FOXHALL ROAD, IPSWICH

SUFFOLK

GEOENVIRONMENTAL AND

ARCHAEOLOGICAL INVESTIGATION

TRIAL PIT EVALUATION AND BOREHOLE SAMPLING

ISSUE 1

Essex County Council

Field Archaeology Unit

August 2007

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Client: Barratt East Anglia (previously Barratt Eastern Counties)
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SUMMARY

A geoenvironmental and archaeological investigation was carried out before a housing development at Foxhall Road, Ipswich, where Pleistocene (Ice Age) deposits containing Lower Palaeolithic (Early Old Stone Age) remains had previously been recorded in a series of excavations undertaken between 1903 and 1921, when the site was a brick pit. It was thought that the Palaeolithic remains were related to the banks of a lake, later filled with brickearth, which formed at the end of the Anglian glacial period.

A trial pit evaluation was carried out in relatively undisturbed areas in the north, west and south of the site, to evaluate whether or not significant Pleistocene and Palaeolithic deposits survived beyond the limits of the former brick pit. The aim of the evaluation was to establish the geological levels and locate the original archaeological sites, to enable a mitigation strategy to be implemented before construction works began.

The trial pit evaluation established that the strata affected by the construction groundworks consisted of fluvial upper sands and gravels. These seal the significant Pleistocene and Palaeolithic deposits, which would be preserved beneath the development at a depth of over 5m below present ground level, with only a very low impact on them from piling. In the north-west of the site, trial pit A6 located an arm or a feeder channel of the` lake. Nearby, trial trench A17 successfully located the site of Smith's excavation of 1914, and from this it is possible to locate the sites excavated in the same area by Layard in 1903-5 and Moir in 1921

and relate them to the present investigation. An Acheulian flint handaxe was recovered from trial pit A6, close to the area of the earlier excavations, from which 134 flint handaxes, other flint artefacts and mammal bones had previously been recovered.

In consultation with the Suffolk County Council monitoring officer and Barratt East Anglia it was decided that no further evaluation trenching or excavation was necessary as the significant Palaeolithic deposits would be almost completely preserved in situ*. Mitigation would consist of four boreholes sunk in the area of the previous excavations to recover core samples for scientific analysis, which would add to the palaeoenvironmental information relating to the site, and hopefully also provide an absolute date.*

It has been possible to reconstruct the palaeogeography of the site in more detail than before, by combining analysis of published reports on earlier geological and archaeological work, recent geotechnical borehole logs, and the borehole records obtained in the present investigation. This evidence provides a context for the large number of Palaeolithic artefacts in the north-west of the site, and suggests that early humans were particularly active on the banks of a feeder stream leading to the lake that was subsequently filled with brickearth. The lake was part of a poorly organised drainage system and its configuration changed over time.

Palaeogeographical reconstruction of the site and palaeoenvironmental analysis confirms that the stream and lake, which was the focus for human activity, formed during the transition from the Anglian glacial period to the Hoxnian temperate period. This phasing is strongly supported by new optically stimulated luminescence (OSL) dating, which provides a date of c. 425,000 years Before Present, and by the results of the heavy minerals analysis. Other evidence, in the form of palaeogeographical reconstructions, ostracods and artefacts, is consistent with this dating. The relative angularity of the gravel recovered from site argues against it being part of the widespread pre-Anglian Kesgrave formation, and again suggests an Anglian or later date. There is unfortunately no evidence of fauna or plant remains, as no vertebrate material was present in the samples and pollen did not survive.

These results are a significant advance on previous knowledge and it is proposed to publish them as an article in the Proceedings of the Geologists' Association*, or a journal of equal status, with a short note on the Palaeolithic flint handaxe in the* Proceedings of the Suffolk Institute of Archaeology and History.

1.0 INTRODUCTION

This report presents the results of a geoenvironmental and archaeological investigation of Pleistocene (Ice Age) deposits known to contain Lower Palaeolithic (Early Old Stone Age) remains before a housing development on the site of the former Bull Motors and Celestion Works Foxhall Road, Ipswich. The investigation followed earlier archaeological desk-based assessment reports (Orr 2004; Allen 2005), which established the significance of the previously recorded Palaeolithic remains, their potential survival within the present-day site, and the likely impact of the proposed development on them.

The investigation was undertaken by the Essex CC Field Archaeology Unit (ECC FAU) and its specialist consultants on behalf of the site developer, Barratt East Anglia. It comprised a trial-pit evaluation of the overall development area, followed by borehole sampling and scientific analysis of key deposits in the main area of interest in the north-west of the site, where previous investigations had been carried out between 1903 and 1921. This work was carried out under the terms of a condition placed on planning consent by Ipswich Borough Council (IP/05/11290/FUL), as advised by the Suffolk CC Archaeological Service's Conservation Team in accordance with Planning Policy Guidance note 16 on Archaeology and Planning (DoE 1990). The work followed the Brief and Specification issued by Suffolk CC (2005) and the Written Scheme of Investigation prepared by ECC FAU (2005).

The decision to proceed directly from trial-pit evaluation to borehole sampling and scientific analysis was taken at a site meeting between ECC FAU, the geological consultant, Barratt East Anglia and the Suffolk CC monitoring officer. It was recognised that potentially significant Pleistocene and Palaeolithic deposits survived in the north-west of the site, but as these were at a depth of over 4m the development impact would be limited to a few areas of deep piling. Since any remains would be preserved largely undisturbed beneath the development, it was decided that the only mitigation necessary was a programme of targeted sampling and scientific analysis to enhance the results of the previous investigations.

An interim summary of results (Allen and Allen 2005) was presented immediately after the end of the field investigation to enable planning clearance to be given for the building works to proceed. The present report provides a detailed update of the interim summary by adding the results of specialist geoenvironmental analyses and scientific dating, and assessing the overall results against the wider landscape and environmental background.

Copies of this report are supplied to Barratt East Anglia (including a copy to be forwarded to Ipswich Borough Council Planning Department), Suffolk CC Archaeological Service, the Suffolk Historic Environment Record, Ipswich Museum and the Ipswich branch of the Suffolk Records Office. A digital copy of this report will form part of the OASIS online record (http://ads.ahds.ac.uk/project/oasis). The site archive and finds will be deposited at Ipswich Museum.

2.0 THE SITE

2.1 Location and Site Description

The development site lies 2km east of Ipswich town centre (TM 1855 4385; Figs 1 and 2). It is situated on the south side of Foxhall Road, between Orwell Road to the west and Camden Road to east. It lies to the north of the Ipswich-Felixstowe railway line, immediately to the north-east of Derby Road station.

The site lies in a shallow north-south valley, and ground levels are around 3-4m below those in Orwell Road and Camden Road to the west and east. It is mainly rectangular, measuring 350m north-south and 160m east-west, covering an area of 5.7ha, and until recently was occupied by the buildings and yards of the Bull Motors and Celestion Works. Demolition of the works buildings and removal of the related concrete slabs reduced the ground surface to between 34.5 and 35.5m OD over most of the site. Ground levels were a little higher, at around 36m OD, on the Foxhall Road frontage in the north, and at 37.5m OD at the south-western limit of the site. The construction of the former works buildings appears to have truncated the ground level by about 1m over most of the site.

The archaeological desk-based assessment reports (Orr 2004; Allen 2005) established that the site and its surrounding area was agricultural land until the second half of the 19th century. From 1881 to 1927 the site was occupied by the Valley Brick Works, including a large, deep brickearth quarry or brick pit across its eastern half, and a shallower sand pit in its north-eastern corner (Figs 1 and 6). Over half of the site area had been quarried and subsequently infilled before the construction of the Bull Motors and Celestion Works in the mid-20th century. The ground surface at the time of the fieldwork was formed by disturbed modern overburden, with natural sand-gravel showing in several areas across the west of the site (Plates 1 and 2).

2.2 Regional Geological Background

The shallow north-south valley which runs down the centre of the site cuts into a plateau on the north-eastern bank of the river Orwell (Fig. 2). The valley, now dry, formed the upper part of the Mill River drainage system, with the direction of flow from north to south. The uppermost geological sequence on site (Figs 2 and 3) consists of post-Hoxnian sands and gravels, overlying clay and sand lake deposits (also described as brickearth), in their turn overlying outwash sands/gravels and boulder clay associated with the Anglian glaciation, which occurred c. 500,000-450,000 years ago.

Table 1. Geological sequence

	Years before present
Youngest	
Post-Hoxnian sands and gravels	**post – c. 400,000**
Hoxnian interglacial deposits (lake clays and sands)	**c. 450,000-400,000**
Anglian glacial deposits (till and outwash gravels)	**c. 500,000-450,000**
hiatus	
Pre-Anglian Thames river deposits (Kesgrave Formation)	
hiatus	
Shallow marine shelly sands (Red Crag)	
major hiatus	
Lower London Tertiaries (Reading Beds and London Clay)	
major hiatus	
Chalk	
Oldest	

Bold = beds occurring on site

The oldest deposits in the area, comprising the Chalk, the Lower London Tertiaries and the Red Crag, are seen only in the valley sides of the Gipping-Orwell valley and not at the site (Fig. 3). The upper surface of the Chalk lies at 40m OD at Great Blakenham, 0m OD at Ipswich and -30m OD at Felixstowe. However, the valley cuts into the Chalk and, as in the vicinity of the A12/A45 Orwell Bridge (TM 174413), its bottom is sub-glacially scoured, to a depth of -44m OD (Fletcher and Nicholls 1984), so along the river bed the Chalk surface is much lower. Valley-side outcrops occur between Stowmarket and Bramford on the northern outskirts of Ipswich.

The Lower London Tertiaries comprise principally the Reading Beds and the London Clay. The Reading Beds have a basal bed of coarse flints (Bullhead Bed), but the main outcrop is interbedded clay, silt and sand. The London Clay forms a stiff clay, dark blue-grey clay when fresh, brown when weathered. There are many outcrops along the valley sides of the Orwell downstream of Ipswich. The Red Crag comprises a basal pebble bed overlain by shelly, slightly clayey, medium sand. Again outcrops occur in the valley sides of the Orwell.

The surface landscape of eastern Suffolk comprises a series of flat plateau-like elements reflecting the underlying terraces of the Thames. The major deposits of the local plateau surface were designated as glacial in origin (Wood and Harmer 1872 and 1877; Whitaker *et al*. 1881; Whitaker 1885; Salter 1896; Boswell 1913 and 1931), but Hey (1965), Rose *et al*. (1976) and Rose and Allen (1977) redefined them in part as early Thames gravels of the Kesgrave Formation. Subsequently the sedimentology, stratigraphy and palaeogeography of the Kesgrave Formation have been recorded in further detail, the most recent summary being in Rose *et al*. (1999). Older versions of the local geological map (Sheet 207, 1:50,000, Geological Survey) show the gravels as glacial gravel, and most recent version of the map (1990), modified this to 'Glacial Gravels and Kesgraves (undifferentiated)'. The relationship of the Kesgrave sands and gravels and the glacial gravels was resolved by Mathers *et al*. (2007) who showed the glacial gravel to have a lobe-like distribution spreading out from the Gipping Valley at Ipswich, suggesting the presence of a pro-glacial outwash fan. Thus at Kesgrave (TM 225465), on the fan, glacial gravel is shown overlying the Kesgrave sand and gravel, while at Foxhall Heath (TM 239438), Waldringfield Heath (TM 257448) and Trimley (TM 288363) quarries and temporary exposures beyond the fan display only Kesgrave material.

The main components of the glaciogenic sequence comprise outwash sands and gravels, deposited by meltwater from the ice, and till (boulder clay), deposited directly from the ice during the Anglian ice advance, c. 500,000 to 450,000 years ago. The stratigraphy of the glaciogenic sequence is summarised by Allen *et al*. (1991).

The glacier itself laid down till extensively over East Anglia. Till is mapped as a reasonably continuous sheet covering the county, locally as far south as Rushmere St Andrew (TM 190460) and Playford Heath (TM 220468), with two outliers at Kesgrave (TM 218456 and 235453) and possibly others at Waldringfield Heath (TM 265442) and Levington Heath (TM 253410), with a further record at the Foxhall Road site, at depth. The exact position of the ice-limit is not known as there are no specific features to define it. The limit is implied from the southerly extent of the till outcrops and outliers and the deep sub-glacial scours of the bed of the Orwell. Thus the glacial limit lay further south than the Foxhall Road site.

Locally, limited outcrops of outwash are found above the till, usually adjacent to the Gipping-Orwell, e.g. that forming the fan. The upper part of the Mill River would have been a distributary stream on that fan. Thus, the broad elements of the landscape as we know it today were already in place by the end of the Anglian glaciation, with the till and earlier deposits forming high ground, broken by minor valleys, and into which the Gipping-Orwell was deeply incised.

2.3 Lower Palaeolithic Remains and Palaeogeography

The archaeological desk-based assessments (Orr 2004; Allen 2005) established that Lower Palaeolithic remains were recovered during a series of investigations between 1903 and 1921 in the north-west of the site, at the edge of the Valley brick pit (Fig. 1). These remains included 134 Acheulian handaxes, other flint artefacts, and mammoth, rhinocerous, ox and deer bones, from an undisturbed land surface sealed beneath the brickearth deposits at a depth of c. 5m below the contemporary surface.

The site was investigated by Nina Layard in 1903-5, Smith in 1914 and Moir in 1921, and the results reported by Layard (1902; 1903; 1904; 1906a; 1906b), Smith (1921) and Boswell and Moir (1923). This work was summarised by Wymer (1985) and reappraised in detail by White and Plunkett (2004). These reports located the successive excavation sites as lying to the north-west of the brick pit, but on maps that lacked precision so the sites could be located only to within a few metres. The excavations were carried out in an area where land could be bought for the purpose and where the brick-pit workers had reported more frequent finds.

These earlier reports also provided a stratigraphy relating to the area of the excavations and a limited amount of geological information about the wider area of the site. From this it was apparent that the palaeography of the area of the excavations was different from that of the rest of the site. Reconstruction of the palaeography from the earlier reports suggested that there was a lake in the eastern area of the site in which the brickearth accumulated, broadly corresponding to the area of the former brick pit (Figs 1 and 6). The equivalent area to the west comprised sands or sands and gravels, often clayey (‘pug’), thought to be of fluvial origin. To the north-west of the site, where the earlier investigations occurred, the excavations revealed a complex stratigraphy with dipping gravels, sands and clays overlain by horizontally bedded gravels (Plate 3). These are described in more detail below (see 5.0 Site Palaeogeography and Stratigraphy).

2.4 Archaeological Impact Assessment

The second desk-based assessment (Allen 2005) concluded that Palaeolithic remains might survive in undisturbed areas in the north, west and south of the site, around the edges of the former brick pit, although they would already have been destroyed in the area of the brick pit itself. The housing development would involve ground disturbance from foundations, roads and services to a depth of 1.2m, with localised disturbance from drainage/sewer runs down to 1.5m. The depth of ground disturbance would not be significantly greater than that already caused by the Bull Motors and Celestion Works. Below this there would be an impact from deep piling, although the piling is low-density with piles sunk by continuous flight augur, a displacement technique which minimises secondary disturbance. Taking this into account, piling density is less than 2% of individual house footprints, and there is no piling at all in gardens, car parking areas and access roads. Piling would thus have only a very low adverse impact limited to areas of house building.

The desk-based assessment was unable to establish the absolute level of the significant Palaeolithic deposits, as these were only approximately related to Ordnance Datum on the published section (Wymer 1985, fig. 74; reproduced in Allen and Allen 2005, fig. 3). It was uncertain whether Palaeolithic levels outside the area of the brick pit had already been destroyed by the foundations of the former works buildings, or whether they had survived and might be affected by the new development. Because of this uncertainty it was decided that trial trenching should be carried out to establish the survival or otherwise of Palaeolithic deposits beyond the limits of the former brick pit.

3. AIMS AND OBJECTIVES

The objectives for the project relate to the archaeological research framework for East Anglia (Brown and Glazebrook 2000). One of the most important objectives in the research framework is to improve understanding of human activity in the Palaeolithic, especially in relation to the landscape and environment following the Anglian glaciation. Survey and analysis of Hoxnian (post-Anglian) interglacial lake deposits (as seen at Hoxne, north-east of Ipswich) form an important part of such a study (Austin 2000, 6).

The objectives of the evaluation, as set out in the Written Scheme of Investigation, were:

1. To establish the survival or otherwise of potential Palaeolithic deposits on the site, especially any deposits sufficiently important to merit preservation *in situ*.

2. To establish the character and date of surviving Palaeolithic or Pleistocene deposits.

3. To evaluate the degree of impact by the development on any significant Palaeolithic or Pleistocene deposits, and formulate a mitigation strategy.

Mitigation measures formulated during the evaluation involved two further objectives:

4. To locate the previous archaeological trenches, to enable the 2005 investigations to be related to the previous investigations of 1903-21.

5. To recover samples to carry out palaeoenvironmental study to determine the nature of the environment and climate within which the Palaeolithic people lived, and to establish an absolute date.

4.0 METHOD

The investigation was undertaken in accordance with the Institute of Field Archaeologists' *Standard and Guidance for Archaeological Field Evaluation* (IFA 1999), and the Association of Local Government Archaeological Officers' *Standards for Field Archaeology in the East of England* (Gurney 2003). The ECC FAU is a registered archaeological organisation with the Institute of Field Archaeologists.

The evaluation of the Palaeolithic site has combined further research into the earlier records, maps and reports of the excavations carried out between 1903 and 1921, borehole and test pit information from the geotechnical report by Knight Environmental Ltd (2005), and the evaluation trial pits/trenches and boreholes carried out by the Essex CC Field Archaeological Unit (ECC FAU). The location of the trial pits and boreholes is shown on Fig. 1. Those excavated by Knight Environmental are marked TP1-43 and BH5-15. The trial pits/trench excavated by the ECC FAU are marked A1-A10 and A12-A17, and the boreholes AA-AD.

The archaeological brief (Suffolk CC 2005) stipulated that the trial pits/trenches should be excavated to a maximum depth of 33m OD, up to 2m below present ground level, to evaluate the deposits affected by ground disturbances from house foundations and service trenches. The presumption behind the evaluation strategy was to avoid disturbing deposits at a greater depth if at all possible, where there would only be limited disturbance from piling. The trial pits would be extended into longer trial trenches only if this would obtain further information useful for evaluating the site.

Fifteen trial pits were excavated by a machine fitted with a ditching blade, targeted on areas of potential survival of significant Pleistocene and Palaeolithic deposits around the edges of the former brick pit. An additional trial trench was excavated in the north-west of the site to locate the trenches of the previous excavations carried out between 1903 and 1921. All trial pits and trenches were surveyed in to an Ordnance Survey base map. The geological strata exposed in the trial pits/trenches were recorded in detail by the consultant geologist. Where undisturbed sediments survived a representative section was drawn and related to Ordnance Datum, and a detailed description was made of the sediments and their form of deposition.

While the trial pit/trench evaluation was in progress it became clear that deposit survival was much better than expected, and that the previously recorded Palaeolithic deposits would have survived to the north-west of the brick pit at a depth of c. 5m below present ground level. Since these remains would be preserved largely intact beneath the development, it was decided that no further excavation was necessary. It was agreed with the Suffolk CC monitoring officer that mitigation would consist of borehole sampling to confirm the sequence that contained the Palaeolithic remains, and to recover core samples from these deposits for scientific analysis of palaeoenvironmental material and to provide absolute dating.

Four boreholes were sunk in the area of previous excavations using a sampling tracker rig, in which sample tubes are driven into the ground within a steel casing by a hydraulic ram. The aim was to recover a continuous sequence of core samples down to a depth of 6m, to bracket the significant Palaeolithic levels. The samples were recovered in clear sample liner tubes 1m long and up to 100mm in diameter, and the tubes were immediately wrapped in black plastic on recovery to protect them from light. Details of the sampling strategy and the extent of sample recovery are given in the desription below (see 6.3).

The sample tubes were cut open under controlled conditions and sub-samples are taken to assess the survival of different materials for palaeoenvironmental analysis, especially flora (pollen) and the water environment (diatoms and ostracods), and for absolute dating (optically stimulated luminescence (OSL)). A detailed lithological description was made of the deposits in the cores to provide a stratigraphic context, and stone clast analysis was carried out to determine the nature of the drainage basin. Detailed methodologies are set out below at the beginning of each scientific analysis (see 7.0).

5.0 SITE PALAEOGEOGRAPHY AND STRATIGRAPHY

5.1 Palaeogeography

From geomorphological field mapping, Allen (in Allen and White 2004) showed that the site lay within a shallow valley, now dry, that formerly was the headwaters of the Mill River (Figs 2, 4 and 5). Flow along this section of the river would have been from north to south. Between Rushmere (TM 189455) and Priory Heath (TM 195430) the valley can be traced as a discernible feature from Spring Road, possibly indicating the source of the river before the area was built up, to Bixley Heath (Fig. 4), beyond which it has a stream channel (Fig. 5). This confirms the proposed existence of such a river by Smith (1921).

Within this upper valley, three discrete areas of brickearth have been mapped, that between Foxhall Road and Felixstowe Road being the largest (Figs 4 and 5). The brickearth reflects deposition in quiet water, such as a lake. The outcrop at Starfield Close, to the north of Foxhall Road, was the also the site of a former brick pit. The current ground surface at Starfield Close, considered to broadly represent the height of the working surface of the pit at the time of abandonment, is significantly below the surrounding valley bottom, suggesting a deepened section. The deposits at Foxhall Road similarly lie in a relatively deep channel. Excavations and boreholes reach the Anglian till (boulder clay) at 8.5m below the ground surface. Over 1m of till was proved by Layard (she cites 4ft), but its full thickness could not be penetrated, so the exact depth of the channel cannot be determined, though a minimum of 9.5m can be inferred. Whilst this is minor compared to some of the scouring in the major valleys (cf. Fig. 3), it is still considerable and certainly more than would be expected in a purely fluvial system.

Between the brickearth outcrops, sand and gravel is mapped and there is no indication of deepening. The built-up nature of the area prevents a full investigation, but the brickearth outcrops appear to reflect the presence of lakes in the over-deepened sections of the valley. Such an irregular long profile, with till in at least one of the over-deepened sections, would be in keeping with sub-glacial formation by scouring. The scouring of the river bed at the site of the nearby Orwell Bridge (Fletcher and Nicholls 1984) is also of sub-glacial origin.

The 2nd edition Ordnance Survey (1904) showed the worked area of the brick pit in the centre and south of the eastern part of the site (Fig. 6), reflecting the shape of the lake in which the brickearth was deposited. There was an irregular narrower extension to the north-west, towards the area of the excavations carried out between 1903 and 1921. The implication of this is that there was a narrow extension of the brickearth, hence also the lake, in that direction, possibly along the feeder stream/river. A similar alignment was proposed by Smith (1921, fig.1, shown on Figs 4 and 5). Such a site might well have been particularly suitable for human activity.

The equivalent area to the west comprised sands or sands and gravels, thought to be of fluvial origin. In the north central part of the site, where the archaeological investigations occurred, the excavations both of Layard and of Smith revealed a complex stratigraphy with dipping gravels, sands and clays overlain by horizontally bedded gravels (discussed below).

