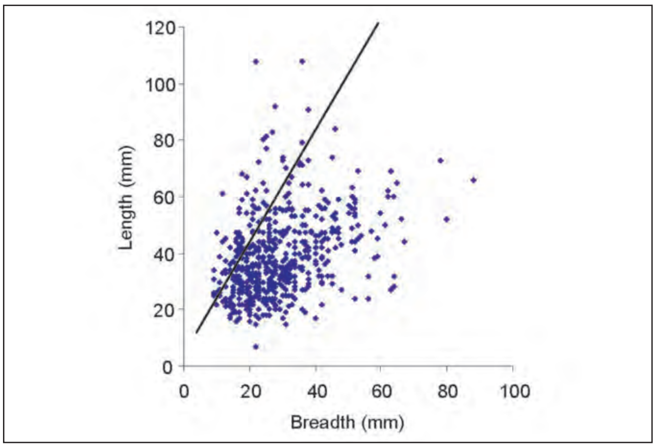


Figure 21.7 Length to breadth scatter diagram for unretouched flakes from Early Neolithic flint scatters (STDR401)

Low-power use-wear analysis

Low-power use-wear techniques (see methodology, Appendix I) were employed on a random sample of 215 flints from scatter 4043. This analysis aimed to provide information on the depositional and post-depositional history of the assemblage and also the extent and nature of the use of the lithics. It was not possible to assess 28 flints within the sample due to edge-damage caused by excavation or burning.

The condition of the lithic assemblage was fresh to exceptionally fresh, but 85 flints (45.5%) exhibited minor edge-damage that was not clearly related to use. This edge-damage primarily comprises small isolated nicks and a few larger crescent fractures. This damage may result from the contact of the flints with other stone tools or represent drop-nicks from contact with a hard surface (Moss 1983). The overall impression is that the condition of the assemblage is exceptionally fresh, with little evidence for post-depositional movement, or damage, such as may be caused by trampling.

Use-damage was identified on 128 of the 187 flints examined, indicating 68.5% of the flints were utilised.

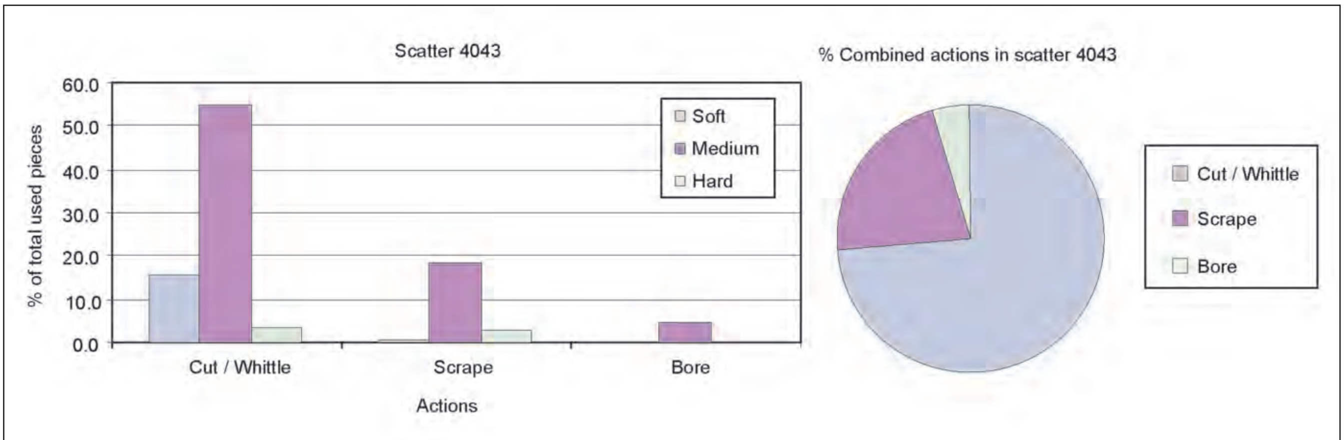


Figure 21.8 The pattern of utilisation in flint scatter 4043, Area 4 (STDR401)

Table 21.6 Technological attributes of Early Neolithic worked flint from Area 4 (STDR401)

	Termination type				
Context	**Hinge**	**Step**	**Plunging**	**Feather**	**Other**
4042 Layer	2 (6.3%)	1 (3.1%)	5 (15.6%)	24 (75%)	–
4043 Layer	32 (15%)	4 (1.9%)	49 (22.9%)	125 (58.4%)	4 (1.9%)
4044 Layer	20 (15.9%)	4 (3.2%)	22 (17.5%)	80 (63.5%)	–
4045 Scatter	6 (11.8%)	–	10 (19.6%)	34 (66.7%)	1 (2%)
4048 Scatter	11 (18.6%)	2 (3.4%)	9 (15.2%)	36 (61%)	1 (1.7%)
4052 Scatter	6 (15.4%)	2 (5.1%)	11 (28.2%)	20 (51.3%)	–
4054 Scatter	3 (10%)	3 (10%)	6 (20%)	17 (56.7%)	1 (3.3%)
Neolithic combined	80 (14.5%)	16 (2.9%)	112 (20.3%)	336 (70%)	7 (1.3%)

	Butt type						
Context	**Cortical**	**Plain**	**>1 Removal**	**Facetted**	**Linear**	**Punctiform**	**Other**
4042 Layer	1 (3.1%)	26 (81.3%)	–	–	1 (3.1%)	3 (9.4%)	
4043 Layer	6 (2.8%)	157 (73.4%)	13 (6.5%)	–	13 (6.5%)	15 (7%)	10 (4.7%)
4044 Layer	5 (4%)	93 (73.8%)	5 (4%)	–	5 (4%)	11 (8.7%)	7 (5.6%)
4045 Scatter	3 (5.9%)	36 (70.6%)	1 (2%)	–	2 (3.9%)	7 (13.7%)	2 (3.9%)
4048 Scatter	3 (5.1%)	47 (79.7%)	1 (1.7%)	–	3 (5.1%)	3 (5.1%)	2 (3.4%)
4052 Scatter	1 (2.6%)	28 (71.8%)	6 (15.4%)	–	1 (2.6%)	2 (5.1%)	1 (2.6%)
4054 Scatter	1 (3.3%)	26 (86.7%)	–	–	–	1 (3.3%)	2 (6.7%)
Neolithic combined	20 (3.6%)	413 (75%)	26 (4.7%)	–	25 (4.5%)	42 (7.6%)	25 (4.5)

	Dorsal extent of cortex					
Context	**0**	**1–25%**	**26–50%**	**51–75%**	**76–99%**	**100%**
4042 Layer	13 (40.6%)	8 (25%)	5 (15.6%)	3 (9.4%)	2 (6.3%)	1 (3.1%)
4043 Layer	94 (43.9%)	57 (26.6%)	25 (11.7%)	17 (7.9%)	19 (8.9%)	2 (0.9%)
4044 Layer	51 (40.5%)	32 (25.4%)	17 (13.5%)	9 (7.1%)	11 (8.7%)	6 (4.8%)
4045 Scatter	30 (58.8%)	7 (13.7%)	7 (13.7%)	2 (3.9%)	5 (9.8%)	–
4048 Scatter	29 (49.2%)	12 (20.3%)	7 (11.9%)	4 (6.8%)	6 (10.2%)	1 (1.7%)
4052 Scatter	14 (35.9%)	12 (30.8%)	3 (7.7%)	2 (5.1%)	7 (18%)	1 (2.6%)
4054 Scatter	13 (43.3%)	9 (30%)	4 (13.3%)	1 (3.3%)	3 (10%)	–
Neolithic combined	244 (44.3%)	137 (24.9%)	68 (12.3%)	38 (6.9%)	53 (9.6%)	11 (2%)

	Flake type					
Context	**Preparation**	**Side trim.**	**Distal trim.**	**Misc. trim.**	**Non-cortical**	**Rejuvenation**
4042 Layer	3 (9.4%)	6 (18.8%)	5 (15.6%)	5 (15.6%)	13 (40.5%)	–
4043 Layer	15 (7)	44 (20.6)	40 (18.7)	16 (7.6)	95 (44.4)	4 (1.9)
4044 Layer	15 (11.9)	29 (23%)	20 (15.9%)	9 (7.1%)	53 (42.1%)	–
4045 Scatter	3 (5.9%)	10 (19.6%)	7 (13.7%)	1 (2%)	29 (56.9%)	1 (2%)
4048 Scatter	8 (13.6%)	9 (15.3%)	12 (20.3%)	1 (1.7%)	28 (47.5%)	1 (1.7%)
4052 Scatter	6 (15.4%)	7 (18%)	8 (20.5%	3 (7.7%)	14 (35.9%)	1 (2.6%)
4054 Scatter	3 (10%)	6 (20%)	3 (10%)	5 (16.7%)	13 (43.3)	–
Neolithic combined	53 (9.6%)	111 (20.2%)	95 (17.2%)	40 (7.3%)	245 (44.5%)	7 (1.3%)

	Proportion of blades, presence of platform-edge abrasion and dorsal blade scars		
Context	**% flakes >2:1 L:B ratio**	**% flakes with platform edge abrasion**	**% flakes with dorsal blade scars**
4042 Layer	2 (6.3%)	9 (28.1%)	3 (9.4%)
4043 Layer	52 (24.3%)	55 (34.6%)	47 (22%)
4044 Layer	30 (23.8%)	41 (32.5%)	22 (17.5%)
4045 Scatter	8 (15.7%)	11 (21.6%)	5 (9.8%)
4048 Scatter	6 (10.2%)	13 (22%)	6 (10.2%)
4052 Scatter	6 (15.4%)	11 (28.2%)	3 (7.7%)
4054 Scatter	8 (26.7%)	16 (53.3%)	7 (23.3%)
Neolithic combined	112 (20.3%)	156 (28.3%)	93 (16.9%)

	Hammer mode		
Context	**Hard**	**Soft**	**Indeterminate**
4042 Layer	3 (9.4%)	18 (56.3%)	11 (34.4%)
4043 Layer	50 (23.4%)	92 (43%)	72 (33.6%)
4044 Layer	28 (22.2%)	50 (39.7%)	47 (37.3%)
4045 Scatter	10 (19.6%)	22 (43.1%)	19 (37.3%)
4048 Scatter	16 (27.1%)	25 (42.4%)	18 (30.5%)
4052 Scatter	6 (15.4%)	20 (51.3%)	13 (33.3%)
4054 Scatter	11 (36.7%)	14 (46.7%)	5 (16.7%)
Neolithic combined	124 (22.5%)	241 (43.7%)	186 (33.8)

Table 21.7 Patterns of use among utilised flakes in scatter 4043, Area 4 (STDR401)

Hardness of		**Action**		
contact material	**Cut/whittle**	**Scrape**	**Bore**	**Total**
Soft	27 (15.4%)	1 (0.6%)	–	**28 (16.0%)**
Medium	96 (54.9%)	32 (18.3%)	8 (4.6%)	**136 (77.7%)**
Hard	6 (3.4%)	5 (2.9%)	–	**11 (6.3%)**
Total	**129 (73.7%)**	**38 (21.7%)**	**8 (4.6%)**	**175 (100.0%)**

This figure represents a high proportion of use, but should be considered as a minimum number since the low magnifications employed may not identify brief periods of use on softer materials. The 128 utilised flints exhibit a total of 175 utilised edges, an average of 1.5 utilised edges per flint. The edge-damage identified was, however, not particularly intensive, suggesting few of the flints in the assemblage were used for extensive periods.

The flints from scatter 4043 exhibit a relatively distinctive pattern of use, indicating the performance of a limited range of tasks or activities at this location. Cutting and whittling was the most frequent activity, accounting for nearly three-quarters (73.7%) of all use actions. Scraping was relatively poorly represented at 21.7% of actions, and boring accounted for 4.6% (Table 21.7 and Fig 21.8). The hardness of contact materials also exhibits a distinctive pattern. The majority of actions were against materials of medium hardness (77.7%), with comparatively few actions against soft (16%) or hard (6.3%) materials. The low proportion of actions against soft materials is particularly noteworthy and suggests the working of fleshy plants or meat was not a significant part of the activities undertaken. The dominant activity was cutting or whittling medium hardness materials (54.9% of actions). A broad spectrum of materials can be considered to be of medium hardness, such as unseasoned woods, fibrous plants or dry hide.

The high level of utilisation is particularly notable in relation to the low proportion of retouched tools. The activities present, however, complement the few retouched tools recovered as scraping actions were limited and simple retouched flakes are most appropriate for cutting and whittling activities. The high proportion of use further demonstrates that scatter 4043 results from the performance of various use-activities, rather than flint knapping, although it is likely that the flakes were produced near by. This interpretation may also assist in explaining the absence of refits to cores, as the flakes were removed from an area of production for use. Moreover, the comparatively short sequences of refits result from the dispersal of knapping sequences, by selective removing flakes for specific use activities.

Discussion of activities in the valley bottom

The flint assemblage in the valley bottom reflects considerable activity during the earlier Neolithic. The assemblage results from the knapping of local flint nodules for flakes and blades rather than specialised blanks or cores tools. The scatters are, however, not solely the product of knapping as their distribution reflects the use and abandonment of a large number of unretouched flakes as *de facto* refuse. The activities focused on cutting and whittling actions and notably involve the manufacture and/or use of few retouched tools. The activities also produced numerous burnt worked flints and burnt unworked flints, indeed, the quantities burnt suggest that this was intentional, although it is unclear if burnt flint was a product or bi-product of other activities. The burnt flint may, for example, have been employed in cooking before discard or burnt for use as temper in pottery.

The distinctive depositional signature of the scatters in the valley bottom is not readily paralleled to pit deposits or midden deposits, as these contexts frequently exhibit higher levels of retouch, a broad range of retouched tool types and few refits (Lamdin-Whymark 2008). The most comparable deposits have been found on the floodplain of the River Thames at Dorney (Lamdin-Whymark 2001). These scatters were preserved in alluvium and similarly contain evidence for knapping and a low incidence of retouched artefacts. Most notably one of the scatters (10010) contained a large quantity of burnt worked and unworked flint. These scatters can be interpreted as relatively short-term activity areas, perhaps related to specific tasks, although the precise nature of activity undertaken remains unclear.

Late Neolithic to Early Bronze Age (*c* 3000–1500 BC)

Springhead (Zone 11)

The Ebbsfleet River Crossing (ARC ERC01)

At the Ebbsfleet River Crossing (Fig 21.9) a shallow hollow filled with a deposit of yellowish-brown sandy silt loam (457) was identified in the southern part of the excavation area. The fill of this hollow contained an abundance of worked flint and some pottery sherds. The pottery assemblage was residual, mainly flint-tempered, dating to the Early to Middle Neolithic period (see above). However, a fairly large flint assemblage (447 pieces), dominated by flakes and small chips, was recovered. A refitting exercise demonstrated the presence of knapping debris with 27 flints in nine refitting sequences. The combination of the product and techniques of manufacture are suggestive of a Late Neolithic or Early Bronze Age date for the assemblage. The scatter appears to result from the production of flakes for use with only limited evidence for further tool production and use at this location (see below).

Pit group 552 was located towards the southern end of the excavation (Fig 21.9 and Pl 21.8) and comprised seven small pits (428, 430, 435, 442, 451, 453 and 456) adjacent to the former edge of the river channel. The pits were generally sub-circular or oval, and between 0.65m and 1.9m in width. The depth of the features varied between 0.12 to 0.60m (Fig 21.10). The fills of all of the pits were broadly similar, very dark grey silty clay with abundant burnt flint, charcoal and occasional worked flints (Pl 21.9). Early Neolithic pottery sherds were recovered from the fills of pits 430 and 453 but are likely to be residual (see above), possibly derived form the soil the features were cut through. Two distinct phases of activity can be discerned within this pit group (Fig 21.2; Table 21.2). The earlier phase is dated to the

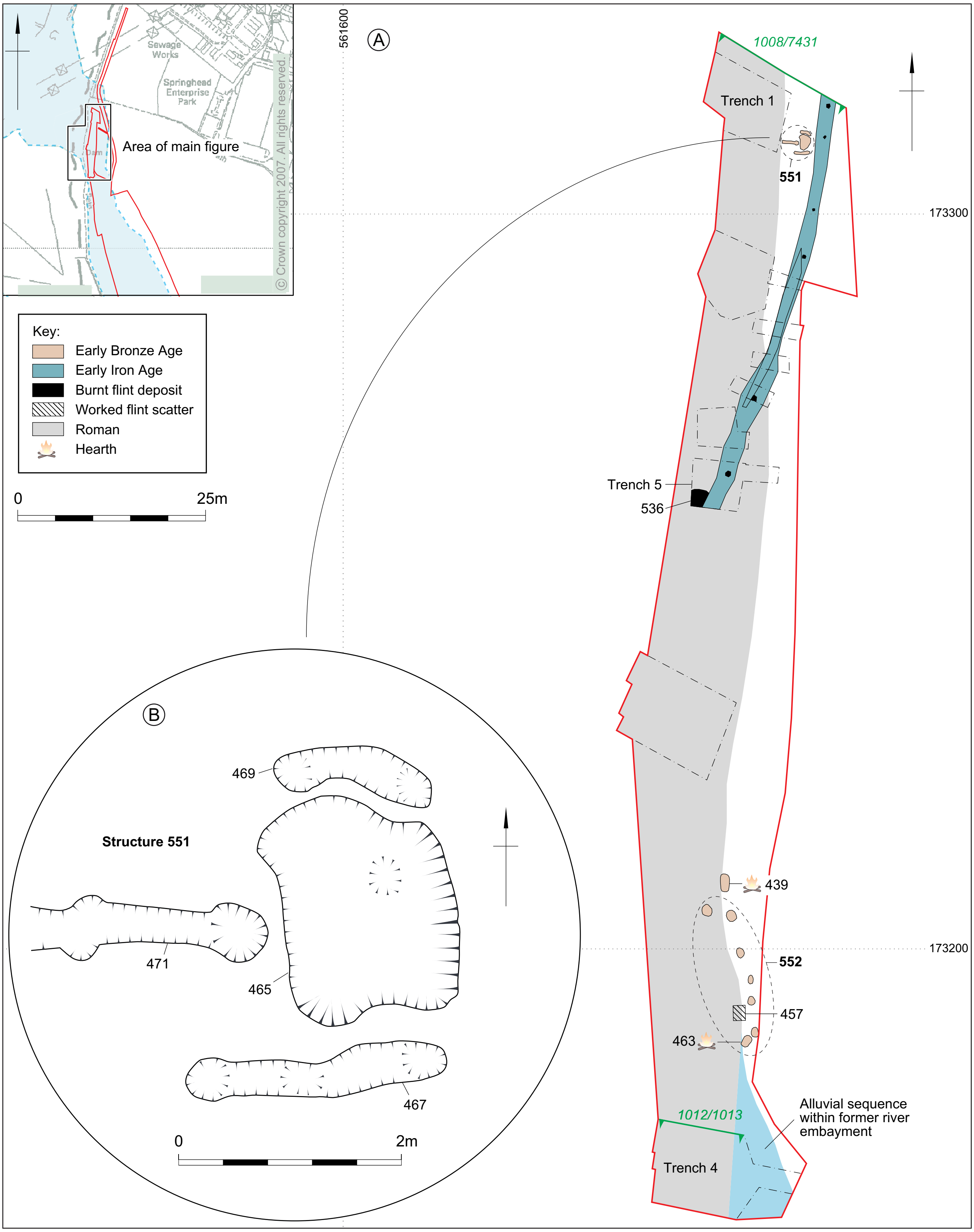


Figure 21.9 (a) Plan of prehistoric features, Ebbsfleet River Crossing (ARC ERC01); (b) detail of structure 551

later half of the 3rd millennium BC, recognised from the two dates obtained on material from pit 453. One sample of *Betula* sp. charcoal was dated to 3808±35 BP (NZA-28450, 2460–2130 cal BC) and a sample of charred hazelnut shell was dated to 3844±35 BP (NZA-28443, 2460–2200 cal BC). The second phase occurs towards the end of the Early Bronze Age; *Alnus glutinosa* charcoal from pit 430 was dated to 3316±30 BP (NZA-

Plate 21.8 Excavation of Early Bronze Age pits at the Ebbsfleet River Crossing (ARC ERC01)

28618, 1690–1520 BC), as was a sample of *Betula* sp. charcoal from pit 435 at 3386±30 BP (NZA28615, 1760–1600 cal BC).

Additional features that may be contemporary with the earlier phase of activity include a hearth (463) located beneath, and truncated by pit 453 (Fig 21.10). The hearth, although heavily truncated, appeared to comprise a shallow, bowl-shaped pit measuring 0.65m diameter and 0.28m deep. The fill (context 462) comprised reddish-brown burnt clay. A shallow ill-defined linear feature ran westwards from feature 463, possibly representing the remnants of a flue. A possible second hearth 439, located immediately to the north of the pit group 552 was shallow and sub-rectangular, measuring 2.50m by 0.57m. The base of the feature comprised a layer of reddish-brown burnt clay (440) 0.06m thick, overlain by a deposit of burnt flints (441) 0.14m thick. A discrete layer or spread of burnt flint and charcoal, 536, was also exposed within the river channel in the central part of the site (Trench 5, Fig 21.9). This was cut by a later ditch to the east and by the base of the (Roman) river channel to the west. No datable artefacts were recovered from this deposit, however, Pomoideae charcoal from context 536 was dated to 3930±30 BP (NZA 28608, 2560–2290 cal BC; Fig 21.2; Table 21.2).

Feature group 551, was associated with the second phase of activity (Pl 21.10), and was located in the northern part of the excavation area (Fig 21.9) overlying and truncating an early sequence of colluvial deposits. The group consisted of a shallow flat-bottomed, kidney-shaped pit (465) measuring 0.25m in depth, 2.0m in length and 1.45m wide. The fill (466) comprised a dark grey silty clay with frequent burnt flint and charcoal. Eight pieces of worked flint and a single fragment of bone were also recovered. A sample of *Prunus* sp. roundwood charcoal was radiocarbon dated to the Early Bronze Age – 3379±35 BP (NZA-28445, 1760–1530 cal BC; Fig 21.2; Table 21.2), placing it within the second phase of activity at the site. Pit 465 was flanked on either side by curvilinear slots (467 and 469). Slot 467 was steep-sided with a flat bottom and measured 2.20m in length, 0.40m wide and 0.30m deep. The feature appeared to be slightly angled northwards and was undercut on parts of its southern edge. Three possible postholes were identified in the base of the feature appearing as slight indentations. Slot 460 was similarly steep sided and flat-bottomed. It measured 1.40m in length, 0.30m wide, 0.30m in depth and contained two possible postholes. The slots contained two fills each. The primary fills (510 and 511) comprised a thin lens, up to 0.05m thick, of mid-brownish-grey clayey silt probably derived from the

Plate 21.9 Pit 456, Ebbsfleet River Crossing (ARC ERC01)

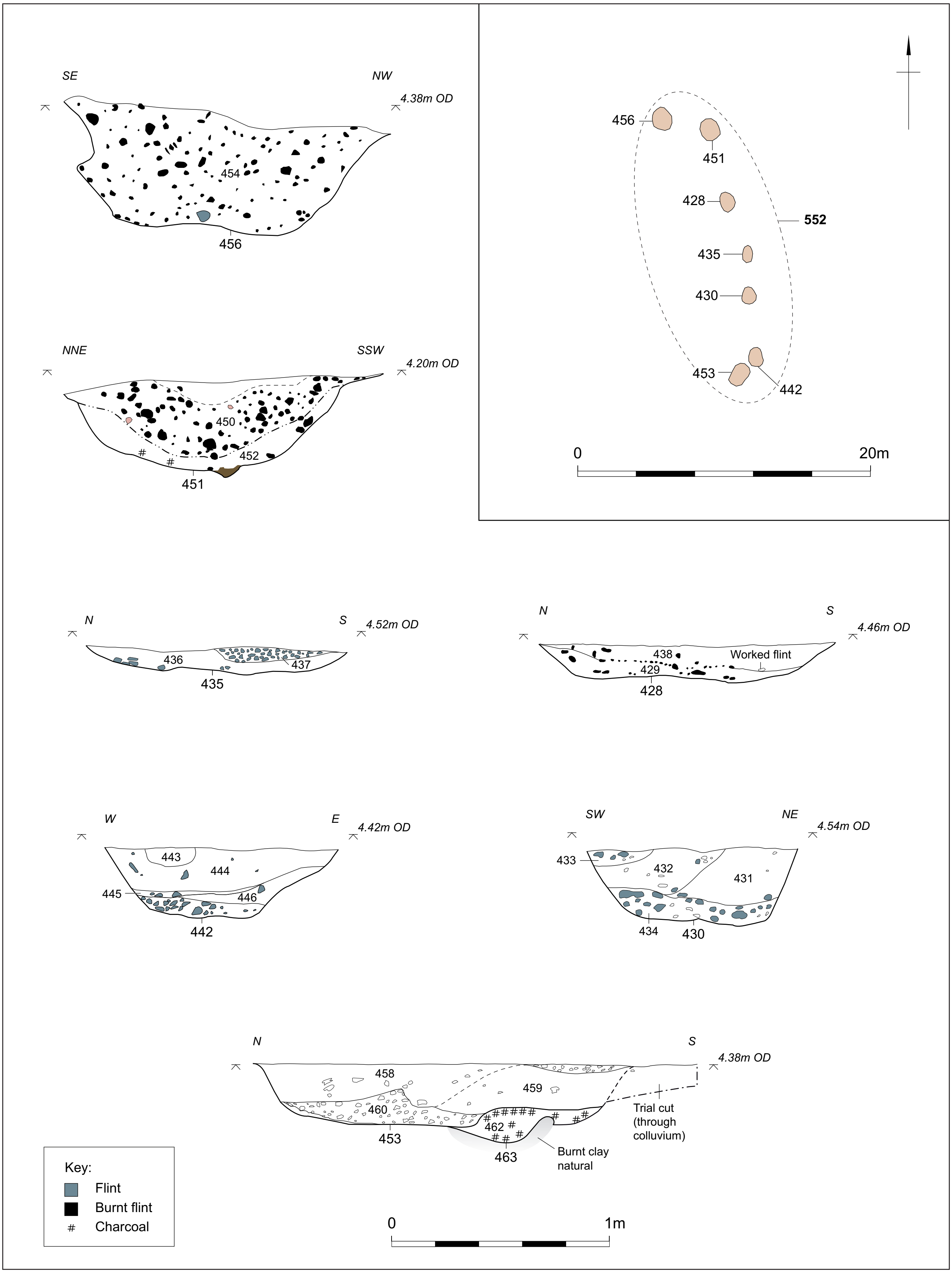


Figure 21.10 Sections of Early Bronze Age pits, Ebbsfleet River Crossing (ARC ERC01)

colluvium the gullies were cut through. The secondary fills (468 and 470) averaged 0.25m thick and were very similar to fill 466, containing frequent burnt flint and charcoal. Eighteen pieces of worked flint were recovered from the secondary fills along with two residual sherds of Early to Middle Neolithic pottery. A shallow central gully, 471, led from the edge of pit 465, but was truncated eastwards by the later Roman river channel. The gully measured 2.10m in length, 0.30m wide and 0.15m deep, had a concave base and a single fill, 472. The fill comprised a dark grey silty clay with abundant burnt flint. No evidence of *in situ* burning was identified within any of the features associated with Group 551. All of the features were sealed by later colluvial deposits.

A spread of dark greyish-brown loam that may represent a contemporary soil (contexts 405 and 2896) containing frequent burnt flint and charcoal extended north from structure 551 (recorded in the main section in Trench 1, Fig 15.3b) and contained three sherds of Early Bronze Age pottery including a body sherd with two rows of twisted cord impressed decoration. The sherds are more likely to derive from urns rather than Beakers.

Of additional note was a further spread of burnt flint recorded during a targeted watching brief for an electricity cable trench (ARC ERC01/ARC SPH00), 250m to the north of structure 551. Layer 2963 was identified within a sequence of colluvial deposits and comprised a dark grey clay-silt containing abundant burnt flint. The full extent of the deposit was not established; however, Pomoideae charcoal produced a date of 3354±30 BP (NZA-28410, 1740–1530 cal BC; Table 21.2; Fig 21.2), contemporary with the later phase of activity at the Ebbsfleet River Crossing.

Springhead (ARC SPH00)

Notable among the artefact assemblage is a single sherd (9g) decorated with a simple vertical grooved herringbone pattern (Fig 21.3, 6) typical of the Clacton substyle of Grooved Ware (Wainwright and Longworth 1971, 237 and fig 89) recovered as a residual find from Middle Bronze Age deposit 5872 (Fig 15.9). This type of Grooved Ware was current during the early 3rd millennium cal BC (Garwood 1999, 159–61 and illus 15.6) (Barclay and Seager Smith, Appendix H). Late Neolithic to Early Bronze Age flintwork is extensively spread over the excavation areas at Springhead (Anderson-Whymark, Appendix I), key elements of which are described below.

Worked flint from Springhead (ARC SPH00) and the Ebbsfleet River Crossing (ARC ERC01)
by Hugo Anderson-Whymark

Summary

An *in situ* flint scatter (457) was located adjacent to a former channel of the River Ebbsfleet in the Ebbsfleet River Crossing excavations. A sizeable assemblage of flint was recovered from the colluvial sequence at Springhead Roman Town and the flint from colluvium 5875 was subject to a technological attribute analysis. In addition, it is probable that a large proportion of the redeposited and unstratified flint from Springhead Nursery (ARC SHN02) is of Late Neolithic/Early Bronze Age date. The flake assemblage is dominated by

Plate 21.10 Early Bronze Age 'sauna' structure 551, Ebbsfleet River Crossing (ARC ERC01)

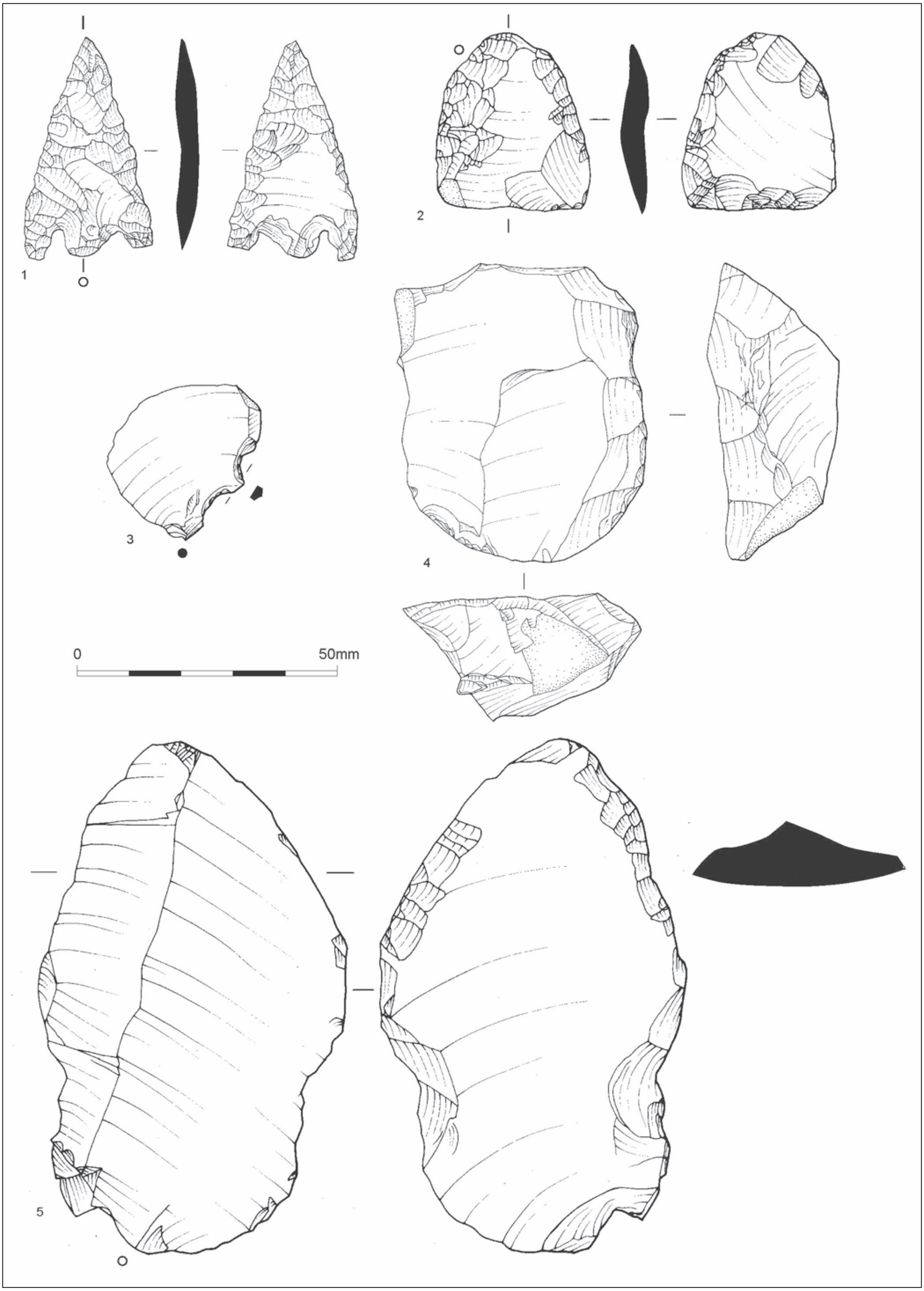


Figure 21.11 Late Neolithic to Early Bronze Age worked flint from HS1 investigations (1–5) (see catalogue for details)

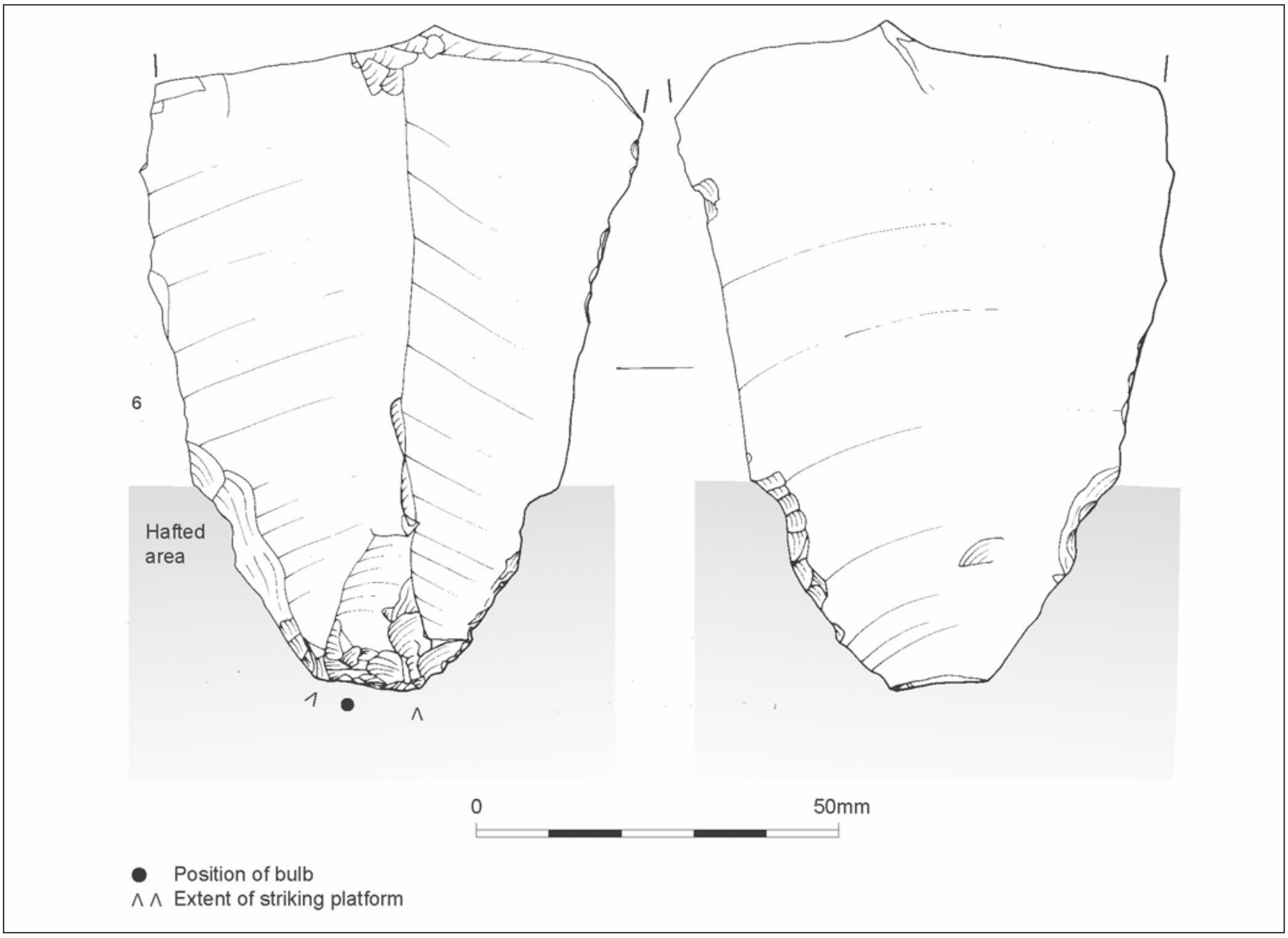


Figure 21.12 Late Neolithic to Early Bronze Age worked flint from HS1 investigations (6) (see catalogue for details)

relatively broad flakes, with only a small blade component, but a significant proportion of the flints exhibit platform-edge abrasion indicating control of the reduction strategy; a small number of rejuvenation flakes are also present. Moreover, chronologically diagnostic artefacts were also recorded. A barbed and tanged arrowhead of Sutton type B (Green 1980) was recovered from context 11739 (SF 15275, Fig 21.11, 1) and a thumbnail scraper from context 19433. A Levallois-style discoidal core was recovered from context 19512. Two knives with proximal notches, presumably to facilitate hafting, are also probably of later Neolithic/Early Bronze Age date (contexts 16794 and 16967, Figs 21.11–12, 5 and 6). The blank for the knife from context 16967 was struck from a core aimed at the production of large straight flake blanks. The platform-edge of the core was heavily abraded before the flake was removed by soft-hammer percussion. The residual flintwork from Springhead Sanctuary may also include a significant number of pieces dating from the Late Neolithic/Early Bronze Age, but it is probably that this material is admixed with residual Middle Bronze Age flintwork.

