Evidence of the Palaeolithic: A Digital Reconstruction, Prior to the Landfill, of Rookery Farm, Lower Kingswood, UK

Julie. E Scott-Jackson, William. B. Scott-Jackson

Evidence of the Palaeolithic: A Digital Reconstruction, Prior to the Landfill, of Rookery Farm, Lower Kingswood, UK

Julie. E Scott-Jackson, William. B. Scott-Jackson

The PADMAC Unit
Oxford, UK

This work should be cited as:

Authors:	Julie. E. Scott-Jackson William. B. Scott-Jackson
Year of publication:	2014
Title:	Evidence of the Palaeolithic: A Digital Reconstruction of Rookery Farm, Prior to the Landfill, Lower Kingswood, Surrey, UK
Publisher:	The PADMAC Unit. Oxford. UK
Copyright:	© Dr Julie Scott-Jackson

Any queries about this book should be addressed to:

Julie Scott-Jackson. julie.scott-jackson@arch.ox.ac.uk

British Library Cataloguing-in-publication Data
A catalogue record for this book is available from the British Library

ISBN: 978-1-910325-00-1

Printed on demand as pdf from:
http://users.ox.ac.uk/~padmac/rschinfo.htm

Contents

List of Figures and Tables

Preface

In all good detective stories there are several facets to the plot. Identifying the facts that matter and those which are no more than a distraction, is vital to solving the mystery.

A classic example of an abstruse situation and the approach taken to determine both the location of a previously reported Palaeolithic knapping-site (now seemingly destroyed and buried beneath rubbish in a landfill site) along with the integrity of the recently identified Palaeolithic surface-scatters/sites on the high-level plateau at Rookery Farm, Lower Kingswood, Surrey, are addressed in this geoarchaeological research report. Surface-scatter/site investigations are generally considered 'difficult' in the sense of understanding site-formation and ascertaining archaeological integrity. As surface-scatters (particularly those on high-level plateaus and hilltops) may be the only evidence of a Palaeolithic presence in a region/country and could be indicative of embedded (i.e. in situ) site/s at that specific locale. This is an important challenge to be addressed.

In 1999, the PADMAC Unit was set up (at the University of Oxford) with the first guide to investigating and excavating high-level Palaeolithic surface-scatters/sites published in 2000 (Scott-Jackson, 2000). The prescribed techniques use methods and concepts of the earth sciences that have, by definition, been extended to the study and interpretation of sediments and landscapes. The Unit continues to develop the modelling framework which includes geophysical techniques, geospatial 3D modelling, spatial analysis, soil/sediment analysis and artefact techno-typological analysis and to expand the range of techniques and methodologies for the investigation and excavation of Palaeolithic surface-scatters/sites in various environments (Scott-Jackson, 2011).

This range of techniques and methodologies have now been widely deployed both in the UK and the Middle East (see http://users.ox.ac.uk/~padmac) in areas of Palaeolithic research as diverse as: resolving competing 'Out of Africa' models; early hominin use of the landscape; landscape exploitation; migration patterns and population change; lithic procurement; stone-tool manufacture (techno-typological analysis); usage of stone-tools and inter-regional (and arguably inter-species) comparative analysis of these various factors. It is anticipated therefore, that this research report will serve as a useful addition to the Palaeolithic archaeological record of Rookery Farm, Lower Kingswood.

Julie. E. Scott-Jackson
Oxford
April 2014

Acknowledgements

Financial support for the PADMAC Unit research was provided by Oxford Strategic Consulting Ltd, for which I am most grateful.

I am also especially indebted to the 'Policy & Environment Department' of Reigate and Banstead Borough Council for making available: the results of the Rookery Farm, 1988, 1993, 1994 and 2012 borehole and trial pit investigations commissioned by Surrey County Council and Reigate & Banstead Borough Council; annotated maps; Banstead Urban District Council letters relating to the Rookery Farm landfill construction and the Surrey County Council ecological assessments.

Special thanks are accorded to Reynolds Geo-Science Ltd, Surrey Archaeological Society and 'The Plateau Archaeological Group' for practical assistance.

Author Contributions

Julie Scott-Jackson designed the research, analysed the results and wrote most of the manuscript; William Scott-Jackson modelled the geophysical and geo-spatial data. Alice Thomas and Helen Walkington undertook the reconnaissance-level survey and produced the raw particle-size data; Vicky Winton analysed the Palaeolithic artefact assemblage.

Introduction

The study of the Palaeolithic surfaces scatters/sites at Rookery Farm, Lower Kingswood, Surrey UK. (hereafter RFLK) has increased exponentially in recent years following the well documented discoveries in the 1950s and 1960s by L.W. Carpenter (1955; 1956; 1960; 1963) of Palaeolithic artefacts as surface-finds and then, in 1959 when a landfill site was being constructed in this area, an embedded Palaeolithic knapping floor, which he described as being situated on the edge of the plateau overlooking a small dry valley. Subsequent infilling of this valley is reported to have destroyed and buried the knapping floor.

To better understand the integrity of the RFLK surface-scatters/sites *per se* and the associated Palaeolithic artefacts, the PADMAC Unit (University of Oxford) embarked on a long-term programme of geoarchaeological research. Central, and indeed crucial, to this research were data relating to the results of the RFLK borehole and trial pit investigations commissioned by Surrey County Council (hereafter, SCC) and Reigate & Banstead Borough Council (hereafter, RBBC). Boreholes were drilled around the edge of the site in 1988 (Sondadores Ltd, 1989 (hereafter, SDL 1989)), for landfill gas monitoring purposes by SCC waste disposal section. Further comprehensive site investigations were conducted in 1993 and 1994 (for RBBC) by the Environmental Assessment Group (hereafter, EAG, 1993, 1994). And more recently (2012) RBBC appointed Leap Environmental Ltd. (hereafter, LEAP 2012) to undertake intrusive site investigations and to install additional gas monitoring wells.

The results of all three investigations and additional material, in the form of annotated maps, Banstead Urban District Council (hereafter, BAN) letters regarding the tipping at Rookery Farm and ecological assessments by SCC, were made available to the PADMAC Unit through the Policy & Environment Department of RBBC. The (SCC/BAN/RBBC) comprehensive datasets provided the core information for the PADMAC Unit's geospatial modelling and spatial analysis of the RFLK area. Supplementary information was derived from the results of the series of systematic field surveys of RFLK and the surrounding areas undertaken by the PADMAC Unit (2000-2003) using a variety of established soil/sediment analyses and geophysical techniques/ methodologies.

To determine the potential of the RFLK Palaeolithic assemblages to yield information on early human technological behaviour, we also undertook a techno-typological analysis of RFLK artefacts in the Plateau Archaeology Group Collection (Surrey Archaeological Society) and the Walls Collection (British Museum) and compared and contrasted these results with data the PADMAC Unit had obtained from the investigation of two other high-level Palaeolithic sites on deposits mapped as Clay-with-flints in the UK. Namely, Wood Hill, East Kent, (Scott-Jackson, 2000) and Dickett's Field, Alton, Hampshire, (Scott-Jackson & Winton, 2001; Winton, 2004, Cuthbertson, 2013). Also, the raised-beach Palaeolithic site at Boxgrove, Sussex (Mitchell, 1998).

Although it is not the express intention of this study to provide a comprehensive list of the numerous investigations conducted at RFLK and in the immediate area, the significant findings and advances that various discoveries have made are addressed in the context of the results of the research conducted by the PADMAC Unit.

Section 1: Evidence found and lost; a brief overview of the significant archaeological investigations at the Palaeolithic site/s at Rookery Farm, Lower Kingswood, Surrey.

The Palaeolithic surface-scatters/sites (Ps-s/s) at RFLK are situated on a discrete plateau (British National Grid OS reference TQ 245 542) of the North Downs (~O.D.170m) in an area mapped as Clay-with-flints (Figure 1).

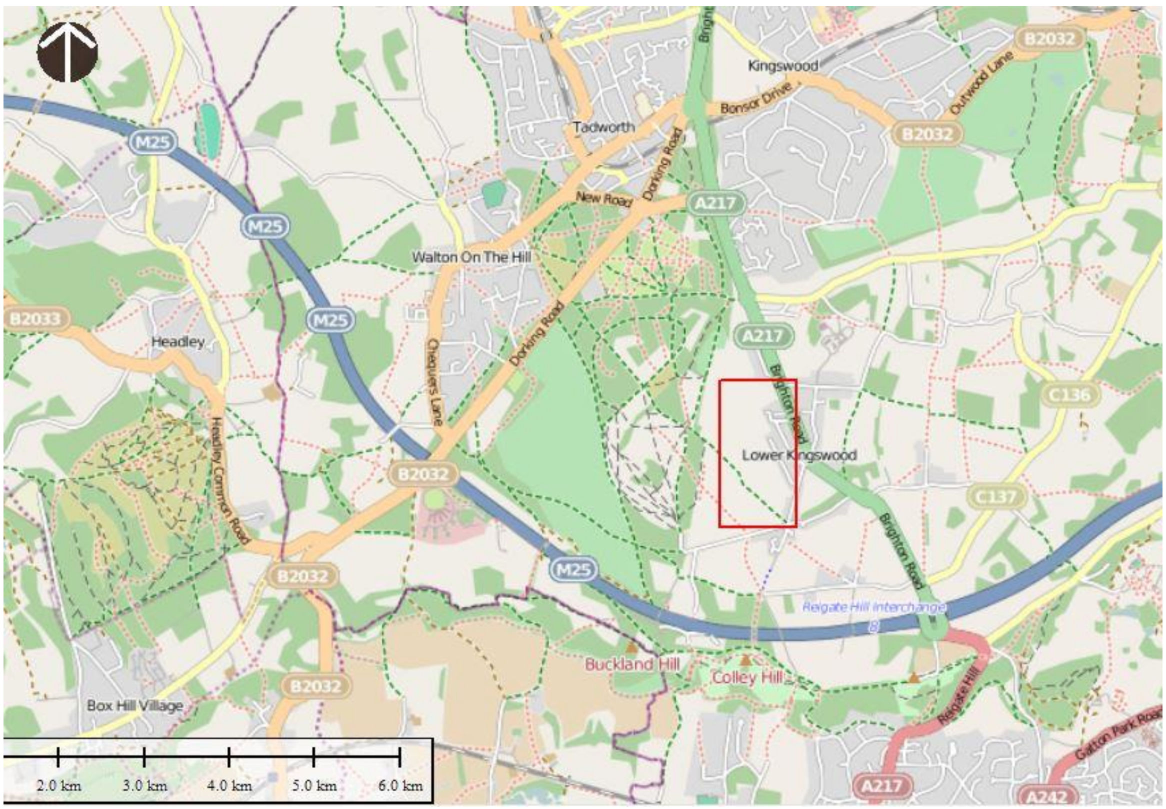


Figure 1: Location of Rookery Farm, Lower Kingswood, Surrey, (Global mapper using Openstreetmap download)

As such, it is similar to other high-level Ps-s/s found across the Downlands of southern England (Scott-Jackson, 2000). The land immediately surrounding RFLK was, until World War I, mainly uncultivated heathland but after World War II the heathland was cleared and the area deep-ploughed. A notable feature of RFLK, at this time, was a deep narrow elongated dry valley running from a high point in the south, extending northwards through the centre of Rookery Farm and down towards an area known as Hogden Bottom. In 1951 permission was granted to Banstead Urban District Council (the name of which changed over time to RBBC) for controlled tipping in the valley, starting at the lower (northern) end. Today nothing can be seen of this valley: the farm buildings have been demolished and now the fields extend seamlessly across the landfill site to what is essentially, the opposite sides and ends of the valley.

The discoveries of Leslie. W. Carpenter at RFLK in the 1950s and 1960s.

During the 1950's and 1960's, Leslie. W. Carpenter (1955; 1956; 1960; 1963) fieldwalked the Lower Kingswood area and the adjacent Walton and Banstead Heaths (Figure 1). Many of the artefacts found by Carpenter during this period are described as Palaeolithic handaxes and flakes, most of which appeared to have been brought to the surface by the deep ploughing. After 1956, his fieldwalking was curtailed as cultivation in the locality decreased. Three years later however, in the autumn of 1959, Carpenter made an important discovery in the RFLK area. He records that:

…'a small dry valley or coombe on the edge of the plateau at Lower Kingswood had all the top soil removed by bulldozers and scrapers. The top soil was heaped up around the perimeter, while the floor of the valley was raised by dumping of ashes, clinker, and hard rubbish and the top soil subsequently re-spread. This soil removal exposed the old Clay-with-flints surface which seems to lie mainly between 18 inches and 3 feet below the present agricultural surface. The cleared area was carried up to just above the 550 feet contour line. After scouring by autumn and winter rains the surface could be searched for worked flint, … at first no trace of Palaeolithic worked flint could be found but at length in the S. W. corner of the cleared area and just above the 550ft. contour line I found the ovate, embedded in the Clay-with-flints. An intensive search on this spot soon revealed other specimens and numerous flakes. Most of the illustrated flints and flakes [see Carpenter, 1960] were found embedded in the surface of this corner or were dug from just beneath the surface. Others, of course, may have been scraped off the clay surface and become buried in the soil mounds … The flints found embedded in this clay are all deeply patinated and frost bleached, and show the characteristic thermal fractures due to the extremes of temperatures encountered during the last great glaciations'… and… With the recovery of the hand axes and other pieces together with eighty-three flakes from this small site there seems little doubt that here we have the remains of a Palaeolithic working floor, one of the several that must have existed on this plateau. The culture would appear to be Middle Acheulian and is probably contemporary with the material which has recently been excavated from the Middle Gravels at Swanscombe' (Carpenter 1960:99-100).

The work of Tom Walls and Jon Cotton at RFLK from 1969 to 1992

Tom Walls and (later with) Jon Cotton also took an active interest in the RFLK site. From 1969 until shortly before his death in 1992 Walls fieldwalked the area (see Walls and Cotton, 1980; Cotton, 1985). Deep ploughing during 1969 offered Walls an exceptional opportunity for the retrieval of flint artefacts. A succession of visits to the site had produced;

'…a number of implements of Lower Palaeolithic type, together with a quantity of waste-flakes and several hammerstones of arguably similar date. Other flints, with traces of fire-crackling and the remains of surface-patination similar to that of the Palaeolithic artefacts, were also noted and some samples retained. Despite further deep ploughing, recent visits to this site have failed to produce any other Palaeolithic finds, and it would appear that all the surface material has now been picked up' (Walls and Cotton 1980:17).

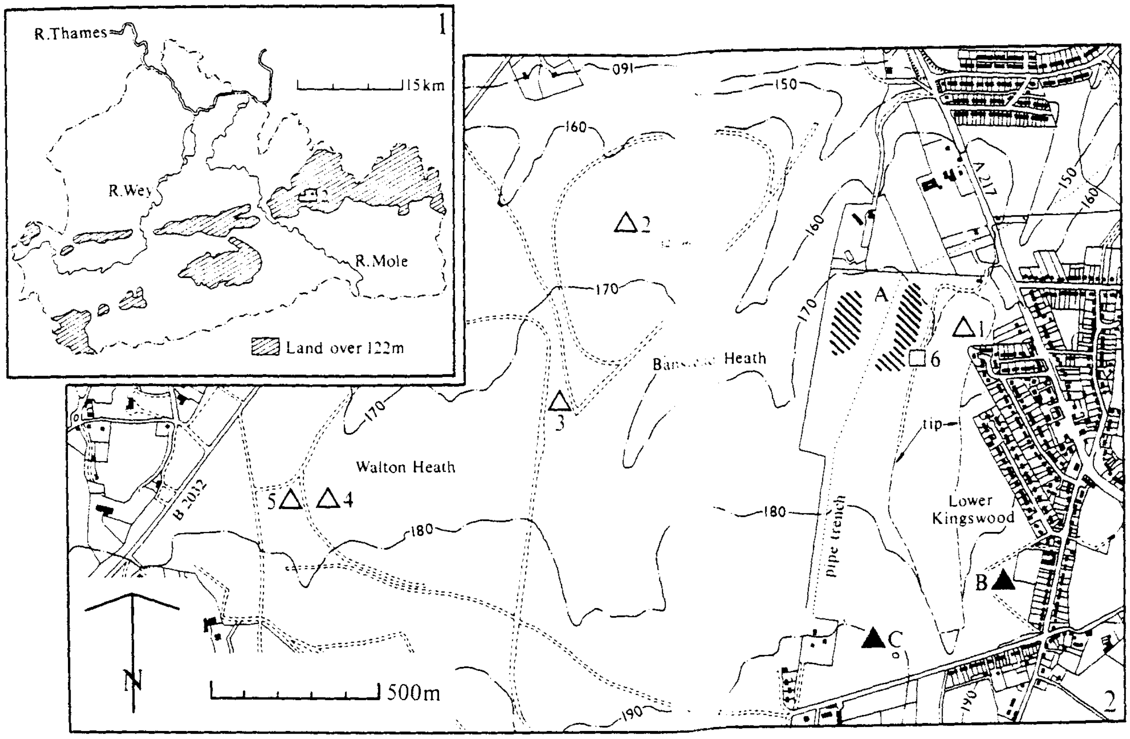


Figure 2: Location maps showing the main area of Palaeolithic finds on Banstead and Walton Heaths, including Lower Kingswood, and the finds (marked A-C) by Walls and Cotton (after Walls and Cotton, 1980).

Following these successes, fieldwalking was extended onto arable land to the south of the RFLK site, where Palaeolithic artefacts were recovered. In the 1980 Walls and Cotton report, Carpenter's 'working-floor' is shown as No.1 on their map (see Figure 2). The recorded finds are listed as a collection of artefacts recovered as surface-finds at A (Figure 2) close to Carpenter's 'working-floor' and several other individual finds from separate locations (shown as B and C, in Figure 2) in the same parish (op.cit 1980:16-17). They also report that the area in which Carpenter had made his original find of a 'working-floor' had: 'all but been filled in with dumped rubbish' but that a small section of its original profile remained, unaltered and unused, at the southern end of Mogador Rd (Figure 2). However, the remaining area had been filled in with rubbish and was now levelled and returned to agriculture use. Site A overlooked the western slope of this former valley, but had not been disturbed by the rubbish dumping. Cotton in a personal communication to Harp (2005:235) states that, 'By the 1980s Walls believed he had recovered all the Palaeolithic material in the plough-soil from the site'.

Excavations at RFLK by Frank F. Pemberton during 1969 and 1970

Inspired by Carpenters' (1960) discoveries, a number of small-scale excavations were undertaken by Frank Pemberton on behalf of the Nonsuch Antiquarian Society, from 1969 to 1970 in the RFLK area, in an attempt: …'to trace a knapping floor and also to determine the ecological sequence … the results … proved rather negligible, with only a few primary flakes occurring in section' however, 'a fossil layer containing erratics and patinated frost shattered flints … was revealed above the natural Clay-with-flints at a similar depth to that at which the original knapping-floor was located … In a field adjacent to the site, double-ploughing has recently brought to the surface a number of pointed and ovate hand-axes with a white patina. These latest finds are similar to the assemblage of hand-axes recovered from the original floor' (Pemberton, 1971:190).

Included in the 'Surrey Archaeological Collections' is a report by Harp, (2005:235) in which he states that Pemberton during 1969 and 1970 excavated:

… 'three parallel trenches (at TQ2437 5404) just inside the ploughed field recently walked by Walls - positioned adjacent to the shed housing the land fill equipment and mid-way between Carpenter's floor and the suggested densest concentration of Wall's finds at Site A' (Frank Pemberton and local residents, pers. comm.). The trenches were each 2 yards by 1 yard in size while three further 1yard square sondages were also excavated to the south in the dry valley (Frank Pemberton, pers. comm.) '. … The trenches were not , apparently, excavated very deeply - 'none of them achieved a depth of more than a few inches' - and on occasions just one excavator worked on site, sometimes assisted by pupils from Epsom College (Vivien Ettlinger, pers. comm.), although Pemberton states (pers. comm.) that the trenches went down to the 'natural Clay-with-flints'.

Whilst working at the RFLK site in September 2002, the PADMAC Unit team were visited by two local men who remembered seeing one of Pemberton's excavations - a 20ft long trench. The top-soil, they said, was removed with a digger. The men also described the dry valley, prior to becoming a rubbish tip, as being, 'very deep with large pine trees in the bottom. The tops of which barely reached the top of the slope'.

In addition to these conflicting reports on the depth of excavation there also appears to be a problem with the integrity of the recovered artefacts as the following report illustrates:

'…it is not possible to state whether the only Palaeolithic flake came from an excavated context. The primary flakes referred to by Pemberton were seen only when the north sections of the trenches were being cleared for drawing and were left in place when the trenches were backfilled (Frank Pemberton, pers. comm.). The fact that, at most, only one Palaeolithic flakes was recovered from the trenches, and that the primary flakes were only identified as such while remaining in section, suggest that that the primary flakes, which were not removed from the sections and so cannot now be studied, should be treated with caution' (op. cit 2005:236).

There are several questions then that relate to the Pemberton trenches and the integrity of the RFLK artefacts. Certainly, one common feature of high-level sites on deposits mapped as Clay-with-flints is the frequent abundance of thermally and plough-shattered flints and to the non-specialist these naturally fractured flints may easily be mistaken for genuine artefacts (see Scott-Jackson, 2000).

Fieldwork at RFLK by the Plateau Archaeological Group from 2001-2005

In 2001, the Surrey Archaeological Society's, 'Plateau Archaeology Group' (hereafter, Plateau Group) under the direction of Peter Harp, re-examined Walls and Cotton's Site A (see Harp 2002; 2005 for the detailed reports). The stated aims of their investigations were to resolve the following questions:

'A. Was there any Palaeolithic material currently present in the ploughsoil or had Walls' period of collection retrieved all the artefacts, as Walls had believed?
B. Was the Palaeolithic scatter where it had been published in 1980?
C. Could the scatter be more precisely plotted than the rather vague 1980 plan?
D. Would it be possible to distinguish the site into smaller sub-sites than the two identified in 1980?'

Based on the results of these investigations the Plateau Group concluded that the 'analysis of these data has demonstrated, or at least provided evidence for the following hypotheses':

'A. That the Palaeolithic material collected by Walls was derived from material brought to the surface by one episode of deep ploughing.
B. The episode of deep ploughing in 1969 probably inverted about 38mm of Palaeolithic artefact-rich stratigraphy.
C. There is no metrical evidence that material recovered in 2001 was derived from a further episode of deep ploughing after 1969.
D. Walls' eastern part of his 'A' scatter can be sub-divided into two discrete scatters (Plateau's 'A1' and 'A2').
E. Walls' artefact retrieval rate after 1969 was lower than that by Plateau in 2001, yet because of (C) above, the difference is unlikely to be due to a lower artefact presence in the ploughsoil in the period 1970-1980 compared to that in 2001.
F. The Kingswood biface morphology is similar to material from Hoxne and Dovercourt and significantly different to material from Farnham terrace A and Limpsfield.
G. The Kingswood biface size and weight is significantly different to bifaces from Limpsfield'.

Fieldwork undertaken by the Plateau Group at RFLK continued from 2001- 2005. During the 2002 fieldwork season, 5 trenches (1m x 2m) were excavated. Trenches 1,2,3,5 were excavated by the Plateau Group (see Harp 2005 for the results). Trench 4, excavated by the PADMAC Unit, is discussed below in Section 2 and Section 4. Although these investigations had produced answers to various questions, predominately those associated with distribution patterns and number of Palaeolithic artefacts in the surface-scatters, pertinent questions relating to the geomorphological integrity of the RFLK Ps-s/s *per se* remained to be answered, as did the location of the (Carpenter's) destroyed 'working floor' (knapping site).

Section 2: Research by the PADMAC Unit at RFLK – the rationale

To better understand site formation in the archaeological area of RFLK, the PADMAC Unit excavated a designated area, Trench 4 (T4:2002), and then embarked on a long-term geoarchaeological research programme in an attempt to both model the location of the reported 'knapping site' and to resolve questions with wider concerns regarding the integrity of the RFLK Ps-s/s on the deposits mapped as Clay-with-flints.

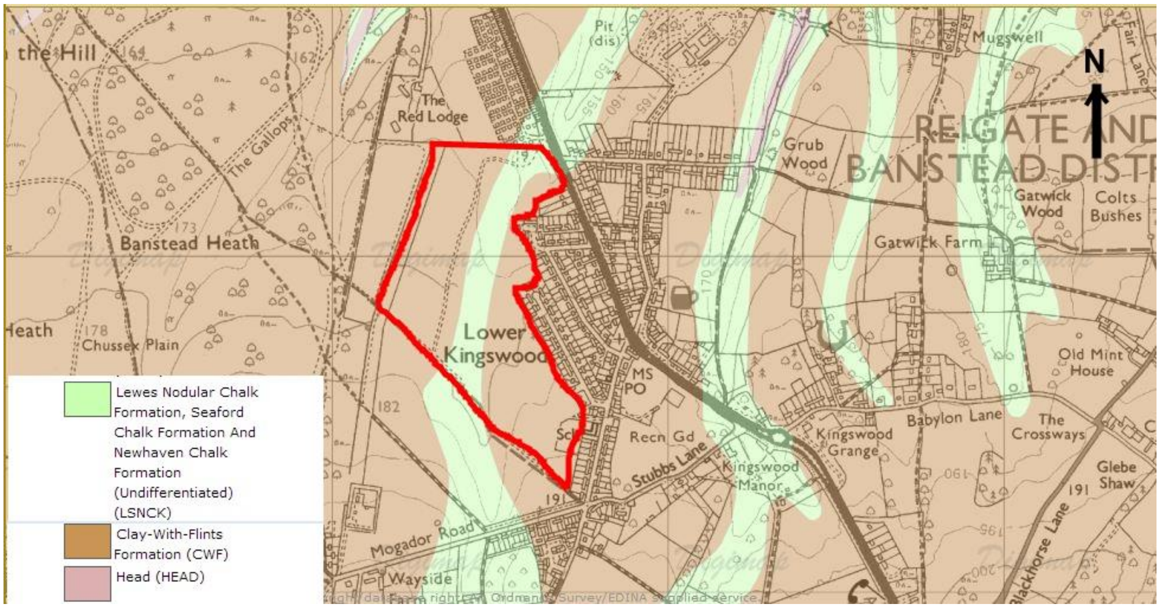


Figure 3: Geology of the Rookery Farm area with the area of archaeological interest highlighted in red. (Geological Map Data © NERC 2013: Digimap data entered into GlobalMapper)

The RFLK area is mapped as superficial drift deposits of Clay-with-flints which in turn are underlain by three Chalk formations (i.e. Lewes Nodular Chalk, Seaford Chalk and Newhaven Chalk together these formations were previously mapped as Upper Chalk). The (now infilled) dry valley runs north – south across the centre of the site. No superficial deposits are recorded here but the chalk is mapped as outcropping at the surface in the valley bottom (Figure 3). The Clay-with-flints are very variable residual deposits formed principally from Palaeogene formations and the dissolution of the underlying Chalk (see Scott-Jackson 2000:19-26 and the soils/sediments Section 4 below).

