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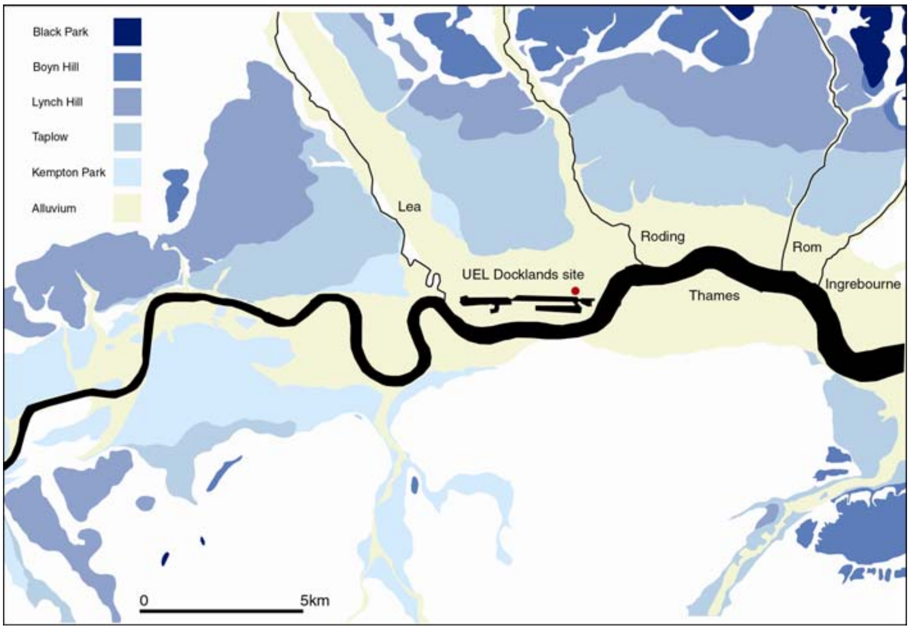
UNIVERSITY OF EAST LONDON DOCKLANDS CAMPUS
STUDENT RESIDENTIAL ACCOMODATION
ROYAL ALBERT DOCK
LONDON E16

GEOARCHAEOLOGICAL BOREHOLE SAMPLING
EVALUATION



Essex County Council

Field Archaeology Unit

January 2008

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GEOARCHAEOLOGICAL BOREHOLE SAMPLING
EVALUATION (REVISION 1)

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STUDENT RESIDENTIAL ACCOMMODATION
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LONDON E16

GEOARCHAEOLOGICAL BOREHOLE SAMPLING EVALUATION (REVISION 1)

Client: Gardiner and Theobald LLP for the University of East London
NGR: 543750 180700
Planning Application: London Borough of Newham (app. no. not known)
Site Code: DKC05
OASIS No: 8608
ECC FAU Project No: 1578
Dates of Fieldwork: 15-17 June 2005

SUMMARY

A geoarchaeological evaluation was carried out on core samples recovered from boreholes drilled through sediments of the river Thames at the Royal Albert Dock before construction of student residential accommodation at the University of East London's Docklands Campus. The geoarchaeological work was undertaken as a condition placed on planning consent by the London Borough of Newham following advice by English Heritage's Greater London Archaeological Advisory Service (GLAAS). The evaluation comprises assessment of the sediments and the palaeoenvironmental material within them, accompanied by radiocarbon dating of key points in the sequence, enabling the results to be related to previous studies of the palaeoenvironment and sea level change in the Lower Thames.

In the site area braided river gravels (Shepperton Gravels) were laid down in tundra-like environments at the end of the last Ice Age between about 20,000 and 11,600 years ago. During the early Holocene there may have been a hiatus in deposition and soil formation on

the terrace surface. During the mid Holocene sea level rose and marine-estuarine deposits began to be laid down about 6800 years ago. A regression of the sea from the site occurred between 6290 and 6170 years ago, but this was probably caused by a slowing of the rate of sea-level rise allowing peat growth to outstrip marine mineral sedimentation. A true fall in sea level occurred during the Neolithic and may be represented by the mixed deposit in boreholes 106 and 108. Sea level rose once more and the peat was again covered by marine-estuarine sediments between 3730 and 3550 years ago during the middle Bronze Age. As a result of this rise in sea-level trackways were constructed across the Thames floodplain in the Bronze Age, of which an example has been recorded nearby at Beckton. There is good archaeological evidence for a fall in sea level during the early Roman period followed by a rise, reflected in the sequence of waterfront structures in the Roman port area around London Bridge and its Saxon successor further upstream at the Strand. This helps explain the formation of the thin upper peat layer and renewed marine sedimentation after 2190-2000 years ago.

The pollen evidence shows an elm decline at about 6290-6170 cal B.P during the early Neolithic, in accord with other data from south-east England. The later Tilia *(lime) decline is dated to 3730-3550 cal B.P in the Middle to Late Bronze Age. At the University of East London site it seems to be coincident with the first appearance of* Cerealia *(cereal-type) pollen and* Pteridium *(bracken) spores, suggestive of forest clearance and arable farming. Total tree pollen frequencies decline after the elm decline and microscopic charcoal counts increase especially from pre-Roman Iron Age times onwards, indicating the environment was becoming more open. Evidence for arable cultivation continues to be present through Roman and Saxon levels. Finally, reedswamp environments became established at or near the site.*

The evaluation results add to the understanding of changes in sea level and the vegetational sequence of the Lower Thames from the late Neolithic to the Roman and Saxon periods, with radiocarbon dating of key points in the sequence. The results could be enhanced by further analysis of the pollen but, following consultation with English Heritage, it was decided that the results from this relatively limited group of samples did not justify publication in an academic journal. Nevertheless, the evaluation has provided data that can be used in any future synthetic study of the geoenvironment of the Lower Thames beyond the scope of this project.

1. INTRODUCTION

This report presents the results of a geoarchaeological evaluation of core samples recovered from boreholes drilled through a deep sequence of sediments of the river Thames before construction of student residential accommodation at the University of East London's Docklands Campus. The development site is situated on the north side of the Royal Albert Dock at its east end, immediately to the south of University Way and Cyprus Station on the Docklands Light Railway (NGR 543750 180680).

The evaluation was carried out by the Essex CC Field Archaeology Unit (ECC FAU) and its consultant, Dr B. A. Haggart, on behalf of Gardiner and Theobald LLP, as advised by the Waterman Group, acting for the University of East London. The evaluation was required as a condition on planning consent placed by the London Borough of Newham, following advice by English Heritage's Greater London Archaeological Advisory Service (EH GLAAS) in accordance with Planning Policy Guidance note 16 on Archaeology and Planning (DoE 1990). It follows the Brief and Specification prepared by EH GLAAS (2005) and the Written Scheme of Investigation prepared in response to it by ECC FAU (2005).

Three boreholes were drilled to recover core samples in June 2005 after an archaeological impact assessment prepared by the Museum of London Archaeology Service (2004) had highlighted the potential for Thames sediments, including peat deposits, to survive at depth. Soon after the completion of fieldwork an interim report (Haggart and Allen 2005) gave a preliminary assessment of the core samples and the paleoenvironmental material within them, and recommended a programme for further evaluation and analysis of the samples.

Although the buried peat deposits would be disturbed by deep piling for the development, EH GLAAS decided that the core samples already taken would be sufficient to reconstruct the site's geoarchaeological sequence, and that no further on-site recording or sampling was necessary. EH GLAAS gave permission for construction works to proceed, on condition that the programme of evaluation and analysis of the core samples, as recommended in the interim report, would be carried out. The present report completes the evaluation process.

Copies of this report will be supplied to Gardiner and Theobald LLP, management consultants to the University of East London, including a copy to be forwarded to the London Borough of Newham, and to Waterman Group, environmental consultants. Copies will also be supplied to English Heritage's Greater London Archaeological Advisory Service, English Heritage's scientific advisor for the London region, and the Stratford Local History Library. A digital copy of this report will be uploaded onto the Online Access to Index of Archaeological Investigations (OASIS) (http://ads.ahds.ac.uk/project/oasis). The project archive will be deposited at the Museum of London's Archaeological Archives Resource Centre (LAARC).

2. RESEARCH AIMS

The research frameworks for archaeology in London (Museum of London 2002, 18-23 and framework objectives P1-P3) and the Greater Thames Estuary (Williams and Brown 1999, 11 and 27-8) set out the main research priorities for the study of the palaeoenvironment and prehistory of the region. Both research frameworks emphasize the importance of multi-disciplinary environmental studies for understanding changes in sea level, climate, geomorphology, vegetation and fauna for the Lower Thames, and establishing the sequence and chronology of these changes, as a pre-requisite for understanding the impact of early humans. The main aim of this study is set out in the Greater Thames Research Framework (Williams and Brown 1999, 28), as follows:

- To increase understanding of the physical evolution of the Thames estuary and associated climatic and environmental change, and their relationship with human activity, during the Holocene.

The research frameworks emphasize the importance of building well-dated stratigraphical and palaeoenvironmental sequences at a local level as a basis for developing a synthetic study of the palaeoenvironment and prehistory of the region.

The research aims for the project were:

1. To reconstruct and understand the nature of the Thames flood-plain sequence at this point and the processes involved in its formation.
2. To establish absolute dates for the peat deposits, to provide a chronological framework for the analysis of associated palaeoenvironmental material for comparison with other sites locally and in the Lower Thames generally.
3. To reconstruct and understand changes in sea level and climate in the Holocene, especially in comparison with the well-preserved alluvial sequence downstream at Tilbury and the evidence there for major marine regression and the formation of peat deposits in the Neolithic (Tilbury Stage III; Devoy 1979).
4. To reconstruct and understand changes in vegetation, adding to the model of the Holocene vegetational succession for the region (Rackham and Sidell 2000).
5. To identify any potential human impact on the environment (e.g. breaks in the pollen sequence consistent with woodland clearance).
6. To discuss all of the above in comparison with relevant sites both in the immediate area and in the Lower Thames as a whole.

3. GEOLOGICAL BACKGROUND

The river Thames was diverted into its present valley by ice advancing from the north during the Anglian period some 500,000 years ago (Bridgland 1994). Since that time an extensive series of gravel terraces have been laid down, the flat surfaces of which decrease in altitude, rather like a staircase, towards the present-day river (Fig.1) probably reflecting periods of downcutting superimposed on regional uplift (Maddy 1997).

Table 1. Post-Anglian terrace sequence in the Lower Thames, Mid-Thames BGS equivalence and oxygen isotope stages. Stages 7 and 9 have more than one warm peak between the age ranges given.

Formation	**Member**	**BGS Nomenclature**	**Oxygen Isotope Stage**	**Climate**	**Age**
(Bridgland 1994; 1995)	**(Bridgland 1994; 1995)**				**(000 years)**
(Youngest) Tilbury	Tilbury Alluvial Deposits	Alluvium	1	Warm	11.6 to present
Shepperton	Shepperton Gravel	Shepperton Gravel	2	Cold	22-11.6
Downcutting					
East Tilbury Marshes Formation	East Tilbury Marshes Upper Gravel	Kempton Park Gravel	5d - 2 Devensian	Cold	
	Trafalgar Square Deposits		5e Ipswichian	Warm	122
	East Tilbury Marshes Lower Gravel		6	Cold	
Downcutting					
Mucking Formation	Mucking Upper Gravel	Taplow Gravel	6	Cold	
	Aveley Silts and Sands		7	Warm	196-239
	Mucking Lower Gravel		8	Cold	
Downcutting					
Corbets Tey Formation	Corbets Tey Upper Gravel	Lynch Hill Gravel	8	Cold	
	Purfleet Silts and Sands		9	Warm	312-331
	Corbets Tey Lower Gravel		10	Cold	
Downcutting					
Orsett Heath Formation	Orsett Heath Upper Gravel	Boyn Hill Gravel	10	Cold	
	Swanscombe Interglacial Deposits		11	Warm	406
	Orsett Heath Lower Gravel		12	Cold	
(Oldest)	Black Park Gravel	Black Park Gravel	12	Cold	

The marine oxygen isotope record indicates that during the last half million years, climate has oscillated in a cyclical fashion between cold glacial and temperate interglacial conditions. According to the model of Bridgland (1994; 2000; 2001) and Bridgland and Westaway (in press) these climatic cycles typically produce a characteristic "sandwich" of deposits. Initially terrace gravels are deposited in a cold-climate periglacial braided river environment. As the cycle progresses and climate warms, vegetation stabilises the land surface and river discharge becomes less variable resulting in a meandering river system in which finer clays, silts, sands and organic material are deposited. The return to colder climates leads to renewed deposition of cold stage gravels and extensive erosion of the finer temperate deposits. Occasionally, however, at selected locations, either protected in channels or in quieter environments near the valley side, the finer deposits have been preserved. These sites often contain temperate interglacial fossils and Palaeolithic artefacts and have been invaluable in providing a temporal framework for the post-Anglian Thames terrace system (Schreve 2001; Bridgland and Schreve 2004; Bridgland 2006).

Table 1 shows the correlation between river terrace gravels and marine oxygen isotope stages based on the work of Bridgland (1994; 1995) and British Geological Survey mapping and interpretation (Ellison *et al*. 2004).

The University of East London Docklands Campus site lies on the present floodplain of the Thames between the rivers Lea and Roding (Fig. 1). It occupies a position to the north of the Royal Albert Dock at its eastern end and south of Cyprus Station on the Docklands Light Railway (Fig. 2) where the ground surface lies approximately between 4.6 and 5.6m O.D. The site has had over a century of industrial use between 1875 when construction of the Royal Albert Dock began and 1981 on its closure. As a consequence the uppermost deposit comprises up to 4m of made ground of variable consistency (Soil Consultants Ltd 1998). Beneath the made ground, the 1998 survey reported alternating layers of clay, clayey peat and peat to depths of about 7.5m below present ground surface overlying brown sands and gravels which were between 6 and 10m thick.

It seems likely therefore, given the location of the site within the terrace system, that the basal unconsolidated sediments relate to the most recent climatic cycle and represent Shepperton Gravels, cold-stage Thames river gravels dating to between about 22,000 – 11,600 years ago. The overlying finer clays and peats and clays are likely to represent more temperate conditions of the Holocene. They were proved in the 1998 survey to lie between about -3.1 and +4.8m O.D., which suggests that at least the lower parts are within the altitudinal range affected by Holocene marine-estuarine conditions (Devoy 1979; 1982; and Table 2).

Table 2. Thames Transgression periods of Devoy (1979; 1982)

Transgression period	**Beginning** (^{14}C yrs B.P)	**Altitudinal range (m O.D.)**	**End** (^{14}C yrs B.P)	**Altitudinal range (m O.D.)**
Thames I	8200	-25.5 to -13.2	6970	-8.0 to -12.5
Thames II	6575	-6.8 to -12.3	4930	-3.0 to -6.9
Thames III	3850	-1.9 to -6.7	2800	-1.0 to -2.0
Thames IV	2600	-0.8 to -1.8	no data	+0.4 to -0.9
Thames V	*c*. 1700	+0.44 to -0.75		

4. THE 2005 BOREHOLE SURVEY

Three U100 boreholes, 105, 106 and 108 (Fig. 2) were sampled and sediment recovered for further analysis. The cores were sampled in 45cm long plastic tubes and the sediment retained in the 15cm cutting shoe was also sampled. The quality of the cutting shoe samples was variable and in some cases the boundaries between units were not observed directly. The best core retention and preservation was in borehole 108 and this is why it was chosen for more detailed analysis. Detailed stratigraphic descriptions of boreholes 105, 106 and 108 are contained in Appendix 1.

A generalized diagram of the stratigraphy is given in Fig. 3. It shows that there is considerable variation in the detail of units between the boreholes. Typically though, the overall pattern is grey clay overlying a complex organic series of organic clays, herbaceous and woody peats. Beneath these in borehole 105 there is a second layer of clay whilst in 106 and 108 the sequence is more organic. At the base is either flint gravel or sand.

5. RADIOCARBON DATING

Eight AMS radiocarbon dates on organic material were provided by the Scottish Universities Environmental Research Centre (SUERC) at East Kilbride (Table 3). Five samples were taken from borehole 108 through the organic complex between 675 and 965cm. Each was of

2cm thickness and located at peat-clay contacts. The contact at 840cm (-3.01m O.D.) was not sampled due to poor core recovery. For comparison, three samples were taken from borehole 106, two on the lowermost woody detrital peat between 925-940cm and the third at the erosion contact at 650cm (-1.85m O.D.). Figure 3 shows the three boreholes relative to Ordnance Datum and the stratigraphic location of the eight radiocarbon dates.

Table 3. Radiocarbon dates

Borehole	**Lab code**	**Date ^{14}C yrs B.P.**	**$\delta^{13}C$ (‰)**	**cal B.P.**	**Depth (cm)**	**Altitude (m O.D.)**
106	SUERC 9800	5875±35	-28.8	6970-6630	938-940	-4.73 - -4.75
106	SUERC 9799	5835±35	-25.7	6740-6540	908-910	-4.43 - -4.45
106	SUERC 9798	1975±35	-28.3	2000-1860[1]	650	-1.85
108	SUERC 9808	5905±35	-28.5	6800-6650	959-961	-4.20 - -4.22
108	SUERC 9807	5390±35	-29.4	6290-6170[2]	889-891	-3.50 - -3.52
108	SUERC 9806	4510±35	-28.6	5310-5040	817-819	-2.78 - -2.80
108	SUERC 9805	3390±35	-28.6	3730-3550	752-755	-2.13 - -2.16
108	SUERC 9804	2145±30	-27.6	2190-2000[3]	678-680	-1.39 - -1.41
cal B.P. dates show the 95.4% probability unless otherwise stated. [1]93.3%; [2]76.3%; [3]70.5%						

Taken together, the age and altitude information suggests that clay and peat sedimentation may have begun during the interval covered by Devoy's Thames II transgression period (Devoy 1982 and Table 2). Assuming uninterrupted sedimentation, the five dates for borehole 108 suggest sediment accumulated at about 9.2cm/100years between about 6275 and 5175 cal B.P., slowing to half that or about 4.5cm/100years thereafter (Fig. 4).

6. PARTICLE SIZE ANALYSIS

Size is one of a number of properties of sediment particles that affects their entrainment, transport and deposition. As such, particle size analysis can provide clues to sediment provenance, transport and deposition and can be used as a general measure of the energy present in depositional environments.

Forty samples, each of 2 cm thickness, were taken from the minerogenic units for particle size analysis. Organic material was removed by adding 30% Hydrogen peroxide and waiting until the effervescence stopped. The samples were then agitated using a magnetic stirrer and a disposable pipette used to collect a subsample. Three repeat measurements for each sample were made on a Malvern Mastersizer 2000 using laser diffraction. The data generated were then entered into GRADISTAT, an Excel-based package for calculating grain size distributions and statistics in unconsolidated sediments (Blott and Pye 2001; Blott et *al*. 2004)

Table 4. Average particle size parameters for the four main minerogenic layers in borehole 108.