5.2 Stratigraphy

Although no till is mapped at the site, a borehole sunk by Layard proved the Anglian till at a depth of 8.5m below the ground surface. Both Moir (in Layard 1903) and Boswell (1931) were able to identify it visually at the site at the time of Layard's excavations and Layard (1904; 1906b) and Boswell (1931) listed fossils (*Gryphea* and *Belemnites*) and erratics (Chalk, Red Chalk, Jurassic oolite and volcanic tuff) which are characteristic of the Anglian till. Layard (1906b) noted also the presence of striated flint and that one face of the oolite had been smoothed by abrasion to show sections through the oolites. Within the heavy mineral suite (Boswell and Moir 1923), a number of 'softer' heavy minerals occur, such as kyanite and apatite (see 7.3 below). Such material is absent from earlier deposits and some is sufficiently fragile that it rarely survives reworking into younger deposits in any quantity. However, inspection of later borehole records (in the BH series described below) shows no descriptions of material that could readily be interpreted as Anglian till.

Above this is the brickearth, predominantly a silty clay or sandy silty clay, with fine to medium sand, or even gravel, interbeds (Boswell and Moir 1923). This, in turn, is overlain by sands and gravels, often clay-rich or interbedded with the upper part of the brickearth. At both Layard's and Smith's sites, these sands and gravels appear to fall into two units. From c. 2m below the ground surface, they are dipping. Whilst the mode of deposition is not clear, there are indications that the inclined beds have been affected by post-depositional movement downslope (Allen and White 2004). The direction of dip seems variable. Layard (1906a) provided photographic evidence (Plate 3) and Smith (1921) a section drawing (Fig. 7). From both of these it can be deduced that the dip was towards the north-east. However Layard in her field notes recorded the dip as being to the south-west. In part, this may be accounted for by reference to the local microtopography reconstructed by White in Allen and White (2004), which is irregular (Fig. 8), so the local slopes varied greatly in orientation. However, as the description of the direction of dip presumably came from the same pit as that photographed, that explanation is not too convincing. Similarly, Smith's section drawing shows quite clearly a dip to north-east, but measurements taken when trial pit A17 (see below) was opened up, cutting through his pit, showed dips to the south-west (08° towards 233° and 20° towards 240°).

Above the dipping beds is a discordance above which the beds are horizontal and often geologically disturbed in their uppermost 1-2m (Fig. 9). This feature was picked up in trial pits A6 and A15 (see below). A stylised cross-section of the valley at the site was provided by Boswell (1914) (Fig. 10).

6.0 FIELDWORK RESULTS

6.1 Geotechnical Boreholes and Test Pits

Borehole information recorded during the geotechnical investigation (Knight Environmental 2005) was examined and collated from the present ground surface to a depth of 26m OD, to ensure coverage of the altitudinal range of the previous excavations and give information on the evolution of the brickearth-filled lake (Fig. 1, BH5-15).

The boreholes confirmed the distribution of the brickearth and sand/gravel as described above (see 5.2) and BH7 and BH12 were particularly valuable in confirming the extension of the brickearth to the north-west. Tentative reconstructions of the history of the lake by examining the borehole data for 25m OD, 26m OD and so on at 1m intervals to 34m OD, suggests that deposition in the area of the lake was initially on a substrate of Red Crag. The first deposits were of sand were in the eastern area (BH15), with pug (sandy clay sometimes with pebbles) and clay suggesting lacustrine deposition to the south (BH9) and west (BH7 and BH12), at 25-34m OD (Fig. 11), though over time the area around BH15 became lacustrine (29m OD and above) and that around BH7 sandy (31m OD and above) (Fig. 12).

The presence of the arm to the north-west is hinted at from 25 to 29m OD by clay recorded in BH7 (other boreholes did not penetrate to that depth). From 30m OD, the channel is well defined (BH7 and 12, confirmed by trial pit A6 and boreholes AA and AD) though its shape changed as sedimentation altered to sand in BH7 from 31m OD. Thus the lake shows a long history, but that its shape changed in a minor fashion over time. The lake presumably extended across the south of the former brick pit, but lake deposits are not shown in this area on Figs 11 and 12 due to the lack of local borehole data.

BH10 and 14 showed a further limited deposit of clay in the south-west corner of the site, and BH6 and Layard's borehole (Figs 13 and 14) another to the north-east. Both appear to be separated from the area of the excavations.

It is significant to note that none of these boreholes, nor the archaeological boreholes (see below), recorded till, though several reached the Red Crag and the London Clay (BH5, 6, 7, 8, 9, 11, 13, 14, 15). At depths of c. 8.5m below ground surface the depth at which Layard encountered till, these boreholes record sand, gravelly sand or gravelly clay, noting the presence of quartz (rather than chalk which is a characteristic of the till).

The trial pit information from the geotechnical investigation (Knight Environmental 2005) also confirmed the distribution of brickearth and sand/gravel, with clay recorded in TP1 in the north-west of the site, though overlying gravel (Fig. 1, TP1-43). Gravel, sand and pug were recorded in the other pits (Figs 11 and 12).

6.2 Archaeological Trial Pits and Trial Trench

The sequences recorded in the trial pits and trial trench are presented as an overview, to relate them to the overall palaeogeography and stratigraphy of the site following the Anglian glaciation (see 5.0 above) and the more detailed interpretation obtained from analysis of the geotechnical boreholes (see 6.1 above). Detailed descriptions of the trial pit and trench sequences are included in Appendix 1, and a full record, including section drawings and photographs, is held in archive.

Fifteen trial pits were excavated by machine around the edges of the former brick pit to define the extent of the brickearth deposits and potential Palaeolithic remains sealed beneath them (Fig 1, A1-10 and A12-16). A sixteenth trial pit (A11) to be located in the south-east of the site was not excavated due to the presence of a spoil heap. The trial pits were between 5m and 10m long by 1.85m wide, and were generally excavated to a depth of 1.2-1.5m, down to between 33m and 34m OD. Trial pit A6 was enlarged and stepped to record sequences down to a depth of 2.4m, to 32.8m OD. An additional trial trench (Fig 1, A17) was excavated in the north-west of the site to locate the earlier excavation trenches dug between 1903 and 1921.

Trial pit A6 in the north-west of the site was particularly important, linking with the earlier work of Boswell and Moir (1923), Smith (1921) and Layard (1906a). Their stratigraphic descriptions are closely mirrored by those from this trial pit (Table 2), exposing a sequence from the post-Hoxnian upper sand and gravel, much deformed by load structures, down to reddish grey and light grey clay, the brickearth (Plate 5). The deformation structures affecting beds A6/2, 3, 4a and 4b are comparable with those described by Boswell (1914) and Boswell and Moir (1923).

Table 2. Comparison of bed designations

Trial Pit A6 (this report)	**Layard (as sumarised by White and Plunkett 2004)**	**Smith (1921)**	**Boswell & Moir (1923)**
A6/3. Gravelly sand	Upper sand and gravel	Sand	Bed 2. Fine reddish gravel
A6/4a, b and A6/5. Pebbly sandy clay, brown	Gravelly clay	Reddish and dove pug	Bed 3. Pug – stony reddish sandy clay
		Stiff grey clay (brickearth)	
		Red band α	
A6/6. Clay, light grey	Red and grey clay	Red and dove pug (brickearth)	Bed 4. Laminated dove brickearth

Trial pit A15 in the south-west of the site also showed textures and deformation structures similar to trial pit A6. As A15 is at the southern extremity of the site, it is quite possible that the deformations were widespread across the site.

An Acheulian flint handaxe, whose point had been broken in antiquity, was recovered from upcast spoil excavated from trial pit A6, and is described in detail below (see 7.9). Pebbly sandy clay 'pug' material adhered to it and it was presumably stratified in one of layers A6/4a-b or A6/5. This find was almost certainly from a secondary context, having been disturbed from its original context lower down the sequence. The handaxe came from the same area of site as the large assemblage of handaxes recovered during the earlier excavations between 1903 and 1921, although these were mainly stratified in sandy deposits sealed below the 'pug' and clay/brickearth.

Trial trench A17 was also of major importance. This trench was located on the basis of the map provided by Smith (1921) and photographs by Layard (Plate 3) to intersect the presumed positions of the early excavations and locate them more precisely. The pit did indeed record the site of Smith's excavation trench (Fig. 13). This conclusion is supported by photographic evidence, comparing a photograph taken from trench A17 (Plate 4) with one taken by Layard in 1905, whose site was only c. 15m further east. Only the top of Smith's trench was recorded, however, with fluvial sands exposed around it. As mentioned above (see 5.2), a particular problem at this site is that the bedding was measured and proved to be dipping to the south-west (08° towards 233° and 20° towards 240°) (see Appendix 1), whereas Smith's section drawing (Fig. 7) indicates a dip to the north-east.

Trial pit A12 at the site's western limit, 60m to the south of A6, revealed only a 0.6m depth of modern overburden, below which were cross-bedded fine sands, recorded to a depth of 33.9m OD. The sands dipped to the north and the south and are interpreted as part of a micro-delta formation either side of an ephemeral gravel bar (see Appendix 1). Ten further trial pits (Fig. 1, A1-5, A7-9 and A13-14), excavated to a depth of 1.2-1.4m, revealed c. 1.0m of disturbed modern overburden and only c. 0.2-0.4m of undisturbed sediment. In each case, the sediment exposed was sand or gravelly sand, sometimes with a proportion of silt or clay in the sand matrix. Where suitable structures occurred, they were measured in order to obtain water-flow direction, but the total number of readings (9) was small and spread over a wide area, and so is statistically unreliable. Two trial pits (Fig. 1, A10 and A16) revealed only modern overburden, to a depth of at least 1.2m.

The trial pits exposed fluvial upper sands and gravels, believed to be post-Hoxnian, at a depth of 1.2-1.4m in all areas of the site beyond the limits of the former brick pit. In addition, trial pit A6 identified a sequence sealed beneath the sands and gravels, consisting of sandy clay (pug) and clay/brickearth deposits in the top of the north-western arm of the brickearth-filled glacial lake, to a depth of at least 2.4m (32.8m OD). The trial pit and borehole data demonstrates that the Ordnance Datum levels shown on the published section were c. 4.5m too high, and that any Palaeolithic deposits would be at least 5m below the present surface at c. 29-30m OD, well below the general level of disturbance caused by the development.

6.3 Borehole Sampling

Four boreholes were sunk in the north-west of the site to recover samples from the deeper, more productive sediments that had been worked on by Layard, Smith and Moir, of which only the upper deposits had been exposed in the trial pits (Fig 1). The objective was to supplement the sedimentological information gained from the geotechnical boreholes (BH series) and to obtain environmental information, particularly from the clays, about the flora (pollen) and water conditions (micro-organisms such as *Ostracoda*) and dating information from the sands by optically stimulated luminescence (OSL). It was decided that the least damaging way of carrying out the sampling was by recovering cores from boreholes, which would also give a spread of information over a wider area and to a greater depth than would be the case with an excavation.

A strategy of four boreholes was adopted (Figs 1 and 13). Two boreholes (AA and AB) were sited along the presumed line of the north-west branch of the brickearth between trial pit A6 and geotechnical borehole BH12, to give information along that branch. Borehole AA was sited close to trial pit A6 to ensure that *in situ* material was sampled, avoiding the earlier excavations. Borehole AB was sited approximately half way between AA and BH12. Boreholes AC and AD were sited at right angles to the first alignment. This was partly to obtain a section across the north-western arm of the glacial lake, and partly to locate AC close to Smith's site and borehole. The bores were sunk to 6m below the ground surface. In each case the first 1m was disregarded as it was filled largely with modern overburden. Descriptions of the cores recovered from the boreholes are included along with the borehole logs in Figs 15-18. For comparison, the sequence recorded by Layard in 1904 by trenching and a borehole is shown on Fig. 14.

In the event, only borehole AC was fully successful. From borehole AB the bottom 1m (5-6m below ground surface (bgs) could not be recovered. From borehole AD the 4-5m bgs section was badly damaged and could not be recovered. From borehole AA a mixture of damaged cores and wet, running sediment meant that only three 1m sections were recovered.

Only borehole AD showed significant amounts of clay (= brickearth), suggesting that the lake arm lay to the south of the estimated alignment. Although having very poor recovery, the cores from AA, together with the exposure in trial pit A6, showed clay from 34.0m OD to a point between 32.8 and 31.9m OD and again at c. 30.2m OD, suggesting that the lake extended to that location at times. The cores from AB and AC were dominated by sand, occasionally gravelly, with only minor amounts of silt and clay. Given the context of the site, this suggests AB and AC were in a sandy bank of the lake, immediately north of the water body. The archaeological sites of Layard, Smith and Boswell and Moir were very close to the point where AC was sunk, thus a contribution has been made to the reconstruction of the palaeogeography of the lake/stream bank area where a large number of Palaeolithic flint artefacts has been recovered, and where early humans presumably lived. An absolute date of c. 425,000 BP (Before Present) for the sandy lakeside deposits has been obtained by optically stimulated luminescence (OSL) dating (see 7.8 below).

A series of scientific analyses (see 7.0 below), based on samples selected from the cores recovered from boreholes AA-AD, has added additional information to help interpret the palaeoenvironment of the lakeside area.

7.0 SCIENTIFIC ANALYSIS

7.1 Particle Size Analysis, D. Wilson and Dr A. Haggart

Thirty-two samples were taken from the silty clays for particle size analysis to derive information about the lacustrine periods of deposition. A spatula was used to scrape away the top layer of the sediment, to avoid contamination, and two incisions were made, using a scalpel, about 2cm apart. The sample was then lifted out. The samples were dispersed in calgon and then placed in a sonic bath for 30 minutes to break up the particles and then transferred into a large beaker. The samples were then heated and stirred using a magnetic stirrer and a hot plate. A pipette was used to collect the sample out of the beaker, whilst stirring, and then placed in the Malvern Mastersizer 2000 and given 2 minutes ultrasound to facilitate dispersal and then the results were measured by laser diffraction.

The data generated were entered into GRADISTAT, an Excel-based package for calculating grain size distributions and statistics in unconsolidated sediments (Blott 2001; Blott et *al*. 2004).

Table 3. Average percentage by particle size category

Borehole	AA	AD	AD	AA	AB
Depth	110-192cm	123-200cm	257-300cm	480-500cm	485cm
Very coarse sand	0.3	0.1	0.0	0.0	0.0
Coarse sand	1.3	0.9	0.7	0.0	0.0
Medium sand	4.5	3.3	2.2	0.0	0.0
Fine sand	4.6	3.6	1.8	0.2	0.3
Very fine sand	9.7	9.3	9.4	1.8	3.3
Very coarse silt	17.8	17.4	19.6	2.4	6.2
Coarse silt	15.4	15.4	17.8	6.5	9.4
Medium silt	11.7	12.2	13.5	14.7	12.1
Fine silt	11.0	12.0	11.6	22.4	18.2
Very fine silt	10.0	11.2	9.8	21.9	20.6
Clay	13.7	14.7	13.5	30.1	30.0

The results (Table 3) show that the field descriptions of the cores probably overestimated the proportions of finer grained sediment. There is a noticeable difference in grain size between the upper and lower clay units. For instance in borehole AA (Fig. 19) the upper clay between 110 and 192cm has a mean grain size of 71.8 ± 37.9μm (n = 11) which places some of the samples in the fine sand category whilst the lower clay between 480 and 500cm has a mean grain size of 8.2 ± 1.4μm (n = 3) within the medium silt category. Between the coarser upper and finer lower units the average percentage of sand decreases from 20.4% to 2.0% and there is a complementary rise in clay from 13.7 to 30.1%. The middle finer unit in borehole AD seems to have a similar particle size distribution to the upper units in AA and AD.

Within the upper clay there may be evidence for a coarsening upward sequence. In borehole AA (Fig. 19) the mean grain size rises from 48.2µm at 190 cm to 130.2µm at 120 cm before falling to 52.5µm in the uppermost sample. The coarsening upwards is better demonstrated in borehole AD where the average grain size increases from 25.4µm at 195 cm to 62.9µm at 125 cm. This does not seem to be the case within the middle clay in borehole AD where no trend is evident and there are not enough samples through the lower clay to enable any judgment to be made.

For clays to settle extremely quiet water is necessary; the slightest flow will keep the clay particles afloat. The almost ubiquitous presence of silt, coarsening to fine sand at times, indicates that there was gentle water flow of varying strengths through the lake for most of the time. This would be in keeping with a lake within a stream system, as opposed to an isolated water body such as an ox-bow lake. This would be typical of an immediately post-glacial landscape with disrupted drainage before an integrated system became established (cf. Mangerud 1991).

7.2 **Gravel Analysis**, Dr D. Bridgland

A gravel sample was analysed to determine the lithology of the clasts and so make an assessment of the catchment and history of the fluvial input to the site. The sampling followed the methodology recommendations in Technical Guide No. 3 of the Quaternary Research Association (Bridgland 1986a). The sample was first separated, by wet sieving, into 16-32mm and 11.2-16mm fractions for separate analysis (Tables 4, 5).

Table 4. Stone counts: angularity/roundness categories

Category	Characteristic features
Well-rounded (wr)	No flat faces, corners or re-entrants discernible; a uniform convex clast outline
Rounded (r)	Few remnants of flat faces, with corners all gently rounded.
Sub-rounded (sr)	Poorly to moderately developed flat faces with corners well rounded.
Sub-angular (sa)	Strongly developed flat faces with incipient rounding of corners.
Angular (a)	Strongly developed faces with sharp corners.
Very angular (va)	As angular, but corners and edges very sharp, with no discernible blunting.

Based on verbal descriptions by Schneiderhölm (1954, in Pryor 1971) of the categories devised by Powers (1953). Simplified by Fisher and Bridgland (1986).

Table 5. Stone counts: percentage angularity/roundness of 16-32mm flint fraction

All flints as % total flint (excluding unmodified nodules and unbroken Palaeogene pebbles).
Sources for comparative material: Bridgland (1983a, 1983b, 1999); Bridgland and D'Olier (1995); Bridgland *et al.* (1995).

	Category (see Table 4)							
Location	**wr**	**r**	**sr**	**sa**	**a**	**va**	**Total**	**Notes**
Foxhall Road			**2.7**	**23.0**	**44.1**	**30.2**	**222**	
Comparative material								
Pleistocene beaches								
Boxgrove 1	1.9	5.8	23.0	29.9	21.0	18.0	618	
Boxgrove 2	1.4	7.4	38.5	28.8	19.1	4.8	351	
Bembridge 1	9.6	21.0	30.5	24.6	11.4	2.9	509	
Bembridge 2	4.6	11.7	30.0	35.9	13.6	4.3	582	
Southwold 1	37.7	27.1	16.9	10.7	3.2	4.4	591	*Westleton Beds*
Pleistocene fluvial gravels								
Barvills Farm 1	24.8*	7.2*	3.1*	24.1	21.2	19.6	638	*Lower Thames*
Barvills Farm 1			1.0	36.8	32.3	29.9	418	*Lower Thames*
Shakespeare Pit 2A	24.1*	6.9*	1.3*	18.5	22.3	26.8	622	*Lower Medway*
Shakespeare Pit 2A			0.7	27.1	32.8	39.4	424	*Lower Medway*
Aylesford 1[#]			0.8	31.1	17.6	50.4	119	*Middle Medway*
Aylesford 2[#]		0.7	0.7	26.8	28.9	43.0	142	*Middle Medway*
Little Hayes 1			0.6	26.7	34.8	37.9	546	*R.Crouch*
Little Hayes 2			0.6	30.5	41.0	28.6	466	*R.Crouch*
Rampart Field 4				18.3	54.5	27.2	226	*Ingham River*
Knettishall 2			1.5	14.1	52.0	32.3	474	*Glacial outwash*
Kesgrave Group Thames gravels								
Newney Green 1			2.1	51.9	30.7	15.3	287	
Newney Green 2			2.9	45.9	23.9	27.3	209	
Cooks Green 1A			1.2	47.3	31.2	31.2	493	
Cooks Green 2			1.6	45.5	32.4	20.3	380	
St Osyth 1A			0.3	33.4	29.9	34.0	341	
St Osyth 1B		0.4	1.5	58.4	24.9	14.8	539	
Holland Haven 1A			0.3	27.5	28.2	44.0	382	
Holland Haven 1B			1.1	38.2	18.9	41.9	191	
Solifluction gravels								
Great Fanton Hall 1[£]			0.6	35.2	34.4	29.8	540	
St Mary's Marshes 1[$]			0.6	15.7	32.9	50.9	540	*TQ 8413 9812*
Skinners Wick 1[$]				0.6	18.9	74.8	222	*TQ 8106 7804*
Lodge Hill 1[#]			0.7	14.6	27.2	57.6	151	*TQ 7566 7389*

Abbreviations: wr = well-rounded; w = rounded; sr = subrounded; sa = subangular; a = angular; va = very angular; nods = unmodified nodules.
Notes: ∗ - reworked Palaeogene marine flint pebbles (mainly); counts with these are also shown with them excluded, i.e. with broken (**bkn**) flint only; £ - from Bridgland (1983a, 1986b); $ - from Bridgland (1983a); # - from Bridgland (1983a; 2003)
bkn – unbroken flint pebbles present, but excluded from analysis

Both the 16-32mm and 11.2-16mm fractions showed domination by flint, at 73% and 72% in the coarser and finer fractions respectively. The proportion of the flint from Tertiary marine pebble beds falls from about 38% to 30% in the smaller fraction, whereas flint of clear nodular origin is more than halved; both are more difficult to identify amongst the smaller material, which will also have a higher incidence of clasts bounded entirely by fracture surfaces.

About a quarter of both fractions is quartzose/quartzitic, although vein quartz declines in favour of quartzites in the smaller fraction. Of the minor (but important) far-travelled constituents, Carboniferous chert rises from 0.8 to 2.4% in the smaller subfraction, although *Rhaxella* cherts account for 0.3% in both. There is 0.3% schorl-rock in the 11.2-16mm fraction, although this did not appear amongst the coarser material. The same applies to Lower Greensand chert (0.4% of the 11.2-16 mm fraction), which has a southern (Weald) origin. Various unprovenanced sandstones, ironstones and a schistose clast account for the rest of the minor components.

Compositionally the gravel at Foxhall Road is indistinguishable from Kesgrave Formation Thames gravels. Outside the Crag basin, these pre-Anglian Thames gravels would lack *Rhaxella* chert, an indicator of the Anglian glaciation (Bridgland 1986b), but the presence of this rock in pebbly facies of the Red Crag means that at Ipswich its presence in pre-Anglian contexts would not be unusual.

The angularity/roundness characteristics of the flint component of the coarser (16-32mm) fraction were also assessed, using a modified version of the Powers (1953) method, adapted for gravel-sized clasts (cf. Fisher and Bridgland 1986) and using the categories defined in Table 4. Its principal purpose is to determine environment of deposition (see Fisher and Bridgland 1986; Bridgland 1999). Unbroken Tertiary flints were thus excluded from the data, as their marine roundness characters are clearly an inherited feature.

It is this characteristic that distinguishes the Foxhall Road gravel from Kesgrave Thames deposits, from which, according to the clast lithologies, it was undoubtedly derived. Angular flint is strongly modal in the Foxhall Road gravel (Table 5), whereas Kesgrave Thames flint generally has the subangular class as modal. This is presumably a reflection of river size and/or transport distance; a large proportion of the flint has clearly been freshly fractured prior to or during entrainment, thereby increasing the angularity of the Foxhall Road gravel. The Ipswich gravel shares its angular characteristics with other smaller rivers (see Table 5, River Crouch) or larger rivers in which the flint source is only a short distance upstream (see

Table 5, Ingham River). The relatively large subrounded component (2.7%) is seemingly out of place; perhaps this is inherited material from the Kesgrave Thames.