The retention and therefore the preservation, of high-level Ps-s/s on the downlands of southern England are (as demonstrated by Scott-Jackson (op. cit., 19-129)) invariably associated with the presence of basin shaped solution hollows (or pipes) in the Clay-with-flints deposits that vary greatly in depth and width (e.g. small shallow features to basin-like depressions which may encompassing a hill-top). These features are produced by the chemical weathering process of dissolution of the underlying Chalk in which calcium carbonate is removed, resulting in the formation of solution features (e.g. basin shaped hollows, dolines, pipes) and which are generally associated with an initial localized increase in water drainage often through pre-existing faults in the Chalk. Over geological time, as the underlying solution feature deepens and/or widens, the Palaeolithic archaeology is held securely within the basin-like features formed in the deposits mapped as Clay-with-flints, deposits which are characteristically thick and sticky when wet but are rock hard when dry (ibid). As previously noted, deposits mapped as Clay-with-flints are highly variable and in addition, generally decalcified (with the possible exception of the pockets of loess/brickearth). Often little actual information exists regarding the nature of the particular deposits at any one place. Characterizing the specific sedimentary facies of the deposits assists in determining the geomorphological processes which have affected the area in general. Also, those processes which may have been modified and/or controlled by the type of deposits and any anthropogenic activity (see op cit. 2000:111-113). The preservation of high-level Palaeolithic sites on deposits mapped as Clay-with-flints requires a positive interaction between the geology, soils/sedimentology and geomorphology in that immediate area over geologic time - coupled with the chance survival of such sites during periods of prehistoric and historic anthropogenic activity. Therefore, understanding the RFLK site formation in the archaeological area and the role of geomorphological processes and diachronic factors, required the PADMAC Unit to address the following questions:

1. What is the depth of the deposits mapped as Clay-with-flints overlying the Chalk?

2. Are there solution features?

3. What is/are the character of the deposits mapped as Clay-with-flints in the archaeological area?

4. Which geomorphological processes are implicated in both the archaeological and general area of RFLK?

5. Where exactly was the (now destroyed) Palaeolithic ‘working floor’ (knapping site) found by Carpenter in 1959?

6. How did this ‘knapping site’ relate spatially, geomorphologically and archeologically to the other recorded surface-scatters/sites?

7. To what degree had the construction of the landfill site impinged on these surface-scatters/sites?

Geophysical survey data was required to answer questions 1 and 2 and soil/sediment analyses of the deposits for question 3. Answers to question 4 were heavily dependent on the results of 1, 2 and 3. Whereas, resolving questions 5, 6, and 7 was far more uncertain, as high resolution data from investigations 1-4 was required and the acquisition of appropriate detailed topographical, geological and historical data. These results of the investigations are the subject of the following sections: Geophysical investigations (Section 3); Soil/sediment analyses (Section 4); Geospatial 3D modelling (Section 5); Spatial analyses (Section 6); Palaeolithic artefact analysis (Section 7).

Section 3: Geophysical investigations at RFLK by the PADMAC Unit

During 2002, the PADMAC Unit undertook geophysical investigations (deep resistivity surveys) across the RFLK area of archaeology. The aims of the resistivity surveys were to:

- Measure the depth from the landsurface (i.e. plough-soil) of the field to the Chalk interface and hence determine the thickness of the overlying deposits mapped as Clay-with-flints in any one area;
- Characterize any variability in the deposits overlying the Chalk as identified by layers of differing resistivity;
- Identify/locate sub-surface 'basin like' features in the deposits mapped as Clay-with-flints;
- Locate sub-surface features (i.e. pipes and basins) formed by solution of the Chalk in areas where carbonation is increased by enhanced drainage;
- Determine trench locations for any subsequent excavation/s.

Methodology

Resistivity is a measure of the resistance to the transport of an electrical current through the ground and is the opposite of conductivity. Geological layers with high resistivity (i.e. low conductivity) typically include chalk, sands and gravels, while deposits with low resistivity (i.e. high conductivity) include clay. Generally, the more water held in a deposit the more conductive it will be. This fact allows different geological layers to be distinguished within a geological sequence. The resistivity equipment (Tigre 64 system) used by the PADMAC Unit utilises an array of 128 electrodes at various spacings (0.5 metre to 2 metre) to identify resistivity differences up to 16 metres below the landsurface - a wider and deeper resistivity method than that normally deployed in archaeological applications. The depth measured is directly related to the length of the array, as determined by the electrode spacing. A wider electrode spacing gives a greater depth but with less detail. A more concentrated electrode array gives a shallow but more detailed analysis. The PADMAC Unit 2002 resistivity survey deployed a Wenner array (which gives a good compromise of depth of investigation and resolution) of 64 electrodes to identify differential conductivity of features (such as Chalk), as well as more detailed surveys of the upper 4m. The raw resistivity values were interpreted through the computer program RES2DINV (http://www.geotomosoft.com/) and the results edited manually to remove anomalies such as spurious data points and edge effects. As a general guide, the relevant resistivity values (ohm-metres) for high-level sites on deposits mapped as Clay-with-flints are as follows:

- Chalk usually gives a resistivity of about 140 ohm-metres but can vary from 100 to 700 ohm-metres;
- Shattered/weathered Chalk will give a slightly lower result and is generally represented by values of 40 to 90 ohm-metres;

The principle soil layers may show values of between 10 and 30 ohm-metres, except for some very low surface layer values which may indicate increased clay content or increased moisture content;

- Clay-with-flints (comparable to boulder clay) may show values between 15 and 35 ohm-metres;
- Chalk (near surface layer) may show values between 50 and 150 ohm-metres.

For the RFLK 2002 geophysical survey, five resistivity lines were run along horizontal transects, up to 128m in length, and to a general operating depth of ~16m below the current landsurface, with the electrode spacing along the transect varying according to the specific depth and detail required. The resistivity lines were variously oriented North/South, East/West (Figure 4, Figure 5) and aligned to incorporate shallow topographic features visible in the immediate area of interest.

Line 1: West to East transect

Line 1 electrodes were spaced at 2m intervals and the depth of investigation set to 15.5m. Line 1 was positioned so that the eastern end was towards the pre-existing (western) slope of the dry valley.

Line 2: South to North transect

Line 2 position was determined by the resistivity results from Line 1. For Line 2 the depth of analysis was reduced to just under 8m with a 2m electrode spacing to increase the resolution of the layer between 1.5m and 4m depth which had registered higher resistivity along Line 1.

Line 3: South to North transect

Line 3 electrodes were again spaced at 2m intervals but the depth of resistivity was set to 15.5m in order to reach the Chalk bedrock.

Line 4: South to North transect

Line 4 covered the central area of Line 2 with an electrode spacing of 0.5m and an analysis depth of 2m to provide greater detail of near-surface features.

Line 5: South to North transect

Line 5 electrodes were spaced at 1m and the depth of resistivity set to 4m to examine near-surface feature, and an area designated as test-pit T4:2002 was intersected to compare in detail, at a later date, the resistivity readings with the test-pit stratigraphy (as recorded on-site) and the results of soil samples analyses.

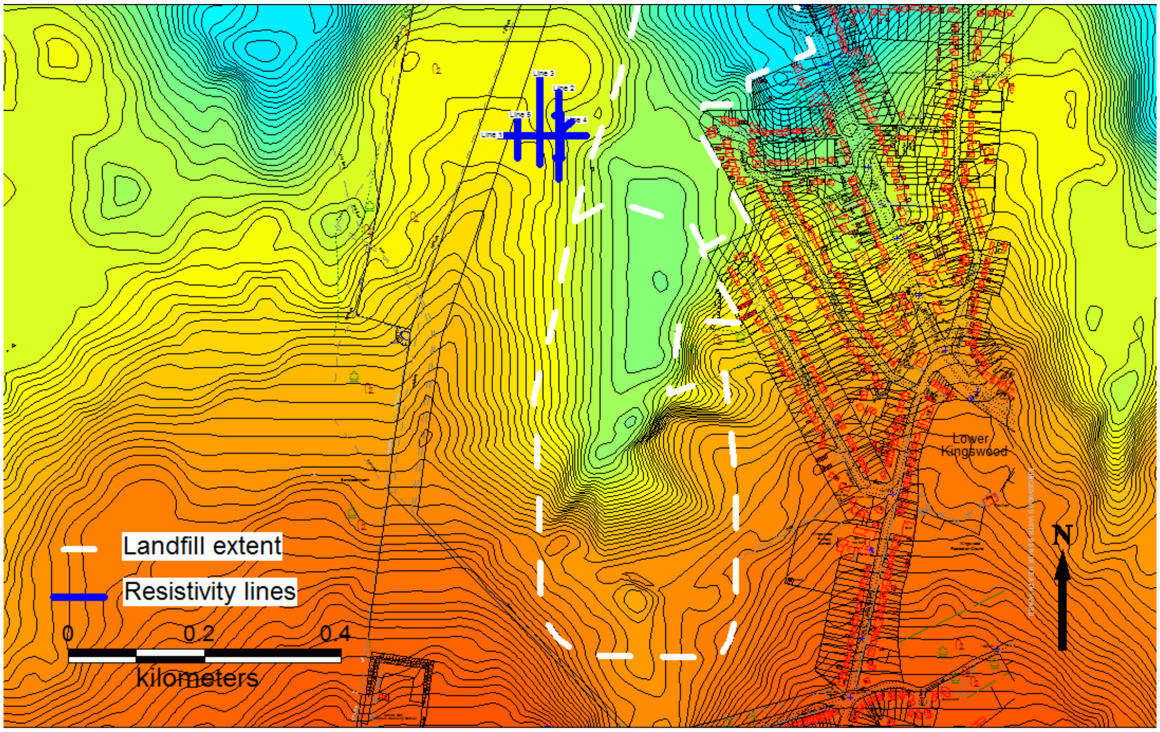


Figure 4: Diagram of the RFLK 2002 resistivity Lines 1-5 in relation to the local topography and landfill site.

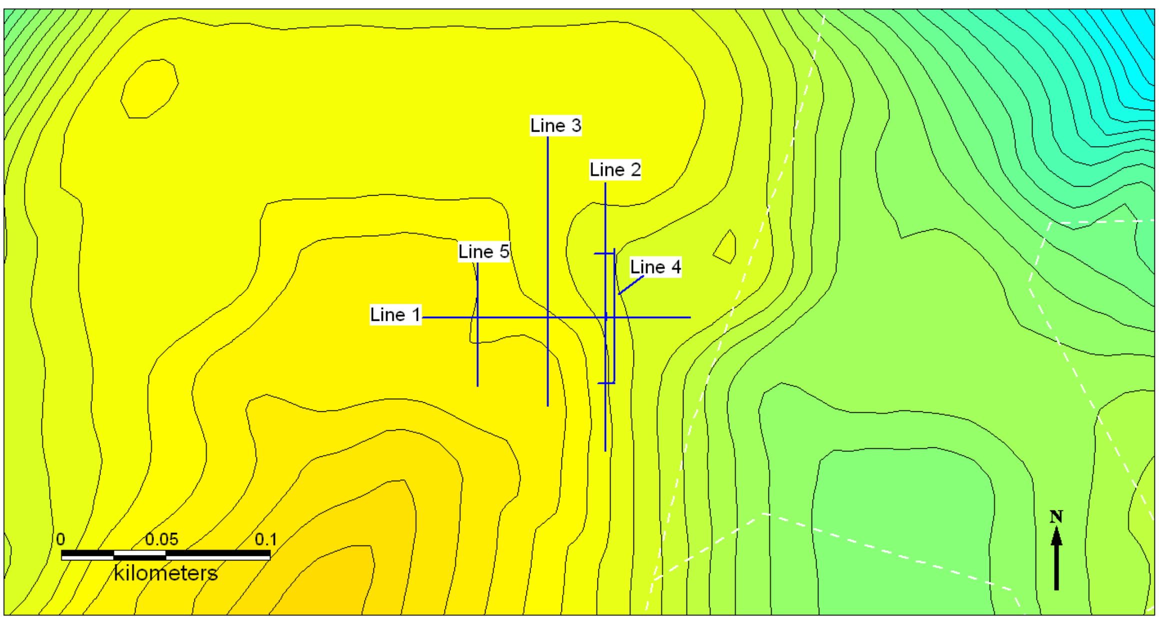


Figure 5: Schematic diagram showing contour lines and the position of RFLK 2002 resistivity Lines 1-5 (Note: Line 4 runs along same trajectory as Line 2).

Results

Line 1: West to East transect

Line 1 (W-E transect) electrodes were spaced at 2m intervals and the depth of investigation set to 15.5m. Line 1 was positioned so that the eastern end was towards the pre-existing (western) slope of the dry valley. The resultant resistivity values for Line 1 (after editing and modelling to remove anomalies) are shown in Figure 6. High resistivity is indicated by red/purple and low resistivity by dark blue.

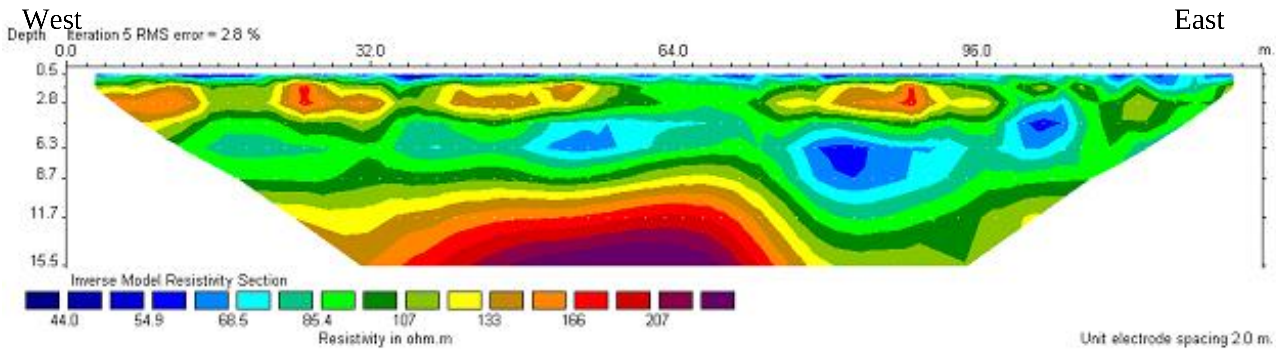


Figure 6: RFLK Resistivity Line 1. 128 metres long, depth 15.5.metres, west (left) to east (right)

The results of the resistivity survey for Line 1 show sub-surface features dipping towards the east. Geomorphologically, this is consistent with the (perhaps original) edge of the dry valley - the Chalk bedrock occurring at ~11m depth. Also, the eastern end of Line 1 exhibits relatively low near-surface resistivity. This could be due to an increase in moisture content in this area or perhaps an increase in clay resulting from slope processes moving material down into what was originally the dry valley. However, there is also the possibility that it is the result (or a contributing factor) of landfill leachate spreading out from the infill material.

Between 1.5m and 4m depth, areas of higher resistivity were recorded and between 1m and 5m depth there appear to be four 'basin like' features in the deposit/s.

In addition, Line 1 resistivity data shows a gradual downward slope in the Chalk towards the west. This could be the eastern slope (on which Line 1 is situated) of a large solution feature. If so, then Line 1 does not extend far enough west to show the opposite (western) side of this feature.

Line 2: South to North transect

The position of Line 2 (crossing Line 1) was determined by the need to investigate the resistivity results from Line 1. For Line 2 (Figure 7) the depth of analysis was reduced to just under 8m, with a 2m electrode spacing to increase the resolution of the layer between 1.5m and 4m depth which had registered higher resistivity.

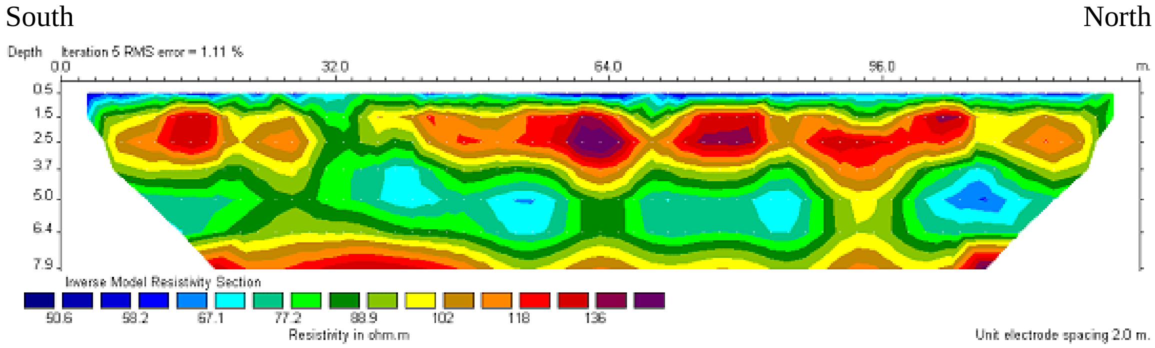


Figure 7: RFLK 2002 Resistivity Line 2. 128 metres long, depth 8 metres, South (left) to North (right).

The results of the resistivity survey for Line 2 show an area of surface low resistivity at the 30m electrode point which probably relates a grubbed out hedge which is no longer evident on the surface but the hedge line is shown running W-E on a 1934 OS map (see Section 6, Figure 30).

At a depth of between ~1.5m and ~4m, there is a higher resistivity layer. Several interpretations exist for this (none of which are mutually exclusive), for example: gravels, sands or pebble layers; flinty layers; perhaps pockets of loess / brickearth rather than a continuous layer as the data seems to suggest; colluvium - in the form of buried Coombe rock deposit of broken Chalk soliflucted down-slope from higher ground or buried soliflucted resistive material that is not Chalk.

At a depth of between 1m and 5m, there appear to be six 'basin like' features in the deposit/s.

As resistivity readings increase at a depth of ~7.9m it would indicate that the uneven surface of the Chalk was detected at ~ 8m in this area.

Line 3: South to North transect

For Line 3 (Figure 8), the electrodes were again spaced at 2m intervals but the depth of resistivity was set to ~15.5m in order to reach the Chalk.

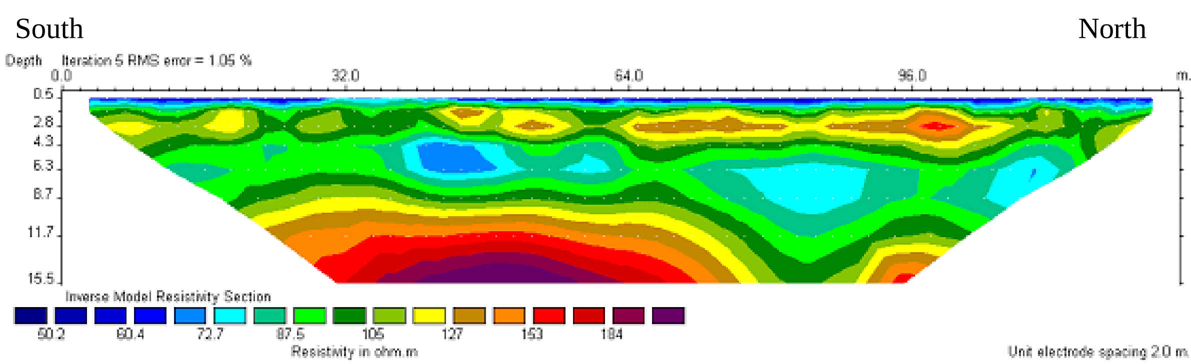


Figure 8: RFLK 2002 Resistivity Line 3. 128 metres long, depth 15.5 metres, south (left) to north (right).

Between 1m and 5m depth there seems to be five 'basin like' features in the deposit/s. At the ~40m electrode point there appears to be a dip in the Chalk (possibly a solution feature) which is holding a conductive (e.g. clay) deposit. However, this feature is beneath ~4m of other, more resistive, material. If this resistive material were to be loess/brickearth, then the conductive material may well be Clay-with-flints *sensu stricto* in a solution feature. The low resistivity material could also be Clay-with-flints *sensu stricto* if the overlying high resistivity material were tertiary deposits/Clay-with-flints *senso lato*.

The dropping away of the deepest high resistance layer at the ~80m electrode point along this line may indicate the presence of a solution feature at ~80m North or possibly the underlying Chalk topography dipping away northwards to form the existing dry valley. (Note: The apparent high resistivity (red) in the very bottom right hand corner is an 'edge effect' which is often produced by spurious line data, so this can be ignored).

Line 4: South to North transect

Line 4 (Figure 9) reproduces the central area of Line 2 but in more detail with an electrode spacing of 0.5m and an analysis depth of ~2m, in order to provide a higher resolution of near-surface features.

South North

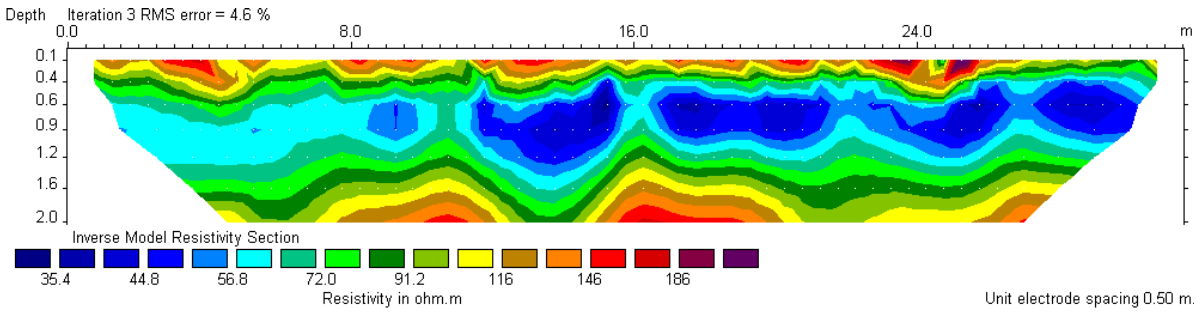


Figure 9: RFLK 2002 Resistivity Line 4. 32 metres long, depth 2 metres, South (left) to North (right).

The top 0.5m shows a relatively high resistivity layer, probably reflecting the large numbers of flints found in the top soil and upper layers of the excavations. A lower resistivity layer extends between 0.5 and 1.6m suggesting a downward continuation of a similar deposit but containing less flints (possibly Clay-with-flints *senso stricto*).

Lines 2 and 4 have the same central points (electrode point at 16m on Line 4 is equivalent to 64m on Line 2). The central high resistivity feature at ~2.5m depth on Line 2 can be seen very clearly in the Line 4 reading at the base of the section. The potential nature of this high resistivity layer has been discussed under Line 2 (above). Again the section shows no apparent dip in the sediments.

Line 5: South to North transect

For Line 5 (Figure 10) electrodes were spaced at 1m and the depth of resistivity set to ~4m in order to examine near-surface features. An area designated RFLK T4:2002 (the intended PADMAC Unit test-pit) was intersected to compare in detail, at a later date, the resistivity readings with the T4:2002 stratigraphy (as recorded on-site) and the results of soil/sediment samples analyses (Section, 4).

South North

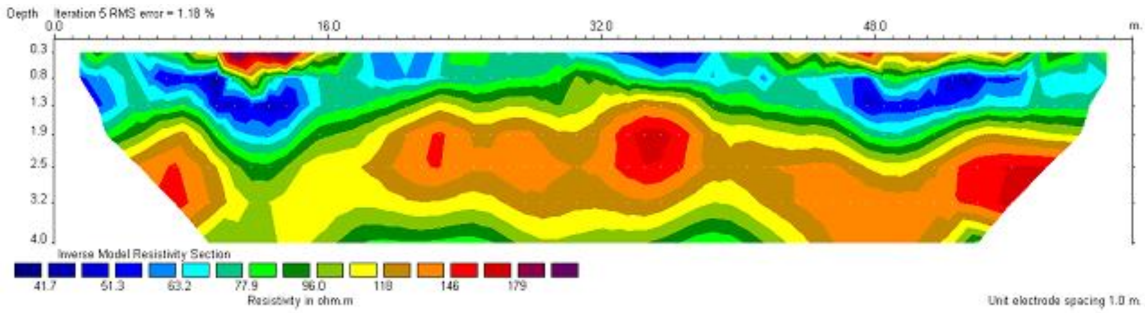


Figure 10: RFLK 2002 Resistivity Line 5. 64 metres long, depth 4 metres, South (left) to North (right).

The results of the resistivity survey for Line 5 suggest the presence of low resistivity material infilling high resistivity solution features at both the 12m at electrode point (to a depth of ~2.5m) and at electrode point 50m (to a depth of ~2m).

Section 4: Soil/sediment analyses of the RFLK area

The plan for the RFLK 2002 - 2003 fieldwork was that the Plateau Group would concentrate specifically on an archaeological focused excavation of Trenches 1, 2, 3 and 5 (see Harp 2005:238-239). And the PADMAC Unit would focus on Trench 4 (T4:2002) for detailed analyses of the RFLK T4:2002 geology; soils/sediments and geomorphology. The aim of these analyses was to record spatial variation in soil/sediment properties (both vertically and horizontally) in the areas mapped as Clay-with-flints and to elicit (where sufficient data existed) evidence of landscape history from the soils and superficial deposits. A two stage, multi - method soil survey was therefore undertaken by the PADMAC Unit during 2002/2003 (Note: the definition of soils/sediments used in this report follows that of Avery, 1990). The first stage of the investigations required a basic reconnaissance-level soil survey (by A. Thomas and H. Walkington) to be carried out across Banstead Heath (Figure 2) (the area adjacent to the west of RFLK) to assess the spatial variation of soil properties. Whereas, the second stage of the PADMAC Unit investigations focused solely on determining the soil profile of the RFLK Trench 4 (T4:2002).

Stage 1: Banstead Heath; the reconnaissance-level soil survey

The RBBC, 'Borough Wide Landscape and Townscape Character Assessment' (RBBC 2011:7) describes Banstead Heath as an Area of Great Landscape Value (AGLV) and a Site of Nature Conservation Importance (SNCI). The Heath which covers an area of 310 Ha.is part of the Metropolitan Green Belt and Metropolitan Common land (Metropolitan Commons Supplemental Act and Banstead Commons Byelaws). Banstead Heath is managed by the Banstead Commons Conservators (BCC) but owned by RBBC. Management of the area is detailed in the Banstead Heath Management Plan (BHMP). The area is in daily use by local people for recreation and has archaeological importance as finds from differing prehistoric and historic periods have been recovered.

Methodology

As no previous soil survey of the area had been published at the time of this particular reconnaissance-level soil survey (2002), the soil sampling strategy related to the Management Units as defined in the BHMP. The BHMP was based upon a series of identified vegetation units on Banstead Heath (Figure 11) and was therefore seen as the most likely indicator of changing soil types.

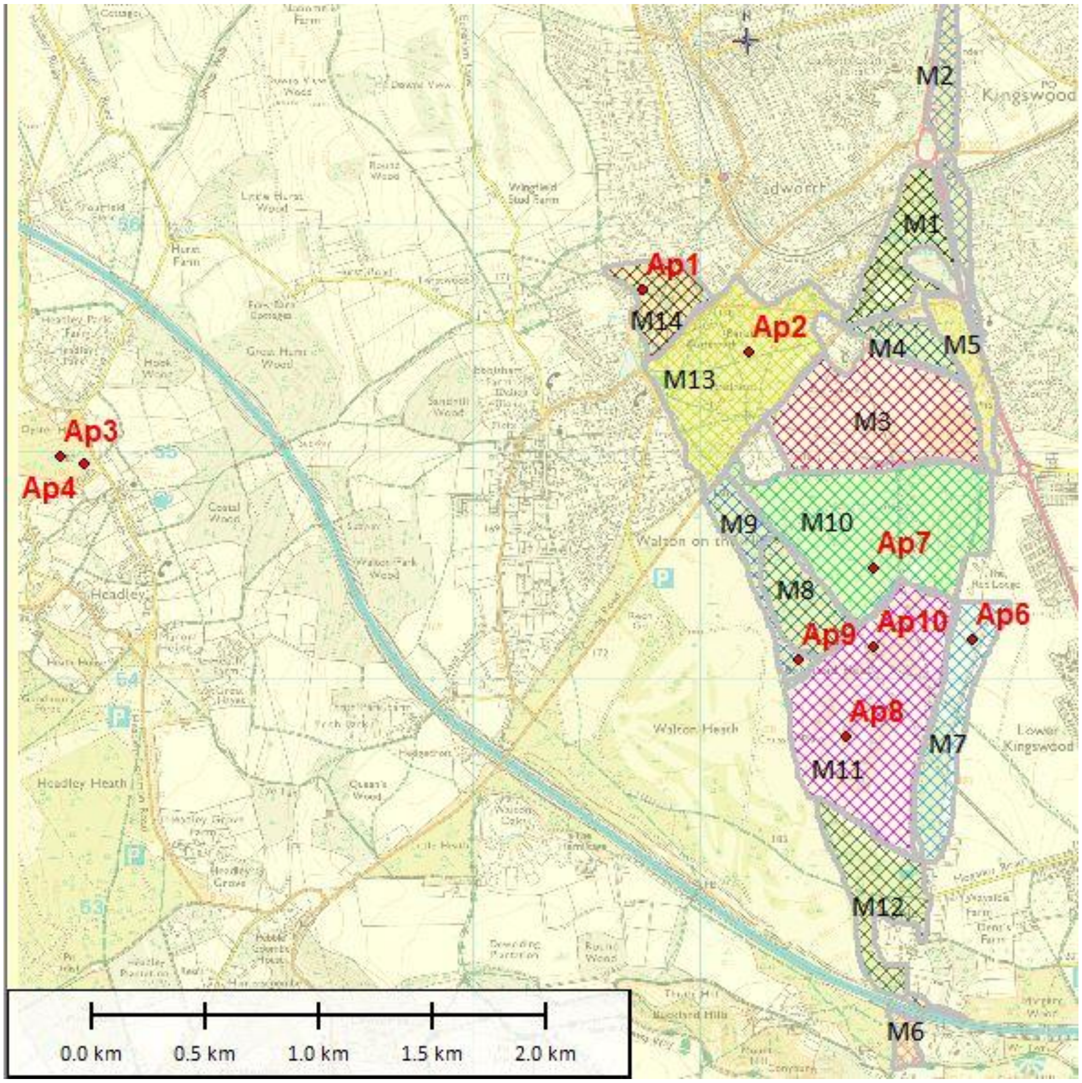


Figure 11: Map showing the Management Units (M) as defined in the Banstead Heath Management Plan (BHMP 2000 -2005) and the locations of the PADMAC Unit soil survey auger points (Ap).