	Lower organic clay (n=20)	Middle organic clay (n=5)	Upper organic clay (n=8)	Upper clay (n=7)
Mean size (µm)	11.46±1.71	12.74±2.01	11.13±1.07	13.68±3.25
Sorting	11.67±1.25	16.48±3.04	14.25±2.98	13.18±3.75
Skewness	3.31±1.24	4.52±2.15	3.80±1.07	2.19±0.72
Kurtosis	25.03±16.84	39.82±35.57	26.04±14.09	11.75±6.16

Table 4 shows mean particle size in microns and mean sorting, skewness and kurtosis from the four main minerogenic layers. Sorting is a measure of dispersion or scatter around the mean value which is related to the transporting agent's ability to segregate its load according to size. Skewness is a measure of asymmetry from the normal frequency distribution curve. A negative (fine) skew represents a greater amount of coarser material than would be expected in a normal distribution and the tail of the distribution points towards the finer grain sizes – the converse is true for a positive (coarse) skew. Kurtosis is a measure of the peakedness of the size distribution. A normal distribution curve is mesokurtic, one that is flatter than the normal curve is platykurtic while a more peaked curve is leptokurtic.

The GRADISTAT results indicate that the majority of samples can be classed as unimodal, poorly sorted, negatively skewed, mesokurtic fine and medium silts. It also shows the visual inspection and description of the cores in Appendix 1 may have overestimated the amount of clay present in the stratigraphy.

Figures 4a and b show particle size groupings for each sample and average particle size distribution curves for each minerogenic layer. There appears at first view to be little variation within and between the four minerogenic layers. However on closer inspection some differences may be detected.

Recently, McCave *et al*. (1995a) suggested that in the marine environment, sediments below about 10 μm in equivalent spherical diameter (fine silts to clays) generally behave in a cohesive fashion and are mainly deposited as aggregates. Indeed flocculation and aggregation of smaller particles is particularly marked at the freshwater/saltwater boundary in estuaries where fine silt and clay particles of terrestrial origin encounter salt nuclei in a turbulent environment. They argued that as modern particle size methods such as laser granulometry measure a particle's disaggregated size, what is measured cannot be related to the depositional environment. They considered the 10 μm limit to be much more meaningful in terms of sedimentary processes than the traditional 2 μm boundary between clay and silt or even the 63 μm boundary between silt and sand.

This led these authors to define the 'sortable silt' mean, which is the average size of the 10–63 μm fraction. They suggested that this is the size fraction that varies in response to hydrodynamic processes at the sea bed and from which relative changes in current speed can be inferred. They used this proxy successfully to map palaeocurrent fields in the North Atlantic (McCave et al. 1995b).

Figure 4a contains the average 'sorted silt' curve, the average of the 10-63 μm fraction for each sample. There appear to be main 3 peaks in the diagram equating to about 900-920cm in the lower organic clay, 830-840cm in the middle organic clay and about 570-580cm in the upper clay. A rise in very fine sand percentages also accompanies the rise in 'sorted silt' and suggests that these may have been times of slightly higher energy in the environment. In each of these three mineral units therefore there may be evidence for a slight increase in energy of environment to a peak, followed by a decrease.

One proviso needs to be mentioned. McCave *et al*. (2006), reiterating the findings of Konert and Vandenberghe (1997), suggested that laser particle sizers may overestimate the size of clay and fine silt particles since the measured size of platy minerals can be dominated by their large projected area. Platy clay and fine silt particles would be recorded as the same size as larger equant grains (which have axes all of similar length) although they have much smaller settling velocity.

In this study however, no quantitative estimate of current speed is being made and there is no major change evident in the source of sediment. It is suggested therefore that even if the 'sorted silt' average may be overestimated, because all samples were prepared and measured in the same way, the trends of the curves and the presence of the very fine sand accompanying the peaks do suggest periods of slightly higher energy. In the lower and middle organic clays these occur within the central parts of the units and there is evidence for a decline in energy as the overlying peat contact is approached.

7. LOSS ON IGNITION AND CARBONATE CONTENT

Loss on ignition is a simple and widely used method to estimate the organic and carbonate content of sediments. It provides a fast and inexpensive means of determining carbonate and organic contents of sediments and rocks with a precision and accuracy comparable to other, more sophisticated geochemical methods (Heiri *et al*. 2001).

Determination of weight per cent organic matter and carbonate content is based on sequential heating of the samples in a muffle furnace and weighing the difference before and after each step. First a known weight of sample is oven-dried to constant weight overnight at 105 °C. The loss in sample weight represents the pore water content. The sample is then heated to 550 °C over four hours and reweighed. This second weight loss represents the combustion of organic material. Finally the sample is returned to the furnace and heated at 950°C for two hours during which carbon dioxide is evolved from carbonate, leaving oxide. The weight loss at 950 °C multiplied by 1.36 equals the weight of the carbonate in the original sample (Bengtsson & Enell 1986).

Forty-two samples were analysed, mainly from the four minerogenic units. Average results for %Pore Water, Carbon and $CaCO_3$ are given in Table 5 below. % Pore water is calculated as a percentage of the original wet weight of sample whilst the other two are given as a percentage of dry sample weight.

Table 5. Average loss on ignition figures for the four main minerogenic layers.

	Lower organic clay (n=21)	Middle organic clay (n=5)	Upper organic clay (n=8)	Upper clay (n=8)
% Pore Water	48.96±6.96	35.39±3.73	55.17±10.67	71.72±2.70
% Carbon	26.17±12.66	47.83±7.32	24.46±2.43	7.69±2.38
%$CaCO_3$	2.89±2.42	2.98±0.60	2.49±0.25	4.02±2.68

Two main findings are that the organic clays have a markedly higher % carbon content compared to the upper clay, which in turn has a higher average percentage of $CaCO_3$

Figure 5 shows % Loss on Ignition values for each sample. The diagram again illustrates the difference in carbon content between the organic clays and upper clay whilst the detail shows the lower and middle organic clays show an increase in organic content towards the peat-clay contacts at 893cm and 819cm. The upper clay has a maximum $CaCO_3$ content of 8.8% at 592cm.

8. POLLEN ANALYSIS

Fifty-nine samples were extracted from Borehole 108 in the laboratory at approximately 8cm intervals, where the core retrieval permitted, between 980cm (-4.41m O.D.) and 524cm (0.15m O.D.)

The samples were prepared using standard pollen extraction techniques. A known number of exotic *Lycopodium* spores in tablet form were added to either 0.5 or 1 cm^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 fine silt and 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 normally scanned at 400x magnification until a total of 100 total land pollen (TLP) was reached, though in samples with low pollen concentrations where this was not possible, a minimum of 10 traverses were completed. All pollen and other significant content including microscopic charcoal fragments were recorded. Pollen identifications were made using Moore, Webb and Collinson (1991), Reille (1992) and the reference type slide collection at the University of Greenwich. Nomenclature follows Bennett (1994a), Bennett, Whittington and Edwards (1994) and Stace (1991)

The preservation of each determinable grain counted was recorded under the categories amorphous, corroded, broken, folded or well preserved whilst indeterminable grains were also categorised using the first four categories above to which a fifth, concealed, was added.

Microscopic charcoal was counted on a simple presence basis; no attempt was made to quantify size, shape or surface area parameters.

The pollen results are shown as a table in Appendix 2. A preliminary pollen diagram (Fig. 6) has been drawn up but because of the low numbers of pollen counted per level, it is not of publication quality and should be seen as an aid to visualisation only. The diagram was constructed using Psimpoll v 2.23, a program for plotting and analyzing pollen data (Bennett, 1994b), as were the following two diagrams. Figure 7 shows a summary pollen diagram and Figure 8 a summary preservation diagram.

9. DIATOM ANALYSIS

Sixty-four samples were prepared for diatom analysis from borehole 108 through the four layers containing silt and clay. About 20 ml Hydrogen peroxide (30%) was added to 1 g of fresh sediment in a glass beaker and heated on a hotplate at 90°C in a fume cupboard until all organic material has been oxidised (1-3 hours). After cooling, a few drops of Hydrochloric acid (50%) were added to remove remaining Hydrogen peroxide and carbonate. The samples were then transferred to centrifuge tubes, with any coarse sand being left behind in the beaker and centrifuged at 2500 rpm for 3 minutes. The supernatant liquid was decanted and the pellet resuspended with fresh distilled water. This washing process was repeated three times. During the last wash a few drops of very weak ammonia solution to the sample to remove clay size particles. A random sample was transferred using a pipette to a coverslip and allowed to settle and dry. The coverslip was then fixed on a microscope slide using Naphrax diatom mountant. Diatoms were identified using an Olympus BX40 microscope at a magnification of 400x.

Identifications were made with reference to Hustedt (1930-61), Cleve-Euler (1951-55), Hendey (1964), Hartley (1996) and van der Werff and Huls (1957-64). Nomenclature follows Williams *et al*. (1988) and the UCL Amphora checklist.

Diatom preservation throughout was very poor, perhaps due to post-depositional dissolution of silica and none of the samples provided countable numbers. An example of a degraded valve of the brackish diatom *Nitzschia navicularis* is given in Plate 1. In several samples no diatoms were encountered yet a marine influence in the depositional environment could be inferred from the remaining more robust fragments of sponge spicules (Plate 2).

10. OSTRACOD ANALYSIS, Dr Ian Slipper

Method

Twelve sub-samples were selected for ostracod analysis from within the clay layers: 530-534, 574-578, 616-620, 652-656 and 668-672 from the uppermost very dark greyish brown clay; 684-688, 708-713, 724-728 and 748-752 from the next lowest very dark greyish brown organic clay; 830-834 from the next lowest dark reddish-brown organic clay; 900-904 and 926-930 from the lowest dark olive grey organic clay. An additional sample, 600-604, was supplied ready-processed. (The sample numbers represent depth in cm below modern ground level).

All sub-samples were broken into centimeter-sized pieces and placed on drying trays in an oven at 50°C for four days. The dried samples were immersed in a 1% solution of sodium hexametaphosphate in distilled water, agitated gently and allowed to stand for one day. The samples were boiled using a microwave oven to help dispersion of the clays. At this stage it was clear that samples from the upper clay between 530-534 and 668-672 showed signs of disaggregation, but samples from the lower horizons between 684-688 and 926-930 did not. These appeared to contain much organic material which was resistant to the dispersion. Samples were sieved onto 63µm and 250µm sieves, dried and bottled ready for examination. Examination was carried out by scattering the dry residue on a picking plate and examining each grain with a Nikon low power binocular zoom microscope (10-40x magnification). Ostracods were picked out using a 000 sable hair brush moistened with distilled water and placed on glued assemblage slides for further examination.

Results

Of the 13 samples processed only three produced ostracod assemblages, 574-578, 600-604 and 616-618, all from the uppermost very dark greyish brown clay.

Four species were found, these are identified as *Cyprideis torosa* (Jones, 1850), *Candona* ex gr. *candida* (O.F Müller, 1776), *Cytherura gibba* (O.F Müller, 1785), *Leptocythere* sp. Identifications are made with reference to Athersuch *et al.* (1989) and Meisch (2000), representative specimens are shown on Plate 3. For *C. torosa*, the most abundant taxon, a full suite of adult and juvenile stages was recovered. *Candona* ex gr. *candida* was present in all three samples, but few in numbers, mostly broken valves of juveniles. *Cytherura gibba* was present only in two samples, and was scarce. Two specimens of a *Leptocythere* were recovered from the upper sample, one a juvenile and the other a fragment, so specific identification is uncertain.

Since *C. torosa* was found abundantly in the three samples, an analysis of sieve pore shape was carried out according to the method of Rosenfeld and Vesper (1975). This method relates the shape of sieve pores to levels of salinity; round pores indicate low salinity brackish water, elongate and irregular pores become more common as salinity increases. Fifty specimens were examined on the assemblage slides in a JEOL 5310LV scanning electron microscope under low vacuum conditions. The sieve pore shapes were assessed as either round, elongate, or irregular and recorded; a chart is given in Fig. 9.

Interpretation

Ostracods present in the upper clay show a low diversity assemblage dominated by a single species which is consistent with a marginal marine, estuarine brackish water conditions. The main component, *Cyprideis torosa*, is a well known species which can tolerate a wide range of salinities from almost freshwater to hypersaline conditions down to about 30m water depth, preferring a mud or sandy mud substrate (Athersuch et al. 1989). This species is presents a full range of instars from A-5 to adult males and females, which show that it was living in this environment and has not been transported by current activity. The two forms of intraspecific ecophentypic morphological changes present in *C. torosa*, noding and pore shape, give valuable additional information on the possible salinity range. Noding in *C. torosa* is known to become more frequent in populations living between 2-6ppth (Vesper 1972a, b; see discussion in Frenzel & Boomer 2005). No noding was observed in any of the specimens from this site, suggesting that the salinity was higher than about 6ppth. The result of the sieve pore shape analysis on *C. torosa*, Fig. 9, is consistent with a salinity range of 4-10ppth based on the results of Rosenfeld and Vesper (1975) for recent occurrences of this species.

C. gibba, while tolerant of a wide range of salinities, is more commonly encountered in brackish conditions than fully marine. Eight specimens only of this species were recovered, and it is not certain whether this is allochthonous. Similarly with the two specimens of *Leptocythere*, many *Leptocythere species* are known to be oligohaline, but without being able to determine the species any further analysis is not possible.

Candona ex gr. *candida* is present mostly as fragments and juvenile stages, thus a certain identification is not possible. *Candona candida* occurs in a wide variety of water bodies of fresh and very low salinities up to about 5.7ppth (Meisch 2000). The scarce and fragmental nature of these specimens, however, suggests that this was not living at this site, and has been transported, which indicates that there was a nearby source of freshwater to very low salinity brackish water. This is also supported by the few examples of charophyte oogonia which also indicate nearby fresh to low salinity water.

11. INTERPRETATION

The preliminary pollen diagram has not been zoned and the following discussion is based on the pollen and diatom content of the major lithostratigraphic units, their age and physical characteristics.

The lowermost unit in borehole 108 between 961-980 cm is a subrounded to subangular flint gravel with a matrix of dark grey to black clay silt and sand (Fig. 3 and Appendix 1). Three levels were counted for pollen through this unit but frequencies were extremely low and they are not shown on the pollen diagram. It probably represents the upper part of the Late Devensian fluvial Shepperton Gravel, with the finer material perhaps signifying early to mid-Holocene soil formation.

Above lies a dark brown organic clay, between 891-961 cm which began to form about 5900 ^{14}C yrs B.P. (6970-6630 cal. B.P.). The lower part is more organic and contains woody detritus whilst the upper part is slightly lighter in colour and contains evidence of oxidation along rootlet channels. The lowermost pollen count in this unit at 960 cm also contained low pollen frequencies and again is not included in the pollen diagram. The remainder of the unit is dominated by tree pollen with frequencies of between 53 and 89%. Initially *Quercus* (oak) is the dominant tree pollen with over 40% TLP but then it declines to between 10 and 20% and there is a complementary rise in *Alnus glutinosa* (alder) pollen to over 70%. Alder is a tree that favours damp conditions and is often found fringing lakes and rivers. It can also tolerate occasional saline inundation. Other trees recorded in this unit at lower frequencies include *Pinus sylvestris* (Scots pine), *Ulmus (elm)*, *Tilia cordata* (small-leaved lime) and *Fraxinus excelsior* (ash) and the shrub *Corylus avellana* (hazel) is also present.

Non-arboreal pollen types are present, most notably Chenopodiaceae, which occurs in continuous though low percentages. The Chenopodiaceae or goosefoot family is a large one with 7 genera and perhaps up to 32 species that are native or probably native to the British Isles (Stace, 1991), so viewed alone its diagnostic value is limited. However some genera such as *Atriplex* (oraches), *Salicornia* (glassworts) and *Suaeda* (sea-blites) contain species that are often dominant members of saltmarsh communities. Saline conditions are also suggested by the presence of sponge spicules, first noted at 948cm, the marine diatoms *Pseudopodosira westii*, *Podosira stelliger* and *Plagiogramma staurophorum* at 914cm and dinoflagellate cysts in four levels.

Taken together the evidence suggests the organic clay first formed in an environment where oak was the dominant tree but then marine conditions encroached and the site became an alder carr landwards of a saltmarsh, with periodic marine inundation. Oxidation along small herbaceous root channels may indicate intermittent drying out of the land surface. Support for an increase in the marine influence is given by the rise in %sorted silt (Fig. 4a) and the fall in %carbon (Fig.5) both suggesting a slightly higher energy environment. Backing evidence also comes from borehole 106 (Fig. 3) where a woody peat gives way to organic clays and silts after about 5835 ^{14}C yrs B.P. (6740-6540 cal B.P.).

As the boundary with the overlying peat is approached there is an increase in *Quercus* pollen and %carbon and a decrease in *Alnus glutinosa* and Chenopodiaceae pollen and %sorted silt suggesting marine conditions retreated from the site. This regressive contact is dated to about 5390 ^{14}C yrs B.P. (6290-6170 cal B.P.).

Although these changes occurred during the early Neolithic period there is nothing to suggest human presence at the site. Charcoal concentrations are low and the vegetation changes described above are probably due to natural environmental change, first an increase then decrease in the marine influence. One potential human impact noticeable in the pollen record, however, is the mid-Holocene Elm Decline. *Ulmus* pollen is present in continuous but low frequencies until the lower peat is reached at about 890cm, thereafter becoming sporadic. Parker *et al*. (2002) in a comprehensive review of the Elm Decline in the British Isles place its start between 6343 – 6307 cal B.P. in accord with the date on the regressive contact of 6290-6170 cal B.P. in borehole 108. They suggest that the Elm Decline can be explained to a large extent by the outbreak of Dutch Elm Disease but that climatic change and human activities may also be implicated.

Between 840 – 891cm in borehole 108 is a dark brown well humified herbaceous peat with woody detritus. The lower 30cm is darker, drier and crumbly while the upper part is more reddish brown and cohesive. Pollen is initially dominated by *Alnus glutinosa* at nearly 80% TLP but this declines to 31% at the upper contact, mirrored by a rise in Cyperaceae (sedge) pollen to 12% TLP. One level in the lower part at 874cm contained virtually no pollen perhaps suggesting a drying out of the peat surface and destruction of the pollen by oxidation. The exotic *Lycopodium* spores added to this sample to enable pollen concentration to be calculated were well preserved and common, which suggests this is not an artifact of the pollen preparation procedure.

Above the peat in borehole 108 is a dark reddish brown organic clay with woody and herbaceous detritus. It seems to have an equivalent in borehole 106 where a grey clay with flecks of dark grey to black sulphide staining is overlain by a mixed deposit containing abundant woody and herbaceous detritus set in a matrix of dark grey clay with inclusions of dark reddish-brown peat (shown as organic clay in Fig. 3). The fossil content also provides mixed messages. The layer contains Cyperaceae initially at about 30% though declining thereafter with variable amounts of *Alnus glutinosa*, *Iris* and *Filipendula* (meadowsweet) which might suggest freshwater fen. No diatoms were preserved though sponge spicules and Chenopodiaceae pollen hint at marine conditions nearby. The layer also has the highest pollen concentration for the site, 580 x 10^3 grains / cm^3 at 828cm and a peak in undifferentiated fern spores at 820cm.

A return to peat sedimentation is dated to about 4510 ^{14}C yrs B.P. (5310-5040 cal B.P.) at 819cm. The peat is largely herbaceous with an increased wood content towards the upper boundary, which is clearly erosional. *Alnus glutinosa* and *Quercus* are again the dominant pollen types with *Corylus avellana* type also present. Three levels at 784, 776 and 768cm in the middle of the peat layer have very low pollen content and concentrations again suggesting desiccation and oxidation, though there is no clear signal in the pollen preservation diagram (Fig.8).