Table 21.8 Worked flint from Late Neolithic/Early Bronze Age flint scatter 457 (ARC ERC01)

Category type	Context 457
Flake	155
Blade	3
Bladelet	4
Blade-like	5
Irregular waste	6
Chip	268
Rejuvenation flake core face/edge	1
Rejuvenation flake tablet	1
Tested nodule/bashed lump	1
Multiplatform flake core	1
Piercer	1
Notch	1
Total	**447**
No. Burnt worked flints (%)*	7 (3.9)
No. Broken worked flints (%)*	93 (52)
No. Retouched flints (%)*	1 (0.6)

KEY: *percentage excludes chips

Catalogue of illustrated flint

(Figs 21.11 and 21.12)

1. Barbed and tanged arrowhead. Sutton type B (context 11739, SF 15275, ARC SHN02)
2. Roughout of barbed and tanged arrowhead. This flake has been bifacially retouched and roughly shaped to a barbed and tanged form. It is unclear why the blank was abandoned, but it is possible that it was too curved to create a flat arrowhead (context 16238, ARC EBB01)
3. Piercer. Flake with slight edge retouch to leave a small spur (context 5875, ARC SPH00)

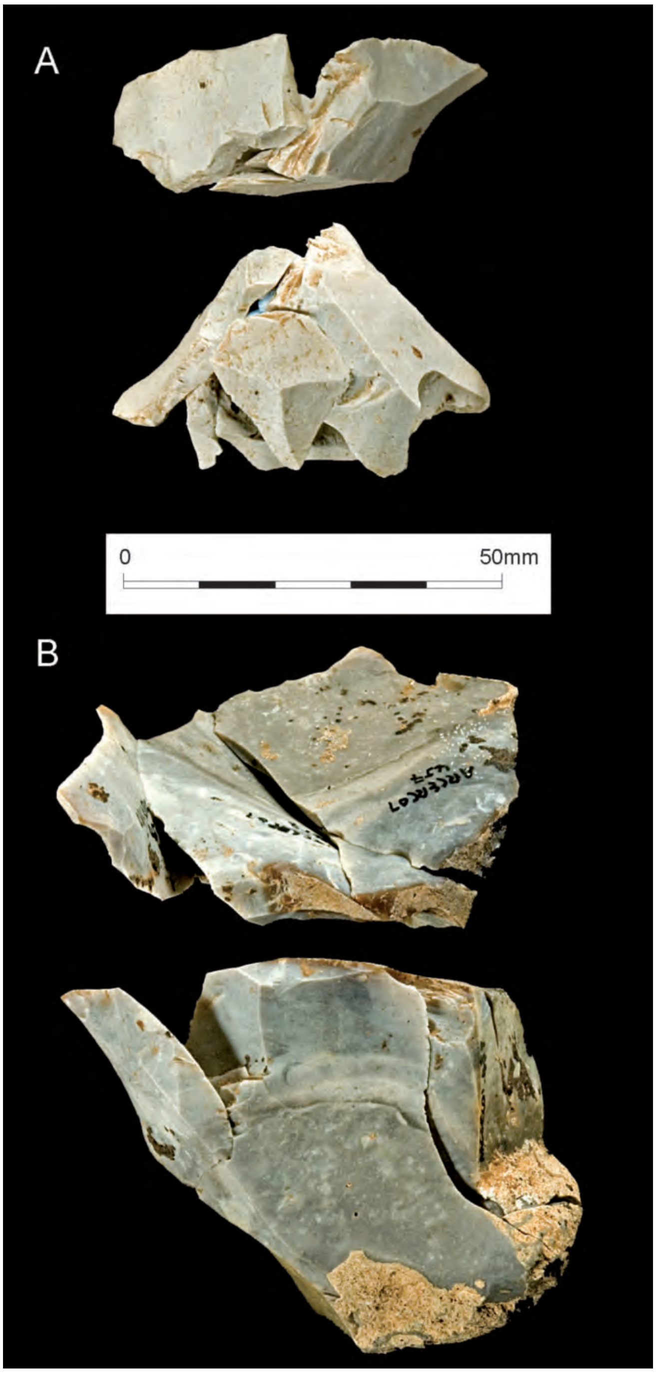


Plate 21.11 Late Neolithic/Early Bronze Age refitting sequences from context 457 (ARC ERC01) (a) refitting sequence of five flint flakes with a small tablet rejuvenation; (b) refitting sequence of five flakes containing a piercing tool

4. Levallois-style discoidal core (context 5643, ARC SPH00)
5. Knife. Flake with edge retouch and two proximal notches, presumably to facilitate hafting (context 16794, ARC SHN02)
6. Knife. Large flake soft hammer flake with heavily abraded linear platform. Two proximal notches possibly relate to hafting. The distal break many have occurred during knapping due to a fault in the flint, indicating the artefact is complete. The left- and right-hand side exhibited heavy scaring possibly relating to use (16967, ARC SHN02)

Table 21.9 Worked flint from colluvial contexts 5874 and 5875 at Springhead (ARC SPH00)

Category type	5874	5875
Flake	141 (11)	444 (22)
Blade	2 (9)	13 (5)
Bladelet	–	3
Blade-like	1	12 (2)
Irregular waste	10	24
Rejuvenation flake tablet	(1)	–
Rejuvenation flake other	–	(3)
Core single platform blade core	1	1
Tested nodule/bashed lump	4	5
Single platform flake core	1	8
Multiplatform flake core	1	5
Unclassifiable/fragmentary core	1	2
Core on a flake	1	1
Bruised blade/flake	–	(1)
End scraper	–	3
End and side scraper	–	1
Disc scraper	–	1
Awl	–	1
Piercer	–	1
Retouched flake	–	1
Hammerstone	–	–
Total	**163 (21)**	**526 (33)**
No. Burnt worked flints (%)*	1(0.5)	9 (1.6)
No. Broken worked flints (%)*	33(17.9)	114 (20.4)
No. Retouched flints (%)*	–	8 (1.4)

KEY: Percentage excludes chips

Worked flint from scatter 457 at Ebbsfleet River Crossing (ARC ERC01)

The Ebbsfleet River Crossing excavations revealed an apparently *in situ* flint scatter (context 457). The scatter contained 447 flints, dominated by flakes (155) and small chips recovered from sieving (268) (Table 21.8). A refitting exercise demonstrated the presence of knapping debris with 27 flints in nine refitting sequences. These sequences all appeared to derive from the working of small gravel flint nodules. The majority of sequences are pairs of refitting flakes generally struck during the early stages of core reduction. Two longer sequences of five flakes are more informative of reduction sequences and activities in the scatter. The first sequence is from a core producing small flakes. After the removal of the first flake in the sequence the platform was rejuvenated by striking a small tablet and then flaking continued from the platform (Pl 21.11A). The rejuvenation of cores, particularly by the removal of a tablet, demonstrates a careful and considered reduction strategy, despite the fact that the core was only producing small flakes. The combination of the product and techniques of manufacture are suggestive of a Late Neolithic/Early Bronze Age date for the assemblage. A second sequence of five flake removals is significant as the second removal has a natural distal spur that has been enhanced by abrupt retouch to form a piercer (Pl 21.11B). This demonstrates that at least one simple flake tool was produced at this location, but the presence of the artefact may indicate the tool was used and abandoned at its place of manufacture. The

Table 21.10 Technological attributes at flint from colluvial context 5875 at Springhead (ARC SPH00)

	Termination type				
Context	Hinge	Step	Plunging	Feather	Other
5875	44 (22%)	5 (2.5%)	38 (19%)	98 (49%)	15 (7.5%)

	Butt type						
Context	Cortical	Plain	>1 Removal	Facetted	Linear	Punctiform	Other
5875	35 (17.5%)	131 (65.5%)	17 (8.5%)	0	4 (2%)	6 (3%)	7 (3.5%)

	Dorsal extent of cortex					
Context	0	1–25%	26–50%	51–75%	76–99%	100%
5875	55 (27.5%)	68 (34%)	26 (13%)	12 (6%)	27 (13.5%)	12 (6%)

	Flake type					
Context	Preparation	Side trim.	Distal trim.	Misc. trim.	Non-cortical	Rejuvenation
5875	38 (19%)	52 (26%)	29 (14.5%)	24 (12%)	56 (28%)	1 (0.5%)

	Proportion of blades, presence of platform-edge abrasion and dorsal blade scars		
Context	% flakes >2:1 L:B ratio	% flakes with platform edge abrasion	% flakes with dorsal blade scars
5875	5.5%	9.5%	0%

	Hammer mode			
Context	Hard	Soft	Indeterminate	
5875	LN/EBA	95 (47.5%)	15 (7.5%)	90 (45%)

scatter contained only one other retouched artefact, a notched flake. Retouched artefacts therefore only represent 0.6% of the assemblage, excluding chips. The scatter appears to result from the production of flakes for use, with only limited evidence for further tool production and use at this location.

Worked flint from Springhead colluvial sequence: deposits 5874 and 5875 (ARC SPH00)

The colluvial sequence at Springhead includes at least two contexts (5874 and 5875), containing *c* 700 flints, dated to the Late Neolithic/Early Bronze Age on the basis of the lithic assemblages (Table 21.9). Technological attribute analysis was undertaken on 200 complete flakes from context 5875 to clarify reduction strategies employed in this stratigraphically post-earlier Neolithic and pre-Middle Bronze Age context (Table 21.10). The flint from context 5875 derives from a flake-based industry, with only 5.5% of flakes achieving blade proportions; none of the flakes exhibited blade scars. This result concurs with Ford's (1987, table 4) study which suggests that assemblages containing less than 7% blades, with no blade scars, can be considered to date from the Late Neolithic or Bronze Age. A significant proportion of the assemblage exhibits platform-edge abrasion (9.5%), suggesting careful reduction, not apparent in the Middle Bronze Age assemblage considered below. The cores also reflect a flake-based reduction strategy. Twenty-one cores and tested nodules from the context were orientated at flake production, whilst only one bore the scars of blade removals; the latter possibly represents a residual Mesolithic blade core. The flake cores exhibited a simple pattern of reduction, generally from a simple platform, with a slight tendency toward single platform cores (eight) over multi-platform cores (five). Percussion, where identifiable, was predominately by hard hammer, but soft-hammer percussion was still employed (Table 21.10).

In total, 72.5% of the flakes exhibit some of the original cortical surface, with 25.5% of flakes exhibiting more than 50% cortex on their dorsal surfaces. This suggests the primary reduction of nodules was undertaken at this location. The relatively low proportion of entirely non-cortical flakes (27.5%) indicates core preparation was not undertaken prior to flaking and that the desired product may have been a partly cortical flake; the cortex perhaps providing natural backing for a working edge. This is perhaps supported by the relatively low core to flake ratio of 1:20, that would suggest perhaps only in region of four flakes per core were entirely free from cortex.

The retouched component of the assemblage from context 5875 is limited to eight artefacts, representing 1.4% of the assemblage (excluding chips). The range of tools is also limited with five scrapers, a piercer, an awl and a simple edge-retouched flake. No retouched artefacts were recorded in context 5874.

Discussion of the assemblage

The distribution of the Late Neolithic/Early Bronze Age flint assemblage suggests that the spring-head was, as in early periods, a significant focus of activity in the area. However, in contrast to earlier periods, an extensive distribution of flint across the excavation indicates considerable activity in the wider landscape. The Ebbsfleet River Crossing excavations identified activities performed beside the River Ebbsfleet, whilst an

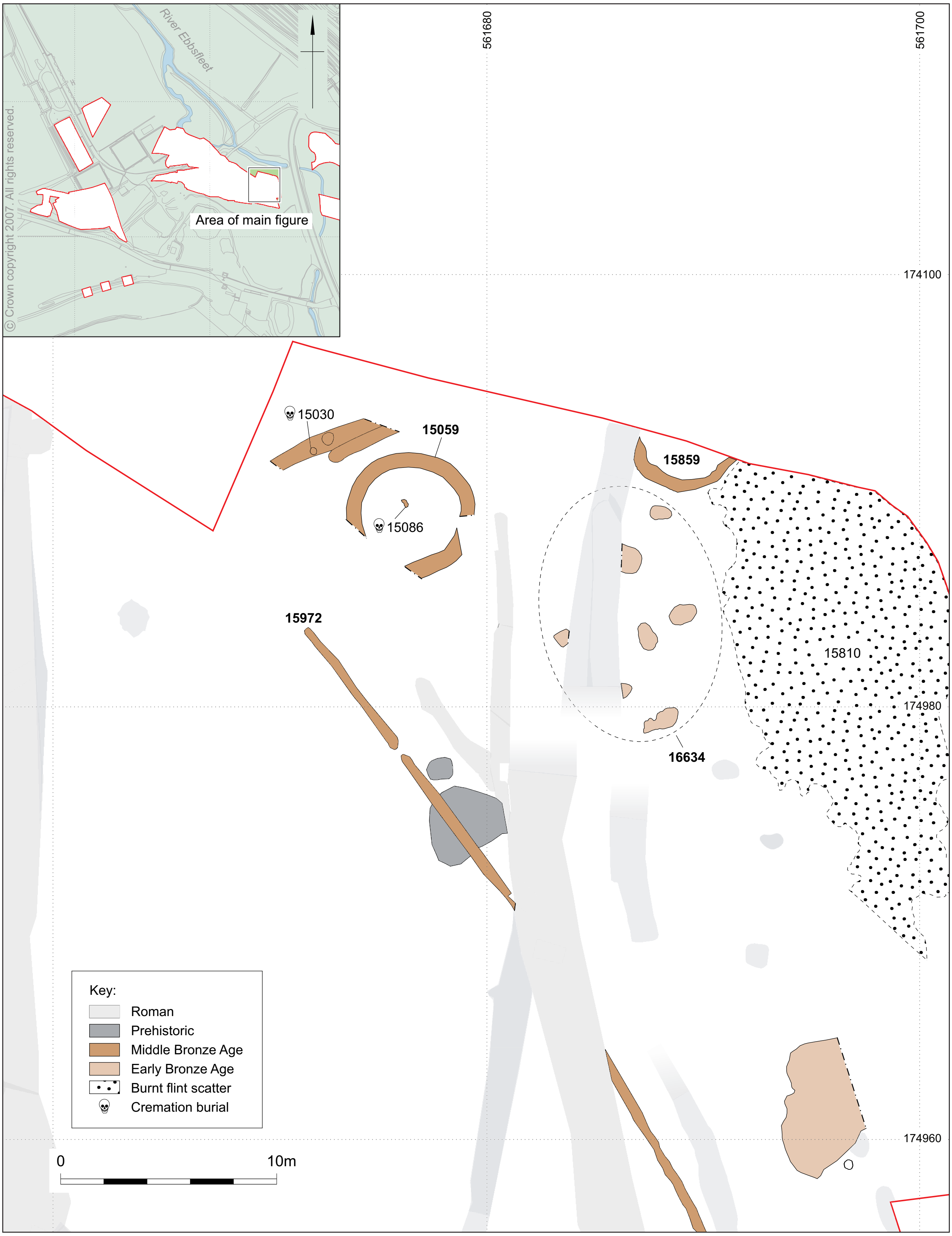


Figure 21.13 Plan of prehistoric features beneath the Roman Villa complex (ARC EBB01)

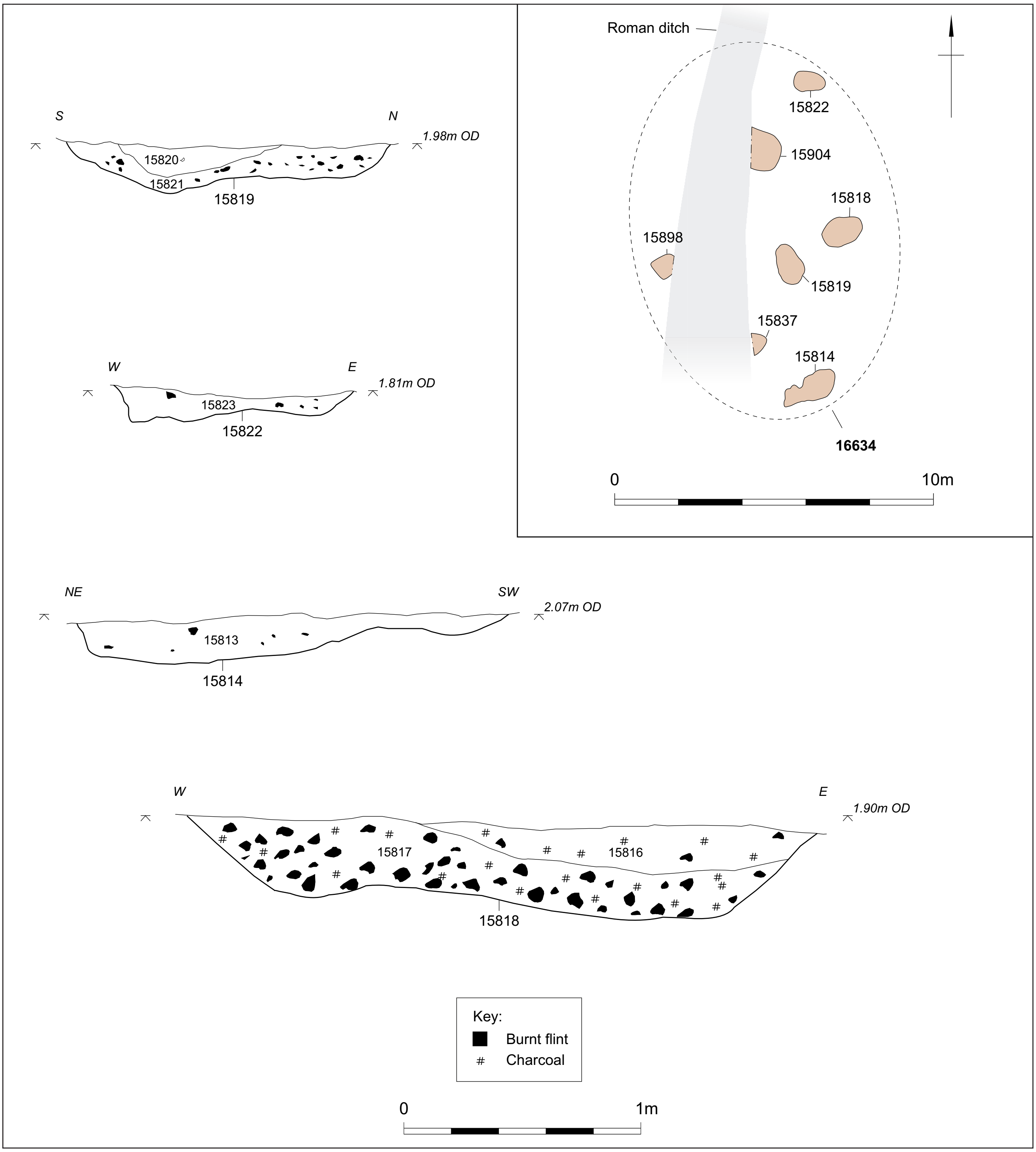


Figure 21.14 Sections of Early Bronze Age pits beneath the Roman Villa complex (ARC EBB01)

extensive scatter of redeposited Late Neolithic/Early Bronze Age flint at Springhead Nursery (ARC SHN02) indicate a presence in this area. The flint assemblages recovered present a challenge in interpreting the activities performed at any location and across the landscape. The colluvial deposits at the spring-head contain evidence for the production of unspecialised flakes. The limited range and quantity of retouched tools, dominated by scrapers, is not suggestive of typical 'domestic' assemblage and may reflect activities performed away from habitation areas. The scatter (457) by the River Ebbsfleet captures a fleeting moment of tool production and use in this area. The broader range of tools recovered from Springhead Nursery may reflect a more balanced assemblage, typical of habitation sites. The ephemeral nature of Late Neolithic/ Early Bronze Age habitation often leaves few traces beyond a surface artefact scatter, which as in this case are frequently redeposited into later archaeological features.

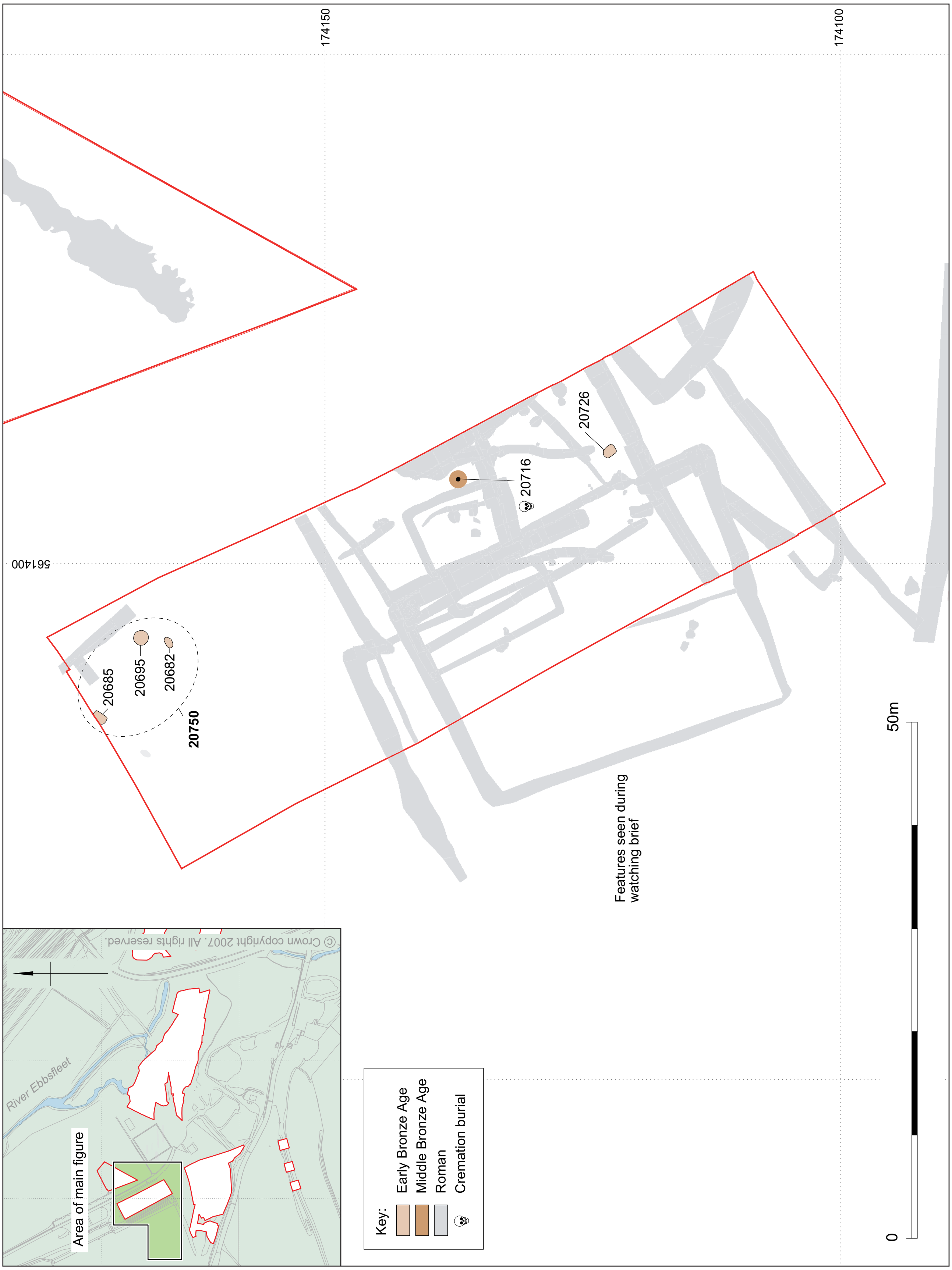


Figure 21.15 Plan of prehistoric features at the Ebbsfleet Sports Ground site (ARC EBB01)

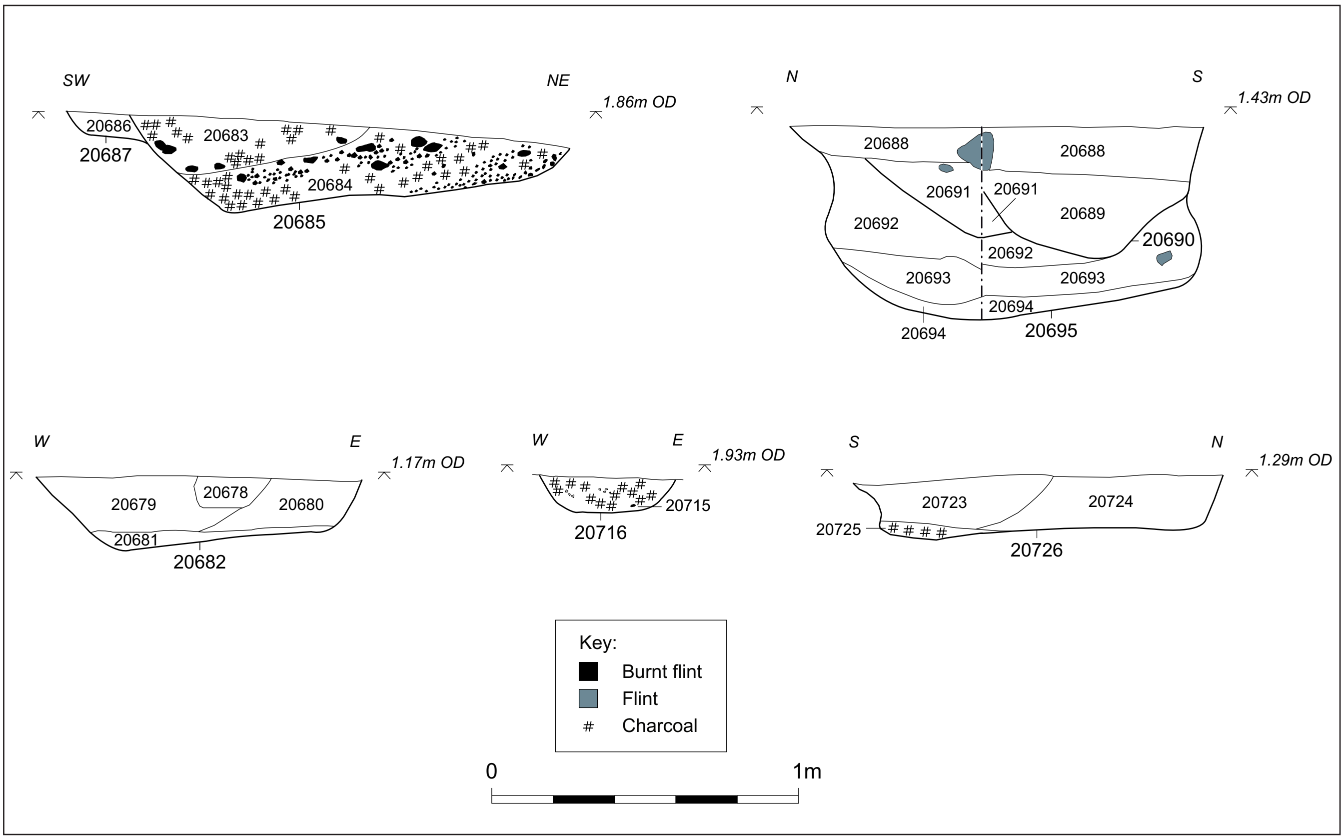


Figure 21.16 Sections of Early Bronze Age pits at the Ebbsfleet Sports Ground site (ARC EBB01)

The Lower Valley Slopes (Zones 1–7)

A cluster of seven pits (Group 16634) was located on the Chalk Spur (Zone 7) beneath the Northfleet Villa Complex (Fig 21.13). The pits (15822, 15904, 15818, 15819, 15898, 15837 and 15814) varied in shape between sub-circular or oval to very irregular, the latter probably representing natural subsoil hollows rather than cut features. The depth of the features varied between 0.16m to 0.20m and all contained similar fills comprising very dark brownish-grey silty clay loam (Fig 21.14). Three of the features were substantially truncated by a north–south Roman ditch. Apart from abundant burnt flint, comprising between 10% and 60% of the fills, all of these features were devoid of artefactual material. However, Pomoideae charcoal from the fill of pit 15818 was radiocarbon dated to the latter part of the Early Bronze Age at 3404±30 BP (NZA-28400, 1770–1620 cal BC; Table 21.2; Fig 21.2).

Further to the west, a cluster of three pits (Group 20750) were located in the north-eastern part of the Sports Ground excavation (Fig 21.15). All three pits (20682, 20685 and 20695) were sealed beneath a thin layer of pre-Roman colluvium and contained similar fills with abundant burnt flint (Fig 21.16). *Prunus* sp. charcoal from the primary fill (context 20681) of pit 20682 produced a date of 3293±30 BP (NZA- 28249, 1670–1490 cal BC) and Pomoideae charcoal from pit 20685 (fill 20684), 3313±30 BP (NZA-28250, 1690–1510 cal BC). A further isolated pit, 20726, also containing abundant burnt flint was recorded to the south of pit group 20750 (Fig 21.15). *Salix*/*Populus* sp.

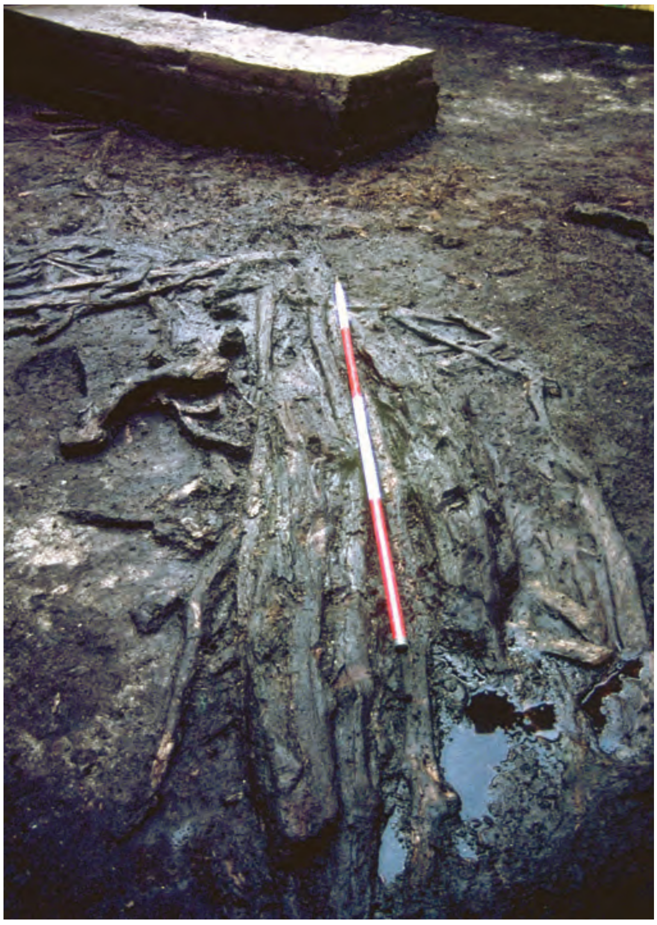


Plate 21.12 Late Neolithic 'trackway' structure 4027, Area 4 (STDR401)

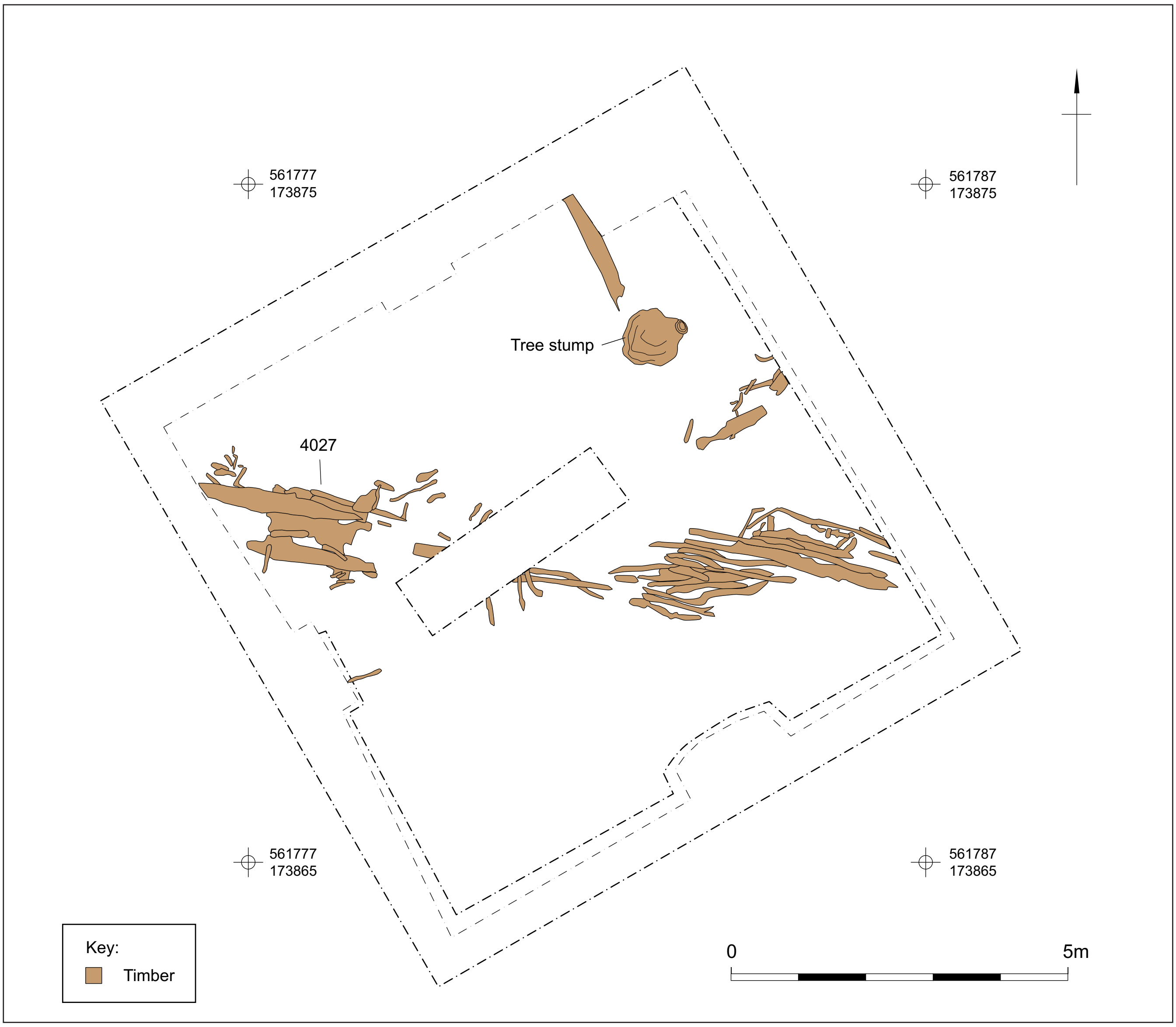


Figure 21.17 Plan of Late Neolithic 'trackway' structure. 4027, Area 4 (STDR401)

roundwood charcoal produced a date of 3394±30 BP (NZA28398, 1770–1610 cal BC) (Fig 21.2; Table 21.2). Artefactual material was largely absent from these features, although the primary fill of 20682 produced a leaf-shaped arrowhead.

Early Bronze Age pottery, however, was recovered from other contexts. Notably this includes part of a plain grog-tempered base from the fill of a natural hollow (context 30014) that could be from a Beaker, urn or Food Vessel. The worn condition indicates that the sherd may have been redeposited. Evaluation trench 3787TT (Fig 7.1) also produced two small and worn sherds (context 3787004) which are almost certainly Beaker based on firing (outer margin oxidised reddish-brown and inner margin non-oxidised black) and wall thickness (6–8mm). One sherd has non-plastic finger-tip impressions, which could be a tentative indicator of an early date (2500–2050 cal BC – also see Needham 2005, fig 13) (Barclay and Seager Smith, Appendix H).

The Floodplain (Zones 8 and 9)

Area 4 (STDR401)

Evidence of Late Neolithic to Early Bronze Age activity was sparse in the floodplain area (Zones 8 and 9). However, in the upper part of the peat sequence in Area 4 a concentration of waterlogged wood was recorded (Structure 4027). The concentration comprised a clear linear deposit of weathered logs and poles, 1.1–1.2m wide and orientated roughly north-west–south-east with clearly defined edges (Figs 13.8 and 21.17; Pl 21.12). There were doubts during excavation as to whether this feature was a humanly-made structure, or a waterlain deposit of driftwood accumulating along the edge of a channel. However, it later became clear, from the plan evidence and close examination of some lifted fragments (by Damian Goodburn), that it was a simple trackway in which the log and pole elements were laid in the long axis of the feature. The material used was quite varied including cleft and charred log sections. Timber 4046 was a weathered cleft section of oak with charring, whilst other cleft material comprised alder going down to cleft ¼ poles. Hazel was also identified as an additional constituent of the structure. The edges of several lifted sections bore traces of weathered axe trimming but no clear-cut ends were lifted. A piece of alder roundwood from the structure was radiocarbon dated to the Late Neolithic – 4120±30 BP (SUERC-19950, 2870–2570 cal BC; Table 21.1; Fig 21.1).