7.3 **Heavy minerals**, Dr P. Allen

Heavy mineral analyses of the brickearth were not undertaken as part of this geoarchaeological investigation, but such analyses were conducted by Boswell (Boswell and Moir 1923, 237) and the results are germane. Boswell noted the similarity between the heavy mineral suites of the Lowestoft Till and those of the overlying sands, clays and brickearth. These records, in turn, agree well with more recent analyses from the Lowestoft Till (Perrin *et al*. 1979). Minerals such as tourmaline, rutile and staurolite are common to abundant in both the till and the Foxhall Road sands and brickearth, while softer minerals such as kyanite and apatite are ‘not uncommon’ to variable/abundant in the till and in the sands and brickearth. These softer heavy minerals are conspicuously lacking in the pre-glacial Kesgrave Thames gravels, thus their presence here indicating their introduction during the Anglian glaciation. The survival of the softer minerals into the sands and brickearth arguably indicates that they did not experience much weathering or transport before deposition, making a gap in the order of a whole climatic cycle between the deposition of the till and deposition of the sands and brickearth very unlikely Thus the deposits at Foxhall Road are likely to be late Anglian to early Hoxnian in age.

7.4 **Geochemistry**, D. Wilson and Dr A. Haggart

Twenty samples were taken for geochemical analysis of both the major minerals and the trace elements. Samples 1-11 and 18-20 were obtained from the upper and lower clays in borehole AA, and samples 12-17 from the middle clay in borehole AD (Fig. 20).

The samples were oven-dried overnight then crushed to a powder in a ball mill. They were then transferred to glass tubes and dried overnight at 105°C. For the major and trace elements a lithium metaborate fusion process was used prior to Inductively Coupled Plasma-Mass Spectrometry and Inductively Coupled Plasma-Optical Emission Spectrometry analyses.

Figures 21 and 22 show changes in both the major and the trace elements. There is a clear difference between the lower clay (samples 18-20) and the middle (12-17) and upper (1-11) clays. Compared to the lower clay the upper clay it is deficient in calcium, magnesium, phosphorus, nickel and to a lesser extent potassium. In the trace elements the major differences are shown by decreases in the concentration of strontium and vanadium, and increases in zirconium, hafnium and the lanthanides, most obviously lanthanum, cerium and neodymium.

Calcium is one of the most abundant elements in the earth's crust, averaging just over 4%. In borehole AA the upper clay has an average of 0.3%, whilst the lower clay averages 22%. It is possible that this may reflect decalcification. The coarser-grained upper clay may have been subjected to post-depositional percolation of acid groundwater leading to dissolution of mineral and biological calcium salts. The finer-grained lower clay would have been less susceptible to ground water percolation and has retained its calcium content, including the calcareous shells of ostracods. The depletion of manganese, phosphorous, nickel and potassium, all of which are acid soluble, would tend to support the hypothesis of decalcification.

Among the trace elements that show depletion in the middle and upper clay are strontium and vanadium. Strontium, like calcium, is often incorporated into invertebrate shell material. This may account for its high value of about 325 ppm in the lower clay. Its depletion in the upper clay, like calcium, suggests dissolution by acid groundwater. Vanadium is abundant in most soils, at approximately 100 ppm. The average value of 115 ppm in the lower clay in borehole AA is in accord with this figure. Vanadium is susceptible to weathering because vanadates are generally very soluble. This may explain the slightly decreased values of 90 and 80 ppm in the middle and upper clays.

Some of the trace elements show higher concentrations in the middle and upper clays, such as zirconium, hafnium and most of the lanthanides (La to Lu on Fig. 22), notably lanthanum, cerium and neodymium. Zirconium's most common mineral, zircon, is highly resistant to weathering and only slightly mobile in the environment. Hafnium shares the same chemistry as zirconium and, like it, is resistant to corrosion from alkalis and acids. Given this fact and the high values of acid-soluble minerals in the lower clay, it is very unlikely that the decrease in concentration of these two elements within the lower clay is a result of weathering. It may reflect a different source of sediment supply.

Lanthanum, cerium and neodymium are lanthanides, formerly known as rare earths. They have tri-positive ions which have the general formula Ln^{3+} and which are about the same size as those of calcium, which they can partly replace in the mineral lattice. When calcium compounds break down under weathering they release lanthanides into the environment. However these are soon rendered immobile by contact with carbonate and phosphate ions with which they form insoluble salts. Most of the lanthanides show higher concentrations in the middle and upper clay and within the upper clay most decline towards the surface. This could reflect a different source of sediment supply or an initial higher calcium content. On decalcification higher concentrations of lanthanides would have been released into the surrounding sediments. The decrease in most of the minerals towards the surface may reflect a vestigial reference to an original decline in calcium content.

7.5 Vertebrate Remains

No vertebrate material was recovered.

7.6 Ostracods, D. Wilson and Dr A. Haggart

Ostracods are small laterally compressed bivalve-like crustaceans with a chitinous or calcareous valves or ‘shells’. They are typically around 1mm in size, but can vary between 0.2 to 30mm. Ostracods are common in most types of aquatic environments including lakes, ponds, streams and rivers, with some species even appearing in semi-terrestrial environments and within groundwater. Ostracods grow by moulting their shells, which can occur up to eight times before adulthood (Griffiths and Holmes 2000). Due to the shells being frequently discarded, they are often very well preserved in Quaternary sediments. Their particular value in Quaternary research is their sensitivity to climatic, environmental and habitat factors, such as temperature, salinity, anionic composition, nutrient balance, water body depth, size, permanence, substrate type, aquatic macrophyte cover and energy levels (Griffiths and Holmes 2000). Ostracods are, therefore, a valuable way of deducing palaeo-environmental factors from Quaternary sediments.

Twelve samples were collected from the cores, in the same manner as for the geochemical analyses. The samples were placed in 250ml glass beakers of dilute calgon and boiled. Once boiled the beakers were left simmering for up to an hour to allow the calgon to work on breaking up the finer clay particles. The sediments were not stirred or agitated as this could break up any microfossils. The sediments were then passed through 125µm sieves. Between samples the sieves were stained with methylene blue so that any particles not washed away from previous samples could be identified. The contents of the sieves were then transferred to petri dishes and dried out in the oven for a few hours or overnight. The sediments were processed to find any microfossils, mainly ostracods. This was done by transferring small amounts of sediment onto a picking tray and using a fine-tipped paintbrush to sort through it, whilst looking through a microscope at 20x magnification. When any microfossils were found they were transferred onto an assemblage slide. On completion, the microfossils were organised into groups of similarities and placed into numbered boxes on the slide for identification to be carried out.

Of the twelve samples, only two contained any microfossils, borehole AD 130cm and borehole AB 485cm (see Fig. 20). The ostracods in sample AD 130 were very broken up and no whole ostracods were found, making identification almost impossible. Sample AB 485 contained more ostracods, but again mostly broken though, fortunately, two could be identified down to species level.

The two ostracods identified, subject to confirmation, were *Ilyocypris* cf*. decipiens* and *Cyclocypris serena* (Plates 6 and 7). The two species have slightly different living conditions. Today, both species are often found in water bodies where the main substrates are silts and sands. *I. decipiens* is most commonly found in oxbow lakes, and still water bodies, but also in flowing water (Nagorskayia and Keyser, 2005). This fits in well with the site at Foxhall Road, as the site is known to be a riverside or lakeside. *C. serena* is commonly found in ponds and temporary water bodies, although it can also tolerate water bodies that have a slight flow (Nagorskayia and Keyser, 2005), for example a slow river running into a lake.

The two ostracods have slightly different, but overlapping, climatic requirements. *I* cf. *decipiens* has not been studied in detail and is poorly known ecologically, but from the small amount of research carried out on the species, it is believed to occur during cold conditions. *C. serena* has also been associated with the cold-water colonization fauna (Davies and Griffiths 2005).

The two species have existed through a long span of Quaternary geological time, from the Cromerian (over 500,000 years ago) to the present day, so they do not offer useful stratigraphic information for dating the sediments. However, their discovery is exciting. From other information offered in this report, the sediments are almost certainly about 400,000 years old, covering the transition from the Anglian cold stage to the early Hoxnian temperate stage. *I*. cf. *decipiens* and *C*. *serena* are poorly recorded, if at all, from this time period.

7.7 **Pollen Analysis**, D. Wilson and Dr A. Haggart

Thirty-two samples were taken from cores for pollen analysis. Sixteen samples were selected for analysis and prepared using standard pollen extraction techniques, twelve from the upper clay in borehole AA, three from the lower clay in borehole AA and one from the lower clay in borehole AB.

A known number of exotic *Lycopodium* spores in tablet form were added to $1cm^3$ of fresh sediment allowing pollen concentration values to be derived (Stockmarr 1971). The samples were then deflocculated overnight in a sonic bath using calgon and passed through sieves of 180 µm and 10µm. The larger sieve is designed to remove coarser plant debris and the smaller sieve allows clay-sized particles to pass through but retains the pollen-sized fraction.

The samples were then mixed with a non-toxic heavy liquid, sodium polytungstate, made up to a specific gravity of 2.0. At this specific gravity, the organic component, including pollen, floats and the majority of the mineral component sinks, enabling physical separation. This procedure reduces degradation of pollen grains during extraction from mineral sediments and represents a significant and safer advance on the former use of hydrofluoric acid to digest the mineral fraction. Following separation, the samples were subjected to standard acetolysis procedures to remove cellulose (Erdtman 1960), then stained with safranine and mounted on slides using glycerine jelly.

The slides were systematically scanned at 400x magnification. No pollen was detected in any of the samples and so it was decided not to process the remaining sixteen samples. However the exotic *Lycopodium* was present and in good condition which suggests the lack of pollen was not a consequence of the preparation procedure but was due to absence in the original sediment. The most likely explanation for this is post-depositional oxidation of the sediments and/or removal by percolating groundwater.

7.8 **Luminescence Dating**, Dr J-L Schwenninger

Two samples from borehole AC cores 4-5m and 5-6m (Fig. 17) were selected for optically stimulated luminescence (OSL) dating, which was carried out at the Luminescence Dating Laboratory of the University of Oxford. The results and a summary of their interpretation are set out below, and are supported by a fully detailed laboratory report (Schwenninger 2007) in the project archive.

The upper sample (X2729) was taken from a medium to coarse sand deposit at 4.2m below ground level, at 31.0m OD, and the lower sample (X2728) from horizontally bedded fine sand at 5.6m below ground level, at 29.6m OD (Fig. 17). For each sample, six small sized multigrain aliquots were measured according to procedures described in further detail in the laboratory report (Schwenninger 2007). The luminescence characteristics of both samples (X2728 and X2729) were very good, providing mean recycling ratios close to unity (1.01 and 0.98), low mean thermal transfer (0.7% and 1.3 %), and confirming the absence of feldspar contaminants (respective mean IRSL/OSL ratio = 0.008 and 0.003). For each sample only one or two aliquots were rejected due to the onset of signal saturation and palaeodose estimates were based on the weighted mean of all the measurements. The basal sample X2728 provided a much larger palaeodose estimate (~395Gy) compared to the overlying sample X2779 (~216Gy). This is mainly due to the increased concentration of radioisotopes within the basal sands which are characterised by a finer texture and are known to contain a higher proportion of silt-size material.

Table 6. Optically Stimulated Luminescence (OSL) dating results

Field code	Lab. code	Depth (m)	Palaeodose (Gy)	Dose rate Gy/ka)	OSL age estimate (ka)
Borehole AC Core 5-6m	X2728	5.62-5.68	394.93 ± 19.25	0.95 ± 0.07	416 ± 36
Borehole AC Core 4-5m	X2729	4.18-4.28	215.93 ± 23.05	0.50 ± 0.03	434 ± 54

The results are based on luminescence measurements of sand-sized quartz [180-255 μm]. All samples were measured using a single aliquot regenerative-dose (SAR) post-IR blue OSL measurement protocol (Murray and Wintle 2000; Banerjee *et al.* 2001). Dose rate calculations are based on the concentration of radioactive elements (potassium, thorium and uranium) derived from the elemental analysis by ICP-MS analysis using a fusion sample preparation technique. The final OSL age estimates include an additional 2% systematic error to account for uncertainties in source calibration. Dose rate calculations are based on Aitken (1985). These incorporated beta attenuation factors (Mejdal 1979), dose rate conversion factors (Adamiec and Aitken 1998) and an absorption coefficient of the water content (Zimmerman 1971). The contribution of cosmic radiation to the total does rate was calculated as a function of latitude, altitude, burial depth and average over-burden density based on data by Prescott and Hutton (1994). Further details regarding individual samples may be found in Appendix 1 of the laboratory report (Schwenninger 2007).

The lower sample (X2728) gave a date of 416,000 BP, the upper (X2729) 434,000 BP (i.e. dates reversed). A high modern water content of 36.2% was recorded for sample X2729 but, surprisingly, the basal sample X2728 only contained 2.7%. It is unusual for a lower sample to be dry and an upper nearly fully saturated; usually the reverse is true. Although the sandy nature of these sediments implies that they may drain very easily, it is difficult to explain the very large difference observed between the two samples, especially given their close proximity. In the core, c. 20cm below the upper sample, there was the edge of a 2mm-thick clay lens, so there could have been a perched water table. Four other boreholes in the vicinity (BH7, 10, AA and AB) show perched water tables at depths of c. 4m below ground surface and several show dry conditions to depths of 6m or even 9m bgs. However, the very low value recorded for the basal sample at a considerable depth of almost 6m below the surface is unlikely to represent the original moisture content. Given the very high water content of the overlying sample, it is suspected that the lower sample had dried up in storage, perhaps as a result of a puncture or other damage to the plastic wrapping which could have occurred during the handling and/or transport of the core.

Due to the attenuating affect of water with respect to the radiation dose received by quartz mineral grains, it is important to correctly determine the mean average water content of the sample throughout the burial period. For this reason, and given the problem discussed above, the dose rate calculations for sample X2728 was based on a moisture content similar to X2729 but with an appropriate inflated uncertainty (25 to 45%). The final OSL age estimates are in relatively good agreement (Table 6) and provide a combined mean estimate of c. 425ka (425,000 years). Although the date for the basal sand is slightly younger than the overlying unit, the results are within error and confirm a late Anglian or early Hoxnian depositional age. This supports the interpretation of the sediments as being deposited in a recently deglaciated, post-Anglian landscape.

7.9 **Flint Artefacts**, Dr M. White

Two new artefacts were recovered from the recent investigations, a handaxe and a simple core. Both were recovered from the investigations in trial pit A6 and, while neither was recovered *in situ*, material adhering to both suggests that they were originally from the sandy clay (pug). Recent work has suggested that material from the pug is in secondary context, having been derived from primary context horizons on the sloping surfaces of the underlying Red Gravels and Grey Clays (White and Plunkett 2004). The condition of the majority of the material from the pug suggests that it was unlikely to have been moved very far.

The handaxe

The handaxe is typologically a point with a thick, partially worked butt. It conforms to Wymer's Type F c/- (Wymer 1968) and also falls into Roe's (1968) pointed category, having a tip length/length ratio (L1/L) of 0.219. Although very pointed, with a sharply converging tip, the piece is not particularly elongated. It is also relatively unrefined, having a very thick butt, although the tip is much thinner and more refined. The handaxe is illustrated in Figure 23 and Plate 8 and its metrical attributes are listed in Table 7.

Table 7. Metrical attributes of the handaxe

Length	127.5mm
Width	87.5mm
Thickness	45.3mm
B1 (width at 1/5 of length from tip)	38.4mm
B2 (width at 1/5 of length from butt)	86.5mm
L1 (distance from butt to position of maximum width)	28mm
Elongation Index (Width/Length)	0.686
Refinement Index (Thickness/Width)	0.517
Tip Pointedness Index (B1/B2)	0.443

The morphometric indices follow Roe 1968. In all cases, values approaching 1 show that the two attributes are of equal value. So, high values indicate that levels of refinement, elongation and tip pointedness were low, and vice versa.

Technologically the piece has been fairly well, if boldly, worked around the entire circumference; some soft hammer and finer retouch is in evidence, particularly at the tip. Working to the butt appears to have been restricted by poor angles caused by two diamond-shaped meplats (corners), one on either margin. In these two areas there is evidence, in the form of a stepped series of short blows, that the knappers had attempted further working but failed. There are also several incipient fractures evident on the piece, predominantly at the butt. The majority of working appears to have been entirely unaffected by these, although there are a number of instances where the negative flake scars exhibit very steep terminations or other percussion features that respect the line of a flaw. This suggests that at least some of the flaws were present in the flint prior to manufacture, but that the knapper was skilful enough to circumvent most problems.

The piece is in very fresh condition, but is stained orange-brown and shows a moderate amount of yellow-white patination. The arêtes between flake scars are all fresh and, critically, the edges do not display any rounding or crushing, again suggesting that the piece had not been transported far from its original location. The tip of the handaxe has been broken in antiquity and the margin immediately below the break shows spalling or retouch. Although natural damage cannot be ruled out, the condition of the object would rather suggest that both the break and edge damage were use-related.

The core

The core is a simple or ‘multiple platform’ type made on what appears to be a beach pebble. It has been minimally worked, bearing just five negative scars. These represent two episodes of parallel flaking (Ashton and McNabb 1996), with two scars and three scars respectively, both of which have been organised from platforms formed by natural fracture surfaces on the original pebble. The core is relatively small, with dimensions of 64 x 61 x 45 mm. Although the final dimensions and technological features of cores are often held to be a representation of their discarded state only, in this case the high percentage of cortical/natural surfaces (>50%) and the configuration of the flake scars and cortex indicates that the original blank was not much larger than the final core.

Comparison with previous finds from Foxhall Road

The morphology and condition of the handaxe fits comfortably with those recovered from the sand clay pug by Layard, Moir and Smith in their respective excavations, but would also not be out of place in the material from the *in situ* material from the underlying Red Gravels. As the former are believed to have been derived from the latter, this is not surprising. These comparisons are illustrated in Figure 24.

The core is also very similar to those from earlier excavations, having been minimally worked on a small pebble. The cortex on the pebble shows chatter marks characteristic of collision and battering in a high energy environment, possibly indicating a marine or glacial context. Similar material was noted amongst the finds from Layard's excavations and was suggested to be an autochthonous element of the local fluvial/solifluction gravels at Foxhall Road.

8.0 CONCLUSIONS AND ASSESSMENT OF RESULTS

The main aim of the trial pit evaluation was to determine the survival or otherwise of the Pleistocene (Ice Age) deposits and Lower Palaeolithic (Early Old Stone Age) remains previously excavated by Layard, Smith and Moir between 1903 and 1921, when the site was a brick pit, and whether they would be affected by the new housing development. The Palaeolithic remains are highly significant, and were thought to represent evidence of early human activity on the banks of a lake that formed at the end of the Anglian glacial period and became filled with brickearth.

The trial pit evaluation identified the strata affected by the construction groundworks (which penetrate to a depth of up to 1.5m) as upper sands and gravels. These seal the pebbly sandy clay (pug) and clay/brickearth deposits recorded in the earlier excavations and the geotechnical boreholes as infilling the post-glacial lake, and are interpreted as post-Hoxnian fluvial deposits, a later geological episode than the lake sediments.

Stratigraphic survival is clearly much better than was originally expected, and reconstructions based on trial pit and geotechnical borehole data (Figs 11 and 12) suggest that clay and brickearth lake deposits survive at depths of up to 8-9m below present ground level. They extend beyond the brick pit into the north-west of site, with two other, separated, areas of probable lake deposit in the north and south of the site. The trial pit and borehole results also confirm that the site's geological sequence was plotted c. 4.5m too high relative to Ordnance Datum on the published section (Wymer 1985, fig. 74). As a result, the Palaeolithic levels recorded in the previous excavations can now be shown to survive beneath the brickearth at a depth of over 5m below present ground level (c. 30m OD), well below the construction level of the housing development.

The evaluation successfully located the area of the previous excavations, where the Palaeolithic remains were recovered, as lying in the north-west of the site, a short distance beyond the limits of the former brick pit. Trial pit A6 (Fig.1) identified a sequence sealed beneath the upper sands and gravels, consisting of sandy clay (pug) and clay/brickearth, in the top of an arm or a feeder channel extending north-west from the glacial lake (Figs 11 and 12), comparable to the upper part of the sequences recorded in the previous excavations. Trial trench A17 relocated Smith's 1914 excavation trench 25m to the east of trial pit A6, and from this it is possible to locate the sites excavated in the same area by Layard in 1903-5 and Moir in 1921, and relate them to the present investigation (Fig. 13). An Acheulian flint handaxe was recovered from trial pit A6, adding to the assemblage of 134 other flint handaxes that had previously been recovered from this area of site.

The concentration of Palaeolithic remains in the north-west of the site suggests that early humans were particularly active by a feeder stream leading to the post-glacial lake in which the brickearth accumulated. Geological analysis suggests that the lake was part of a poorly organised drainage system and its configuration changed over time.

It was agreed with the Suffolk CC monitoring officer that mitigation should consist mainly of preservation of remains *in situ* beneath the housing development. The upper geological strata that would be truncated by the construction levels were not considered significant. There is an impact on the brickearth lake deposits and associated Palaeolithic levels from deep piling, but this is very low. The piling density represents less than 2% of individual house footprints, well within the acceptable zone of disturbance by deep piling (5%) recommended by English Heritage (2005).

The other agreed mitigation was the programme of borehole sampling and scientific analysis to enhance the results of the previous excavations. This has enabled the evolution of the palaeogeographies of the brickearth-filled lake and the area of human activity beside it to be better understood.

The lake and its feeder stream formed during the transition from the Anglian glacial period to the Hoxnian temperate period, as indicated by optically stimulated luminescence (OSL) dating and strongly supported by the heavy minerals analysis. Other forms of evidence, palaeogeographical reconstructions, ostracods, and flint artefacts, would be consistent with this dating. The roundness/angularity characteristics of the gravel argue against it being part of the widespread pre-Anglian Kesgrave gravels, again suggesting an Anglian or later date. There is no evidence of fauna or plant remains, as no vertebrate material was present and pollen did not survive. The OSL dating provides a mean date of c. 425,000 years Before Present for the sandy deposits on the banks of the stream/lake which were the focus for early human activity in the Palaeolithic.

These results are a significant advance on previous knowledge and it is proposed to publish them as an article in the *Proceedings of the Geologists' Association*, or a journal of equal status, with a short note on the handaxe in the *Proceedings of the Suffolk Institute of Archaeology and History*.

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APPENDIX 1: TRIAL PIT AND TRENCH DATA

TRIAL PIT A1

Dimensions	4.5m x 1.85m, aligned E-W
Co-ordinates	SW X = 618548.0 Y = 244040.0
	NE X = 618543.9 Y = 244042.7
Ground surface height	34.69m OD
Trench base height	33.32m OD
Face recorded	South

Bed No.	Description
	Site ground surface.
A1/1	Thickness 1.3m. Made ground.
A1/2	Thickness variable, up to 0.1m seen. Gravel, up to 100mm diameter, in a matrix of fine to medium sand (2.5YR5/8 - red). Concave bedding sympathetic with A1/3 below. A sample was taken from this bed for gravel analysis.
A1/3	Thickness variable, up to 0.1m seen. Fine to medium sand (10YR6/8, 6/4 – brownish yellow to light yellowish brown.) coarsening upwards to become medium to coarse (7.5YR5/8, 5YR5/8 - strong brown to yellowish red). Bedded, on the east side, dipping at 20° towards 210°, and on the west side at 32° towards 003°. The floor of the pit, cut into this bed, showed an acicular disturbance pattern (discussed below).