A radiocarbon date on the upper 2cm of peat below the erosion contact gave a date of about 3390 ^{14}C yrs B.P. (3730-3550 cal B.P.). The organic clay above contains 25% organic matter and the mineral material has a mean size within the fine silt category. There are fragmentary and degraded marine and brackish diatoms including *Rhaphoneis amphiceros*, *Nitschia navicularis*, *Cyclotella striata*, *Actinoptychus senarius*, *Coscinodiscus sp.* and *Pseudopodosira westii*. The first two are epontic and benthic forms respectively. Epontic species are sessile and normally live firmly attached to a substrate, while benthic diatoms live in the sediment and can move about within it. *Nitschia navicularis* is a common brackish form while *Rhaphoneis amphiceros* can tolerate more saline conditions. The last four diatom species are marine planktonic species. Chenopodiaceae pollen again hints at the presence of saltmarsh while there is a marked decline in *Quercus* and *Tilia* across the stratigraphic boundary, perhaps suggesting a slight erosional hiatus.

A decline in *Tilia* is well marked in many pollen sites in south-east England and there is debate as to whether the decline is climatic (Godwin 1940), environmental (Waller, 1994) or humanly-induced (Turner 1962). Radiocarbon dating has demonstrated that the decline is diachronous, occurring between the Neolithic and Saxon periods. However most dates fall within the Middle and Late Bronze Age (Sidell *et al*. 2000) and there is often an association with arable weed pollen and an increase in *Pteridium* (bracken) spores indicative of forest clearance.

This may also hold true for borehole 108. The pollen diagram shows a first appearance for *Cerealia*-type at this level and *Pteridium* frequencies rise. There is also an increase in the Plantaginaceae (plantains) including *Plantago lanceolata* (ribwort plantain), indicative of more open conditions and disturbed ground. At nearby Silvertown a similar *Tilia* decline is dated to 3070 ± 60 ^{14}C yrs B.P. (3400 – 3150 cal B.P.; Wilkinson *et al*. 2000).

There is also debate at present concerning the correct identification of cereal pollen (Tweddle *et al*. 2005). Grass pollen usually has a psilate (smooth) surface and a single round pore surrounded by a ringlike annulus. Cereals are domesticated grasses, and their pollen is generally of larger size than most wild grasses. However the distinction is not absolute and there is overlap in annulus size and grain diameter between cereal pollen and a number of wild grass species, many of which are potentially present in the coastal zone (Behre 2007). A recent paper by Joly *et al*. (2007) suggests a limit of 47μm for diameter and 11μm for annulus diameter was best at discriminating between the two groups, putting a minimum of large grass pollen types into the *Cerealia*-type group. The single pollen grain attributable to *Cerealia*-type at 750cm in borehole 108 had a maximum diameter of 51μm and an annulus diameter of 13μm suggesting that it is probably a cereal grain.

At this time therefore the site was probably a saltmarsh as shown by the marine diatoms, Chenopodiaceae pollen and high organic content. It is probable that to landwards forest clearance had preceded cereal cultivation. One proviso is that the deposit is partially waterlain and transport of pollen from further away by this pathway cannot be discounted.

Above the organic clay is a thin (2cm) peat layer. Again the upper boundary is erosional with small rip up clasts of peat preserved within the overlying clay and silt. Tree pollen including alder has reduced to 18% by this level, suggesting the landscape was much more open with Poaceae (grasses), Cyperaceae and Chenopodiaceae dominating. A radiocarbon date from the peat gave an age of about 2145 ^{14}C yrs B.P. (2190-2000 cal B.P.) putting it towards the end of the pre-Roman Iron Age.

In the overlying dark grey-brown clay and silt fragmentary marine diatoms, sponge spicules and dinoflagellate cysts suggest a marine influence continued. The loss on ignition values suggest this unit is the least organic of the mineral layers with about 5% carbon. Interesting features within this uppermost deposit are the continuous curve for Lactuceae (a subfamily of the daisy family) pollen, the peak in Brassicaceae (cabbage family) pollen between 626 - 600cm, the disappearance of *Cerealia*-type pollen and the subsequent rise of *Sparganium emersum* type. *Sparganium emersum* type includes *Sparganium* spp. (bur-reeds) and *Typha angustifolia* (lesser bulrush). Both suggest reedswamp conditions existed at or close to the site. The low organic content of the upper clay might suggest the latter rather than the former.

Grains provisionally attributed to *Avena* type (oats) which includes *Triticum* spp. (wheats) on the basis of their maximum diameter, annulus diameter and pore diameter were present between 646 and 610cm. This suggests cereal cultivation in the vicinity though again with the proviso the deposits are predominantly waterlain. Extrapolation of the radiocarbon timescale would give a Roman to early Saxon date for this cultivation.

The upper dark grey-brown clay and silt contains on average between 10 and 20% tree pollen including alder which suggests the area was largely deforested by this time Charcoal also reaches highest values for the borehole. Such high and consistent values indicate human wood burning was responsible.

12. WIDER COMPARISONS

Melting continental ice caps contributed to a rise in sea level during the Holocene. Sea-level rise affected the Thames between 9200 and 2400 years ago (Devoy 1977; 1979; 1980; 1982; Long 1995; Sidell *et al*. 2000; Wilkinson 1988; Wilkinson *et al*. 2000). The initial rise was rapid, perhaps by as much as 2m per century but between about 5500 and 3000 cal B.P. the rate of rise fell to about 0.08m per century. The first indication of marine conditions at the University of East London Campus site is within the lower organic clay dated to about 6900 cal B.P. at -4.0m O.D. This early marine episode was not noted at the nearby Silvertown site where there seems to have been a hiatus in deposition (Wilkinson *et al*. 2000).

In the Thames estuary it is sometimes paradoxically the case that freshwater peat forms under conditions of rising relative sea level, with biogenic sedimentation overwhelming marine sedimentation as their respective sedimentation rates change. Under conditions of reduced marine mineral sediment supply, if the hydrological conditions are favourable, biogenic peat growth can keep pace with and outstrip mineral sedimentation. Haggart (1995) demonstrated that the Tilbury III peat actually began to accumulate under conditions of slowed sea-level rise between 7200 – 5400 cal B.P. It is likely that the lower peat dating to 6200 cal B.P. at -3.5m O.D. in borehole 108 began to form at this time. In central London this phase is shown by peat formation over a 2000-year period at Joan Street, Union Street and Canada Water (Sidell *et al*. 2000). Further east at Silvertown peat began to accumulate about 5600 ^{14}C yrs B.P (6700-6300 cal B.P.) at -3.3m O.D.

Between about 5625 and 4725 cal B.P sea level fell in the Thames estuary and there is evidence for channel incision and peat desiccation in the Tilbury area (Haggart 1995). In borehole 108 this period may be demonstrated by the mixed deposit between -3.0 and -2.8m O.D.

The estuary began to expand once more as sea level rose after about 4250 years ago and by just before 3000 years ago tidal waters had reached as far upstream as Westminster. This process occurred laterally as well, with the evidence of tidal penetration in the east London marshes, Southwark and Rotherhithe occurring at this time (Meddens 1996; Rackham 1994; Sidell *et al*. 2000; Wilkinson *et al*. 2000). This phase is represented by the erosional transgressive contact on the middle peat between 3730-3550 cal. B.P. at -2.1m O.D. in borehole 108. This rise in sea level probably caused a rise in the groundwater table in adjacent coastal wetlands and helps to explain the proliferation of Bronze Age trackways in the East London marshes (Meddens 1996), the nearest to the site being at Beckton (Beasley 1993).

Following this transgression the location of the tidal head seems to have fluctuated but in a generally downwards direction (Sidell *et al.* 2000). This could explain the thin peat layer which formed between 2190-2000 cal B.P. at about -1.4m in borehole 108. During the Roman period there was a notable downstream movement of the tidal head, probably due to a fall in sea level, which had a marked effect on the location and altitude of quays and jetties (Milne 1985; 1995; Sidell *et al*. 2000; Watson *et al*. 2001).

This may be marked at the University of East London site by evidence of channel incision in borehole 106. The upper contact of the upper peat is clearly erosional and plunges at an angle of 70° in the core over a vertical distance of up to 50cm. It probably represents the side of an infilled saltmarsh creek. The younger sediments of the channel fill may explain the anomalously young age of 1975 ± 35 ^{14}C yrs B.P. (2000-1860 cal B.P.) for the upper contact of the upper peat in borehole 106. In an attempt to date the highest point on the erosion contact there may have been some contamination with younger fill material.

During the later Roman/Early Saxon period (between about 1300 and 1650 years ago) there was a reversal of this downwards trend and it is possible that Saxon *Lundenwic* was sited at the approximate location of the tidal head (Sidell *et al*. 2000). This would provide a possible mechanism for the reintroduction of marine sedimentation at the University of East London site represented by the upper dark grayish brown clay and silt.

13. ASSESSMENT OF RESULTS

The deep sequence of sediments of the river Thames on the site will have been extensively disturbed by deep piling for the development, but the core samples obtained from preliminary boreholes have provided sufficient information to understand the site's geoarchaeological significance.

The evaluation and initial analysis of the core samples has enabled the reconstruction of an important geoarchaeological sequence through sediments of the river Thames, dating from the late Mesolithic to the Roman and early Saxon periods. Sediments of later periods had previously been destroyed by construction of the Royal Albert Dock. Analysis of the sediments and other indicators of the river environment, such as diatoms and ostracods, and a preliminary reconstruction of a pollen sequence, have been supported by radiocarbon dating of key points in the sequence. This has produced well-dated evidence of changes in sea-level and the character of the river and its environment, including riverbank woodland and vegetation.

There is also indirect evidence of human activity alongside the river, especially that for the clearance of land for arable farming. The environmental changes that have been recorded also provide a setting against which human impacts, such as the development of the Roman port of London, can be better understood.

The evaluation results have met the project research aims in full (see section 2, above), and confirm that the site evidence can contribute to the wider study of the geoarchaeology of the Lower Thames estuary, as defined in both the London and Greater Thames Estuary archaeological research frameworks (Museum of London 2002; Williams and Brown 1999).

The most important results are as follows:

- Evidence of a rapid rise in sea level in the late Mesolithic, with an oak-wooded riverbank replaced by salt marsh fringed by alder;

- Evidence of peat formation outstripping marine sedimentation as sea-level rise slowed in the late Mesolithic/early Neolithic, comparable to the Tilbury III peat. This was accompanied by evidence of elm decline, widely recorded across south-east England;

- Evidence of a true fall in sea level leading to further peat formation in the Neolithic/ early Bronze Age;

- Evidence of a rise in sea level in the middle Bronze Age, which led to the laying of brushwood trackways across the East London marshes, including a local example at Beckton;

- Evidence for deforestation from the Bronze Age onwards, with a lime decline, and the beginning of arable cultivation;

- Evidence for a short-lived peat formation in the Roman period, reflecting a fall in sea level, followed by a rise in the early Saxon period. This is consistent with evidence of the quays of the Roman port being advanced out into the river as mean tide levels fell (Watson *et al*., 2001).

These results provide a case study of well-dated new evidence that can be used to develop and refine the existing models for sea-level change and the vegetational sequence of the Lower Thames. The wider significance of the site evidence has been discussed in general terms, but interpretation would benefit from detailed comparisons with other work in the surrounding area. Potentially the most significant sites locally are 800m to the south, on the riverbank at Albert Road and Barge House Road, North Woolwich (MoLAS 2004, sites 2 and 3, site codes AET01 and BJA00). Analysis of borehole samples on these sites has produced pollen sequences supported by radiocarbon dating, and comparative study should identify local variations as well as more common trends for the Lower Thames. Another significant local site is that of a Bronze Age brushwood trackway laid over waterlogged peat 1.5km to the north-west at Evelyn Denington Road, Beckton (Beasley 1993). Comparative study of the UEL results in relation to this evidence will improve understanding of how Bronze Age people reacted to rising water levels and a changing riverside environment.

The evaluation of the pollen recovered from the UEL site shows that this has some potential for further study. Pollen preservation is variable between different levels (Fig. 8) but is relatively good, except in sandy deposits at the very bottom of the sequence. However, the evaluation results are based on pollen counts per level of 100 (total land pollen) and a count of 300 per level would be required for a statistically reliable result.

The diatoms and ostracods are not worth further study. The diatoms were highly degraded. The ostracods provided useful information on the environmental conditions of the river from the Bronze Age onwards, but only small quantities were recovered, and these came exclusively from the upper levels, so their value is limited.

The results of the evaluation of core samples from the site confirm that there is potential in the general area for the type of interdisciplinary study recommended by both the London and the Greater Thames archaeological research frameworks. These results could be refined with further analysis of the pollen but, after consultation with English Heritage, it was decided that the relatively small sample from the site did not justify the further work required for publication in a scientific journal. Nevertheless, the evaluation has provided data that can be used in any future synthetic study of the geoarchaeology of the Lower Thames beyond the scope of this project.

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APPENDIX 1. BOREHOLE LOGS

Borehole 105 (TQ 54369 18067) stratigraphy

Depth (cm)		Altitude (m O.D.)		Description
0	540	-0.68	4.72	Not sampled
540	548	-0.76	-0.68	Dark grey clay with black iron sulphide flecking together with larger patches of dark yellowish brown iron mottling
548	560	-0.88	-0.76	Olive brown clay with occasional black iron sulphide flecking and larger dark yellowish brown iron mottling. Upper boundary gradual over 5 cm.
560	583	-1.11	-0.88	Olive brown clay with traces of silt and comminuted shell fragments. Upper boundary not observed
583	619	-1.47	-1.11	Dark grey clay with flecking of black iron sulphide staining. Upper boundary sharp over 2 mm. Shell fragments present. Towards the base there are occasional yellowish red fine sand sized iron concretions around presumed former root channels or small pipes. Upper boundary gradual over 5 cm.
619	659	-1.87	-1.47	Very dark greyish brown organic clay. Well decomposed herbaceous peat with a mineral component of dark grey to black clay. Occasional herbaceous rootlets in position of growth. One thin clay layer up to 2 mm thick at 643 cm. Upper boundary not observed.
659	676	-2.04	-1.87	Dark greyish brown organic clay and well humified dark brown peat with woody and herbaceous detritus. Upper boundary gradual over 5 cm.
676	705	-2.33	-2.04	Dark greyish brown organic clay with increased minerogenic component. Occasional herbaceous rootlets in position of growth. Upper boundary gradual over 5 cm.
705	716	-2.44	-2.33	Not sampled
716	723	-2.51	-2.44	Dark brown to black woody and herbaceous detrital peat. Very dry and crumbly. Upper boundary not seen.
723	839	-3.67	-2.51	Brown compact and cohesive well humified herbaceous peat with occasional woody detritus. Upper boundary sharp over 1 cm with woody detritus and ?*Phragmites* rhizomes at the contact. Large piece of wood sampled 8 cm thick in the interval 755-770 cm. A second large piece of wood sampled between 815-830 cm.
839	875	-4.03	-3.67	Grey clay with woody and herbaceous rootlets, some in position of growth and some detrital. Upper boundary sharp over 1 cm.
875	938	-4.66	-4.03	Grey silty clay. Well rotted detrital wood between 907-910 cm. Upper boundary not seen.
938	950	-4.78	-4.66	Grey clay silt with a woody detritus and common detrital shells
950	955	-4.83	-4.78	Grey brown organic clay.
955	961	-4.89	-4.83	Dark grey organic clay. Small sub-rounded flint pebble at 957 cm.
961	990	-5.18	-4.89	Grey clay-silt with occasional yellow brown iron mottling Occasional white ?Calcium carbonate precipitate. Coarse band of oxidised yellow brown and olive grey silt and sand between 973-976 cm. Upper boundary gradual over 2 cm.
990	1010	-5.38	-5.18	Sub-rounded to sub-angular chattermarked flint gravel with grey clay, silt and sand. Shell fragments including *Ensis ensis*. Upper boundary sharp over 1 cm.

Borehole 106 (TQ 54372 18068) stratigraphy

Depth (cm)		Altitude (m O.D.)		Description
0	450	0.15	4.65	Not sampled
450	478	-0.13	0.15	Olive grey clay with some silt. Occasional dark yellowish brown iron mottling.
478	510	-0.45	-0.13	Dark olive grey clay with some silt. Occasional dark yellowish brown iron oxide staining. Upper boundary gradual over 2 cm.
510	542	-0.77	-0.15	Dark grey clay with some silt. Flecks of very dark grey to black sulphide staining together with white flecks of ?Calcium carbonate precipitate. Upper boundary gradual over 2 cm.
542	625	-1.60	-0.77	Dark olive grey clay with some silt. Flecks of dark grey to black sulphide staining increasing in the lower 15 cm. Upper boundary gradual over 2 cm. Large 9 mm diameter dark reddish-brown iron concretion at 621 cm.
625	630	-1.65	-1.60	Dark greyish brown organic clay with iron concretions and dark grey to black sulphide staining. Upper boundary gradual over 2cm.
630	650	-1.85	-1.65	Dark grey clay with dark grey to black sulphide staining. Many small peat rip-up clasts adjacent to contact with peat below.
650	675	-2.10	-1.85	Dark reddish-brown herbaceous peat. Upper contact erosional and irregular, plunging at an angle of 70° in the core between 650 and 675 cm. It probably represents the side of an infilled saltmarsh creek.
675	690	-2.25	-2.10	A disturbed sample again cutting across the high angle erosion contact. Contains dark red brown herbaceous peat with some woody detritus and a dark grey clay with flecks of dark grey to black sulphide staining.
690	700	-2.35	-2.25	Not sampled.
700	712	-2.47	-2.35	Dark reddish-brown peat with well rotted woody detritus.
712	738	-2.73	-2.47	A mixed deposit. Abundant woody and herbaceous detritus set in a matrix of dark grey clay. Some inclusions of dark reddish-brown peat
738	745	-2.80	-2.73	Grey clay with flecks of dark grey to black sulphide staining. Upper boundary gradual over 2 cm.
745	760	-2.95	-2.80	Disturbed sample. Dark reddish-brown to black peat with woody remains. Dry and crumbly.
760	775	-3.10	-2.95	Loose drier crumbly dark brown to black peat with woody inclusions and irregular lenses of grey clay, perhaps a contaminated sample.
775	865	-4.00	-3.10	Dark reddish-brown cohesive herbaceous peat with woody detritus. Upper boundary sharp over 1 cm
865	880	-4.15	-4.00	Brown organic clay. Only 870-880 cm observed. Peat does lie above but the boundary was not seen.
880	897	-4.32	-4.15	A mixed deposit, perhaps contamination. Grey clay with herbaceous detritus and an eroded peat layer between 887-89 cm.
897	908	-4.43	-4.32	Brown organic clay with herbaceous and woody detritus.
908	925	-4.60	-4.43	Large piece of wood.
925	940	-4.75	-4.60	Brown woody detrital peat with a minerogenic component of grey clay. Upper boundary not observed.
940	985	-5.20	-4.75	Grey homogeneous sand with a brown 10YR component. Occasional detrital wood. Upper boundary not observed.
985	1000	-5.35	-5.20	Brown sand