A handheld soil auger was used to extract a soil column from within the selected Management Units (i.e. M7, M8, M9, M10, M11, M13, M14 and in a small N – S trending dry valley). Management Unit M7 was given over to Banstead Heath when the M25 motorway was constructed though an area of the Heath to the south (the equivalent acreage of the area taken up by the M25). This long N –S trending strip is adjacent to the field where the PADMAC Unit excavated RFLK T4:2002 (i.e. west of RFLK). Previously a farmer's field until ~20 years ago, Management Units M3, M8 and M11 had been cleared and deep ploughed following World War II. Also sampled was the soil in the area mapped as doubtful Pliocene deposits at Headley Heath (Oyster Hill Ap3 (TQ20190 54970) and Ap4 (TQ20290 54940)). Hand augering often proved problematical as pebble layers near the surface were commonly encountered. In some instances this meant that a second boring had to be tried nearby but in others that augering was not possible. (Note: deposits mapped as Clay-with-flints have been associated historically with the extraction of gravels and brickearths).

Results of Banstead Heath reconnaissance level soil survey.

Although the auger (soil) survey of Banstead Heath encountered a major problem in terms of the flinty and pebbly nature of the deposits mapped as Clay-with-flints, this basic survey revealed the soils to be generally loamy (pebbles and large flints were noted but not used in soil textural analysis, this being carried out on the matrix only). Some soil profiles became finer textured with depth whereas others became coarser. Parent material variability was found to heavily influence the textural profile in each case. For example, at auger point Ap6 (TQ24196 54164, Management Unit M7, see Figure 11) surface loams gave way to clay loam at depth. This could be interpreted as a clayey parent material being modified at the surface by windblown /waterlain sands and silts. A similar pattern was found at auger point Ap7 (TQ2376 554478, Management Unit M10). Both aeolian deposits and older 'superficial drift deposits' can be considered as soil parent materials. In contrast auger points Ap9 (TQ23432 54075, Management Unit M9) and Ap10 (TQ23769 54133, Management Unit M11) exhibited a coarsening with depth from silty clay loam to soil loam to loam (auger point Ap10) and clay loam to loam (auger point Ap9). The finer texture at the surface could equally arise from organic matter being incorporated, influencing the texture recorded in the field. Indeed it could be considered leaf litter and decaying organic matter are also soil parent materials in the broadest sense. A combination of these two textural profiles was found in auger point Ap4 (TQ20290 54940, base of Oyster Hill). Silty clay loam (organic matter influence) at the surface gives way to loam but clay (parent material influence) is found at depth. The profile developed on the Thanet Sand had silty loam overlying silty clay, here it is impossible to know whether this clay was part of an illuvial horizon or whether the texture would change again, as accessing material at greater depths was not possible.

Stage 2: RFLK Trench 4 (T4:2002); the geoarchaeological investigations

Location: RFLK Trench 4 (T4:2002); TQ 243 541. Height ~185m asl. Location: Banstead Heath. (Ordnance Survey data provided by Edina Digimap under © Crown Copyright/database right, 2014). Geology: Drift type; Clay-with-flints (Geological Map Data provided by Edina Digimap under BGS © NERC 2014.

Soil associations for the area of T4:2002

RFLK Trench 4 was sited in an area mapped as Clay-with-flints on the top of the chalk plateau which forms the dip slope of the North Downs. As previously discussed (Section 1) the small dry valley to the east now infilled with landfill waste, has made the top of the plateau appear to extend continuously to the other side of the valley. Also, that the heathland immediately surrounding RFLK *per se* was, until World War 1, mainly uncultivated but following World War 11 the heathland was cleared and the area deep ploughed. How many times, and to what depth deep ploughing occurred is not recorded.

Methodology

RFLK T4:2002 (2 x 1m trench, later reduced to 1m x1m) was dug in 5cm spits to a depth of 67cms and then hand-augered down to a depth of 124 cm. Soil profile descriptions were recorded contemporaneously with the archaeological excavation. Details of both archaeological and pedological significance, such as the patination of flint clasts and changes in soil structure, colour and texture were recorded as the excavation proceeded to ensure that both soils/sediments and archaeology data could be combined. Soil samples were taken from each 5cm spit for the production of particle size data (processed by H. Walkington). In addition, a Kubiena monolith sample was taken for detailed micromorphological investigation of thin sections. The excavation and recording techniques used in RFLK T4:2002 followed the methodology developed by Scott-Jackson (2000) for excavating/ recording/interpreting Palaeolithic sites on deposits mapped as Clay-with-flints.

Results of the RFLK T4:2002 geoarchaeological investigations

Soil samples from RFLK T4:2002 produced good analytical particle size data. Less so, that of the Kubiena monolith sample as an (unpredictable) over-representation of large clasts within the sample rendered it largely unsuitable for thin sectioning. The particle size data which focused on relative percentages of: Clay; Silt; fine Sand; medium Sand and coarse Sand is considered first. These results are followed by the soil profile description.

Particle size data for RFLK T4:2002

Table 1 lists the samples taken during excavation of RFLK T4:2000 and the location of each.

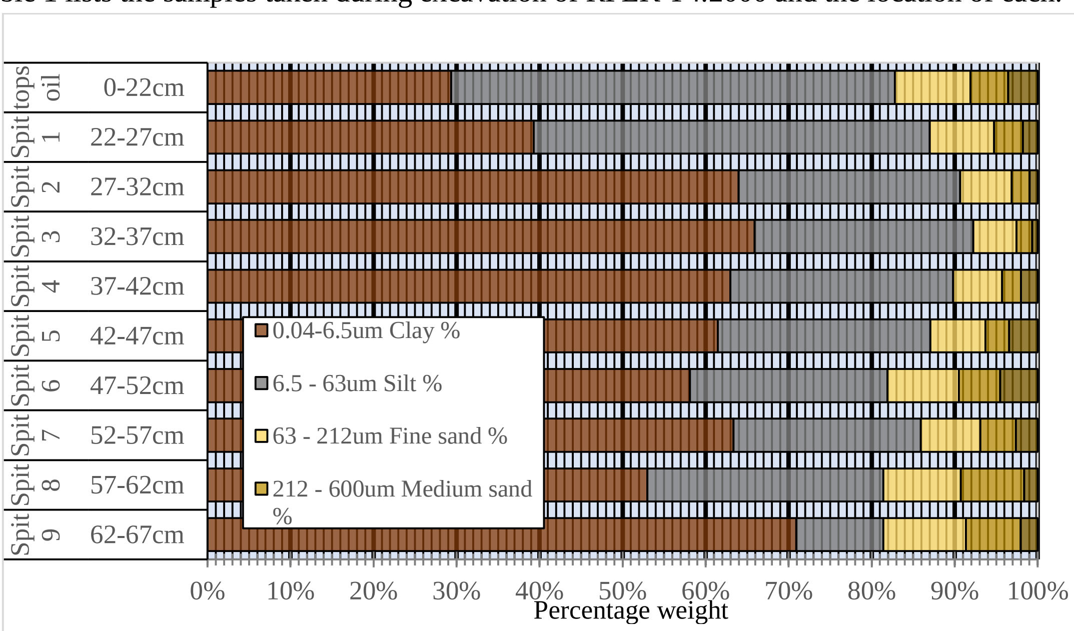


Table 1: RFLK T4:2002 Particle size data showing percentage weights (by spit) of: Clay; Silt; Fine Sand; Medium Sand and Coarse Sand.

Soil profile description for RFLK T4:2002

RFLK T4:2002 was excavated by the PADMAC Unit in an arable field that had recently been ploughed (data collection September 2002), wheat stalks were still evident (Figure 12). The plough depth (top soil depth) appeared to be ~ 25cms. However, when the top-soil of RFLK T4:2002 was removed, the sub-soil surface (spits 2/3) exhibited significant scorings (in the form of channels) by deep ploughing at a depth of >35cms. The RFLK T4:2002 parent material is deposits mapped as Clay-with-flints and the climatic regime, Sub-humid temperate.

Figure 12: View of the northern area of Rookery Farm, Lower Kingswood, during 2002 investigations.

As previously noted, RFLK T4:2002 was dug in 5cm spits to a depth of 67cms and then augered down to a depth of 124 cm. In the process, 4 horizons were identified (Table 2) which correspond to the following notations: **Ap** (depth, 0 – 30/35cm); **B1** (depth, 30/35cm – 40/45cm); **B2g** (depth, 40/45cm – 60cm); **Cg** (depth, 60cm – ~124cm). (Note: 'The term 'horizon' is applied to all morphological distinct layers, with or without characteristics attributable to soil formation'… and… [the horizon notations] are based on properties that differentiate horizons from those above or below' (Avery (1990:99)).

Ap 0 – 30/35cm	Wavy sharp boundary. Yellowish brown 10YR 5/4 (moist). Sandy Clay Loam texture or Silty Clay Loam texture depending on sample. Moderately stony but laterally variable. Angular and sub angular flints in a range of sizes (very small, small, medium and large). Dry soil state. Moderate ped development into coarse angular blocky peds. Brittle moderately firm consistence. Common coarse, medium and fine roots.
B1 30/35-40/45cm	Smooth diffuse boundary. Yellowish brown 10YR 5/6 (moist). Sandy Clay texture. Moderately stony but with lateral variations. Generally fewer stones but still some medium angular black broken flints with 'pot lid' fractures. Dry soil state. Apedal (massive). Moderately firm consistence. Fine roots common.
B2g 40 / 45 – 60cm	Smooth gradual boundary. Strong brown 7.5YR 5/6 (moist). Very many medium strong brown (7.5YR 5/8, 5/6) and red (2.5YR 4/6) mottles in ped centres in a brown (7.5YR 4/4, 5/4), yellowish brown (10YR5/6) and dark yellowish brown (10YR 4/6, 4/4) matrix, with occasional zones of depletion in pink (7.5YR 7/4). Clay grading to Clay loam texture. Moderately stony but with lateral variations. Small pebbles and small white and creamy yellow patinated angular and sub angular flints. Very flinty, range of sizes lateral variations. Very small white flint chips embedded in the matrix. One angular sharp unpatinated flint with chalky cortex (10cm). Dry / moist soil state. Apedal (massive) structure. Small pores. Root holes lined with topsoil and occasionally with mangans. Firm consistence. Some mangans on pebbles, ped faces and down root channels. Few fine roots. Few medium roots (decaying).
Cg 60 - 124cm	Smooth gradual boundary. Yellowish red 5YR 5/8 (moist). Very many coarse red (2.5YR 4/8) mottles in ped centres with light grey (2.5Y 7/2) zones of depletion in a strong brown (7.5YR 5/6) matrix. Sandy Clay texture. Moderately stony but with lateral variations. Predominantly patinated flints, one unpatinated, on one side of pit only. 5cm is average size at 70 – 75cm, 2cm is average at 65 – 70cm. but up to 10cm sub angular and sub rounded clasts white patinated. Dry / moist soil state. Apedal to weak angular blocky but poorly developed. Vertical root holes with mangans. Firm consistence. Very frequent and well developed mangans on pebbles and ped faces, occasional argillans. Few medium roots.

Table 2: RFLK T4:2002 horizon notations (**Ap; B1; B2g; Cg**) and soil profile descriptions.

Interpretation of the diagnostic features of the RFLK T4:2002 soil horizons

Interpretation: Horizon Ap (depth 0 – 30/35cm) (Table 2) plough soil and Spits 1-3) is a surface mineral horizon that has been mixed by cultivation. The wavy sharp lower boundary suggests that Ap incorporate the E horizon (or part of E and perhaps part of B1) but not perhaps that of B2g and Cg. The moderate ped development into coarse angular blocky peds is associated with both cracking around roots and burrows, and swelling and shrinking of the soil aggregates on wetting and drying. Permeability is moderate. Although they may occur in surface soils, angular blocky peds which are equant with sharp interlocking edges are more usually found in subsoil (Bt) horizons.

Particle size data (Table 1): Clay depth function for Ap horizon; Plough soil (0-22cm) 29.36%; Spit 1 (22cm-27cm) 39.31%; Spit 2 (27cm to ~ 32cm at base) 63.98%; Substantial increase in the percentage of clay at a depth of ~30/35cm.

Interpretation: Horizon B1 (depth 30/35cm – 40/45cm) (Table 2: Spits 3 – 5) is a mineral subsurface horizon that formed below the Ap (plough soil). A classification of B1 is given for this horizon as a colour value of Yellowish brown 10YR 5/6 (moist) is not commensurate with an E horizon (see op.cit:100). It is an Apedal (massive) structureless soil, with low permeability, that shows evidence of illuvial concentration of silicate clays. Massive/coherent soils have their particles adhering without any regular cleavage and are in large cohesive blocks and are relatively impervious to air and water. They are indicative of puddled soils or soils repeatedly cultivated (ploughing) under very wet conditions.

Particle size data (Table 1): Clay depth function for B1 horizon; Spit 3 (at top of spit ~32cm-37cm) 65.90%; Spit 4 (37cm to ~42cm at base of spit) 62.99%. Although this horizon directly underlies the Ap horizon it does not meet the requirements to qualify as an E horizon as the percentage of clay is higher in this horizon than the underlying horizon (ibid).

Interpretation: B2g (depth 40/45cm-60cm) (Table 2: Spits 5-8) this mineral subsurface horizon which formed in vertical succession to B1. It is an Apedal (massive) structureless soil, with low permeability, and shows evidence of illuvial concentration of humus, iron and alteration of the original material involving solution and removal of carbonates, liberation of silicate clays and mangans (i.e. oxides or hydroxides of iron and manganese oxides, on pebbles, ped faces and root channels). Ferruginous mottles (>40%) and pink zones of depletion (attributed to reduction and segregation or removal of iron conditioned by periodic saturation with water in the presence of organic matter) are sufficient to qualify this as a (suffix g) gleyed horizon (op.cit:101).

Particle size data (Table 1): Clay depth function for B2g horizon; Spit 5 (at top of spit ~42cm-47cm) 61.48%; Spit 6 (47cm-52cm) 58.31%; Spit 7 (52cm to ~57cm at base of spit) 63.36%. Although the relative percentage of clay is high, this horizon it does not meet the various requirements to qualify as a Bt or Btg (Argillic B horizon), particularly the percentage and distribution of clay coats (argillans) on ped faces, in pores, and/or intrapedal clay concentrations (op.cit:102, 109).

Interpretation: Cg (depth 60cm – ~124cm) (Table 2: Spits 8-9, augered 67cm-~124cm) the soil structure is Apedal to weak angular blocky but poorly developed. Blocky peds are irregular in shape and usually not quite equidimensional and may have angular interlocking faces. Where there has been erosion or coating of ped margins they appear less sharp and more subangular, permeability is moderate. Cracking ground, roots and burrows, swelling and shrinking on wetting and drying are implicated in the formation of blocky peds. Although not uncommon in subsurface horizons, blocky peds are more usually associated the Bt soil horizon (i.e. a B horizon that contains translocated silicate clay and which meets specific requirements (op.cit:102)). The occasional argillans (coating of clay along cracks or grains within the soil) in this horizon are evidence for illuviation soil building process by the enrichment of clay washed in from higher horizons (clay films can also be original depositional (parent material) features). As this horizon occurs below a B2g and not below a Bh or Bs it does meet the requirements to be considered as part of a buried profile (ibid).

Evidence of illuviation is the concentration of humus, iron and alteration of the original material involving solution and removal of carbonates, liberation of silicate clays and mangans (i.e. oxides or hydroxides of iron and manganese oxides, in vertical root holes, on pebbles and ped faces). The ferruginous mottles (>40%) and light grey zones of depletion, attributed to reduction and segregation or removal of iron conditioned by saturation with water for long periods of time (op.cit:105) are characteristic of a gleyed horizon.

Particle size data (Table 1): Clay depth function for Cg horizon; Spit 8 (at top of spit 57cm-62cm) 53.01%; Spit 9 (62cm to 67cm at base of spit) 70.92%. The percentage of clay in Spit 9 was the highest recorded in T4:2002. This increase in silicate clay (in Spit 9) is indicative of an illuvial horizon. Below 67cm (base of Spit 9) to a depth of 124cm. only hand augering of the ~57cm. was undertaken (with difficulty). Soil samples were not collected for particle size analysis. Textural analysis of the upper part (of the augered ~57cm Clay-with-flints) indicated a Sandy Clay deposit (red colour, inherited from haematite-bearing parent rock) whereas, the lower part was Silty Clay. Clay-with-flints deposits extended below the 124cm. horizon. Chalk was not reached.

Discussion

It should be noted here that the aim of these investigations was not to produce a definitive study of soils in the RFLK area. But rather, to elicit (where sufficient data existed) evidence of landscape history from the soils and superficial deposits (in relation to the known archaeology) with particular emphasis on identifying/characterizing the soil profile of RFLK T4:2002 (i.e. Trench 4 excavated by the PADMAC Unit in 2002).

The focus of the PADMAC Unit, 2 Stage, soil analyses (Stage 1: Banstead Heath; Stage 2: RFLK, T4:2002) was therefore, to record spatial variation in soil properties (both vertically and horizontally) in the RFLK areas mapped as Clay-with-flints. Set out in Section 2 of this RFLK report are seven geoarchaeological research questions, two of which are addressed in this soil/sediment section, namely: (Q3) Which geomorphological processes are implicated generally across the RFLK area and specifically in the area of the archaeological area?; (Q4) What is/are the character of the deposits mapped as Clay-with-flints in the archaeological area?

Soil associations and characteristics for the general area of RFLK

Data supplied by the National Soil Resources Institute (2013) in the 'Academic Soils Site Report' for location: 524398E, 154491N (4km x 4km) gives the following information for the RFLK area: Batcombe Series, Code 582a, (op.cit:7) being; Fine silty over clayey and fine loamy over clayey soils with slowly permeable subsoils and slight seasonal water logging. Also, the soils of the Batcombe series are developed in Plateau Drift and Clay-with-flints which cap chalk plateaus at ~ 90m to 250m O.D and that, most of the soil association is on level or gently sloping ground but slopes are steeper and convex near the margins of the drift outcrops.

Soil associations (soil mapping units) represent a group of soil series (soil types) which are typically found occurring together, associated in the landscape, (Avery, 1973; 1980; Clayden and Hollis, 1985). The component soil series of the Batcombe (Code 5.82; 50%) association subgroup includes: Hornbeam (Code 5.82; 15%); Carstens (Code 5.81; 10%); Winchester (Code 5.81; 5%). In addition, minor unnamed soil series may also occur at any particular site (National Soil Resources Institute 2013:24).

Hydrology of the soil type (Host) in the given area of RFLK is 18 (op.cit:8) being; slowly permeable soils with slight seasonal waterlogging and moderate storage capacity over slowly permeable substrates with negligible storage. Soil Parent Material is 145 (op.cit:9) being Plateau Drift and Clay-with-flints. The Hydrogeological Rock Type is 23 (op.cit:13) being Plateau Drift and Clay-with-flints.

These Clay-with-flints deposits are derived from Tertiary Beds (possibly Thanet Sands in this area), the clays and sands which have weathered and mixed with flints released by solution of the underlying Chalk and a variable loessic input. Clay-with-flints and other deeply weathered plateau deposits in southern England are classified as Brown Soils (major soil group) and as Stagnogleyic Chromoluvic Brown Soils (subgroup). Avery (1990:228) in his definitive book, 'Soils of Britain', states that these are similarly formed, and often closely associated soils with slowly permeable subsurface horizons and mottles and/or ped-face colours attributable to gleying within 60cm of the surface. Also, 'A loamy Eb horizon is usually but not always present and can be mottled, particularly in the lower part which in places extends down as irregular glossic features'. The deposits in which most of these soils have formed overlie pervious substrata such as chalk or gravel and lie well above the permanent water table, implying that the gleying in the upper one to two metres penetrated by roots results exclusively from impeded drainage of surface water' (ibid). The variably flinty, fine silty and fine loamy over clayey Batcombe and Hornbeam soils, classified as stagnogleyic paleo-argillic brown earths, with grey mottled subsoils dominate the soil association (National Soil Resources Institute 2013).

Results, processes and problems

The results of this two Stage soil analyses (Stage 1: Banstead Heath; Stage 2: RFLK T4:2002), indicate that the (Clay-with-flints) soil parent material variability heavily influences the textural profile across the sampled areas. Whether as clayey parent material being modified at the surface by windblown (or waterlain) sands and silts or that of aeolian (loessic) deposits and older 'superficial drift deposits'. These result are in concordant with the soil and site characteristics for Banstead Heath and the (wider) RFLK area in the 'Academic Soils Site Report' (ibid).

However, determining, with any certainty, a comprehensive classification/clarification of subgroup soil group/s (associated here with the Batcombe series) in the RFLK T4:2002 study area (mapped as Clay-with-flints) has been complicated by the historic landuse of the area, as cultivated soils of the Batcombe series have generally received regular dressings of chalk and are often base saturated to at least 1.5m depth (Avery, 1990:228) but perhaps most notable is that of deep ploughing. Deep ploughing will have had implications for the degree of horizonation apparent in the soil as ploughing inverts the soil profile and homogenises mineral and organic material. In RFLK T4:2002 deep ploughing certainly reached a depth of at least 35cms (as indicated by the presence of plough scars). The presence of hydromorphic properties within 50cm of the surface and a lack of diagnostic horizons indicate that this is a gley soil in the FAO (Food and Agriculture Organisation of the UN) classification system. Gleying (as noted above) occurs when drainage of surface water through the soil is impeded.

As previously discussed, Plateau Drift and deposits mapped as Clay-with-flints (both deeply weathered deposits) are classified as Brown Soils (major soil group) and as Stagnogleyic Chromoluvic Brown Soils (subgroup) (ibid). And that the soil association in the area of RFLK is Batcombe series. More specifically, stagnogleyic paleo-argillic brown earths, with grey mottled subsoils dominating the association (National Soils Resources Institute 2013). These soils are characterized by the following features: A loamy (possibly mottled) Eb horizon (usually but not always present); Slowly permeable subsurface horizons and mottles and/or ped-face colours indicating gleying within 60cm of the surface; Deposits/soils generally overlie pervious substrata such as chalk or gravel and lie well above the permanent water table, the gleying in the upper one to two metres penetrated by roots results exclusively from impeded drainage of surface water' (Avery, 1990:228).

The RFLK T4:2002 soil profile – a question of identity

Although the RFLK T4:2002 ploughed surface layers meet the general requirements for an Ap horizon. There is the lack of a clearly identifiable E, more specifically the Eb, horizon (although not mandatory, as shown above). Notable however, is the absence of a Bt (argillic horizon). Neither horizon B1or B2g (or indeed Cg) meets the various and precise requirements for an argillic horizon (i.e. an illuvial horizon in which silicate clay has accumulated to a significant extent by the process of clay translocation during soil formation (op.cit:7; 102).

Data derived from the RFLK T4:2002 particle-size analysis (Table 1) and the soil profile description (Table 2) show that RFLK T4:2002 exhibits characteristics that do not meet (i.e. an absence of a Bt horizon) the specific soil type criteria for the RFLK area which is classified as a stagnogleyic paleo-argillic brown earth (NSRI, 2013:24). However, the Batcombe series (classified as Brown Soils (major soil group); Stagnogleyic Chromoluvic Brown Soils (subgroup)) of which stagnogleyic paleo-argillic brown earth are associated (Avery, 1990:228) does include 'minor unnamed soil series which may also occur at any particular site' (NSRI, 2013:24). It is possible therefore, that the RFLK T4:2002 soil profile is representative of one such group. Although the available data suggests alteration and loss of sedimentary structures within the B1 and B2g horizons, the picture is complicated by the fact that illuvial horizons may be preserved in situ or disrupted and incorporated into the matrix as a result of disturbance by bioturbation, frost action, or seasonal swelling and shrinking (Avery, 1990:7; 102), rather than mechanical disruption at the 'B' horizon depth by deep ploughing.

Environmental/climatic information and questions relating to the integrity of associated archaeology within a deposits (at any one place) may be addressed by the presence or absence of a Bt horizon as it relates to that particular soil association. As Bt horizons are generally considered to form slowly, the archaeological implication of a Bt horizon in southern England is that of prolonged landscape stability. Bt horizons are generally within the rooting zones but as Avery (op.cit:2) notes 'buried soil horizons are not considered part of the present-day soil if they lie below the current rooting zone though they are of considerable interest in aiding reconstruction of past landscapes and environments.

RFLK T4:2002 soil profile – the archaeological implications

The siting of RFLK T4:2002 within a visible depression in the field was in accordance with the results of the Geophysical survey (Section 3). Such areas (solution features) may well be susceptible to increased puddling but also known to retain Palaeolithic archaeology (Section 2). There is much circumstantial evidence to suggest that the deep ploughing (plough scars observed at a depth of ~35cm.) dragged up the Palaeolithic archaeology (above and Section 1). But dense concentrations of artefacts are also recorded as being excavated from ~50cm beneath the surface, and 'that most of the artefacts not in the plough soil were located within a loessy clay layer beneath areas of loess and overlying the Clay-with-flints' (Harp, 2005:239). This would certainly suggest that the Palaeolithic artefacts were confined to the top horizons (i.e. Ap; B1; B2g) of the deposits (see Section 7) but this may not be the full picture. Further sites may await discovery as the geophysical survey (Section 3) results show the RFLK subsurface topography/ landform to be undulating with many 'basin like' (possibly solution) features in the deposits which, in theory, may have effectively retained both dateable loessic deposits (i.e. those which are not totally decalcified) and associated Palaeolithic sites.

Section 5: Geospatial 3D modelling of the RFLK area

In 1951, BAN was granted permission for controlled tipping of household waste on 67 acres of the Rookery Farm estate. Although RBBC do not hold any records of boreholes drilled at the site prior to the commencement of landfilling, data is available on the boreholes that were drilled around the edge of the site in 1988 (SDL,1989) for landfill gas monitoring purposes by SCC waste disposal section. During 1993, RBBC commissioned a borehole and trial pit assessment of the Rookery Farm landfill site (EAG, 1993). Additional boreholes were drilled across the site as part of the 1994 site investigation. The 1994 site investigation also included 45 trial pits dug by mechanical excavator. As the objective of the evaluation was to detect any contamination and seepage, the majority of the EAG (1994) boreholes and trial pits were within the landfill area (Figure 13). Several boreholes and trial pits were however, sunk on 'natural ground' around the landfill perimeter to reveal any horizontal seepage of leachate or contaminants. The boreholes were also deep enough to penetrate the Chalk bedrock beneath the landfill.