The concave bedding pattern and the size of the clasts involved in bed A1/2 is thought to indicate infilling of a minor channel. The dip and orientation measurements suggest that the channel trended NW-SE. The size of the channel, only 1-2m wide, indicates that it was not the main channel feeding the site of the brickearth deposits, but would have been broadly parallel to it

A particularly interesting and unusual disturbance pattern was noted on the floor of the trench, cut into bed A1/3. This comprised a close pattern or mosaic of areas of sub-parallel needle-like features, picked out in brown sand, up to about 0.15m long and c. 0.25m wide (an acicular pattern). These are thought to reflect the development of repeated areas of needle-ice during severe frost. Similar features have been described by Coneybeare and Crook (1968). Although these are rarely recorded in the geological literature, they are probably not too significant as they can be seen during hard frosts in Britain today.

The gravel comprised chiefly flint (with rounded Tertiary flint and sub-rounded to sub-angular flint) with lesser amounts of quartzite and vein quartz. Angularity/roundness data are presented in Tables 4 and 5 and discussion in the body of the report.

TRIAL PIT A2

Dimensions	5.5m x 1.85m, aligned E-W
Co-ordinates	SW X = 618617.9 Y = 244022.0
	NE X = 618612.9 Y = 244025.0
Ground surface height	35.08m OD
Trench base height	33.87m OD
Face recorded	South

Bed No.	Description
	Site ground surface.
A2/1	Thickness 0.97. Made ground.
A2/2	Thickness, up to c. 0.1m seen. Comprised cross-bedded medium to coarse sand, dipping at 16° towards 298°.

With such a small exposure it is difficult to interpret the cross-bedding of A2/2, which could be a straightforward local flow towards 298° or may represent the bank of a minor channel with flow direction of 028-208°.

TRIAL PIT A3

Dimensions	5.6m x 1.85m, aligned N-S
Co-ordinates	SW X = 618598.9 Y = 243992.0
	NE X = 618597.0 Y = 243997.6
Ground surface height	35.51m OD
Trench base height	34.34m OD
Face recorded	West

Bed No.	Description
	Site ground surface.
A3/1	Thickness 1.08m. Made ground.
A3/2	Thickness, up to 0.15m. Fine to medium sand (10YR6/6 – brownish yellow), main body horizontally bedded but basal bedding concordant with sloping lower boundary. A single palaeocurrent measurement gave a dip of 11° towards 284°.
A3/3	Thickness, up to 0.15 m. Gravel, clasts up to 20 cm flint, 10 cm quartz and quartzite, in a matrix of medium to coarse sand (10YR7/6 – yellow).

With such a small exposure it is difficult to interpret the cross-bedding of A3/2, which could be a straightforward local flow towards 284° or may represent the bank of a minor channel with flow direction of 014-194°. The gravel comprised chiefly flint (with rounded Tertiary flint and sub-rounded to sub-angular flint) with lesser amounts of quartzite and vein quartz.

TRIAL PIT A4

Dimensions	7.5m x 1.85m, aligned N-S
Co-ordinates	SW X = 618599.5 Y = 243967.9
	NE X = 618597.6 Y = 243975.4
Site ground surface height	35.43 mOD
Trench base height	34.17 mOD
Face recorded	East

Bed No.	Description
	Site ground surface.
A4/1	Thickness 0.83m. Made ground.
A4/2	Thickness, up to 0.1m in northern part of exposure. Coarse sand and granules, with occasional fine gravel (10YR7/4 – very pale brown). No primary sedimentary structures were seen.
A4/3	Thickness variable, up to 0.25m. Medium sand (10YR6/4 – light yellowish brown) with no apparent bedding.
A4/4	Thickness, up to 0.05m. Coarse gravel with clasts up to 12 cm (recovered from floor of pit), set in a matrix medium to coarse sand (10YR7/4 – very pale brown).

The gravel comprised chiefly flint (with rounded Tertiary flint and sub-rounded to sub-angular flint) with lesser amounts of quartzite and vein quartz.

TRIAL PIT A5

Dimensions	10.5m x 1.85m, aligned N-S
Co-ordinates	SW X = 618546.9 Y = 243974.6
	NE X = 618546.0 Y = 243985.2
Site ground surface height	34.48m OD
Trench base height	33.11m OD
Face recorded	West

Bed No.	Description
	Site ground surface.
A5/1	Thickness 1.25m. Made ground.
A5/2	Thickness, up to 0.1m, occurring in basins north and south of a gravel ridge (5/3).Medium sand (10YR 5/6 – yellowish brown) with no discernible primary sedimentary structures.
A5/3	Thickness, up to 0.15m, forming a ridge. Gravel in a matrix of medium to coarse sand (7.5YR5/8 – strong brown).

The sand (A5/2) appeared to occur in basins or minor channels either side of a gravel ridge (A5/3). The gravel comprised chiefly flint (with rounded Tertiary flint and sub-rounded to sub-angular flint) with lesser amounts of quartzite and vein quartz.

TRIAL PIT A6

Dimensions	6.3 x 4.7m, aligned N-S, W and E sides stepped
Co-ordinates	SW X = 618507.7 Y = 244019.6
	NE X = 618546.9 Y = 243974.6
Site ground surface height	35.17m OD
Stepped in by c. 1m	34.00m OD
Trench base height	32.82m OD
Face recorded	West

Bed No.	**Description**
	Site ground surface.
A6/1	Thickness variable, up to 0.75m. Made ground.
A6/2	Thickness variable, up to 0.4m. Fine sand (10YR 6/6-6/4 – light yellowish brown to brownish yellow), in irregular rounded bodies, possibly due to sinking into 6/3 in saturated conditions.
A6/3	Thickness variable, up to 0.9m. Gravelly sand in a matrix of medium sand and clay (7.5YR 5/8 – strong brown). Upper surface mostly in contact with the made ground and so is unlikely to be original; bottom irregular, projecting down into bed 6/4, again thought to be due to sinking in saturated conditions.
A6/4a	Thickness up to 0.6m. Pebby, sandy clay (7.5YR5/8 – strong brown). Irregular upper surface, as explained above. Bottom not seen as face was stepped for safety reasons.
	Step
A6/4b	Thickness variable, up to 0.15m. Clayey (7.5YR 5/8 – strong brown with 2,5Y - light brownish grey mottles). Base undulating. Thought to be lateral equivalent of 6/4a due to similarity of texture and colour.
A6/5	Thickness variable, up to 0.7m. Sandy clay (10YR5/8 – yellowish brown) with occasional small pebbles (<0.5 cm). Within it the sandy clay there is a discontinuous sequence of sand of variable thickness (up to 0.1 m), suggesting elongation and separation (boudinage).
A6/6	Thickness up to 0.4m. Clay (2.5Y 6/2 – light yellowish grey), massive with occasional small pebbles (<1 cm) and occasional lenses of fine sand (7.5YR 5/8 – strong brown).

The section is particularly important for linking with the original work of Boswell (1914). His descriptions are closely mirrored by those from this trial pit.

Trial Pit A6	**Layard** (as summarised by White and Plunkett, 2004)	**Smith (1921)**	**Boswell & Moir (1923)**
A6/3 Gravelly sand	Upper sand and gravel	Sand	Bed 2 (Fine reddish gravel)
A6/4a,b & 6/5 Pebbly sandy clay, brown	Gravelly clay	Reddish and dove pug	Bed 3 (Pug – stony reddish sandy clay)
A6/6 Clay, light grey	Red and grey clay	*Stiff grey clay (brickearth)* *Red band α* Red and dove pug (brickearth)	Bed 4 (Laminated dove brickearth)

The deformation structures affecting beds A6/2, 3, 4a, 4b are comparable with those described by Boswell (Fig. 9). The gravel comprised chiefly flint (with rounded Tertiary flint and sub-rounded to sub-angular flint) with lesser amounts of quartzite and vein quartz.

TRIAL PIT A7

Dimensions	5.7m x 1.85m, aligned E-W
Co-ordinates	SW X = 618534.4 Y = 243938.1
	NE X = 618511.0 Y = 244012.4
Site ground surface height	35.11m OD
Trench base height	33.94m OD
Face recorded	West

Bed No.	**Description**
	Site ground surface.
A7/1	Thickness 0.94m. Made ground.
A7/2	Thickness varied from 0.15m in west tapering out in east. Base slopes in a concave fashion to the west. Medium sand (10YR6/6 – brownish yellow) with no discernible bedding.
A7/3	Thickness varied from 0.1m in west to 0.25m in east. Sandy gravel, clasts up to 100mm, with a medium to coarse sand matrix (10YR6/6 – brownish yellow)

The sand (A7/2) appears to occupy a minor channel or basin adjacent to a gravel bar (A7/3). The gravel comprised chiefly flint (with rounded Tertiary flint and sub-rounded to sub-angular flint) with lesser amounts of quartzite and vein quartz.

TRIAL PIT A8

Dimensions	7.5m x 1.85m, aligned E-W
Co-ordinates	SW X = 618531.1 Y = 243850.3
	NE X = 618539.7 Y = 243935.2
Site ground surface height	34.45m OD
Trench base height	33.07m OD
Face recorded	South

Bed No.	Description
	Site ground surface.
A8/1	Thickness variable, 0.70-0.94m. Made ground.
A8/2	Thickness, up to 0.3m. Fine to medium sand (10YR7/8 – yellow) with occasional pebbles. The sand lies in wedges let into the gravelly sand (8/3), the wedge sides being angled at c. 60°.
A8/3	Thickness, up to 0.3m. Gravelly sand (10YR6/4 + 5/8 – light yellowish brown to yellowish brown).

The angle and regularity of the wedge sides and the sub-horizontal arrangement of the pebbles are in keeping with tensional cracking (rather than ice-wedge cast formation), possibly caused as the sediments settled on unstable underlying beds. The gravel comprised chiefly flint (with rounded Tertiary flint and sub-rounded to sub-angular flint) with lesser amounts of quartzite and vein quartz.

TRIAL PIT A9

Dimensions	9.0m x 1.85m , aligned E-W
Co-ordinates	SW X = 618525.2 Y = 243799.3
	NE X = 618538.6 Y = 243848.5
Site ground surface height	35.04m OD
Trench base height	33.63m OD
Face recorded	North

Bed No.	Description
	Site ground surface.
A9/1	Thickness variable, 0.94-1.20m. Made ground.
A9/2	Thickness, 0.4m. Medium sand, possibly humic (7.5YR4/4, brown to dark brown), with frequent pebbles, 1-2 cm in diameter; no obvious bedding structures.
A9/3	Thickness, 0.1m seen. Sandy gravel, clasts <2.5 cm, with a fine – to medium sandy matrix (10YR5/6 – yellowish brown).

The gravel comprised chiefly flint (with rounded Tertiary flint and sub-rounded to sub-angular flint) with lesser amounts of quartzite and vein quartz.

TRIAL PIT A10

Dimensions	5.5m x 1.85m, aligned E-W
Co-ordinates	SW X = 618519.0 Y = 243769.0
	NE X = 618533.6 Y = 243795.5
Site ground surface height	34.92m OD
Trench base height	33.70m OD
Face recorded	None

Bed No.	Description
	Site ground surface.
A10/1	Thickness 1.2m+. Made ground.

TRIAL PIT A11

Not excavated – area occupied by large spoil heap

TRIAL PIT A12

Dimensions	6.0m x 5.2m, aligned E-W, N and S sides battered - soft sand
Co-ordinates	SW X = 618502.5 Y = 243955.0
	NE X = 618507.4 Y = 243948.8
Site ground surface height	35.22m OD
Trench base height	33.89m OD
Face recorded	West

Bed No.	Description
	Site ground surface.
A12/1	Thickness 0.63m. Made ground.
A12/2	Thickness, up to 1.0m. Base slopes to north. Medium sand (10YR7/6 – yellow + 7.5YR5/8 - strong brown), cross-bedded, dipping at 26° towards 352°. Within the sand are lenses of coarse sand, granule and fine gravel, inclined within the sand bedding and becoming coarser and thicker downslope. Within the medium sand and at the bases of the coarse lenses there are minor discordances.
A12/3	Thickness up to 0.2m. Medium sand (10YR7/6 – yellow + 7.5YR5/8 - strong brown), cross-bedded, dipping at 24° towards 202°.

The cross-bedding indicates a prograding environment of deposition. The coarsening and thickening of the coarser lenses are typical of sub-aqueous avalanching down inclined beds and the discordances indicate minor interruptions of deposition. The whole assemblage suggests micro-delta formation, possibly off either side of an ephemeral mid-channel gravel bar, to account for the great disparity of the palaeocurrent readings.

TRIAL PIT A13

Dimensions	6.5m x 1.85, aligned N-S
Co-ordinates	SW X = 618491.8 Y = 243882.7
	NE X = 618491.2 Y = 243889.4
Site ground surface height	34.99m OD
Trench base height	33.63m OD
Face recorded	West

Bed No.	Description
	Site ground surface.
A13/1	Thickness 1.07m. Made ground.
A13/2	Variable thickness, up to 0.4m in the infills (see below). Clayey fine sand (10YR5/6, 5/8 – yellowish brown – with 10YR7/3 – very pale brown – mottles) infilling depressions in bed 13/3. Mostly structureless but some cross-bedding/inclined bedding on one side of one of the depressions.
A13/3	Variable thickness, up to, 0.3m. Coarse gravel, occurring in two bodies, with clasts up to 180mm. Matrix of clayey sand (7.5YR6/6 + 10YR6/6 – reddish yellow to brownish yellow)

Bed A13/3 is thought to be a gravel bar complex with an irregular bar top, with basins or crossed by minor channels. The bedding in A13/2 indicates a microdelta prograding into a basin/channel. The gravel comprised chiefly flint (with rounded Tertiary flint and sub-rounded to sub-angular flint) with lesser amounts of quartzite and vein quartz.

TRIAL PIT A14

Dimensions	5.8m x 1.85m, aligned E-W
Co-ordinates	SW X = 618438.5 Y = 243818.9
	NE X = 618434.0 Y = 243823.0
Site ground surface height	37.46m OD
Trench base height	36.07m OD
Face recorded	North

Bed No.	Description
	Site ground surface.
A14/1	Thickness variable, 0.9-1.0m. Made ground.
A14/2	Thickness, up to 0.4m. Sandy gravel, clasts up to 6cm, with a matrix of medium to coarse sand (7.5YR5/6 – strong brown). Where lower contact with A14/3 was seen, it was irregular.
A14/3	Thickness, up to 0.1m, where visible. Clay (7.5YR5/8 – strong brown) with some sand and occasional pebbles. Upper surface contact with A14/2 irregular, as noted above.

The irregular contact between beds A14/2 and A14/3 is considered to reflect settling, the clay, when saturated, not being able to support the weight of the gravel. The gravel comprised chiefly flint (with rounded Tertiary flint and sub-rounded to sub-angular flint) with lesser amounts of quartzite and vein quartz.

TRIAL PIT A15

Dimensions	5.8m x 1.85m, aligned E-W
Co-ordinates	SW X = 618467.0 Y = 243769.0
	NE X = 618470.5 Y = 243762.9
Site ground surface height	35.70m OD
Trench base height	34.05m OD
Face recorded	North

Bed No.	Description
	Site ground surface.
A15/1	Thickness 0.7m. Made ground.
A15/2	Thickness variable, up to 1.0m. Gravel in sand matrix (10YR6/6 – brownish yellow). Lower surface highly irregular, arranged into descending rounded forms and upwards-penetrating inverted-V forms.
A15/3	Variable thickness, up to 0.5 m. Medium sand (10YR6/4, 6/6 – light yellowish brown to brownish yellow). Intimately involved in the loading described for A15/2.
A15/4	Thickness, up to 0.05 m. Fine gravel in clayey, sandy matrix (7.5YR4/4 – brown to dark brown). Involved in the loading structures described for A15/2.
A15/5	Thickness variable and difficult to determine due to complex load structuring, possibly 0.15m. Clay, mottled grey (10YR5/2 – greyish brown) and brown (10YR5/6 – yellowish brown).
A15/6	Thickness; not possible to determine; 0.3m exposed in inverted-V loading form. Clayey sand (10YR6/6 – brownish yellow).

Beds A15/2 to A15/6 display classical loading structures, where the saturated sediments below have not been able to support the weight of the gravel, which has sink into the sand and clay and, in reaction, the clay and sand have injected upwards (diapiring). This corresponds closely to the field drawing of Boswell (1914). The gravel comprised chiefly flint (with rounded Tertiary flint and sub-rounded to sub-angular flint) with lesser amounts of quartzite and vein quartz.

TRIAL PIT A16

Dimensions	5.8m x 1.85m, aligned E-W
Co-ordinates	SW X = 618551.3 Y = 243706.8
	NE X = 618548.1 Y = 243711.5
Site ground surface height	35.67m OD
Trench base height	34.23m OD
Face recorded	None

Bed No.	Description
	Site ground surface.
A16/1	Thickness 1.44m+. Made ground.

TRIAL TRENCH A17

Dimensions	11.6m x 1.85m, aligned SW-NE
	6.8m x 1.85, aligned NW-SE
Co-ordinates	SW X = 618533.6 Y = 244011.5
	NE X = 618547.1 Y = 244011.7
Site ground surface height	35.28m OD
Trench base height	33.93m OD
Face recorded	North-west

Bed No.	Description
	Site ground surface.
A17/1	Thickness 0.9m. Made ground.
A17/2	Thickness could not be determined, >0.2m. Coarse gravel, clasts up to 80mm.
A17/3	Thickness, 0.075m. Fine sand (10YR5/6 – yellowish brown), dipping at 08° towards 233°.
A17/4	Thickness, c. 0.8m. Coarse gravel, clasts up to 100mm.
A17/5	Thickness, 0.05m. Fine to medium sand (10YR5/8 – yellowish brown), dipping at 20° towards 240°.
A17/6	Thickness could not be determined, >0.3m. Fine gravel (<2cm, mostly <1cm) in matrix of medium sand (10YR5/8 – yellowish brown).

This trial trench was dug to locate the site of Smith's excavations (1914). The north face showed vertically-bounded infilling within bed 17/4. This infilling could be traced across the base of the trial pit, satisfactorily revealing the straight sides of a trench complex. It should be borne in mind that trial pit A17 was cut only to a depth of 1.3m which would have impinged only on the highest levels of Smith's workings and is unlikely to reflect his working floor.

APPENDIX 2: CONTENTS OF ARCHIVE

In 1 box file:

1	Copy of this report
1	Copy of Luminescence Dating report (Scwenninger 2007)
1	Copy of the Archaeological and Geological Evaluation interim report (Allen and Allen 2005)
1	Copy of the Archaeological Brief
1	Copy of the Written Scheme of Investigation
1	Copy of the Archaeological Impact Assessment report (Allen 2005)
1	Copy of the Archaeological Desk-Based Assessment report (Orr 2004)
1	Copy of the Site Investigation report (Knight Environmental 2005)
1	Copy of the Site Investigation interim report (Knight Environmental 2004)
1	Copy of the Site Investigation borehole logs
1	Copy of Environmental Assessment: Celestion Works ((WSP Environmental 2004)
1	Copy of Environmental Assessment: Bull Motors (ENSR 2001)
1	Copy of Smith (1920) Publication Report
1	Assorted site plans

In 1 folder

1	Index sheet of Trial Pit/Trench (A1-A17) details
17	Trial Pit/Trench recording sheets and section drawings
1	Index sheet of Borehole (AA-AD) details
4	Borehole logs (AA-AD)
	Colour prints and negatives
	Black and white prints and negatives