Borehole 108 (TQ 54379 18068) stratigraphy

Depth (cm)		Altitude (m O.D.)		Description
0	520	0.19	5.39	Not sampled
520	678	-1.39	0.19	A very dark greyish brown clay with some silt. Occasional dark yellow brown iron mottling. Flecks of dark grey to black sulphide staining. Upper boundary sharp over 0.5 cm. Shells at 597 cm. Possible contamination between 560-572 cm
678	680	-1.41	-1.39	Dark red brown to black well humified herbaceous peat with woody detritus. Upper boundary erosional over 0.5 cm. The contact is undulating with peat rip-up clasts just above the contact.
680	752	-2.13	-1.41	Very dark greyish brown organic clay. Occasional flecks of dark grey to black sulphide staining, herbaceous and woody detritus. More organic in the upper 10 cm. The clay component is a lighter grey colour.
752	757	-2.18	-2.13	Dark reddish-brown to black well humified woody detrital peat. Upper boundary sharp over 1 cm. Contains a small clay component.
757	819	-2.80	-2.18	Dark reddish-brown well humified herbaceous peat with occasional woody detritus
819	840	-3.01	-2.80	Dark reddish-brown organic clay with woody and herbaceous detritus. A mixed deposit. Upper boundary gradual over 5 cm.
840	860	-3.21	-3.01	Dark reddish-brown well humified herbaceous peat with occasional woody detritus.
860	891	-3.52	-3.21	Dark brown to black very well humified dry and crumbly herbaceous peat with well rotted woody detritus. Upper boundary not observed.
891	944	-4.05	-3.52	Dark olive grey organic clay with herbaceous rootlets. Some yellow brown oxidation among the channels and some woody detritus.
944	961	-4.22	-4.05	Dark olive brown organic clay with a higher organic content than the layer above. With woody detritus also present. Upper boundary gradual over 5 cm.
961	980	-4.41	-4.22	Subrounded to subangular flint gravel in the matrix a very dark olive grey to black clay, silt and sand. Upper boundary not observed

APPENDIX 2. POLLEN COUNTS

Depth cm	**980**	**972**	**964**	**960**	**956**	**952**	**948**	**944**	**936**	**928**	**920**
Altitude m OD	**-4.41**	**-4.33**	**-4.25**	**-4.21**	**-4.17**	**-4.13**	**-4.09**	**-4.05**	**-3.97**	**-3.89**	**-3.81**
Trees											
Picea	0	0	0	0	0	0	0	0	0	0	0
Pinus sylvestris	1	0	0	0	0	0	0	0	5	1	6
Taxus baccata	0	0	0	0	0	0	0	0	0	0	0
Ulmus	0	1	1	0	0	1	1	1	3	2	9
Fagus sylvatica	0	0	0	0	0	0	0	0	0	0	0
Quercus	0	2	7	4	48	45	16	11	16	15	19
Betula	0	0	0	0	0	0	0	0	0	1	0
Alnus glutinosa	0	2	0	3	14	18	65	74	67	139	51
Carpinus betulus	0	0	0	0	0	0	0	0	0	0	0
Tilia cordata	1	6	7	2	8	7	4	0	1	3	4
Populus	0	0	0	0	0	1	0	0	0	0	0
Acer campestre	0	0	0	0	0	0	0	0	0	0	1
Fraxinus excelsior	0	0	1	2	7	0	0	0	0	0	0
Shrubs											
Corylus avellana-type	1	0	7	4	10	12	7	6	4	6	13
Salix	0	0	0	0	0	0	1	0	0	0	0
Ericaceae	0	0	0	0	0	0	0	0	0	0	0
Rubus undiff.	0	0	0	0	0	0	0	0	0	0	0
Rosa	0	0	0	0	1	0	0	0	0	0	0
Viscum album	0	0	0	0	0	1	0	0	0	0	0
Rhamnus cathartica	0	0	0	0	0	1	0	0	0	0	0
Hedera helix	0	0	1	0	1	2	1	2	0	1	2
Viburnum opulus	0	0	0	0	0	0	0	0	0	0	0
Lonicera periclymenum	0	0	0	0	1	0	0	0	0	0	0
Herbs											
Ranunculaceae	0	0	0	0	0	0	0	1	2	2	1
Caltha palustris-type	0	0	0	0	0	0	0	1	0	3	0
Papaver rhoeas-type	0	0	0	0	0	0	0	0	0	0	0
Glaucium flavum	0	0	0	0	0	0	0	0	0	0	0
Humulus lupulus	0	0	0	0	1	0	0	0	0	0	0
Chenopodiaceae	0	0	0	0	0	3	1	3	3	1	1
Caryophyllaceae	0	0	0	0	0	0	0	0	0	0	0
Cerastium-type	0	0	0	0	0	0	0	0	0	0	0
Sagina	0	0	0	0	0	0	0	0	0	0	0
Persicaria maculosa-type	0	0	0	0	0	0	0	0	0	0	0
Rumex acetosa	0	0	0	0	0	0	0	1	0	0	0
Rumex obtusifolius-type	0	0	0	0	0	0	0	0	0	0	3
Rumex sanguineus-type	0	0	0	0	0	0	0	0	0	0	0
Limonium	0	0	0	0	0	0	0	0	0	0	0
Brassicaceae	0	0	0	0	0	2	0	0	0	0	0
Saxifraga granulata-type	0	0	0	0	0	0	0	0	0	0	0
Rosaceae	0	1	0	0	0	0	0	0	0	0	0
Filipendula	0	0	0	0	1	0	0	0	0	0	3
Alchemilla-type	0	0	0	0	0	0	0	0	0	0	0
Vicia sylvatica-type	0	0	0	0	0	0	0	0	0	0	0
Apiaceae	0	1	0	0	0	0	0	0	0	0	0
Plantaginaceae	0	0	0	0	1	0	0	0	0	0	3
Plantago coronopus	0	0	0	0	0	0	0	0	0	0	0
Plantago maritima	0	0	0	0	0	0	0	0	0	0	0
Plantago lanceolata	0	0	0	0	0	0	0	0	0	0	0
Scrophulariaceae	0	0	0	0	0	1	1	0	0	0	0
Rubiaceae	0	0	0	0	0	0	0	0	0	0	0
Valerianella	0	0	0	0	0	0	0	0	0	0	0
Valeriana officinalis	0	0	0	0	0	0	0	0	0	0	0
Arctium-type	0	0	0	0	0	0	0	0	0	0	0
Cirsium-type	0	0	0	0	0	0	0	0	0	0	0
Lactuceae	0	0	0	0	0	0	0	0	0	0	0
Cichorium intybus-type	0	0	0	0	0	0	0	0	0	0	0
Tragopogon pratensis	0	0	0	0	0	0	0	0	0	0	0
Sonchus	0	0	0	0	0	0	0	0	0	0	0
Mycelis muralis-type	0	0	0	0	0	0	0	0	0	0	0
Asteroideae	0	0	0	0	0	0	0	0	0	0	0
Solidago virgaurea-type	0	0	0	0	0	0	0	0	0	0	1

Depth cm	**980**	**972**	**964**	**960**	**956**	**952**	**948**	**944**	**936**	**928**	**920**
Altitude m OD	**-4.41**	**-4.33**	**-4.25**	**-4.21**	**-4.17**	**-4.13**	**-4.09**	**-4.05**	**-3.97**	**-3.89**	**-3.81**
Artemisia-type	0	0	0	0	0	0	0	0	0	0	4
Achillea-type	0	0	0	0	0	0	0	0	0	0	0
Iris	0	0	0	0	0	0	0	0	0	0	0
Cyperaceae undiff.	0	0	0	2	0	1	0	0	1	4	0
Poaceae undiff.	0	2	0	0	7	6	6	0	1	1	8
Avena-type	0	0	0	0	0	0	0	0	0	0	0
Hordeum-type	0	0	0	0	0	0	0	0	0	0	0
Cerealia undiff.	0	0	0	0	0	0	0	0	0	0	0
Aquatics											
Nymphaea alba	0	0	0	0	0	0	0	0	0	0	0
Myriophyllum spicatum	0	0	0	0	0	0	0	0	0	0	0
Callitriche	0	0	0	0	0	0	0	0	0	0	0
Sagittaria sagittifolia	0	0	0	0	0	0	0	0	0	0	0
Potamogeton natans-type	0	1	0	0	0	0	2	0	2	1	2
Sparganium emersum-type	0	0	0	0	0	0	0	0	0	0	0
Typha latifolia	0	0	0	0	0	0	0	0	0	0	0
Spores											
Isoetes histrix	0	0	0	0	0	0	0	0	0	0	0
Polypodium	0	0	0	0	0	2	0	0	0	0	0
Pteridium aquilinum	1	0	2	0	0	0	1	0	1	0	0
Dryopteris filix-mas-type	0	0	0	0	0	0	0	0	0	0	0
Pteropsida (monolete) indet.	0	1	4	2	1	4	1	0	0	0	3
Pteropsida (trilete) indet.	0	0	0	0	0	0	0	0	0	0	0
Sphagnum	0	0	0	0	0	0	1	0	0	0	0
Pre-Quaternary Spores	0	0	0	0	0	0	0	0	0	0	0
Summary											
Trees	2	11	16	11	77	72	86	86	92	161	90
Shrubs	1	0	8	4	13	16	9	8	4	7	15
Herbs	0	4	0	2	10	13	8	6	7	11	24
Aquatics	0	1	0	0	0	0	2	0	2	1	2
Spores	1	1	6	2	1	6	3	0	1	0	3
Total Land Pollen	**3**	**15**	**24**	**17**	**100**	**101**	**103**	**100**	**103**	**179**	**129**
Total Pollen + Spores	**4**	**17**	**30**	**19**	**101**	**107**	**108**	**100**	**106**	**180**	**134**
Total traverses	**11**	**11**	**11**	**11**	**11**	**25**	**17**	**5**	**7**	**2**	**3**
Pollen and charcoal concentration											
Pollen concentration/cm3*1000	1.01	0.62	11.29	150.10	199.48	36.75	127.98	94.80	228.38	250.94	63.52
Charcoal concentration /cm3*1000	8.82	3.84	2.26	47.40	51.35	5.84	47.40	0.95	32.32	12.55	46.45
Determinable pollen preservation											
Amorphous	2	10	4	5	16	20	21	13	15	15	15
Corroded	0	1	5	0	16	8	17	18	18	13	15
Broken	0	4	0	8	11	10	6	16	17	21	10
Folded	2	1	15	5	45	53	28	26	40	81	54
Well Preserved	0	1	6	1	13	16	36	27	16	50	40
Indeterminable pollen preservation											
Amorphous	0	2	4	2	7	10	6	4	6	3	6
Corroded	0	0	0	0	4	5	5	0	2	1	0
Broken	0	0	1	1	5	6	8	1	1	5	4
Folded	1	2	9	0	5	9	1	2	3	3	5
Concealed	0	0	2	3	5	1	2	0	2	2	7
Unknown Grains	0	1	0	2	0	4	3	1	0	0	0

Depth cm	**912**	**908**	**900**	**894**	**892**	**890**	**882**	**874**	**866**	**844**	**840**
Altitude m OD	**-3.73**	**-3.69**	**-3.61**	**-3.55**	**-3.53**	**-3.51**	**-3.43**	**-3.35**	**-3.27**	**-3.05**	**-3.01**
Trees											
Picea	0	0	0	0	0	0	0	0	0	0	0
Pinus sylvestris	3	4	5	0	0	0	0	0	0	0	2
Taxus baccata	0	0	0	0	0	0	0	0	0	0	0
Ulmus	2	6	1	3	1	4	1	0	2	1	1
Fagus sylvatica	0	0	0	0	0	0	0	0	0	0	0
Quercus	16	41	21	46	42	24	9	1	17	12	28
Betula	1	1	0	0	1	1	0	0	0	3	0
Alnus glutinosa	60	20	66	31	54	88	85	2	67	45	37
Carpinus betulus	0	0	0	0	0	0	0	0	0	0	1
Tilia cordata	4	9	5	2	0	4	1	1	3	4	5
Populus	1	0	0	0	0	0	0	0	0	0	0
Acer campestre	0	0	0	0	0	0	0	0	0	0	0
Fraxinus excelsior	0	1	1	3	1	1	0	0	4	6	2
Shrubs											
Corylus avellana-type	13	16	12	12	14	14	9	0	4	8	13
Salix	0	0	0	0	0	0	0	0	0	0	0
Ericaceae	0	0	0	0	0	0	0	0	0	0	0
Rubus undiff.	0	0	0	0	0	0	0	0	0	0	0
Rosa	0	0	0	0	0	0	0	0	0	0	0
Viscum album	0	0	0	0	0	0	0	0	0	0	0
Rhamnus cathartica	0	0	0	0	0	0	0	0	0	0	0
Hedera helix	2	0	1	0	3	0	0	0	2	0	1
Viburnum opulus	0	0	0	1	0	0	0	0	0	0	0
Lonicera periclymenum	0	0	0	0	0	0	0	0	0	0	0
Herbs											
Ranunculaceae	1	0	0	0	0	0	0	0	1	0	1
Caltha palustris-type	0	0	0	0	0	0	0	0	0	0	0
Papaver rhoeas-type	0	0	0	0	0	0	0	0	0	0	0
Glaucium flavum	0	0	0	0	0	0	0	0	0	0	0
Humulus lupulus	0	0	0	0	0	0	0	0	0	0	0
Chenopodiaceae	4	4	1	0	1	0	0	0	0	0	1
Caryophyllaceae	1	0	0	0	0	0	0	0	0	0	1
Cerastium-type	0	0	0	0	0	0	0	0	0	0	0
Sagina	0	0	0	0	0	0	0	0	0	0	0
Persicaria maculosa-type	0	0	0	0	0	0	0	0	0	0	0
Rumex acetosa	0	0	0	0	0	0	0	0	1	5	0
Rumex obtusifolius-type	1	0	0	0	0	0	0	0	0	0	0
Rumex sanguineus-type	0	0	0	0	0	0	0	0	0	0	0
Limonium	0	0	0	0	0	0	0	0	0	0	0
Brassicaceae	0	1	0	1	3	0	0	0	0	0	0
Saxifraga granulata-type	0	0	0	0	0	0	0	0	0	0	0
Rosaceae	1	0	0	0	0	0	0	0	0	0	0
Filipendula	0	0	0	0	1	0	0	0	0	0	0
Alchemilla-type	0	0	0	0	0	0	0	0	0	0	0
Vicia sylvatica-type	0	0	0	0	0	0	0	0	0	0	0
Apiaceae	0	0	0	0	0	0	0	0	0	0	0
Plantaginaceae	2	1	2	0	2	0	0	0	0	1	3
Plantago coronopus	0	0	1	0	0	0	0	0	0	0	0
Plantago maritima	0	0	0	0	0	0	0	0	0	0	0
Plantago lanceolata	0	0	0	0	0	0	0	0	1	1	2
Scrophulariaceae	0	0	0	0	0	0	0	0	0	0	0
Rubiaceae	0	0	0	0	0	0	0	0	0	0	0
Valerianella	0	0	0	0	0	0	0	0	0	0	0
Valeriana officinalis	0	0	0	0	0	0	0	0	0	0	0
Arctium-type	0	0	0	0	0	0	0	0	0	0	0
Cirsium-type	0	0	0	0	0	0	0	0	0	0	0
Lactuceae	0	0	0	0	0	0	0	0	0	0	0
Cichorium intybus-type	0	0	0	0	0	0	0	0	0	0	0
Tragopogon pratensis	0	0	0	0	0	0	0	0	0	0	0
Sonchus	0	0	0	0	0	0	0	0	0	0	0
Mycelis muralis-type	0	0	1	0	0	0	0	0	0	0	0
Asteroideae	0	0	0	0	0	0	0	0	0	0	0
Solidago virgaurea-type	1	0	1	0	0	0	0	0	0	0	0

Depth cm	**912**	**908**	**900**	**894**	**892**	**890**	**882**	**874**	**866**	**844**	**840**
Altitude m OD	**-3.73**	**-3.69**	**-3.61**	**-3.55**	**-3.53**	**-3.51**	**-3.43**	**-3.35**	**-3.27**	**-3.05**	**-3.01**
Artemisia-type	1	0	0	0	0	0	0	0	0	0	0
Achillea-type	1	0	0	0	0	0	0	0	0	0	0
Iris	0	0	0	0	0	0	0	0	0	0	0
Cyperaceae undiff.	1	3	2	1	0	1	0	1	5	15	14
Poaceae undiff.	4	2	1	2	3	2	2	0	5	3	6
Avena-type	0	0	0	0	0	0	0	0	0	0	0
Hordeum-type	0	0	0	0	0	0	0	0	0	0	0
Cerealia undiff.	0	0	0	0	0	0	0	0	0	0	0
Aquatics											
Nymphaea alba	0	0	0	0	0	0	0	0	0	0	0
Myriophyllum spicatum	0	0	1	0	0	0	0	0	0	0	0
Callitriche	0	0	0	0	1	0	0	0	0	0	0
Sagittaria sagittifolia	0	0	0	0	0	0	0	0	0	0	0
Potamogeton natans-type	4	0	2	0	4	1	0	0	0	0	0
Sparganium emersum-type	0	0	0	0	0	0	0	0	1	1	0
Typha latifolia	0	0	0	0	0	0	0	0	0	0	0
Spores											
Isoetes histrix	0	0	0	0	0	0	0	0	0	0	0
Polypodium	0	3	0	0	1	2	1	0	0	0	0
Pteridium aquilinum	1	0	0	0	0	0	1	0	1	1	2
Dryopteris filix-mas-type	0	0	0	0	0	0	0	0	0	0	0
Pteropsida (monolete) indet.	1	2	0	0	1	2	3	1	3	14	28
Pteropsida (trilete) indet.	0	1	0	0	0	0	0	0	0	0	0
Sphagnum	0	0	0	0	0	0	0	0	0	0	0
Pre-Quaternary Spores	0	0	0	0	0	0	0	0	0	0	0
Summary											
Trees	87	82	99	85	99	122	96	4	93	71	76
Shrubs	15	16	13	13	17	14	9	0	6	8	14
Herbs	18	11	9	4	10	3	2	1	13	25	28
Aquatics	4	0	3	0	5	1	0	0	1	1	0
Spores	2	6	0	0	2	4	5	1	4	15	30
Total Land Pollen	**120**	**109**	**121**	**102**	**126**	**139**	**107**	**5**	**112**	**104**	**118**
Total Pollen + Spores	**126**	**115**	**124**	**102**	**133**	**144**	**112**	**6**	**117**	**120**	**148**
Total traverses	**3**	**9**	**3**	**3**	**3**	**2**	**3**	**10**	**6**	**3**	**3**
Pollen and charcoal concentration											
Pollen concentration/cm3*1000	53.33	26.99	57.62	127.23	71.64	262.52	221.20	4.31	120.56	101.57	120.95
Charcoal concentration /cm3*1000	55.02	26.75	10.22	39.92	9.70	0.00	0.00	0.72	4.12	0.00	8.99
Determinable pollen preservation											
Amorphous	18	31	12	15	26	26	14	2	6	7	19
Corroded	13	4	7	5	20	22	18	1	32	33	8
Broken	15	14	27	9	19	13	12	0	10	15	21
Folded	30	43	32	36	36	54	42	1	47	40	53
Well Preserved	50	23	46	37	32	29	26	2	22	25	47
Indeterminable pollen preservation											
Amorphous	2	1	2	2	2	5	4	0	4	2	1
Corroded	1	1	2	0	1	0	1	0	1	4	3
Broken	1	3	0	1	0	2	2	0	3	2	4
Folded	0	3	1	1	2	5	4	0	1	4	6
Concealed	5	2	0	1	7	10	1	0	3	1	3
Unknown Grains	1	1	2	3	3	0	0	0	1	1	2