More recently (2012) RBBC appointed Leap Environmental Ltd (hereafter, LEAP) to undertake intrusive site investigations and to install gas monitoring wells at RFLK to supplement existing wells, (particularly where previous wells had been lost) and to assess the risks of land gas migration from the landfill adversely affecting properties bordering the landfill site to the south and east. In total, 22 gas monitoring wells were installed: 14 wells to a depth of 4m; 3 wells to a depth of 6m; 5 wells to a depth of 10m. The site locations to the south of the landfill were LEAP designated Areas 1a, 1b and those to the east as Area 2. At the southern boundary of the landfill was Area 1a, which encompassed land to the north of Mogador Lane, whereas Area 1b was immediately to the south of Mogador Road. A total of 16 boreholes were drilled in Areas 1a and 1b. Two replacement wells, on the SE boundary were sunk to a depth of 10m. Three pairs of well were sunk along the southern boundary (northern side of Mogador Lane). Each pair comprised: one well to a depth of 6m (entirely in the deposits mapped as Clay-with-flints) and one well to a depth of 10m (through the Clay-with-flints deposits) to the underlying Chalk. On the southern side of Mogador Road, a total of 8 shallow monitoring wells were sunk to a depth of 4m through made ground, Clay-with-flints deposits and into Chalk. To the east of the landfill was Area 2. Here 26 trial pits/holes were hand dug to a depth of ~1m in the gardens of Orchard Way and six (additional) shallow gas monitoring wells were sunk to a depth of 4m. The LEAP (2012) summary ground conditions for Area 2 state that; holes H1-4, WS1 and WS5 encountered none, or very little shallow fill. At holes, H9-13, H15, H17-19, H22-23, H25-26, and WS4, reworked clay, made ground with occasional brick and ash were found. Whereas, the remainder of the locations encountered fill below depths of between 1 to 9m. At a depth of ~4m, off-white structureless Chalk was recovered as fine to course angular to sub-rounded chalk gravel in a white silt matrix. As the LEAP (2012) investigations at RFLK were confined to the southern and eastern periphery of the landfill site, data derived from site work in Areas 1a, 1b and 2 serves only to substantiate the results from boreholes that were drilled around the edge of the site in 1988 (SDL, 1989) and those of the 1993 and 1994 borehole drilling and trail pit excavations by EAG (1993; 1994).

Methodology

The five datasets of the RFLK sub-surface vertical stratigraphy (derived from the PADMAC Unit's 2002 geophysical survey of the area (Section 3)) and data from the RFLK soil/sediment analyses (Section 4) were combined with the results of extensive borehole and trial pit investigations undertaken across the RFLK on behalf of RBBC. This data integration was one way to produce a 3D model of the RFLK sub-surface landform particularly that of the now in-filled deep elongated dry valley. Selected borehole and trial pit data were analysed, in conjunction with the PADMAC Unit 2002 resistivity results to construct two geospatial models.

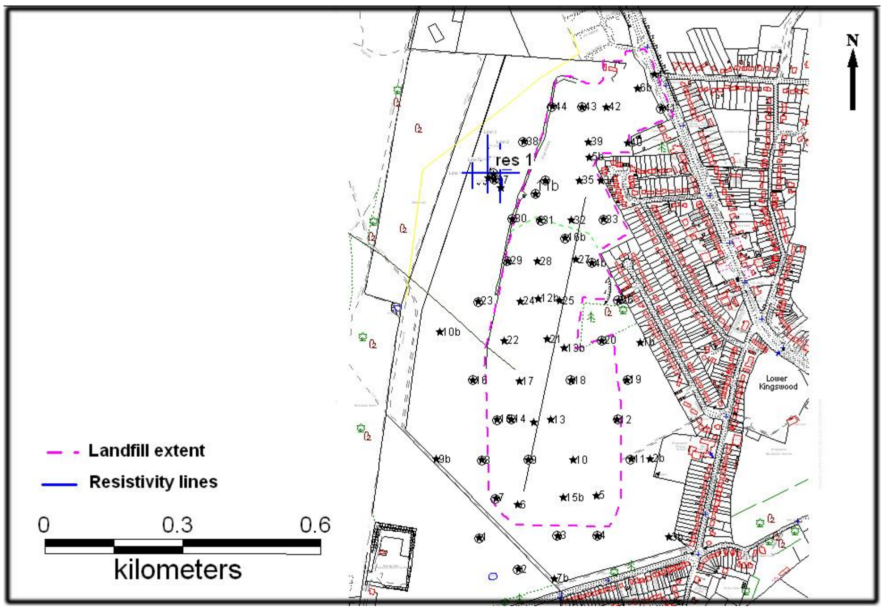


Figure 13: Locations of the Rookery Farm: Boreholes (annotated 'b'); Trial pits and PADMAC Unit 2002 resistivity Lines 1-5, in relation to the landfill extent.

For Model 1; the contours of the sub-surface Chalk interface, the depth from the surface of the field to the Chalk interface across the area was calculated and hence the thickness of the overlying deposits mapped as Clay-with-flints and the topography of the Chalk sub-surface. Each borehole/trial pit's depth to Chalk was converted to metres OD. These data were then exported to MapInfo to extrapolate the contours of the entire Chalk sub-surface.

To construct Model 2; cross-section profiles, specific cross-sections of sub-surface stratigraphy were extrapolated from the sequences obtained from relevant borehole, trial pit and resistivity data. The Chalk sub-surface heights (calculated from the stated (EAG) 1994 land surface heights minus the depth to Chalk in each borehole) were converted to meters OD. Slope profiles of the (Getmapping bare earth, DTM) 1990 landsurface and the Chalk sub-surface along the cross-section were then calculated within the Vertical Mapper routines of MapInfo. Data from these analyses were also used to verify the results of the PADMAC Unit's geophysical survey (Section 3), by characterizing the deposit/s overlying the Chalk as identified by layers of differing resistivity, particularly as they relate to geomorphological processes (Section 4) which have affected the deposits since the Palaeolithic period.

The RFLK cross-section profiles

Data from the RFLK boreholes, trial pits and the resistivity survey (PADMAC Unit, 2002, Section 3) were used to calculate the cross-section profiles: BCS1; BCS2; BCS3; TCS1; TCS2 (Figure 14)

The orientation of these profiles and the sequence in which they are considered are as follows:

BCS1: Borehole cross-section, Northwest to Southeast (incorporating depth readings from resistivity Line 1 at point 62.

BCS2: Borehole cross-section, South to North along the bottom of the pre-landfill dry valley.

BCS3: Borehole cross-section, South to North, through deepest section of the dry valley.

TCS1: Trial pit cross-section, West to East, including trial pit 37.

TCS2: Trial pit cross-section, South to North, along the plateau to the West of the landfill, entirely on ‘natural ground’ to the West of the landfill.

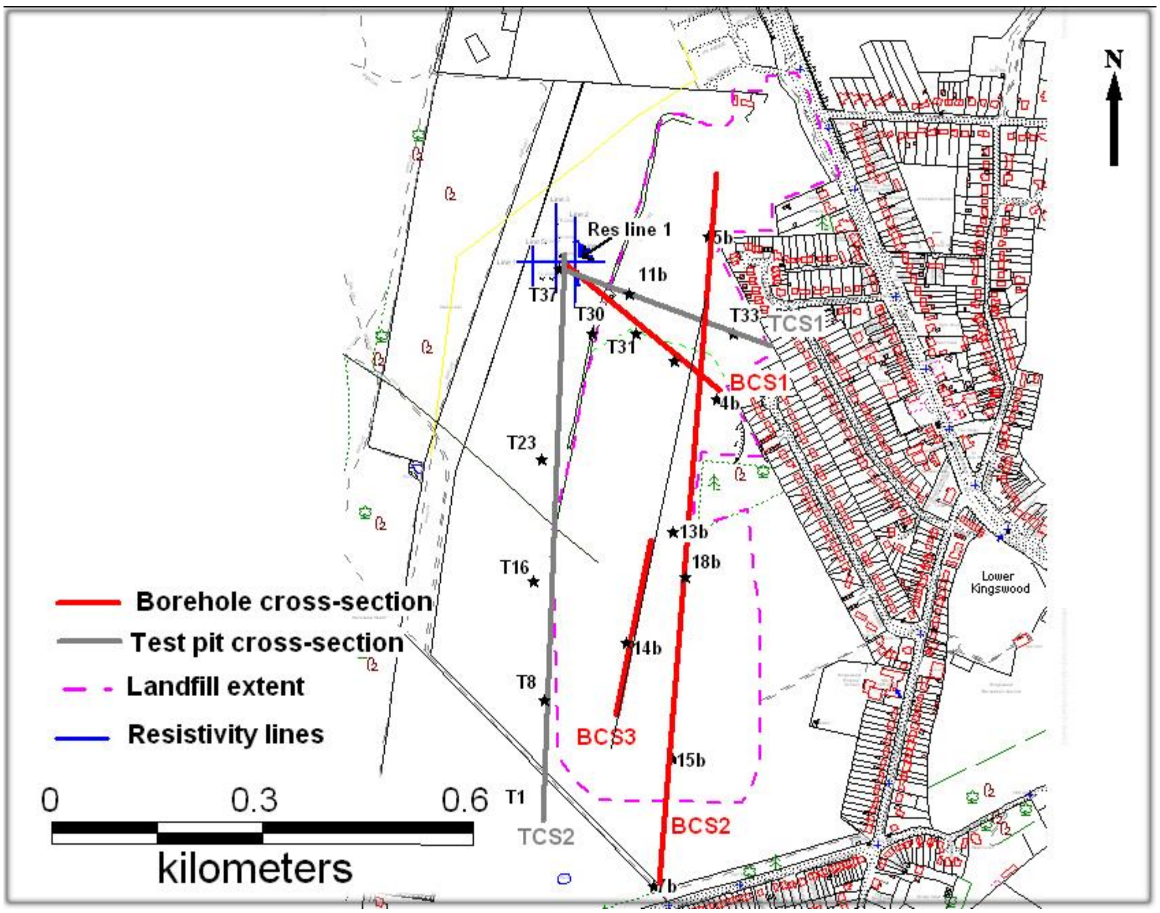


Figure 14: Locations of RFLK borehole cross-section profiles (BCS1; BCS2; BCS3), trial pit cross-sections profiles (TCS1; TCS2), resistivity lines and landfill extent.

BCS1: Borehole cross-section profile northwest to southeast across the pre-landfill dry valley

The cross-section BCS1 (Figure 15) runs northwest to southeast and transverses the (now-infilled) dry valley. This cross-section was calculated using data from Boreholes 4, 16 and 11 (see Figure 15) and a sub-surface column derived from the values at point 62 along resistivity Line 1 (Figure 16).

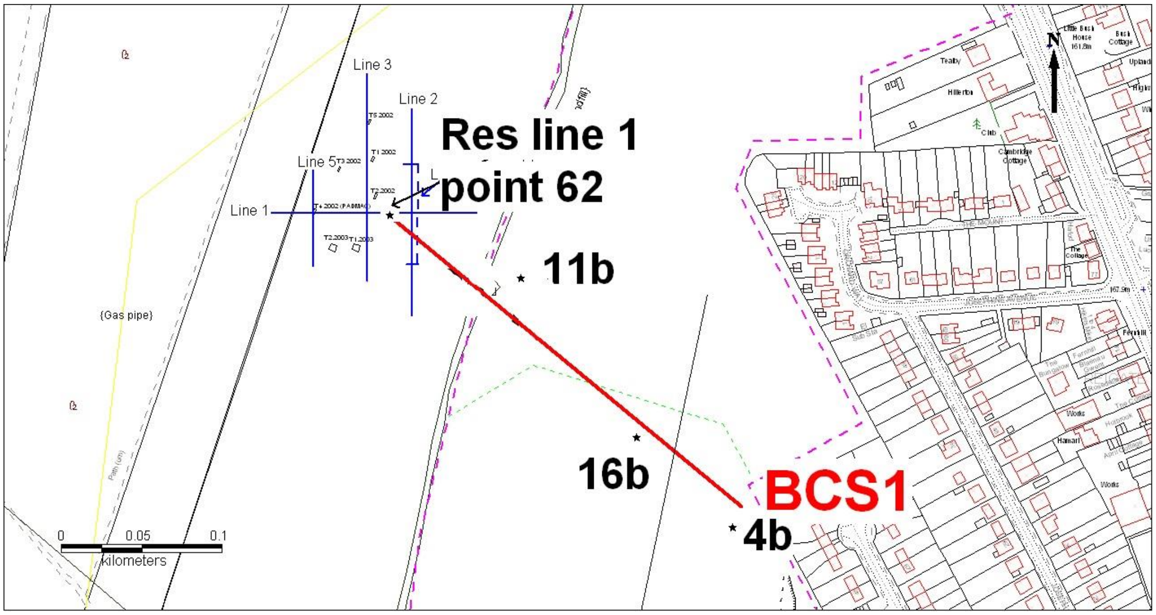


Figure 15: Location of cross-section profile BCS1; Northwest-Southeast, incorporating Boreholes: 4; 16; and 11 and the PADMAC Unit 2002 resistivity Line 1 at point 62.

West East

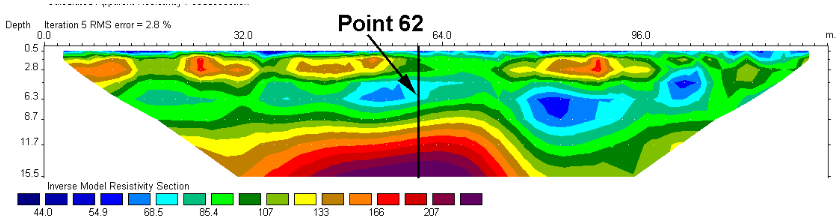


Figure 16: PADMAC Unit (2002) resistivity Line 1 West - East, showing position of vertical section at point 62.

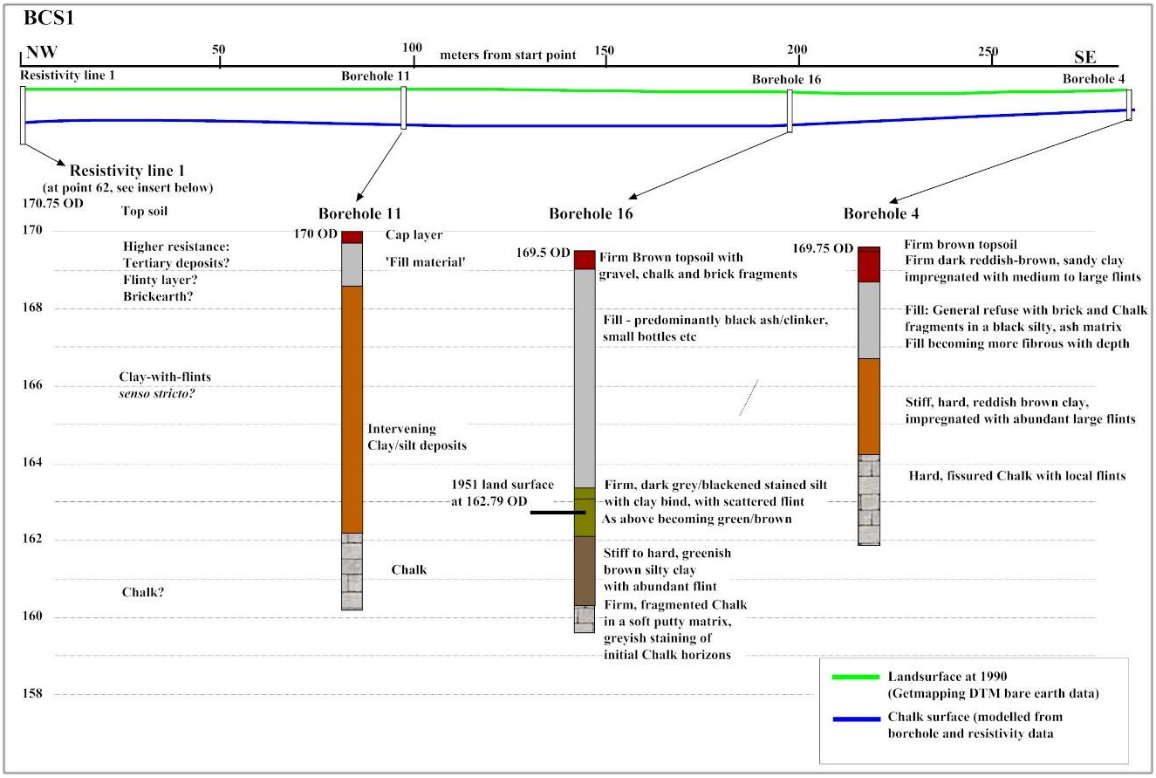


Figure 17: Profile of cross section BCS1, Northwest-Southeast showing the 1990 (post-landfill) surface, Chalk sub-surface, resistivity section (Line 1 point 62) and stratigraphic columnar diagrams for Boreholes 4, 16 and 11.

The cross-section profile BCS1 (Figure 17) shows that the depth of the overburden above the Chalk appears greater at resistivity Line 1 (point 62) than at Borehole 11, suggesting perhaps a solution feature in this vicinity, particularly as the chalk sub-surface is stratigraphically higher at Borehole 11 before dropping down into the dry valley.

BCS2: Borehole cross-section profile South to North; along the bottom of the pre-landfill dry valley

Cross-section BCS2 (Figure 18) runs from high ground to the South of Rookery Farm, along the now-in-filled dry valley to the lower ground to the North. The cross-section (Figure 19) was calculated using data from Boreholes 7, 15, 13, 4 and 5.

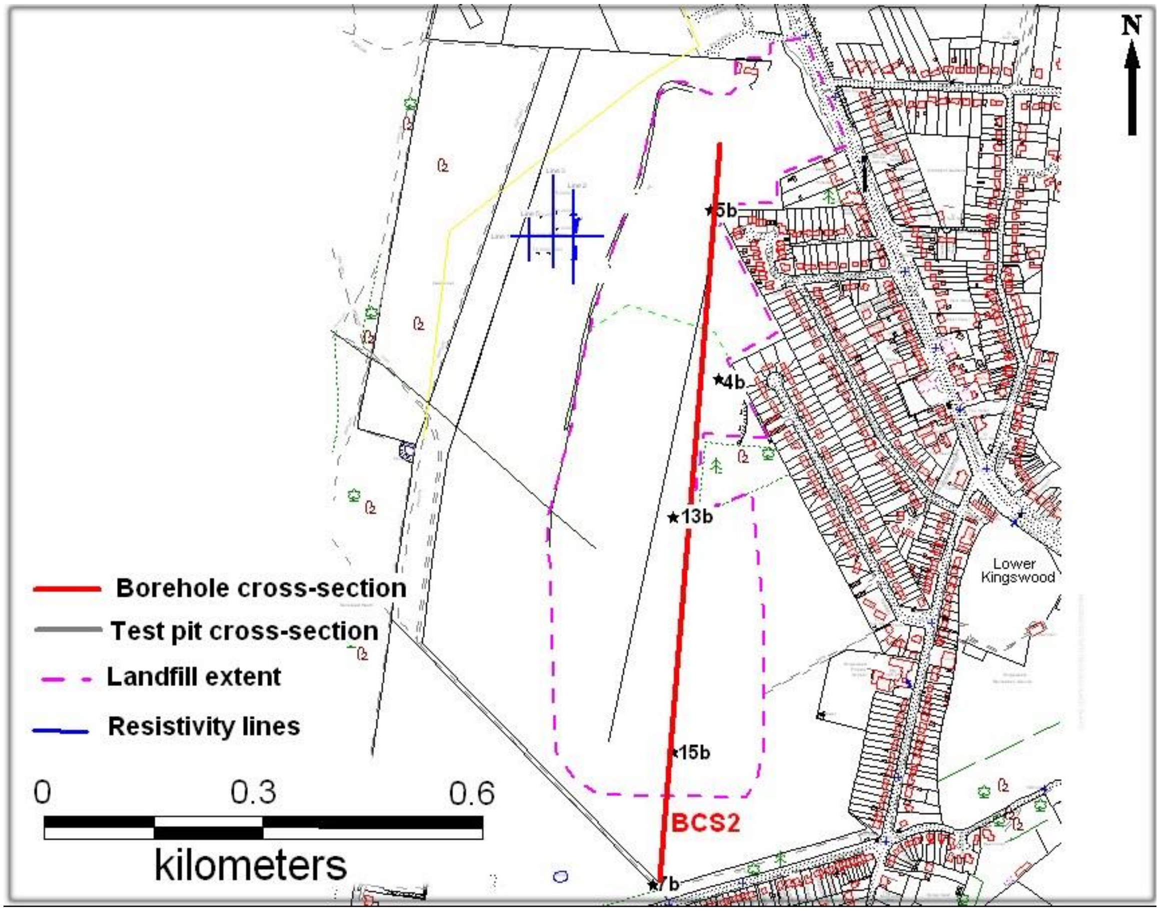


Figure 18: Location of cross-section profile BCS2; South to North, incorporating Boreholes 7, 15, 13, 4 and 5.

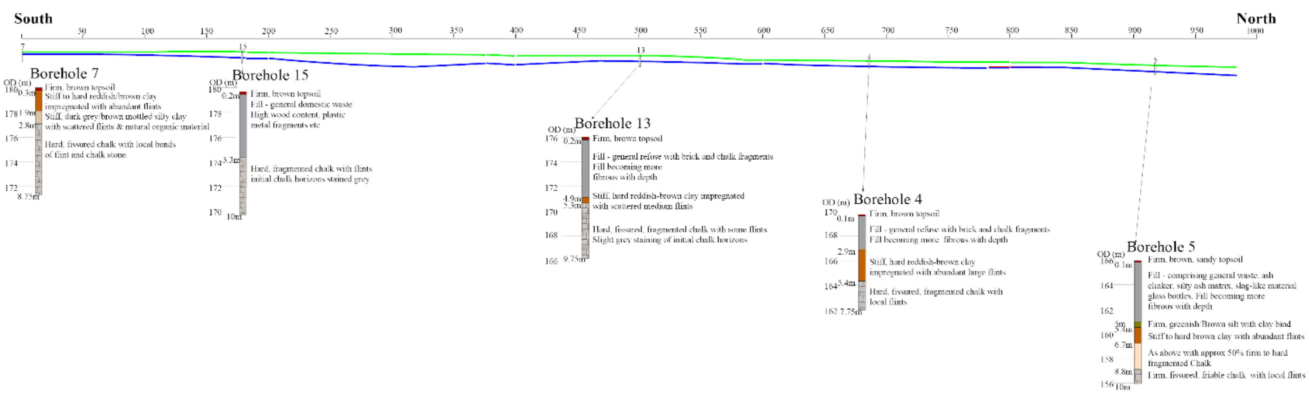


Figure 19: Profile of cross-section BCS2 South-North showing: 1990 landsurface, sub-surface Chalk and stratigraphic columnar diagrams for Boreholes 7, 15, 13, 4 and 5.

The cross-section profile BCS2 South-North (Figure 19) shows a gradual lowering (northwards) of the Chalk sub-surface within the dry valley and a substantial depression roughly 200m wide and centred on grid reference TQ 524480 153570 (~200m to ~400m from the start of the cross-section). This depression perhaps reflects a natural feature or could result from excavation of the Chalk during the landfill site construction. These hypotheses are further discussed below, in relation to cross-section BCS3.

BCS3: Borehole cross-section profile South to North: through the deepest section of the dry valley.

The cross-section BCS3 was selected to explore the depression in the Chalk sub-surface highlighted in cross-section BCS2 above. It is therefore positioned to run through the centre of the depression (Figure 20). This cross-section (Figure 21) was calculated using data from both, Borehole 14 and the modelled Chalk sub-surface.

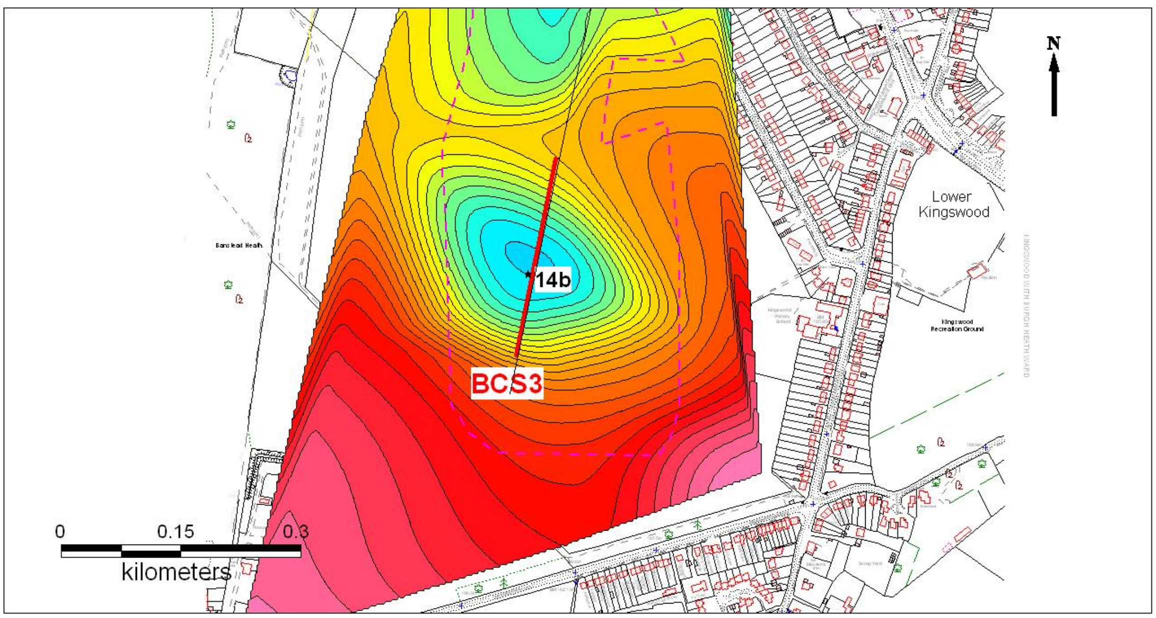


Figure 20: Location of cross-section profile BCS3; South-North though Borehole 14 and the deepest part of the depression in the Chalk sub-surface.

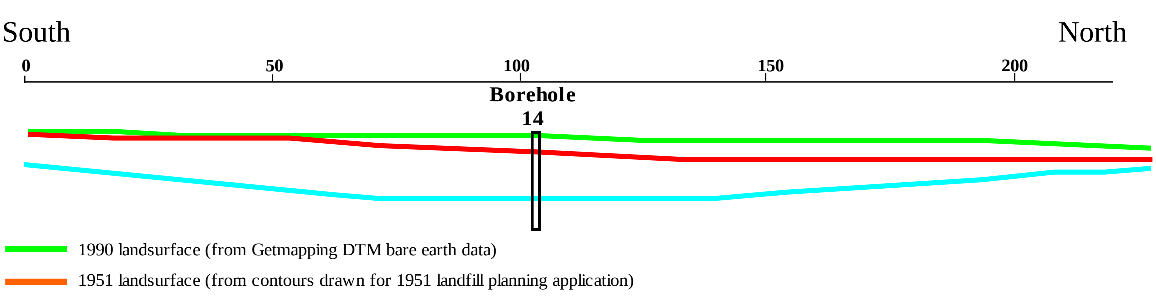


Figure 21: Cross-section profile south to north through Borehole 14; with the 1990 and 1951 land surfaces shown and the modelled sub-surface depression in the Chalk.