Summary

The Neolithic and Early Bronze Age fall with the broad period division of 'Early Agriculturalists' as defined by the original CTRL research strategy (Drewett 1997), the aims of which are outlined in Chapter 3. Traditionally the beginning of the Neolithic was seen to be a change from a mobile hunter-gather lifestyle to a more sedentary way of life which involved widespread woodland clearance and the adoption of cereal cultivation, domestication of animals, monument building and pottery production. More recent research, however, suggests that the adoption of the 'Neolithic package' was more gradual; although arable and pastoral farming were practised, reliance on natural resources; hunting and gathering, remained an important element of Neolithic subsistence practices (Entwistle and Grant 1989; Moffett *et al* 1989; Robinson 2000). The general absence of evidence for permanent settlement also suggests lifestyles were still quite mobile during the Early Neolithic (Whittle 1997); in Kent the only real evidence for permanent structures or 'houses' comes from the HS1 site of White Horse Stone on the North Downs (see Hayden below; also, Garwood 2011; Hayden and Stafford 2006).

Exploitation of Natural Resources

Although there was no real evidence for permanent occupation, undoubtedly groups were frequently visiting the valley, probably to exploit the range of natural resources adjacent to and within the wetland zone. Much of the material evidence was recovered as residual occurrences in later features and as such brings limited understanding to the nature of activities carried out in the valley. *In situ* Early Neolithic scatters such as those recorded in Area 4 (STDR401) suggest episodes of flint knapping occurred that utilised the locally abundant flint. Activities may have involved the working of unseasoned woods, fibrous plants or dry hide. The fact that many of the flints recovered had been burnt and were found in association with unworked burnt flint suggests that the activities carried out involved the use of fire, although no clear hearth features or areas of burning were identified in Area 4 associated with the Early Neolithic remains (Anderson-Whymark, Appendix I).

The faunal assemblage from deposits of this period, although small, included a number of wild species such as aurochs, red and roe deer whose meat would have complemented the diet. The skeletal representation included both meat-rich body parts and those with little or no meat, indicating that game butchery may have taken place in the vicinity. Fur animals were, however, absent. A single bird bone is likely to derive from a wild bird as domestic fowl does not appear to have been introduced into England until the Late Iron Age (Hamilton-Dyer 2007, 106), although whether its presence at the site is due to natural causes or whether it was hunted is impossible to determine. The only fish remains recovered were the cod (*Gadus morhua*) bones recovered from the peat in Trench 11 (context 1119, STDR400). The association with the Ebbsfleet Ware bowl is rather intriguing; cod is often associated with deep-sea fishing, but these fish can also be caught closer to land. Cod has been found on Danish Mesolithic sites, where it has been suggested that they may have been caught in stationary fish traps (Enghoff 1995), although cod are more usually caught using hook and line. The occurrence of sea fish (cod) within freshwater peat deposits, formed in a freshwater alder carr environment, clearly indicates that it was brought to the site from some distance (Strid, Appendix R).

The charcoal assemblages were primarily recovered from Early Bronze Age contexts in the Upper Valley at the Ebbsfleet River Crossing and from features on the Lower Valley slopes, and indicate the use of a variety of native deciduous trees and shrubs. Notably, although large tree types such as oak and more rarely elm and ash were exploited (in the case of oak, for specific purposes including use in a boiling pit), smaller trees and shrubs that thrive in open canopy woodland, scrub and hedgerows, such as field maple, hawthorn and blackthorn, were dominant. It is suggested this is a good indication of the nature of the local landscape during the Early Bronze Age, with these habitats more common in the immediate area than dense stands of woodland. Substantial use was also made of alder wood, reflecting the presence of alder carr woodland fringing the Ebbsfleet. Overall, opportunistic use of available woody types for fuel appears to have occurred. However, scant evidence of management of these woody resources was apparent in assemblages (Barnett, Appendix Q).

Timber Structures

Concentrations of large oak timbers at the base of the peat in Trench 9 (STDR400), dated to 4926±35 BP (NZA-29080, 3780–3640 cal BC), may represent the remains of some form of Early Neolithic trackway, although no evidence of working was identified in this small intervention and the evidence remains equivocal. It is, however, noteworthy that a concentration of large timbers was also interpreted as a possible trackway at the base of the peat at Burchell's original site to the south-west of Area 4 (Sieveking 1960); latterly radiocarbon dated to 4660±150 BP (BM-113, 3750–2900 cal BC). The possible Late Neolithic log and pole trackway from within the peat sequence in Area 4 (STDR401), dated to 4120±30 BP (SUERC-19950, 2870–2570 cal BC; Fig 21.1; Table 21.1), is more convincing and utilised oak, hazel and alder; it was a simple structure that was probably used to traverse a boggy area of the alder carr.

A number of timber trackway structures have been identified within the Lower Thames floodplain area in recent years. The majority appear to date to the 2nd millennium BC (see Stafford *et al* 2012 for a recent review); however, an example recently excavated from the base of a peat deposit at Belmarsh on the Plumstead Marshes is the earliest yet found in the Thames Basin (3960–3700 cal BC) and was constructed of tangentially split timber planks of alder and hazel laid side by side (Hart 2010). A Late Neolithic structure at Fort Street, Silvertown (3030–2700 cal BC) also utilised timber planks with vertical anchoring posts (Crockett *et al* 2002). Parallels for the log and pole trackway from Area 4 (STDR401) include a structure recorded during the A13 road scheme (Stafford *et al* 2012) and at the Beckton Golf Driving Range (Carew *et al* 2010) in East London, although both of these structures date to the Early to Middle Bronze Age.

Cereal Cultivation and Animal Husbandry

The evidence recovered from the Ebbsfleet Valley during the HS1 and STDR4 works provides little direct evidence for the cultivation of cereals during this period. No charred cereal assemblages were recovered and the pollen evidence indicates only limited opening of the woodland on the Lower Valley slopes or further upstream at Springhead therefore before the beginning of the Bronze Age.

As previously noted, the pollen evidence indicates that during the Early Neolithic the area would have been predominantly wooded, although more open clearings probably existed within this woodland and it is likely that these areas were used for grazing domesticates (Huckerby *et al,* Appendix J). The insect assemblages from the basal (Early Neolithic) part of the peat sequence in both Area 4 (STDR401) and Trench 9 (STDR400) contained a small component dependent upon grassland habitats, probably located on the well-drained soil of the valley side rather than in the valley bottom. Also present in abundance were scarabaeoid dung beetles which feed on the droppings of larger herbivorous mammals and it is likely that the grazing extended from the grassland into partly wooded areas (Robinson, Appendix N).

In addition to the wild species, the small faunal assemblage (largely recovered from the STDR4 trenches in the valley bottom) included the usual range of domesticated species: pig, sheep/goat, cattle and horse. Excluding the large number of sheep/goat bones comprising a deposit of 31 ribs and rib fragments (STDR401, Area 4, context 4049), cattle was the most frequently identified domestic animal. Due to its larger size, cattle are likely to have been the main meat provider of the three species. While not all skeletal elements were represented in the assemblage, bones from meat-rich body parts as well as meat-poor body parts were present. This would suggest that all domestic species were butchered in the vicinity. Butchering marks were found on bones from cattle, sheep/goat and horse, as well as unidentified ungulate. Most of these were cut marks deriving from filleting and/or disarticulation. A large mammal vertebra had both transverse processes chopped off, suggesting portioning of the carcass, and a cattle radius had been chopped off mid-shaft to expose the marrow. Horizontal cutmarks indicative of skinning occurred distally on an ungulate metatarsal, possibly from a large sheep or goat. Seventeen of the 31 articulated sheep/goat ribs (context 4049), found in the vicinity of the Early Neolithic flint scatters, displayed cut marks suggesting disarticulation from the vertebral column and the sternum, as well as filleting meat from the bone (Strid, Appendix R).

The Ebbsfleet Ware Pottery Assemblage

With reference to the pottery assemblage recovered from Neolithic and Early Bronze Age deposits, the most significant find was part of an Ebbsfleet Ware bowl, as well as sherds from two further vessels that may have been used as cooking pots, recovered from the base of the peat in Trench 11 (STDR400) (Barclay and Seager Smith, Appendix H). The radiocarbon dates approximate well to the suggested range of 3500–3550 to 3350–3300 cal BC for this style of pottery (see Barclay 2007, 343 and table 15.1; Barclay 2002, 90; Cotton 2004, 133; Gibson and Kinnes 1997) and from the nearby type site for Ebbsfleet Ware (Burchell and Piggott 1939). The date of Ebbsfleet Ware is poorly understood partly because so little of this pottery has been recovered from closed secure contexts with many of the larger groups and assemblages being recovered from secondary contexts within monuments or from open sites such as middens and occupation spreads. The vessel from Trench 11 cannot be precisely matched with any of the vessels from the larger assemblage recovered from the bed of the Ebbsfleet (Burchell and Piggott 1939). At this site rims tend to be of simpler form and shoulders are generally more rounded. Neither can the vessel be paralleled with the small assemblage of pots recovered from Baston Manor, in West Kent (Smith 1973, 9 and figs 3–4). The form is somewhat similar to a plain vessel from Runnymede Bridge, Surrey (Longworth and Varndell 1996, fig 57 NP53) and a decorated vessel from Mixnam's Pit, Thorpe, Surrey (Grimes 1960, fig 71:3). Ebbsfleet Ware is usually found in occupation spreads, occasionally in pits and in secondary deposits at monuments such as causewayed enclosures (eg, Staines and Windmill Hill, Robertson-Mackay 1987; Smith 1965) and long barrows (eg, Burn

Ground and West Kennet, Grimes 1960; Piggott 1962). Within the Thames Valley notable assemblages containing Ebbsfleet Ware outside of North Kent occur at Runnymede (Kinnes 1991; Longworth and Varndell 1996), Eton (Barclay 2013); Drayton (Cleal 2003), and Yarnton (Barclay and Edwards 2016).

The Early Bronze Age Features and Burnt Mounds

Perhaps one of the most intriguing aspects of the evidence from this period is the quantities of burnt flint, particularly associated with a series of Early Bronze Age pits along with other discrete spreads at the Ebbsfleet River Crossing. Many of the pit fills contained large quantities of burnt flint with charcoal. Concentrations of burnt flint are a feature of prehistoric settlement sites and provide evidence for the use of heated stones for various activities such as cooking (Lambrick with Robinson and Allen 2009, 179–80). However, some sites produce much larger quantities of burnt flint and include the much debated class of monuments commonly referred to as burnt mounds. Burnt mounds are more generally dated to the Middle and Late Bronze Age and remains of this date were found associated with the Bronze Age barrows during the HS1 works at Springhead (see Chap 22). They are often found adjacent to water courses and in the classic form appear as a crescentic or circular mound of burnt stone often associated with a central trough, probably used to boil water with heated stones (Raymond 1987). Activities that have been suggested for these features include cooking, perhaps large pieces of meat for communal gatherings (O'Kelly 1954; Barber 1990), the processing of fleeces (Jeffery 1991), salt production (Barfield 1991) or the creation of large amounts of steam for the use in sweat lodges (Barfield and Hodder 1987).

The only other published burnt mound sites in Kent include the Late Neolithic feature at Crabble Paper Mill, near Dover (Parfitt 2006b) and a Late Bronze Age example excavated during the A2/A282 road improvements at Dartford (Simmonds *et al* 2011). Further afield a few examples have been found in the Greater London area; the example from Phoenix Wharf, Bermondsey also included a 'boiling pit' and a series of stakeholes, possibly representing a revetment or windbreak, and was interpreted as a possible cooking site (Bowsher 1991; Sidell *et al* 2002).

In common with many other sites, the Early Bronze Age remains identified during the HS1 works did not produce any quantity of faunal remains or midden-type deposits that one would perhaps expect of domestic settlement activity. The Early Bronze Age feature group 551 at the Ebbsfleet River Crossing was particularly enigmatic; the identification of a series of possible postholes within the gullies flanking the central pit or hollow suggests some form of enclosing structure which may support the sauna hypothesis of Barfield and Hodder (1987). If this interpretation is correct the absence of any evidence for *in situ* burning within the main pit or hollow might suggest stones were heated outside of the structure, perhaps on the hearths identified a little further to the south. The central gully could have fed water from the nearby River Ebbsfleet to pour on the hot stones that had been brought into the structure to create steam. Parallels for such 'sauna' structures may be found in Scandinavian and North American cultures.

The Hinterland

The Neolithic to Early Bronze Age evidence recovered from the Ebbsfleet Valley during the HS1 and STDR4 investigations, although perhaps a little sparse, should be considered as only one component of a much wider prehistoric landscape. The evidence for Kent is summarised in a number of recent reviews (eg, Ashbee 2005; Champion 2007). Within a few kilometres to the south-east of Springhead, large-scale investigations associated with HS1 at Whitehill Road, Northumberland Bottom and Tollgate (Booth *et al* 2011), along with the A2 Pepper Hill to Cobham road scheme (Allen *et al* 2012), have provided further insight to activity on the higher ground. To the west in the Darent Valley recent work includes the A2/A282 junction improvements (Simmonds *et al* 2011), adding to the earlier investigations at the nearby Darenth Gravel Pit (Philp *et al* 1998).

The Early Neolithic activity in the Ebbsfleet Valley is consistent with the varied exploitation of the local landscape at this time that probably extended over large territories (see Garwood 2011). The excavations along the A2 corridor revealed scatters of Early Neolithic worked flint probably representing short-lived occupation sites (Allen and Hayden 2012, 97). Intriguingly a single large 'ramped' posthole that would have held a substantial timber post on Site G was dated to the period *c* 3640–3360 cal BC. The function of the apparently isolated post is difficult to interpret but it has been suggested it may represent a way-marker to those emerging from a nearby dry valley onto the level plateau, or maybe a territorial marker (*ibid*, 97). A Cornish granite axe from Site C on the same excavations, while found as a curated item in an Iron Age pit, is likely to have been rediscovered locally, and so is important evidence of the wide-ranging contacts of the Neolithic community in this area (*ibid*, 97). Three and a half kilometres to the south-east of Springhead, just north of the HS1 route at Tollgate, is a sub-rectangular enclosure thought to be a mortuary enclosure of Neolithic date (Bull 2006a).

Approximately 6km to the west of the Ebbsfleet Valley a scatter of Early Neolithic pits was identified during the A2/A282 excavations (Simmonds *et al* 2011, 61–5). The pits contained worked flint, Carinated Bowl and Plain Bowl pottery, suggesting activity spanning the early to middle 4th millennium BC. Radiocarbon dates from three of the pits provided a range of 3970–3380 cal BC (*ibid*, 101). Earlier excavations in the nearby

Darenth Gravel Pit (Philp *et al* 1998) revealed Neolithic activity associated with a peat filled lake at the floodplain edge, sealed beneath colluvium. Artefacts recovered from the peat included abundant fragments of burnt flint, struck flint, pottery and bone fragments leading the excavators to suggest the presence of a nearby settlement. The peat unit predominantly associated with the Neolithic artefacts was dated to *c* 4000–2500 cal BC. The flint assemblage included fragments of polished flint axes, possible sickle blades and arrowheads. Notably one of the polished stone axes, of amphibolite, probably originated in Cornwall and, as with the item from the A2, provides evidence of contact over long distances. The animal bone assemblage, similar to the Ebbsfleet Valley, included cattle, sheep, pig, red deer and roe deer.

Late Neolithic to Early Bronze Age activity is represented along the A2 by scatters of worked flint in residual contexts and a number of deposits in small pits. Some of the pits contained rich assemblages of fragmented Beaker pottery, worked flint and animal bone and may represent domestic midden material, perhaps placed in the pits at key boundaries in the landscape (Allen and Hayden 2012, 97). There is also a Late Neolithic to Early Bronze Age enclosure, pit and flint scatter just to the north at Coldharbour Road (Philp and Chenery 1992; Mudd 1994).

In terms of funerary activity a double Beaker burial was excavated for HS1 at Northumberland Bottom (Askew 2006). The primary burial was radiocarbon dated to 3601±40 BP (NZA-22735, 2120–1780 cal BC) and the secondary burial to 3743±40 BP (NZA-22736, 2280–1980 cal BC). A single cremation burial of Early Bronze Age date was also found at this site in an upturned Collared Urn. Funerary monuments excavated for HS1 include the barrow at Whitehill Road, 2km south of Springhead which contained a secondary inhumation dating to 3273±30BP (NZA-22740, 1620–1440 cal BC) along with an amber necklace (Bull 2006b).

Wider Overview

by Chris Hayden

Earlier Neolithic Settlement Systems

Introduction

Although much of the earlier Neolithic evidence was, like the Mesolithic evidence, residual, changes in the local environment, and in particular the formation of peat in the valley bottom, means that there is more extensive, less disturbed evidence for the earlier Neolithic than for the Mesolithic. The factors leading to the better preservation of some of the Neolithic evidence, however, also introduce certain biases. The mixture of residual and less disturbed evidence makes interpretation difficult in several ways. In some respects the finds from sites above the valley floor provide evidence which is not of much higher quality than that provided by flint scatters recorded as a result of fieldwalking. The valley floor sites, however, provide evidence which is much less disturbed, more complete, and more clearly defined than such flint scatters. Despite the potential biases and other possible deficiencies, the evidence from Ebbsfleet nonetheless has particular significance in relation to the question of the character of Neolithic settlement systems, and in particular, the extent to which they involved mobile or sedentary elements.

Characterising mobility

Patterns of mobility can vary in a large number of ways – in the frequency of movement, its relation to seasonality, the degrees to which aggregation and separation are involved, and whether movement involved the relocation of places of residence or logistical trips from a centre of occupation, amongst others (Kelly 1992; Eder 1984; Pollard 1999). As a result, unless a more precise specification is given of the patterns of movement involved, characterising a pattern of settlement as more or less mobile or sedentary (if degrees of sedentism are allowed), is almost meaningless. In southern England, the Middle Bronze Age is often taken to provide the starting point for sedentary life, but even in this period Brück (1999) has suggested that settlement was mobile on the level of generations (which she characterises as a neolocal pattern of residence). For the Neolithic, the suggestion of a more mobile way of life implies more frequent movements, but beyond suggestions that the pattern consisted of a form of tethered mobility, the exact pattern remains poorly defined, and attention has been drawn rather to the potential regional variation in settlement systems (Whittle 1997; *cf* Pollard 1999). Patterns of mobility have been much more extensively theorised in the context of hunter-gatherer societies (eg, Binford 1982; Wiessner 1982; Testart 1982; Woodburn 1982; Price and Brown 1985; Spikins 2000) than amongst farming societies (but see David and Kramer 2001). If it is accepted that Early Neolithic settlement patterns were, to some extent like those of the Mesolithic, also mobile, then much of that theory may also be relevant to the Neolithic.

Here, it will be argued that much of the evidence from Ebbsfleet reflects a pattern of exploitation which involved relatively brief episodes of occupation by small groups of people, presumably to exploit specific resources. The presence of possible trackways perhaps suggests that the exploitation of the valley bottom was more organised and involved more repetitive patterns of activity than the small groups of artefacts recovered from the other excavated sites might be taken to indicate. Although the trackways may indicate the presence of more or less fixed paths through certain parts of the valley, it will be argued that this reflects the character of the local environment, and that the sites chosen for occupation appear not to have been fixed, but were presumably sited at the most appropriate locations to exploit specific resources. In short, the sites reflect a flexible and quite highly mobile aspect of the Early Neolithic settlement system, perhaps involving logistical trips, which contrasts with other more fixed points in the landscape.

Chronological context

Like the Mesolithic evidence, much of the earlier Neolithic evidence consists of worked flint which often cannot be very precisely dated. Where pottery and radiocarbon dates have been obtained, however, they suggest that most activity dates from a late phase of the Early Neolithic associated especially with Ebbsfleet Ware (and elsewhere with Decorated Bowl styles). Garwood (2011) contrasts this Early Neolithic with a preceding earliest Neolithic.

It is important to highlight the specific chronological context of the sites, since it seems likely that the development of settlement patterns from the Mesolithic to the Middle Bronze Age did not form a simple linear progression. Stevens and Fuller (2012) have recently suggested that after its introduction at the beginning of the Neolithic, agriculture was effectively almost abandoned in southern England in the Middle and Late Neolithic. Although their methodology (based upon summing probability distributions of calibrated radiocarbon dates on cereals) may not sufficiently take account of all of the biases in the available data (and notably the greater likelihood that potentially Early Neolithic cereals will be selected for dating – given that the date of their introduction has been regarded as of special interest – than will Late Neolithic cereals – the existence of which has generally been assumed to be unproblematical), their suggestion is consistent with the wider evidence.

Potential fixed points in the settlement system

Some of this evidence suggests that the Early Neolithic was characterised by sites which, if not occupied permanently, were at least returned to frequently over long periods of time. The long house at White Horse Stone, which appears to have been in use for at least 70 years and probably over 180 years (and perhaps over 300 years), from the beginning of the Neolithic, provides one example, although its interpretation as a house or as a specialised ceremonial or ritual structure is open to debate (*cf* Garwood 2011; Hayden and Stafford 2006). The middens at the Eton Rowing Lake provide another example, dating predominantly from the earliest part of the Neolithic, although activity also continued into later periods (Allen *et al* 2013). The Stumble, further north along the coast in Essex (Wilkinson *et al* 2012) and deposits at Runnymede Bridge, Staines, Surrey (Needham 2000; Needham and Spence 1996) provide examples of midden deposits which appear to be closer in date to the better dated earlier Neolithic evidence from Ebbsfleet. Although no comparably rich midden sites are known in the vicinity of the Ebbsfleet Valley, it is worth stressing that the contrast between the relatively rich assemblages recovered from these sites and the much smaller assemblages from the sites in the Ebbsfleet Valley plays an important role in supporting the suggestion that occupation in the Ebbsfleet Valley was of limited scale and duration and did not involve repeated visits to the same site. Causewayed enclosures may have provided further fixed points in the landscape in the same period (Whittle *et al* 2011; Oswald *et al* 2001), although none is known in the immediate area of the Ebbsfleet Valley (see Chap 2).

Mobility and the representation of activity in the archaeological record

The suggestion, made above, that the theory developed in relation to hunter-gatherer settlement systems might also be relevant to the Neolithic implies that the difficulties of interpretation (see above) – and above all the fact that if settlement was mobile, the distribution of lithics may reflect more the places where flint was worked rather than where other activities occurred – are equally relevant to the Neolithic. (It should also, of course, be stressed that as settlement became more sedentary it becomes more likely that the artefacts deposited at a site will reflect the activities occurring.) The numbers of pieces of worked flint occurring on a site may be influenced to a large extent by the extent to which flint production took place. Sites where knapping did not take place may well have left negligible archaeological signatures. Similar arguments apply to pottery, although in this case the quantity of pottery may reflect how many vessels were broken, rather than the extent to which pottery was in use (although again, over a sufficient time period, it might be expected that some more or less consistent relationship would be established between pottery use and breakage). These observations do not so much detract from the significance of the evidence which has been recovered, as underline the fact that much may not be evident in the archaeological record. The pottery which marks out the finds from Trench 11, for example, consists of a large part of one vessel, and single sherds from perhaps two more vessels. It is possible that the absence of pottery from the other sites discussed simply reflects the fact the no pots were broken at those sites rather than the fact that pottery was not in use. It is not, therefore, credible to draw simple conclusions from the composition of the finds assemblages about contrasts in the kinds of activities which occurred at each site.

Lithic production at Springhead

The assemblage of earlier Neolithic flint recovered from a colluvial deposit at Springhead provides an example of the interpretative issues just discussed. Like the Early Mesolithic assemblage found in the same area, the earlier Neolithic assemblage consisted largely of knapping waste, the products of which appear to have been removed to be used elsewhere. The assemblage again contained very few retouched tools. Anderson-Whymark (Appendix I) notes the similarity in this respect with the earlier Mesolithic material. Like the Mesolithic material, then, the Neolithic assemblage can be taken as an indication that trips – or one trip at least – was made to the site to acquire flint and carry out the preliminary phases of production. The total quantity of flint in the Neolithic assemblage – amounting to just over 100 pieces – is smaller than that recovered from the underlying Mesolithic deposits. The significance of this contrast is uncertain, since in both periods the activity at the site is limited – but it does suggest that the site was not visited repeatedly in the Neolithic (or at least that lithic production took place on a limited number of occasions).

Exploitation of the valley bottom

As has been mentioned above, elsewhere at Ebbsfleet, the best preserved earlier Neolithic scatters were recovered from the valley bottom (especially in Area 4). The assemblages recovered in this area also contained a large proportion of knapping debris as well as relatively large numbers of cores, and the sites were clearly the location of flint working. In contrast to the Springhead assemblage, however, although retouched tools were again rare, the assemblages in this area contained quite large numbers of utilised flakes. Analysis of the usewear suggests that many of these flints were used to cut, whittle and scrape medium-hard materials such as unseasoned wood, fibrous plants or dry hides. Unlike the Springhead assemblage, then, the scatters in Area 4 in the valley bottom appear to have been related not just to lithic production, but also to a range of other activities. The insects from Area 4 and Trench 9 include dung beetles suggesting that animals may have been grazed in the area. Whether the lithic scatters were related to this activity is, again, unclear.

A further contrast between the assemblages at Springhead and in Area 4 was marked by the presence of burnt worked and unworked flint in Area 4. The worked flint assemblage from Area 3 – smaller, but broadly comparable in terms of compositions to those in Area 4 – was also associated with burnt unworked flint. The use to which the burnt flint was put is uncertain, but again suggests a range of activities which went beyond lithic production.

Because of their location, a small range of other evidence has survived in the valley bottom sites which may not have been preserved elsewhere. Unfortunately, this makes it more difficult to compare the sites with those elsewhere, since it is unclear whether the contrasts between them reflect differing degrees of preservation or differences in the material which was originally deposited. It is nonetheless worth noting that in Area 4 the lithics were associated with a small range of animal bone including red deer, aurochs, cattle and articulated sheep ribs (from which the radiocarbon date which suggests an Early Neolithic date was obtained). Butchery marks were found on the sheep ribs. The presence of the articulated sheep ribs is significant since it suggests that the absence of pottery from the site is not just the result of poor preservation but reflects the fact that no pottery was deposited on the site (although as has been suggested was the case with flint, if the pattern of settlement was mobile to a significant degree, the presence of pottery might only reflect the places where pots were broken, rather than where they were used).

In this respect the Area 4 assemblage contrasts with the small group of *in situ* Early Neolithic finds from Trench 11. In Trench 11 a small assemblage of flint and burnt flint was found associated with pig, cattle and cod bone and Ebbsfleet Ware pottery. Charred residue and signs of having been subjected to heat suggest that the bowl had been used for cooking. The cod bone clearly shows that food was transported to the site (albeit not necessarily from a very great distance), and it is worth noting that the other animal bones might equally have been transported to the site rather than reflecting the primary activities occurring on the site.

Given the presence of pottery, Trench 11 perhaps provides the closest parallel for the Ebbsfleet type-site (Burchell and Piggott 1939), although in the absence of more detailed records and more extensive excavation, it is difficult to be certain of how comparable the sites might have been.

Site variation in the Ebbsfleet Valley

Even within the confines of the Ebbsfleet Valley, then, there is considerable variation in the assemblages of earlier Neolithic finds. This variation appears to include sites related to specialised trips to acquire flint and carry out preliminary working. It also encompasses sites where flint knapping occurred alongside a limited range of other activities which might have involved processing plant resources which grew in the valley bottom, perhaps for fibres, or the preparation of hides. Some of the sites may also have been related to the use of the valley to graze cattle.

The generally small scatters of artefacts appear to be consistent with relatively brief periods of occupation – which in turn implies that the wider settlement system at least incorporated more or less mobile elements. Since, however, the possible absence of any direct relationship between the artefacts on a site and the activities carried out there, or between the quantities of artefacts (at least in the case of lithics) and the length or scale of occupation has been stressed, this suggestion needs to be treated with some care. A measure of the complexity of the relationship between length of use and quantities of associated finds is provided by the Early Neolithic house at White Horse Stone. This structure appears to have been in use over a long period of time but was associated with very few artefacts. One possible reason for the scarcity of artefacts in this case was that material was deposited away from the structure – perhaps in a midden – which did not survive the Iron Age agriculture which affected the surroundings of the house.

Sites with large quantities of Early Neolithic artefacts do, however, exist – at Runnymede Bridge and the Stumble – and clearly in these cases the size of the assemblage suggests either long or often repeated occupation, or extravagant consumption (perhaps feasting at Runnymede Bridge). The contrast between these sites and the artefact scatters at Ebbsfleet – even though they all occur in contexts which have lead to the good preservation of archaeological finds – suggests corresponding differences in the scale and duration of occupation. Furthermore, in the case of the Springhead assemblage and the Area 4 assemblages which suggest that lithic production was a significant activity, the number of pieces of flint is small compared to that recovered from the Early Mesolithic site at Springhead. Even in these cases, then, it appears that occupation was of limited scale and duration. A number of the test pits and other excavations revealed smaller and less well-preserved scatters of flint which, however, suggest that such earlier Neolithic activity was quite widespread.

Overall, then, although it is impossible to provide anything like precise estimates, the Ebbsfleet Valley appears to have been exploited by small groups of people, who occupied sites for relatively brief periods, and who do not appear to have returned regularly to the same sites. The pattern of exploitation seems, then, to have been mobile and flexible. Rather than the inhabitants returning to particular settlement locations, which endured over time, they appear to have moved their settlements, presumably to take advantage of the resources available at the time (although it is, of course, also possible that settlements were located in particular locations for social reasons).

The pattern of occupation suggested is perhaps seen more clearly within the area investigated at the Eton Rowing Lake (Allen *et al* 2013). Alongside artefact-rich midden deposits in two areas, which suggest either prolonged occupation, or, as Allen suggests, repeated occupation over a long period, a large number of much smaller artefacts scatters, many consisting only of worked flint, but often also including burnt flint, were found.

The contrast raises several further questions which are beyond the scope of this discussion. The argument above has relied on a contrast between the small assemblages of finds from the Ebbsfleet Valley and much richer assemblages from broadly contemporaneous sites at Runnymede Bridge and the Stumble. In the absence of any direct evidence for large accumulations of artefacts similar to the middens at Runnymede and the Stumble at Ebbsfleet, it could be argued that the Ebbsfleet sites derive from a system which lacked enduring locations of occupation. It might thus be argued that whilst settlement was not necessarily more mobile at Ebbsfleet than it was at the other sites (assuming that the large deposits of finds there derive from repeated episodes of occupation rather than from permanent occupation), it nonetheless differed in a significant way. The difficulty with this argument is that such deposits have clearly only been preserved elsewhere because of particularly fortuitous circumstances, and it is quite possible that in other contexts they would not have survived in the same way.

The small size of the assemblages found in the Ebbsfleet Valley, and the rather limited range of finds they contain, suggest that they only formed parts of a wider settlement system (which must have included sites of other kinds). If it is accepted that a similar enduring site may have existed somewhere in the vicinity of the Ebbsfleet Valley, then the characterisation of the settlement system would depend upon a number of parameters which are difficult to quantify. There is nothing in the evidence from the Ebbsfleet sites which prevents them from being anything more than the product of brief forays from a more or less permanent focus of settlement. The settlement system would then be essentially sedentary, and the small artefact scatters would reflect nothing more than trips to exploit particular resources. This form of mobility is characteristic of even wholly sedentary settlement systems. It is alternatively possible that the Ebbsfleet sites reflect a possible seasonally specific aspect of a wider settlement system, of the kind described by Thomson (1939). The potentially significant social implications of such systems – characterised by significant seasonal differences in social organisation were famously defined by Mauss and Beuchat (1950). In the light of this possibility, it is perhaps worth mentioning a final issue, which concerns how activity at causewayed enclosures may have been related to this system. No causewayed enclosures are known in the vicinity of the Ebbsfleet Valley, but the existence of a number of examples in Kent and to the north of the Thames in Essex (Whittle *et al* 2011; Oswald *et al* 2001; Dyson *et al* 2000; Allen *et al* 2008; Hedges and Buckley 1978) suggests at least the possibility that the inhabitants of the Ebbsfleet Valley were involved in activities at such a site.

The trackways

The final component of the evidence found at Ebbsfleet perhaps gives a rather different impression of the character of occupation in the Ebbsfleet Valley. The possible trackway found in Trench 9 has a radiocarbon date of 3780–3640 cal BC (NZA-29080: 4926±35 BP) which suggests that it was broadly contemporaneous with the artefact scatters just discussed. The apparently comparable example found at the base of Burchell's site has an unfortunately very broad radiocarbon date of 3750–2900 cal BC (BM-113: 4660±150 BP) which, however, is at least consistent with it belonging to the same period (Sieveking 1960).

Both were quite crude structures, but their presence nonetheless suggests that exploitation of the valley bottom occurred on a sufficiently regular basis to make the construction of such trackways worthwhile. By defining an enduring path, they also seem to imply more or less repetitious patterns of movement through the valley, which contrasts with the apparent lack of evidence for repeated occupation of sites.

Whilst it is possible that the presence of trackways reflects only the difficulty of moving through certain parts of the landscape, this contrast could be taken to imply a landscape which, at least locally, was defined more by pathways than by locations. This possibility highlights the potential significance of more enduring foci of settlement and of causewayed enclosures.

Later Neolithic

Following the Early Neolithic, very little evidence for activity in the Middle and Late Neolithic periods was found at Ebbsfleet. The only evidence which can be dated with any certainty to this period is the Late Neolithic trackway in Area 4, for which a date of 2870–2570 cal BC (SUERC-19950: 4120±30 BP) has been obtained. The only other evidence that might fall into this period consists of flint scatters which can be dated only broadly to the Late Neolithic/Early Bronze Age (and which are discussed further in the next section). The scarcity of evidence for activity in this period is not confined to the Ebbsfleet investigations reported here. Very few finds of this date have been found in other investigations around Ebbsfleet (eg, along the A2 and the northern end of HS1) and, indeed, more widely in the Thames Estuary. The absence, in particular, of finds from these periods in riverine and estuarine contexts is noticeable. The same pattern is repeated in the extensive investigations at Eton Rowing Lake, where Middle and Late Neolithic finds were very limited compared to the quantities of earlier Neolithic material (Allen *et al* 2013).

Accounting for the paucity of evidence for activity in these periods is difficult and beyond the scope of this discussion, but does suggest a significant change in the way in which the landscape was exploited. It is perhaps worth noting that the beginning of this period corresponds to the sharp decline in evidence for cultivation of cereals noted by Stephens and Fuller (2012).

The presence of the trackway in Area 4, dating from the Late Neolithic, however, shows that the area had not been abandoned in this period. Indeed, although it appears to have been of relatively crude construction, its presence nonetheless suggests that the area was exploited more or less systematically. The absence of other evidence from this period may, therefore, simply reflect the fact that whatever activities were taking place they have left no archaeologically recognisable trace. Overall, then, the pattern of occupation could be seen as having been similar in some respects to that which characterised the earlier Neolithic, but with even less indication of occupation of any duration.

Late Neolithic/Early Bronze Age Settlement Systems

Following the Late Neolithic, the quantity of evidence recovered at Ebbsfleet increases. Almost all of the evidence, however, consists of either lithic scatters, which can be dated only broadly to the Late Neolithic/Early Bronze Age, or of pits. The pits are generally characterised by the presence of burnt unworked flint and charcoal, but with few artefacts. They have been assigned to this phase on the basis of a number of radiocarbon dates. These dates suggest that a small number of pits and at least one hearth at Springhead date from early in the period (*c* 2500 to 2200 cal BC), but that most of the pits date from a period towards the end of the Early Bronze Age (*c* 1800–1500 cal BC). Given the small number of dates involved, the apparent gap between these two phases of occupation cannot be regarded as marking a significant hiatus in occupation.

It is worth stressing at this point that although the Early Bronze Age evidence from Ebbsfleet is limited, because of the scarcity of evidence of similar date elsewhere in Kent – and more widely – in non-funerary contexts, the Ebbsfleet evidence has a particular interest. Along the A2, for example, the finds from this period were limited to a few pits associated with Beaker pottery – one of which, however, contained a notably rich assemblage of finds – and a single sherd from a Collared Urn recovered from an animal burrow which cut a pit. Similarly, along HS1, aside from funerary contexts, Beaker pottery was recovered from a small number of pits, including again a couple which were notably rich in finds, while finds of Early Bronze Age pottery – Collared Urns, Food Vessels and Biconical Urns – from non-funerary contexts were made on only two sites (White Horse Stone and Eyhorne Street: Hayden and Stafford 2006; Hayden 2006).

Given this scarcity, it is striking that the features assigned to this period at Ebbsfleet lack any pottery, and have all been dated using radiocarbon. In other contexts, isolated pits, lacking apparently significant finds, are unlikely to considered worthy of radiocarbon dating. It is possible, then, that more evidence of non-funerary activity in the Early Bronze Age is contained in the undated features from other sites.

Flint scatters and lithic production

Whilst non-funerary Early Bronze Age features remain rare in Kent, lithic scatters which can, unfortunately, be assigned only a broad Late Neolithic or Early Bronze Age date have been identified at a number of sites. Most of these assemblages, however, were residual (eg, the A2 and Dartford Football Club assemblages: Simmonds *et al* 2011; Allen *et al* 2012), and lack the integrity of the Ebbsfleet groups.

The lithic scatters at Ebbsfleet provide evidence which in some respects is comparable to that from earlier periods, and its interpretation raises issues similar to those discussed in relation to the Mesolithic and Neolithic lithic scatters. Much of this evidence appears to reflect the processes of lithic production, rather than the activities for which lithic tools may have been produced, and as in the Mesolithic, it appears that different sites can be related to different stages in the production of lithic tools.