Depth cm	**836**	**828**	**820**	**812**	**804**	**784**	**776**	**768**	**760**	**754**	**750**	**742**
Altitude m OD	**-2.97**	**-2.89**	**-2.81**	**-2.73**	**-2.65**	**-2.45**	**-2.37**	**-2.29**	**-2.21**	**-2.15**	**-2.11**	**-2.03**
Trees												
Picea	0	0	0	0	0	0	0	0	0	0	1	0
Pinus sylvestris	3	1	2	1	0	0	1	0	1	1	0	1
Taxus baccata	0	0	0	0	0	0	0	0	1	0	0	0
Ulmus	0	0	0	3	3	0	0	0	7	2	1	0
Fagus sylvatica	0	0	0	0	0	0	0	0	0	0	0	0
Quercus	15	10	12	33	26	1	3	3	12	26	7	7
Betula	0	1	0	1	0	0	0	0	1	0	0	1
Alnus glutinosa	17	76	24	42	51	5	12	13	48	43	50	31
Carpinus betulus	0	0	0	0	0	0	0	0	0	0	1	0
Tilia cordata	6	5	4	7	3	1	1	2	3	5	0	0
Populus	1	0	0	0	0	0	0	0	1	2	0	0
Acer campestre	0	0	0	0	0	0	0	0	0	0	0	0
Fraxinus excelsior	1	0	1	0	0	0	0	0	1	2	1	2
Shrubs												
Corylus avellana-type	21	14	12	14	5	1	6	2	10	17	13	6
Salix	0	0	0	0	0	0	0	0	0	3	0	1
Ericaceae	0	0	0	0	0	0	0	0	0	0	0	0
Rubus undiff.	0	0	0	0	0	0	0	0	0	0	0	0
Rosa	0	0	0	1	0	0	0	0	0	0	0	0
Viscum album	0	0	0	0	0	0	0	0	0	0	0	0
Rhamnus cathartica	0	0	0	0	0	0	0	0	0	0	0	0
Hedera helix	2	0	0	0	3	0	0	0	1	0	0	0
Viburnum opulus	0	0	0	0	0	0	0	0	0	0	0	0
Lonicera periclymenum	0	0	0	0	0	0	0	0	0	0	0	0
Herbs												
Ranunculaceae	0	0	0	0	0	0	0	0	0	0	0	2
Caltha palustris-type	0	0	0	0	0	0	0	0	0	0	0	0
Papaver rhoeas-type	0	0	0	0	0	0	0	0	0	0	0	0
Glaucium flavum	0	0	0	0	0	0	0	0	0	0	0	0
Humulus lupulus	0	0	0	0	0	0	0	0	0	0	0	0
Chenopodiaceae	1	1	0	0	0	0	0	0	2	0	7	2
Caryophyllaceae	0	0	0	0	0	0	0	0	0	0	0	0
Cerastium-type	0	0	0	0	0	0	0	0	0	0	0	0
Sagina	0	0	0	0	0	0	0	0	0	0	0	0
Persicaria maculosa-type	0	0	0	0	0	0	0	0	0	0	0	0
Rumex acetosa	0	0	1	3	1	0	0	0	0	0	0	0
Rumex obtusifolius-type	0	0	0	0	0	0	0	0	0	0	0	1
Rumex sanguineus-type	0	0	0	0	0	0	0	0	0	0	0	0
Limonium	0	0	0	0	0	0	0	0	0	0	0	0
Brassicaceae	0	0	0	0	0	0	0	0	0	0	1	0
Saxifraga granulata-type	0	0	0	0	0	0	0	0	0	0	0	1
Rosaceae	0	0	0	0	0	0	0	0	0	0	0	0
Filipendula	1	0	0	0	0	0	0	0	0	0	0	0
Alchemilla-type	0	0	0	0	0	0	0	0	0	0	0	0
Vicia sylvatica-type	0	0	0	0	0	0	0	0	0	0	0	0
Apiaceae	0	0	0	0	0	0	0	0	0	0	0	0
Plantaginaceae	3	0	4	9	0	0	0	0	5	4	3	3
Plantago coronopus	0	0	0	0	0	0	0	0	0	0	0	0
Plantago maritima	0	0	0	0	0	0	0	0	0	0	0	0
Plantago lanceolata	1	0	0	1	0	0	0	0	0	0	0	3
Scrophulariaceae	0	0	0	0	0	0	0	0	0	0	0	0
Rubiaceae	0	0	0	0	0	0	0	0	0	0	0	0
Valerianella	0	0	0	0	0	0	0	0	0	0	0	0
Valeriana officinalis	0	0	0	0	0	0	0	0	0	0	0	0
Arctium-type	0	1	0	0	0	0	0	0	0	0	0	0
Cirsium-type	0	0	0	0	0	0	0	0	0	0	0	0
Lactuceae	0	0	0	0	0	0	0	0	0	0	1	0
Cichorium intybus-type	0	0	0	0	0	0	0	0	0	0	0	0
Tragopogon pratensis	0	0	0	0	0	0	0	0	0	0	0	0
Sonchus	0	0	0	0	0	0	0	0	0	0	0	0
Mycelis muralis-type	0	0	0	0	0	0	0	0	0	0	0	0
Asteroideae	0	0	0	0	0	0	0	0	0	0	0	0
Solidago virgaurea-type	0	0	0	0	0	0	0	0	0	0	3	0

Depth cm	**836**	**828**	**820**	**812**	**804**	**784**	**776**	**768**	**760**	**754**	**750**	**742**
Altitude m OD	**-2.97**	**-2.89**	**-2.81**	**-2.73**	**-2.65**	**-2.45**	**-2.37**	**-2.29**	**-2.21**	**-2.15**	**-2.11**	**-2.03**
Artemisia-type	0	0	0	0	0	0	0	0	0	0	0	0
Achillea-type	0	0	0	0	0	0	0	0	0	0	0	0
Iris	1	0	0	0	0	0	0	0	0	0	0	1
Cyperaceae undiff.	32	13	5	7	6	0	0	0	1	2	15	11
Poaceae undiff.	5	0	2	3	2	1	1	1	5	5	17	26
Avena-type	0	0	0	0	0	0	0	0	0	0	0	0
Hordeum-type	0	0	0	0	0	0	0	0	0	0	0	0
Cerealia undiff.	0	0	0	0	0	0	0	0	0	0	1	0
Aquatics												
Nymphaea alba	0	0	0	0	0	0	0	0	1	1	0	0
Myriophyllum spicatum	0	0	0	0	0	0	0	0	0	0	0	0
Callitriche	0	0	0	0	0	0	0	0	0	0	0	0
Sagittaria sagittifolia	0	0	0	0	0	0	0	0	0	0	0	0
Potamogeton natans-type	0	0	0	0	0	0	0	1	1	1	1	0
Sparganium emersum-type	1	1	1	0	0	0	0	0	0	0	0	0
Typha latifolia	0	0	0	0	0	0	0	0	0	0	0	0
Spores												
Isoetes histrix	0	0	0	0	0	0	0	0	4	0	0	0
Polypodium	0	0	1	2	0	1	2	0	3	3	2	0
Pteridium aquilinum	0	0	1	0	0	0	0	0	1	2	13	19
Dryopteris filix-mas-type	0	0	0	0	0	0	0	0	4	1	0	0
Pteropsida (monolete) indet.	46	24	146	29	16	6	6	9	10	10	37	11
Pteropsida (trilete) indet.	0	0	0	0	0	0	0	0	0	0	0	0
Sphagnum	0	0	0	0	0	0	0	0	0	0	0	0
Pre-Quaternary Spores	0	0	3	2	0	1	1	0	0	0	0	0
Summary												
Trees	43	93	43	87	83	7	17	18	75	81	61	42
Shrubs	23	14	12	15	8	1	6	2	11	20	13	7
Herbs	44	15	12	23	9	1	1	1	13	11	48	50
Aquatics	1	1	1	0	0	0	0	1	2	2	1	0
Spores	46	24	151	33	16	8	9	9	22	16	52	30
Total Land Pollen	**110**	**122**	**67**	**125**	**100**	**9**	**24**	**21**	**99**	**112**	**122**	**99**
Total Pollen + Spores	**157**	**147**	**219**	**158**	**116**	**17**	**33**	**31**	**123**	**130**	**175**	**129**
Total traverses	**7**	**2**	**10**	**6**	**4**	**10**	**10**	**10**	**7**	**7**	**3**	**5**
Pollen and charcoal concentration												
Pollen concentration/cm3*1000	70.21	580.65	50.19	73.94	85.91	13.08	13.54	25.33	67.79	88.03	109.14	74.57
Charcoal concentration /cm3*1000	4.92	19.75	3.72	0.00	0.00	12.26	3.39	20.43	15.25	16.25	32.82	36.42
Determinable pollen preservation												
Amorphous	11	7	13	18	5	4	6	6	24	10	22	13
Corroded	16	25	28	21	20	2	7	2	15	14	11	10
Broken	28	9	34	31	13	0	6	5	17	15	23	27
Folded	52	44	78	52	46	4	10	11	38	61	73	54
Well Preserved	50	62	66	34	32	6	4	7	29	31	46	25
Indeterminable pollen preservation												
Amorphous	4	4	7	5	1	1	3	1	5	4	8	2
Corroded	2	1	1	2	0	0	0	0	3	1	0	1
Broken	5	3	7	5	3	0	0	2	3	4	1	3
Folded	5	0	7	6	3	1	2	2	3	11	7	2
Concealed	5	2	1	5	4	0	1	1	7	10	7	1
Unknown Grains	0	0	0	0	0	0	0	1	3	1	0	3

Depth cm	**734**	**726**	**718**	**710**	**702**	**694**	**686**	**678**	**670**	**662**	**654**
Altitude m OD	**-1.95**	**-1.87**	**-1.79**	**-1.71**	**-1.63**	**-1.55**	**-1.47**	**-1.39**	**-1.31**	**-1.23**	**-1.15**
Trees											
Picea	0	0	0	0	0	0	0	0	0	0	0
Pinus sylvestris	0	0	5	0	4	2	3	0	6	6	3
Taxus baccata	0	0	0	0	0	0	0	0	0	0	0
Ulmus	1	1	1	3	0	2	2	0	0	0	0
Fagus sylvatica	0	0	1	0	0	0	0	0	0	0	0
Quercus	5	8	14	9	13	12	5	4	7	6	3
Betula	0	0	0	0	0	2	1	0	1	0	1
Alnus glutinosa	75	56	16	34	26	63	25	22	15	22	11
Carpinus betulus	0	0	0	0	0	0	0	0	0	0	0
Tilia cordata	1	0	2	2	0	0	2	0	1	0	1
Populus	0	0	0	0	0	0	0	0	0	0	0
Acer campestre	0	1	0	0	0	0	0	0	0	0	0
Fraxinus excelsior	1	0	1	0	1	7	2	0	0	0	0
Shrubs											
Corylus avellana-type	5	11	9	9	9	5	7	7	16	18	12
Salix	0	0	0	1	0	0	0	3	0	0	1
Ericaceae	0	0	0	0	0	0	0	0	0	0	0
Rubus undiff.	0	0	0	0	0	0	0	1	0	0	0
Rosa	0	0	0	0	0	0	0	0	0	0	0
Viscum album	0	0	0	0	0	0	0	0	0	0	0
Rhamnus cathartica	0	0	0	0	0	0	0	0	0	0	0
Hedera helix	1	0	0	2	0	0	0	2	0	0	0
Viburnum opulus	0	0	0	0	0	0	0	0	0	0	0
Lonicera periclymenum	0	0	0	0	0	0	0	0	0	0	0
Herbs											
Ranunculaceae	0	0	0	0	0	0	1	0	0	0	0
Caltha palustris-type	0	0	0	0	0	0	0	0	0	0	0
Papaver rhoeas-type	0	0	0	0	0	0	0	0	0	0	0
Glaucium flavum	0	0	0	0	0	0	2	0	0	0	0
Humulus lupulus	0	0	0	0	0	0	0	0	0	0	0
Chenopodiaceae	1	4	2	1	0	5	3	6	3	7	5
Caryophyllaceae	0	0	0	1	0	0	0	0	0	1	0
Cerastium-type	0	0	0	0	0	0	0	0	0	0	0
Sagina	0	0	0	1	0	0	0	0	0	0	0
Persicaria maculosa-type	0	0	2	0	0	0	0	0	0	0	0
Rumex acetosa	0	1	0	0	0	0	0	0	0	0	0
Rumex obtusifolius-type	0	0	0	0	0	0	0	0	0	0	0
Rumex sanguineus-type	0	0	1	0	0	0	0	0	0	0	0
Limonium	0	0	0	0	0	0	2	0	0	0	0
Brassicaceae	0	0	0	0	1	0	3	3	0	1	1
Saxifraga granulata-type	0	0	0	0	0	0	0	0	0	0	0
Rosaceae	0	0	0	1	0	0	0	0	0	0	0
Filipendula	1	0	1	0	0	0	0	0	0	0	0
Alchemilla-type	0	0	0	0	0	0	0	0	0	0	0
Vicia sylvatica-type	0	0	0	0	0	0	2	0	0	0	0
Apiaceae	0	1	0	0	0	0	1	1	0	0	0
Plantaginaceae	1	4	3	1	3	0	2	2	2	1	3
Plantago coronopus	0	0	0	0	0	0	0	0	0	0	0
Plantago maritima	0	0	0	0	0	0	0	1	1	0	0
Plantago lanceolata	2	1	1	4	1	0	0	0	1	0	0
Scrophulariaceae	0	0	0	0	0	0	0	0	0	0	0
Rubiaceae	0	0	0	1	0	0	0	0	0	0	0
Valerianella	0	0	0	0	0	0	0	0	0	0	0
Valeriana officinalis	0	0	0	0	0	0	1	0	0	0	0
Arctium-type	0	0	0	0	0	0	0	0	0	0	0
Cirsium-type	0	0	0	0	0	0	0	0	0	0	0
Lactuceae	0	0	0	0	0	0	0	7	2	5	2
Cichorium intybus-type	0	0	1	1	1	0	0	0	0	0	0
Tragopogon pratensis	0	0	1	0	0	0	0	0	0	0	0
Sonchus	0	0	0	0	0	0	0	0	0	0	0
Mycelis muralis-type	0	0	0	0	0	1	0	0	0	0	0
Asteroideae	0	0	0	0	0	0	0	0	0	0	0
Solidago virgaurea-type	0	1	1	2	0	0	0	9	1	1	3

Depth cm	**734**	**726**	**718**	**710**	**702**	**694**	**686**	**678**	**670**	**662**	**654**
Altitude m OD	**-1.95**	**-1.87**	**-1.79**	**-1.71**	**-1.63**	**-1.55**	**-1.47**	**-1.39**	**-1.31**	**-1.23**	**-1.15**
Artemisia-type	0	0	0	1	0	0	0	0	0	0	0
Achillea-type	0	0	0	0	0	0	0	0	1	0	1
Iris	0	0	0	0	0	0	0	0	0	0	0
Cyperaceae undiff.	0	1	5	12	1	6	16	27	3	3	21
Poaceae undiff.	10	12	29	34	8	12	30	50	37	32	46
Avena-type	0	0	0	0	0	0	0	0	0	0	0
Hordeum-type	0	0	0	0	0	0	0	0	0	0	0
Cerealia undiff.	0	1	2	3	0	0	1	0	1	0	1
Aquatics											
Nymphaea alba	0	0	0	0	0	0	0	0	0	0	0
Myriophyllum spicatum	0	0	0	0	0	0	0	0	0	0	0
Callitriche	0	0	0	0	0	0	0	0	0	0	0
Sagittaria sagittifolia	0	1	0	0	0	0	0	0	0	0	0
Potamogeton natans-type	0	0	0	1	0	0	1	0	1	3	1
Sparganium emersum-type	0	0	0	0	0	0	0	0	0	0	0
Typha latifolia	0	0	1	0	0	0	0	0	0	0	0
Spores											
Isoetes histrix	0	0	0	0	0	0	0	0	0	0	0
Polypodium	1	1	1	0	1	0	1	2	1	1	0
Pteridium aquilinum	7	10	11	19	21	8	7	8	2	5	13
Dryopteris filix-mas-type	0	0	0	0	0	0	0	0	0	0	0
Pteropsida (monolete) indet.	2	5	3	7	11	25	30	108	8	4	7
Pteropsida (trilete) indet.	0	0	0	0	0	0	0	0	0	0	0
Sphagnum	0	0	0	0	0	0	0	0	0	1	1
Pre-Quaternary Spores	0	1	0	0	0	0	0	0	2	0	0
Summary											
Trees	83	66	40	48	44	88	40	26	30	34	19
Shrubs	6	11	9	12	9	5	7	13	16	18	13
Herbs	15	26	49	63	15	24	64	106	52	51	83
Aquatics	0	1	1	1	0	0	1	0	1	3	1
Spores	10	17	15	26	33	33	38	118	13	11	21
Total Land Pollen	**104**	**103**	**98**	**123**	**68**	**117**	**111**	**145**	**98**	**103**	**115**
Total Pollen + Spores	**114**	**121**	**114**	**150**	**101**	**150**	**150**	**263**	**112**	**117**	**137**
Total traverses	**1**	**3**	**4**	**4**	**10**	**2**	**2**	**2**	**1**	**2**	**4**
Pollen and charcoal concentration											
Pollen concentration/cm3*1000	142.20	59.25	57.49	65.83	29.84	107.73	151.28	148.41	67.71	40.48	40.59
Charcoal concentration /cm3*1000	3.74	15.80	29.25	37.31	15.80	16.52	45.38	12.41	81.26	112.10	175.68
Determinable pollen preservation											
Amorphous	13	9	3	16	9	12	22	29	31	57	44
Corroded	20	9	6	3	14	14	9	13	5	5	4
Broken	13	14	29	22	22	32	15	34	13	5	20
Folded	44	52	39	66	39	52	81	152	48	37	62
Well Preserved	24	36	37	42	17	40	23	35	13	13	7
Indeterminable pollen preservation											
Amorphous	0	2	2	0	5	4	3	4	0	15	4
Corroded	0	0	1	1	0	2	0	4	0	0	1
Broken	1	2	5	8	0	2	12	4	1	4	7
Folded	1	2	5	5	5	4	8	31	3	8	13
Concealed	2	2	5	11	4	3	1	14	0	2	3
Unknown Grains	0	0	2	1	2	4	1	3	9	0	5