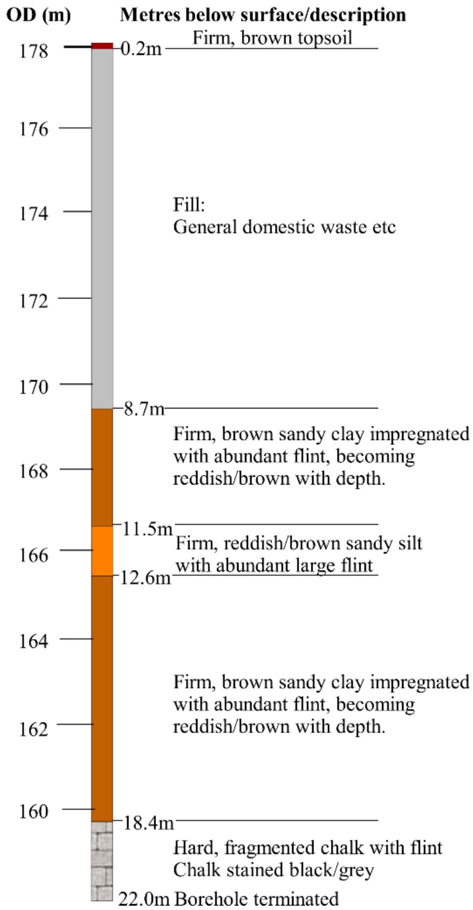


Figure 22: Borehole 14 stratigraphic column (EAG, 1993)

The Borehole 14 stratigraphic columnar diagram (EAG 1993) shows the succession of named litho-stratigraphic units (Figure 22). Here, the lowest stratigraphic unit, Chalk, is overburdened (~10m) by 3 units having similar characteristics but with varying proportions of firm brown sandy, clay, or silt and with the inclusion of many flints. This deep layer of deposits mapped as Clay-with-flints is in turn, overlain by ~8.7m of landfill. The ~10m of Clay-with-flints is perhaps in-situ, as it seems unlikely that landfill construction would have involved digging down ~18.4m to the Chalk, through 3 units (~10m) of Clay-with-flints deposits and then backfilling whilst maintaining the integrity of these 3 units (within the identified depression (Figure 20) in the Chalk) before filling with waste. The balance of evidence suggests that this depression (as modelled) is a natural feature in the Chalk.

From the original (pre-landfill) landsurface contours heights (as shown on the 1951 landfill planning application), it would appear that the RFLK landfill site was constructed by first removing the topsoil and then ~ 5m of the underlying deposits mapped as Clay-with-flint. Subsequent infilling raised the landsurface 3.7m higher (as recorded by the Getmapping (1990) transect South-North down the valley (Figure 21). This is substantiated by ~8.7m of infill shown in the (EAG 1993) stratigraphic columnar diagram for Borehole 14 (Figure 22).

TCS1: Trial pit cross-section profile West to East

The trial pit cross-section profile TCS1 runs from the plateau to the West of the landfill and across to the Eastern slope (Figure 23). This cross-section was calculated using stratigraphic columnar data from Trial pits 37 and 30 (on natural ground to the West of the landfill) and 31 and 33, both on the East slope within the area of what is now landfill (Figure 24).

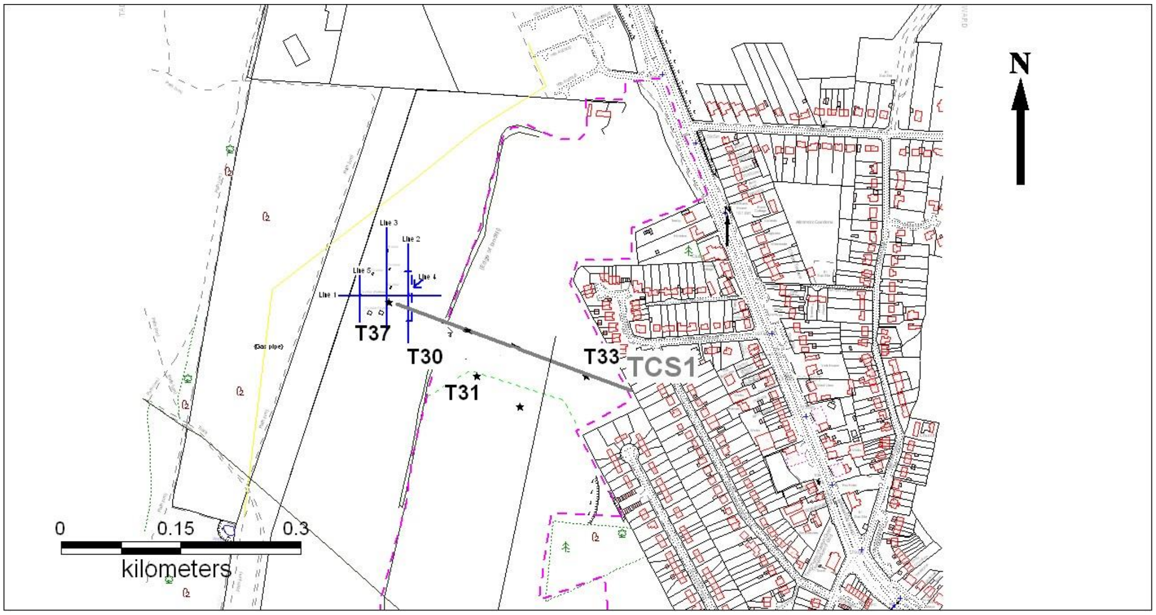


Figure 23: Location of cross-section profile TCS1; West to East, incorporating Trial pits 33, 31, 30 and 37.

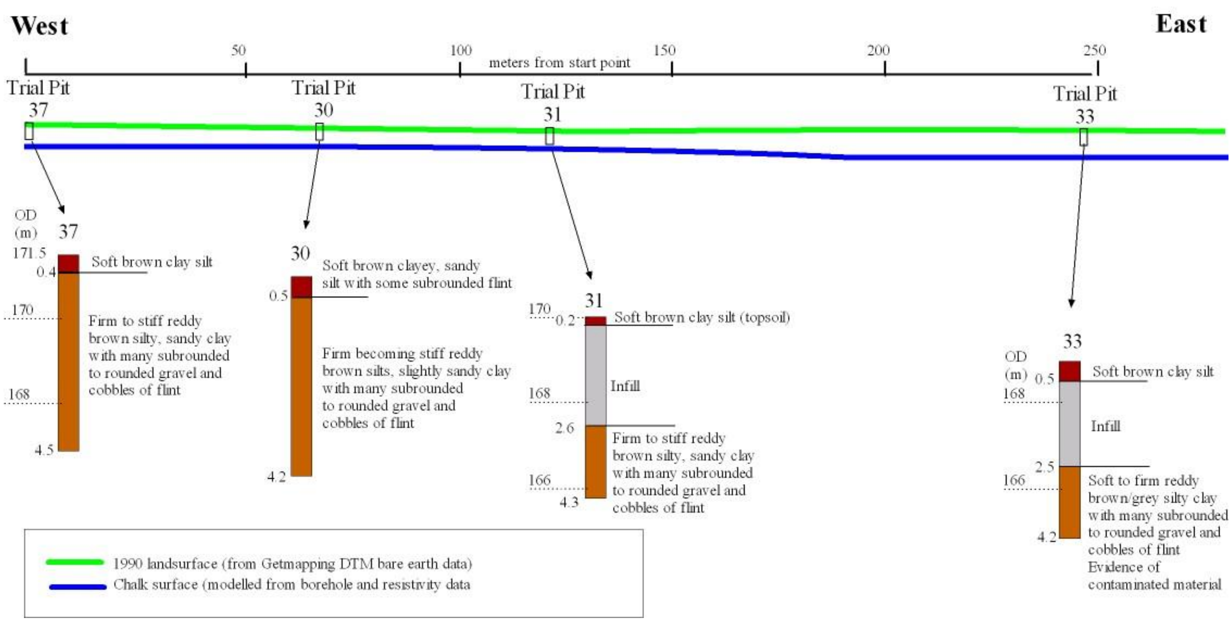


Figure 24: Profile of cross-section TCS1 West to East showing; 1990 landsurface, sub-surface Chalk and stratigraphic columnar diagrams for Trial pits 33, 31, 30 and 37.

The following trial pit stratigraphic columnar diagrams, (EAG 1994) show the succession of named litho-stratigraphic units for Trial pits 33, 31, 30 and 37 (Figure 23, Figure 24). Trial pits 37 and 30 were dug on the plateau, to the West of the landfill, the presence of a layer of Clay-with-flints *senso lato* down to ~ 4m and confirmed the RFLK 2002 PADMAC Unit resistivity results. The height of the 1990 landsurface at the location of Trial pit 33 was ~199.5m OD. Trial pit 33 stratigraphic columnar data shows the landfill extending down to ~166.3m (which may represent the pre-landfill 1951 landsurface). The deposits underlying the landfill are recorded to a depth of ~4.2m deep (~165m OD) and are described as reddy brown grey, sandy silty clay and flint. The same pattern is evident in Trial pit 31, where the infill overlies a pre-landfill deposit of reddy brown, silty sandy clay (Figure 24). For Lines 1, 2 and 3 the layer between 1.5m and 4m depth registered higher resistivity. The evidence from the Trial pit 37 exposure (Figure 24) shows that the high resistivity layer is a reddy brown, silty, sandy clay with gravel and flint cobbles. Chalk was not reached in this pit, so the high resistivity layer does not represent Chalk with flints, resistant Chalk or Coombe rock but is more likely to be indicative of Clay-with-flint *senso lato.*

Trench 4 (T4:2002) and Lines 1 and 5

Trench 4 (T4:2002) excavated by the PADMAC Unit in 2002 was positioned (Figure 25) at the intersection of resistivity Line 5 (at 32 m i.e. the mid-point) with resistivity Line 1 (see Section 3). The southeast corner of the working area was at exactly 32 m on Line 5 and 24 m along Line 1. As the soil profile analysis of T4:2002 has been discussed in detail in the Soils/sediments Section 4 (above) it is sufficient to reiterate here that the Sandy Clay and Silty Clay Clay-with-flints deposits which extended below the 124cm. horizon could effectively produce the low resistivity reading (shown in blue in Figure 10). And that despite auguring down through the bottom of T4:2002 at the end of the excavation we could not penetrate deep enough through this clay layer to identify the underlying deposits or to locate the Chalk bedrock. The results of the resistivity survey for Line 5 suggest the presence of a low resistivity material infilling high resistivity solution feature at both the 12m point at (to a depth of ~ 2.5m) and at electrode point 50m (to a depth of ~ 2m).

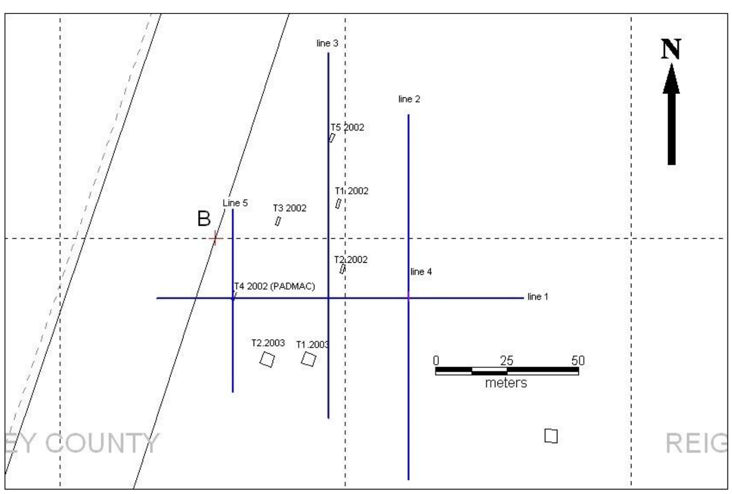


Figure 25: Diagram showing the RFLK 2002 resistivity Lines 1-5 and Trench 4 (T4:2002).

TCS2: Trial pit cross-section profile South to North

The trial pit cross-section profile TCS2 (located west of the landfill), runs from south to north on the plateau along 'natural ground' and, to the north, intersects the PADMAC Unit (2002) resistivity Line 1 (Figure 26, Figure 27). This cross-section was calculated using stratigraphic columnar data from Trial pits 1, 8, 16, 23 and 37. Along this cross section there are no discernible differences between the 1990 (post-landfill) and the 1951 (pre-landfill) landsurface heights (i.e. the area appears not to have been lowered or raised between 1951 and 1990).

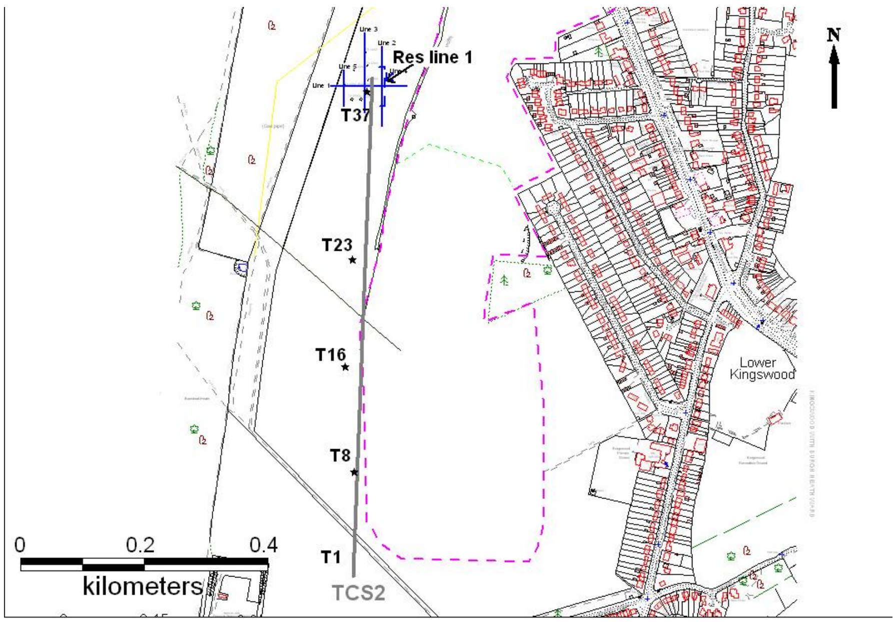


Figure 26: Location of trial pit cross-section profile TCS2; south to north, incorporating Trial pits 1, 8, 16, 23 and 37.

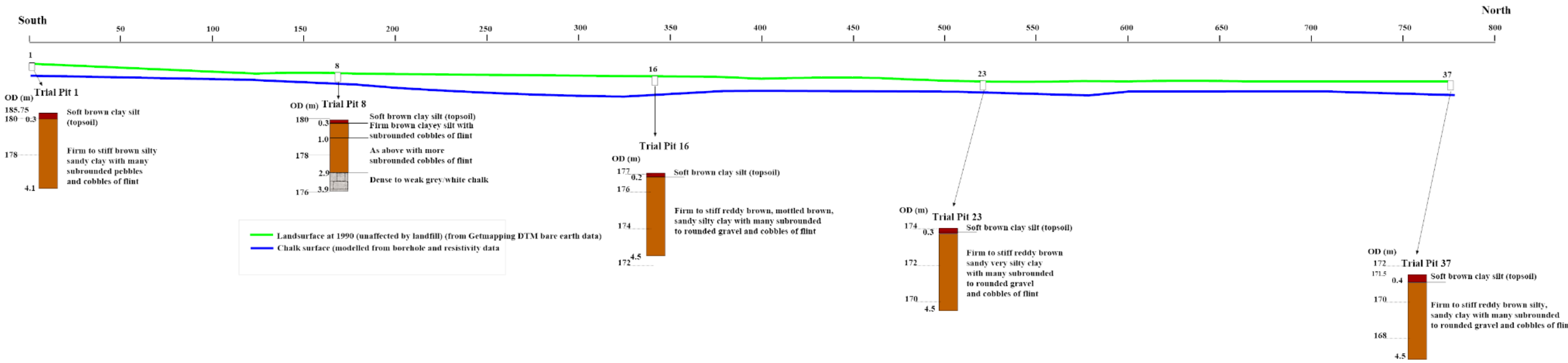


Figure 27: Profile of cross-section TCS2 South to North showing; 1990 landsurface, sub-surface Chalk and stratigraphic columnar diagrams for Trial pits 1, 8, 16, 23 and 37.

The analysis of TCS2 stratigraphic columnar diagrams (Figure 27) for trial pits 1, 8, 16, 23 and 37 reveals that only one of the trial pits (Trial pit 8) reached Chalk at a depth of ~2.9m. The Chalk appears to be nearer the surface in the south of the area but the trial pits were excavated to an average depth of ~4m which, for most of the site, is too shallow to reach the Chalk. All the trial pit stratigraphic columnar diagrams show, ~0.3m topsoil overlying a deposit described as firm to stiff reddy brown silty/sandy (or sandy/silty) clay with many sub-rounded to rounded gravel and cobbles of flint, with the addition of brown mottling (of the deposits) in Trial pit 16. In addition, there was no reported evidence of contamination or leachate in any of these (western) trial pits. Importantly, the results of this TCS2 analysis suggests that the landfill has had a minimal impacted on this part of the high plateau and in particular, the area of Palaeolithic site investigations.

Section 6: Spatial analyses of the RFLK area

The aim of the spatial analyses was to produce, by extrapolation, a topographic model of the RFLK area prior to the landfill and a detailed relief topography of the contours, specifically that of the southern half of the dry valley prior to the landfill. And, to place Carpenter's (1960) and Pemberton's (1971) areas of investigations (as discussed in Section 1) in their correct topographic context. The RFLK spatial analyses was carried out by the PADMAC Unit using MapInfo (www.mapinfo.com), a computer based Geographic Information System (GIS). Also, five datasets which were incorporated into separate layers of the spatial database, specifically:

- Digital Elevation Model data (DEM) from Digimap (www.edina.ac.uk) – for contours and heights;
- Ordnance Survey landline data from Digimap (www.edina.ac.uk);
- Historic mapping (from www.old-maps.com) (also available from Digimap);
- Aerial photography;
- Geophysical survey results (PADMAC Unit, 2002) and the geospatial 3D datasets.

Methodology

The extrapolation of historical contour data using DEM data and Ordnance Survey landline data became the first stage in constructing the spatial database. The RFLK contours submitted for the landfill planning application (BAN 321/50) (Figure 28) were scanned into MapInfo and geo-referenced against landline mapping (from Digimap) contained in the PADMAC Unit MapInfo GIS workspace for RFLK. These contours were then digitised as polygons into the MapInfo workspace and a grid of heights calculated using the kriging method in Vertical Mapper. Ordnance Survey panorama 10m DEM spot heights (as at 1999) were downloaded from Digimap for the area. These data were interpolated (in Vertical Mapper) to give contoured and 3D representations of current topography (Figure 29). The given heights along the pre-landfill contour lines were then used to replace the spot heights from the 1999 panorama data (Digimap). Null points were left in landfill areas not covered by the contours. This second interpolation provided contoured maps (Figure 30) and the development of 3D representations of the reconstructed topography, prior to the landfill. The 1950 contours of the southern half of the RFLK dry valley, prior to the 1960 landfill, were geo-referenced, digitised and added to the GIS datasets for further analysis.

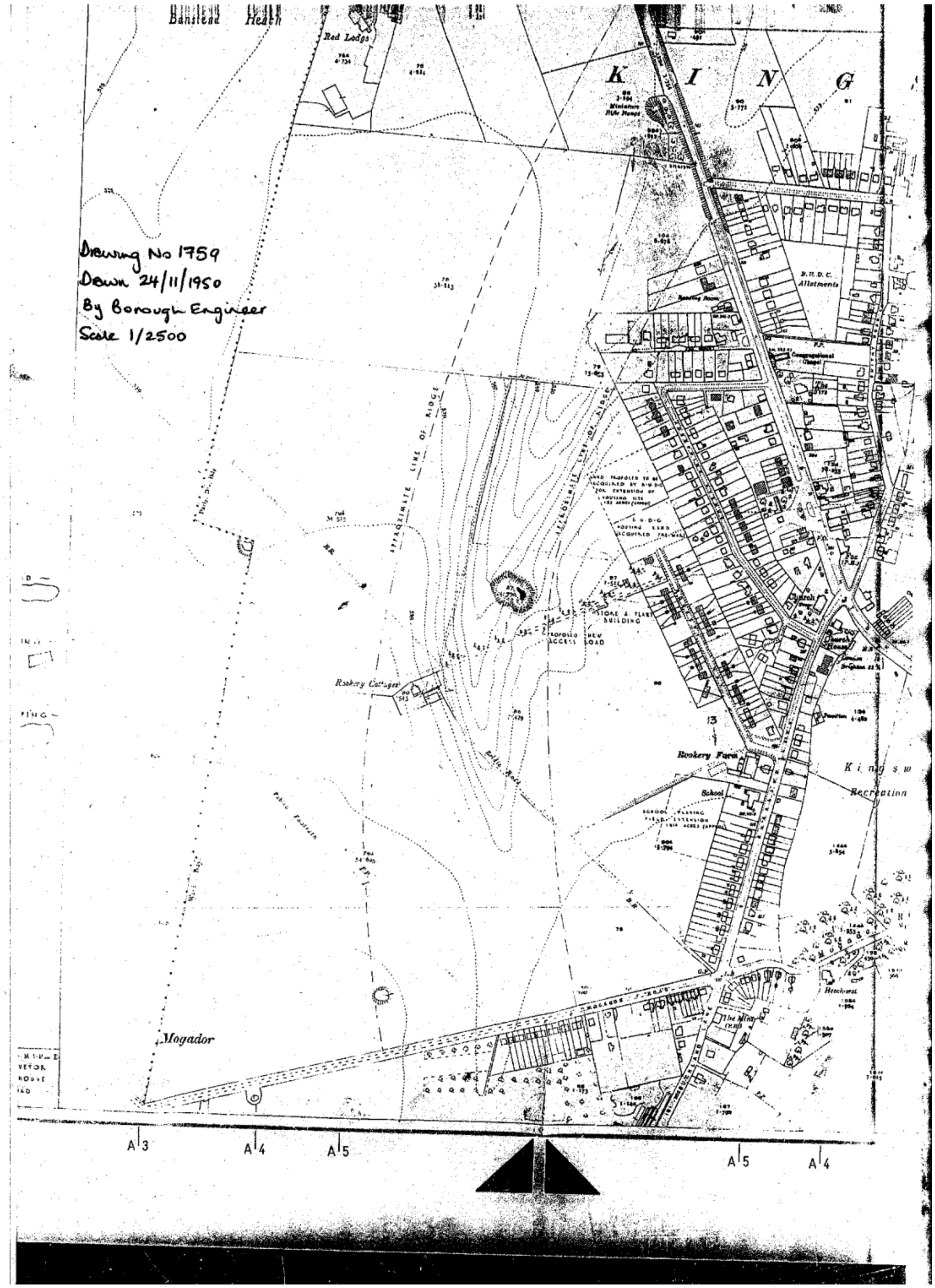


Figure 28: Map of 1950 showing the contours of the southern half of the Rookery Farm Lower Kingswood dry valley, prior to the 1960 landfill (reproduced with the permission of Reigate & Banstead Borough Council).

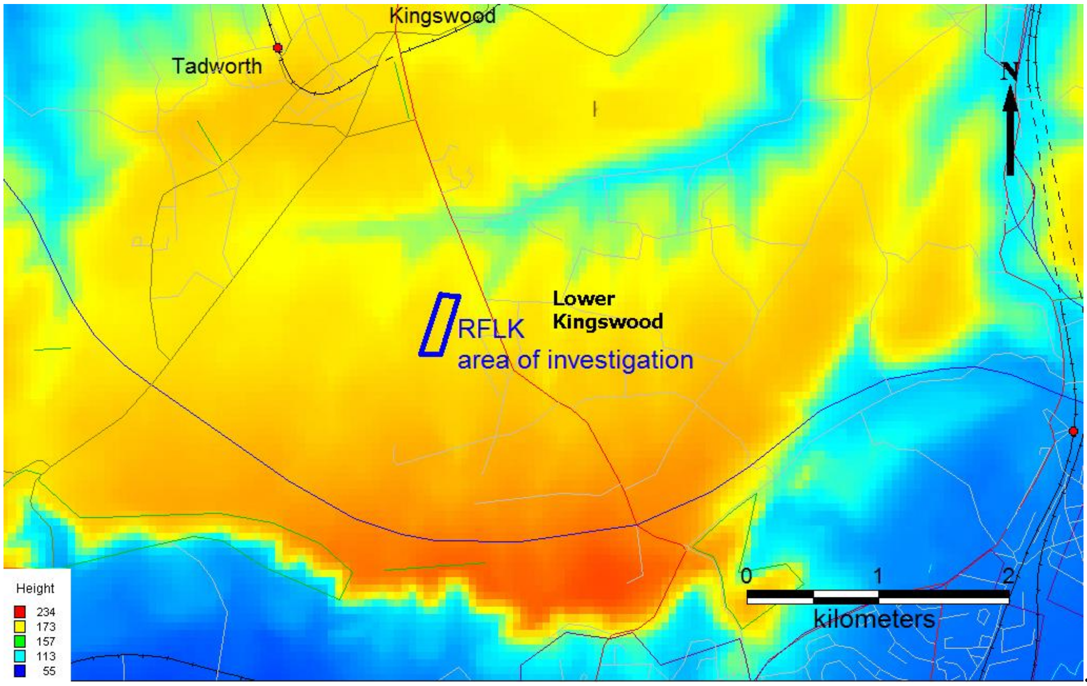


Figure 29: Relief topography of RFLK environs (~10km radius of the Rookery Farm Palaeolithic site).

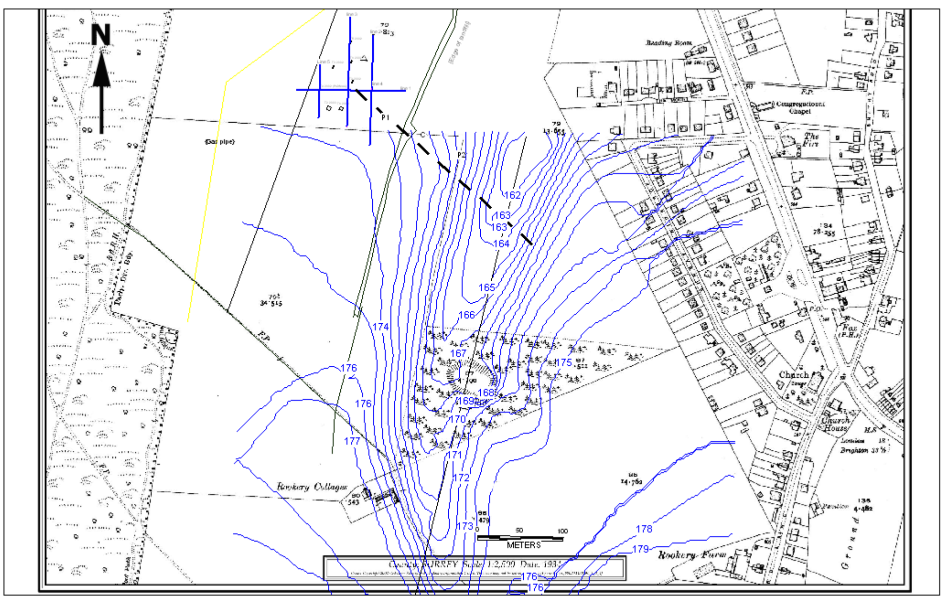


Figure 30: Overlay of the RFLK contour map of the dry valley (reconstructed from 1950 contours on the OS map of 1934 (Digimap data entered into GlobalMapper): Showing increase in depth of dry valley (reducing from a height of ~177m OD in the south to ~162m OD in the north).

Assessing anthropomorphic activity in the RFLK area

In order to investigate the Palaeolithic of RFLK, it is necessary to understand more recent changes in the landscape and their possible impact on much earlier evidence. The impact of anthropomorphic activity on the landscape may well have increased in historic periods, especially with changes in farming practices and land ownership during the 19th and 20th centuries. To facilitate the identification of such changes, maps were obtained from www.old-maps.co.uk (also available from Digimap); for the years 1869, 1874, 1896, 1897, 1913, 1914, 1932 and 1934 and geo-referenced as layers into the PADMAC Unit Rookery Farm MapInfo GIS database.