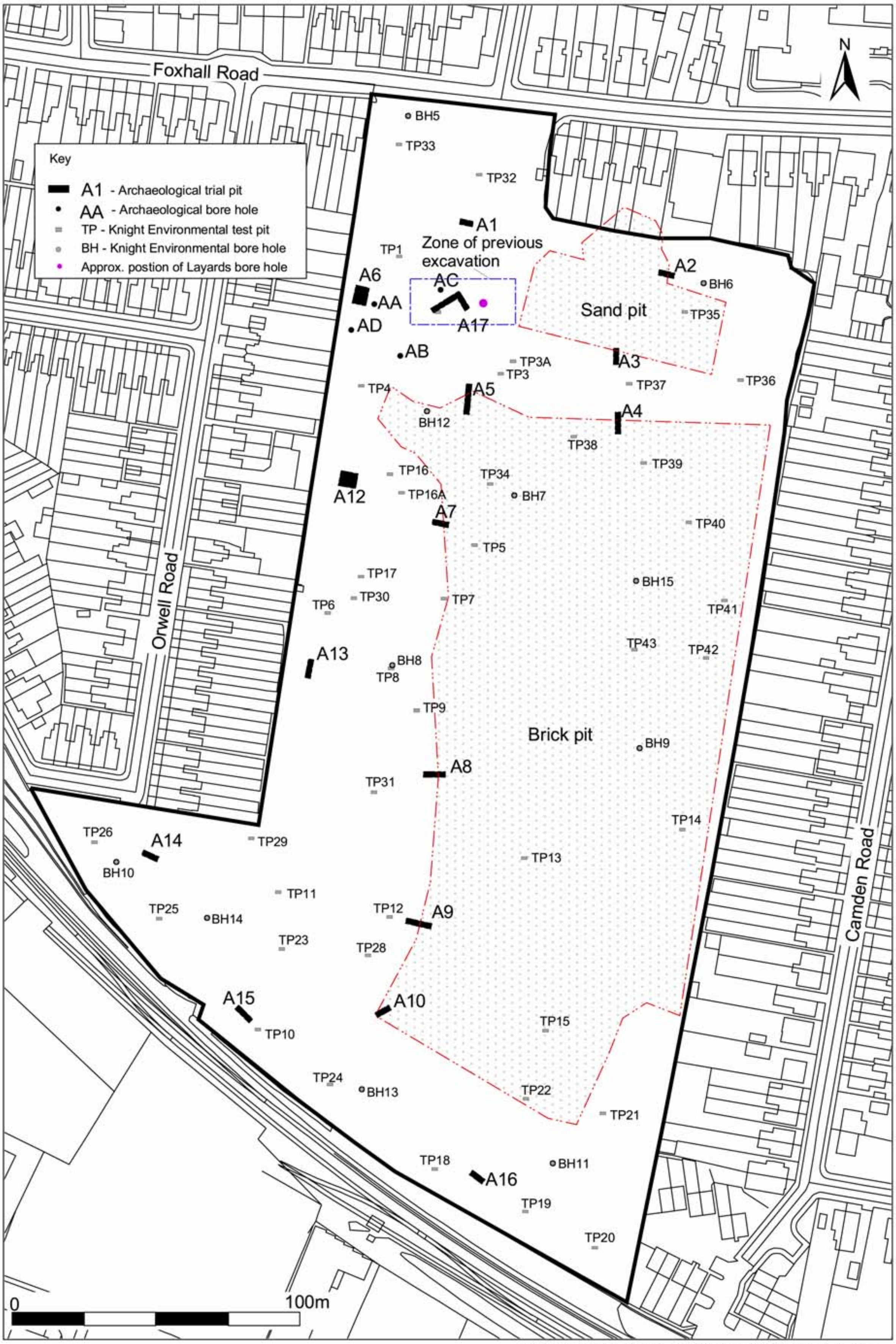


Fig.1. Locations of bore holes and trial pits

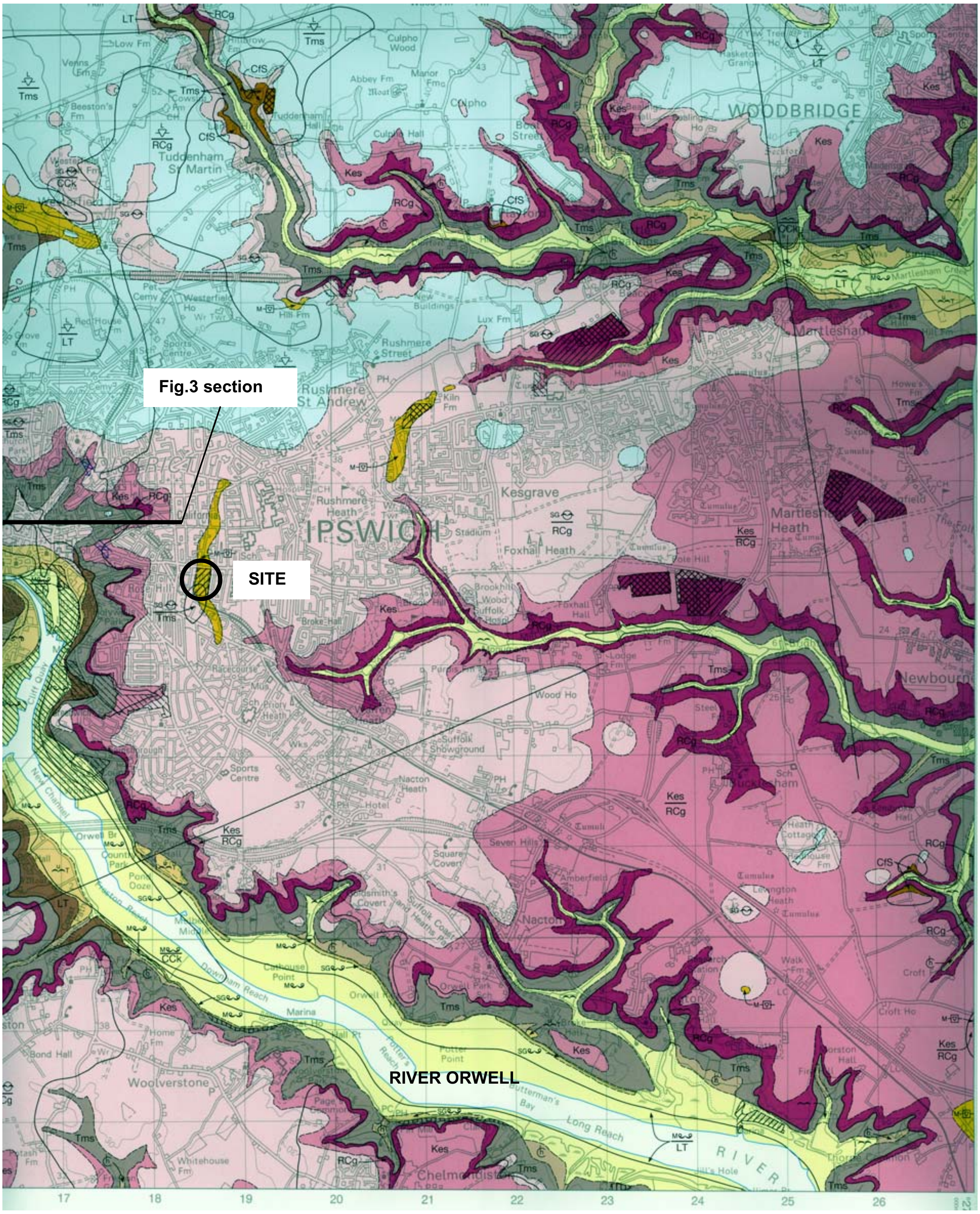
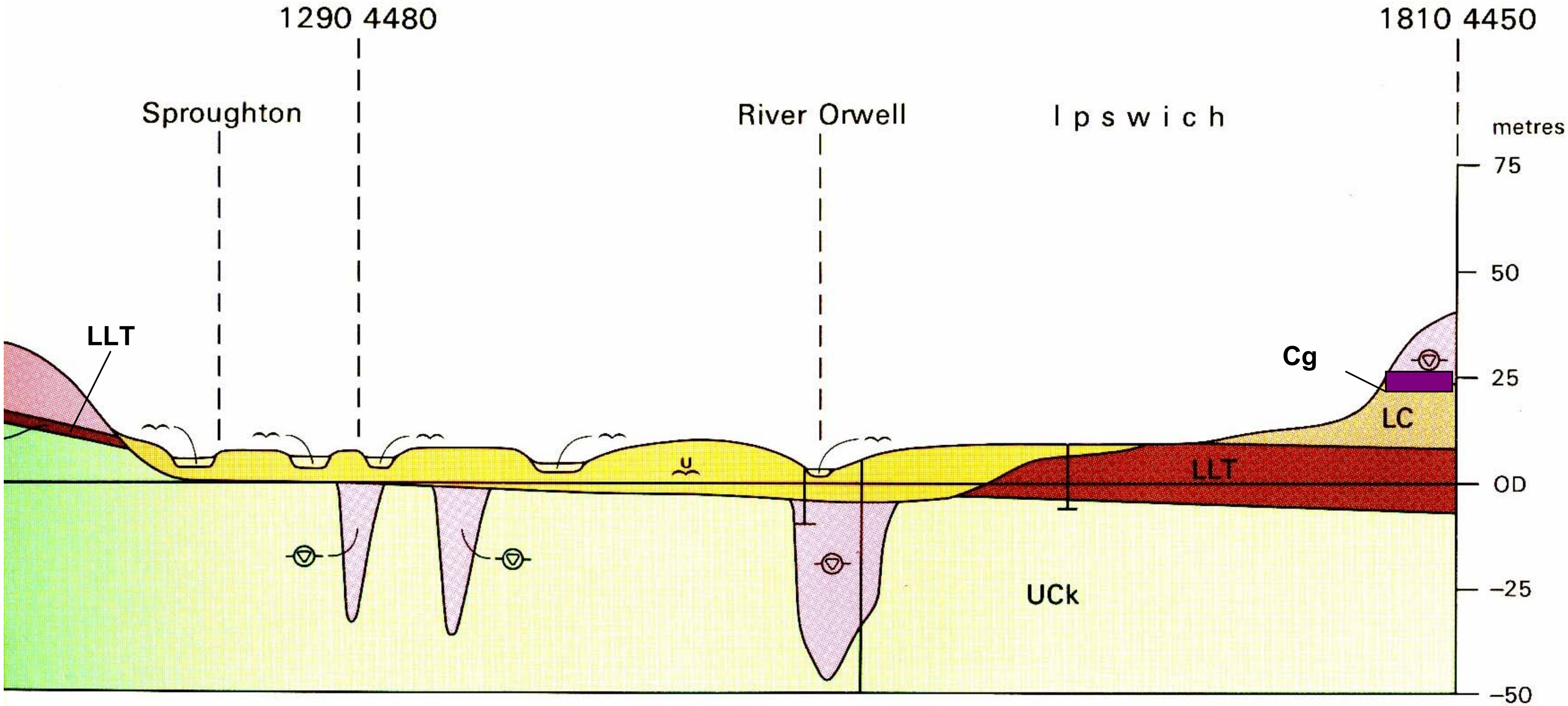


Fig.2. Geology of the eastern Ipswich area, based upon British Geological Survey England and Wales Sheet 207 at 1:50,000 scale (see Key on Fig. 3).



<u>Key to Figs 2 and 3</u>
Yellow = Alluvium; Brown = Brickearth; Light / medium purple = Glacial gravel / Kesgrave Formation gravel; Dark purple (Cg) = Red Crag; Light brown (LC) or grey (on Fig. 2) = London Clay; Dark red-brown (LLT) = Lower London Tertiaries; Light yellow (UCk) = Upper Chalk

Fig. 3. Geological cross-section of the Orwell

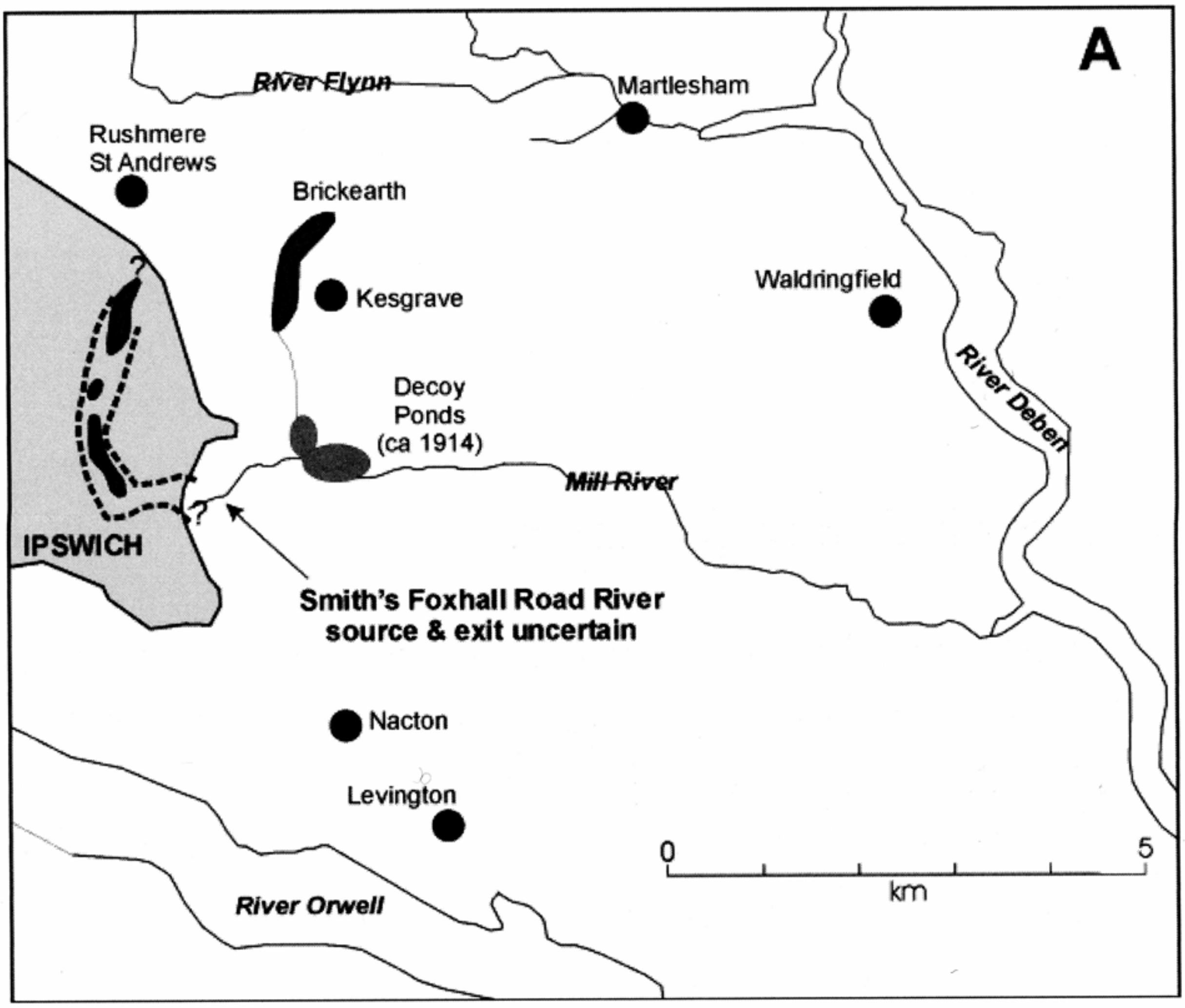


Fig. 4. Alignment and setting of Smith's (1921) proposed river

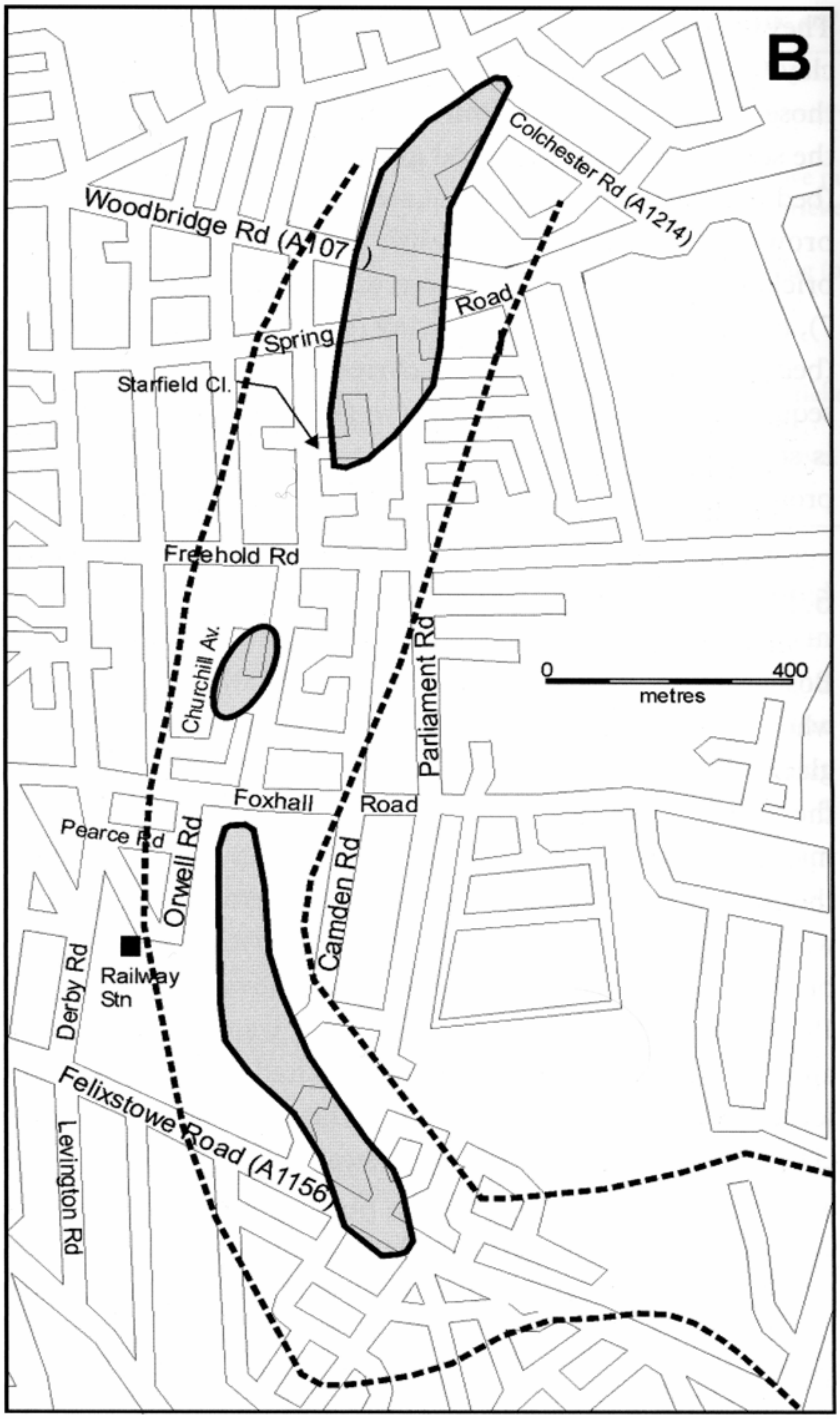


Fig. 5. Detail of the upper valley of the Mill River. The shading shows areas of brickearth.

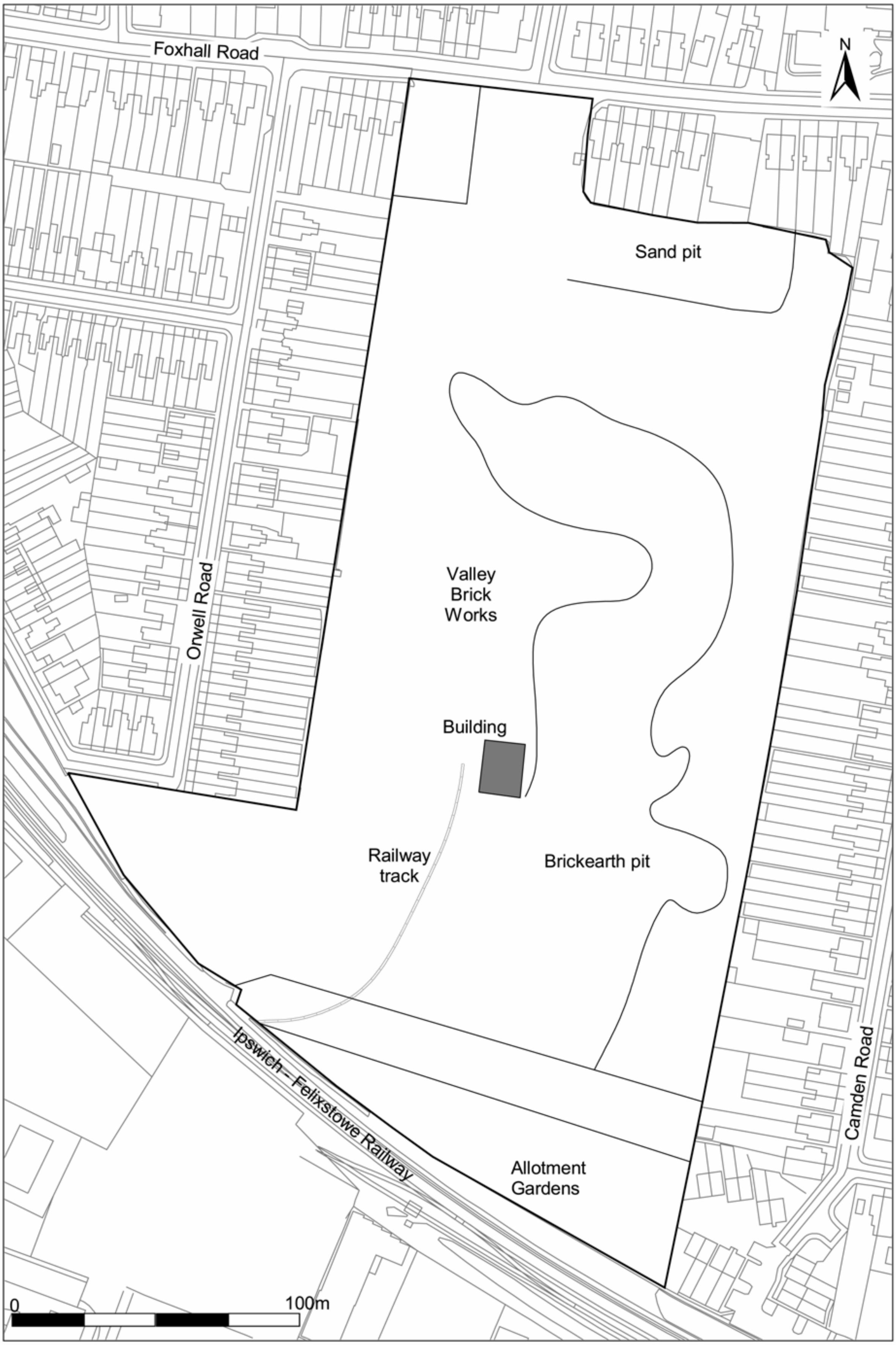


Fig.6. Site of the Valley Brick Works (from Ordnance Survey 2nd Edition map, 1904)

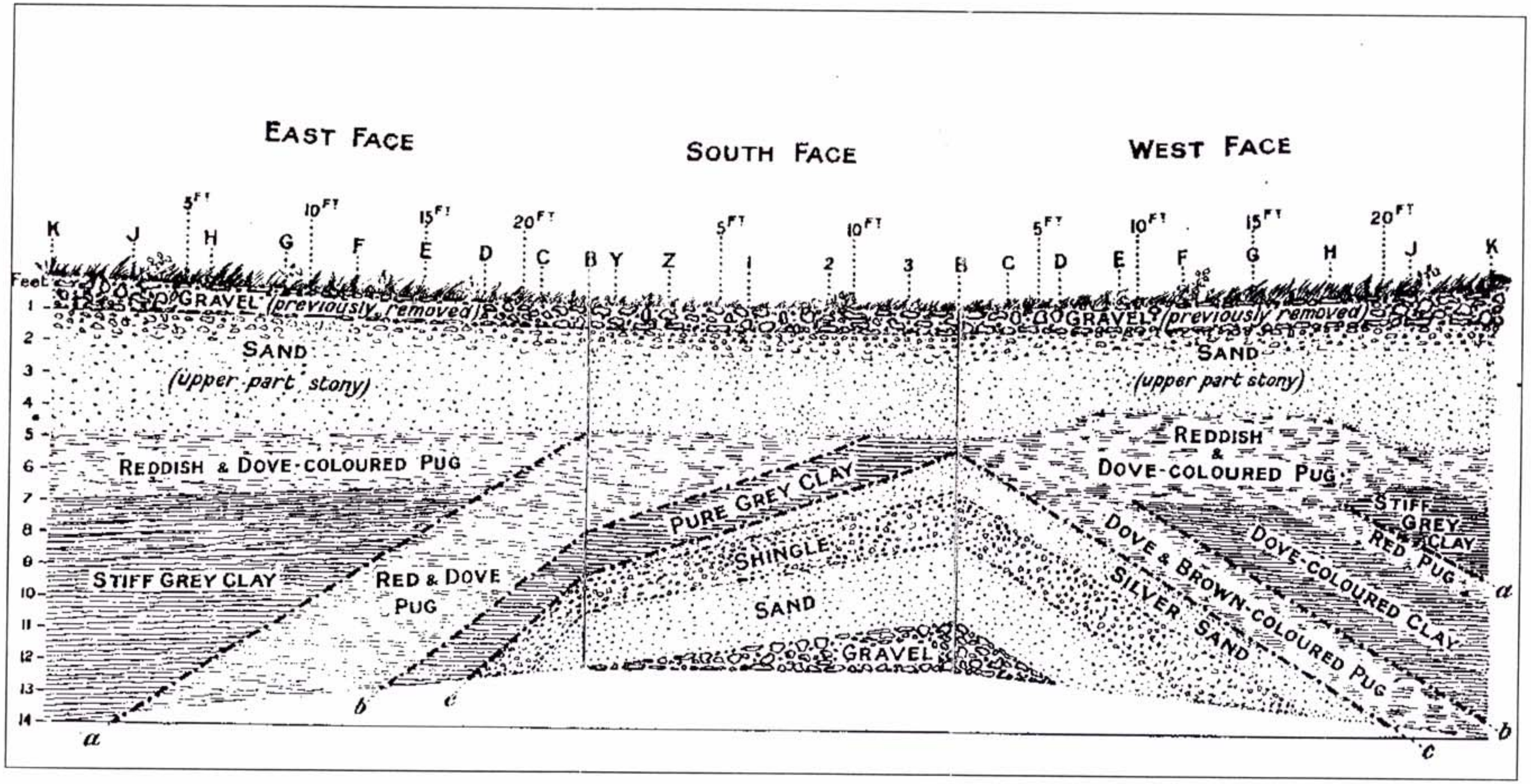


Fig. 7. Smith's section (Smith 1921)