Depth cm	**646**	**638**	**626**	**618**	**610**	**600**	**592**	**584**	**576**	**556**
Altitude m OD	**-1.07**	**-0.99**	**-0.87**	**-0.79**	**-0.71**	**-0.61**	**-0.53**	**-0.45**	**-0.37**	**-0.17**
Trees										
Picea	0	0	0	0	0	0	0	0	0	0
Pinus sylvestris	4	8	5	0	7	3	3	0	8	7
Taxus baccata	0	0	0	2	0	0	0	0	0	0
Ulmus	0	0	0	1	1	0	2	3	1	0
Fagus sylvatica	0	0	0	1	1	0	0	1	1	0
Quercus	3	5	2	2	3	1	11	4	6	4
Betula	1	2	0	0	0	0	0	0	1	1
Alnus glutinosa	3	7	2	2	2	10	30	16	9	10
Carpinus betulus	0	0	0	0	0	0	0	0	2	0
Tilia cordata	2	0	0	0	2	2	0	0	0	0
Populus	1	0	0	0	0	0	0	0	0	0
Acer campestre	0	0	0	0	0	0	0	0	0	0
Fraxinus excelsior	0	1	0	0	0	0	0	0	0	1
Shrubs										
Corylus avellana-type	16	8	5	2	5	7	15	11	7	11
Salix	0	0	0	0	0	0	0	0	0	0
Ericaceae	0	0	0	0	0	0	1	0	0	0
Rubus undiff.	0	0	0	0	0	0	0	0	0	0
Rosa	0	0	0	0	0	0	0	0	0	0
Viscum album	0	0	0	0	0	0	0	0	0	0
Rhamnus cathartica	0	0	0	0	0	0	0	0	0	0
Hedera helix	0	1	0	0	0	0	0	0	0	0
Viburnum opulus	0	0	0	0	0	0	0	0	0	0
Lonicera periclymenum	0	0	0	0	0	0	0	0	0	0
Herbs										
Ranunculaceae	0	0	0	0	1	3	0	2	0	0
Caltha palustris-type	0	0	0	0	0	0	0	0	0	0
Papaver rhoeas-type	0	0	1	0	0	0	0	0	0	0
Glaucium flavum	0	0	0	0	0	0	0	0	0	0
Humulus lupulus	0	0	0	0	0	0	0	0	0	0
Chenopodiaceae	5	3	7	9	4	5	8	9	5	9
Caryophyllaceae	0	2	0	0	0	0	0	0	0	0
Cerastium-type	0	3	0	0	0	0	0	0	0	0
Sagina	0	0	0	0	0	0	0	0	0	0
Persicaria maculosa-type	0	0	0	0	0	0	0	0	0	0
Rumex acetosa	0	0	0	0	0	0	1	0	0	0
Rumex obtusifolius-type	0	0	0	0	0	0	0	0	0	0
Rumex sanguineus-type	0	0	0	0	0	0	0	0	0	0
Limonium	0	0	0	0	0	1	0	0	0	0
Brassicaceae	0	9	40	32	13	37	12	11	8	4
Saxifraga granulata-type	0	0	0	0	0	0	0	0	0	0
Rosaceae	0	0	0	0	0	0	0	0	0	0
Filipendula	0	0	0	0	0	0	0	0	0	0
Alchemilla-type	0	0	0	0	0	0	0	0	0	0
Vicia sylvatica-type	0	0	0	0	0	0	0	0	0	0
Apiaceae	0	0	0	0	0	0	0	0	0	0
Plantaginaceae	0	0	0	6	2	1	2	0	0	0
Plantago coronopus	0	0	0	0	0	0	0	0	0	0
Plantago maritima	0	1	0	0	0	0	0	0	0	0
Plantago lanceolata	0	0	0	0	0	0	0	0	1	0
Scrophulariaceae	0	0	0	0	0	0	0	0	0	0
Rubiaceae	0	0	0	0	0	0	0	0	0	0
Valerianella	0	0	1	0	0	0	0	0	0	0
Valeriana officinalis	0	0	0	0	0	0	0	0	0	0
Arctium-type	0	0	0	0	0	0	0	0	0	0
Cirsium-type	1	0	0	0	0	0	0	0	0	0
Lactuceae	8	3	6	7	8	7	5	3	4	12
Cichorium intybus-type	0	0	0	0	0	0	0	0	0	0
Tragopogon pratensis	0	0	0	0	0	0	0	0	0	0
Sonchus	0	0	4	0	0	0	0	0	0	0
Mycelis muralis-type	0	0	0	0	2	0	0	0	0	1
Asteroideae	7	0	0	0	0	0	0	0	0	0
Solidago virgaurea-type	0	0	0	2	3	3	2	5	5	2

Depth cm	**646**	**638**	**626**	**618**	**610**	**600**	**592**	**584**	**576**	**556**
Altitude m OD	**-1.07**	**-0.99**	**-0.87**	**-0.79**	**-0.71**	**-0.61**	**-0.53**	**-0.45**	**-0.37**	**-0.17**
Artemisia-type	0	0	0	0	0	0	0	0	0	0
Achillea-type	0	1	2	2	0	0	1	1	1	0
Iris	0	0	0	0	0	0	0	0	0	0
Cyperaceae undiff.	35	12	25	9	22	9	10	11	15	11
Poaceae undiff.	53	44	22	32	30	21	27	32	37	41
Avena-type	1	0	1	0	1	0	0	0	0	0
Hordeum-type	0	0	2	0	0	0	0	0	0	0
Cerealia undiff.	3	2	1	0	0	0	0	0	6	1
Aquatics										
Nymphaea alba	0	0	0	0	0	0	0	0	0	0
Myriophyllum spicatum	0	0	0	0	0	0	0	0	0	0
Callitriche	0	0	0	0	0	0	0	0	0	0
Sagittaria sagittifolia	0	0	0	0	0	0	0	0	0	0
Potamogeton natans-type	2	0	1	0	0	7	0	0	0	0
Sparganium emersum-type	0	0	0	0	2	12	46	93	91	81
Typha latifolia	3	2	0	0	3	0	1	3	2	0
Spores										
Isoetes histrix	0	0	0	0	0	0	0	0	0	0
Polypodium	0	1	1	0	0	0	1	0	0	0
Pteridium aquilinum	10	11	9	3	20	9	4	6	15	18
Dryopteris filix-mas-type	0	0	0	0	0	0	0	0	0	0
Pteropsida (monolete) indet.	20	7	11	8	10	10	9	3	9	6
Pteropsida (trilete) indet.	0	0	0	0	0	0	0	0	0	0
Sphagnum	0	0	0	0	0	0	0	0	0	0
Pre-Quaternary Spores	0	0	0	0	0	1	0	2	0	0
Summary										
Trees	14	23	9	8	16	16	46	24	28	23
Shrubs	16	9	5	2	5	7	16	11	7	11
Herbs	113	80	112	99	86	87	68	74	82	81
Aquatics	5	2	1	0	5	19	47	96	93	81
Spores	30	19	21	11	30	20	14	11	24	24
Total Land Pollen	**143**	**112**	**126**	**109**	**107**	**110**	**130**	**109**	**117**	**115**
Total Pollen + Spores	**178**	**133**	**148**	**120**	**142**	**149**	**191**	**216**	**234**	**220**
Total traverses	**3**	**4**	**3**	**5**	**7**	**2**	**3**	**3**	**4**	**4**
Pollen and charcoal concentration										
Pollen concentration/cm3*1000	44.88	26.94	56.12	48.20	49.86	71.58	55.20	128.40	94.00	53.20
Charcoal concentration /cm3*1000	148.50	107.56	150.16	120.51	153.79	121.40	100.29	222.00	143.00	84.64
Determinable pollen preservation										
Amorphous	74	33	36	22	17	13	21	19	29	42
Corroded	3	1	3	2	3	3	18	8	7	9
Broken	20	23	29	15	25	19	19	24	54	26
Folded	70	73	69	75	87	94	101	139	114	128
Well Preserved	11	3	11	6	10	19	31	25	29	15
Indeterminable pollen preservation										
Amorphous	36	12	3	5	11	5	8	10	12	11
Corroded	2	2	0	0	2	1	1	1	3	2
Broken	6	5	5	7	15	6	11	13	9	12
Folded	23	13	9	24	24	18	11	5	8	19
Concealed	1	2	2	2	6	11	5	0	4	0
Unknown Grains	1	3	1	4	2	2	1	4	0	3

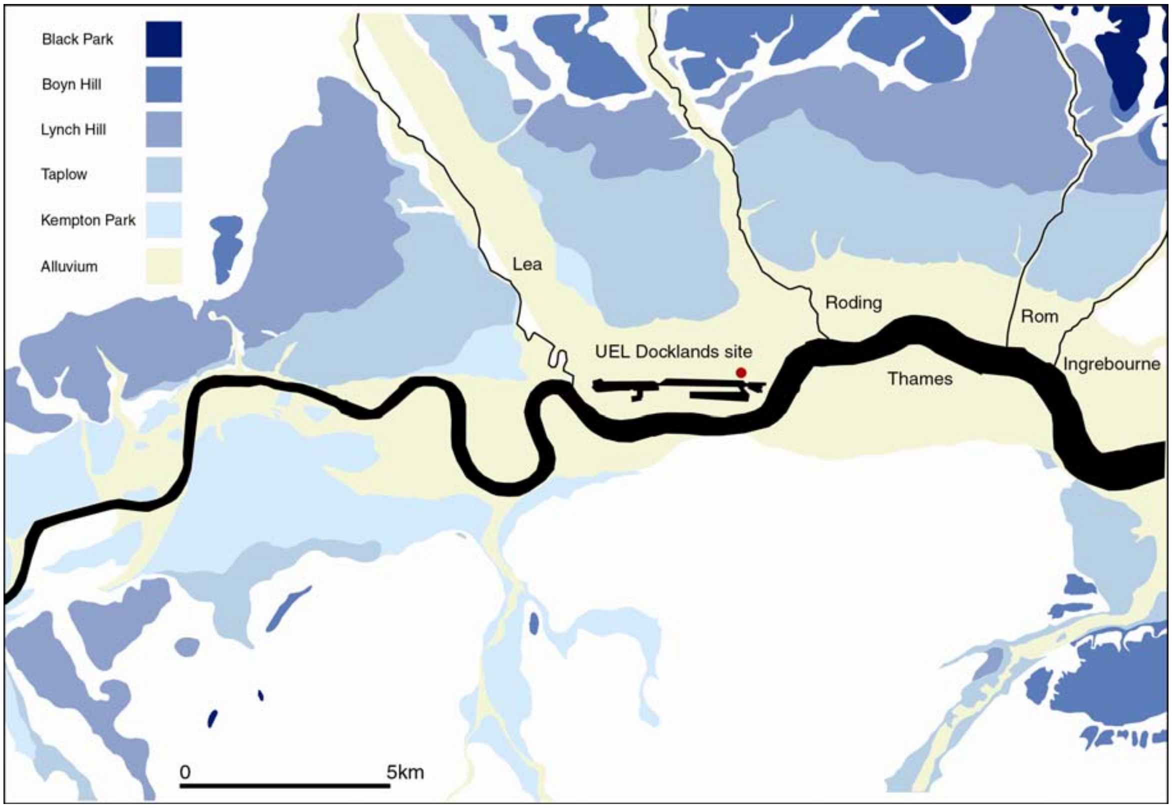

Fig. 1. Location map showing the position of the University of East London Docklands site in the context of the Thames terrace system. Based on Bridgland (1994) and Geological Survey Maps 256, 257, 270 and 271

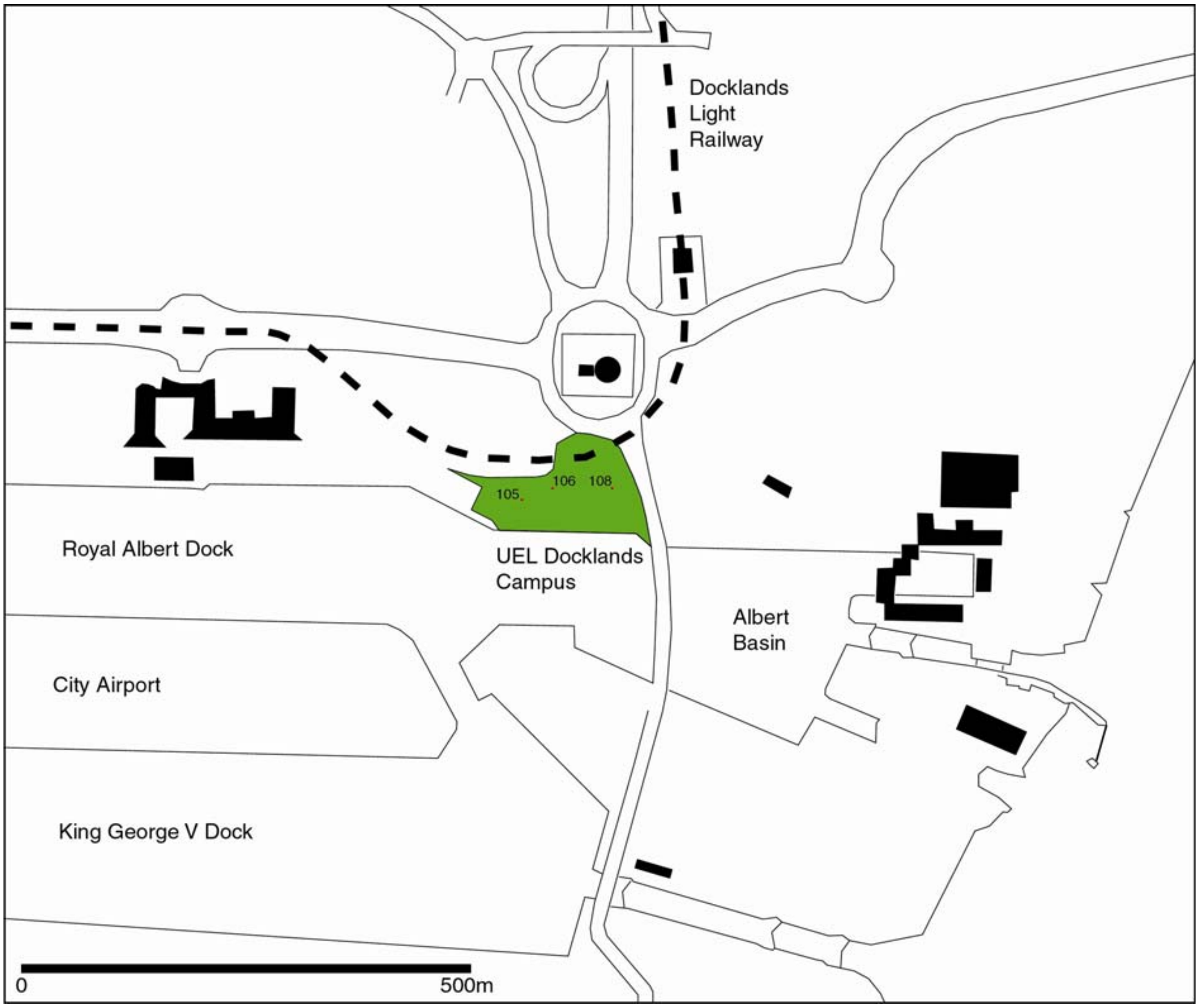

Fig. 2. Location of the University of East London Docklands Campus site at the east end of the Royal Albert Dock, showing the positions of Boreholes 105, 106 and 108

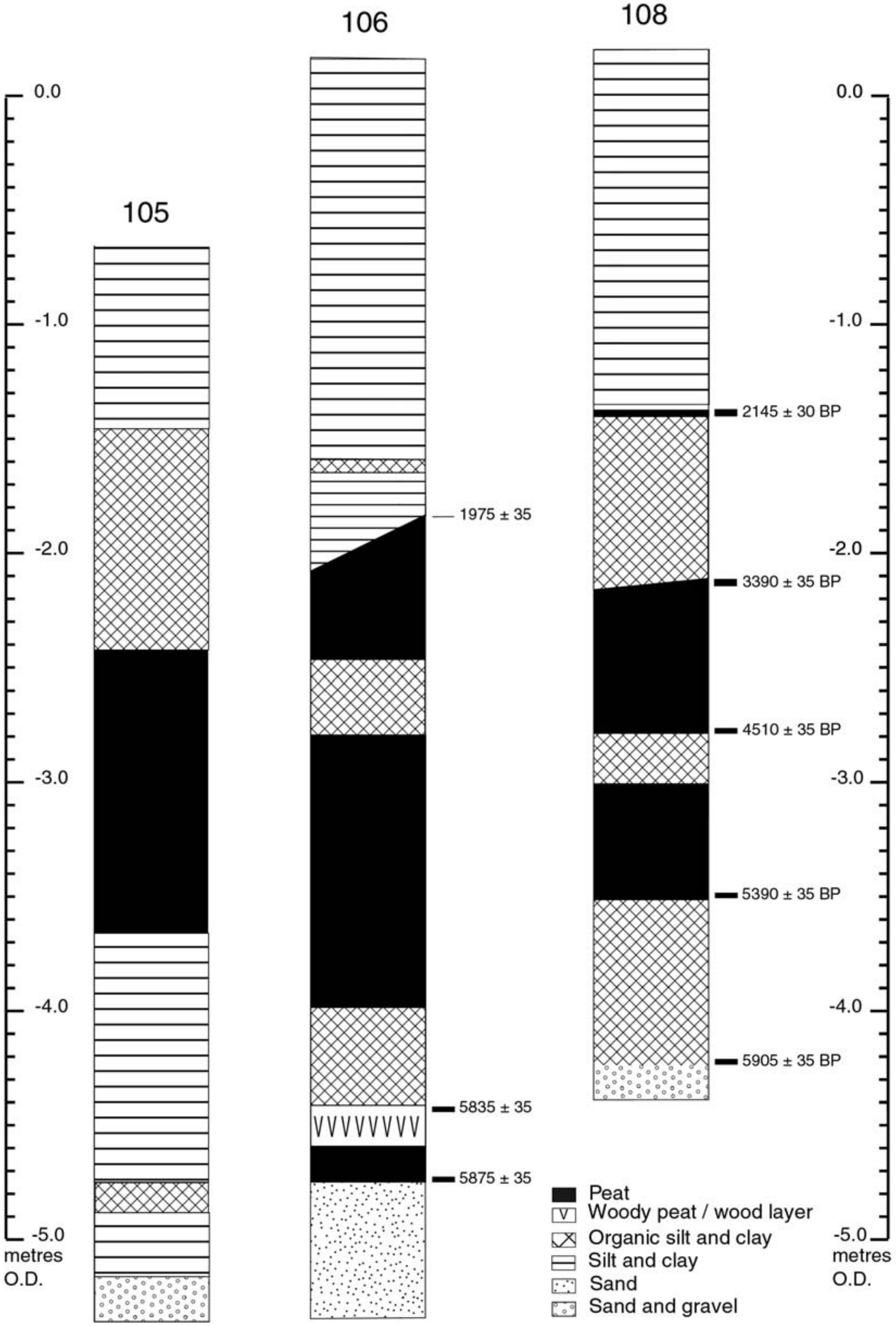

Fig. 3. Generalised stratigraphy and location of radiocarbon dates (^{14}C yrs B.P.)