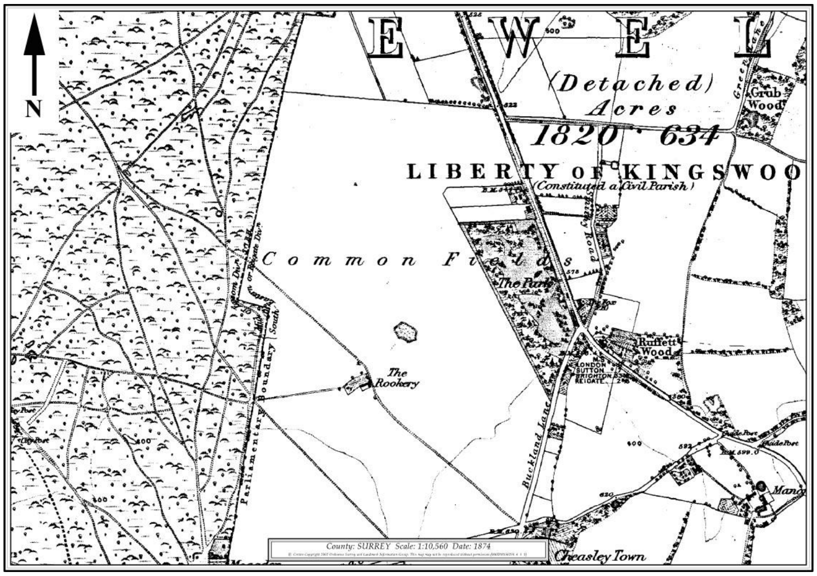


Figure 31: Rookery Farm historical map of 1874 (Landmark Information Group, 2002)

This 1874 map (Figure 31) reveals a pit (referred to as 'Old Chalk Pit' on the 1896 map) and woodlands to the east which were replaced with housing by 1934 (now to the east of the landfill).

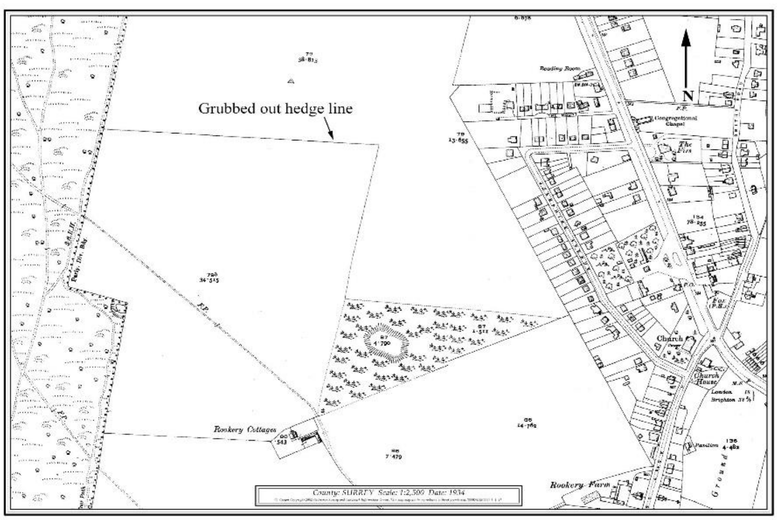


Figure 32: Rookery Farm historical map of 1934 (Landmark Information Group, 2002).

The 1934 Ordnance Survey map (Figure 32) shows a small wood and a pit to the southeast of the site and immediately to the north, what appears to be a hedge line running from west to east (terminating in the centre of the map). This boundary is no longer visible at ground level but does show as a crop mark on an aerial photograph of 1967 (Figure 33), which suggests that the hedges was grubbed out and the ditch in-filled. (It is not inconceivable that spoil scattered on the surface during the grubbing out of the hedge, may have included Palaeolithic artefacts which were subsequently recorded as surface-finds).

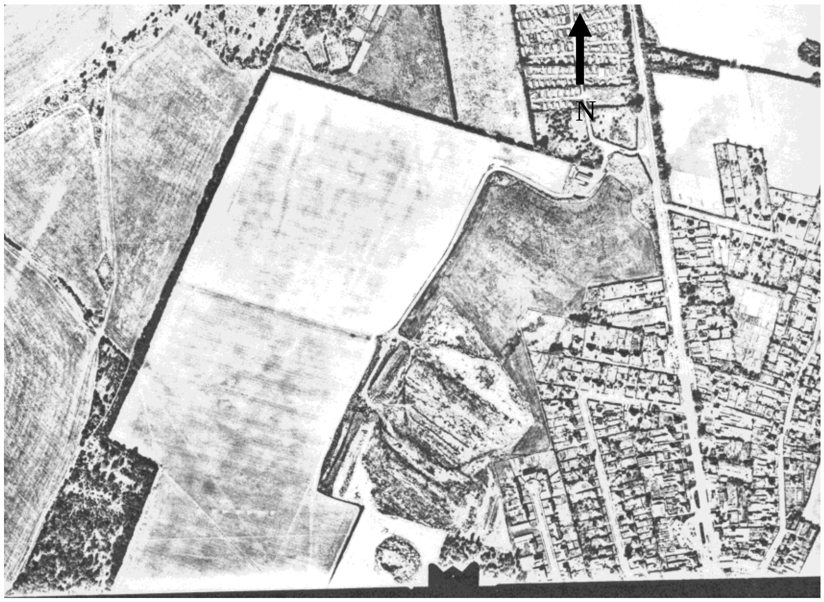


Figure 33: Aerial photograph of Rookery Farm (1967) (National Monuments Records, English Heritage, Swindon)

In the 1967 aerial photograph of RFLK (Figure 33), houses can be seen to the east, the landfill area (in the middle of the picture) and the high plateau to the west. Clearly visible on the high plateau are crop-marks indicative of a grubbed-out hedge (the line running East-West) and perhaps 4 tracks. There are no other signs of anthropomorphic activity on this plateau (e.g. field systems or monument traces) which may have disturbed/displaced the Palaeolithic surface-scatters/sites.

Spatial analyses modelling

The geospatial 3D modelling of RFLK (Section 5) utilised the 1993 and 1994 borehole and trial pit survey data (EAG, 1993, 1994). Dataset BCS1, borehole cross-section profile northwest to southeast (Figure 34) is of special interest as it transects: the (now-infilled) dry valley; Boreholes 4, 16 and 11; the PADMAC Unit 2002 resistivity Line 1 (with point 62) and the general area of Palaeolithic archaeological interest (annotated: Carpenter (1960) C; Pemberton (1971) P1/P2. (Note: cross-section profile BCS1 was calculated using data from Boreholes 4, 16 and 11 (Figure 15) and a sub-surface column derived from the values at point 62 along resistivity Line 1 (Figure 16)). As previously noted (Section 1) the discovery in 1959, of a Palaeolithic 'knapping site' at RFLK (Carpenter, 1960) took place during the removal of the top soil prior to the landfill site construction, whereas the borehole and trial pit survey's (i.e. 1988, (SDL, 1989); 1993 and 1994, (EAG, 1993, 1994); 2012, (LEAP, 2012)) were all undertaken many years after the dry valley was infilled.

Crucially, the geospatial 3D modelling (Section 5) of this raw post-landfill stratigraphic columnar borehole and trial pit depths, required the transformation of horizons to align with the pre-landfill (1951) RFLK landsurface. A reconstruction of this landsurface using BCS1: Borehole 11 (EAG, 1993) data-set (Figure 17) gives a height of 170 m, similar to the recorded height in 1993 and slightly lower than the plateau area to the West. In 1959, this area of the high plateau was on the edge of the deep dry valley (orientated south to north). The stratigraphic columnar diagram for BCS1: Borehole 11 shows the sub-surface Chalk bedrock occurring at ~162m OD (the bottom of the valley) which is now ~ 8m below the present land-surface (Figure 17).

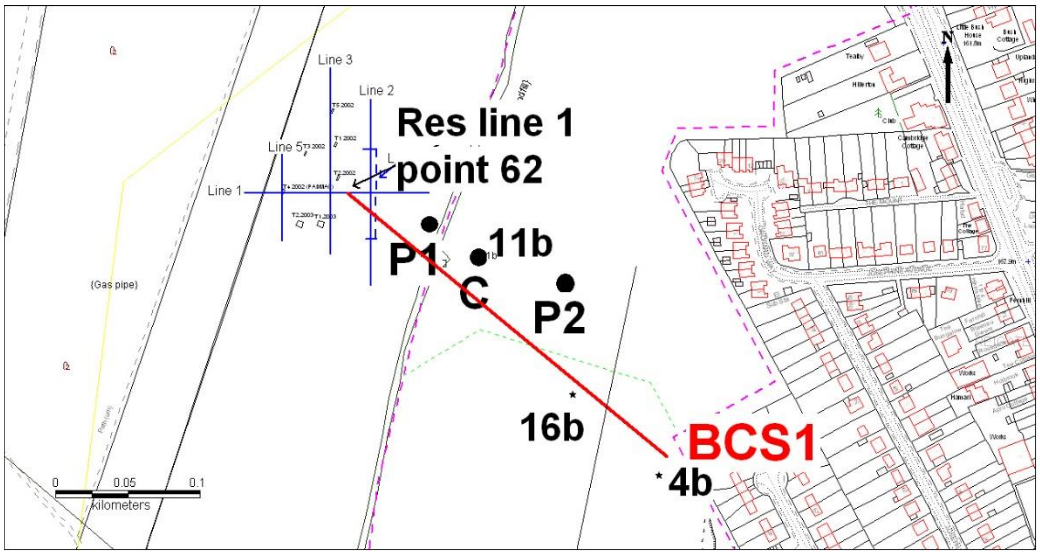


Figure 34: Location of cross-section profile BCS1; Northwest-Southeast, incorporating Boreholes: 4; 16 and 11. Also shown is the PADMAC Unit 2002 resistivity Line 1 (with point 62) intersecting the general area of Palaeolithic archaeological interest (annotated: Carpenter (1960) C; Pemberton (1971) P1/P2).

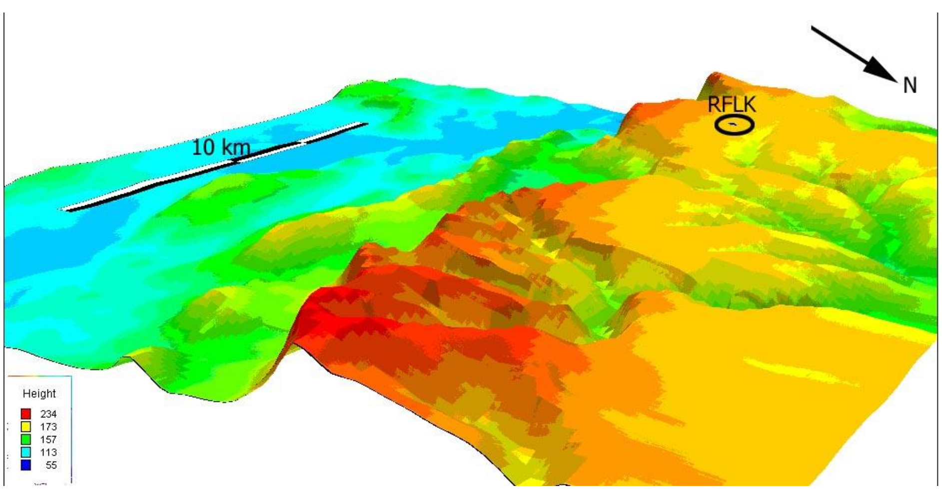


Figure 35: 3D digital terrain model of Rookery Farm, Lower Kingswood general environs

Reconstructing the RFLK dry valley

A 3D digital terrain model of RFLK (Figure 35), produced within MapInfo, reveals the Ps-s/s positioned on the high-level plateau, overlooking a valley to the north, a steep escarpment to the south and a number of ridges which are intersected by north-south trending valleys running northwards from the escarpment. Topographic maps (Figure 29, Figure 30) also show that the Ps-s/s are situated on a relatively level plateau overlooking a valley to the North and the now infilled dry valley (and houses) to the east.

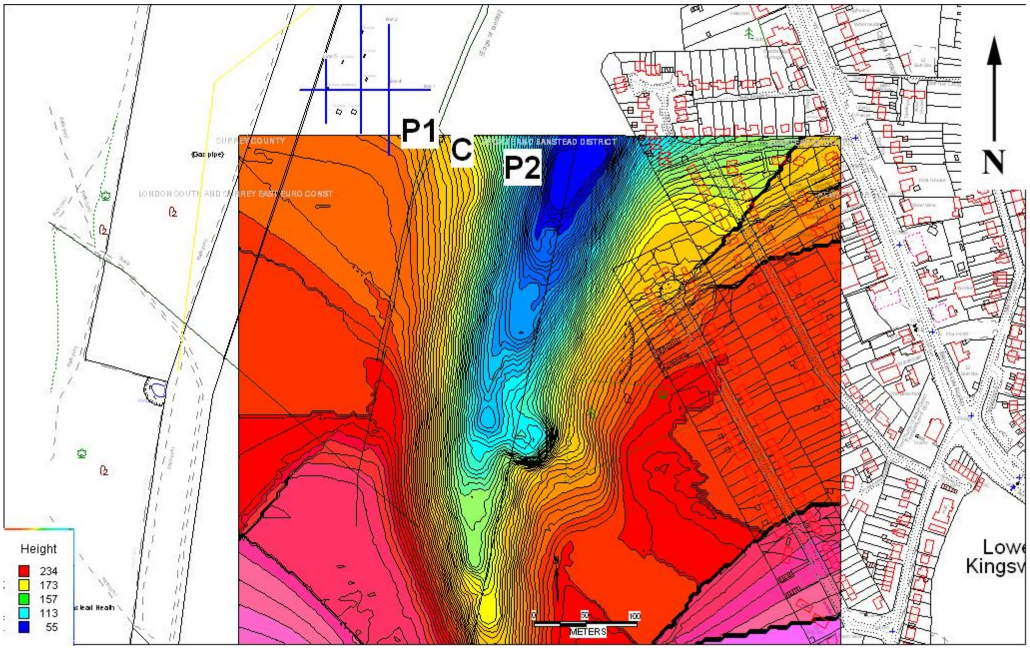


Figure 36: 3D Geospatial reconstruction (by the PADMAC Unit) of heights and contours of the dry valley prior to landfill. Point C is the location of the Carpenter (1960) discovery and points P1 and P2 the Pemberton (1971) excavations.

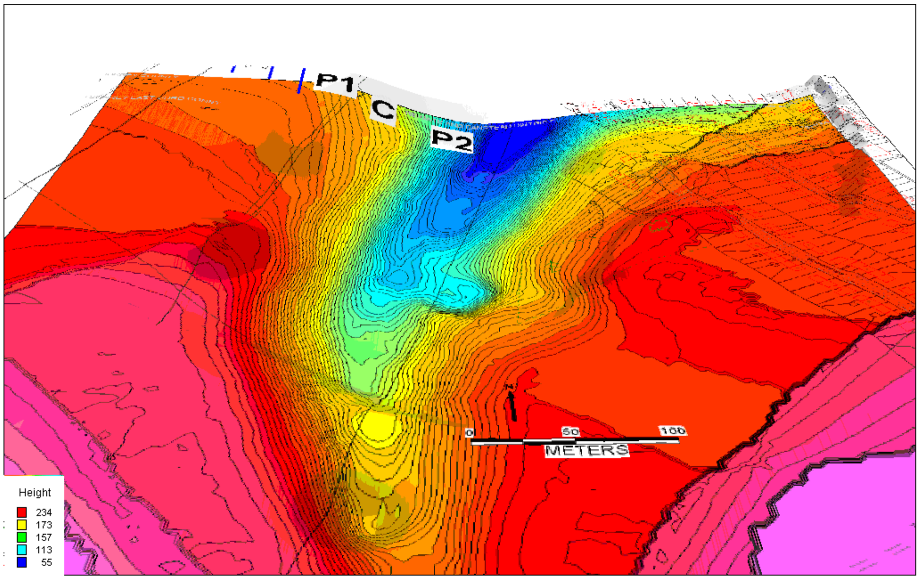


Figure 37: 3D Geospatial reconstruction (by the PADMAC Unit) of the contours of the dry valley prior to landfill. Point C is the location of the Carpenter (1960) discovery and points P1 and P2 the Pemberton (1971) excavations.

The pre-landfill dry valley, reconstructed by the PADMAC Unit 3D geospatial analyses is shown in Figure 36 and Figure 37. In addition to determining the location of Carpenter's (1960) discovery and Pemberton's (1971) excavations, ascertaining the original relief topography of both the high plateau and the dry valley has provided a better understanding of the geomorphology processes that have impacted on the RFLK Palaeolithic in general.

Section 7: The RFLK Palaeolithic artefact analysis

The analysis of technological attributes of the RFLK Palaeolithic artefact assemblage (as assessed here by V. Winton) contributes to the general understanding of Palaeolithic human behaviour and demonstrates the archaeological value of Palaeolithic artefact assemblages from the high-level sites on deposits mapped as Clay-with-flints. In addition, it adds fuel to the (ongoing) debate as to whether the size and shape of handaxes is more strongly governed by constraints of the raw material used, or functional and/or cultural considerations of the Palaeolithic toolmakers (Emery 2010). The results of the RFLK artefact analysis were compared and contrasted with artefact data that the PADMAC Unit had obtained from the investigation of two other high-level Palaeolithic sites on deposits mapped as Clay-with-flints, namely Wood Hill, East Kent, (Scott-Jackson 2000) and Dickett's Field, Alton, Hampshire (Scott-Jackson & Winton 2001; Winton 2004; Cuthbertson 2013). Also, the raised-beach Palaeolithic site at Boxgrove, Sussex (Mitchell 1998).

The RFLK Palaeolithic assemblage comprises flint artefacts found on the surface of the fields, in the topsoil and during excavation of the subsoil. The RFLK artefacts held in the Walls Collection (British Museum) were all recovered as surface-finds. Whereas the Plateau Group Collection, (privately curated by Harp), includes both surface-finds and excavated artefacts. As such, it is necessary to assess whether there are differential patterns of weathering and damage affecting the artefacts that might distort the analyses. The aims of a technological assessment of the RFLK Palaeolithic artefacts were therefore:

- To describe the condition of the artefacts with regard to possible effects upon interpretations of technological attributes and as an indicator of post-deposition environmental conditions;
- To describe adequately the technological characteristics of the assemblage (Walls Collection and Plateau Group Collection) employing comparative datasets as appropriate.
- To test the hypothesis (White 1998, 2006; Emery 2010) that the size and shape of handaxes is governed by the dimensions and quality of the stone raw material available to knappers.

A framework for the technological assessment of the RFLK Palaeolithic assemblages.

As previously noted (Section 1) Palaeolithic artefacts have been found in the RFLK area both as excavated and surface-finds (Carpenter 1955, 1956, 1960; Pemberton 1971; Walls and Cotton 1980; Harp 2002; 2005). The Palaeolithic 'working floor' that Carpenter (1960) discovered at RFLK is reported to have been embedded within the deposits mapped as Clay-with-flints and to have consisted of white patinated artefacts including handaxes and 83 flakes (i.e. handaxes, handaxe fragments and waste products (flakes and cores) from the tool-making process. A later series of excavations by Pemberton (1971) failed to re-locate Carpenter's Palaeolithic floor. From 1969 Walls (and later with Cotton) fieldwalked the RFLK area and amassed a collection of Palaeolithic artefacts (Walls and Cotton 1980). Then in 2002 and 2003, the Plateau Group, in conjunction with the PADMAC Unit, recovered many Palaeolithic artefacts embedded within the deposits mapped as Clay-with-flints (Harp 2005:231-244).

Datasets for this technological assessment of the RFLK Palaeolithic assemblages (Table 3) were compiled (by Winton) from an examination of the Walls Collection (British Museum) and (by Scott-Jackson and Winton) from the Plateau Group Collection (Harp Private Collection). Secondary information was derived from published accounts of artefacts currently unavailable for research (specifically, a number of the Palaeolithic artefacts collected by Carpenter, which are now missing). As far as can reasonably be ascertained, the Walls and Plateau Group (Harp) Collections provide a representative sample of the RFLK Palaeolithic assemblage in terms of artefact size, typology and condition.

Investigator:	Carpenter Collection	Pemberton Collection	Walls Collection	Harp Collection
Context of finds:	Excavation	Surface-finds + Excavation	Surface-finds	Surface-finds + Excavation
Handaxe + Fragments:	6	'a number on surface'	55	14
Cores:	2	?	1	3
Flakes:	'numerous'	'a few' from excavation	43	212
Other:	3 flake tools	?	1 scraper; 12 other items	38 other items
Current Storage:	Unknown	Unknown	British Museum	Harp private

Table 3: Inventory of various collections assembled through fieldwork at RFLK.

Distinct patterns of spatial distribution, assemblage composition and condition characterize the RFLK Palaeolithic site (see Scott-Jackson 2000; 2011 for parameters). Given the non-random nature of the assemblage and the site characteristics, it appears that although there has been historical/modern disturbances, the assemblage retains a strong, archaeologically significant signature (see Section 2 and Section 6). It is generally considered therefore, that the Palaeolithic artefacts at RFLK are:

- Unlikely to have travelled far from the position in which they were made, used and deposited (Carpenter 1956:9; Walls and Cotton 1980:15; Wymer 1987:24).
- Biased towards pointed handaxes (i.e. Walls Collection; Plateau Group Collection (Harp 2002).

Datasets for the RFLK assemblage analysis include:

- The rate of artefact recovery achieved by Tom Walls during fieldwalking between 1969 and 1980s;
- The basic survey of handaxe shape undertaken by Harp (2002).

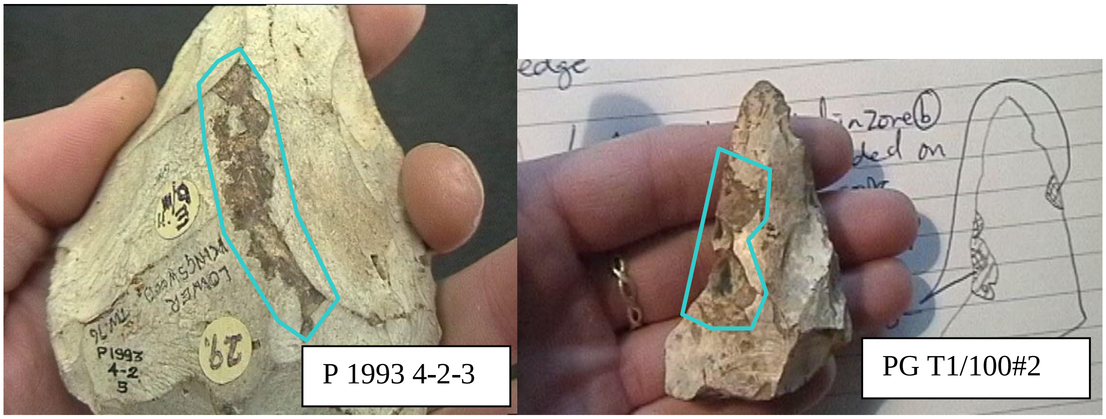
Weathering processes, patination and site formation

The distinctive weathering process known as patination results in a visible change to the surface of naturally flaked material and humanly made artefacts. Where flint is concerned, this involves the leaching of silica from within the body of the flint, which causes a diffraction of light and opacity or whitening of the surface (Graetsch & Grünberg 2012). For Palaeolithic high-level sites on deposits mapped as Clay-with-flints, several distinct patterns of patination have been identified: a high lustre white patina associated with in situ sites; dull white patina; pale yellowish patina and commonly, ocherous patinated flints which display deep brown/red tones (Scott-Jackson 2000; Scott-Jackson 2005:66-76). Other frequently observed changes to the surface of the flints include Manganese staining, which results in black patches and mechanical and/or biological processes associated with the formation of ferruginous spot and streak stains.

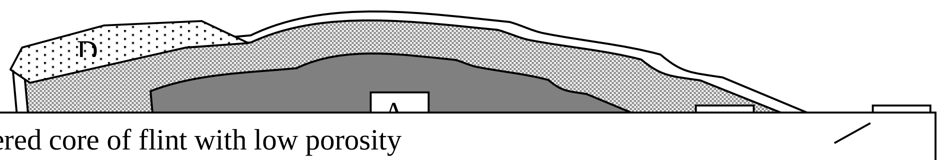
The lustrous white patina which is a particularly characteristic of Palaeolithic artefacts from in-situ sites on deposits mapped as Clay-with-flints is described by Winton (2004, and this artefact analysis) to be the result of a process associated with a deposition zone (c) of silica on the surface of the flint. In this study, this is referred to as; white patina type *a*, and a second type of white patina, white patina type *b*, which does not have a highly lustrous surface acquired in silica deposition zone c. Patinated artefacts of either type *a* or type *b* can subsequently be subject to staining effects. Diffuse, orangey-brown hues can be caused by percolation of iron rich fluids, or by oxidation of the iron content within the flint (Scott-Jackson & Winton 2001:214-222; Winton 2004; Scott-Jackson 2005:66-76).

RFLK artefact patination

The RFLK assemblage exhibits extensive dark mauve mottled staining (approximating to Munsell Colour 10R5/1 – reddish grey) affecting the silica depleted zone of a white patinated artefacts (i.e. patina zone *b*). Figure 38 shows the dark mottle staining, which can give the artefacts a dark grey appearance, particularly when wet. The mottles are often most prevalent along the margins of cortex, as though increased porosity promotes the precipitation of the mottle staining. It is possible that biological agents are involved in the production of mottle stains, microbes for example dwelling within the porous patina zone *b*. Carpenter (1956: 8) supposed that lichen growths in sub-arctic conditions preceding or following a glacial period may have given rise to unusual patterns of staining on the RFLK Palaeolithic assemblage. However, it seems equally likely that artefacts lying within well aerated soils and sediments during more recent, temperate times could be subject to microbial action (Graetsch & Grünberg 2012).



Schematic cross-section through patinated Palaeolithic flint from RFLK:



A = unaltered core of flint with low porosity
B = Patina zone ***b*** – leached of silica, porous zone where mottle stains occur
C = Patina silica enriched veneer – coherent surface preserving flake scar surfaces
D = Cortex – mottle stains are often concentrated in areas adjacent to cortex, presumably as a result of increased porosity.

Figure 38: Two artefacts from RFLK with intense mottle staining in patina zone *b* and a schematic cross-section through a patinated Palaeolithic artefact

Patina type	Walls Collection (surface) n = 80	Plateau Group Surface Collection n = 67	Plateau Group Excavated Collection (includes topsoil and sub-soil) n = 193
White type *a*	46%	41%	61%
White type *b*	29%	31%	18%
White undiff.	11%	9%	16%
Ocherous	6%	3%	4%
Other	8%	16%	1%

Table 4: Proportion of patina types recorded for RFLK Palaeolithic artefacts.

White patina type *a* characterised the excavated artefacts from the Palaeolithic in-situ site at Wood Hill, Kingswood, East Kent (hereafter, WHK) (Scott-Jackson 2000) whereas, at RFLK, more of the artefacts lacked this highly lustrous finish. However, Table 4 shows relatively high proportions of white patina type *b* and undifferentiated white patinas (i.e. neither highly lustrous nor matt in appearance were present). Patinas described as 'other' are generally those that have acquired extensive dark mottle stains of the sort described above. These give the artefacts a dark grey colouration that seems inappropriate to label as white patina type *a* or *b*, though generally the mottles stain the '*b*' zone of a white patina, which may or may not be covered by a lustrous siliceous layer on the outermost surface of the flint. Ocherous staining of the RFLK artefacts was rarely observed.

Lost soil horizons and the archaeological implications

In Section 4 the question of lost soil horizons and the archaeological implications of RFLK T4:2002 soil profile are discussed. Certainly, the rarity of ocherous Palaeolithic artefacts and sharp to slightly weathered condition of the RFLK assemblage (discussed below) combined with the presence on-site of later prehistoric artefacts (in the immediate area) suggest that there is a 'lost horizon' of deposits (and any associated Palaeolithic artefacts) at this site The timing of this loss of deposits which had once covered, sealed-in and protected this Palaeolithic site would have been, in geological terms recent. With the loss (or thinning) of the covering deposits, newly exposed Palaeolithic artefacts would be subject to surface weathering processes but this exposure seems to have been of insufficient duration or perhaps intensity, for the majority of the (surviving) artefacts to acquire an ocherous patina.