The assemblage of around 700 flints from the colluvial sequence at Springhead, to which a broad Late Neolithic/Early Bronze Age date has been attributed (see Anderson-Whymark, Appendix I), appears to relate primarily to the primary reduction of flint nodules, but not to the preparation of cores. Only a small number of retouched tools were recovered. The flint scatter preserved in a hollow at the edge of a palaeochannel at Ebbsfleet River Crossing, in contrast, consisted primarily of knapping debris from the production of flakes. Only two retouched tools – a piercer and a notched flake – were recovered from this site. In contrast to these two scatters, the range of flint recovered from Springhead Nursery, although residual, included a much wider range of retouched types, including a barbed and tanged arrowhead, a thumbnail scraper and knives with proximal notches.

As in earlier periods, then, it seems that the Late Neolithic/Early Bronze Age settlement system also incorporated logistic trips, represented by the scatter in the Springhead colluvial sequence, which may have been specifically to acquire lithic raw materials and to undertake the first stages of preparation. This element of the settlement system appears to have been complemented by sites such as that at Ebbsfleet River Crossing which were involved in the production of flakes. Unfortunately, the use to which these flakes were put remains uncertain. The residual context of the lithics from Springhead Nursery makes it difficult to define clearly a coherent assemblage, but the range of tools recovered at least gives a glimpse of the fact that a wider range of activities must have been taking place in that area.

Pits

Alongside the lithic scatters, a number of pits and other features were found, all of which were associated with burnt flint and charcoal, but with few other finds. The earliest of these features dates from the earlier phase of Late Neolithic/Early Bronze Age activity, *c* 2500–2200 cal BC, but most seem to belong to a period near the end of the Early Bronze Age, *c* 1800–1500 cal BC.

The lack of finds from these features beyond burnt unworked flint and charcoal makes it difficult to argue that they derive from everyday settlement, and suggests instead that they were related to a more specialised form of activity. Comparisons have been made above with burnt mounds. Although typically burnt mounds date from the Middle or Late Bronze Age, earlier examples have been found along the Thames (eg, Early Bronze Age examples at Little Marlow and Yarnton; Richmond *et al* 2006; Hey *et al* 2016). Spreads of burnt flint probably dating from the Late Neolithic and the Late Neolithic/Early Bronze Age were also identified at the Eton Rowing Lake (Allen *et al* 2013), and an example associated with a pit at Shepperton (Jones 2008) has been dated to the end of the Late Neolithic. As the discussion of burnt mounds above suggests, the precise use to which the flint had been put remains uncertain.

The suggestion that the burnt flint may have been associated with a specific activity is supported by some of the features at Ebbsfleet. The most striking of these was the distinctive arrangement of pits forming structure 551. No precise analogies for this structure have been identified. One of the hearths in the area of pit group 552 was associated with a possible flue. Although, again, the use to which these features were put remains elusive, the apparently deliberate arrangement of features suggests a more or less specialised task.

The fact that there is some variety in the features associated with burnt flint – much of the rest of it having been recovered from pits or natural hollows – could be taken to imply a corresponding variety in the uses to which the flint was put. It is, however, also possible that whatever was achieved with the more complex set of features forming structure 551 could also be achieved, albeit perhaps less efficiently, with less specialised arrangements.

Whatever the case, the distribution of these features at Springhead and on the lower valley slopes (in Zones 1–7) suggests intermittent activity. Some of the features form small groups – groups of seven in pit group 552 and in Zone 7 – but they occur equally often as smaller groups or as isolated features. Thus, whilst the excavations suggest that the area formed a focus for activity associated with burnt flint, it was a diffuse focus, the centre of which appears to have shifted over time.

This scale of activity is consistent with that suggested by the small groups of pits associated with Beaker pottery which were found along the A2 and HS1. However, the composition of the assemblages of finds associated with the pits elsewhere is very different, and suggests significantly different associated activities (Garwood 2011, 118–24). Furthermore, most of these pits were associated with Beaker pottery, and whilst they may have been broadly contemporary with the earlier burnt flint associated pits at Ebbsfleet, most of the pits at Ebbsfleet were probably later in date, and very little evidence for pits of this date was found along the A2 or HS1 (*ibid*, 118–24).

Although the scale of activity suggested by the small groups of pits at Ebbsfleet is consistent with the rather different pit deposits found elsewhere, the fact that the Ebbsfleet pits may have been associated with a specialised activity means that it is difficult to draw any wider conclusions from them about the character of Late Neolithic/Early Bronze Age patterns of settlement. Like the exploitation of flint at Springhead, it is possible that the features at Ebbsfleet were associated with brief trips to carry out specific activities.

Chapter 22

Middle Bronze Age to Iron Age

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Introduction

Middle Bronze Age to Iron Age activity in the Ebbsfleet Valley falls within Holocene Landscape Stage 4a as outlined in Chapter 16. This stage is marked by the onset of marine incursion into the Lower Valley, which eventually caused the cessation of peat formation and the accumulation of a thick unit of clay silts. Towards the top of the peat profiles, there is evidence locally for an increase in marsh/sedge fen environments with abundant ferns, indicating increased wetness in the valley bottom. The actual change to minerogenic sedimentation is dated in the Outer Basin to the latter part of the Early Bronze Age in Borehole 7 at 3527±30 BP (NZA-28973, 1940–1750 cal BC), and in the Inner Basin in Trench 9 to the Late Bronze Age or Early Iron Age at 2605±35 BP (SUERC-16660, 840–590 cal BC). Analysis indicates the development of a tidal river with mudflats and fringing saltmarsh, fen and reedswamp environments. Further up the valley, towards the springs, the river remained freshwater and here the environment appears to have been quite open with areas of grazed grassland and probably some arable.

Evidence of activity dating to the Middle Bronze Age away from the valley bottom includes two intersecting ring-ditches, possibly representing barrows, and associated burnt mound deposits at the springs in the Upper Valley (ARC SPH00; Zone 11). Two further ring-ditches and a small number of cremation burials were also identified on the Chalk Spur promontory in the Lower Valley, beneath the remains of the Roman villa complex (ARC EBB01; Zone 7). In the valley bottom (ARC ESG00; ARC 342W02; Zones 8 and 9) contemporary activity is represented by a number of wooden structures, a wattle panel of intertwined hazel branches and concentrations of cut roundwood laid on the surface of the peat that appear to follow the line of the wetland edge, perhaps representing a prehistoric routeway linking areas of drier ground (Fig 16.6c). One structure, however, was more substantial and comprised a double row of very large oak timber piles driven into alluvial clay. The size of the piles suggests they could have supported a walkway, perhaps even a bridge traversing an ancient water course (Fig 22.1, Table 22.1).

Evidence for activity dating to the Late Bronze and Iron Age periods is sparser although potsherds and worked flint attest to occasional visits. In the Upper Valley a possible boundary ditch at the Ebbsfleet River Crossing (ARC ERC01; Zone 11) contained deposits of burnt flint. On the Lower Valley floodplain excavations for STDR4 (Area 1, STDR401; Zone 8) recorded a series of small Late Bronze Age wooden structures, possibly revetting the edge of a channel (Fig 22.2, Table 22.2). Possible fragments of briquetage and other artefactual material of Iron Age date were also found on a cobbled surface in Area 1, buried by estuarine silts, and may suggest salt production was carried out nearby. A cetacean vertebrate from a dolphin or porpoise and two cormorant bones emphasise the maritime influence on the Ebbsfleet Valley during this period (see Strid, Appendix R). One or more Iron Age stake-built structures was also recorded in Zone 8 during the watching brief for HS1 (ARC 342W02).

Table 22.1 Radiocarbon dates associated with Middle Bronze Age activity in the Upper Valley (ARC SPH00), the Lower Valley Slopes (ARC EBB01) and the Floodplain (ARC 342W02)

Event code	Feature/ layer type	Context	Sample	Material dated, identification	Lab code	δ^{13}C ‰	Result BP	Calibrated date (2 sigma, 94.5%)
ARC SPH00	Hearth/ boiling pit 300007/6238	6239	8561	Pomoideae charcoal	NZA-28790	-26.8	3082±35	1430–1260 cal BC
ARC SPH00	Burnt mound 300003	5103	8328	2 year roundwood charcoal	NZA-28804	-25.2	2969±35	1310–1050 cal BC
ARC EBB01	Cremation burial 15030	15039 (15028)	11144	Cremated bone	NZA-28209	-23.1	3096±30	1440–1290 cal BC
ARC EBB01	Cremation burial	15086	11153	Cremated bone	NZA-28208	-22.0	3113±30	1450–1300 cal BC
ARC EBB01	Cremation burial 20716	20715	21163	Cremated bone	NZA-28207	-22.8	3020±30	1390–1130 cal BC
ARC EBB01	Cremation burial 20716	20715	21163	*Corylus avellana* charcoal	NZA-28247	-27.2	3040±30	1410–1210 cal BC
ARC 342W02	Oak piled structure	246	–	*Quercus* sp. waterlogged wooden pile tip, mature outer rings	NZA-28703	-25.9	3055±30	1410–1220 cal BC
ARC 342W02	Trackway 100073	100073	108012	*Corylus avellana*, waterlogged roundwood	NZA-28704	-25.8	2994±30	1380–1120 cal BC
ARC 342W02	Trackway 100000	100000	108000	*Corylus avellana*, waterlogged roundwood	NZA-28706	-25.4	2962±35	1310–1050 cal BC
ARC 342W02	Trackway 100070	100070	108011	*Quercus* sp. waterlogged roundwood, *c* 10 years	NZA-28705	-24.8	2939±30	1270–1040 cal BC

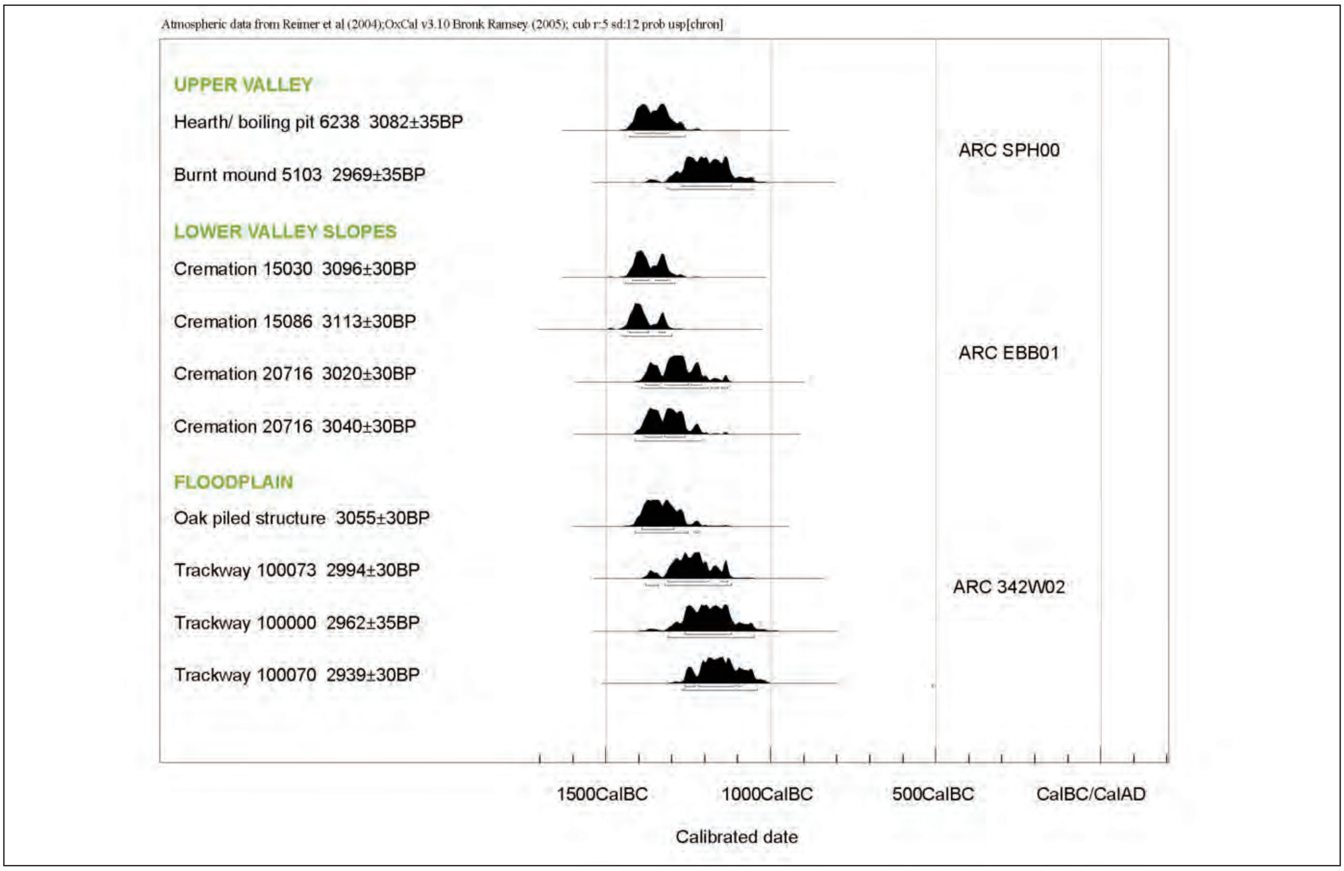

Figure 22.1 Plot of calibrated radiocarbon date ranges associated with Middle Bronze Age activity in the Upper Valley (ARC SPH00), the Lower Valley Slopes (ARC EBB01) and the Floodplain (ARC 342W02)

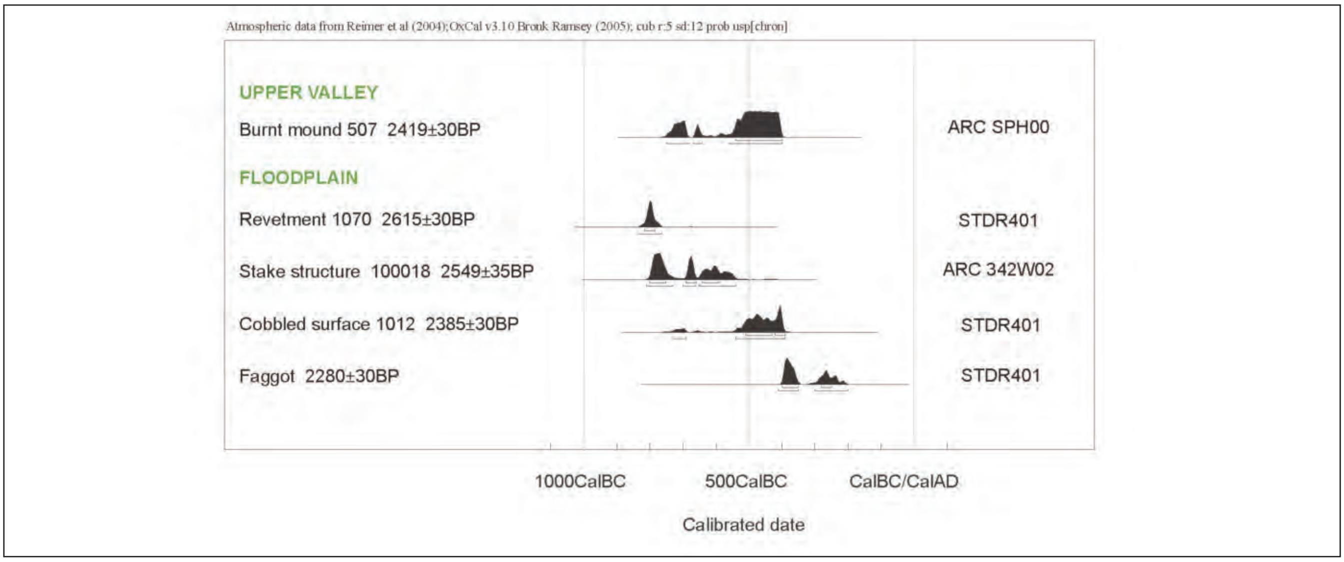

Figure 22.2 Plot of calibrated radiocarbon date ranges associated with Late Bronze Age and Iron Age activity in the Upper Valley (ARC SPH00) and the Floodplain (STDR401 and ARC 342W02)

Table 22.2 Radiocarbon dates associated with Late Bronze Age and Iron Age activity in the Upper Valley (ARC SPH00) and the Floodplain (STDR401 and ARC 342W02)

Event code	Feature/ layer type	Context	Sample	Material dated, identification	Lab code	$\delta^{13}C$ ‰	Result BP	Cal date BC (2 sigma, 94.5%)
ARC ERC01	Burnt mound	507	141	*Acer campestre* roundwood charcoal	NZA- 28619	-27.5	2419±30	750–400 cal BC
STDR401 Area 1	Staked revetment structure 1070	1071		Roundwood (cf. *Frangula alnus*)	SUERC-19949	-26.4	2615±30	835–765 cal BC
ARC 342W02	Stake structure 100018	100007	108003	*Betula* sp. waterlogged roundwood	NZA- 28718	-28.2	2549±35	810–540 cal BC
STDR401 Area 1	Cobbled surface	1012		Cattle femur	SUERC-19947	-21.8	2385±30	730–390 cal BC
STDR401 Area 1	Faggot	1062		Roundwood (*Corylus avellana*)	SUERC-19948	-25.5	2280±30	410–200 cal BC

Middle Bronze Age (*c* 1500–1100 BC)

Springhead (Zone 11)

Two intersecting ring-ditches, possibly representing the remains of barrows, were found at the head of the valley, immediately adjacent to the former springs (ARC SPH00) (Figs 15.1, 22.3 and 22.4). The earliest of these (Group 300001) lay almost entirely within the excavated area, while the majority of the later ditch (Group 300002) extended beyond the limit of excavation to the south-west.

The earlier ring-ditch (Group 300001) had a diameter of *c* 18m, although only just less than half of the ditch survived, the north-western part having been eroded away by the Roman spring line. The possible remains of a central, urned cremation burial survived (6615, Fig 22.3), although this had been substantially truncated by a later Roman road which had been cut through the area down to the water's edge. The feature comprised a shallow ovoid pit (0.45 x 0.30m and 0.10m deep) cut into sandy gravel. The fill (context 6614) consisted of yellowish-brown grey ashy silt. There were some tiny flecks of probable burnt bone and charcoal in the fill but they were too small to be identified or dated. A large pot had been placed in the centre of the pit although it was poorly preserved and only fragments of the base survived. The pot was identified as a Deverel-Rimbury Bucket Urn, marked by a single cereal grain impression (identified as barley (*Hordeum*): C Stevens pers comm; Barclay and Seager Smith, Appendix H). Insufficient of the second later ring-ditch (300002) survived to calculate its diameter, but the ditch was of similar width and depth to the earlier example

The possible source of large amounts of burnt flint within the ring-ditch fills was identified as a large sub-circular hearth and adjacent pit (Group 300007, Fig 22.3). The hearth (6258) comprised a substantial area of burning where the natural silty sand had been scorched reddish-orange and black and the surface was scattered with a substantial quantity of burnt flint. Pit 6238 comprised a very regularly cut rectangular feature 1.20m long, 0.83m wide and 0.42m deep, immediately adjacent to the hearth. The fill (context 6239)

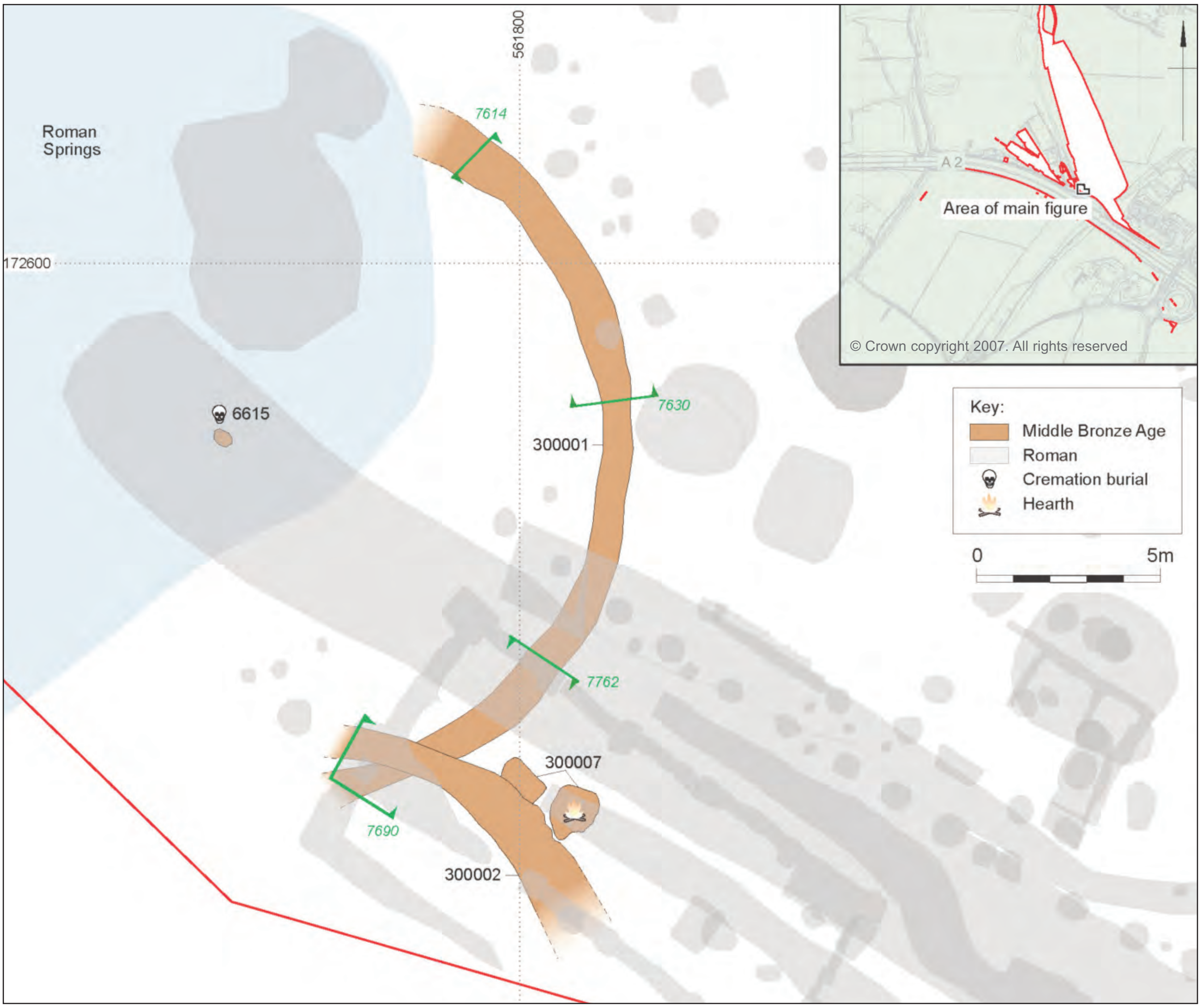

Figure 22.3 Plan of prehistoric features, Springhead (ARC SPH00)

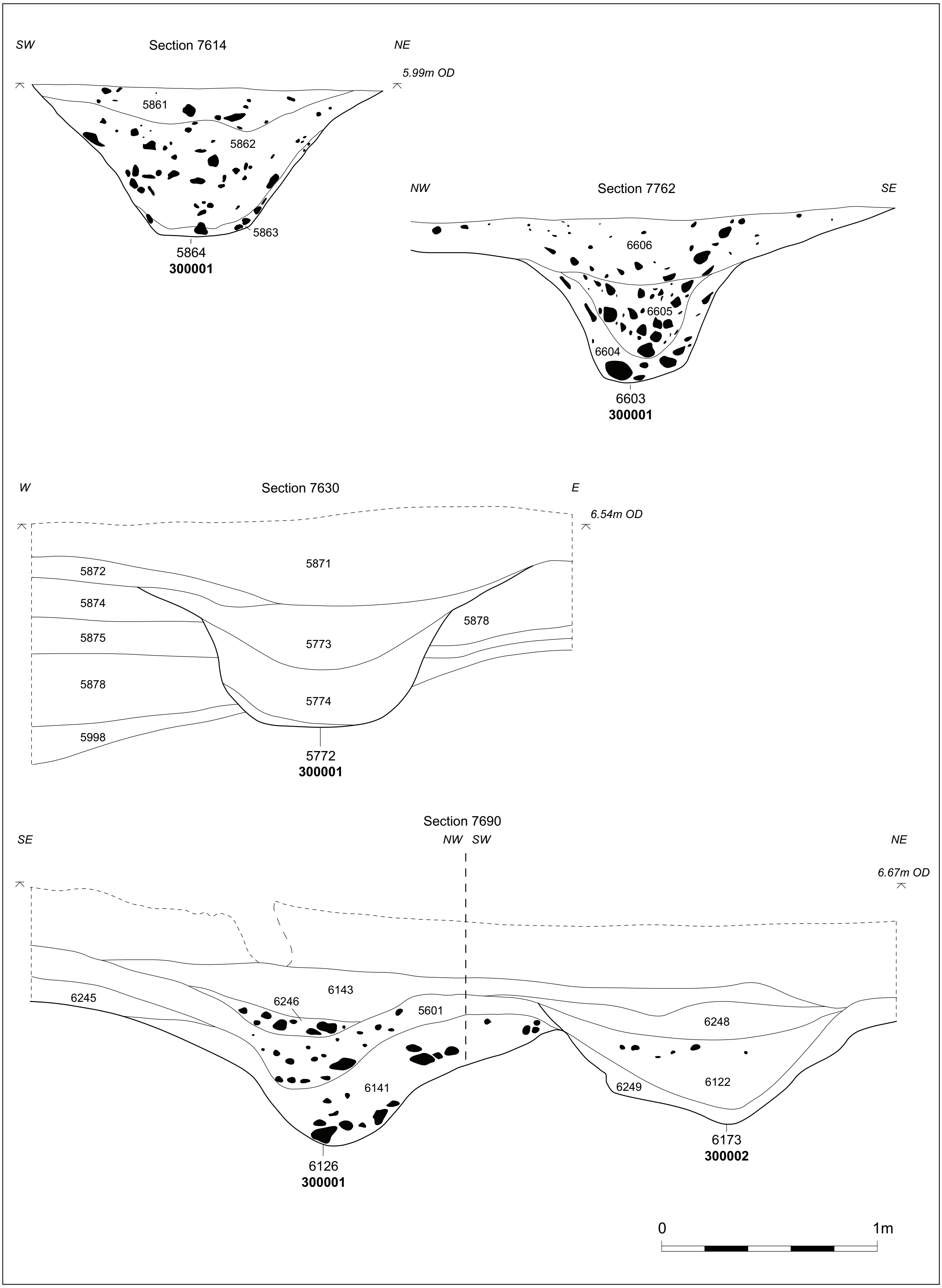

Figure 22.4 Sections of ring-ditches 300001 and 300002, Springhead (ARC SPH00)

comprised a greyish-black silty sand with numerous large burnt flint nodules which led to the suggestion the feature may have been used to boil water. Charcoal of pomaceous fruit wood from pit fill 6239 was radiocarbon dated to the Middle Bronze Age at 3082±35 BP (NZA-28790, 1430-1260 cal BC, Fig 22.1; Table 22.1). Associated with the hearth and pit were spreads of burnt flint, the remains of what appeared to be one or more burnt mounds that had in places slumped into the fill of the later ring-ditch (Subgroup 300008, contexts 5601, 5602, 6139, 6142 and 6427, Subgroup 300003, contexts 5103, 5550 and 5552). Micromorphological analysis from Section 7486/7 (context 5103, Figs 15.8 and 15.9; Macphail and Crowther, Appendix T) revealed that the burnt mound and associated anthropogenic materials (eg, burnt flint, charcoal, ash, burnt pottery and one example of leached bone) was probably not a single event, and the spreads more likely record a series of middening events contemporary with and occurring alongside continuing arable activity and the deposition of colluvium. This complex of features lay immediately outside both ring-ditches, and the evidence indicates that the 'boiling' activity must have commenced very shortly after the later ring-ditch was dug. Sherds of Deverel-Rimbury pottery were retrieved from context 5601. These include four refitting sherds, broken above the base angle, which derive from a large Bucket Urn. A second worn sherd from this layer has the remains of an applied lug or cordon (Barclay and Seager Smith, Appendix H). Roundwood charcoal from context 5103 produced a radiocarbon date of 2969±35 BP (NZA-28804, 1310–1050 cal BC, Fig 22.1; Table 22.1). The burnt mound deposits were sealed by colluvial deposits except where cut through during the construction of a Roman road, and here the burnt flint had been utilised as part of the surface of the later road.

Artefact material associated with the features at Springhead included a substantial assemblage of Middle Bronze Age flintwork (Anderson-Whymark, Appendix I). The majority of this (*c* 1000 fragments) was recovered from the fills of the earlier ring-ditch (Group 300001). Smaller assemblages were recovered from the later ring-ditch (Group 300002), burnt mound deposits and the overlying colluvium. The assemblage from the earlier ring-ditch was in very fresh condition and a refitting exercise demonstrated the presence of knapping refits. Technological attribute analysis was undertaken on 200 complete flakes from the largest assemblage from a single context (5773; see below).

No charred plant remains were recovered from samples of the Middle Bronze Age deposits at Springhead. However, the charcoal assemblage from 'boiling pit' 6238 produced a range of species. Mature oak (*Quercus*) was dominant (78% of the assemblage) with lesser quantities of field maple (*Acer campestre*), hazel (*Corylus avellana*), ash (*Fraxinus excelsior*), pomaceous fruit wood and elm (*Ulmus* sp.). It appears that oak was specifically targeted for fuel in this feature, perhaps to enable a hot sustained burn (Barnett, Appendix Q).

Worked Flint from the Ring-ditches at Springhead (ARC SPH00)

by Hugo Anderson-Whymark

A substantial assemblage of Middle Bronze Age flintwork was recovered from contemporary contexts in the Springhead Roman Town excavations (ARC SPH00). The majority of this assemblage, *c* 1000 pieces, was recovered from the fills of ring-ditch 300001 (Table 22.3). Smaller flint assemblages were recovered from a second ring-ditch 300002, burnt mound deposits (300003, 300007 and 300008) and overlying Middle Bronze Age and later colluvium (300009); the latter contexts also contain redeposited earlier flintwork (Table 22.4).

The flint assemblage from ring-ditch 300001 is in very fresh condition and a refitting exercise demonstrated the presence of knapping refits, although it was not possible refit significant sequences. This flintwork provided a good opportunity to characterise a well stratified and dated *in situ* Middle Bronze Age assemblage. A technological attribute analysis was therefore undertaken on 200 complete flakes from the largest assemblage from a single context, 5773. The results of these analyses are presented in Table 22.5.

Raw materials

The only raw material exploited for flint knapping in the Middle Bronze Age was the locally available gravel flint. It appears that this material was knapped with little regard for careful selection as nodules of varying size and quality were present in the same context. The size of the nodules worked appears to vary between small fist-sized pieces and the more substantial nodules exploited in earlier periods. The high frequency of thermal flaws in the raw materials is particularly notable. The use of flawed raw materials resulted in numerous irregular removals and pieces of irregular waste and reflects an *ad hoc* reduction strategy orientated towards short sequences of opportunistic flake removal.

Debitage

The debitage from context 5773 includes a high proportion of cortical and partly cortical flakes, amounting to 85.5% of the flake assemblage (Table 22.5). Preparation flakes form 20.5% of the assemblage suggesting the primary stages of reduction occurred at this location. This is also reflected by the presence of several tested nodules abandoned after a few flake removals.

The debitage from the Middle Bronze Age industry results from a simple reduction strategy. Flakes were generally struck from a plain or cortical platform using a hard-hammer percussor, without preparation of the platform edge (Table 22.5). Short sequences of flakes were removed until a knapping error or thermal fracture hindered further removals; platforms have not been rejuvenated. The assemblage contains roughly equal proportions of single and multi-platform flake cores indicating cores are either abandoned at this point or

Table 22.3 The flint assemblage from ring-ditches 300001 and 300002 and possible bank 300004 (ARC SPH00)

Group	300001									300002	300004		
Context	**5644**	**5773**	**5774**	**5775**	**5861**	**5863**	**6123**	**6141**	**6605**	**6122**	**5872**	**5873**	**Total**
Flake	69	285	285 (2)	47 (1)	23 (1)	6	7	36	81	11	15 (2)	30	895 (6)
Blade	1	1	1	1	1	–	1	–	1	–	–	(1)	7 (1)
Bladelet	–	1	1	–	–	–	2	–	1	–	–	1	6
Blade-like	–	7	1 (1)	1	2	–	–	–	1	–	–	–	12 (1)
Irregular waste	2	23	9	–	–	–	–	–	1	–	–	3	38
Sieved chips 10–4mm	–	–	–	–	–	–	41	–	–	–	–	–	41
Rejuvenation flake core face/edge	–	–	–	–	1	–	–	–	–	–	–	–	1
Rejuvenation flake other	–	–	–	–	–	–	–	(1)	–	–	–	–	(1)
Tested nodule/bashed lump	1	5	6	1	–	–		–	3	–	–	2	18
Single platform flake core	–	10	5	–	–	–		–	–	–	–	–	15
Multiplatform flake core	–	13	3	–	–	–	–	–	1	–	–	–	17
Unclassifiable/fragmentary core	1	1	–	–	–	–	–	–	–	–	–	1	3
Core on a flake	–	1	–	–	–	–	–	–	–	–	–	–	1
End scraper	–	5	2	–	1	–	–	–	1	–	–	–	9
Side scraper	1	1	–	1	1	–	–	–	–	–	–	–	4
End and side scraper	1	–	–	–	–	–	–	1	–	–	–	–	2
Scraper on a non-flake blank	1	–	–	–	–	–	–	–	–	–	–	–	1
Other scraper (denticulated)	–	–	1	–	–	–	–	–	–	–	–	–	1
Piercer	–	–	–	–	–	–	–	1	–	–	–	–	1
Notch	–	–	2	–	–	–	–	–	–	–	–	–	2
Backed knife	1	–	–	–	–	–	–	–	1	–	–	–	2
Other knife	–	–	1	–	–	–	–	–	–	–	–	–	1
Retouched flake	–	–	–	–	–	–	–	1	1	–	–	–	2
Other heavy implement (waisted tool)	–	–	–	1	–	–	–	–	–	–	–	–	1
Miscellaneous retouch	–	–	1	–	–	–	–	–	–	–	–	–	1
Hammerstone	–	1	–	2	–	–	–	–	–	–	–	–	3
Total	78	354	319 (3)	54 (1)	29 (1)	6	51	39 (1)	92	11	15 (2)	37 (1)	1093 (9)
No. Burnt worked flints (%)*	–	3 (0.8)	2 (0.6)	–	–	–	–	–	–	–	1 (5.9)	–	6 (0.6)
No. Broken worked flints (%)*	10 (12.8)	65 (18.4)	29 (9)	4 (7.3)	4 (13.3)	2 (33.3)	3 (30)	3 (7.5)	9 (9.8)	–	2 (11.8)	5 (13.2)	136 (12.9)
No. Retouched flints (%)*	4 (5.1)	6 (1.7)	7 (2.2)	2 (3.6)	2 (6.7)	–	v	3 (7.5)	3 (3.3)	–			27 (2.6)

KEY: * percentage excludes chips. Late Glacial flints in brackets

Table 22.4 Flint assemblages from Middle Bronze Age burnt mounds and associated features (ARC SPH00)

Group	**300003**	**300007**	**300008**					**300009**							
Context	**5103**	**6239**	**5601**	**5602**	**6139**	**6142**	**6427**	**5600**	**5641**	**5642**	**5643**	**5871**	**6101**	**6143**	**Total**
Flake	14	–	32	57	60	8	8	27	6	81	23	135 (5)	4	5	**460 (5)**
Blade	–	–	1	2	3	1	–	–	–	3	1	3 (1)			**13 (1)**
Bladelet	–	–	–	–	–	–	–	–	–	1	1				**2**
Blade-like	–	–	–	3	2	–	–	1	–	1	1	4	1		**13**
Irregular waste	–	–	–	1	–	–	–	1	–	5	2	8			**17**
Sieved chips 10–4mm	–	–	97	10	–	–	–	–	–	–	–		19		**126**
Tested nodule/bashed lump	–	–	–	1	1	–	1	–	–	1	–				**4**
Single platform flake core	–	–	–	–	–	–	–	–	–	2	–				**2**
Multiplatform flake core	–	–	–	–	1	–	–	1	–	–	–				**2**
Levallois/ other discoidal flake core	–	–	–	–	–	–	–	–	–	–	1				**1**
End scraper	–	1	–	–	–	–	1	–	–	1	–				**3**
Side scraper	–	–	–	–	–	–	–	–	–	1	–				**1**
Scraper on a non-flake blank	–	–	–	–	–	–	–	–	–	–	1			1	**2**
Piercer	–	–	–	–	–	–	–	–	–	–	1				**1**
Notch	–	–	–	–	1	–	–	–	–	–	–				**1**
Hammerstone	–	–	–	–	–	–	–	–	–	–	–	1			**1**
Total	**14**	**1**	**130**	**74**	**68**	**9**	**10**	**30**	**6**	**96**	**31**	**150 (6)**	**24**	**6**	**649 (6)**
No. Burnt worked flints (%)*	–	–	–	–	1 (1.5)	–	–	–	–	2 (2.1)	–	2 (1.3)			**5 (0.8)**
No. Broken worked flints (%)*	1	–	4 (3.1)	9 (12.2)	5 (7.4)	–	1	7	3	18 (18.8)	5	35 (22.4)	3		**91 (13.9)**
No. Retouched flints (%)*	–	1	–	–	1 (1.5)	–	1	–	–	2 (2.1)	2	1 (0.6)		1	**9 (1.4)**

KEY: * percentage excludes chips. Late Glacial flints in brackets

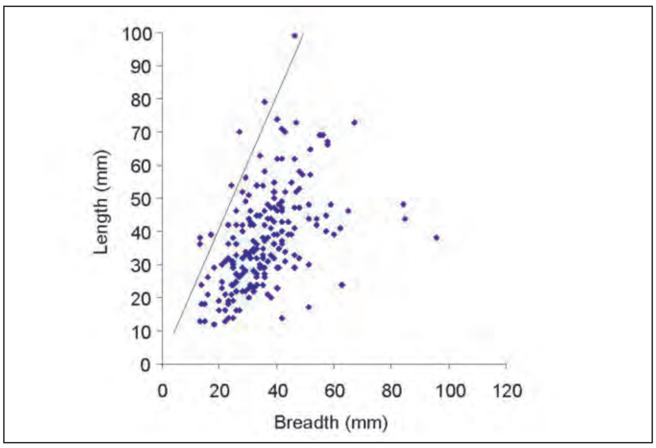

Figure 22.5 Length to breadth scatter diagrams for unretouched flint flakes from Middle Bronze Age context 5773 (ARC SPH00)

rotated to exploit the surface of a flake removal as a platform. The cores were aimed at the production of broad thick flakes averaging 38mm long by 36mm wide and 12mm thick (Fig 22.5). There is no evidence for intentional blade production as blades represent only 3.5% of the flake assemblage in context 5773 and none of the flakes examined exhibited blade scars on their dorsal surface to suggest repeated blade removal.