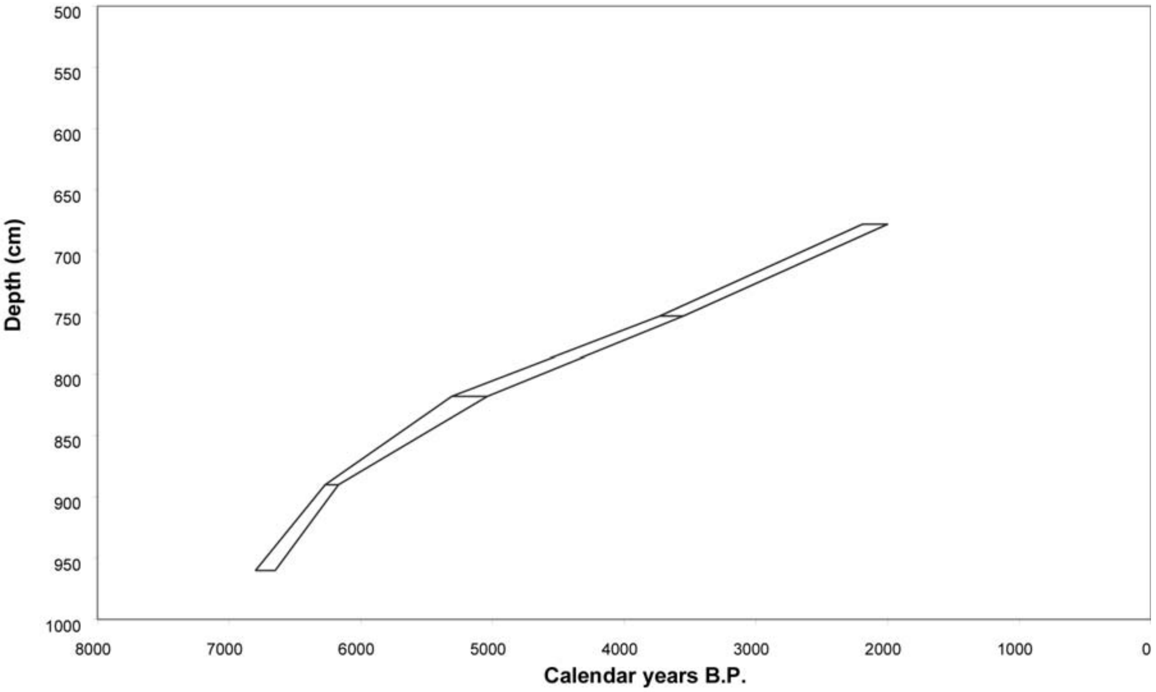

Fig. 4. Age-depth profile of borehole 108. Horizontal bars are the calendar age limits for each date given in Table 4

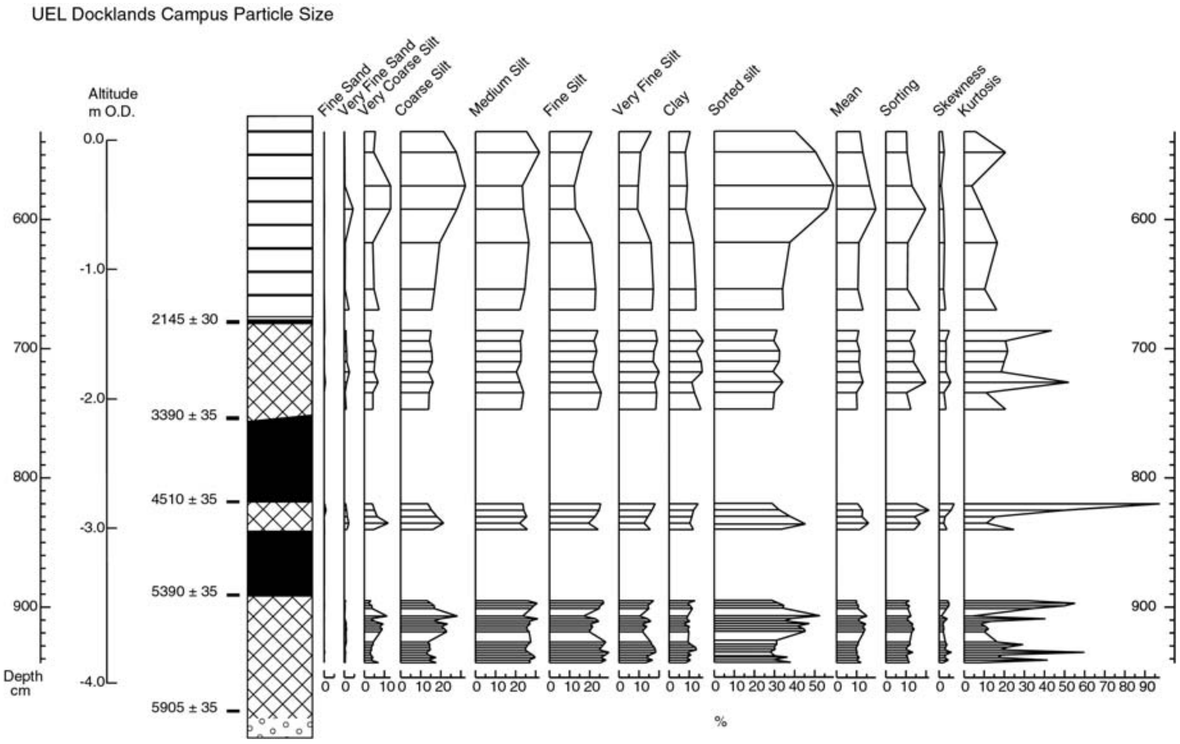

Fig. 4a Particle size classes for individual samples

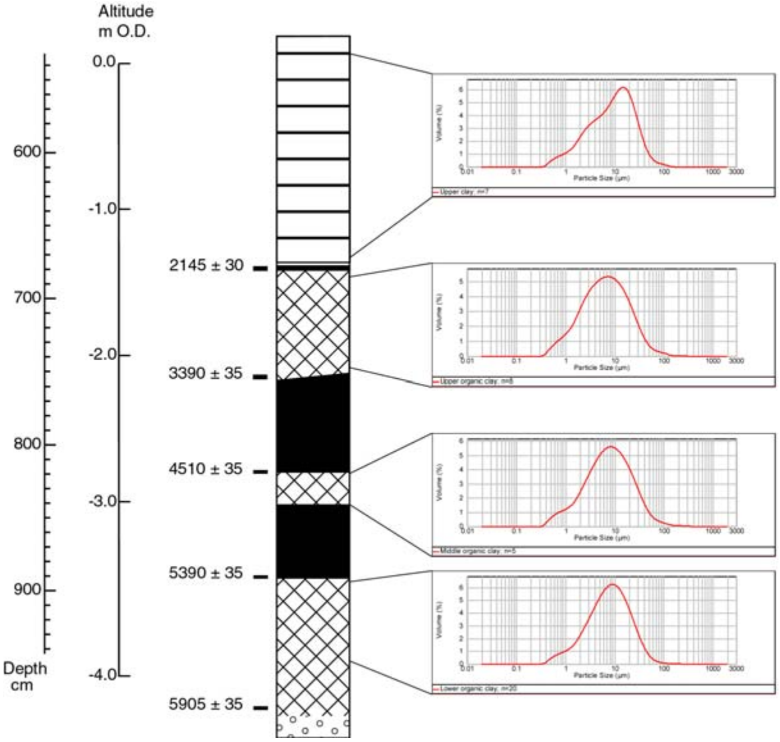

Fig. 4b Average particle size distribution curves for each minerogenic layer

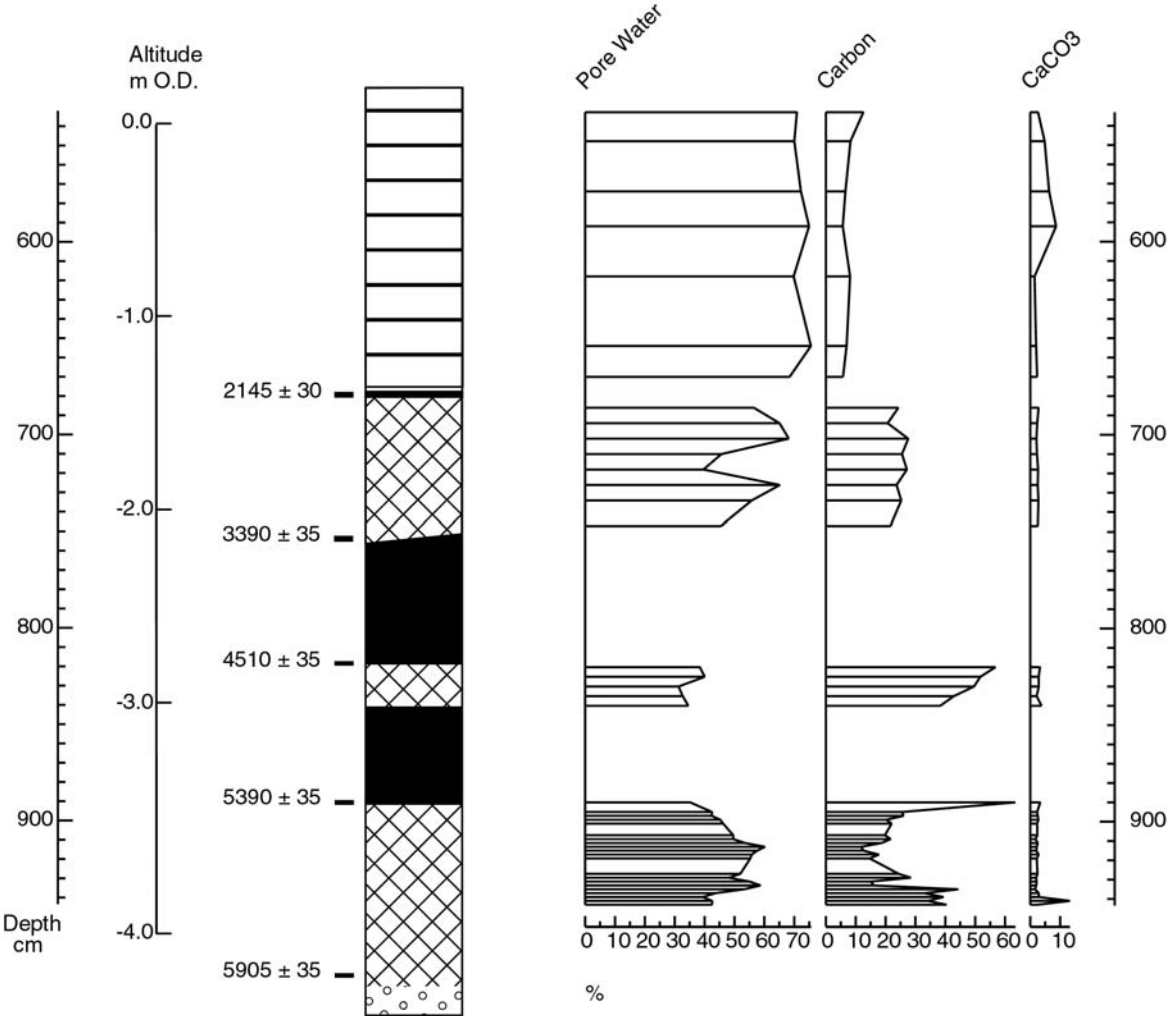

Fig. 5. % Pore Water, Carbon and $CaCO_3$ for individual samples

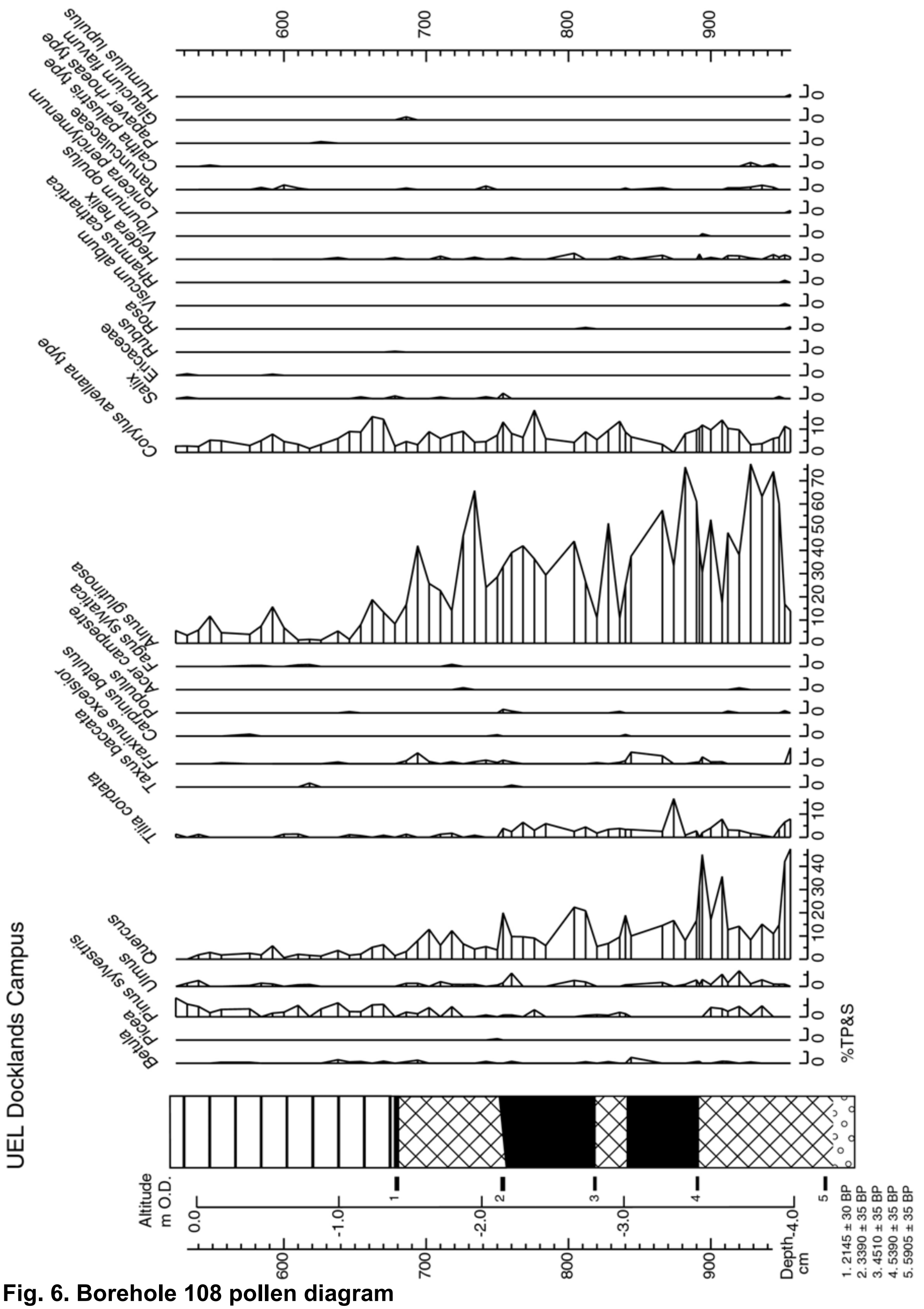

Fig. 6. Borehole 108 pollen diagram

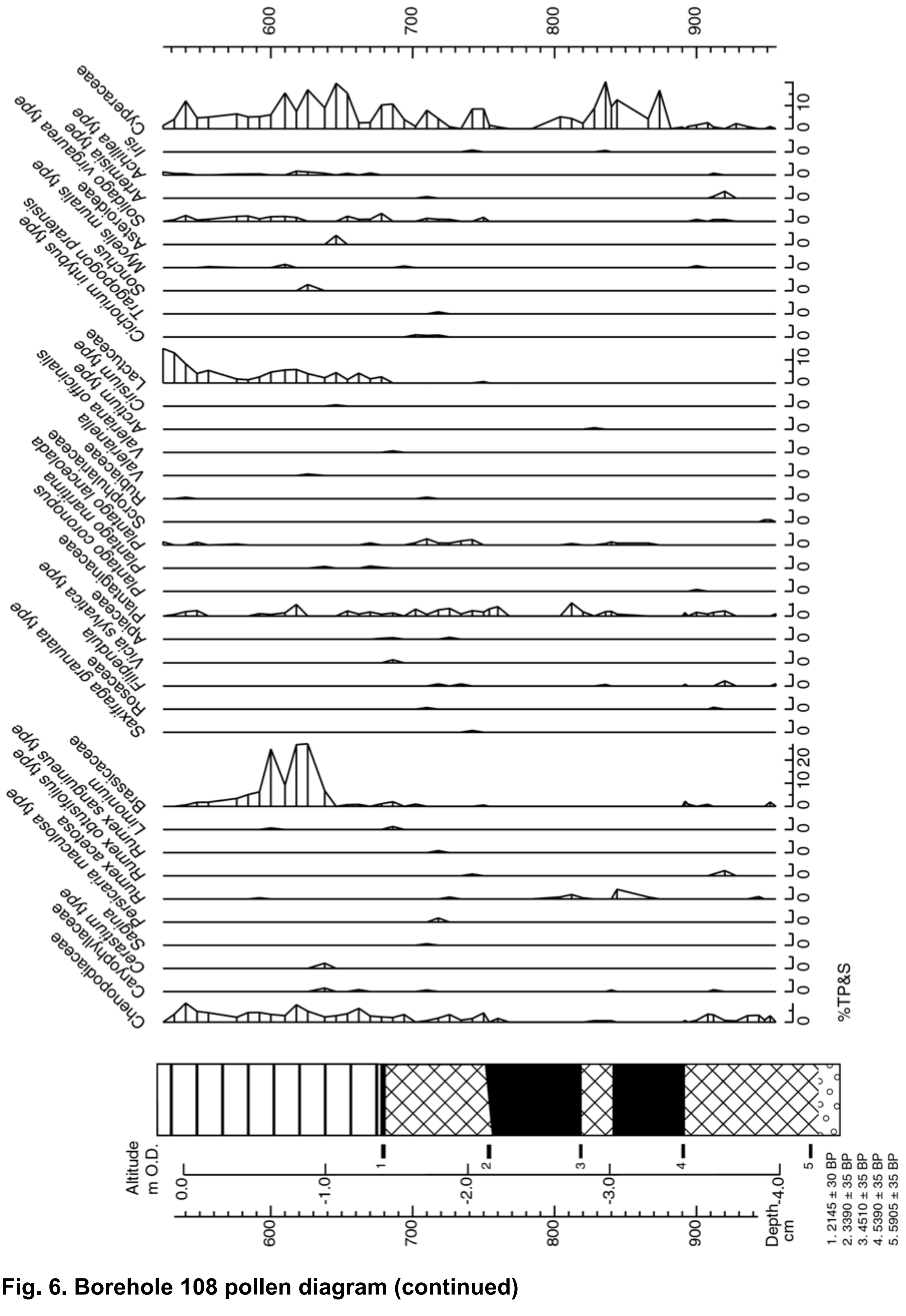

Fig. 6. Borehole 108 pollen diagram (continued)