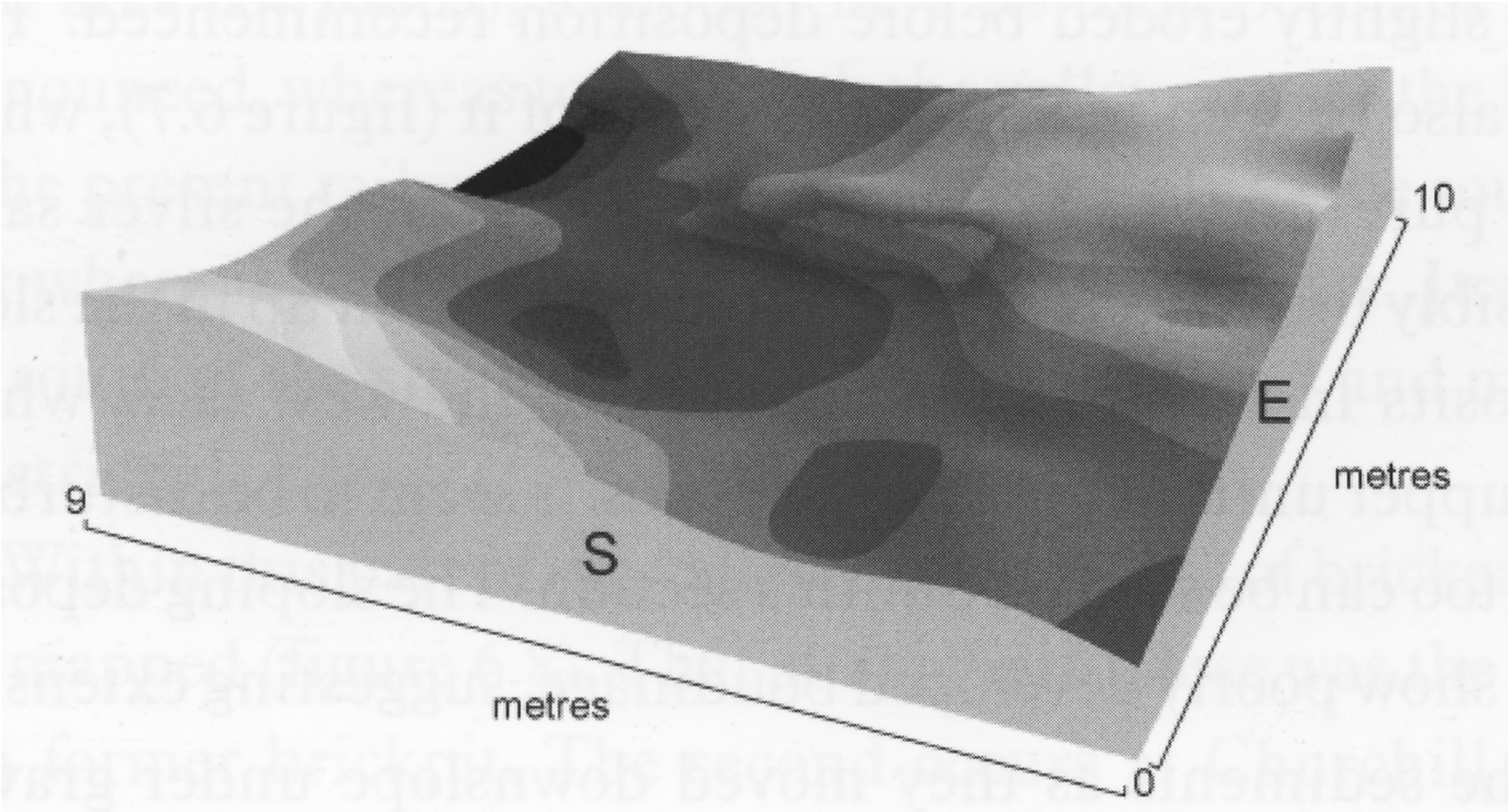


Fig. 8. Reconstruction of the surface topography of Layard's 'floor' (from White and Plunkett 2004)

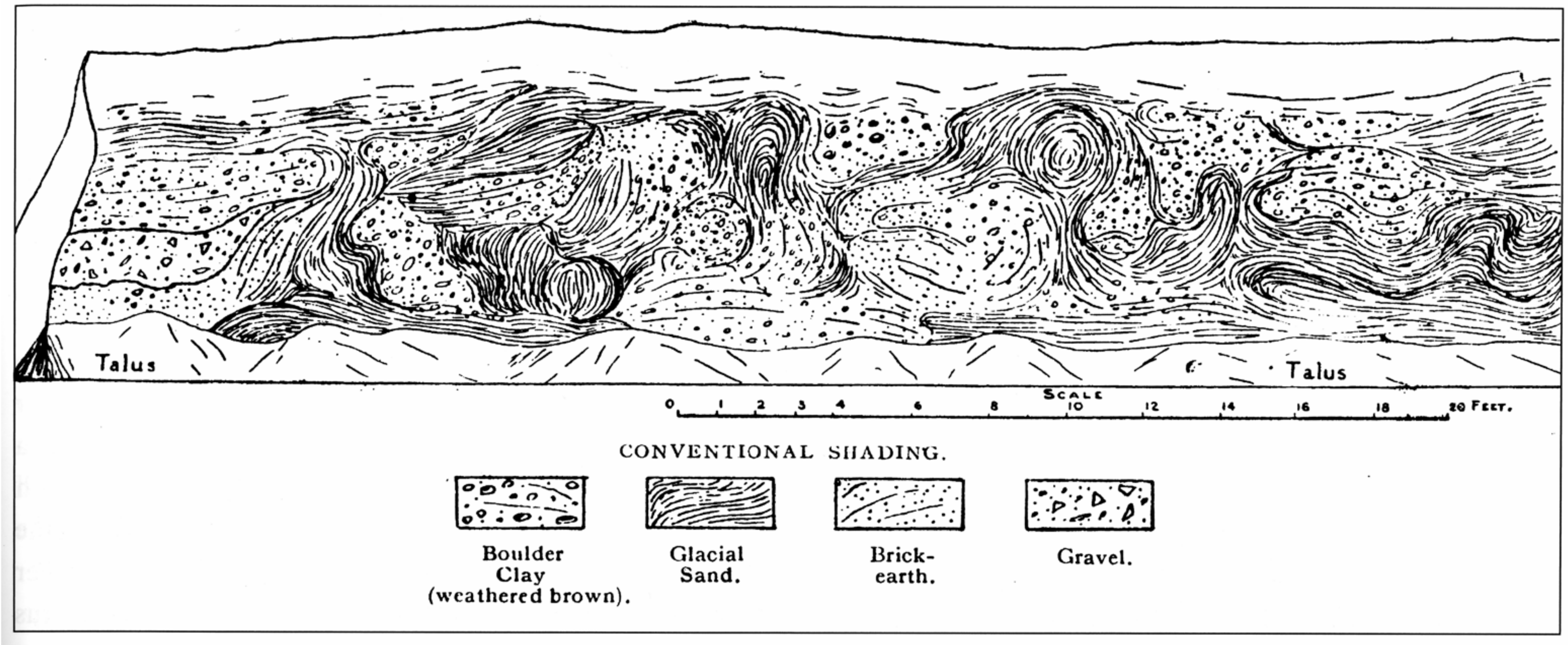
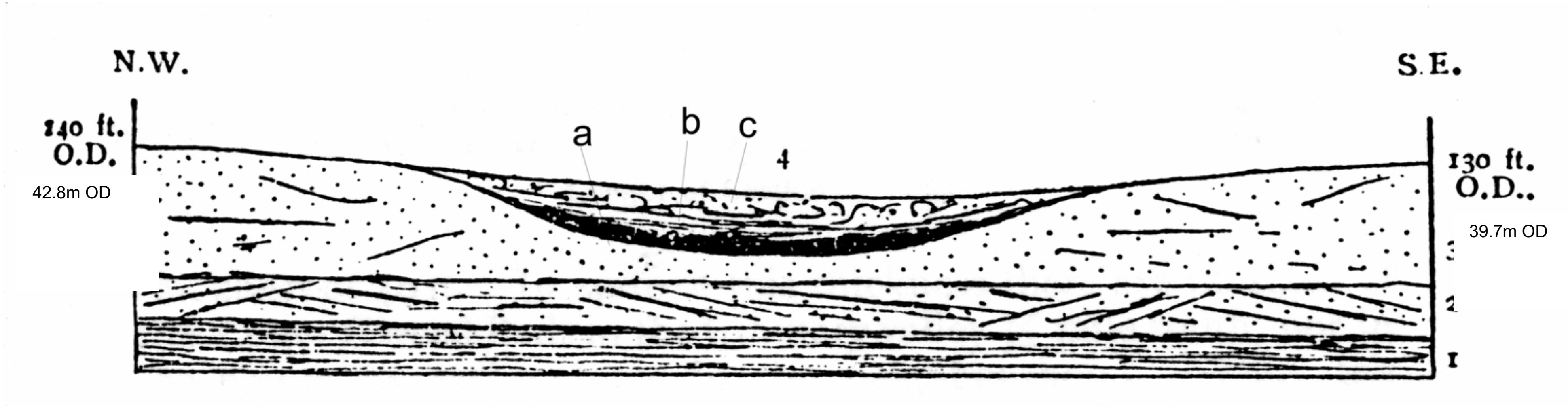


Fig. 9. Deformation of uppermost beds as depicted by Boswell (1914).
(Compare with Plate 5.)



Key

4c	Disturbed sand and gravel
4b	Brickearth
4a	Lowestoft Till
3	Kesgrave sand and gravel/glacial gravel
2	Red Crag
1	Lower London Tertiaries

Fig. 10. Section across the Foxhall Road basin as drawn by Boswell (1914)

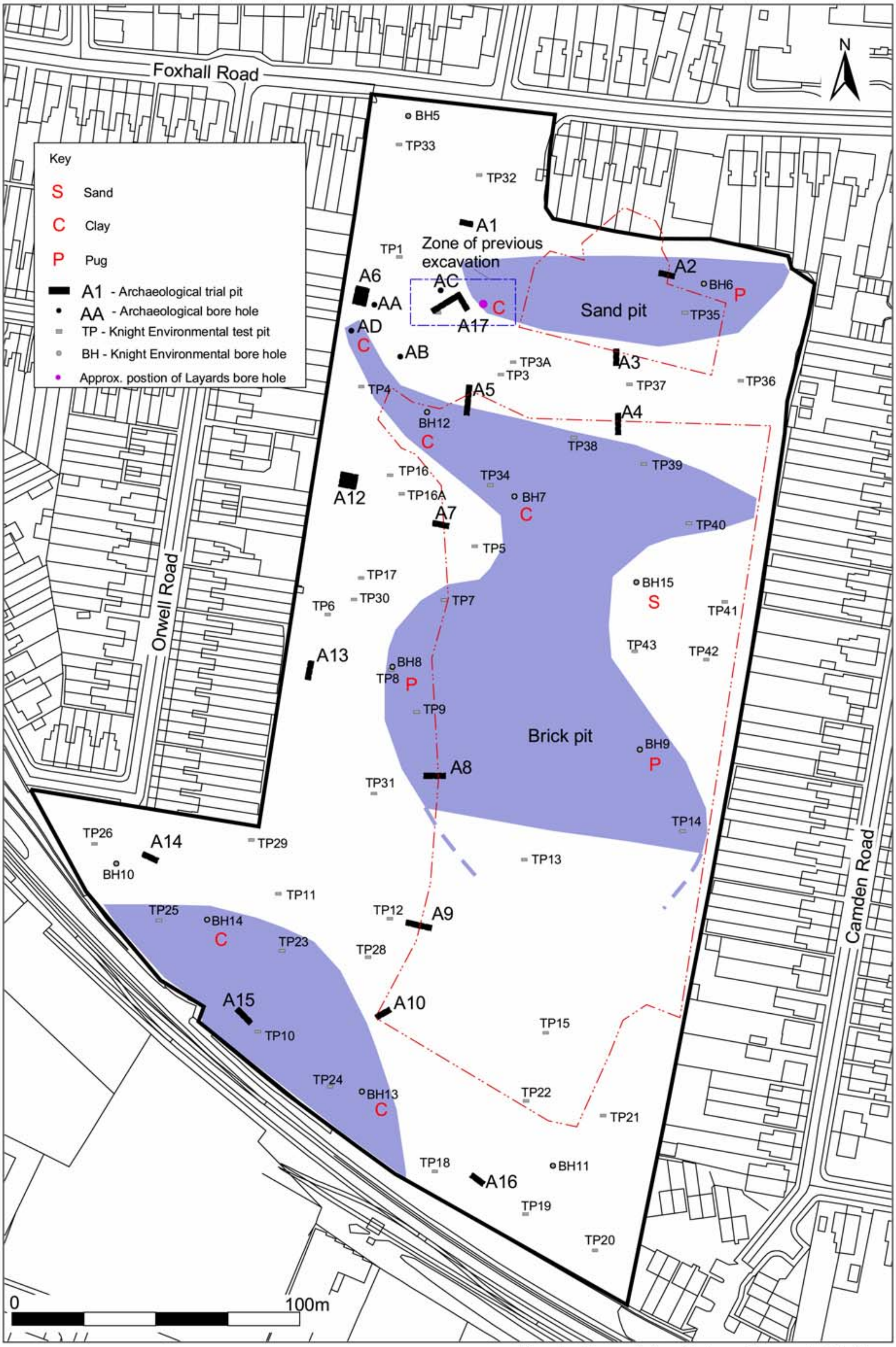


Fig.11. Tentative reconstruction of early stage of the Foxhall Road brickearth-filled lake, late Anglian/early Hoxnian period.

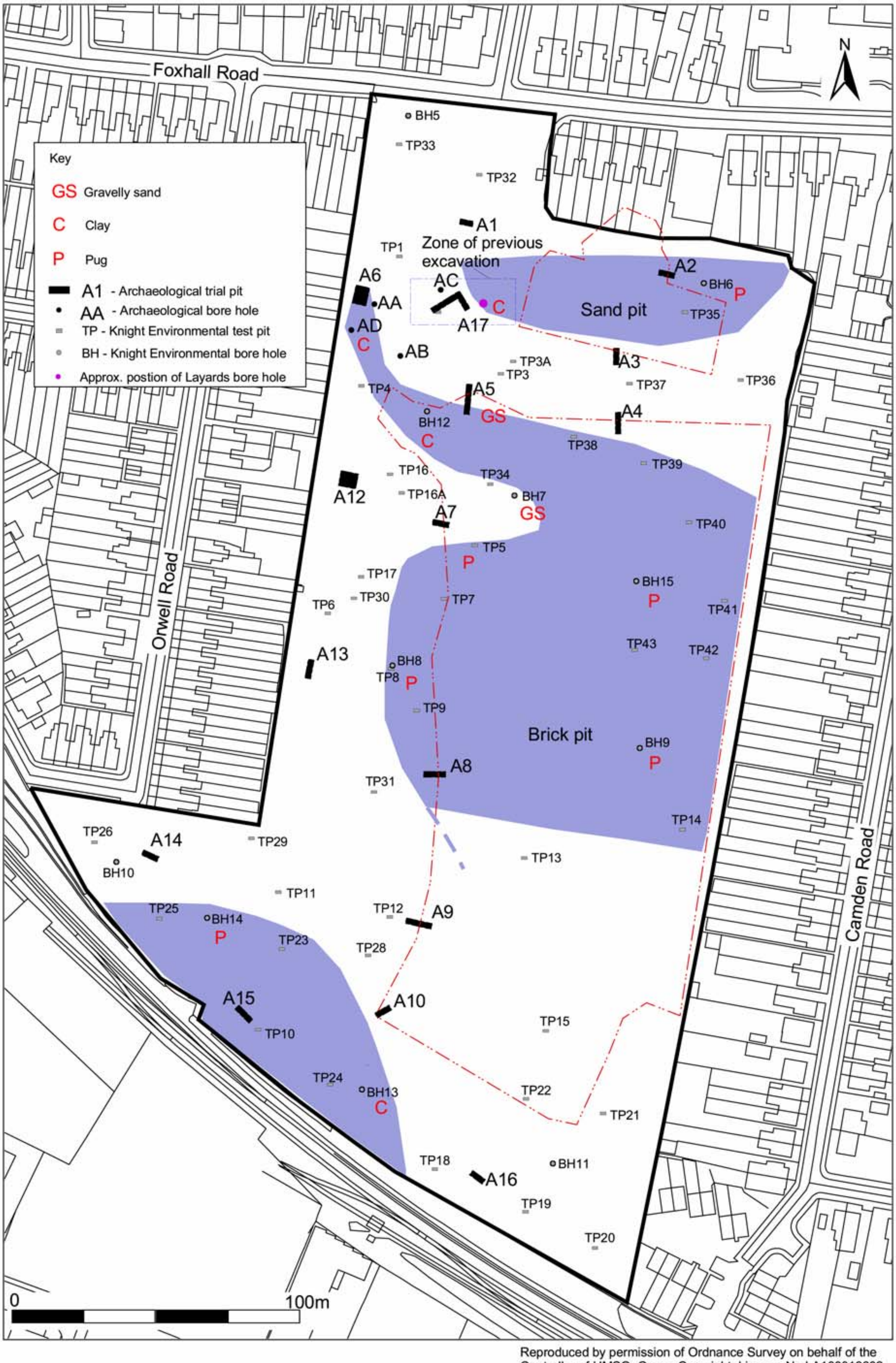


Fig.12. Tentative reconstruction of a later stage of the Foxhall Road brickearth-filled lake, late Anglian/early Hoxnian period.