It is notable that comparatively few Middle Bronze Age flints are burnt. In ring-ditch 300001 only five flints or 0.5% of the assemblage was burnt, whilst only a single worked flint from the burnt flint mounds was burnt. This indicates that the activities around the barrow and activities involving worked flint among the burnt mounds, occurred away from fires.

Table 22.5 Technological attributes of Middle Bronze Age flint from ring-ditch 300001, context 5773 (ARC SPH00)

Termination type				
Hinge	Step	Plunging	Feather	Other
33 (16.5%)	13 (6.5%)	40 (20%)	98 (49%)	18 (9%)

Butt type						
Cortical	Plain	>1 Removal	Facetted	Linear	Punctiform	Other
36 (18%)	133 (66.5%)	16 (8%)	0	0	7 (3.5%)	8 (4%)

Dorsal extent of cortex					
0	1–25%	26–50%	51–75%	76–99%	100%
29 (14.5%)	67 (33.5%)	33 (16.5%)	28 (14%)	32 (16%)	11 (5.5%)

Flake type					
Preparation	Side trim.	Distal trim.	Misc. trim.	Non-cortical	Rejuvenation
41 (20.5%)	51 (25.5%)	41 (20.5%)	37 (18.5%)	29 (14.5%)	1 (0.5%)

Proportion of blades, presence of platform-edge abrasion and dorsal blade scars		
% flakes >2:1 L:B ratio	% flakes with platform edge abrasion	% flakes with dorsal blade scars
3.5%	2%	0%

Hammer mode		
Hard	Soft	Indeterminate
134 (67%)	2 (1%)	64 (32%)

Retouch

The retouched assemblage from ring-ditch 300001 amounts to 27 tools, representing 2.7% of the total assemblage (excluding chips), and is composed of a limited range of artefacts. Scrapers are the most common tool type with 17 present in the assemblage (Table 22.3). End scrapers with semi-abrupt to abrupt distal retouch were most frequent (Fig 22.6, 1), although side scrapers, end and side scrapers and a scraper on a thermal blank were also represented. A denticulated side and end scraper was present in context 5774 (Fig 22.6, 2). Three knives, two notched flakes, a piercer and two edge-retouched flakes were also recovered. A lightly corticated flake exhibited irregular bifacial retouch (miscellaneous retouch); the intended product is unclear and it is possible this flint represents a residual Neolithic tool.

An unusual waisted tool was recovered from context 5775 (Fig 22.6, 4). The tool is relatively irregular, but exhibits two heavily retouched opposed notches presumably to facilitate hafting. The ends of the implement are not well flaked and no edge-damage was noted. A similar artefact was recovered as a residual find in context 2910 (Fig 22.6, 5). In this case, two large notches have been retouched to form a waist on a relatively irregular thermally fractured piece of flint. The broadest end of the artefact from 5775 has been modified by a few flake removals and exhibits smaller scars, perhaps resulting from use. The broader end of the example from 2910 also exhibits a few flake scars from use or retouch, but also exhibits a series of small flake scars on the opposite, narrower, chisel-like end.

The retouched assemblage from the burnt mounds (300003, 300007 and 300008) is even more limited with only two end scrapers and a notch represented (1.5% of the assemblage, excluding chips). It is, however, notable that the flint assemblage from the burnt flint mounds is dominated by unretouched flakes, with few cores or tools. This may indicate that unretouched flakes were being used for the activities associated with the burnt flint mounds, rather than formally retouched tools.

In the assemblage of residual artefacts from ARC SPH00 and ARC SHN02 several coarse-toothed denticulates have been identified (for example, Fig 22.6, 3). These tools are most characteristic of the Middle and later Bronze Age, but they are not unknown in Neolithic assemblages. It is probable that further Middle Bronze Age artefacts are present among the residual assemblage, but in the absence of chronologically distinct retouched tools, it is not possible to distinguish these.

Catalogue of illustrated flint

(Fig 22.6)

1. End scraper (context 5774, ARC SPH00)
2. Denticulated end and side scraper (context 5774, ARC SPH00)
3. Denticulated end and side scraper (context 5774, ARC SPH00)
4. Waisted tool. The blank for this tool was a thermally fractured piece of irregular waste. Two notches have been retouched into the sides of the flint. The wide blade end has been shaped by the removal of a few flakes and exhibits some damage, perhaps from use (context 5775, ARC SPH00)
5. Waisted tool. Two regular notched have been retouched into the side of this flint. The wider end exhibits some small flake scars, possibly adjusting the form or resulting from use. The narrow chisel-like end exhibits a series of small flake scars (context 2910, ARC SPH00)

Lower Valley Slopes (Zones 1–7)

Two ring-ditches (15059 and 15859) were also identified in the Lower Ebbsfleet Valley in the vicinity of the Northfleet Villa Complex (ARC EBB01); these features lay immediately adjacent to the Early Bronze Age pit group 16634 (Fig 21.11, Chap 21). Both features, however, were heavily truncated. Ring-ditch

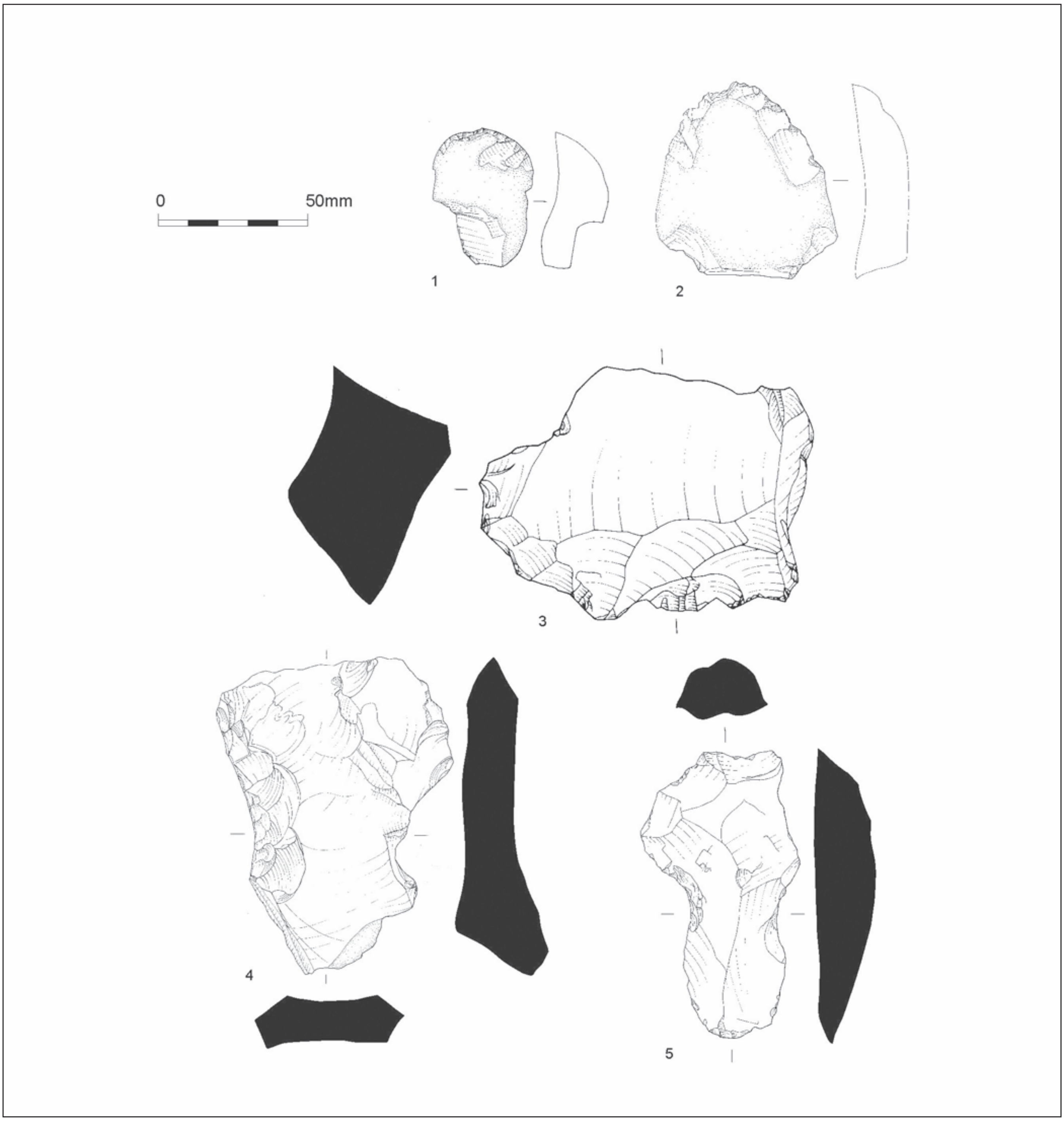

Figure 22.6 Middle Bronze Age worked flint from Springhead (ARC SPH00) (1–5) (see catalogue for details)

15059 measured *c* 5m in diameter, much smaller than those at Springhead (Fig 22.7). A spread of cremated bone (15086), located almost within the centre of the feature, was radiocarbon dated to the Middle Bronze Age at 3113±30 BP (NZA-28208, 1450–1300 cal BC, Fig 22.1; Table 22.1). The bone formed a *c* 0.01m deep, concentrated (*c* 0.18m^2) surface spread. It cannot be conclusively stated that the deposit was wholly *in situ* but the generally good condition of the bone together with its location suggests it probably had a protective covering of soil (?a mound) at some stage. Analysis revealed the bone to be of an adult (>35 years) and probably female with one rib fragment showing signs of osteophytes, a 'normal accompaniment of age' considered reflective of 'wear-and-tear' (McKinley, Appendix S). More than half of the ring-ditch 15859 lay beyond the edge of the excavation, although it was probably of a similar size to the other.

A number of shallow linear features identified in the vicinity of the ring-ditches, although undated, may be associated with this phase of activity. The upper fill of a gully (15017) immediately to the north-west of ring-ditch 15059 was cut by pit 15030 that contained an urned cremation burial (15028) dated to 3096±30 BP (NZA-28209, 1440–1290 cal BC, Figs 21.11, 22.1 and 22.7; Table 22.1). The burial had been substantially

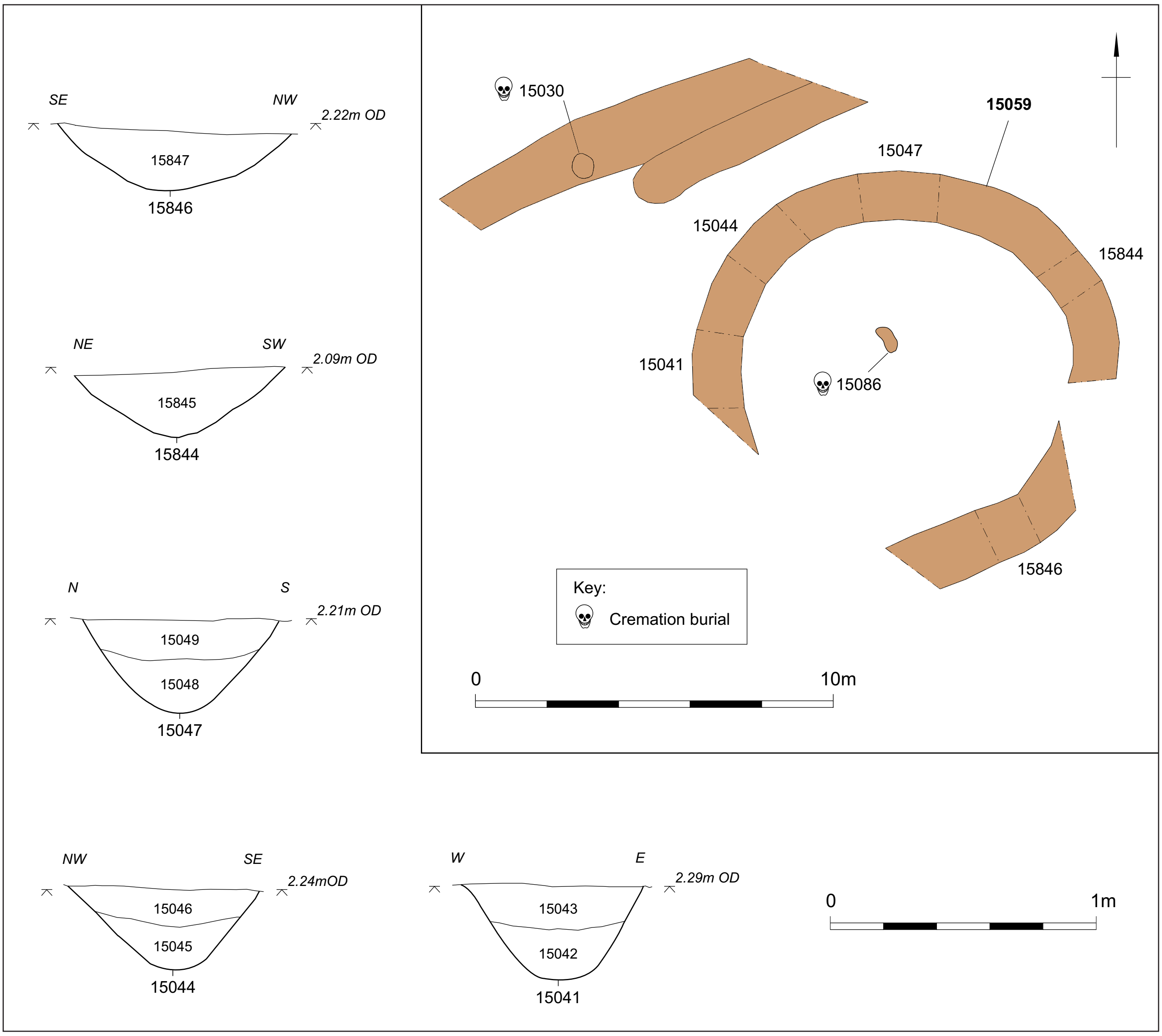

Figure 22.7 Sections, ring-ditch 15059 (ARC EBB01)

truncated leaving only a 0.08m depth of the vessel *in situ*. Analysis revealed the bone to be of an adult (>25 years) and probably female (McKinley, Appendix S). A very small assemblage of charcoal recovered with the cremated remains included elm (*Ulmus* sp.), oak (*Quercus*), willow/poplar (*Salix*/*Populus* sp.) and pomaceous fruit wood. The size of the assemblage and the rootiness of this fill preclude any discussion of the contemporary landscape or of pyre technology (Barnett, Appendix Q).

A shallow isolated pit (20716), 0.12m deep, containing a small amount of cremated human remains was also identified in the Sports Ground excavation to the west (Fig 21.15). The bone appears to represent redeposited pyre debris and was spread throughout the charcoal-rich fill. It is possible that some bone in the upper levels of the deposit may have been lost from this relatively large diameter feature (0.42m) if it was subject to truncation, but in view of the small amount of bone recovered overall and the apparent nature of the deposit, it is unlikely to have been much. Two radiocarbon dates (Fig 22.1; Table 22.1) were obtained on material from the feature (20715); the first, from cremated bone at 3020±30 BP (NZA-28207, 1390–1130 cal BC) and the second from hazel (*Corylus avellana*) charcoal at 3040±30 BP (NZA-28247, 1410–1210 cal BC). Analysis revealed the bone to be of an infant (>5yrs), although it appeared slightly abraded and includes very little trabecular bone, which is subject to preferential destruction in an aggressive burial environment (McKinley, Appendix S). The charcoal recovered from fill 20715 was heavily dominated by oak (>90%); a common feature of pyres, with oak chosen to achieve the high and enduring temperatures required to consume a body. These high temperatures are attested to by the common occurrence of vitrified pieces in this assemblage, which indicate in excess of 800°C (Barnett, Appendix Q).

A total of 110 sherds of flint-tempered pottery were recovered from 12 separate contexts from the

Figure 22.8 Plans of Middle Bronze Age trackway structures (ARC ESG00 and ARC 342W02)

excavations in the Lower Valley (ARC EBB01). Much of this was residual material found in later features. With the exception of a possible rim fragment and two base fragments, the assemblage was made up of plain body sherds. In the absence of diagnostic sherds, it is only possible to assign a broad Middle to Late Bronze Age date to most of this material. A single sherd from the fill of a natural hollow in the Sports Ground excavation (context 20731) could derive from a Bucket Urn on the basis of wall-thickness and fabric (Barclay and Seager Smith, Appendix H).

The Floodplain (Zones 8 and 9)

In the floodplain area of the Lower Valley contemporary activity is represented by a number of wooden structures recorded during two separate phases of fieldwork (ARC ESG00, ARC 342W02); a piece of hazel (*Corylus*) wattle work and concentrations of cut hazel, alder (*Alnus*), birch (*Betula*) and young oak (*Quercus*) roundwood, laid on the surface of the peat. These structures appear to follow the line of the wetland edge, perhaps representing a route linking areas of drier ground (see Figs 16.6c and 22.8).

Structure 100073

Structure 100073, recorded during the watching brief (ARC 342W02), comprised a possible section of trackway made of hazel rods. This rough spread of rather evenly sized small roundwood stems was not woven together or clearly retained by stakes (Fig 22.8a). However, in the field it still gave the impression of being humanly-made; the simplest form of wooden trackway in which cut roundwood was dumped along the line of the intended route. The rods were rather straight and free of side branches and between 12mm and 25mm diameter. A sub-sample of the roundwood has been identified as hazel (Barnett and Druce, Appendix P) and it seems very likely that this material was of coppiced origin. Worked ends were found to have been neatly cross cut with two, shallow, smooth facets almost certainly cut with a metal bladed axe (Fig 22.9). A young hazel rod from this structure has been radiocarbon dated to the Middle Bronze Age at 2994±30 BP (NZA-28704, 1380–1120 cal BC, Fig 22.1; Table 22.1).

Broadly similar dumped roundwood tracks have been found over NW Europe as well as the East London wetlands, and in most cases the rods and branches are laid along the line of the trackway rather than across it (see Coles *et al* 1985, 69; Stafford *et al* 2012).

Structure 100070

Also recorded during the watching brief, *c* 11m to the east, was a more varied accumulation of roundwood and timber fragments (Str 100070, Fig 22.8b). The roundwood material here was much more mixed and branched rather than regular rods, and included alder, young oak and hazel (Barnett and Druce, Appendix P).

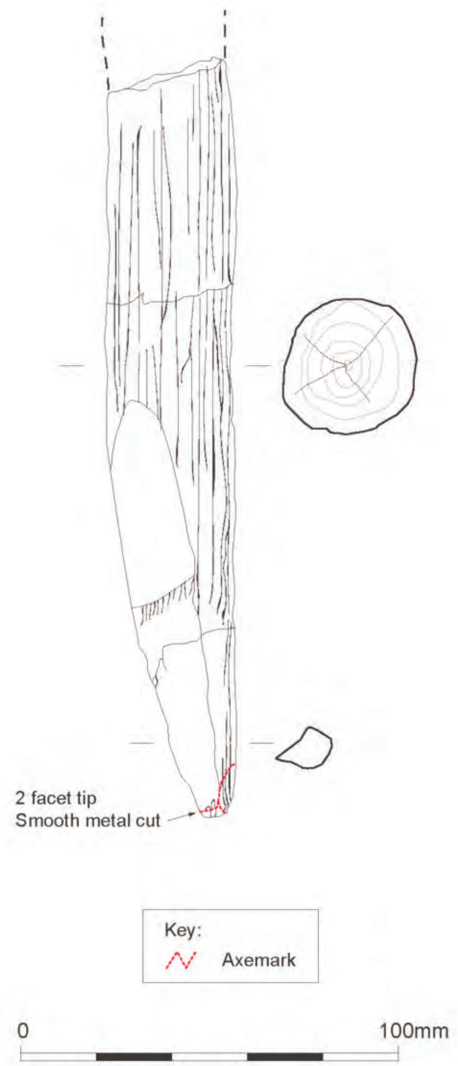

Figure 22.9 The largest cut roundwood end from hazel rod trackway 100073 (ARC 342W02)

Amongst the branches, fragments of cleft timber were also identified, together with some large flint nodules. On the south-east edge of the accumulation lay a deliberately cleft ⅛th log section of alder (*c* 100 x 50mm). This timber had clear rounded axe stop marks *c* 50mm wide on the lifted section. The irregular mixed nature of the material together with the kerb-like cleft beam on the south-east edge suggests that the feature may be rather more like the edge of a platform than a linear trackway, but the evidence is uncertain as the exposure was limited. The varied mix of woody materials appeared to be simply used as 'make up' to raise the upper surface of the platform, which probably decayed *in situ*. Broadly similar platforms of heterogeneous material are known across NW Europe from later prehistory, including the East London area (eg, Atlas Wharf on the Isle of Dogs and along the A13 Road, Stafford *et al* 2012). The large flint nodules are unusual finds in this context but could have been used as weights used to secure nets, traps or even coverings of temporary shelters. The very rounded narrow axe

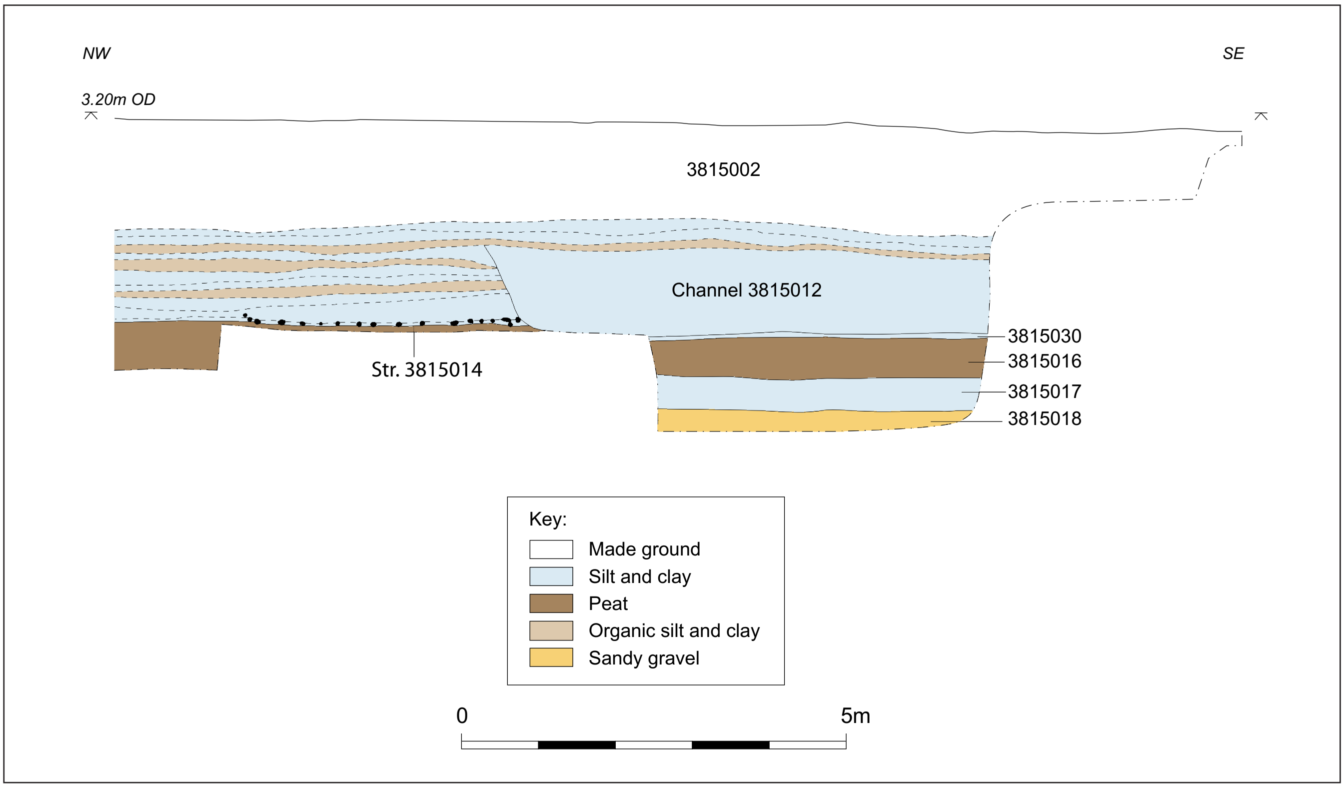

Figure 22.10 Section of 3815TT (ARC ESG00)

Plate 22.1 Excavation of wattle structure 3815014, 3815TT (ARC ESG00)

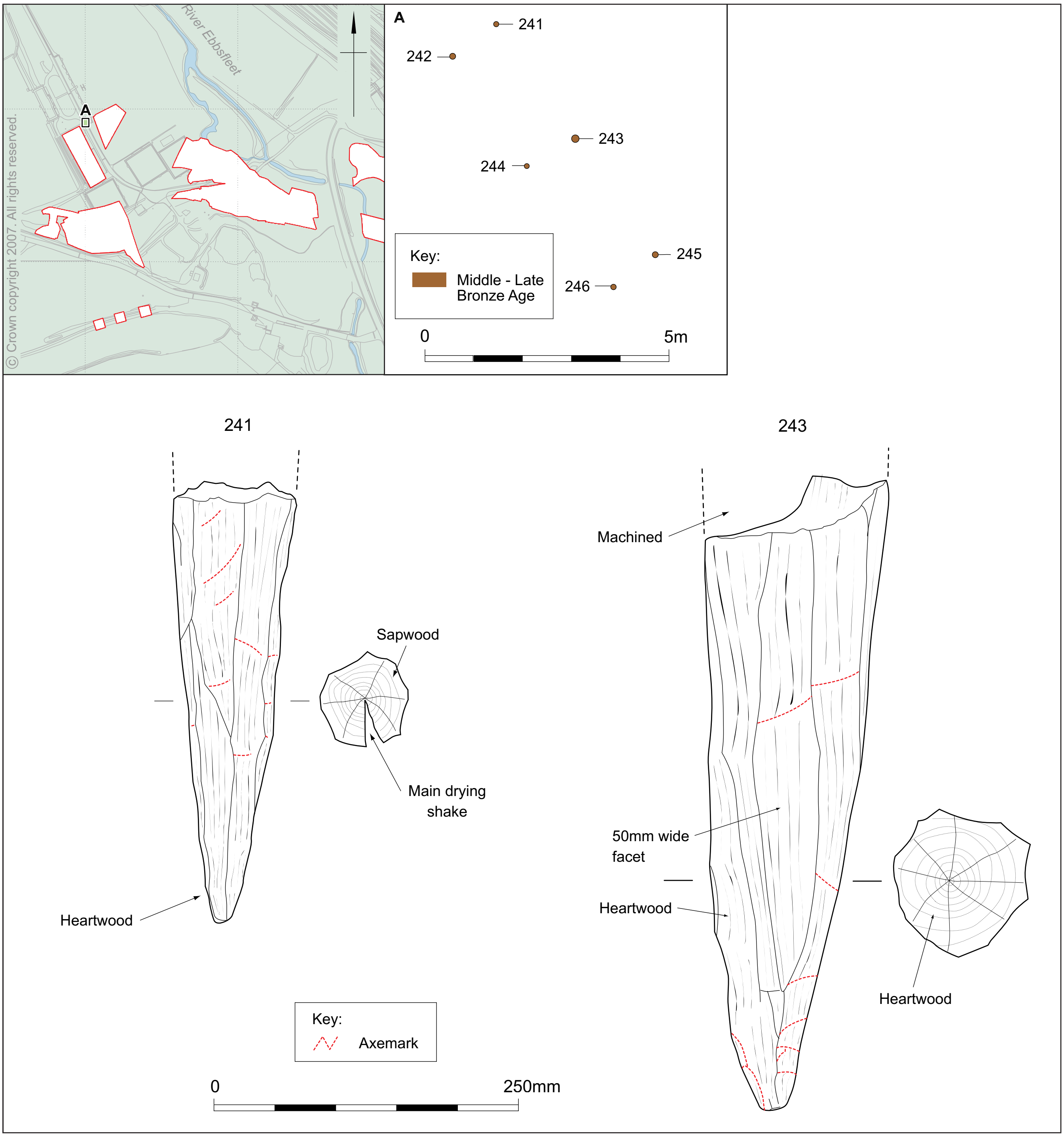

Figure 22.11 Middle Bronze Age double pile alignment (ARC342W02)

marks, 50mm wide, found on the cleft alder log section are typical of the Late Bronze Age (Goodburn 2003, 104). The radiocarbon date of 2939±30 BP (NZA-28705, 1270–1040 BC, Fig 22.1; Table 22.1) on a section of young oak roundwood is broad but tending towards the early part of the Late Bronze Age.

Structure 3815014

Approximately 15m to the east of Structure 1000070 an accumulation of worked wood was excavated during the evaluation phase (Str 3815014, 3815TT, ARC ESG00). This accumulation may have been part of some very disturbed wattle work laid horizontally, or may have collapsed from a vertical position. The former seems more likely, and Structure 3815014 is interpreted as fragments of a section of very disturbed weathered trackway (Figs 22.8c and 22.10; Pl 22.1). The remains of what may have been stakes can be identified in plan as five larger pieces of straight roundwood orientated approximately north–south, *c* 30–50mm in diameter, set *c* 200mm apart. The 'weavers' were more scattered being lighter, and lay at various orientations tending to the east–west, but the remains were far too displaced to provide evidence of the weave used. The use of various

Plate 22.2 Flint scatter 3020, Area 3 (STDR401)

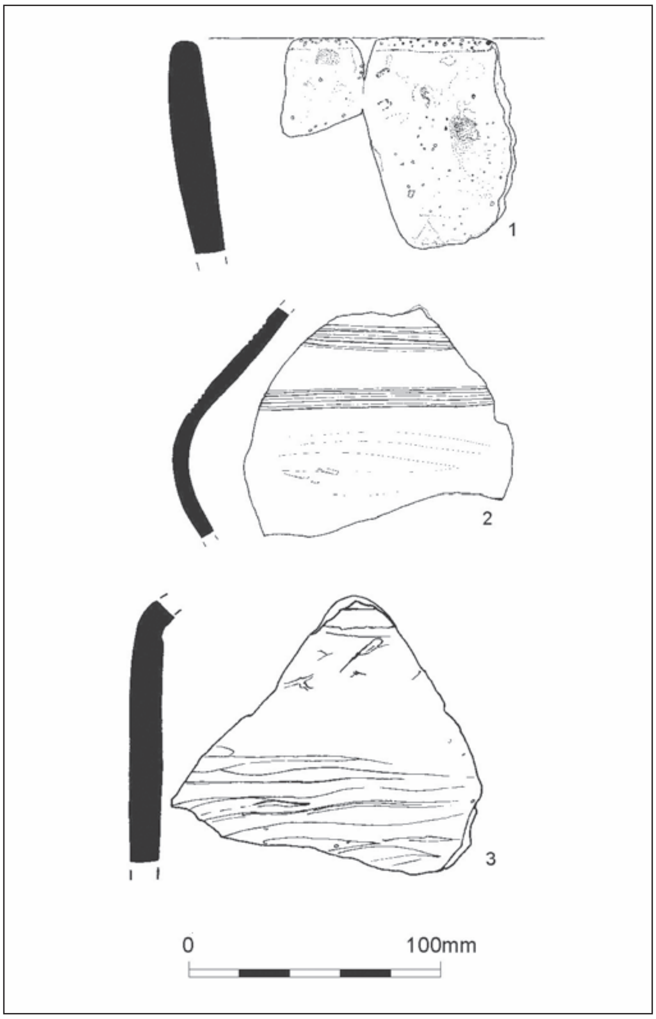

Figure 22.12 Middle to Late Bronze Age pottery from Areas 1 and 4 (STDR401) (1–3) (see catalogue for details)

forms of wattlework in trackways and platforms in NW European wetlands is widespread at all periods. A lightly made narrow wattle trackway with a distinctive weave using multiple uprights was excavated nearby at Erith and has been radiocarbon dated to the Middle Bronze Age (Bennell 1998, 25). None of the woodwork from Structure 3815034 was radiocarbon dated, but the peat below the roundwood gave a date range of *c* 1750–1500 cal BC (Barnett and Stafford, Appendix G).

Structure 100000

Structure 100000 lay *c* 60m the east of the structures described above (Fig 22.8d). It was made of small rods, almost all laid horizontally in an east–west orientation. The rods were *c* 10–30mm in diameter with no side branchlets, implying that they had been trimmed. The rods were again identified as hazel (Barnett and Druce, Appendix P) and closely resembled those used in Structure 100073. Similarly, the impression given was of material of coppiced origin. In the field, several chisel form cut ends were noted, created by cutting in one direction with a thin bladed metal axe. Functionally, it is not difficult to see this as a simple trackway. With such small rods, any tool marks are too small indicate the size and form of tool used, but a small hazel rod from the spread was radiocarbon dated to 2962±35 BP (NZA-28706, 1310–1050 cal BC, Fig 22.1; Table 22.1).

The double oak pile alignment

A double alignment of pile tips was exposed during the construction watching brief (ARC 342W02), *c* 40m to the north-west of Structure 100073, and constitutes the most substantial prehistoric timber structure found (Fig 22.11).

Five oak pile tips and one peaty void of a pile tip were recorded. The pile tip void (244) was almost a perfect cast of a 90mm diameter elongated pile tip replaced by dark grey organic clay silt set in the yellow clay matrix. In the top of the silt lay a small piece of fire cracked flint. Presumably that pile was removed vertically on the abandonment of the structure. The pile tips were clearly prehistoric, mainly due to the small rounded tool marks on the surfaces of the best preserved examples (Piles 241, 243 and 245). The mineralised condition also indicated great age.

Unfortunately, the piles were made from rather fast grown oak and no more than 40 tree-rings could be found – insufficient for attempting tree-ring dating. A radiocarbon date on the outer rings of Pile 246 provided a Middle Bronze Age date of 3055±30 BP (NZA-28703, 1410–1220 cal BC, Fig 22.1; Table 22.1). However, the axe facets at a maximum of 50mm wide, with clear very rounded stop marks of *c* 40mm width (on Pile 241), would be most consistent with Late Bronze Age axes rather than those of the Middle Bronze Age (Goodburn 2004, 131), certainly suggesting the later part of the calibrated range. Here, the assumption is that for heavy work, such as this, the largest axes owned by the working group were used, which seems to hold true for dated late prehistoric British assemblages examined in detail.

The exposure of the pile alignment was small, but a clear deliberate pattern in their driving was plain to see along a north-west–south-east line. The piles were set in pairs *c* 3m from each other, and each pile was *c* 1m apart within the pair. This spacing would seem to be very practical for a substantial foot bridge or jetty-type structure but would not have been wide enough for wheeled vehicles. Should the interpretation be correct the pairs of piles would have been linked with cross-pieces lapped around them with a decking laid on top. The piles varied in diameter from *c* 105mm to *c* 150mm, but must have been a little larger in diameter above the preserved elongated 'pencil points' which tapered over more than 0.55m. If the piles had a total length of *c* 3m and a maximum diameter of *c* 150mm then two or three adults could have man-handled them in a green condition. However, though they are not huge, even in soft ground they would need to be driven in with some kind of ram using a large weight. Experimental work (by Damian Goodburn) during the investigation of a Bronze Age pile alignment in London at Vauxhall demonstrated similar sized oak piles were successfully driven with a very simple ram. This comprised a simple pole tripod with an oak log ram and greased vegetable fibre rope in a sheaveless block. The number of adults required to operate this device was four to six. The ram would need repositioning in the shallow water, probably in the warmer months.

Pile tip 241: This pile tip was probably the best preserved example with the clearest axe stop marks on the 'pencil' type tip (Fig 22.11). The axe stop mark was *c* 40mm wide. It survived 0.36m long with a diameter of 105mm. The timber had about 30 annual rings and was thus unsuitable for tree-ring dating.

Pile tip 243: This oak pile tip was the largest in the lifted group with a length of 0.52m and a diameter of 150mm (Fig 22.11). It had a fairly regular 'pencil' point with deeply concave facets. The widest of the facets was *c* 50mm wide. The timber was fast grown and had *c* 35 annual rings.

Pile tip 245: This pile tip, although in poorer condition, exhibited clear concave axe facets. It was *c* 0.55m long with a diameter of 120mm. Towards the tip lay a sizeable knot, showing that the parent tree's logs had been cut to produce at least two pile logs.