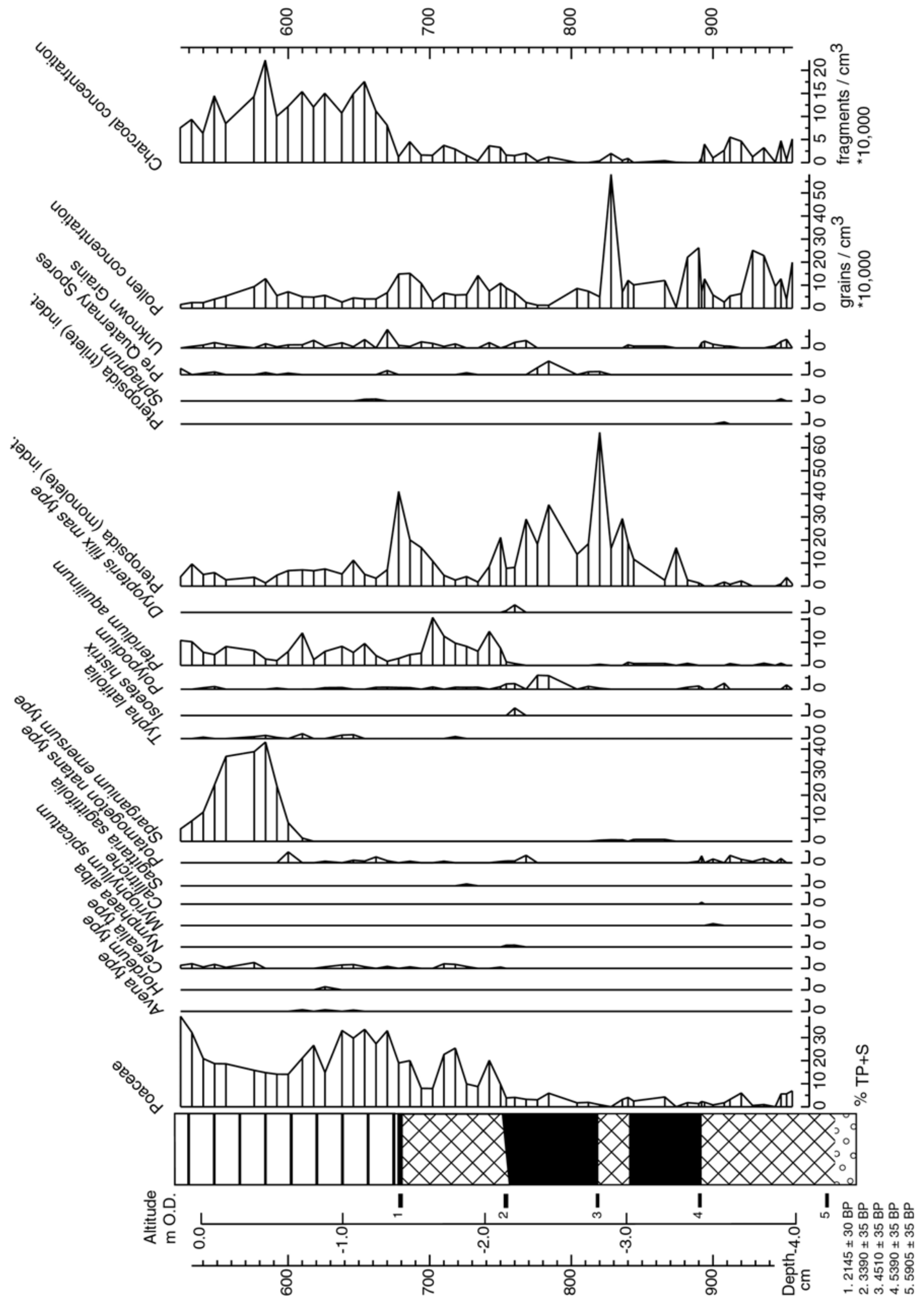

Fig. 6. Borehole 108 pollen diagram (continued)

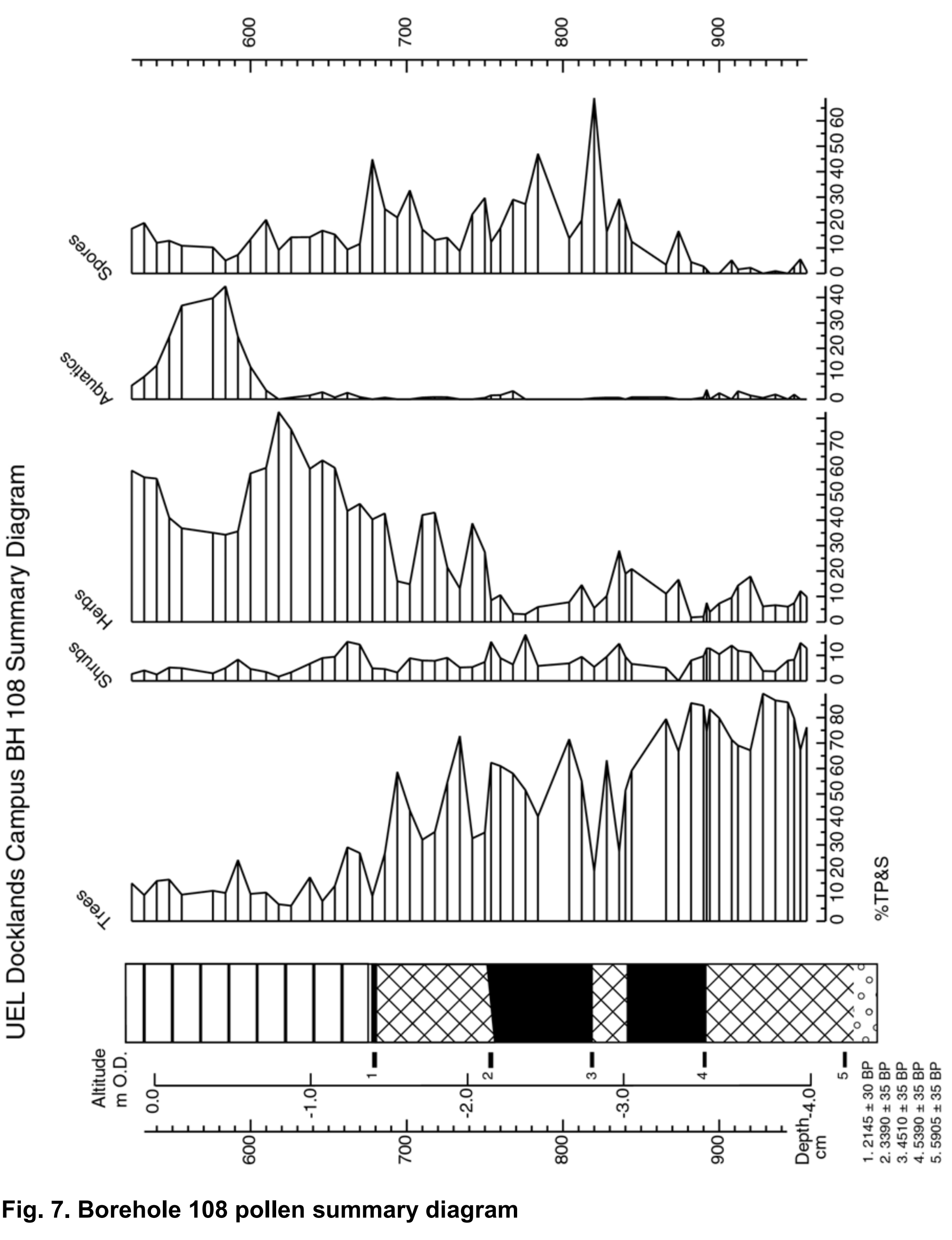

Fig. 7. Borehole 108 pollen summary diagram

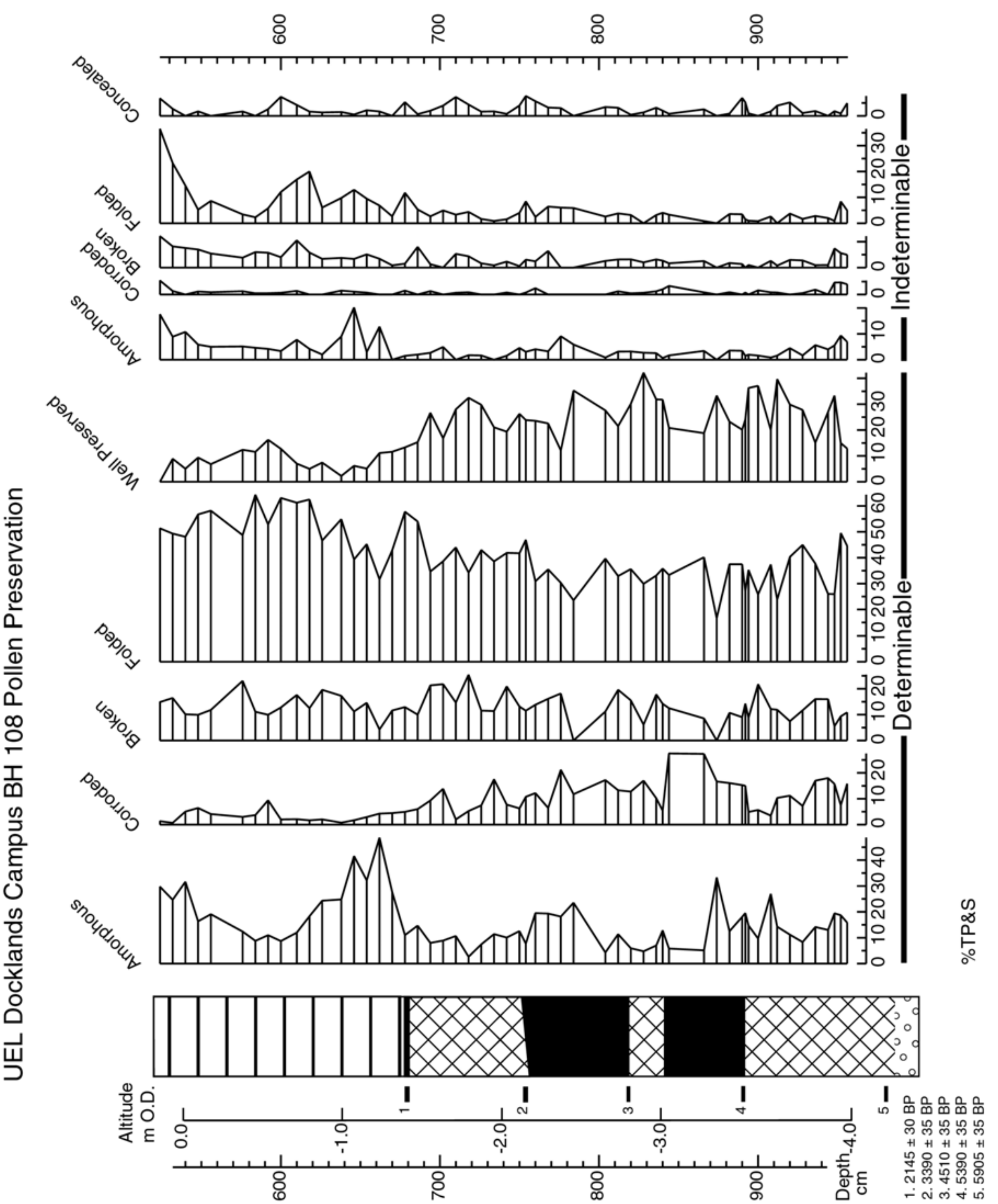

Fig. 8. Borehole 108 pollen preservation diagram

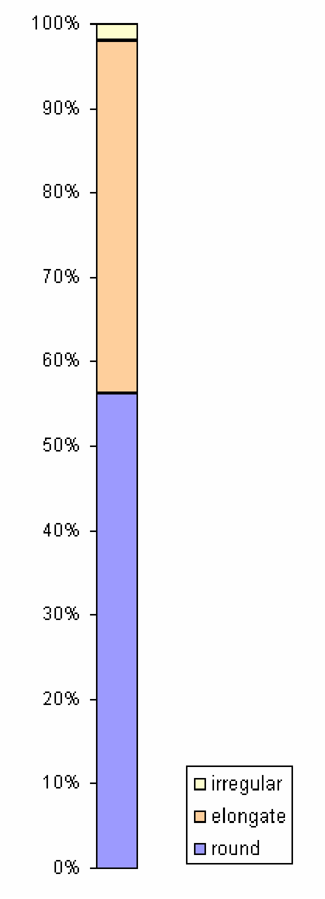

Fig. 9. Sieve pore shape analysis for *Cyprideis torosa*

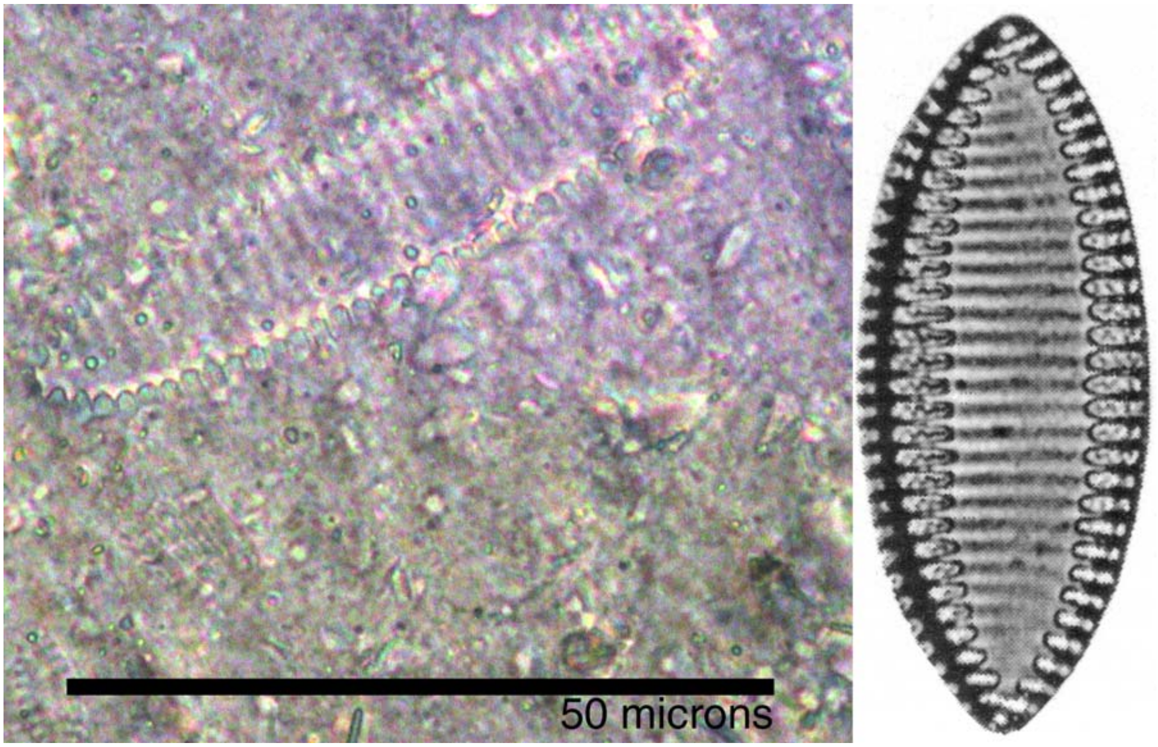

Plate 1. Example of a degraded valve of *Nitzschia navicularis*

Plate 2. A sponge spicule fragment

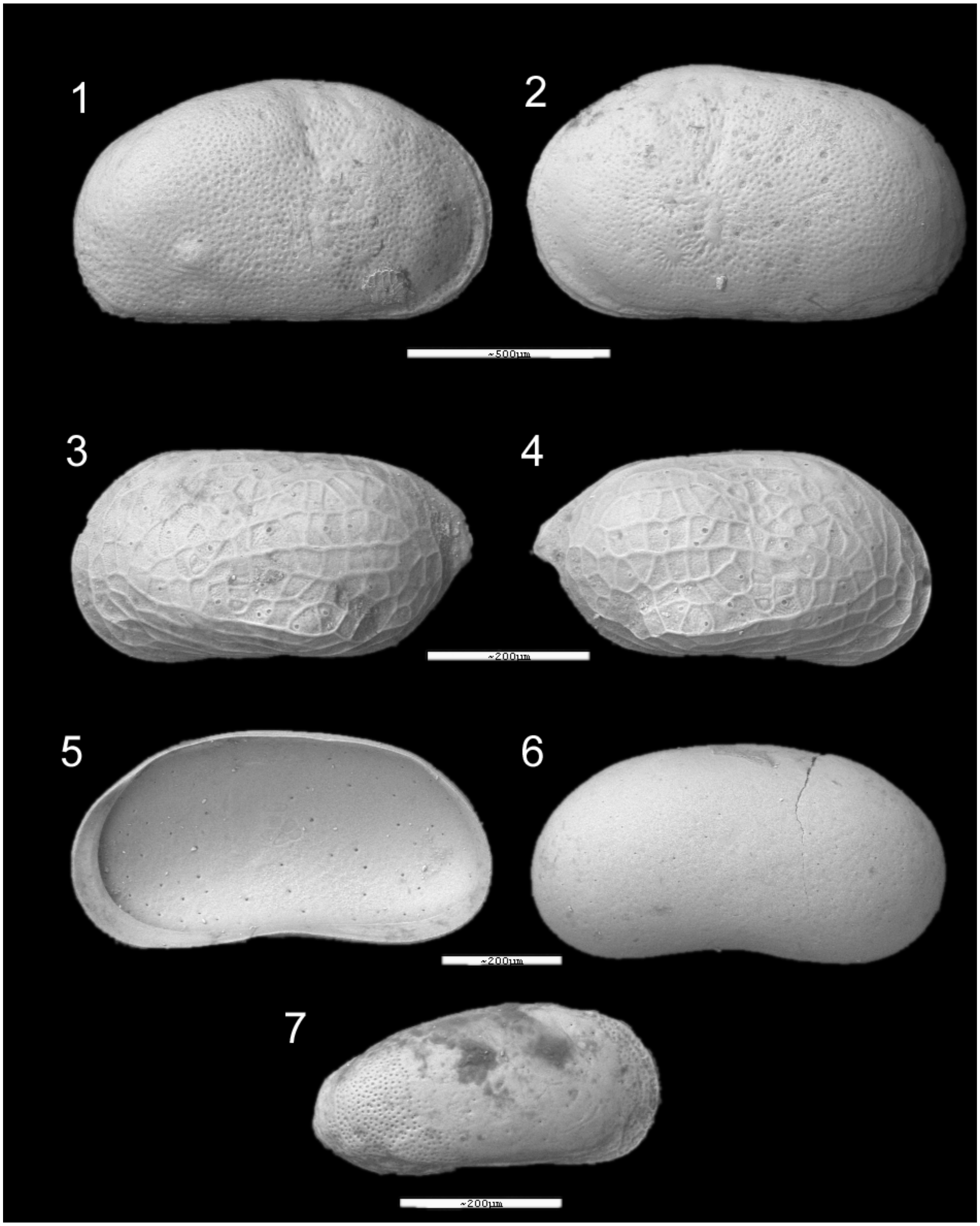

Plate 3. Ostracods

1-2. *Cyprideis torosa* (Jones 1850): 1, right valve; 2, left valve; scale bar 500μm.

3-4. *Cytherura gibba* (O.F Müller, 1785): 3, left valve; 4, right valve; scale bar 200 μm.

5-6. *Candona* ex gr. *candida* (O.F Müller, 1776): 5, right valve internal; 6 right valve external; scale bar 200 μm.

7. *Leptocythere* sp. right valve, juvenile; scale bar 200 μm.