Condition of the RFLK artefacts

The RFLK assemblage is characterized by a sharp to slightly weathered condition. Differential patterns of breakage on artefacts recovered from the surface of the field, within the topsoil or sub-soil (i.e. deposits mapped as Clay-with-flints) could lead to a distortion in technological or metrical analyses. To give a hypothetical example, if 50% of flakes recovered from the surface have been severely damaged through contact with agricultural machinery and/or freeze/thaw activity, then a direct comparison of artefact size with no consideration of patterns of breakage might erroneously suggest that the buried artefacts tended to be much larger than those recovered from the surface. When dealing with partially disturbed assemblages, therefore, it is imperative that the condition of the artefacts as pertains to metrical and technological data be incorporated into analyses. The RFLK assemblage does show some differential patterns of breakage with regards to whether the artefacts were recovered from the surface/topsoil or from within the deposits mapped as Clay-with-flints. Three related criteria were used to record the extent of damage affecting artefacts from RFLK. These were:-

1. The presence or absence of breaks bearing the same patina as the main body (i.e. the original flaked surfaces) of the artefact. This measures of the frequency of ancient, knapping breaks on artefacts.
2. The presence or absence of unpatinated break surfaces or surfaces bearing a different patina from the main body of the artefact i.e. damage that occurred post deposition. This measures the frequency of damage incurred by natural and artificial means subsequent to deposition.
3. The proportion of artefacts that are estimated to have lost 10% or less volume as a result of a post-depositional break or edge damage.

It was not always possible to make a reasonable estimate of the percentage volume of an artefact lost due to post-depositional damage.

Results of the breakage pattern analyses of the RFLK assemblage

The results of the breakage pattern analyses for the RFLK assemblage are given for 3 main groups of artefacts and 2 sub-groups (Table 5. The assemblage is divided into the main groupings of the Walls Collection; the Plateau Group surface-finds; and the Plateau Group excavated finds. The latter is sub-divided into artefacts recovered from the topsoil and those excavated from within the deposits mapped as Clay-with-flints.

	Walls Collection (surface)	Plateau Group Surface Collection	Plateau Group Excavated Collection	
			(Topsoil)	(Clay-with-flints deposits)
Artefacts with original 'knapping' breaks	25% (n=76)	26% (n=65)	35% (n=57)	22% (n=133)
Artefacts with post-depositional breaks	96% (n=76)	55% (n=67)	75% (n=57)	26% (n=133)
Artefacts estimated to be >90% by volume complete	80% (n=35)	77% (n=44)	63% (n=49)	90% (n=120)

Table 5: Patterns of breakage in the RFLK Palaeolithic artefact assemblage.

Knapping breaks

These data show little differentiation with regard to the frequency of original knapping breaks found on artefacts. The frequency of knapping breaks is not excessively high, suggesting that the raw material was of average quality and not particularly prone to breakage during knapping. If anything, it might have expected the artefacts buried within the Clay-with-flints deposits to have a higher frequency of original, knapping break surfaces since post-depositional damage would tend to eradicate older break surfaces. That this is not the case may be accounted for by the generally smaller artefact size of the excavated assemblage (see below) since smaller artefacts are less prone to knapping breaks.

Post-depositional breaks

Post-depositional breaks are most prevalent in the Walls Collection. This may be because the assemblage contains relatively large artefacts (see below) that lay closer to the landsurface and were therefore subject to weathering for a relatively long period of time prior to recovery. The reduction in frequency of post-depositional breaks found amongst the Plateau Group assemblage excavated from the deposits mapped as Clay-with-flints is notable. The small size of the artefacts may have some influence here (see below) though it is likely that the artefacts have been spared post-depositional breaks because they have been protected from the damaging effects of weathering and modern machinery. Accordingly, the Plateau Group finds excavated from within the Clay-with-flints deposits also have the highest percentage of artefacts retaining an estimated 90% or more of their original volume.

Breakage patterns analyses - cautions

Due caution should be employed when undertaking analyses of breakage patterns. Individual artefacts that are estimated to represent only a small amount of the original artefact should be excluded from certain analyses (such as measures of artefact size and dorsal flake scar count etc.) to prevent data distortions. The typological grouping 'Flaked fragments' described below consists largely of artefacts so fragmentary as to be unclassifiable, whilst at the same time clearly retaining flake scars resulting from Palaeolithic flint knapping. However, in the majority of cases for all groups of RFLK artefacts, the extent of post-depositional damage does not exceed a 10% loss of volume. As such, most artefacts can be included in analyses without further qualification to allow for differential patterns of post-depositional damage.

The RFLK artefact technology

The extant RFLK assemblage (Walls and Plateau Group Collections) comprises a total of:

- 69 handaxes;
- 4 cores;
- 255 flakes: (including a small number of flake tools);
- hammerstones;
- 50 or so other items including possible artefact fragments, fossils,
- specimens of patinated and extensively cracked flints (originally recorded as burnt flint).

It is interesting to note that only 17% of these flakes were collected by Walls, the rest were recovered by the Plateau Group since the year 2000, most especially as a result of excavations in 2002 and 2003. This demonstrates the importance of excavating Palaeolithic artefact scatters on deposits mapped as Clay-with-flints in accordance with Scott-Jackson (2000) recommendations, since some types of artefact, particularly small flakes, can be difficult to distinguish on the surface of the field, which can lead to distortions of the technological analyses. As a result of the work undertaken by the Plateau Group, it is clear the RFLK was not only a site where handaxes were used, but also a place where they were made. Other tasks, such as the production and use of flake tools made from cores, were also carried out at the site, though core-working was rare compared to handaxe production. A technological assessment of the various elements of the assemblage now follows.

Technological assessment of specific: cores, flaked fragments and handaxes in the RFLK assemblage

Levallois Core (PG 02/1): Of particular significance is this example of a Levallois core (Figure 39) which was recovered from the surface of the RFLK site by the Plateau Group. This artefact has a lustrous white patina, slightly tinged to a cream colouration with heavy dark mottles in patina zone *b*. The two faces of the artefact are strongly differentiated by the extent of cortex (which covers 90% of the back of the core surface and 10% of the flaking face) and the flake scar patterns (with one clear Levallois flake scar on the flaking face surrounded by preparatory scars on the edge of the flaking face and on the adjacent core back). There are only two small areas of post-depositional damage on the back of the core, causing an estimated 2% loss in artefact volume. The pattern of flake scars and relative thinness of the core suggest that it may have yielded more than one Levallois flake. There is some indication, in the flake scar pattern on the back of the core that two opposed striking platforms had been prepared from which Levallois flakes could be struck.

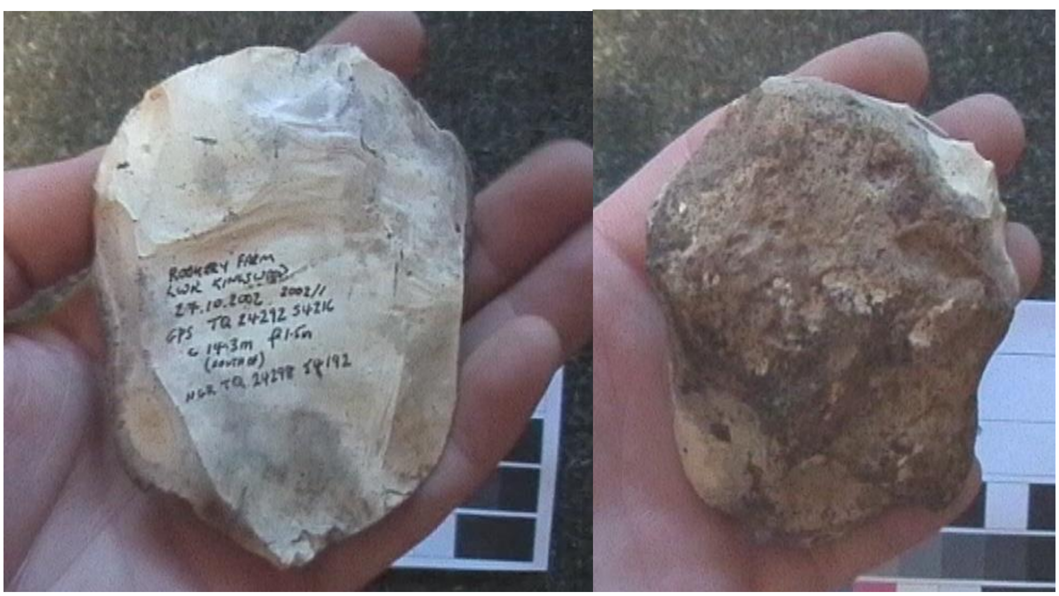


Figure 39: Levallois core from Plateau Group Surface Finds Collection – PG 02/1.

Figure 40: Possible Levallois core from Wallis Collection – P 1993 4-2-15

A bifacial core (Figure 40) in the Walls Collection (P 1993 4-2-15) provides a second possible example of a Levallois core since it has a preferentially large flake scar across one face. The core may have been made on a handaxe fragment, or conversely, may indeed be a handaxe fragment rather than a core. Although Wymer (1987: 24, 29) notes the complete absence of Levallois technique at the site, which he took as an indication that the site was not Late Acheulian or later in date, there is nothing about the condition of this artefact to suggest that it is substantially younger than the handaxes from the site. The presence of a single Levallois core is not a good basis for ascribing a date to the human activity at RFLK, since this particular technique of knapping is not prevalent in the assemblage nor is it, in any case, firmly delimited chronologically in the archaeological record.

Cores PG02/32 and PG 'deeply buried core':

Artefact PG02/32 shown in Figure 41 is in sharp condition with a type *a* white patina, dark mottles and fine cracks. It has a natural, unflaked surface across the back, some centripetal flake scars on the flaking face and two successive preferentially large flake scars struck from a plain (unfacetted) platform. This configuration of flake scar pattern and natural surface on the back is reminiscent of Levallois technique. It is possible that PG02/32 represents a learner 'knappers' attempt at Levallois technique.

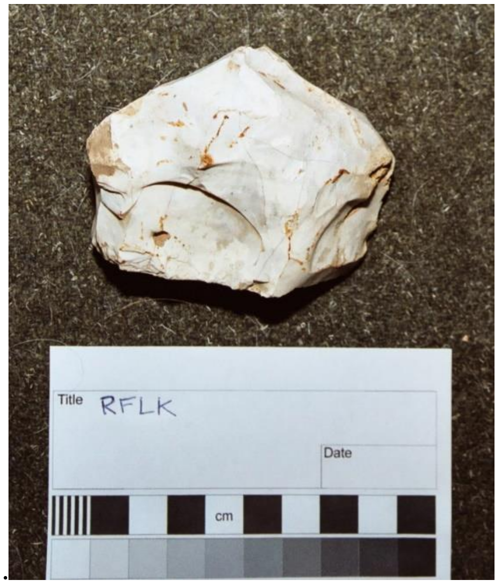


Figure 41: A core, possibly of Levallois type, collected from the surface of RFLK by the Plateau Group – PG 02/32.

Core PG: A 'deeply buried core' was excavated from spit 12. It is in sharp condition and bears a thin patina, suggesting either that it is a younger artefact intruding from levels above, or that, as part of the Palaeolithic assemblage, it has been subjected to different environmental conditions of burial than much of the assemblage (i.e. lying in an environment with fewer patinating reagents). Technologically, the core comprises a single, unidirectional flaking face from which relatively long flakes were detached. There are drawings and descriptions of two other cores found during excavations at RFLK (see Carpenter, 1960). Both are in sharp condition and are described as 'not deeply patinated' with 'thermal fractures' (op. cit.:101). Carpenter suggests that one core was used as a rough handaxe and as a hammerstone. It is interesting to note this instance of re-use in which a core has later been used as a tool.

It is not unlikely therefore, that in some instances, tools (handaxes) were subsequently re-used as cores. Also, the boundaries between artefact types, are further blurred by post-depositional damage.

Typological classification of the RFLK 'Flaked fragment

Undoubtedly, some of the 'flaked fragments' are fragments of Palaeolithic cores.

Flaked fragments (PG01/16; PG01/15; PG02/5; PG02/6; PG02/16; PG02/18; PG02/31; PG02/59; PG02T1/100#8; PG03T2/100#11; PG03T2/100#13; PG03T2/100#14; PG03T1/101#11; PG03T1/101#15; PG03T1/1#1; PG03T1/1#14; PG03T1/4#10; PG03T1/5#15; PG03T1/5#16; PG03T1/5#22; PG03T1/5#24; PG03T1/6#3; PG03T1/6#12; PG03T1/6#15; PG03T1/6#16; PG03T1/7#14; PG03T1/7#20; PG03T1/7#27; PG03T1/7#37; PG03T1/7#11; PG03T1/8#4; PG03T1/8#8; PG03T1/8#16; PG03T1/8#17; PG03T1/11#6).

The typological classification of 'flaked fragments' includes items which could be parts of handaxes, cores and flakes but which are too damaged to classify with certainty. As such, there is limited reliable information to be gathered from flaked fragments regarding artefact technology. If the size of a lithic assemblage is proportional to the amount of knapping activity that took place at any given site, then the count of artefacts designated at flaked fragments is significant. Typological classification of the RFLK Handaxes by Harp (2002) demonstrated that the handaxes from RFLK are strongly dominated by pointed morphologies (as opposed to ovate shapes, for instance). However, the inclusion of fragmentary handaxes within his analysis has produced a data distortion and suggested that a considerable proportion of the handaxes were ovate shaped. A tripartite plot (see Roe 1964; 1968) of handaxe morphology for RFLK, excluding all fragmentary handaxes, is given in Figure 42 below and shows just two plots on the ovate section of the diagram. Significantly, of these, artefact P 1993 4-2-29 is a pointed shape with relatively straight edges, despite having a more central position of maximum breadth than artefacts that plot on the 'ovate' section of Roe's tripartite diagram. Nevertheless, there is an ovate element within the RFLK handaxe assemblage. For example, Plateau Group artefact 02/54 is a large flaked fragment with a natural, post-depositional fracture surface across one face, whilst the opposed face bears a series of centripetal, shallow flake scars. The low angle of the flake scar intersections on the flaked face suggests that this fragment was once part of a wide, ovate shaped tool. Unfortunately, this artefact is too fragmentary to provide many clues as to the knapping sequence that produced it.

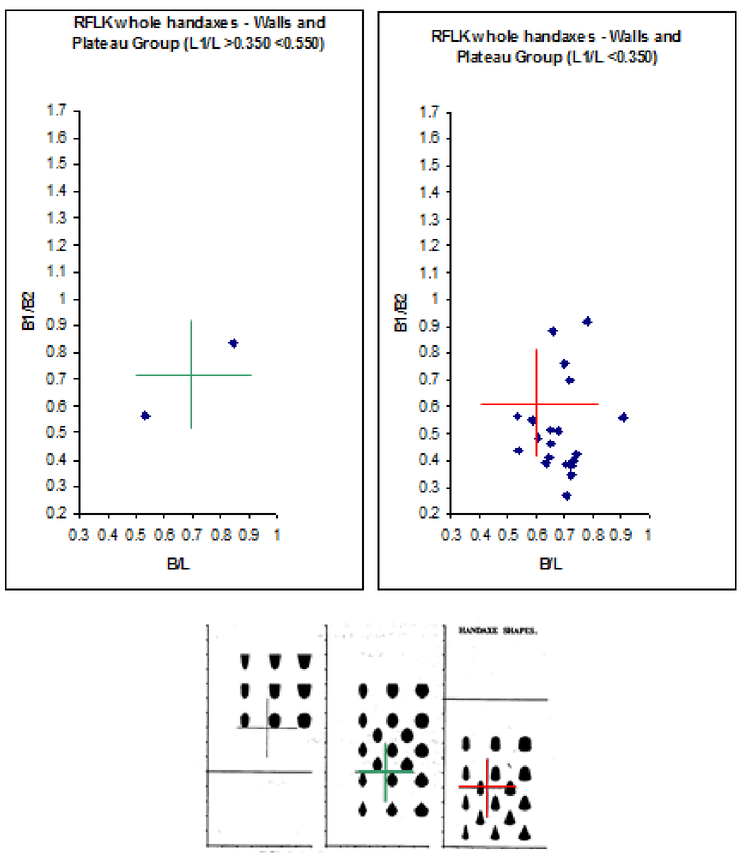


Figure 42: Tripartite plot of handaxe shape for all complete handaxes from RFLK (Walls and Plateau Group Collections). The red and green crosses on the graphs above correspond to the red and green crosses plotted on Roe's original diagram below (after Roe, 1968).

In a second example, a complete ovate handaxe from the Walls Collection, P 1993 4-2-31, combines a low position of maximum thickness (i.e. it is weighted towards the butt end, as is typical for pointed handaxes, rather than the central weighting that is the classic configuration of ovate handaxes) with convex edges (typical of ovates). The butt-heavy configuration suggests that the tool was produced in the same fashion as the butt-heavy, pointed handaxes at RFLK. Other clues to the technological process that produced this handaxe are the two patches of cortex on either side of (the face designated as) 'face 1' and two large flake scars struck from the butt end of the same face. The configuration of the latter in relation to adjacent flake scars and the volume of the tool are suggestive of preferentially large flake scars struck from Levallois cores. It is possible therefore that this handaxe was re-used as a core.

Another handaxe in the RFLK assemblage also shows signs of having been re-used as a core. Walls Collection artefact P 1993 4-2-14 has a large, hard-hammer struck flake scar detached from the right edge of the butt on the face 1. In this case however, the handaxe is pointed. The existence of a similar knapping technique (i.e. use of a handaxe as a core) in the production of both pointed and ovate handaxes suggests that they are products of the same technological process, possibly the very same flint-knappers. A second point of comparison between artefact P 1993 4-2-31 and the more pointed handaxes in the same assemblage is the existence of a section of the edge at the butt end, which lies perpendicular to both faces and is asymmetrically positioned when viewed in plan. An illustration of this trait is provided in Figure 43. This feature is present on at least 60 % of the handaxes in the RFLK assemblage including artefact P 1993 4-2-71, which is the second handaxe in the assemblage to plot on the 'ovate' section of Roe's tripartite diagram (see Figure 42 above). Interestingly, artefact P 1993 4-2-71 is a very small, disc-shaped biface with a flake scar pattern that suggests it may well have been reshaped from the butt end of a pointed handaxe.

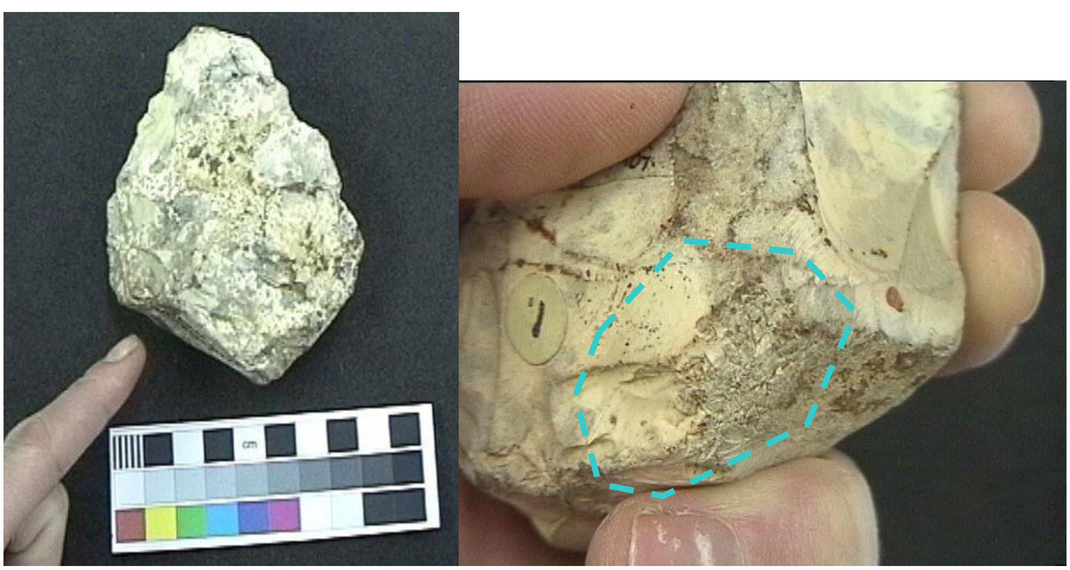


Figure 43: Examples of handaxes with perpendicular sections of edge on their butts (Walls Collection artefacts P 1993 4-2-25 and P 1993 4-2-1 from left to right). Note the area of impaction on the edge of the butt or P 1993 4-2-1 encircled on the right.

Whether or not the perpendicular section of edge observed on handaxes at RFLK had a precise function or was a purely stylistic feature is not certain. However, the feature has been detected on handaxes from other British Lower Palaeolithic sites and may facilitate better grip of the tools during use. At RFLK, there is some evidence of coincidence between handaxes with thick, partially cortical butts, perpendicular edge sections on the butt and areas of impaction and crushing (e.g. PG01/2; PG02/25; W P 1993 4-2-1; W P 1993 4-2-24; W P 1993 4-2-54). Mitchell (1998) noticed similar areas of impaction on handaxes from the British Lower Palaeolithic site of Boxgrove, East Sussex and concluded, on the basis of experimentation, that such damage could only occur as a result of stone on stone contact. Use of handaxes in flint knapping therefore seems the most likely cause of the damage.

The smallest complete handaxe in the RFLK assemblage is just 63 mm long, 41 mm wide and 22 mm thick (PG02/25) whilst the largest is 147 mm long, 104 mm wide and 44 mm thick (Walls Collection P 1993 4-2-28). For comparison, the mean average dimensions (and standard deviations for these values) of complete handaxes from RFLK and the site of Boxgrove, are shown in Table 6. The Boxgrove site is adjacent to a Chalk cliff from which large nodules of flint were procured, typically for the manufacture of ovate handaxes. Accordingly, it is interesting to observe that, although on average longer and wider than RFLK handaxes, the Boxgrove artefacts were also typically thinner than those manufactured at RFLK.

	Mean average length and standard deviation (mm)	Mean average width and standard deviation (mm)	Mean average thickness and standard deviation (mm)
RFLK complete handaxes (n=22)	90 23	62 15	34 9
Boxgrove complete handaxes (n=11)	114 30	74 17	29 8

Table 6: Comparison of handaxe size at RFLK and Boxgrove Quarry 1 areas A and B, Units 4b and 4c respectively (data from Roberts and Parfitt eds. 1999: 322, 348).

This is likely to be due to functional mechanics. Such an ovate, that is long and wide, cannot also be relatively thick, since it would then become prohibitively heavy to grip (due to central position of maximum thickness) and would have obtuse, relatively blunt edges. Both assemblages display a similar spread of values (i.e. comparable standard deviations) about the mean value for artefact dimensions. Remnants of the cortex of the flint nodules from which handaxes were made is retained on 45% of the handaxes, whilst of these 24% bear cortex on both faces, giving a good indication of the original dimensions of the nodule used. The influence of raw material size and shape upon handaxe morphology is discussed in detail below.

Typological classification of the RFLK Flakes

In the RFLK (Walls Collection) assemblage, 42% of flakes are classified as handaxe shaping or trimming flakes. Since these artefacts were recovered from the surface of the site, there could well be a bias towards the collection of handaxe trimming flakes, as opposed to flakes from the earlier stages of knapping, since the latter would tend to have greater amounts of cortex cover and are therefore less distinguishable in the field. It is therefore interesting to note that handaxe trimming flakes are also relatively common in the Plateau Group excavated assemblage. This suggests that either handaxes were brought to the site fully made and subsequently only re-sharpened at RFLK prior to discard at this locality, or, that the raw material units from which handaxes were made at RFLK were small, thereby increasing the relative proportion of finer shaping and thinning flakes to large, hard-hammer struck 'roughing-out' flakes. The relatively small size of handaxes overall and the high incidence of handaxes bearing remnants of cortex, or even cortex on both faces and the occurrence at RFLK of other large waste products from knapping such as cores (items perhaps unlikely to have been transported with fully-made handaxes) suggest that handaxes were indeed made from small units of raw material at RFLK. In total:

- 69% of the flakes in the extant RFLK Palaeolithic assemblage had 'no cortex at all';
- 8% had '< 20% cortex cover';
- 13% had '>20% but <50% cortex cover';
- 8% had '>50% but less than 100% cortex cover';
- 2% were 'entirely cortical'.

By way of comparison, 51% of the re-fitted flake debitage from a modern knapping experiment (by P. Harding reported in Winton 2004), in which an ovate handaxe was made from a large nodule of flint, had no cortex at all. Where handaxes are made from small nodules the mean average maximum dimension of Palaeolithic flakes from RFLK (both excavated and surface finds and including only flakes estimated to have lost less than 10% volume due to post-depositional damage) is 67 mm. In contrast, the mean average maximum dimension of flakes from the hilltop Lower Palaeolithic site on deposits mapped as Clay-with-flints at WHK (again, an assemblage including both surface and excavated finds estimated to have lost less than 10% volume due to post-depositional damage) is 129 mm. These figures can be compared usefully with a mean average maximum dimension of 47 mm for the refitted flake debitage from the modern-day experimental production of an ovate handaxe.

Knapping experimental 'control' data as it relates to the Palaeolithic assemblages

The experimental knapping example provides a 'control' data set (Table 7) for comparison because the size of the nodule, properties of the raw material, flake-by-flake reduction sequence, type of hammers used and skill level of the knapper are all known. The raw material used in the production of the experimental control assemblage was a large nodule of flint that measured 225 mm x 180 mm x 160 mm and had a minimum thickness of 65 mm (Winton, *pers. obs.*). In the first part of the reduction sequence a disc of flint was roughly shaped-out from the nodule using hard hammerstones to detach relatively thick flakes. Subsequently, long, shallow thinning and shorter, edge-shaping flakes were detached using a soft, antler hammer.

The results of the comparison between this experimental control data and the Palaeolithic assemblages (Table 7) are significant as they clearly demonstrate that the high-level Palaeolithic sites on the deposits mapped as Clay-with-flints maintain strong, archaeologically significant signatures.

	RFLK (Walls and Plateau Group)	Wood Hill, East Kent	Experimental control
Mean average of flake maximum dimension:	67 mm	129 mm	47 mm
Standard deviation of flake maximum dimension:	25 mm	146 mm (or 57 mm excluding 1 large flake)	12 mm
Median of flake maximum dimension:	18 mm	42 mm	45 mm

Table 7: Comparison of the size (maximum dimension data) of flakes in the RFLK, Wood Hill, East Kent and Experimental control assemblages respectively.

The variations between these artefact assemblages as they relate to tangible causal factors, particularly the notable differences between the mean average size of flint flakes produced as a result of the experimental control knapping sequence and the archaeological examples, could be due to:

- Differences in the original size of the raw material;
- Differences in the quality of the raw material;
- Differences in the parts of the reduction sequence that are represented;
- Differences in the overall knapping scheme and technology of the reduction sequence represented.

These interrelated technological parameters not only determined the size of flakes in the RFLK Palaeolithic assemblage, but are also the fundamental to our understanding of the cognition and behaviour of the early humans who produced the RFLK assemblage. Having established that the raw material used probably was relatively small, that it was of average knapping quality (as far as can be ascertained from the frequency of original knapping break surfaces on artefacts) and that all phases of the tool-making process are represented in the knapping by-products at the site (cores and flakes), it remains to consider the differences in the overall knapping scheme and technology of the reduction sequence represented.