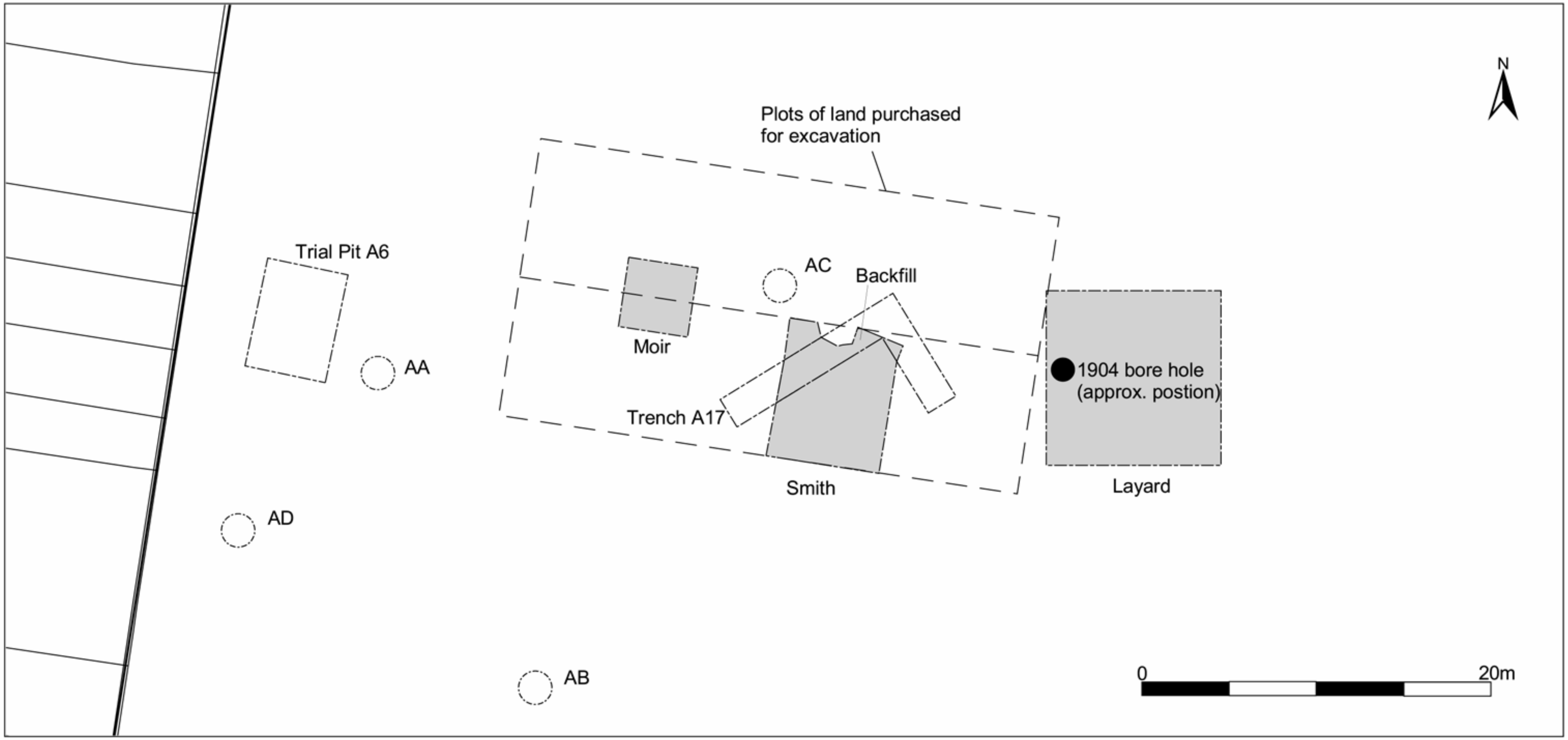


Fig.13. Trial trenches 6 and 17, together with areas of previous excavation

Layard’s Trench and Borehole

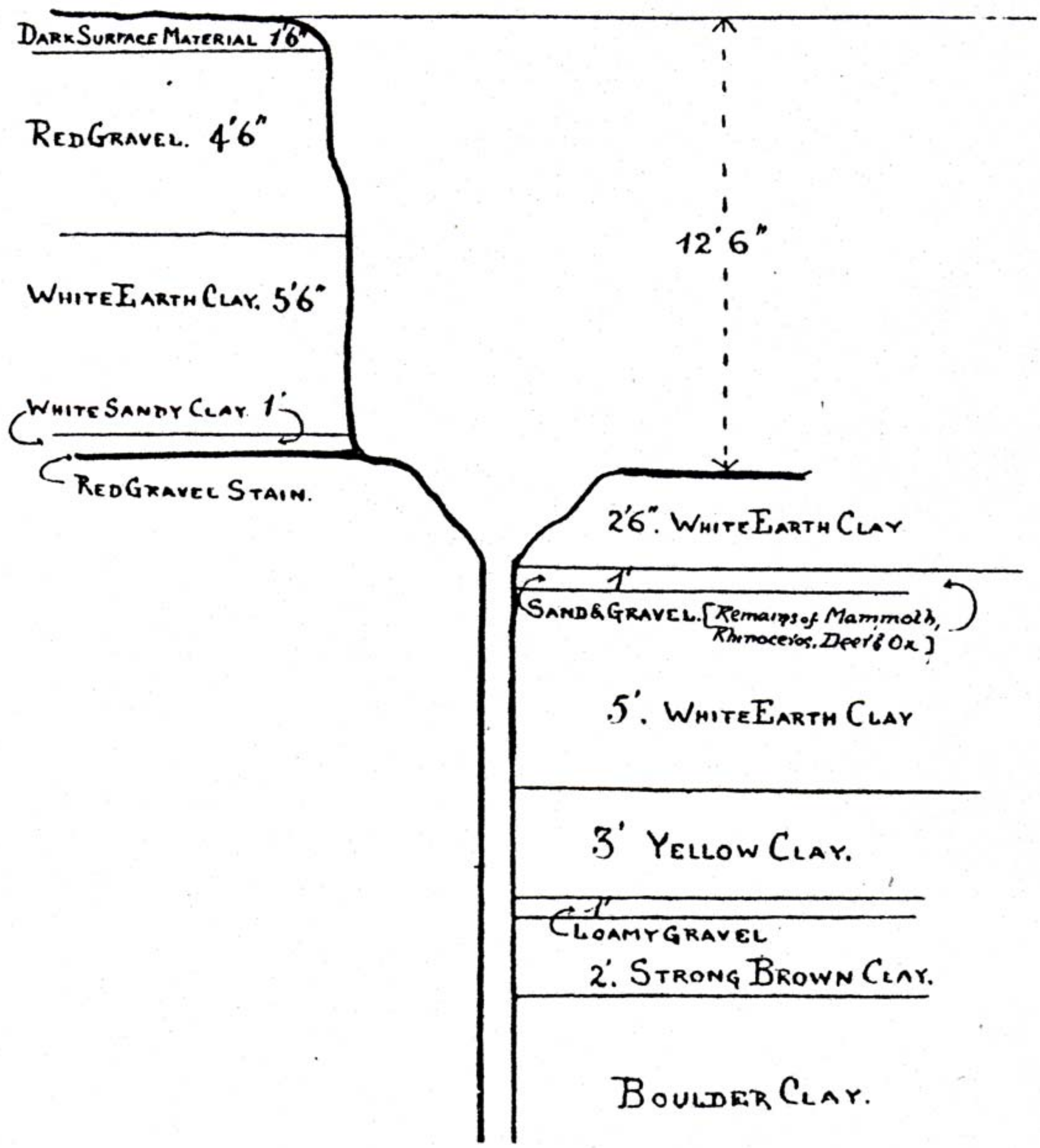


Fig. 14. Dimensioned sketch section of Layard’s trench and borehole

Borehole AA

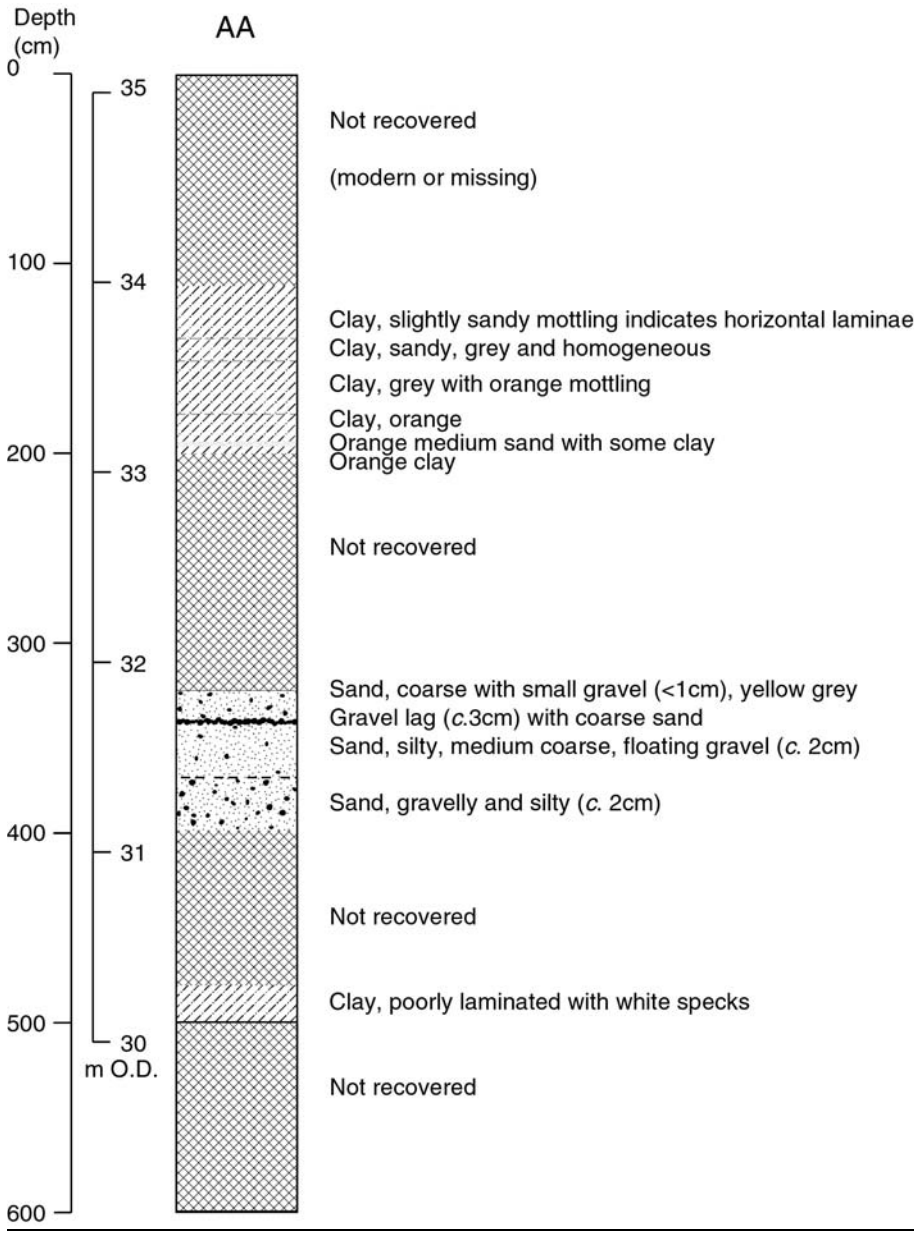


Fig. 15. Log of Borehole AA

Borehole AB

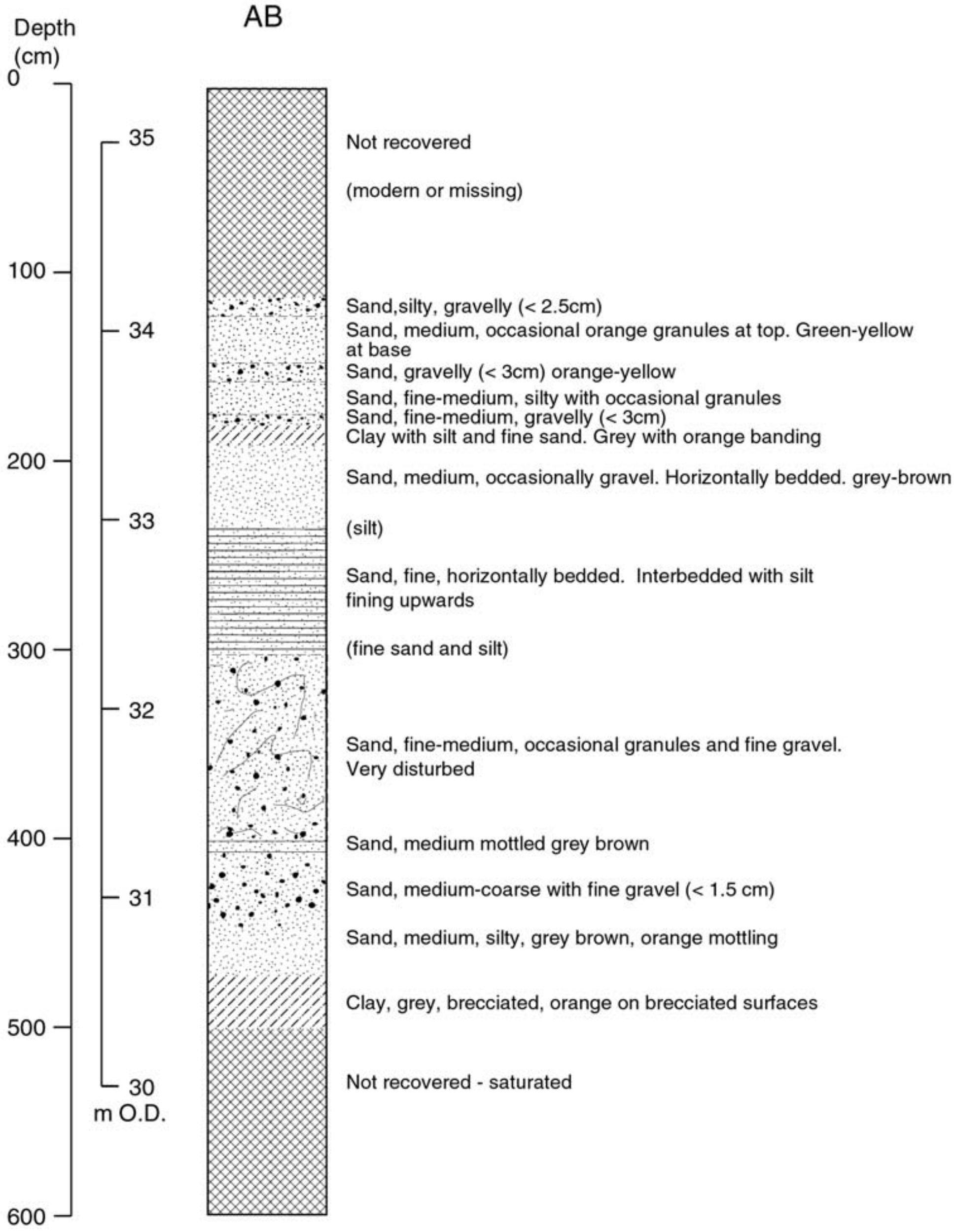


Fig. 16. Log of Borehole AB

Borehole AC

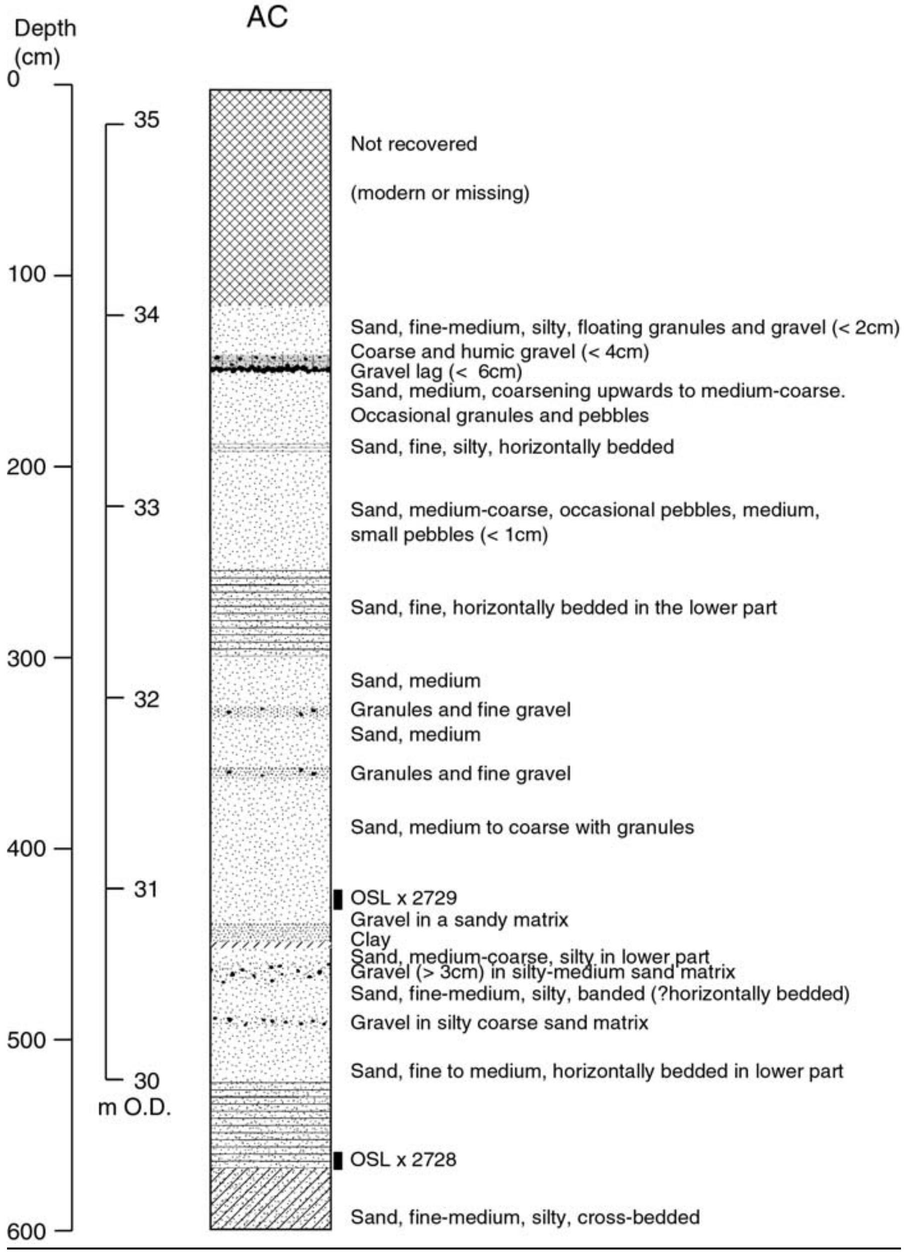


Fig. 17. Log of Borehole AC, including locations of OSL samples 2728 and 2729

Borehole AD

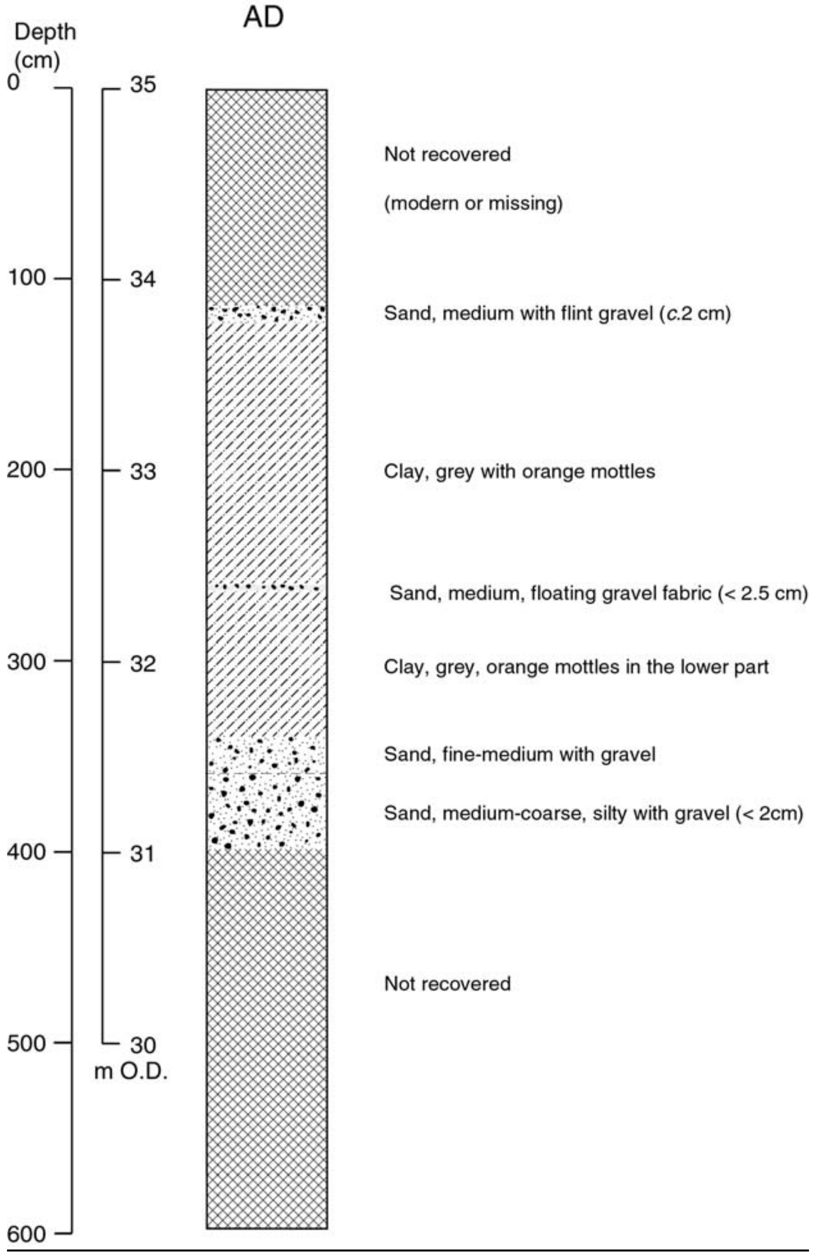


Fig. 18. Log of Borehole AD

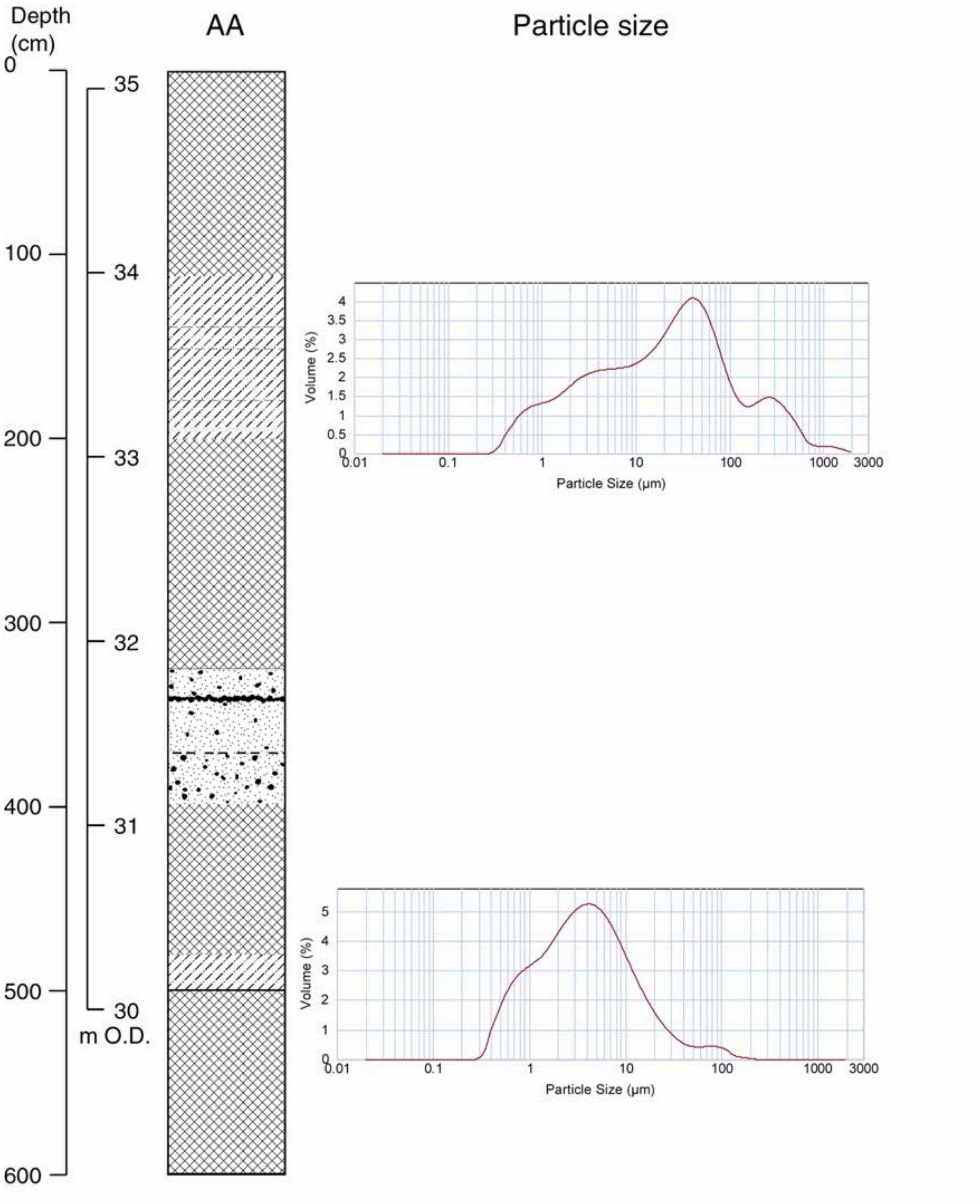


Fig. 19. Borehole AA: particle size data from clay/silt beds

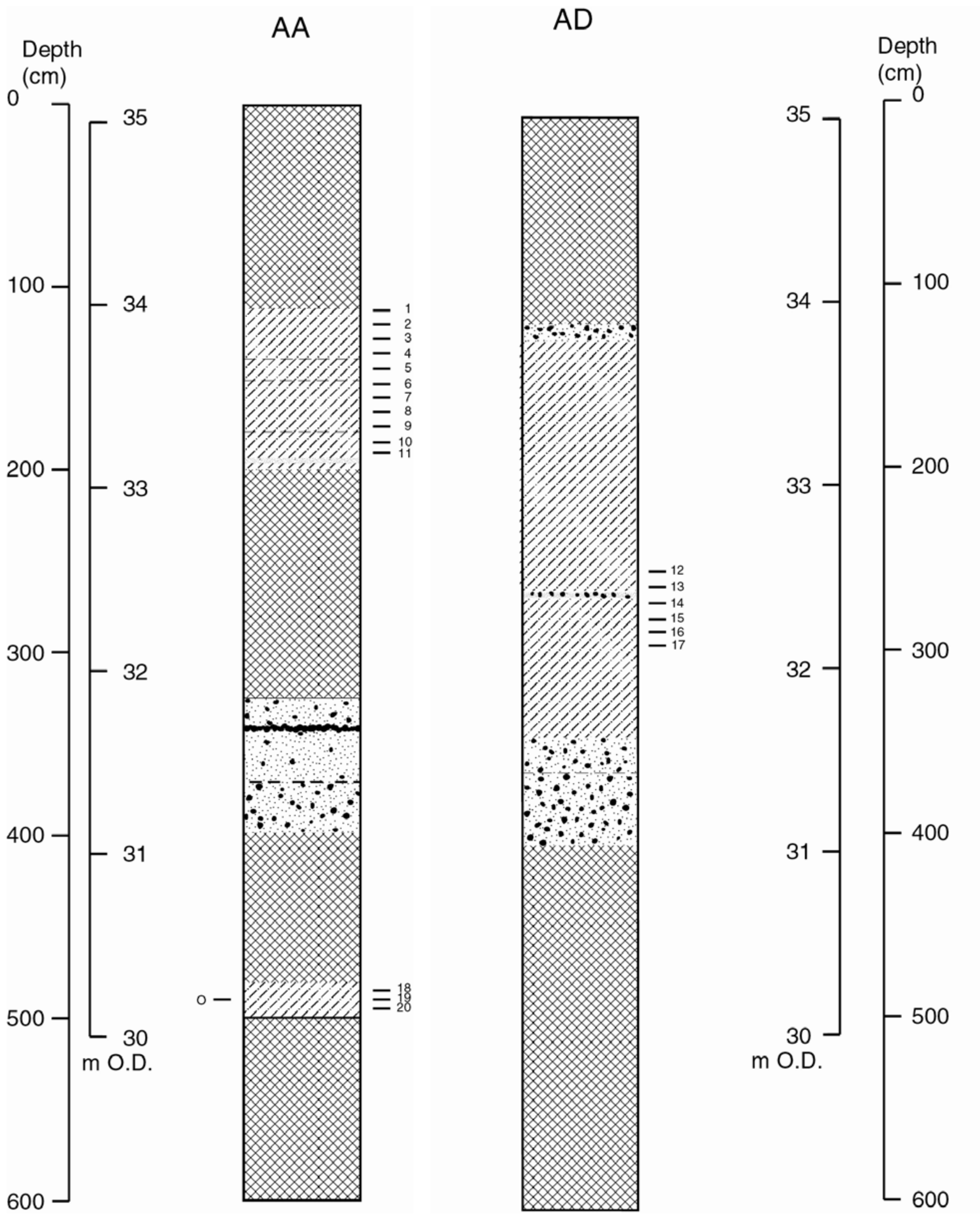


Fig. 20. Boreholes AA and AD: sampling points for geochemical analyses

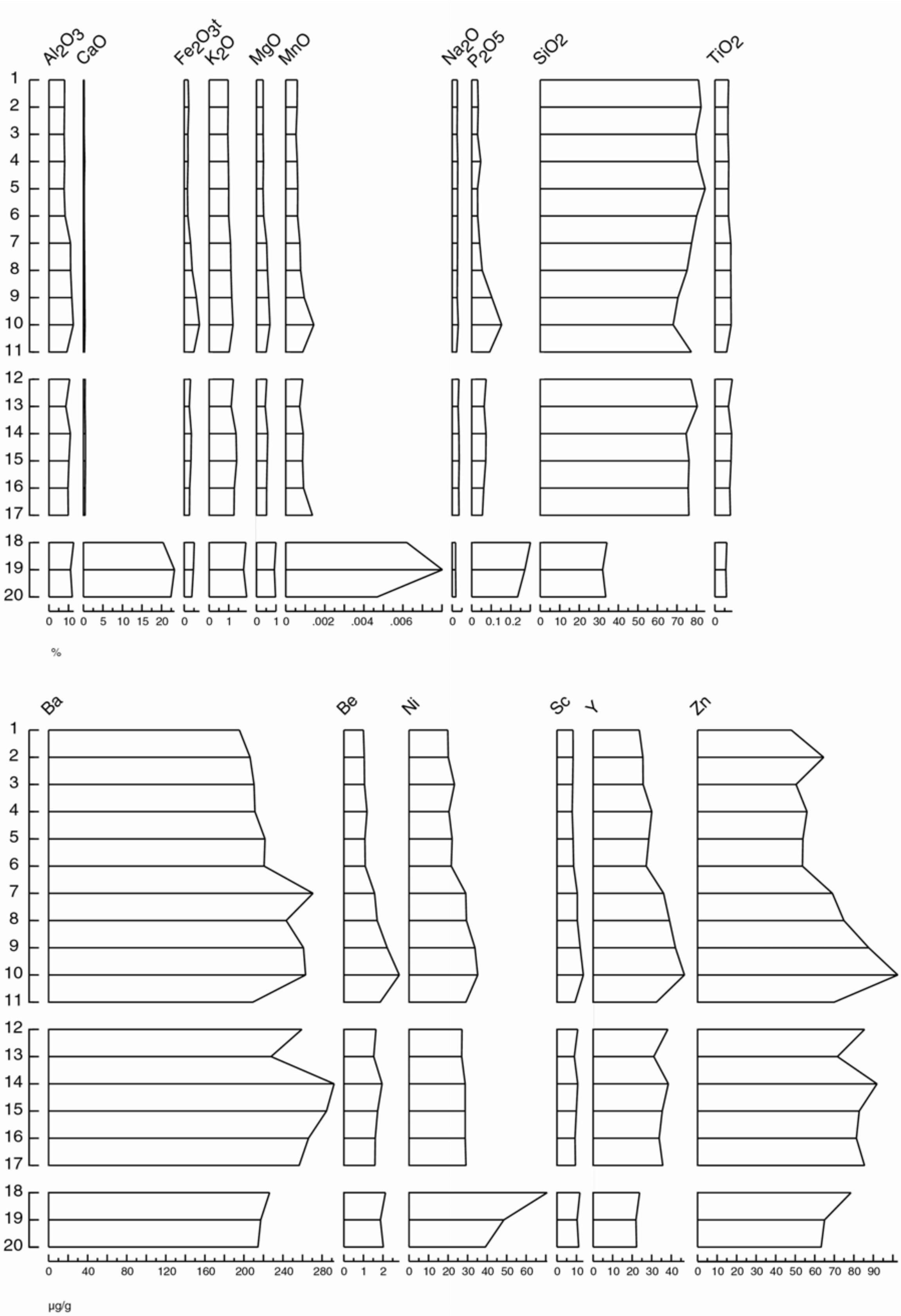


Fig. 21. Major elements: major oxides shown as % (top); other major elements shown as µg/g

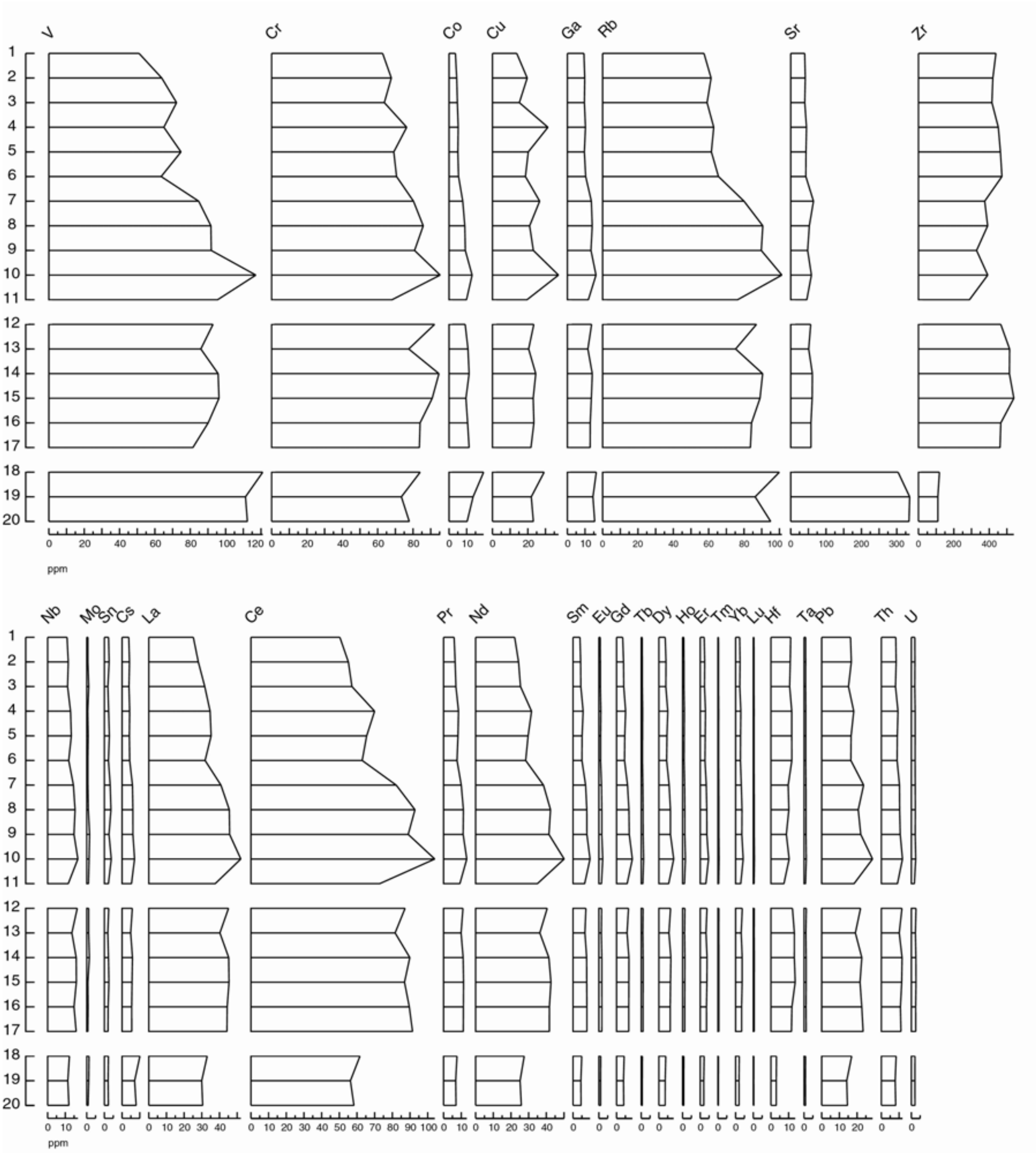


Fig. 22. Trace elements: shown as ppm

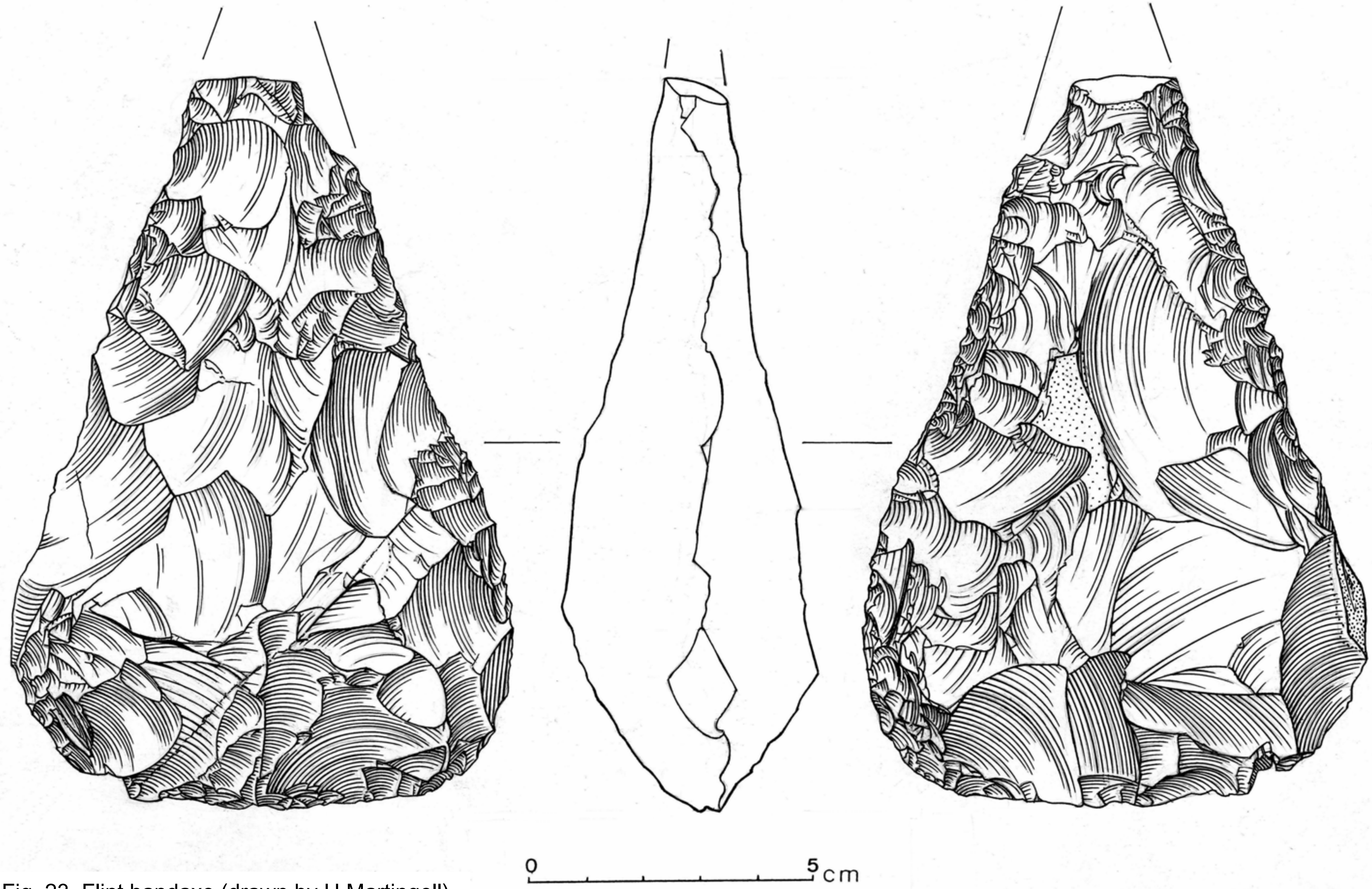


Fig. 23. Flint handaxe (drawn by H.Martingell)

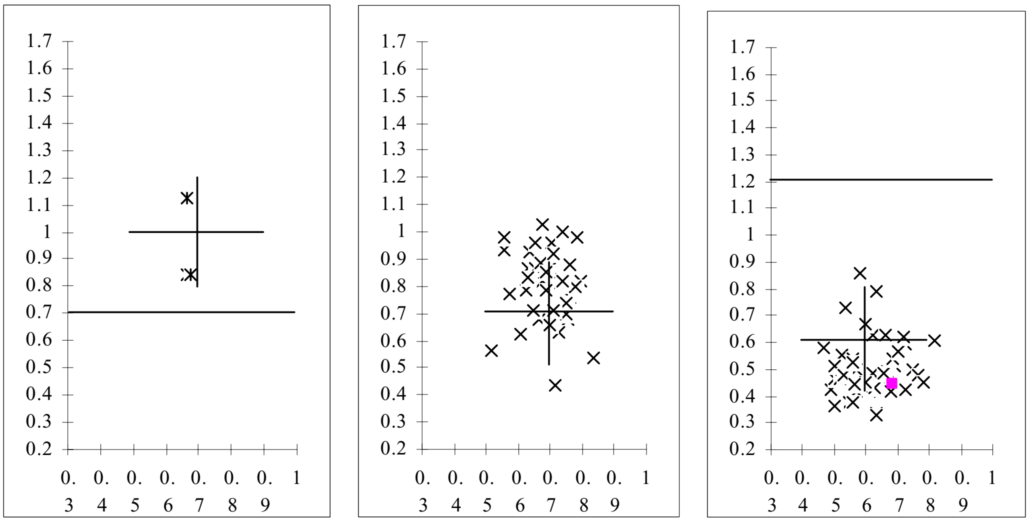


Fig. 24a. Tripartite shape diagrams (after Roe, 1968), showing all handaxes from earlier excavations on the site (crosses) and the find from the 2005 investigation (square)

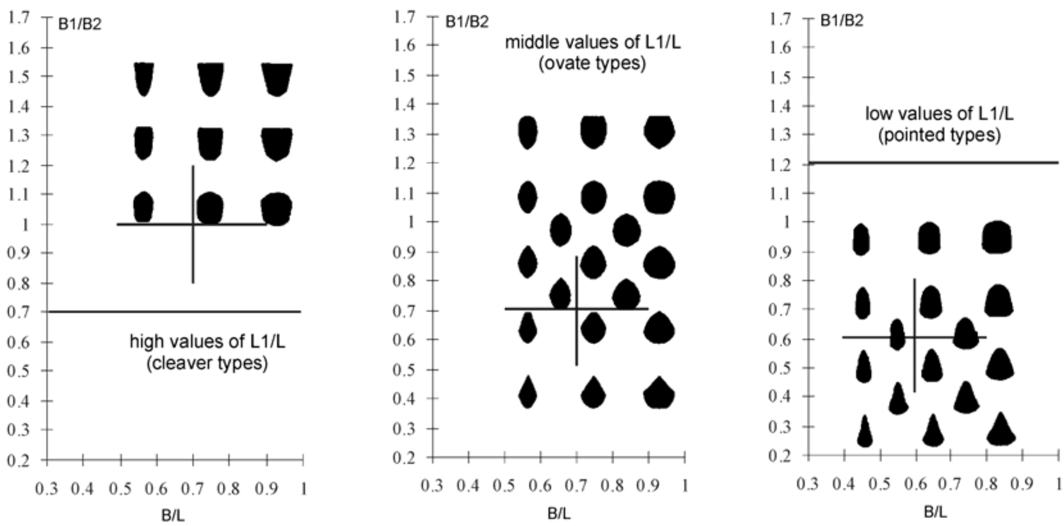


Fig. 24b. Key to interpreting Roe's tripartite diagrams