This small sample of small oak timber, rather than round 'wood', foreshadows the use of similar or only slightly larger material for many of the Roman and mid-Anglo-Saxon piles excavated at Ebbsfleet (Goodburn 2011, 355–62). The fast growth (wide annual rings) of the parent oaks also suggests that they were growing in some form of rather open managed woodland on fertile soil. That is, the local woods of the Late Bronze Age and Roman to mid-Anglo-Saxon periods may have had a rather similar character. There is no evidence of the use of timber from large wildwood trees in the prehistoric assemblage from Ebbsfleet as might have been expected.

Area 3 (STDR401)

In excavation Area 3 (STDR401, Fig 13.1) activity dated to the Middle Bronze Age was located at the top of the peat sequence, at the interface with the overlying 'Upper Clay-Silts'. This comprised a small scatter of 81 worked flints (Pl 22.2). The high proportion of microdebitage and irregular waste in the assemblage implies that it was deposited following a knapping episode. No retouched or utilised pieces were identified. Technologically, the flintwork is probably of Bronze Age date. Five sherds of pottery were also recovered from the alluvial deposit immediately overlying (context 3016), along with a further 44 worked flints and 10 pieces of burnt unworked flint. The pottery from context 3016 comprised thick-walled rim and body sherds which could be from a single large jar or Bucket Urn. The rim is simple and rounded, and there is no surviving evidence to suggest the vessel was decorated. If the vessel is indeed a Bucket Urn then it is likely to belong to the Deverel-Rimbury ceramic tradition (Fig 22.12, 1; Barclay and Seager Smith, Appendix H).

Catalogue of illustrated pottery

(Fig 22.12)

1. Middle Bronze Age rim (context 3016, SF1207, Area 3, STDR401)
2. Late Bronze Age, neck sherd with combed bands (context 1077, Area 1, STDR401)
3. Late Bronze Age, neck sherd with burnished band (context 1153, Area 1, STDR401)

Late Bronze to Middle Iron Age (1100–100 BC)

Springhead (Zone 11)

In the Upper Valley at the Ebbsfleet River Crossing (ARC ERC01, Fig 15.1) a single ditch, possibly a boundary marker, was recorded at the northern end of the site. Ditch 548 was traced for approximately 60m, running adjacent to and parallel with the former channel edge and truncated the Late Neolithic to Bronze Age burnt flint spread (536) in Trench 5 (Fig 21.9). At its southern extent, the ditch veered slightly to the west and was cut by the Roman channel, but here it was deeper

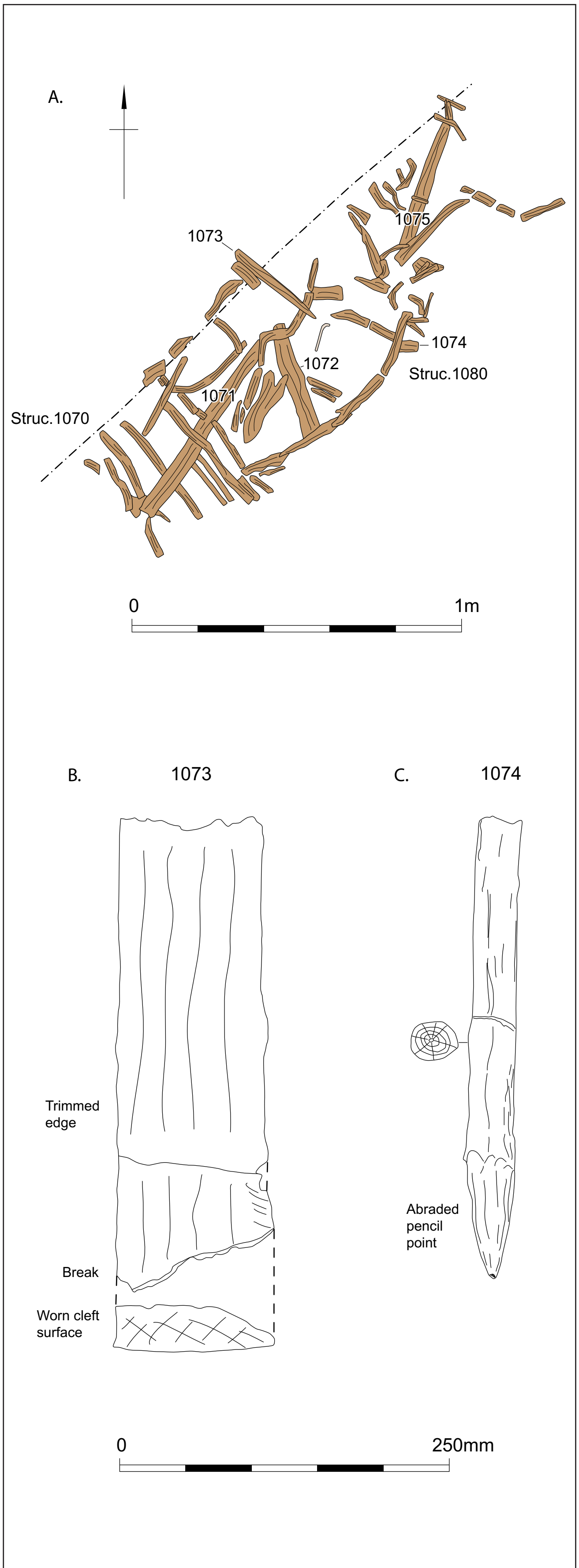

Figure 22.13 (a) detailed plan of revetments 1070/1080, Area 1 (STDR401); (b) ¼ cleft log plank section 1073; (c) roundwood stake 1074

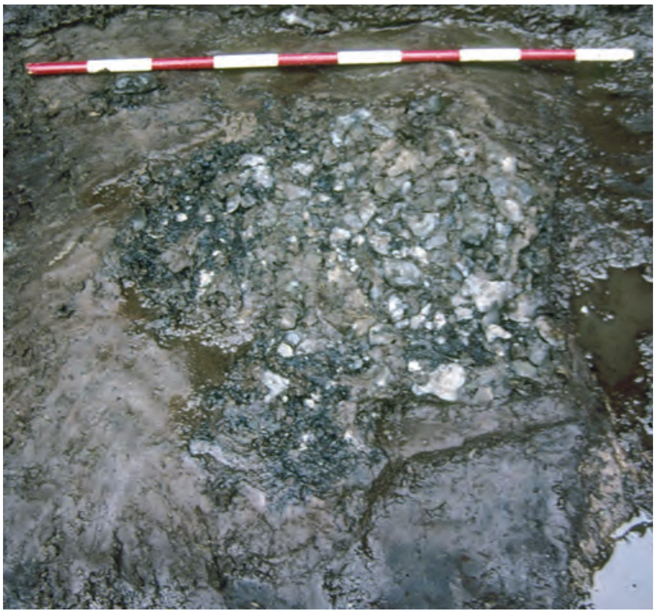

Plate 22.3 Concentration of burnt flint 4024, Area 4 (STDR401)

and partially survived beneath the fills of the Roman channel. In order for this partial survival beneath the Roman channel to occur, ditch 548 must originally have been substantially deeper at this location. The ditch measured up to 2.5m wide, averaged 0.4m deep, and was flat-bottomed. The fills mostly appeared to represent natural infilling. although they produced occasional sherds of Late Bronze Age or Iron Age pottery. This included a neck fragment (418), part of a base (414) and part of what could be a perforated fired clay slab (418). Perforated slabs are a common find on Late Bronze Age sites in south-east England and the fragment is very similar to more complete examples from the North Ring, Mucking (Bond 1988, 39 and fig 27: 1–11).

Several discrete deposits of burnt flint and charcoal were found at irregular intervals along the ditch (506; 514; 531; 532; 533; 2897), sometimes in shallow scoops. These deposits were not at the base of the ditch, but generally occurred in the middle or upper part of the fill. A radiocarbon date on charcoal of field maple (*Acer campestre*) from scoop 507 (fill 506) suggests a Late Bronze Age to Early Iron date at 2419±30 BP (NZA-28619, 750–400 cal BC, Fig 22.2, Table 22.2). The charcoal assemblage from six samples associated with the deposits of burnt flint included field maple roundwood, hazel (*Corylus*) heartwood and roundwood and pomaceous fruit wood (hawthorn type). Small quantities of possible beech (*Fagus sylvatica*), cherry type (*Prunus* sp.) and oak (*Quercus*) were also identified. The presence of these types together indicates selection of woody material from a mixed deciduous hedgerow source, and the high proportion of roundwood indicates regular cutting/coppicing. While such a source of wood might have been used to create a burnt mound, the material might equally be interpreted as having derived from small-scale domestic or agricultural activity (Barnett, Appendix Q)

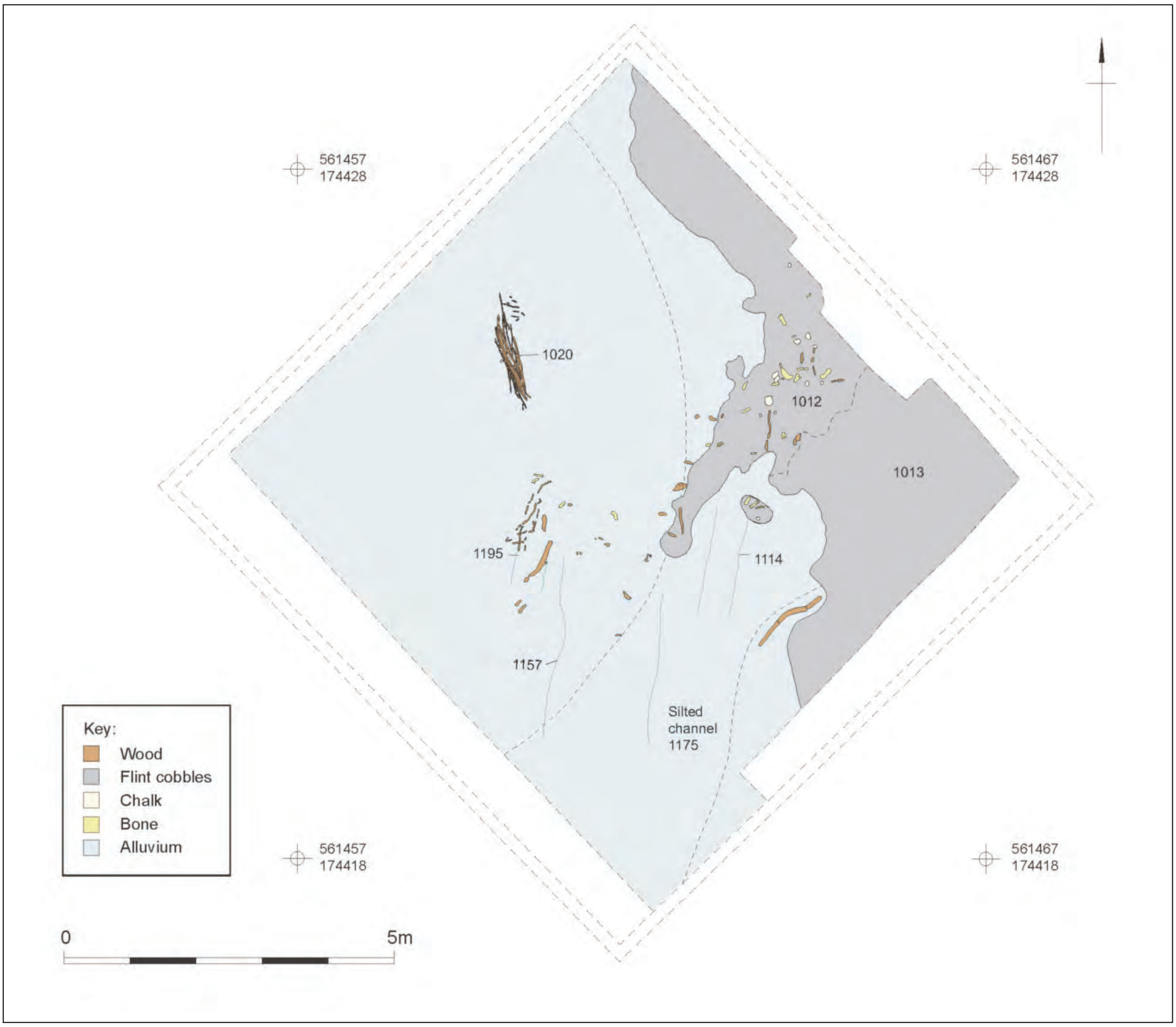

Figure 22.14 Plan of Late Bronze Age and Iron Age features overlying the silted channel sequence, Area 1 (STDR401)

The Floodplain (Zones 8 and 9)

Area 4 (STDR401)

In excavation Area 4 (STDR401, Figs 13.1; 13.8), activity dated to the Late Bronze Age was located at the top of the peat sequence, at the interface with the overlying 'Upper Clay-Silts'. Situated upon the surface of humified peat layer (4021) was a small scatter of 64 struck flints and a concentration of burnt flint (scatters 4024 and 4026, Pl 22.3), together with an area of burning (4025). The quantity of chips and irregular waste suggest that the flint assemblage contains some knapping debitage, whilst similarities in flint type indicate that elements from the same knapping sequence have probably been deposited together. Several fragments of Late Bronze Age pot were retrieved from a sample from 4024 and a radiocarbon date on peat from the same sample produced a Late Bronze Age date of 2841±35 BP (NZA-29078, 1120–910 cal BC, Table 13.2).

Area 1 (STDR401)

In Area 1 (STDR401), located in the Outer Basin of the Lower Valley (Zone 8; Fig 12.1), a series of wooden structures (1070/1080, 1090, 1130 and 1160) were found associated with the edge of a channel sequence within the 'Upper Clay-Silt' unit (Figs 12.9 and 12.10). The structures comprised fragmented wooden stakes, on occasion roughly joined by thin horizontal 'bundles' of rods or 'withies'. The form of the structures is not clear however, and it is likely, in part, they represent repairs, additions or replacements of one or more former structures, as the channel silts accumulated against them. The structures formed a broad linear arrangement concentrated along the western edge of the channel sequence and are largely associated with the western edge of the latest channel phase (1175) (Fig 12.10).

Wood samples from Structure 1070/1080 were examined in detail during the post-excavation phase. The structure was clearly much damaged by collapse and possibly transport of elements by water

Plate 22.4 Section through gravel spread 1013, Area 1 (STDR401)

(Fig 22.13a). However, it included worked roundwood and small cleft timbers and was clearly artificial. The relatively low elevations of between -1.19m and -1.55m OD suggests that it may be have been used when the tide had dropped. As some of the elements are typical roundwood stakes (eg, 1074 and 1072) it is difficult to see them as anything other than supporting a fence or revetment structure, slumped out of position by erosion. Alternatively, they may have been reused and simply dumped as makeup along the edge of a channel, perhaps as hard material for a boat landing. A lifted section of timber (1073) was a weathered cleft and hewn plank shaped from a quarter log of alder (*Alnus glutinosa*). It was over 120mm wide and 35mm thick (Fig 22.13b). Roundwood hazel (*Corylus avellana*) stake 1074 (Fig 22.13c) survived to 0.35m long and 34mm diameter and had an abraded 'pencil' point. Both 1071 and 1075 were simple roundwood stakes 45mm and 30mm in diameter and given smooth axe cut chisel ends. The latter, identified as possibly alder buckthorn (*Frangula alnus*), was dated to the Late Bronze Age – 2615±30 BP (SUERC-19949, 835–765 cal BC, Fig 22.2, Table 22.2). Other wood species identified in these structures include blackthorn/cherry (*Prunus* sp.); silver/downy birch (*Betula pendula*/*pubescens*), and yew (*Taxus baccata*) (Barnett and Druce, Appendix P). Only very incomplete rounded metal axe stop marks survived in places on this weathered material.

A linear feature, 1157, measuring 2.23m wide and 0.27m deep, was recorded on the same general south to north alignment as the channels, truncating the fills of the latest channel (1175). It was filled with minerogenic mid- to dark greyish-brown silty clays (1159 and 1158). Two narrow, shallow gullies were recorded either side of 1157. To the east lay gully 1114 and to the west gully 1195 (Fig 22.14). This group of features is difficult to interpret due to their limited extent in plan, although it was originally suggested they may represent some form of 'slipway' or trackway with drainage gullies either side. Two fragments of post-Deverel-Rimbury pottery were recovered from fills 1069 and 1077 of gully 1195. The sherd from fill 1077 derived from a round shouldered fineware jar decorated with horizontal bands of combed lines (Fig 22.12, 2). A plain burnished sherd in the same fine flint fabric from 1069 is likely to derive from a similar fineware vessel. This form and type of decoration can be closely paralleled at other sites in Kent, the Thames Valley and Essex (eg, Monkton Court Farm, Kent: Macpherson-Grant 1994, fig 6:9–10; Mucking North Ring, Essex: Barrett and Bond 1988, fig 23:95) and is likely to be of 9th–8th-century date. Associated alluvial deposit 1153 produced sherds from a slightly coarser vessel than the above. This sherd (Fig 22.12, 3) is decorated with a horizontal band of roughly executed burnished grooves. Similar vessels occur in Kent, where the decoration is executed using scratched rather than burnished lines (Macpherson-Grant 1994, fig 5:8). (Barclay and Seager Smith, Appendix H).

Sealing this sequence of deposits in the north-eastern area of the excavation was an extensive coarse gravel deposit 1013 (contexts 1012, 1013, 1109, 1139) comprising rounded flint, chalk and chert nodules,

Plate 22.5 Faggot 1020, Area 1 (STDR401)

0.10m thick (Fig 22.14, Pl 22.4). Numerous struck flints, animal bone, pottery and wood fragments were identified within and on the surface of this deposit. This included 10 sherds of Iron Age pottery from layer 1012, as well as fragments of possible briquetage (Barclay and Seager Smith, Appendix H). Although the quantity of animal bone was small there was a wide variety of species among the assemblage, including the main domestic species such as cattle, sheep, pig and horse, in addition to fragments of bird bone identified as cormorant (*Phalacrocorax carbo*). The most unusual element was a cetacean vertebra possibly belonging to a dolphin or porpoise (Strid, Appendix R). The worked flint assemblage totalled 14 flints in fresh, uncorticated condition from layer 1012, and 28 flints from context 1013, many in a lightly rolled and damaged condition. Given its condition, it is likely that the assemblage is composed largely of redeposited material of mixed date (Anderson-Whymark, Appendix I). A radiocarbon date on a cattle femur produced an Early to Middle Iron Age date of 2385±30 (SUERC-19947, 730–390 cal BC, Fig 22.2, Table 22.2). A small amount of slightly decayed roundwood was found lying on the surface of the gravel. in addition to a small cleft pale of timber set almost vertical on one side; perhaps this item was contemporary, as may have been a small number of truncated small pieces of vertically set roundwood (or roots?) also set along the same edge. For the wood to have survived on the surface of the cobbled feature it must have been very wet, probably often flooded and perhaps the isolated cleft pale was some form of marker post to indicate firm footing under shallow water. Such posts or stakes are a feature of 'hards' today.

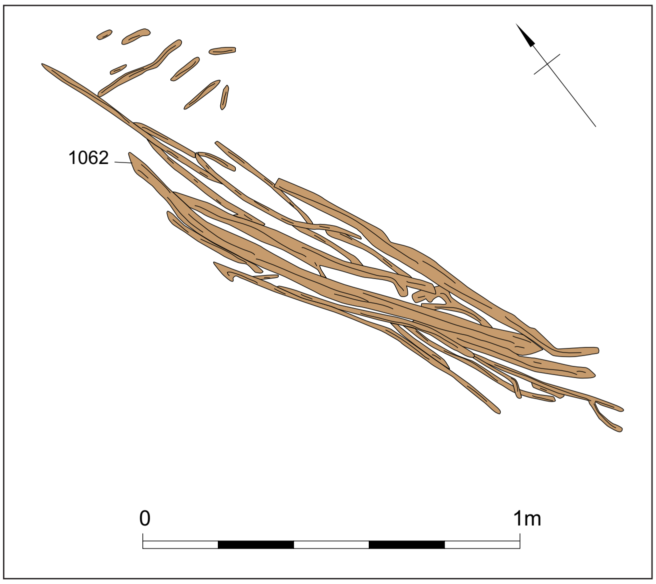

Figure 22.15 Detailed plan of faggot 1020, Area 1 (STDR401)

A clear discrete 'shoulder load' of trimmed roundwood had also been dumped in a neat bundle to one side of the gravel spread (Group 1020, Figs 22.14 and 22.15, Pl 22.5). Hazel roundwood from Group 1020 produced a slightly later date of 2280±30 BP (SUERC-19948, 410–200 cal BC, Fig 22.2, Table 22.2). Further examination revealed that the poles and rods in the bundle give the appearance of having been

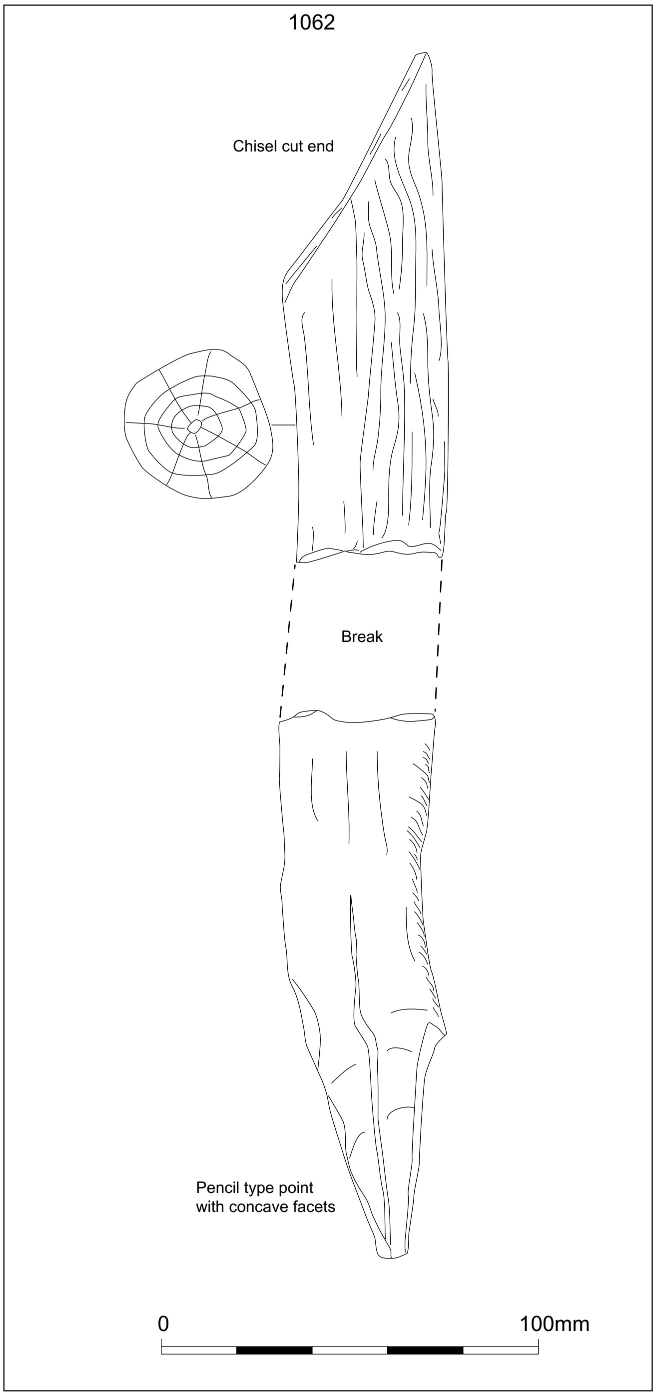

Figure 22.16 Worked wood from faggot 1020, Area 1 (STDR401)

bound together by something that had rotted after deposition, leaving them tightly jammed alongside each other. The approximate dimensions of the faggot were *c* 1.9m long by 330mm wide and included over 30 items. The diameter of the cut poles and rods varied from *c* 15mm to 65mm with most being *c* 40mm. Identified species included mostly hazel, but also ash (*Fraxinus excelsior*) (Barnett and Druce, Appendix P). Of the lifted material, pole 1062 was typical at *c* 40mm diameter (Fig 22.16). Both cut ends were lifted; one being cut smoothly across as a 'chisel' point and the other of 'pencil' form on what was probably a coppiced heel. No clear axe stop marks survived. Although the faggot may have been an abandoned firewood bundle it could also have been used as a small 'fascine', ie, roundwood makeup. Roundwood bundles are still sometimes used today in sea defence building. The material was found at a low level of -1.25m OD which would probably only have been exposed at low tide and the faggot must have been weighed down in some way, even if very green.

Structure 100018 (ARC 342W02)

In addition to the Iron Age remains described above in Zone 8, a cluster of stakes was recorded during the HS1 watching brief to the north-west (Fig 22.17). Structure 100018 comprised two associated stake alignments. They can be subdivided into the southern straight section (stakes 100011–16) and those forming an arc just to the north (stakes 10005–10). One small roundwood stake (100007) tip was radiocarbon dated to the Late Bronze Age to Early Iron Age at 2549±35 BP (NZA-28718, 810–540 cal BC, Fig 22.2; Table 22.2).

All of the five roundwood stake tips of 'arc' group were very truncated; surviving to a maximum of 200mm long with diameters between *c* 35mm and 50mm. Species included alder, hazel and birch (Barnett and Druce, Appendix P). The form of the tips also varied including 'chisel', 'wedge' and 'pencil' points (Fig 22.17, 100006 and 100007). No complete axe 'stop marks' survived but the small, smooth, concave facets up to *c* 35mm+ wide would be most typical of the Late Bronze Age in southern Britain, where axe facets over 45mm wide are uncommon with marks up to a maximum of only *c* 50mm width known (Goodburn 2003, 102). The larger, heavier, socketed iron axes of the Iron Age typically had wider, straighter, blade edges which left wider, flatter facets often up to 70mm or more wide (Sands 1997, 78; Brunning *et al* 2000, 195).

Some of the stakes displayed possible evidence of a 'coppiced heel' (eg, stake 100007, Fig 22.17). This is a sharp kink to the bottom of the stem and a bulge on one side where it joined the 'stool' or stump, with shoots repeatedly cut after every few years (Rackham 1976, 21). Evidence of such woodmanship practices designed to produce handy regular rods, poles and small logs has been seen in other roundwood structures of Late Bronze Age date in North Kent at Swalecliffe. There the evidence is of broadly similar date (Masefield *et al* 2003, 61). The arc described by the location of the stakes with in the trench is perhaps more like a half oval in shape. The plans indicate that the oval would have been *c* 11m long with stakes placed at over 2m intervals. It is difficult to see what function such a dispersed arc of stakes might have had. One possible interpretation is of some form of light temporary 'bender' type shelter as were often used in many regions of the world when low labour cost and time expended was important (eg, the Paiute people of California, where wide grass mats formed the cover of the light bent wood frame; Wheat 1967). Another possibility might be that the arc of stakes was driven to form part of a hunting trap on which nets could be hung for catching wildfowl, as in the recent past.

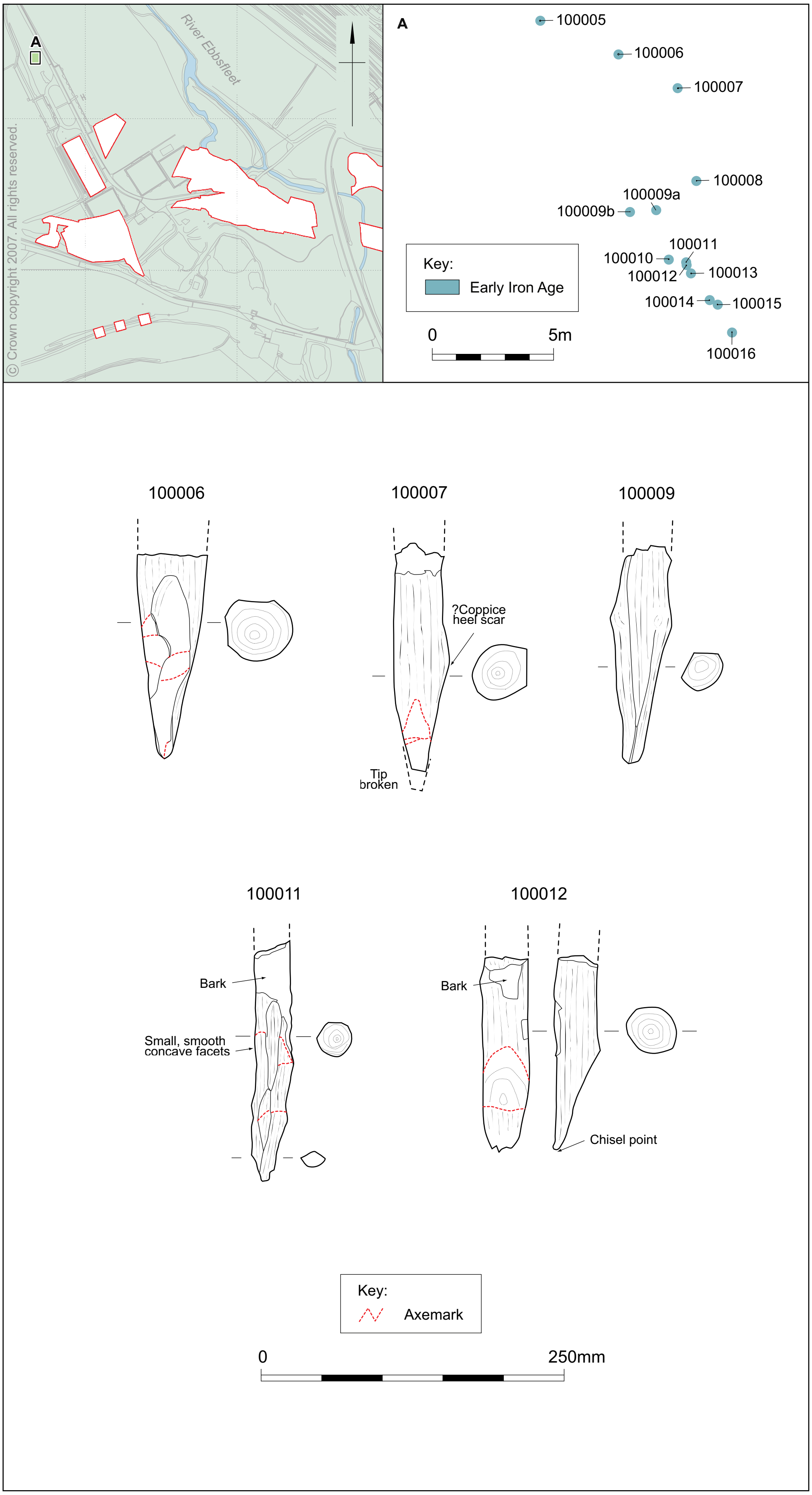

Figure 22.17 Stake structure 100018 (ARC 342W02)

This straight stake alignment comprised similar small roundwood stakes of hazel and alder to those used above 30 to 40mm in diameter. The forms of the points also varied from 'pencil' shapes to 'chisel' points (eg, 100011 and 100012, Fig 22.17). The spacing gave the impression of missing some uprights, but as most of the stakes were only a few centimetres apart it would appear that they would have been part of a woven wattle fence or similar structure. This may be interpreted in many ways – as a light stock fence, a windbreak or possibly a leader fence to direct game into a trap area where the arc of stakes lay to the north.

Middle to Late Bronze Age Worked Flint from Areas 1–4 (STDR4)

by Hugo Anderson-Whymark

Areas 2, 3 and 4 yielded small scatters of Middle to Late Bronze Age flint and burnt unworked flint from deposits overlying the peat. In Area 1, the upper part of the sequence was disturbed by channels, but context 1153 contained a small, possibly Bronze Age, flint assemblage; the remaining flints in the upper deposits are residual and broadly dated from the Neolithic or Bronze Age.

The Middle to Late Bronze Age flintwork is characteristic of material from the region. The assemblage is dominated by flakes, the majority of which are thick, squat, hard-hammer products with little or no platform edge abrasion. The cores are generally irregular multi-platform forms, although single platform cores and cores manufactured on large flakes were also noted. A keeled core from context 1153 is in rolled condition and is probably residual, and can be dated to the Middle or Late Neolithic. Knapping debris appeared to be present in several of the Bronze Age contexts, including numerous piece of irregular waste, but the only refit was found in context 4019. This refit was between a flake and a scraper (Fig 22.18, 1), indicating that simple flake tools were manufactured, used and disposed of at this location. The only retouched tools were simple flake tools; these forms include scrapers (Fig 22.18, 1 and 2), heavy duty awls (Fig 22.18, 3 and 4) and simple edge-retouched flakes.

Catalogue of illustrated flint

(Fig 22.18)

1. A refit between a flake and a denticulated scraper. Flint type 11 (context 4019)
2. End and side scraper. Cortical flake with semi-abrupt retouch around two thirds of the edge (context 4021, SF 1181)
3. Awl. Heavily retouched piercing point. Bulb removed by a flake removal from the dorsal surface (context 1013, SF 1023)
4. Awl. Thermally fractured flake with abrupt retouch along the along one edge and to enhance a natural point (context 2012, SF 1042)

Summary

The Middle Bronze Age to Iron Age falls within the broad period division of 'Farming Communities' as defined by the original CTRL research strategy (Drewett 1997), the aims of which are outlined in Chap 3. The mid-2nd millennium BC is widely considered to be a period of great transformation in British prehistory, witnessing the development of more sedentary communities, complex social hierarchies, the building of hillforts and field systems, along with intensification of agriculture and craft production. On a regional and local scale, however, evidence for this transformation can be quite variable, in both character and tempo (Garwood 2011, 149).

Exploitation of Natural Resources

Evidence for exploitation of natural resources in the Ebbsfleet Valley, as in the preceding periods, suggests utilisation of locally available flint for the production of tools. It appears that this material was knapped with little regard for careful selection as nodules of varying size and quality are present in the same contexts. Scrapers are common, but other items such as knives, notched flakes and piercers were also produced (Anderson-Whymark, Appendix I).

Possible evidence of salt-making activity is provided by a base sherd with pink discoloration recovered from the Iron Age sequence in Area 1, perhaps indicating use as a briquetage salt container, although the sherd is quite hard-fired and it is equally possible that this is the result of some other process (Barclay and Seager Smith, Appendix H). A substantial amount of Early Iron Age briquetage was recovered during excavations along the line of the A2 (Morris 2012, 228–45) and in pits at the HS1 sites of Northumberland Bottom and Tollgate (Askew 2006; Bull 2006a). On the A2, where pedestals and hearth material were present, it was suggested that part-processed salt or brine was brought to more elevated sites to finish production.

The faunal assemblage was quite small and derived largely from the STDR4 excavations, particularly the Iron Age sequence in Area 1. Wild species emphasise the proximity of marine environments during this period and included a small cetacean vertebra, probably from a dolphin or porpoise. Although there were no signs of butchery on the cetacean vertebra from Area 1, hunting and utilization of stranded Cetacea in coastal north-western Europe is known from the Mesolithic up to the present day. There are numerous records of porpoise catching during the historical period (Clark 1989), but cetacean bones occur only occasionally on settlements and are, at least in the Anglo-Saxon period, usually considered to be indicators of 'high status' (Gardiner 1998). Due to their large size, cetaceans would most probably have been butchered on the beach, and the majority of the large bones left with the carcass. The two

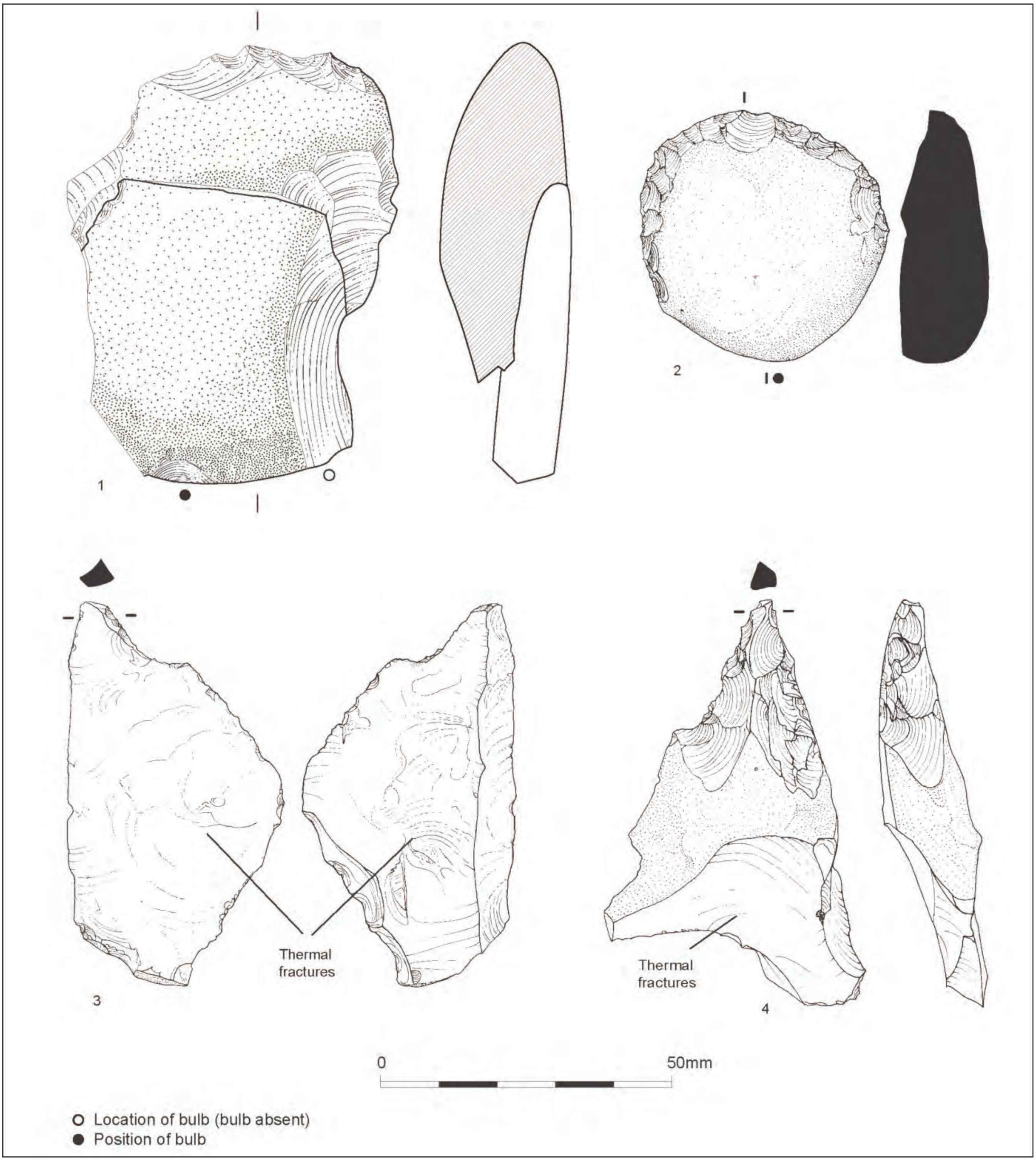

Figure 22.18 Late Bronze Age worked flint from Areas 1–4 (STDR401) (1-4) (see catalogue for details)

bird bones from Area 1 were identified as cormorant (*Phalacrocorax carbo*). Cormorants are fairly common seabirds which can be found on inland lakes and rivers as well as on estuaries and at the coast. Despite not usually being perceived as edible in England today, seabirds were hunted for meat, eggs and feathers in the North Atlantic region throughout the historic period up to the early 20th century (Baldwin 1974; Serjeantson 1988, 210). It would therefore seem reasonable that the cormorant bones could represent food waste (Strid, Appendix R). On the A2 excavations bones of marine fish from Iron Age contexts included herring and plaice or flounder (Allen *et al* 2012, 304).