Discussion: the RFLK Palaeolithic artefact analysis

Peculiarities of the overall knapping schemes represented by the RFLK stone-tool assemblage are now considered with reference to the debate as to whether or not raw material was the single most significant factor in the production of handaxe morphological variability. White (1998, 2006) hypothesized that ovate handaxes were the preferred tool shape during the British Lower and Middle Palaeolithic, since the long, curving edges of the tools offered a greater length of cutting edge than straight-edged, pointed handaxes. As a result, he suggested that archaic humans would have made ovate handaxes wherever suitably large and sufficiently good quality raw material existed and that pointed handaxes would have been made where raw material was available only in small, narrow units. The correlations between handaxe morphology and distance from large, good quality raw material sources in a study of 19 British Palaeolithic assemblages is treated by White (op cit) as evidence that handaxe size and shape resulted from adaptive responses to different raw material properties, rather than differences between human populations in cultural ideals and styles.

At both RFLK and WHK the presence of handaxes, handaxe fragments (including those broken or abandoned during manufacture) and characteristic handaxe trimming flakes show that handaxe manufacture was a key objective of the knapping activity represented by these assemblages. The presence of cores in both the RFLK and WHK assemblages suggests technological differences with the aforementioned experimental handaxe-making control assemblage (hereafter PH - as the handaxe was made by Philip Harding). In the case of WHK, the large size of a number of the cores (some weighing more than 1kg); the presence of skilfully struck, large flakes (7 in excess of 450g in weight also, WHK 84-40-393 weighing in at a massive 1.49kg); and a unifacially flaked handaxe made on a flake (WHK 85-60-26), all suggested that the technique employed in handaxe-making was the striking of large flakes from nodules of flint which were subsequently shaped into handaxes. The WHK reduction sequence was therefore substantially different to the PH assemblage in which, rather than shaping a flake, a handaxe was produced by progressive shaping of an entire nodule. In contrast to the evidence from the WHK assemblage, at RFLK the handaxes were made from small nodules of flint. As the RFLK assemblage is dominated by pointed handaxes rather than ovate shaped tools White (op. cit.) would no doubt argue that at RFLK, handaxes tend to be rather small and pointed because the archaic humans who made the tools were unable to make the preferred ovate shape from the rather small units of flint raw material available at the site. However, several features of the RFLK assemblage suggest that White's (op.cit.) model does not provide a satisfactory explanation of handaxe shape preference at this site. With regard to artefact size, for instance, the assemblage contains a number of large, pointed handaxes, which could perfectly well have acted as blanks for ovate shaped tools – for instance, handaxe P 1993 4-2-28 and handaxe fragment P 1993 4-2-44 (both Walls Collection). In other cases, it seems that pointed handaxes may have been re-shaped into ovate shaped tools, a particularly good example being the handaxe P 1993 4-2-71 as discussed above. An alternative argument to White's (op. cit.) hypothesis is proposed by McPherron (2000, 2006) who suggests that, ovate handaxes result primarily from the reduction of pointed handaxes, such that large, elongated, pointed handaxes become progressively smaller, thinner and more rounded with continued re-shaping and re-sharpening. McPherron's (op. cit.) model seems to fit the evidence from RFLK very well – ovate handaxes are rare and such examples as exist appear to have technological affinities with the pointed assemblage but are more intensively reduced. At RFLK, pointed handaxes were undoubtedly the preferred tool shape and a commonly reproduced stylistic feature (affecting 60% of the assemblage) was to create a section of edge on the butt that was perpendicular to both face 1 and face 2 of the tool. Data from modern knapping experiments contribute further insights to our understanding of the RFLK assemblage (e.g. Eren et al., 2011). A study of the effects of knapping skill development upon handaxe morphology suggests that ovate shaped handaxes are easier to make than regularly shaped, handaxes with straight or concave edges and well-defined, symmetrical, narrow points (Winton, 2004:112). Many of the RFLK handaxes would appear to have been made by very skilful flint knappers who were well able to replicate their preferred shape of handaxe. Thus pointed handaxes were produced at RKLK, even where raw material would have allowed the production of ovate shaped tools. Ovate shaped tools in the RFLK assemblage resulted from the subsequent re-sharpening and re-shaping of pointed tools in much the way McPherron (2000, 2006) and Emery (2010) have suggested. Further to this, the selection of appropriately shaped raw material for the production of preferred shapes of handaxe can be considered an integral part of the ancient flint knapper's skills base. Harding (in Winton 2004: 19) states that the first act of the handaxe-making process is the selection of raw material and visualization of the finished artefact form within that unit of stone.

Clearly, the association between the use of relatively small units of raw material and the production of pointed handaxes at RFLK has more to do with raw material ***selection*** than it does with raw material ***constrain****t*. White's (1998) model citing raw material constraint as the major causal factor in the production of British Palaeolithic handaxe morphological variability does not fit the RFLK evidence. A technological re-assessment of other assemblages studied by White (op.cit.), paying particular attention to the level of knapping skill displayed in an assemblage, may provide further evidence for the *selection* of appropriately shaped raw material though it brings us no nearer to understanding why some assemblages clearly reflect a preference for either pointed or ovate shaped tools. Recent experimental work sheds some light on the effects of tool shape upon function (e.g. Winton 2004:89-113, Emery 2010) but the explanation of handaxe shape preference is most likely to be associated with task specialization and/or cultural choice.

Section 8: Discussion

In this discussion, a certain amount of repetition is necessary for the sake of clarity but where applicable reference to a previous section/s is indicated. The motivation for this research, and indeed that of many other Palaeolithic archaeological investigations at RFLK (Section 1) was the work of L. W. Carpenter (1956; 1957; 1960; 1963) and perhaps more especially, his discovery in 1959 of a 'working floor' (i.e. knapping site). He reports (Carpenter 1960:99-100) that in the autumn of 1959, a small dry valley or coombe, on the edge of the plateau at RFLK had all its top soil removed, which was heaped up around the perimeter, while the floor of valley was raised by the dumping of ashes, clinker and hard rubbish. Carpenter, also noted that, 'the soil removal exposed the old Clay-with flints-surface which seemed to lie mainly between 18 inches to 3 feet below the present agricultural surface' and that 'the cleared area was carried up to just above the 550 feet contour line' (167.64m). Having recovered many flint artefacts, embedded in the Clay-with-flints, from a small area in the S. W. corner of the 'cleared area' (just above the 550ft contour line) he concluded that 'there seems little doubt that here we have the remains of a Palaeolithic working floor, one of several that must have existed on this plateau' (ibid).

A National Monuments Record Field Investigator report (400504 F1 ASP 13-Oct-1965), in reference to the Palaeolithic working-floor discovered by Carpenter (ibid), states that 'Mr Burgess, bulldozer operator at Banstead U.D.C. Refuse Depot, indicated the findspot at TQ 24444.54014 now covered with refuse deposits. The implements came to light when he [Mr Burgess] cleared away a hedge and a bank.' At the time of Carpenter's discovery, only the northern half of the dry valley was being prepared for landfill. The southern half of the dry valley did not become a landfill site until after 1970 (although was used as a rubbish tip prior to being landfilled). A chronology confirmed by the Landfill Manager of Surrey County Council (Mr Richard Bartram, pers. comm.). An extrapolation of these data puts Carpenter's 'working floor' in the SW corner of the northern half of the present landfilled area, shown here at Point C1 (Figure 44).

Further investigations in this area were undertaken by Pemberton (1971), who states that in the summer of 1969 a small dry coombe was cleared, immediately SE of a position where an Acheulian floor had been discovered (i.e. SE of Carpenter's investigation in the general position of P1 (Figure 44)). He adds that a 'fossil layer', containing erratics and patinated frost shattered flints above the 'natural' Clay-with-flints, was found at a similar depth to the original [Carpenters, 1960] 'working floor' and that a field adjacent to the site was then double ploughed, bringing white patinated artefacts to the surface. Pemberton revisited the site in 2000 and verified the area (at TQ2437 5404) of his earlier excavations (Section 1).

Geospatial 3D modelling (Section 5) and spatial analyses (Section 6) by the PADMAC Unit illustrates (Figure 45, Figure 46) the topographical relationship of Carpenter, (ibid) 'working floor' (annotated C) to Pemberton's (1971) excavations (i.e. 'three parallel trenches … each 2 yards x 1yard in size [annotated here as P1], while a further three, 1 yard square sondages [annotated here as P2] were also excavated to the south in the dry valley' (as reported by Pemberton to Harp, 2005:235; see Section 1).

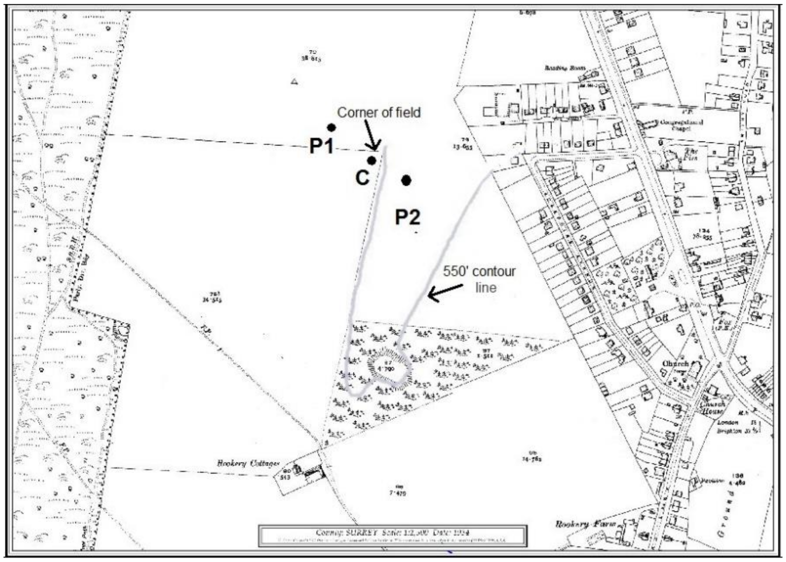


Figure 44: Map showing the 550ft. contour line superimposed of the RFLK 1934 OS map with the field boundary corner. Carpenter's (1960) 'working floor' is annotated C and the possible locations of Pemberton's (1971) excavations are annotated P1 and P2.

If Carpenter's (1960) 'working-floor' (i.e. the knapping site) is indeed at point C (Figure 44), then it can be seen (in Figure 45) that the knapping site is (with reference to BGS Geology Map Data (© NERC 2014) on the edge of the deposits mapped as Clay-with-flints and that Pemberton's (1971) trenches (P1), as described on site by Pemberton to Peter Harp (2005:235; Section 1) are located on the deposits mapped as Clay-with-flints, whereas his sondages (P2) are at the base of the dry valley on chalk formations previously mapped as Upper Chalk (Section 2).

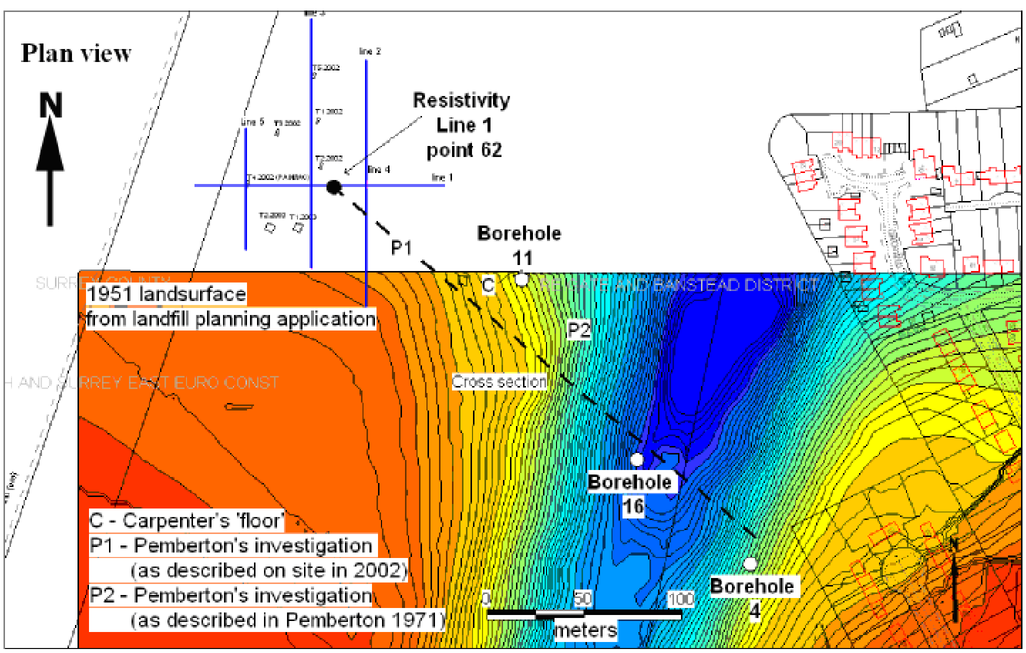


Figure 45: Diagram showing: contours of the RFLK 1951 landsurface; line of cross-section near resistivity Line 1; boreholes 11, 16 and 4; possible locations of Carpenter's (1960) 'working floor' shown at C and for Pemberton's (1971) excavations at P1 and P2.

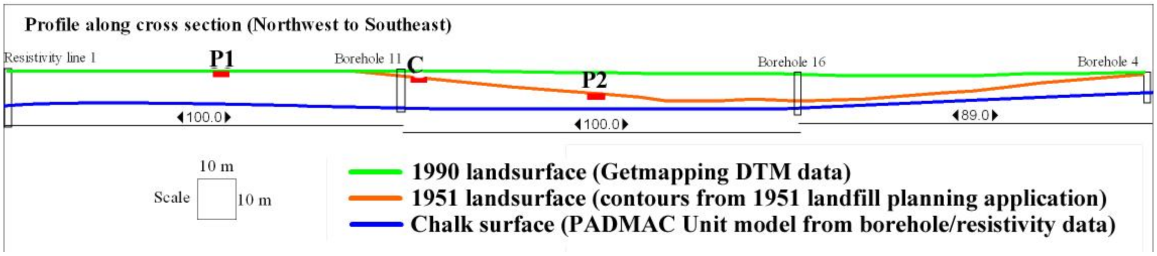


Figure 46: Cross section of RFLK showing landsurface prior to landfill (based on 1950 contours) with Carpenter's (1960) (C) and Pemberton's (P1 and P2) excavations compared to the landsurface after landfill (1990) and the Chalk surface (extrapolated from the RFLK resistivity and borehole data).

The results of the Geophysical (resistivity) survey (Section 3), the 3D geospatial modelling (Section 5) and the spatial analyses (Section 6) suggest that this Palaeolithic knapping site may have been retained in a solution feature, at that specific location on the edge of the high plateau, capped with deposits mapped as Clay-with-flints, overlooking the dry valley (Figure 46). As this area of the plateau was greatly disturbed during the construction of the landfill site (Section 1), this is a hypothesis that cannot be verified. However, on the RFLK high plateau, in the general area of the resistivity survey (Section 3), many solution features were identified (the positive association between the retention of Ps-s/s on high-level plateaux, basin-like features in deposits mapped as Clay-with-flints and solutions features in underlying Chalk (Scott-Jackson, 2000) are addressed in Section 2. It is unlikely therefore that the RFLK Palaeolithic artefacts have been displaced far from their original position (Section 7) of discard (Figure 47) on the Palaeolithic land surface.

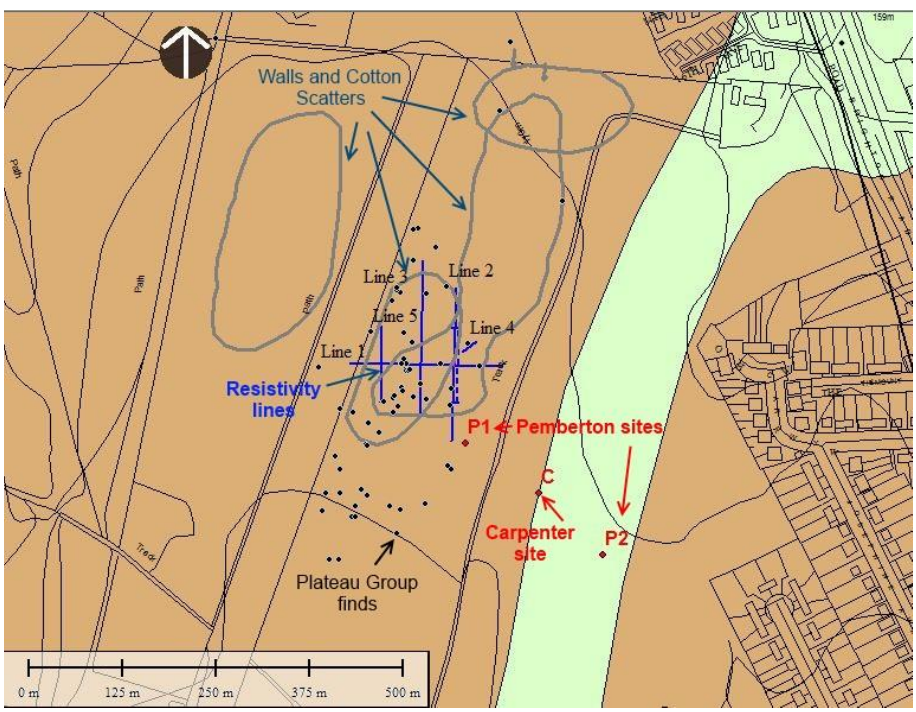


Figure 47: Map showing: calculated locations of; Carpenter's (1960) 'working floor' at C and possible locations for Pemberton's (1971) excavations at P1 and P2; Walls and Cotton (1980) investigations; Plateau Group (2005) finds and excavations; PADMAC Unit (2002) resistivity lines – in relation to the dry valley (Upper Chalk) and the surrounding deposits mapped as Clay-with-flints. (Geological Map Data © NERC 2014)

The RFLK high-level Palaeolithic sites/s on deposits mapped as Clay-with-flints has yielded many artefacts (Section 7). The assemblage comprises Palaeolithic artefacts recovered both as surface-finds and as excavated artefacts. In technological terms, the assemblage comprises handaxes and handaxe fragments, cores, including a fine example of a Levallois core, flakes and some suggestions of flake tools.

The RFLK handaxes are strongly dominated by pointed forms. An association between the production of small (on average) pointed handaxes from small units of raw material (as detected in analyses of the flake debitage and finished tools and tool fragments) is believed to result from the selection, by skilled knappers, of suitably shaped units of raw material, which required a minimal amount of shaping. Additionally, the evidence from RFLK does not support the theory that pointed handaxes were made simply as a response to raw material constraints (*c.f.* White, 1998) since large handaxes, which could easily have been shaped into ovate tools, were of pointed morphology.

Conclusion

The stated aims of this PADMAC Unit research was to better understand the integrity of the RFLK surface-scatters/sites per se and the associated Palaeolithic artefacts. Linked to this was the challenge of determining and then modelling the location of the Palaeolithic knapping-site discovered in 1959 (Carpenter, 1960) on the edge of a small dry valley (which subsequently became a landfill site) and addressing the conflicting reports surrounding the context of Pemberton's (1969 and 1970) RFLK excavations. The benefits of a long term study of RFLK has been the ongoing opportunity to construct the many and varied datasets needed. Much of this information was time constrained, in the sense that essential data required for a specific analysis was not easily obtained or did not (at that particular time) exist.

The RFLK research parameters (as discussed in Section 2) which focused on understanding the geology, soil/sediment and geomorphology of the area in general and the Palaeolithic site formation processes in particular required the PADMAC Unit to address the following questions:

1. What is the depth of the deposit mapped as Clay-with-flints overlying the Chalk?
2. Are there solution features?
3. What is/are the character of the deposits mapped as Clay-with-flints in the archaeological area?
4. Which geomorphological processes are implicated in the both the archaeological and the general area?
5. Where exactly was the (now destroyed) Palaeolithic 'working floor' (knapping site) found by Carpenter in 1959?
6. How did this 'knapping site' relate spatially, geomorphologically and archeologically to the other recorded Palaeolithic surface-scatters/sites?
7. To what degree had the construction of the landfill site impinged on these Palaeolithic surface-scatters/sites?

Although not definitive, the answers to questions 1-5 were generated by using data derived from the RFLK Geophysical (resistivity) survey (Section 3) and the borehole and trial pit investigations (Geospatial 3D modelling: Section 5) together with the soil/sediment analyses (Section 4) and historical mapping (Spatial analyses: Section 6). Geospatial 3D modelling and spatial analyses was undertaken to create a spatial reconstruction of the RFLK area (Figure 47) as it was, prior to the construction of the landfill site and the infilling of the dry valley. Likewise, it has been possible to model the location of Palaeolithic 'knapping floor' discovered by Carpenter (1960) and the Pemberton (1971) excavations. The results of the geospatial 3D modelling and spatial analyses have also been conducive to the identification of areas that have been adversely affected by historic landuse or the landfill construction activities and more specifically those which have not. These (relatively unaffected) areas include the Ps-s/s discovered by Walls and Cotton (1980) and Harp (2005) which are located on the high plateau to the west of the landfill site (Section:1; Section 4 and Section: 7).

Ultimately, what is clearly apparent from the results of this PADMAC Unit research at RFLK, is that the convergent application of a variety of increasingly sophisticated technological innovations to geo-archaeological research will allow future exploration of, what at this point in time are, seemingly intractable archaeological problems.

Bibliography

Avery, B. W. (1973). Soil classification in the Soil Survey of England and Wales. *Journal of Soil Science*, *24* (3), 324-338.

Avery, B. W. (1980). Soil classification for England and Wales [higher categories]. *Technical Monograph, Soil Survey of England and Wales*, (14).

Avery, B. W. (1990). *Soils of the British Isles*. CAB International.

Carpenter, L.W. (1955). *Surrey Archaeological Collections*. 1955, 136.

Carpenter, L.W. (1956). The palaeoliths of Walton and Banstead Heaths, *Proceedings of the Leatherhead and District Local History Society*, 1.10, 6-10.

Carpenter, L.W. (1960). A Palaeolithic floor at Lower Kingswood, *Proceedings of the Leatherhead and District Local History Society*, 2.4, 99-101.

Carpenter, L.W. (1963). More palaeoliths from Walton Heath, *Proceedings of the Leatherhead and District Local History Society*, 2.7, 202-203.

Clayden, B., & Hollis, J. M. (1985). *Criteria for differentiating soil series*. Tech Monograph 17. Soil Survey of England and Wales.

Cotton J, (1985). Palaeoliths from the North Downs at Lower Kingswood. *Surrey Archaeological Collections*. 76, 244.

Cuthbertson. P. 2013). Is the Early Palaeolithic Material from Dickett's Field, Hampshire, a Record of a Few Individual Single-Period Activities or a Multi-Period Palimpsest? Unpublished MSt Dissertation, University of Oxford.

Environmental Assessment Group Ltd. (1993). *Rookery Farm Project C654*. 27/10/93 Environmental Assessment Group Ltd.

Environmental Assessment Group Ltd. (1994). *Rookery Farm Project C654*. Environmental Assessment Group Ltd.

Emery, K. (2010). A re-examination of variability in handaxe form in the British Palaeolithic. *Doctoral thesis*, (University College London).

Eren, M. I., Bradley, B. A., & Sampson, C. G. (2011). Middle Paleolithic skill level and the individual knapper: An experiment. *American Antiquity*, 76 (2), 229-251.

Graetsch, H. A., & Grünberg, J. M. (2012). Microstructure of flint and other chert raw materials. *Archaeometry*, 54 (1), 18-36.

Harp, P. (2000). Watching brief at Lower Kingswood, *Plateau Bulletin 2*, Plateau Archaeology Group, 2.

Harp, P. (2002). Recent Work at Rookery Farm, Lower Kingswood, *Bulletin of the Surrey Archaeological Society*. 355, 7.

Harp, P. (2005). Work at the Palaeolithic site at Rookery Farm, Lower Kingswood, 2001-5. *Surrey Archaeological Collections*. 92, 231-244.

Leap Environmental Ltd. (2012). Factual Report on an Intrusive Site Investigation: Land at Rookery Farm for Reigate and Banstead Borough Council. LP00380.

McPherron, S.P. (2000). Handaxes as a measure of the mental capabilities of early hominids, *Journal of Archaeological Science*. 27, 655–663.

McPherron, S.P. (2006). What typology can tell us about Acheulian handaxe production. In: Goren-Inbar, N. and Sharon, G. (Eds.), *Axe age: Acheulian toolmaking from quarry to discard*. London: Equinox, 267-286.

Mitchell, J. C. (1998). A Use-wear Analysis of Selected British Lower Palaeolithic Handaxes, with Special Reference to the Site of Boxgrove (West Sussex): A Study Incorporating Optical Microscopy, Computer Aided Image Analysis and Experimental Archaeology. D.Phil.Thesis. University of Oxford.

National Soil Resources Institute. (2013). Academic Soils Site Report TQ24395854491. Cranfield University.

Pemberton, F.F. (1971). Lower Kingswood: excavations at Rookery Farm, *Surrey Archaeological Collection*, Surrey Archaeological Society, 68, 190.

Reigate & Banstead Borough Council. (1951). *Planning Application for Rookery Farm landfill*, BAN 321/50.

Reigate & Banstead Borough Council. (2011). Borough Wide Landscape and Townscape Character Assessment.

Roberts, M.B. & Parfitt, S.A. (1999). Boxgrove. A Middle Pleistocene hominid site at Eartham Quarry, Boxgrove, West Sussex. *English Heritage Archaeological Report* 17.

Roe, D.A. (1964). The British Lower and Middle Palaeolithic: Some Problems, Methods of Study and Preliminary Results. Proceedings of the Prehistoric Society 30, 245–67.

Roe, D.A. (1968). A Gazetteer of British Lower and Middle Palaeolithic Sites, *Council for British Archaeology (Research Report no. 8)*. London.

Scott-Jackson, J.E. (2000). Lower and Middle Palaeolithic artefacts from deposits mapped as Clay-with-flints – a new synthesis with significant implications for the earliest occupation of Britain, Oxford, Oxbow Books.

Scott-Jackson, J.E. (2005). The Palaeolithic of the Marlborough Downs and Avebury Area. In: Brown, G., Field, D. McOmish, D. (Eds,), *The Avebury Landscape: aspects of the field archaeology of the Marlborough Downs.* Oxbow Books (for English Heritage), Oxford, 66-76.

Scott-Jackson, J.E. & Scott-Jackson, W.B. (2011). The importance of Palaeolithic surface-scatters to our understanding of hominin dispersal and Neanderthal variability – Key methods for unlocking hidden data. *Proceedings of the 17th Annual Meeting of the European Association of Archaeologists*, EAA.

Scott-Jackson, J.E. & Winton, V.S. (2001). Recent investigations at Dickett's Field, Yarnham's Farm, Holybourne, Hants. In S. Milliken and J. Cook (Eds.), *A Very Remote Period Indeed: Papers on the Palaeolithic presented to Derek Roe*. Oxbow Books, Oxford, 214-22.

Sondadores Ltd. (1989). Site Investigation Lower Kingswood. Borehole Record. Surrey County Council.

Surrey County Council (1992). Landscape Assessment of Rookery Farm. Surrey County Council and Reigate & Banstead Borough Council.

Walls, T. & Cotton, J. (1980). Palaeoliths from the North Downs at Lower Kingswood, *Surrey Archaeological Collections*, Surrey Archaeological Society, 72, 15-36.

White, M. (1998). On the significance of Acheulian biface variability in southern Britain. *Proceedings of the Prehistoric Society* 64: 15-44.

White, M. (2006). Axeing cleavers: reflections on broad-tipped large cutting tools in the British Earlier Paleolithic. In: Goren-Inbar, N. and Sharon, G. (Eds.), *Axe age: Acheulian toolmaking from quarry to discard*. London: Equinox, 365-386.

Winton, V.S. (2004). A study of Palaeolithic Artefacts from Selected Sites on Deposits Mapped as Clay-with-flints of Southern England with Particular Reference to Handaxe Manufacture.
British Archaeological Reports, British Series 360, Archaeopress: Oxford.

Wymer, J.J. (1987). The Palaeolithic period in Surrey. In: J. Bird and D.G. Bird (Eds.), *The Archaeology of Surrey*, Surrey Archaeological Society, Adlard and Son. Ltd, Surrey.