Plate 1. General view of the site, looking south-west. The trenches excavated by Layard (1903-5), Smith (1914) and Moir (1921) were located mid-way between the blue machine and the red brick building in the background (photo: Dr Peter Allen).

Plate 2. General view of the site, looking north-east towards Foxhall Road. The person in the centre of the picture is standing on the approximate site of Layard's 1904-5 excavation trench (photo: Dr Peter Allen).

Plate 3. Layard's 1904-5 trench, looking west (reproduced by permission of the Suffolk Record Office, Ipswich branch).

Plate 4. Trial Trench A17, looking south-west. Note the building in the background with buttresses and lantern, also visible in Plate 3 (three of the four lanterns have subsequently been removed) (photo: Dr Peter Allen)

Plate 5. Trial Pit A6, west face, showing the upper sand and gravel, deformed by load structures, sealing gravelly clay (pug) and grey clay/brickearth (1m vertical scales). These deposits are comparable to the upper part of the sequences recorded by Layard (1903-5), Smith (1914) and Moir (1921). The uppermost 1m of the section corresponds to Boswell's (1914) deformed bed, see Fig. 9 (photo: Dr Peter Allen).

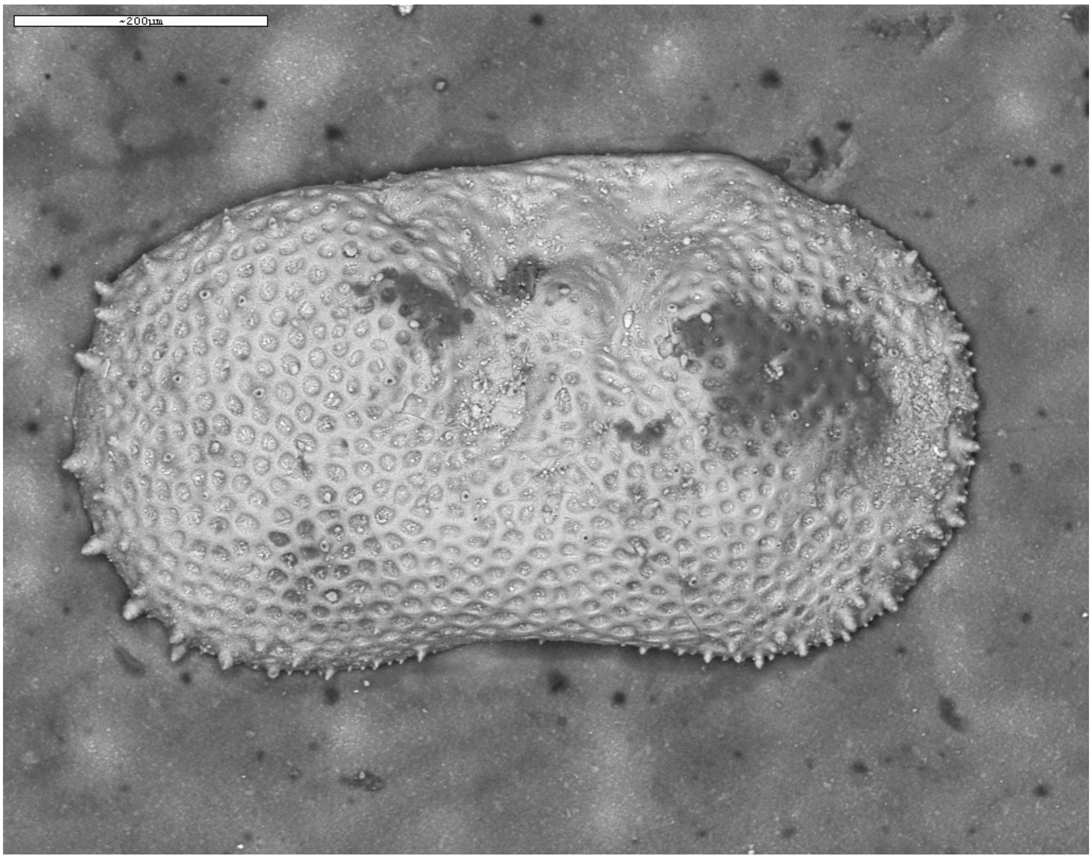


Plate. 6. Ostracods: *Ilyocypris* cf. *decipiens* (scale ~200µm) (photo: Dr A. Haggart).

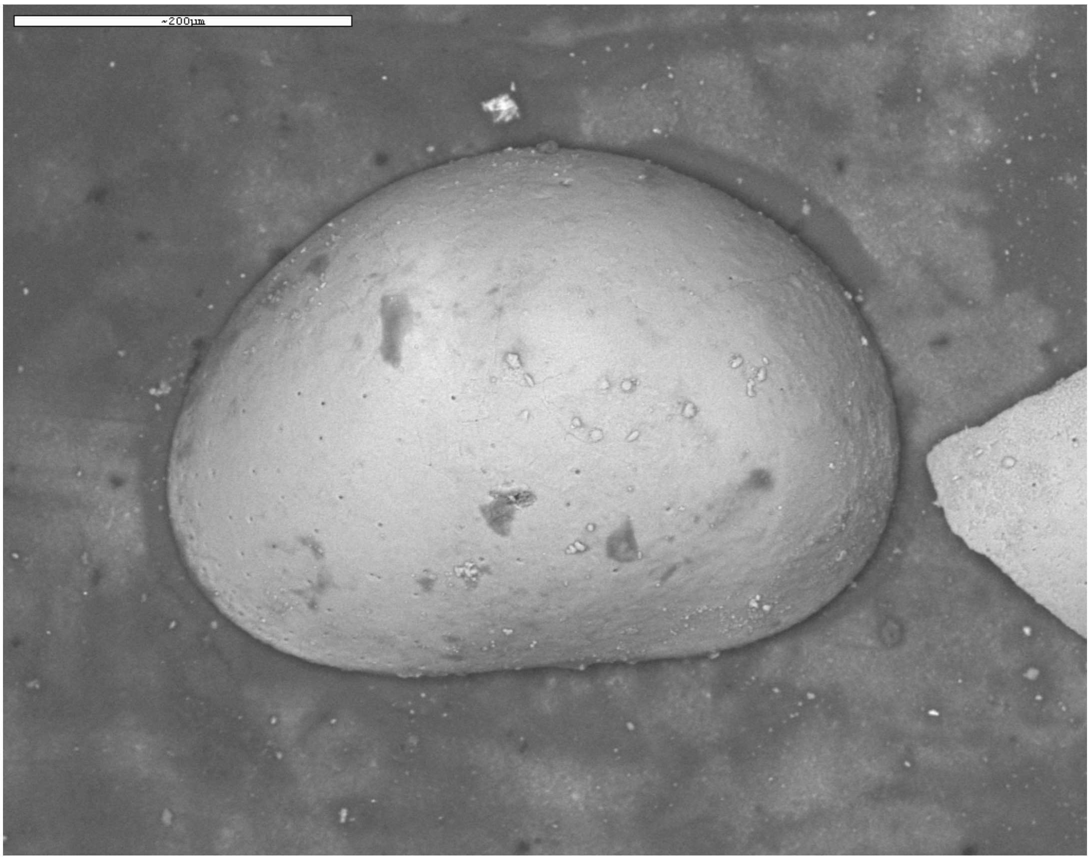


Plate. 7. Ostracods: *Cyclocypris serena* (scale ~200µm) (photo: Dr A. Haggart).

Plate 8. The Palaeolithic flint handaxe recovered in 2005 (photo: Dr M. White).