Although no remains of game animals were recovered from the Ebbsfleet Valley dating to this period, excavations at Northumberland Bottom (Askew 2006), Tollgate (Bull 2006b), and the A2 (Allen *et al* 2012) recovered abundant remains suggesting red deer (*Cervus elaphus*) and roe deer (*Capreolus capreolus*) were hunted for meat as well as antler for bone working. This shows that hunting continued to play a part in the economy at some sites and also suggests that suitable wooded habitats still existed in the vicinity of the settlements. An interesting bone assemblage was found in a pit at Northumberland Bottom, with juvenile bones of cattle and partial young skeletons of red deer, which may be the remains of diseased meat, a feast or sacrifice. Bones of wild boar (*Sus scrofa*), pine marten (*Martes martes*) and cat (*Felis* sp.) were also recovered from the same site (Giorgi and Stafford 2006, 27).

The range of taxa identified in the charcoal assemblages in the Ebbsfleet Valley was similar to the preceding period; again, although large tree types such as oak (*Quercus*) were exploited, smaller trees and shrubs that thrive in open canopy woodland, scrub and hedgerows, such as field maple (*Acer campestre*), hawthorn (*Crataegus monogyna*) and blackthorn (*Prunus spinosa*), were dominant. The charcoal assemblage from the Middle Bronze Age hearth adjacent to the boiling pit in the Upper Valley at Springhead (ARC SPH00) was heavily dominated by charcoal from mature oak, which formed 78% of the assemblage. Small quantities of field maple, hazel (*Corylus avellana*) ash (*Fraxinus excelsior*), pomaceous fruit wood and elm (*Ulmus*) were also present, but it appears oak was specifically targeted for fuel in this feature, perhaps to enable a hot and sustained burn. The charcoal associated with the Middle Bronze Age cremation in pit 15030 on the Lower Valley slopes (ARC EBB01) included elm, oak, willow/poplar (*Salix/Populus* sp.) and pomaceous fruit wood, although the assemblage was small and there was some question of intrusiveness. Conversely, the assemblage from the cremated remains in pit 20716 was dominated by oak (>90%) which supports the interpretation of pyre debris; oak being chosen to achieve the high and enduring temperatures required to consume a body.

For the Late Bronze Age the charcoal associated with the activity in Area 4 (STDR401), at the top of the peat sequence, included a range of taxa such as field maple, hawthorn and blackthorn, with lesser dogwood (*Cornus* sp.), beech (*Fagus sylvatica*) and probable bird cherry (*Prunus avium*). Together, the types are suggestive of a hedgerow population, either the trimmings from maintenance or wholesale removal by, or followed by, burning. Roundwood of several types was common, so it may be this hedge had been regularly cut. A similar assemblage was recovered the from burnt flint deposits in the Iron Age ditch 529 in the Upper Valley (ARC ERC01); field maple roundwood, hazel heartwood and roundwood and pomaceous fruit wood (hawthorn type) were equally well represented. Small quantities of *cf* beech, cherry type and oak were also identified. The presence of these types together indicates selection of woody material from a mixed deciduous hedgerow source, with the high proportion of roundwood indicating regular cutting/coppicing. While such a source of wood might have been used to create a burnt mound, the material might equally be interpreted as having derived from small-scale domestic or agricultural activity. The composition of these two probable hedgerows is somewhat similar to that described for a large charcoal dump in Romano-British roadside ditch 11388 at Springhead (ARC SHN02), which has been interpreted as localised hedge clearance by burning to enable construction of a smithy (Barnett *et al* 2011, 113–118). There, field maple, birch (*Betula*), hornbeam (*Carpinus betulus*), hazel, ash, oak, pomaceous fruit wood, elm and one or more members of the Rosaceae family were identified. Continuity in the presence, maintenance and type of hedgerows present in the settled Ebbsfleet area through the later prehistoric to early historic periods is indicated (Barnett, Appendix Q).

Analysis of the waterlogged wood assemblage suggests a restricted number of taxa were selected for use in wooden structures during the later prehistoric period. Oak was chosen for the Middle Bronze Age piled structure (ARC 342W02). This appeared to be relatively fast-grown and may have derived from stands of managed open woodland, similar to the Bronze Age oak piles excavated at Freemasons Road, Newham (Stafford *et al* 2012, fig 10.9). The strength and longevity of oak wood, even in wet/submerged conditions makes it the natural choice for the production of larger piles and timbers (Barnett, Appendix P). The possible sections of roundwood trackway utilised oak, hazel, alder and birch. This suggests careful selection rather than casual collection of wood, indeed the supply of even-sized, straight roundwood may indicate deliberate management of the woodland resource by coppicing. The choice of taxa compares well with those identified for other Bronze and Iron Age trackways and revetments, the most plentiful and well known being those in the Somerset Levels. Alder is commonly found in the wooden structures there, especially in the Abbot's Way Track (Taylor 1981), Tinney's Ground and Sweet Track (eg, Coles *et al* 1973; Coles *et al* 1978). Alder was also used (along with oak, willow/aspen and ash) in the constructions at Flag Fen, Cambridgeshire (Taylor 1992). Hazel was favoured for making rails and pegs in the Sweet Track, while coppiced hazel cut at 10 years was used to make the sails and three–five year old pieces to make the rods of the Walton Track hurdles (Coles *et al* 1978). The occurrence of these woods reflects the availability of alder in those wet environments requiring revetment and trackway construction, and alder both and hazel respond particularly well to coppicing and pollarding, producing even-sized, flexible rod-like poles suitable for making wattle (Edlin 1949). Young birch wood too is supple and has the advantage of growing quickly in suitably open conditions. It was identified, as here, forming some of the uprights for the Testwood II, Hampshire Iron Age timber revetment along with alder and willow/aspen and bird cherry wattle (Chisham 2006).

Timber Structures

The evidence retrieved from the HS1 and STDR4 investigations fits within the general regional pattern of an increase in the construction of timber structures along the floodplain margins during the 2nd millennium BC. Aside from the Middle Bronze Age piled 'bridge' structure (ARC 342W02), four sections of possible Middle Bronze Age trackway were recorded (ARC 342W02, Str 100073, 100070 and 100000 and ARC ESG00, Str 3815014), along with a series of Late Bronze Age structures revetting a channel (Area 1, STDR401). A stake built structure was also dated to the Iron Age (ARC 342W02, Str 100018).

The dating of the structures is largely based on radiocarbon dating of the worked wood (Figs 22.1 and 22.2, Tables 22.1 and 22.2), supported by the analysis of woodworking technology. With reference to the double oak pile alignment, there are a number of Bronze Age sites in the south-east of England which have produced similar piles used in single row alignments. Single rows of piles seem to indicate the construction of of revetting, defensive or possibly ritual structures, whilst the Ebbsfleet example of paired rows seems to have a quite plausible practical function as a bridge. At Runnymede on the Thames, several phases of close set single pile alignments were recorded. The Late Bronze Age examples included many with elongated, carefully made, 'pencil'-type points (Needham 1991). The size-ranges are very similar to those from Ebbsfleet, and clearly piles of *c* 150mm diameter were considered a common size used in the Later Bronze Age along the Thames.

The closest parallel to the Ebbsfleet structure, based on size and form, is the Early to Middle Bronze Age double pile alignment excavated at Freemasons Road, Newham – although some of the piles here were made from cleft logs – which was also interpreted as a footbridge (Stafford *et al* 2012, fig 10.5) The arrangement was similar, pairs of piles (150–210mm in diameter) were set 2.2–2.8m apart with the centres of each pair *c* 1.0m apart. Obvious comparisons can also be drawn with the Middle Bronze Age pile group, interpreted as a bridge structure, at Vauxhall (Haughey 1999; Sidell *et al* 2002, 29) and further upstream at Eton (Allen *et al* in prep; Lambrick with Robinson and Allen 2009, 232), although these uprights were very much larger and not set out in neat pairs (Stafford *et al* 2012, fig 10.6). This may have been due to the structures spanning wider, faster flowing water courses, and a longer lifespan requiring some maintenance. The greater size of these latter structures suggests they could have accommodated wheeled vehicles.

The Middle Bronze Age dates for the possible trackway structures from the Ebbsfleet Valley are consistent with a number of other timber structures recorded on the Thames floodplain, particularly in East London (eg, Beckton 3-D, Beckton Nursery, the Golf Driving Range and Bridge Road Rainham, see Stafford *et al* 2012, figs 10.3 and 10.4). The building of the trackways, an activity which appears to have significantly increased during the 2nd millennium BC along the margins of the Thames floodplain, may have been a means of accessing the floodplain wetlands. The majority of the structures recorded at other sites invariably lead from the dry ground of the gravel terraces out onto the floodplain either of the Thames or Thames tributary channels. At Ebbsfleet, the alignment of the excavated structures altogether covers a distance of *c* 140m and appears to follow the contours of the wetland edge (Fig 16.6c). This may suggest a routeway through the valley, perhaps leading from the Thames up to Springhead and beyond.

The apparent repair and possible replacement of trackways, seen at sites such as Movers Lane and Woolwich Manor Way in East London (Stafford *et al* 2012, 139), suggests that the construction and maintenance of these structures retained some relevance with the changing hydrology of the area, and that defined and established access routes were respected and maintained. The palaeoenvironmental evidence from many sites of similar age indicates that construction broadly coincides with rising water levels and a change from predominantly alder carr to a more open environment of sedge fen, reedswamp and marsh. Further into the marsh, and closer to the Thames foreshore, it is likely that saltmarsh environments existed. Access to the floodplain may have been required to exploit the range of natural resources that must have been abundant in such environments: plants for medicinal purposes or reeds for basketry and thatching, as well as activities such as hunting, fishing and waterfowling. Alternatively, the trackways may have been used for herding of animals to seasonal pasture on the marshes. Given the light construction, the trackways themselves were probably only used for human foot traffic, with the herd wading alongside through the wetter areas. The role of animal husbandry, particularly of cattle, in the local subsistence economies of the region is well attested (see below).

Cereal Cultivation and Animal Husbandry

As with the preceding period, the evidence recovered from the Ebbsfleet Valley during the HS1 and STDR4 works provides little direct evidence for the cultivation of cereals during the Middle Bronze Age to Iron Age. No charred cereal assemblages were recovered, although the environmental evidence suggests increasingly open grassland environments and a general reduction of woodland on the Lower Valley slopes and further upstream at Springhead. There was some evidence in the pollen record for cereal cultivation; however, the similarity of cereal pollen with some wild grasses, such as sweet-grass (*Glyceria*), in coastal locations means that the evidence remains equivocal (see Waller and Grant 2012). Part of the base from a Deverel-Rimbury style Bucket Urn from the cremation within the ring-ditch at Springhead (context 6614, ARC SPH00) was marked by a single barley (*Hordeum*) grain impression (Barclay and Seager Smith, Appendix H). In the vicinity of the Ebbsfleet Valley the A2 excavations recovered a few charred grains of spelt wheat (*Triticum spelta*) and barley from Late Bronze Age features. The Iron Age assemblage was dominated by emmer wheat (*Triticum dicoccum*), although spelt wheat and hulled barley were also present (Smith 2012, 83, 273–79). The HS1 sites at Northumberland Bottom and Tollgate produced similarly small assemblages from Middle to Late Iron Age deposits that included emmer and spelt wheat along with hulled barley and oats (*Avena* sp.). Charred weed seeds from common plants of disturbed ground and arable fields included stinking mayweed (*Anthemis cotula*), bedstraw (*Galium* sp.), orache (*Atriplex* sp.), sheep's sorrel (*Rumex acetosella*), black bindweed (*Fallopia convolvulus*), docks (*Rumex* sp.) and vetch/tare (*Vicia*/*Lathyrus* spp.) (Davis 2006a and 2006b).

Domestic species in the faunal assemblages from the Ebbsfleet Valley, again mostly from the Iron Age sequences in Area 1 (STDR401), included cattle, sheep/goat and pig. While the assemblage was small, the skeletal element representation and slaughter age pattern appear similar to the preceding period, implying the animals were slaughtered and butchered nearby, mostly at sub-adult or adult ages. Three cattle mandibles could be aged. These gave mandible wear stages of 25, 27 and 45 (after Grant 1982), equating to two young cattle (Halstead stage D; Halstead 1985) and one old adult (Halstead stage H). Butchery marks were found on two cattle bones, a humerus and a tibia, both of which had had their distal ends chopped off. It is unclear whether this procedure is related to portioning and/or to marrow extraction. At the HS1 sites at Northumberland Bottom and Tollgate the main domesticates during this period were also cattle, sheep/goat and pig, with cattle the most abundant species. There was limited ageing data from the bone remains, although the results suggest that cattle were used for traction and milk as well as meat, and at Tollgate horn from cattle was also used. Sheep were used for wool, milk and meat, with evidence for lambing on site or close by at Northumberland Bottom. Occasional horse bones would have been used for traction and possibly for riding (Stafford and Giorgi 2006).

A number of dog bones were recovered from Area 1 (STDR401), although, as with the other HS1 sites, they did not exhibit butchery marks, suggesting that the meat was not eaten; these may have been scavengers, working animals or simply pets. Dog bones with butchery marks have occasionally been found on Bronze Age and Iron Age sites, suggesting that dogs were sometimes exploited for their meat for dietary, ritual or medicinal purposes (see discussion of the assemblage from Freemasons Road Newham, Strid and Nicholson 2012, 129, 265–70).

Ritual and Funerary Practices

Four ring-ditches, two at the head of the valley at Springhead and two smaller examples recorded beneath Northfleet Roman villa on the Chalk Spur of the Lower Valley, may represent the remains of Middle Bronze Age barrows. Central cremation deposits were recorded in one ring-ditch within each location. At Springhead, the possible urned cremation (6615), contained within a shallow pit and associated with the earlier ditch (300001), was very truncated and only tiny flecks of probable burnt bone and charcoal were recovered. The spread of cremated bone (15086) associated with ring-ditch 15059, beneath Northfleet Villa, was in better condition and was probably of a female adult (>35 years). A further cremation burial recorded nearby, within pit 15030 immediately adjacent to ring-ditch 15059, was probably of a female adult (>25 years). The cremated remains recovered from pit 26016 in the Sports Ground excavation represent redeposited pyre debris from the cremation of an infant (>5yrs) and spread throughout the charcoal-rich fill. The radiocarbon dates processed from four samples from the cremated remains in the Lower Valley are presented in Figure 22.1 and Table 22.1. The dates passed a chi square test and are statistically consistent (T=6.5 at 3df). The Deverel-Rimbury Bucket Urn associated with the Springhead cremation would also be consistent with these dates and burial context.

In the vicinity of the Ebbsfleet Valley a number of Middle to Late Bronze Age cremation burials were recorded along the line of the A2; five deposits were contained within shallow pits, two of which were isolated features, whereas the others lay in a cluster close to field boundaries. The date ranges at 1380–1010 cal BC are slightly later than those in the Ebbsfleet Valley; all were adults but age and sex could not be determined (Gibson *et al* 2012, 80–2). A single isolated urned cremation burial, dated to the Middle to Late Bronze Age, was also recorded on the HS1 site at Northumberland Bottom (Askew 2006, 16). In the wider region, the HS1 burial evidence has been reviewed by Champion (2011, 232–40). Although cremation burial appears to remain common, there is some evidence to indicate a movement away from burials associated with ring-ditches in the Middle Bronze Age towards burials associated with trackways and field boundaries, or isolated locations, in the Late Bronze Age. The shift appears to have begun in the latter part of the Middle Bronze Age, after *c* 1300 BC (Allen *et al* 2012, 111). The cremation deposits recovered from the Ebbsfleet Valley would be consistent with this hypothesis.

The later ring-ditch at Springhead was found to be associated with extensive deposits of burnt flint, a hearth and a possible 'boiling' pit. The radiocarbon dates are presented in Figure 22.1 and Table 22.1. Some of the burnt flint had slumped into the fill of the ring-ditch and this together with the proximity indicates the 'boiling' activity must have commenced very shortly after the later ring-ditch was dug. Micromorphological analysis revealed the burnt flint spreads to contain charcoal, ash, burnt pottery and one example of leached bone (Macphail and Crowther, Appendix T). Interestingly, only one piece of worked flint recovered from these deposits was burnt, indicating activities involving worked flint occurred away from fires (Anderson-Whymark, Appendix I). The evidence is perhaps somewhat similar that found at Eton Rowing Lake in the Middle Thames Valley. Here, an Early Bronze Age ring-ditch, situated very close to a channel on the floodplain, was modified during the Late Bronze Age with an additional enclosure, an inhumation burial, and was closely associated with a number of burnt flint filled pits (Allen *et al* in prep). As discussed in Chapter 21, burnt mounds are often found adjacent to water courses and are often associated with a central trough, probably used to boil water with heated stones (Raymond 1987). It has been suggested these features were used for cooking, perhaps for communal gatherings (O'Kelly 1954; Barber 1990), the processing of fleeces (Jeffery 1991), salt production (Barfield 1991) or as sweat lodges (Barfield and Hodder 1987). The latter interpretation has been suggested for Early Bronze Age features at the Ebbsfleet River Crossing (ARC ERC01). Regarding the remains at Springhead, the close association of the barrows, hearth and trough would perhaps suggest some form of ritual or ceremonial activity.

The Hinterland

Some reference has been made in the preceding sections to remains recorded in the vicinity of the Ebbsfleet Valley on other HS1 sites and along the line of the A2 dated to the Middle Bronze Age to Iron Age periods. More generally, the excavations along the line of the A2 revealed a wide range of evidence for Middle to Late Bronze Age activity, including settlement evidence. This included a pair of L-shaped enclosures, both associated with possible lengths of metalled trackway. One of the enclosures, associated with domestic activity, included a roundhouse with pits and hollows. The other was associated with gullies and palisade slots, and the area became a focus for cremation burials. Smaller dispersed scatters of pits and postholes along the route may also be related to domestic activity. One isolated pit contained an unusual deposit comprising a Deverel-Rimbury Urn that may have contained a deposit of cremated animal remains, along with the remains of two cups and other vessels lying on a large deposit of fired clay, some fragments of which bore impressions of wattle (Allen and Hayden 2012, 100). At the nearby site of Coldharbour Road (Mudd 1994), Middle Bronze Age trackway ditches, succeeded by a hollow-way and metalled trackway, appear to extend south towards the A2 excavations. Five cremation burials were found alongside the trackway, one in a post Deverel-Rimbury Plain Ware urn. Apart from the Late Bronze Age cremation described above from Northumberland Bottom (Askew 2006, 16), little evidence was found on the adjacent HS1 sites other than a small number of residual pottery sherds in Middle Iron Age features. As Allen *et al* (2012, 107) point out, this does indicate low-level activity across a large area, but there is no convincing evidence for large scale enclosure or field systems such as those found along the Thames Valley (Lambrick with Robinson and Allen 2009).

Early and Middle Iron Age activity was dispersed along the route of the A2 and HS1 with clusters of activity; pits and probably four-post structures or granaries, spaced at intervals of *c* 1.0–1.3km apart, with more dispersed scatters of features extending beyond these clusters, and unenclosed four-post structures dotted around the landscape (Allen 2012, 317). Excavations at Northumberland Bottom, for example, revealed two areas of Iron Age occupation. The first, dated to the Middle Iron Age, included rubbish pits containing domestic debris of pottery and animal bone and fragments of loomweights, cooking pits, furnaces, an area of possible animal pens, a waterhole and associated boundary ditches. The evidence suggests pasturage and industrial activity within an arable landscape that was carried out by a small community on a seasonal basis, at a distance from the settlement. The second area of occupation, dated to the Middle to Late Iron Age, included a rectilinear enclosure and a series of boundary ditches along with two four-post structures. A shallow hollow-way may represent a droveway for cattle (Askew 2006).

Wider Overview

by Chris Hayden

Introduction

The later part of the Bronze Age is characterised by a number of significant and probably related changes in the subsistence economy, settlement systems, and, no doubt, social structure. Stevens and Fuller (2012) note that agriculture first clearly takes off in southern England in the Middle Bronze Age. Evidence from excavations to the south of the Ebbsfleet Valley exemplifies many of the wider changes in settlement and subsistence systems. On the A2 roadscheme, an L-shaped enclosure associated with a possible roundhouse, pits and other features provides an example of a focus of settlement that has widely been regarded as typical of the Middle Bronze Age elsewhere in southern England (eg, Brück 1999; Ellison 1978; Woodward 2008) but which, until the excavations along the A2, appeared to have been absent from Kent (Champion 2011).

Alongside such changes in the form of settlements, the second major development is the establishment of field systems in the Middle and Late Bronze Age – an extensive example of which has been documented extending from Coldharbour Road (Mudd 1994), through the A2 Activity Park (Dawkes 2010) and into the A2 (Allen *et al* 2012). Yates (2007) provides documentation of numerous other examples of similar date in Kent and elsewhere.

A third notable feature of the wider evidence is the appearance of four-post structures. Although there are no examples earlier than the Early Iron Age in the vicinity of Ebbsfleet (on the A2), there are Late Bronze Age examples elsewhere in Kent (eg, Holborough Quarry and Shelford Quarry; Boden 2004; 2006; 2007) and Middle Bronze Age examples in other parts of southern England (Gent 1983). Such structures are significant because they suggest that storage, especially of agricultural produce, and perhaps the display of stored produce, had come to play a significant social role.

Whilst these new strands of evidence suggest significant social and economic changes, the nature of those changes is, of course, open to debate (see, for example, Yates 2007; Thomas 1997; Brück 2000; Gingell 1992; Barrett 1994).

Corresponding to the appearance of these new forms of evidence, there is a decline in the kinds of evidence which typify the preceding Early Bronze Age, most notably in the construction of barrows and of the burials associated with them.

Most of the evidence from Ebbsfleet was perhaps connected only tangentially to the central processes involved in these economic and social changes. The aim of the discussion here is to examine how the evidence at Ebbsfleet fits into these wider developments.

Burial Evidence

The burial evidence from Ebbsfleet exemplifies the gradual change in burial practices which characterises the Middle and Late Bronze Age. The tradition of Early Bronze Age burials associated with round barrows, and sometimes containing strikingly rich grave goods, might be seen as being exemplified near Ebbsfleet by the burial associated with an amber bead necklace at Whitehill Road (Bull 2006a), although its date is late in the Early Bronze Age. The four ring-ditches found in the excavations reported here – two at Springhead and two in the Lower Valley – all appear, however, to date from the Middle Bronze Age. What may have been the truncated remains of central cremation burials were found associated with two of the ring-ditches, one at Springhead and the other in the Lower Valley (the other two ring-ditches lay only partly with the excavation and any such burial would have been outside the limits of excavation). The Springhead burial was associated with a Deverel-Rimbury Bucket Urn. The example in the Lower Valley was dated using radiocarbon to 1450–1300 cal BC (NZA-28208). A second urned cremation burial in a small pit cutting a gully adjacent to the latter ring-ditch gave a very similar radiocarbon date of 1440–1290 cal BC.

These burials are consistent in several respects with the limited evidence from elsewhere in Kent. Most of the other burials of this period in Kent were cremation burials, although possibly Middle Bronze Age inhumations were found in the A2 Activity Park excavation (Dawkes 2010), and another inhumation burial was found at Godmersham which had been cut by a Middle Bronze Age cremation burial in a chalk cist (Champion 1982, 34). A number of sites (eg, Monkton: Bennett *et al* 2008, 35–46; and Bridge: Macpherson-Grant 1980) are known where cremation burials were associated with relatively small ring-ditches (with diameters of around 5m) comparable to those in the Lower Valley. The Springhead ring-ditch, with a diameter of 18m is relatively large, but although overall there was a trend towards smaller ring-ditch diameters, size is not necessarily a reliable indication of date in particular cases (Garwood 2011, 129). The occurrence of satellite burials around the ring-ditches, of which the burial cutting the earlier gully provides an example, is also evidenced at these sites. The only other Middle Bronze Age burial associated with a ring-ditch in Kent which has been dated using radiocarbon is a satellite burial at Tutt Hill, the date from which (1440–1210 cal BC, NZA-20102: 3094±40 BP) is very similar to those from the burials at Ebbsfleet (Brady 2006b). These burials are the latest radiocarbon dated examples associated with ring-ditches in Kent.

The possibly slightly later, apparently isolated cremation burial found at the Sports Ground, dated to 1390–1130 cal BC (NZA-28207: 3020±30 BP) provides an example of the trend for later burials to occur either as isolated features or in association with field systems. Such isolated burials are also known from earlier in the Middle Bronze Age – the earliest radiocarbon dated example is at Saltwood Tunnel (1420–1260 cal BC, NZA-20655: 3063±30 BP) and appears to have been roughly contemporary with the burials at Tutt Hill and Ebbsfleet which were associated with ring-ditches (Riddler and Trevarthen 2006).

From the 13th century cal BC up to the 9th century cal BC, however, the burial record in Kent includes cremation burials, often consisting of quite small deposits of cremated human remains, in small pits, usually associated with few or no artefacts, which occur either in isolated contexts or associated with field systems. Such burials can, of course, usually only be identified on the basis of radiocarbon dates. Examples are now known from a number of sites in Kent (Allen *et al* 2012; Hayden and Score in prep.) as well as elsewhere in southern England (Webley and Timby 2007).

Whether the occurrence of such burials in association with field systems or in more isolated contexts is significant is open to question. At Pinden Quarry, a group of pits was found which appear to have been cut sporadically throughout the Late Bronze Age (Hayden and Score in prep.). Around half of the pits contained cremated human remains, which may, however, derive from just two episodes of activity involving cremation. The earliest of the pits pre-date the laying out of a field system whilst the latest post-date it. Unfortunately, the pits containing cremated human remains cannot be related directly to the field system ditch. However, the general pattern of development at Pinden Quarry at least highlights the fact that the field systems might post-date the cremation burials, rather than the burials being deliberately positioned relative to field boundaries.

The wider significance of this change in burial practices is open to debate, and a detailed consideration is beyond the scope of this discussion. It is, however, perhaps worth noting that the trends in burial practices

– the decline in the deposition of rich grave goods (largely over by the Middle Bronze Age), the general decline in the size of barrows, and the increasing number of burials which were not associated with barrows – appear to complement the changes in settlement and the setting out of field systems mentioned above, and suggest a significant change in the sources of social and economic power, and perhaps in the significance of genealogical links in obtaining them (*cf* Thomas 1997; Brück 2000; Barrett 1994).

Bradley (2007) has noted a contrast between the scale of field systems of the Middle and Late Bronze Age and the scale of the associated settlements. A similar contrast exists between the field systems and the scale of the burials. It is striking that the burials in isolated contexts or associated with field systems usually occur in small numbers or as single burials, and do not appear to have formed long-lived cemeteries (in contrast to some of the earlier barrows). Even the exceptional group of 16 deposits of cremated remains at Pinden may derive from only two episodes of activity. In this respect the pattern of burial appears to correspond to the neo-local pattern which Brück (1999) has suggested characterised Middle Bronze Age settlement (ie, that upon or after marriage, settlements were formed in new locations, away from those of the parents of both the husband and wife: Keesing 1975).

The contrast between what appear to have been at least generationally mobile patterns of settlement and burial contrast with what seems to have been the relatively rigid parcelling out of the landscape marked by field systems. This contrast could be taken to imply that new systems had developed which mapped population onto agricultural land. Such a system might be taken to imply the development of corresponding new, related forms of social and economic power (*cf* Gingell 1992; Allen *et al* 2012, 107).

Trackways, Bridges, Field Systems and the Exploitation of the Landscape

The major indicators of the wider social and economic changes alluded to above – and in particular the appearance of new forms of settlement, and the widespread laying out of field systems – are not directly evidenced in the Ebbsfleet valley. Some of these developments may, however, be reflected in the trackways and possible bridge structure found on the floodplain at Ebbsfleet.

The dates from these structures at Ebbsfleet are concentrated in the Middle Bronze Age, from around 1400 to 1100 cal BC. This date range appears to reflect a broader pattern in the Thames Estuary, in which this period appears to be marked by a floruit in the construction of such structures (Stafford *et al* 2012, fig 10.4). The reasons for this chronological pattern appear, in part, to derive from environmental changes. As the work at Ebbsfleet demonstrates, the valley bottoms became increasingly wet in this period, and there is greater evidence for marsh and sedge environments compared to the preceding period.

There may, however, be further reasons why the floruit for such structures occurs in the Middle Bronze Age. In certain respects, it is possible to see parallels between the laying out of field systems and the construction of bridges and trackways. Both imply relatively large investments – especially compared to the apparently relatively slight settlements (Bradley 2007), and the repairs to the bridge could be seen as paralleling the recuts found in some field systems which imply ongoing maintenance and repairs. Furthermore, the bridges and trackways can be seen as reflecting changes in the way in which the landscape was exploited which mirror those suggested by field systems.

The most obvious of these changes is perhaps the fact that like the imposition of systems of boundaries on the agricultural landscape, the construction of the bridges and trackways suggests that the patterns of use of the landscape had become more fixed. It has already been suggested in the context of the Neolithic that the presence of trackways implies a certain degree of regularity in the way in which the landscape was exploited. Whereas, however, in the Neolithic this appears to contrast with the apparently fluid pattern of exploitation suggested by the artefact scatters (see above), in the later Bronze Age, it could be seen as part of the wider set of changes reflected in the laying out of field systems.

One question that arises in the case of field systems concerns the extent to which they may have been related to changes in the way in which the landscape was conceptualised. Whilst it seems likely that the laying out of field systems was associated with major changes in the way in which the landscape was viewed, the situation with respect to the bridges and trackways is less clear. As has already been discussed, trackways had long been a feature of the landscape in the Ebbsfleet Valley, and it has already been suggested that the presence of trackways in the Neolithic in the context of apparently rather fluid patterns of occupation might suggest that at least locally, the landscape was conceptualised more in terms of pathways than of fixed points. As will be discussed further below, there is evidence that although there are likely to have been clear foci of occupation in the later Bronze Age (as exemplified by the enclosures on the A2), there is also evidence that much activity was dispersed widely across the landscape, away from these foci. Such dispersed activity appears to have characterised the Ebbsfleet Valley. Although in certain respects, the later Bronze Age situation thus appears similar to that in the Neolithic, the more widespread construction of trackways and bridges may have helped to define a new geographical framework of humanly-made structures which was at least more extensive if not as clearly new as the field systems.

The question of how the landscape was conceptualised is significant, since, as Bohannan (1973) has argued, a system of conceptualising space forms a significant part of any system of land tenure (and as

Bohannan stresses, the fixed systems of measuring space which developed in the modern western world are not characteristic of societies in other contexts). The laying out of field systems has been taken to imply significant changes in systems of tenure (eg, Gingell 1992; Allen *et al* 2012, 107), or more broadly in the systems which were used to distribute resources. This question remains the subject of debate which is beyond the scope of this discussion. Here, however, it is perhaps worth noting that although no boundaries similar to the field systems were found in the Ebbsfleet Valley (except perhaps for Structure 1070/1080), if the existence of trackways and bridges was related to a more precise geographical understanding of the landscape (in the sense that it was at least partly defined by humanly-made structures), they could also have been involved in more clearly defined distribution of rights to exploit the area. It is also worth briefly raising the related questions of who built – or provided the impetus to build – the bridges and trackways. Although it is impossible to answer this question definitively on the basis of archaeological evidence, it is possible that the more extensive construction of trackways and bridges were products of a new relationship between a social hierarchy and the power to distribute rights to land.

The Remaining Evidence

The evidence for the way in which the Ebbsfleet Valley was exploited in the later Bronze Age and Early Iron Age is relatively slight, but does suggest a range of activities, including lithic production, possibly catching wild fowl, and whatever activities were associated with burnt mounds. As in the Neolithic, most of these activities appear to have been associated with relatively brief episodes of occupation.

Activity on the floodplain in the Early Iron Age was represented by two small structures made of stakes. One of these consisted of an arc of five stakes and could have been a waterfowl trap, although it is possible that the stakes formed part of some other kind of structure, perhaps a small shelter. The absence of any associated artefacts does not, however, suggest prolonged occupation.

Elsewhere on the floodplain, two scatters of flint knapping debris were found associated with Late Bronze Age pottery. Although the presence of this flint suggests activity not dissimilar to that which occurred in the Neolithic, both scatters were small (consisting of 61 and 84 pieces respectively).

Some of the remaining evidence from Ebbsfleet and Springhead appears to reflect a different aspect of Middle and Late Bronze Age systems, which work along the A2 has highlighted. Despite the fact that new foci of settlement appear in the archaeological record in the Middle Bronze Age, there is still much evidence for the dispersal of activities across the landscape. In the case of the A2 it was noted that the largest deposits of finds were associated not with the apparent foci of settlement, but with ditches and pits that lay some distance from the settlements. Such a pattern appears also to be evidenced by the finds from an Early Iron Age ditch at Springhead. This ditch, which followed the edge of the palaeochannel, did not appear to have been directly related to a focus of settlement. Nonetheless, it contained a relatively rich range of finds including pottery, fired clay, burnt flint and charcoal. The final evidence for activity at the end of the Middle Bronze Age – the burnt mound deposits at Springhead – has already been discussed above.

Part IV

Discussion and Conclusions

Chapter 23

The Ebbsfleet Valley Through Prehistory – Landscape Development, Settlement and Archaeological Investigation

by Francis Wenban-Smith, Martin Bates and Elizabeth Stafford

Why the Ebbsfleet Valley?

If one was to take a bird's eye view of south-east England, or even merely the Lower Thames Estuary, and attempt to judge without prior knowledge where might be archaeological hotspots from the Palaeolithic through to early medieval period, it is doubtful the Ebbsfleet Valley would attract attention. It is a tiny, once-tidal, south-bank tributary of the Thames, extending (before quarrying) *c* 3km south to Springhead. Beyond this, geological mapping and landscape topography attest to a more substantial drainage through much of the Quaternary; but this is nothing very different from numerous other small-scale tributary streams of the chalk downlands of southeast England.

And yet, the Ebbsfleet Valley has proven to be a rich source of some of Britain's most important archaeological remains from the majority of archaeological periods. Above its western flanks the remnant deposits of the Swanscombe '100-ft terrace' outcrop (formally part of the wider Boyn Hill/Orsett Heath Formation) contain abundant remains from the early Palaeolithic, reflecting hominin occupation and cultural change through the Hoxnian Interglacial (MIS 11c, *c* 425,000–390,000 BP). Lower down the valley side, deposits now-quarried-away at Rickson's (Barracks) Pit may once have contained important remains from MIS 10–9, only the most elusive hints of the existence of which now survive: Burchell (1934b) found some curious lithic implements from unrecorded horizons at Barracks Pit, and Louis Leakey carried out unpublished field investigations in the 1930s when a student, copious material from which survives in the Museum of Archaeology and Anthropology at the University of Cambridge. Further down the valley side are the plethora of deposits from late MIS 8 (perhaps) and MIS 7 that have produced the later Lower/Middle Palaeolithic Levalloisian evidence for which the site is so well known amongst Palaeolithic archaeologists.

There is no evidence for early Upper Palaeolithic activity, as for much of Britain, but there is good evidence of late Upper Palaeolithic and Mesolithic activity. After the Mesolithic, there is important evidence for Neolithic and Bronze Age occupation, building towards the development of one of Britain's most extensive ritual temple complexes in the pre-Roman Iron Age and Romano-British periods at Springhead. There is also significant evidence of Saxon and early medieval activity, reflected in both traces of sunken-featured buildings (cut into the Last Glacial slopewash deposits at 3971TT), a rare tidal mill, and a major cemetery on the eastern flank of the valley (Andrews *et al* 2011). Although the Ebbsfleet Valley is now mostly an undulating grassy landscape covering deep landfill, situated between the small towns of Northfleet and Swanscombe, it has a glorious past and a rich heritage.

So, the question is: "Why the Ebbsfleet Valley?" Is it merely an accident of investigation whereby the intensity of quarrying and the chance of antiquarian investigation has led to the recognition and recovery of all these important remains? On this basis, an immense heritage resource survives, or has been destroyed, undetected in countless similarly unprepossessing localities across the country. Or is there something special about the Ebbsfleet Valley, which made it a focus for prehistoric and early historic activity, and/or a prime location for the survival of archaeological remains?

For the earlier Palaeolithic remains, there is accumulating evidence (see Chap 16) that something very unusual happened in the Ebbsfleet Valley in the Middle Pleistocene; a massive landslide that blocked off the Ebbsfleet and ultimately diverted it into a new channel. This created an embayment that served as a sump, accumulating deposits through the late Middle and Late Pleistocene. Although there were significant erosional episodes, leading inevitably to a discontinuous record, there was also significant aggradation, particularly from MIS 8 through to MIS 5, which has left a rare abundance of deposits of this period. Alongside this, the particular upheavals of the Ebbsfleet locale seem to have created a local environment with flint-bearing Chalk bedrock exposed in dry valleys and terrace banks, leading to development of various solifluction and slopewash sediments rich in nodular flint raw material. Thus, the Ebbsfleet Valley was both a landscape favouring aggradation and preservation of sediments, and also one with a rich and accessible flint raw material source. Therefore, although it may not be immediately apparent from geological mapping, and there might be similar major undetected Palaeolithic resources in several other minor tributary valleys across the chalk landscape of south-east England, there may indeed be something special about the Ebbsfleet Valley, that has led firstly to it being the focus of Levalloisian activity and, secondly, to this evidence surviving. The happy coincidence of an intensive history of quarrying and antiquarian investigation has also no doubt contributed to recognition and recovery of the Palaeolithic remains.

For later periods, it is possible that the same geological factors that influenced the deposition and survival of earlier Palaeolithic remains continued to play a role in making the locale attractive to later occupants. The relatively wide and sheltered inlet of the Ebbsfleet may have encouraged late Upper Palaeolithic and Mesolithic activity, and this may have had a knock-on effect drawing attention to the spring at the head of the Ebbsfleet as being situated in a natural amphitheatre. This then became a focus for ritual deposition in later prehistoric times before growing into a major Iron Age and Romano-British ritual temple complex. Continuing deposition throughout the Holocene of silty alluvium and peat created a good environment for the survival of archaeological remains; whether the Ebbsfleet is particularly unique in this latter respect is more doubtful; although it seems to hit a sweet spot in being not too big and not too small, so as to both allow a wide range of activity and to focus this activity within a reasonably restricted area for preservation and investigation.

Wider Landscape Issues

The complexity of the preserved sequences within the Ebbsfleet Valley has been ascribed to the small size of the Ebbsfleet catchment and the absence of a major drainage system flushing out sediments on a regular basis during times of peak discharge. This contrasts with patterns of preservation of sediments in larger systems such as the Darent to the west or the main Thames Valley. In larger valleys such as these, the main preserved deposits are fluvial terrace sequences; by contrast considerably greater variety exists within the Ebbsfleet in terms of what is preserved and from what climate episodes in the past.

Marine isotope records covering the Middle to Late Pleistocene demonstrate numerous cold/warm climatic oscillations. In the past, when smoothed and relatively simple curves were used for marine/terrestrial correlation, matching major phases of gravel aggradation with cooling or warming limbs of the major cold stages was relatively simple (*sensu* Bridgland 2006; 2010). Today, with more complex models available, matching across records is more challenging. For example, the cold event within the early part of MIS 7 (7d/7.4) is a major feature within the benthic $\delta^{18}O$ record that has been matched in the UK with major episodes of gravel deposition within the Solent and Arun systems by Bates *et al* (2010). However, similar correlations with gravel bodies in the Thames either do not exist or remain to be identified. In the Ebbsfleet we have argued here that the situation is even more complex with minor episodes of downcutting and aggradation associated with at least three warm–cold cycles of MIS 7.

Spatial variability in sedimentary records associated with events of different magnitudes and length in the Quaternary may be explained by local geomorphology including catchment size and geomorphological position of the depositional area with relationship to current and contemporary coasts. For example, within the middle reaches of major drainage basins such as the Thames, the ability of the river to adapt to regional and global change may be limited and inherent buffers in the fluvial systems may inhibit transformation of a system from one state to another until a critical barrier has been overcome. By contrast in smaller systems such as the Ebbsfleet with restricted catchments and perhaps steeper gradients than the main valleys, change may be more easily accommodated by local adjustments of base level thereby registering smaller-scale change within the climate history of the Pleistocene. In this scenario, we might envisage the Ebbsfleet reacting to the changing conditions in MIS 7 with a number of phases of deposition and erosion. If this scenario is correct the Ebbsfleet Valley appears to be unusual within southern England, although other instances of multiple terrace formation within a single marine isotope stage have been suggested in the Avon and Solent river systems (Bridgland 2010). A comparable situation of complexity has been argued for by Bates *et al* (2010) to explain the apparent age of two of the raised beaches of Sussex. The importance of these conclusions is that in future the focus of our attention for refining detailed terrestrial/marine correlations should be on seeking comparable smaller-scale systems such as the Ebbsfleet Valley, allowing correlations at a sub-stage level, and seeking geomorphological responses to change at a range of scales and contexts.

Overall, there do seem to be some unique, or at least unusual, landscape factors that have led to the Ebbsfleet Valley being the particular focus that it is of archaeological remains from a range of periods. However, it also embodies a number of factors that have disproportionately enhanced archaeological recognition and recovery. In conclusion, while there may not be many locales with the particular multi-period richness of the Ebbsfleet Valley, there are still likely to be numerous locales with important undetected remains preserved under unquarried bodies of slopewash sediments or undisturbed alluvial accumulation.

Marine Isotope Stage 7

The main outcome of the Palaeolithic/Pleistocene aspects of the pre-HS1 investigations in the Ebbsfleet Valley has without doubt been the increase in understanding of MIS 7 and, in particular, archaeological remains, terrestrial environments, depositional regimes and mammalian assemblages matching the sub-stage oscillations of the continuous marine and ice-core record. This research has been severely hampered by the inadequacies of much previous work, and frustrated by the knowledge of the fantastic resource that must once have existed and was lost to quarrying without scientific investigation. However, it has pulled together the results of previous investigations and new work done for HS1 to produce a new framework for climatic change and faunal turnover through MIS 7, evidence for which is still available for more thorough investigation in the statutorily protected sediments of the Baker's Hole Scheduled Ancient Monument (SAM) and Site of Special Scientific Interest (SSSI).

There is evidence for at least two, and probably three, distinct phases of fully-temperate woodland development, followed in each case by a transition to temperate open grassland; there is also evidence of at least one sustained phase – in the Middle Loam, at Site B – of cool, dry, open grassland conditions. The three phases of woodland development have mutually exclusive small vertebrate assemblages, supported by amino acid dating results, which suggest that they are likely to represent separate sub-stage events, here correlated with MIS 7a, 7c and 7e.

We propose MIS 7e as represented by the lower part of the sequence – Bed 2a – at the British Museum Site A, and probably also by Burchell's Lowermost Loam/Brickearth in the vicinity of the British Museum Site B. We propose MIS 7d as being represented in the build-up of Middle Loam at Site B, and the Levalloisian "floors" recorded by Burchell as therefore occurring in the transitional phase between MIS 7e and 7d, *c* 230,000 BP. We then propose phases 3776-D/E at the ZR4 pylon as most-likely representing MIS 7c, progressing upward through 3776-F to MIS 7b. We do, however, acknowledge the possibility that the Temperate Bed aggradation may alternatively be associated with MIS 7c and its cooling aftermath.

Finally, contrary to the suggestion of Candy and Schreve (2007), we see no basis for interglacial woodland not to have developed in the last warm sub-stage MIS 7a, which we here suggest is represented by the Temperate Bed aggradation at Site B, with a lower woodland episode developing into more-open conditions in its upper part.

Levalloisian in the Ebbsfleet Valley

The small Palaeolithic collection resulting directly from the HS1 work (Chap19) mostly represents derived evidence of the rich Levalloisian horizons that were once present at the site, now sadly all lost to quarrying except vestigial remnants in the vicinity of Sites B and F, in the southern part of the Baker's Hole SSSI. One particular large Levalloisian blade core, reported on in more detail, is probably from the same deposits as Burchell's "floors" (Chap 18). It provides a good example of the blade-focused laminar Levalloisian approach characteristic of Burchell's collection from this horizon, also known from the key nearby comparator site of Stoneham's Pit in Crayford, thought to be of broadly similar age (Scott 2011).

A major re-analysis is also presented here of the two main Levalloisian lithic collections resulting from previous work: (a) the APCM collection (Chap 17), collected by quarry workers at RA Smith's behest in 1909 and donated to the British Museum in 1914; and (b) the collection made by Burchell (Chap 18), probably mostly in the 1930s, from "floors" towards the base of his Ebbsfleet Channel sequence in the vicinity of what is now known as Site B.

The dating and provenance of these two collections has previously been discussed in detail in their respective chapters. Here, the important conclusions on which to focus are: (1) both collections come with their own specific problems as regards provenance and integrity; (2) there is no litho-stratigraphic link recorded between the deposits that produced these two collections (contra Scott *et al* 2010), the dating of each rests on independent grounds relating to biostratigraphical interpretation of associated faunal remains, OSL dating of litho-stratigraphically related deposits and (in the case of Burchell's collection) amino acid dating of *Bithynia* opercula surviving from his original investigations; and (3) both collections contain technological and typological variety not previously widely recognised and reported on.

The Coombe Rock deposit at Southfleet Pit that contained the APCM lithic and faunal collection has been dated to MIS 7 or earlier. The inclusion within the collection of a number of mammoth teeth of the "Ilford-type" mammoth *Mammuthus* cf. *trogontherii*, regarded as characteristic of MIS 7 (Lister, Appendix C3), establishes that at least some of the collection is potentially of MIS 7 date. However, it remains unclear whether the lithic collection can be regarded as a single assemblage, or whether it includes mixed material from assemblages made at different times, including perhaps prior to MIS 7. The co-occurrence of several mammoth teeth from *Mammuthus primigenius* suggests that some mixing of material from different periods has occurred (*cf* Lister and Sher 2001 and Lister *et al* 2005 who suggest *M. primigenius* and *M. trogontherii* may have co-existed in late MIS 7), and that the APCM collection might include lithic and faunal material from a variety of cool and warm periods in the general period MIS 8 through to mid-MIS 7. It also has to be recognised that the quarry workers who recovered the collection may have included material from other nearby deposits, as well as from the Coombe Rock.

Analysis of the condition of the lithic material in the collection did not, however, identify any differences between different technological elements of the collection that would indicate distinct derivational histories. There was little difference in the range of conditions for the handaxe and Levalloisian components of the collection, suggesting that (contra Scott 2010), there is no reason (apart from the preconception that handaxes are an early tool type) to regard the entire handaxe component of the collection as reworked and intrusive. The consistently abraded condition of the pointed and ovate handaxes does, however, suggest derivation from the nearby Swanscombe '100-foot terrace' outcrop in which these forms are known to occur commonly. In contrast, the more varied conditions of the quite abundant sub-cordate handaxe element of the APCM collection demonstrates the same range of conditions as the Levalloisian element, suggesting that these parts of the assemblage should be considered as an integral whole, rather than separated on typological/technological grounds.

For the Levalloisian material, reporting of the APCM collection has previously focused (eg, Smith 1911; Wymer 1968; Roe 1981) upon the Classic Levalloisian flake/core element, involving the removal of single, large oval radially prepared flakes from the front privileged surface of a large tortoise core. The more-detailed technological analysis presented here has, as previously reported (Wenban-Smith 1990b; 1992b; 1995) and also as more recently summarised by Scott (2011), demonstrated the presence within the APCM collection of both a significant element of laminar Broad-blade Levalloisian production, technologically similar to that at Crayford, and also the presence of recurrent Levalloisian flake production, whereby cores are subject to removal of a series of progressively smaller privileged flakes, divided by separate phases of renewed front surface preparation. Nevertheless, many cores were still abandoned at a large size and prominently displaying the flake scar of a successful Levalloisian removal. Considering the wastage of usable flint demonstrated, this is interpreted as a socially meaningful act, displaying both prowess of the knapper and an extravagant consumption of lithic resources.

An attempt was made to investigate the organisation of production represented in the assemblage, and its role within the wider *chaîne opératoire* represented at the site. Contra the standard, and naturally intuitive, explanation of the site as a Levalloisian flake production location conveniently located by the raw material source (for instance as most recently articulated by Scott *et al* 2010) this analysis suggested that the assemblage was disproportionately dominated by retouched flake tools and flakes from the later stages of production, suggesting a site to which part-prepared cores were bought, and their knapping completed, and where flake tools and cores were typically abandoned. However, the low integrity of the collection might not support this level of analysis, as the thick and more cortical flakes from earlier stages of production may be under-represented in the assemblage due to either bias at the initial collecting stage, or subsequent discard at the early analytical stage prior to removal to the British Museum. Nonetheless, this analysis is presented both as an example of a new avenue of lithic research that could usefully be pursued on other collections, and to stimulate consideration of alternative interpretations of the APCM collection in particular.

The most important part of Burchell's large lithic collection from the Ebbsfleet Valley is that provenanced by him to his Levalloisian "floors" from the "Lower Gravel" at the base of his Ebbsfleet Channel sequence, between the so-called "Lower Loam" and "Lowermost Loam". This material, the fresh condition parts of which can reasonably treated as a coherent assemblage, has been dated here to the period corresponding with the transition from substage MIS 7e–7d, *c* 230,000 BP, being sandwiched between the "Lowermost Loam", for which amino acid dating and biostratigraphy suggest an early MIS 7 temperate substage date, and the "Middle Loam", which (a) is a slopewash deposit with molluscan evidence indicating a sustained period of cool dry conditions (here related to MIS 7d), and also (b) underlies the Temperate Bed, here thought most likely to relate to MIS 7c. Thus, although the age of this material is much more precisely pinpointed than that comprising the APCM collection, it is not necessarily very different. It is important to note that the Coombe Rock deposit that directly underlies Burchell's Ebbsfleet Channel sequence has no recorded litho-stratigraphic relationship with the Southfleet Pit Coombe Rock, so the assemblage from Burchell's "Lower Gravel floors" cannot be *a priori* regarded as post-dating the APCM collection on litho-stratigraphic grounds.

Technologically, this assemblage shows a broadly similar range of Levalloisian knapping strategies as the APCM collection, with both Classic Levalloisian flake/core knapping strategies and laminar Levalloisian Broad-blade production. There is, however, a relative lack of fresh condition Classic Levalloisian flake cores. This absence could be due to bias in the collection imposed by the retention by Burchell, and the various people to whom he gave artefacts, of the very desirable classic flake cores, rather than a real feature of the archaeological material. There is evidence in the fresh condition debitage for, an admittedly small, component of linear and recurrent Classic Levallois flake production. This occurs alongside a much greater prevalence of debitage representing laminar Broad-blade Levalloisian production, for which there are also several cores in fresh condition. The main difference with the APCM collection is the much greater predominance of laminar Broad-blade production compared to Classic Levallois flake production. Burchell (1936c) drew attention to a number of handaxes from these floors. However, these handaxes are mostly in abraded condition, and a pretty sorry bunch, with none of them indisputably intentional core-tools, apart from one small abraded and pointed form that is almost certainly derived from the nearby Swanscombe '100-ft terrace' outcrop. The others could easily be bifacial remnants of cores, rather than deliberate core tools. So, it does appear that another apparent difference with the APCM collection is the absence of handaxes from Burchell's floors.

Organisational analysis was also attempted for this material, although interpretation of the results was likewise problematic. As for the APCM collection, the analysis seemed to show a disproportionate presence of debitage from end-stages of production. This could be explained in various ways, most likely due to biases in collection, or due to inadequacies of the experimental models upon which the analysis was based.

In a wider regional and national context, the evidence of Levalloisian activity in the Ebbsfleet Valley has been pinpointed not just to MIS 7, but to the earliest part of it, specifically the period embracing the end of MIS 7e and the start of MIS 7d, represented by Burchell's "floors" towards the base of his Ebbsfleet Channel sequence. The date represented by the APCM collection is more poorly constrained, and covers the general period MIS 8–7. It also remains uncertain whether the APCM collection represents a single coherent assemblage, or whether it includes mixed material from different periods.

The evidence for Levalloisian occupation in the Ebbsfleet Valley at the start of MIS 7 matches current thinking that there is a sudden expansion in Britain of Levalloisian technology in the period MIS 8–7, for instance as represented at Crayford, Botany Pit and West Thurrock (Bridgland 1994; Schreve *et al* 2006; Scott 2011). The date of Levalloisian occupation at Purfleet is less certain; although some suggest its presence before the end of MIS 9 (Bridgland *et al* 2013), there remain question-marks over how the date of the Levalloisian material ties in with the well-dated MIS 9 deposits. The attribution of deposits containing Levalloisian material to MIS 9 is not based on independent evidence of climate or date; rather, it relies upon lateral correlation of different sediment bodies lacking direct lithostratigraphic connection. The sediments with Levalloisian remains could thus be as likely to date to MIS 8 as MIS 9. Interestingly, all the rich Levalloisian sites are within the Lower Thames Basin; there is little good, and well-dated, evidence of Levalloisian activity outside this area. Whether or not this is an accident of research, or genuinely represents the Lower Thames as a core region of Levalloisian presence in the UK at this period requires further investigation. A second area requiring further investigation, is how/whether this expansion of Levalloisian activity in MIS 7 can be tied in with specific sub-stages and with evidence from nearby continental Europe, and whether there is any coherent evidence of a trajectory of material cultural change in Levalloisian production techniques through the period MIS 8–7.

It also needs to be considered whether Levalloisian and handaxe manufacturing strategies were differentially applied across the landscape by a single hominin cultural network with a diverse knapping repertoire, or whether these different and technologically contrasting knapping approaches were the domain of distinct networks, each with a more restricted technological repertoire. The evidence presented here suggests that handaxe manufacture and Levalloisian technology co-occurred in the APCM collection, but not in the collection represented by the material from Burchell's "floors", where only Levalloisian technology appears to be present. Taken alongside the evidence from broadly contemporary handaxe manufacturing sites such as Harnham (Bates *et al* 2014) and Cuxton (Wenban-Smith *et al* 2007a), which have been dated to late in MIS 8 and early in MIS 7 respectively, it appears that both technologies were occurring in the same general period. In contrast therefore to earlier periods – for instance as in MIS 11, where it is now clear that there was a distinctive non-handaxe Clactonian phase of occupation early in MIS 11, followed by later development within the same warm stage of a handaxe-dominated tradition (Wenban-Smith *et al* 2006; Wenban-Smith 2013) – perhaps we should embrace the possibility that hominins of this later period possessed the capacity for a more varied material cultural repertoire across the landscape; indeed this could have been an important aspect of "Becoming Neanderthal" (*cf* Scott 2011).

Later Prehistory

From the outset of both the HS1 and STDR4 projects much focus was given to the potential of the Ebbsfleet Valley sequences to preserve evidence of activity for periods following the Last Glacial Maximum – the Late Glacial and Early to Middle Holocene periods. Burchell's early investigations had revealed evidence of rare late Upper Palaeolithic activity at Springhead in the form of a Long Blade assemblage, and in the valley bottom the eponymous site from which Neolithic Ebbsfleet Ware takes its name. HS1 Investigations at Springhead did not disappoint and the flint assemblages described in Chapter 20, albeit essentially redeposited in slopewash deposits, are an important addition to the corpus of regional evidence of late Glacial–Early Holocene transition. Similarly, investigations in the valley bottom, particularly associated with STDR4, produced further evidence of Neolithic activity which included a fragmented Ebbsfleet Ware bowl (Chap 21). Discussion of the wider significance of these discoveries along with associated evidence has been reviewed by Chris Hayden at the end of each respective chapter.

Perhaps surprising, however, was the amount of Bronze Age evidence that was recovered from the valley overall. Apart from the possible barrows, cremation deposits, and burnt mounds at Springhead and Northfleet Villa, apparently isolated artefact scatters, small clusters of pits and concentrations of worked wood were recorded in trenches, excavations and watching brief areas across the valley. It was not until the post-excavation stage, when the evidence from all stages of work from this complex project was brought together, was it fully appreciated the evidence was perhaps more substantial when viewed within the wider landscape context (Chaps 21 and 22). Although the evidence is admittedly equivocal, the suggestion that the concentrations of worked wood may represent the remains of trackways or routeways through the valley, linking the Thames to areas of activity at the wetland edge and the higher ground beyond Springhead, is an intriguing one, particularly taking into account the remains of the possible piled bridge structure recorded during the watching brief stage. If correct, the evidence contrasts somewhat with other trackways recorded in the Lower Thames area, skirting the edges of the wetland along the valley contours, rather than traversing the marsh itself. The bridge itself is a rare example, its dimensions and plan is almost a carbon copy of a structure excavated on the north bank of the Thames in Newham (Stafford *et al* 2012, figs 10.5 and 10.6), albeit of slightly later date.

Overall the combined size of the exceptional post-glacial worked flint assemblage recovered during various phases of investigation for HS1 and STDR4 amounted to *c* 12,500 items, spanning the Late Glacial through to the later Bronze Age periods. Detailed analysis was carried out on elements of the assemblage considered to be *in situ* or material that had clearly not moved far from its original place of deposition. However, the material redeposited in later features and deposits is of value and formed a sizeable component of the assemblage, much dating from the Late Neolithic/Early Bronze Age, and perhaps hints at a more intensely utilised landscape than indicated by the distribution of surviving features alone.

Infrastructure Projects, Methods and the Archaeological Heritage

Infrastructure projects of the scale of HS1 bring investigative resources of a scale beyond the dreams of the purely academic world. The counterpoint to this is that they also have a major archaeological impact, with the investigative strategy and methods not determined purely by academic research programmes, but also by curatorial research frameworks and archaeological consultants. In the first place, we want to emphasise that in our experience those involved in this and other development projects – at every level from site worker to senior management – recognise the wider cultural value of a mediated heritage. And in the case of HS1 a great deal of time and attention has been devoted by HS1 archaeologists, curators and external specialists to designing and implementing a programme of evaluation and mitigation in the Ebbsfleet Valley. At this point, it is worth reviewing in retrospect the successes, challenges and difficulties encountered during this project in the context of future developments on this scale, or indeed on any scale. These comments are presented in a constructive light; it has been a privilege to have maintained such a long-standing relationship with such a major project, including the hard work of such a wide range of collaborators from the consultants and archaeologists working for HS1, the various curators and the very numerous staff of Oxford Archaeology and Wessex Archaeology with whom the fieldwork was carried out. Much very good work was carried out, in particular perhaps the series of investigations for the ZR4 pylon where the evaluation of each separate footing led to the development of separate sampling and mitigation strategies in the two deeper uplift footings, the results from which contribute to a wholly new understanding of Marine Isotope Stage 7 in Britain (Chaps 5 and 16).

Firstly, archaeological investigation was driven by, and carried out under, the statutory framework of the enabling bill under which HS1 was constructed, with archaeological work being approved by a curatorial committee – the Statutory Consultees – made up of regional English Heritage advisors and relevant local authority curators. Without this vital statutory framework, and the vigilance of the Statutory Consultees, some good work was done that may not otherwise have taken place.

There are two areas where useful comments can be made: specific issues that arose in course of the HS1 work in the Ebbsfleet Valley, and general principles for archaeological work in advance of large-scale development. Concerning the former, there were some difficulties in dealing with the significant Palaeolithic/Pleistocene aspects of the archaeological heritage of the Ebbsfleet Valley. Even though a separate Palaeolithic/Pleistocene research framework for the HS1 work in the Ebbsfleet Valley was prepared (Roberts 2000), it proved difficult to implement some of its recommendations in practice. Even though this research framework clearly specified core goals such as 'to link the classic Spurrell, Burchell and British Museum sequences with the more complex depositional sequences deeper in the valley' (Roberts 2000, 10) and 'to place the Ebbsfleet deposits in a secure litho-stratigraphical, chrono-stratigraphical and bio-stratigraphical context that enables intra and inter valley correlation' (Roberts 2000, 11), it proved difficult to bring the necessary resources to bear to achieve these aims.

As is clear from Part II of this volume, one of the challenges of reporting on this project has been to integrate the results from hundreds of separate boreholes and stepped trench interventions. One of the key lessons from the longer stepped trenches (eg, 3972TT – Chap 10) is that the Pleistocene deposits of the Ebbsfleet Valley did not cover broad horizontal swathes, but varied greatly over short distances. Clearly it would have been excessive to implement a network of stepped trenches across the whole of the Pleistocene resource; however, any attempt to develop an accurate integration of deposits across wider areas requires examination of continuous sections at key locations.

This exemplifies a wider issue that the key chrono-stratigraphic framework objective of Palaeolithic/Pleistocene investigation, and its reliance upon palaeoenvironmental remains, was perhaps less implicit than for the later periods with definable buildings, features and earthworks. Other similar issues affect Palaeolithic/Pleistocene investigations across the country, concerning how and whether to carry out geological recording, environmental sampling, and lithic recovery. These issues need to be addressed by more engagement of the Palaeolithic/Pleistocene community with the curatorial and consulting community – although in this instance we would like to place on record our appreciation of the fact that the Kent County Council curatorial member of the Statutory Consultees is exceptional in this regard. It is necessary for Palaeolithic and Quaternary specialists to be more proactive in communicating and explaining the nature and objectives of Palaeolithic/Pleistocene research and the potential of different types of evidence and strategies of investigation. Recent useful steps in this direction have been the English Heritage (2008) *Research and Conservation Framework for the British Palaeolithic* and the numerous regional research frameworks, eg, for the South-East and Solent–Thames regions (Wenban-Smith *et al* 2010; Hey and Hind 2014) that have emphasised the inter-dependence of Palaeolithic archaeological and Quaternary geological and environmental investigations.

There were also some more general issues that related less to the specifically Palaeolithic/Pleistocene aspects of the work, but inevitably resulted from the sheer scale and complex programme of work. In some instances, sampling for mitigation was carried out during the evaluation phase of test pitting. In such cases, standard evaluation methods may require modification, vitally, provision of direct access to deeper sequences to record and sample in detail from exposed sections. This strategy is more labour intensive and does tend to produce a considerable volume of samples that require appropriate storage. In addition, a more considered or targeted specialist assessment is required which takes into account the availability of a range of specialists, budget, duration of the overall post-excavation programme and avoids duplication of results. Large quantities of unprocessed samples from waterlogged organic deposits, particularly bulk samples, are logistically difficult to store indefinitely without some level of degradation occurring. Where possible initial sample processing should be considered as soon as possible following fieldwork, particularly if there is likely to be a time lag between fieldwork, assessment and analysis.

Our approach to investigating the HS1 and STDR4 footprint was outlined previously (Chap 3) and the fact that we have been able to progress a series of field interventions, incorporating a very significant number of boreholes, trenches and area excavations, within a progressive framework where one phase of investigation informed and led to a refined subsequent phase of investigation indicates the success of the approach. The intensity of the field investigation has provided us with an unparalleled perspective on the nature of Quaternary landscape change and variability within a very restricted area of the Ebbsfleet Valley. We would argue that our approach, at the landscape scale with refinement to local site specific scale only where required, was the only way in which to adequately address the problems not only of the size of the site but which also reflected the complexity of the site. There is no doubt that detailed information from individual interventions has not been picked up and remains within the archive of information perhaps for future generations to identify and interpret, however, time and resources required a clear focus on the landscape scale of investigation at the site.

When examining the distribution of archaeological interventions within the various phases of work, it should be recognised – in contrast to purely research driven landscape projects – the degree of development impact on areas considered to be of high archaeological potential was the primary concern for all. To some extent, from an interpretative point of view, this was offset by the very large number of interventions spread across the landscape. The number and size of interventions undertaken for an area of this size and complexity are probably unprecedented and reflect a step change in our understanding perhaps of what it takes to really begin to understand a landscape of this type. Perhaps thankfully for the world of Quaternary Science the Ebbsfleet Valley 'sump' appears atypical of many parts of the major river valleys of southern England and therefore cannot necessarily be used as a yardstick for judging the adequacy of future investigation strategies at other sites in the UK.

The range of approaches to fieldwork and their success need also to be viewed against the extended lifespan of the field project, with targeted archaeological fieldwork spread over six years, preceded by numerous geotechnical engineering interventions. In 1997 work at Ebbsfleet Rise utilised a fairly basic geophysical approach using Surface Direct Current (DC) electrical soundings along a single transect to examine sub-surface geo-electrical properties. Since then more sophisticated methods have been used at the Thames River Crossing (Bates and Stafford 2013) and elsewhere in southern England (Bates *et al* 2000; 2007). Today were we to be designing the field programme in the footprint of the HS1 development it is likely more use would be made of this approach (certainly for the Holocene) with a concomitant reduction in the number of boreholes in some places.

The use of a range of different types of physical interventions can also be addressed. While there is no doubt that at an early stage in the project the use of machine excavated test pits, to which access was difficult, did provide baseline data for understanding the landscape and directing survey in later stages of the project, they have only provided supporting evidence in most cases during the analysis stage of the project. As previously noted, it is clear from this study that within a landscape such as that in the Ebbsfleet only through large, stepped or shored trenches (where applicable) can the sediments, their associated archaeology or biological material and context be understood. This is because of the considerable lateral variation in sequence that is a result of the complex nature of the Ebbsfleet. Long sections exposed in trenches cut between test pits have clearly demonstrated the difficulties of attempting to draw correlations between test pits only a few metres apart. Furthermore, it is only through examining long sequences through the deposits that the often discrete pockets of fossiliferous material can be identified. This observation is important for curatorial staff attempting to judge the success and significance of a test pitting programme within an area of landscape such as the Ebbsfleet.

The landscape approach to the investigation was also developed in order to attempt to use this information in a predictive way to identify locations in the landscape at which archaeological material might occur. This was principally adopted in the Holocene areas of the valley where the methodology outlined by Bates and Stafford (2013) within the alluvial corridor of the Thames was applied to the Ebbsfleet. The success of this approach is best illustrated by reference to the four major cofferdams excavated within the STDR4 corridor. The location of the trenches was predicated on location in landscape relative to known and perceived areas of likely past human activity. All four trenches produced significant archaeological remains. This success was also replicated in identifying the position of a similar trench at the southern portal crossing of the Thames (Bates and Stafford 2013) where late Upper Palaeolithic as well as Neolithic archaeology was found at the base of the alluvium. This approach to prediction worked well within the Holocene zones because of the relative complete and laterally continuous preservation of the Holocene sequences remaining within their landscape context of deposition. By contrast the fragmentary nature of the Pleistocene deposits, within a modern landscape bearing little similarity with the pre-quarrying landscape, and even less to the landscapes associated with the environments of deposition of the sediments, has made it much more difficult to predict how and where sediment bodies are likely to exist sub-surface and what their relationship to archaeology was likely to have been. Consequently, a predictive mapping exercise for the Pleistocene deposits is significantly reduced and remains more heavily reliant on direct observations of sequences through purposive investigation.

The implementation of a watching brief as the mitigation option on Pleistocene deposits in some areas did prove particularly challenging in the context of this large project. For example, the calcareous gravel at the south-east end of 3972TT and the Coombe Rock of the Chalk Spine. Such an approach requires a suitable specialist to attend site full-time when specific and relevant ground works are taking place and requires clear lines of communication and agreed working methods between archaeologists, managers and contractors.

A major consideration with watching briefs during major groundworks is the safety and practicality of any meaningful archaeological recording. It is rarely a suitable strategy for investigation of known remains whereby delays to the contractor's programme to allow recording to take place can have significant implications. While watching brief is a useful adjunct to the archaeological arsenal, it should be deployed primarily as a precautionary measure to ensure against the discovery of important, but as yet unknown remains.

The scope of works associated with the HS1 and STDR4 works was designed from the outset to integrate fully with the engineering works and impacts along the route corridors for construction. As noted previously the location of all interventions (boreholes, test pits, trenches, excavation areas) was predicated on the engineering scheme and the schedule of the works. From the earliest works on the project it was recognised that important issues regarding the likely location of buried archaeological and palaeoenvironmental deposits would have an impact on the timescales for the construction of the routes and their associated infrastructure. As outlined by Bates and Stafford (2013) the key to developing a successful strategy to investigate the buried sequences was dependent on developing a strategy that was able to identify locations at which archaeological risk (ie, the likelihood of discovering archaeological material) was high as well as being flexible enough to cope with changing engineering constraints and new opportunities for investigation through the lifetime of the project. Additionally, in a project with a field time duration of some 10 years or more from start to finish, the impact of new technologies on the range of possibilities for investigation also needed to be taken into account. Developing such a strategy therefore involved the implementation of approaches on an area by area (zones) basis within a standardised approach to investigation. From the engineering perspective, our approach sought to ensure:

- The methodology was flexible and capable of being implemented at any point within the impact areas;
- The methodology and results could integrate with and be refined/tested by further geotechnical investigations, archaeological purposive investigations or observations/recording made prior to, or during, scheme construction;
- The methods used maximised information gain, minimised costs, and specifically targeted information unavailable at the start of the project (as required for evaluative purposes);
- Data generated were capable of being verified/falsified by subsequent supplementary or purposive field investigations and/or mitigation measures;
- Data generated were sufficiently reliable to be accessed to archive, and robust.

In the majority of cases the integration between the phases of archaeological intervention and engineering programme worked well and most areas of the site were adequately investigated through the combined approach outlined. Working within the devised program, no delay to the engineering programme was encountered or created as a result of the archaeological program. The only exception to this was the discovery late in the day of the Southfleet Road Elephant. However, this discovery (reported on separately – Wenban-Smith 2013) was made in an area of wider infrastructural impact beyond that of the core station and rail link, which were the focus of targeted archaeological work.

Conclusion

The HS1 and STDR4 work has provided a vital umbrella under which to pull together and investigate the disparate Palaeolithic and later prehistoric researches of more than a century, since Spurrell's first examination of a newly excavated pit rail cutting in the 1880s. With reference to the Palaeolithic/Pleistocene resource, although virtually all the original deposits are now gone, it has been possible to: (a) clarify the rough period and likely degree of integrity of the seminal APCM lithic and faunal collections; (b) establish an improved framework for MIS 7, with clear evidence of three distinct fully temperate episodes characterised by well-differentiated mammalian assemblages; and (c) place the higher-integrity Levalloisian discoveries of Burchell within this framework, early in MIS 7. We have also provided a methodological case study of how the history of climate change and landscape development can be investigated at a particular locale, and how the events of subsequent human behaviour in a landscape are intimately integrated with its geological history. Finally, in a world of ever-increasing infrastructural development, we have embarked on a valuable learning curve for investigation of the environmental, and particularly archaeological, impact of such projects – one whose experience and lessons we hope will feed into subsequent developments of similar scale.

Along with the accompanying Ebbsfleet elephant volume (Wenban-Smith 2013), this is the first time that a major Palaeolithic project has been brought to publication entirely through developer-funding. By demonstrating what can be achieved, the work in the Ebbsfleet Valley has specifically helped to raise the profile of Palaeolithic archaeology as a mainstream concern in developer-funded archaeology, and for this HS1 is to be commended for their support. Palaeolithic specialists, perhaps more than archaeologists from other periods, benefit most greatly from large-scale development that exposes deep-lying deposits to reveal important new discoveries. The history of archaeological discovery in the Ebbsfleet Valley begins with the start of quarrying in the late 19th century, and will no doubt continue in the 21st century as 'Ebbsfleet' is reinvented as a new settlement on very ancient foundations. Exceptionally important Palaeolithic investigations on this scale, where they are accompanied by an appropriate level of research and publication, can be regarded as a positive benefit arising from the development, rather than merely as 'mitigation' of an environmental impact.

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Index

by Chris Hayden

The construction of High Speed 1 (HS1; formerly the Channel Tunnel Rail Link) entailed a major programme of archaeological investigation across Kent, Essex and Greater London. In the Ebbsfleet Valley, a small tributary of the River Thames, a remarkable array of archaeological evidence was discovered, attesting to human occupation spanning a period of 400,000 years.

This volume is the last in a series of HS1 archaeological reports for the Ebbsfleet Valley. It also incorporates evidence recovered during the construction of the South Thameside Development Route 4 (STDR4), a road upgrade funded by Kent County Council for the new Ebbsfleet International Station. The focus is the prehistoric landscapes and human occupation of the valley and its hinterland, from the Palaeolithic through to the Early Iron Age. This period incorporates fluctuating extremes of climate between harsh sub-arctic conditions when southern Britain would have been a frozen and uninhabitable treeless waste, and warmer interludes, when luxuriant forest was interspersed with grassy plains, rich in what we would now regard as tropical fauna, such as lion, hippopotamus and hyaena.

New scientific data, including amino acid and luminescence dating, is used to develop a framework of the changing environment of the Ebbsfleet Valley, providing a context for the prolific numbers of artefacts recovered by antiquarians and archaeologists during the 19th and 20th centuries.

A reappraisal of the Palaeolithic flint artefact collections from localities within the valley, such as Baker's Hole and the Ebbsfleet Channel, is also presented.

Evidence for prehistoric occupation following the end of the last glacial period includes Late Upper Palaeolithic and Mesolithic flint scatters, Neolithic Ebbsfleet Ware pottery and a series of Bronze Age timber structures, routeways and burnt mounds. At the head of the valley around the springs – later the site of a Roman temple – and beneath the foundations of Northfleet Roman Villa lay the remnants of Bronze Age barrows with cremation burials. In the lower part of the valley, close to the River Thames, this activity is set within a myriad of wetland environments, from saltmarsh to freshwater reedswamp and alder carr. By the Iron Age, activity becomes more sporadic as estuarine conditions expand under rising sea levels and faunal remains include dolphin or porpoise alongside cormorant.

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