Wessex Archaeology

Lynn and Inner Dowsing Offshore Wind Farms

Stage 3 Subsample Assessment

Ref: 59094.02

March 2007

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Stage 3 Subsample Assessment

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Centrica Renewable Energy Limited

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Summary

Wessex Archaeology was commissioned by AMEC Wind Energy, on behalf of Centrica Renewable Energy Limited, to undertake a Stage 3 subsample assessment of samples taken from borehole BHID25. The samples have been assessed for pollen, diatoms, foraminifera and ostracods. Stage 4 work is recommended.

Diatoms and foraminifera were not present in significant quantities, however pollen and ostracods were recovered in sufficient numbers for assessment. The pollen was indicative of a generally open herbaceous environment including pine, birch, sedges and grasses, surrounding a freshwater depositional environment indicative of a cold stage within the Pleistocene. The ostracods indicate the depositional environment to be on the fringes of a glacial lake.

Four major sedimentary units were identified during the Stage 1 and Stage 2 assessments. **Unit 4**, Chalk is overlain by Pleistocene sediments, **Unit 3**, **Unit 2** and **Unit 1**. Biostratigraphic marker species of ostracods including "*Leucocythere batesi*" and *Limnocythere falcata* suggest that deposition of the lowest part of **Unit 2** occurred during a cold stage between the Hoxnian and Devensian periods. The presence of *Picea* (spruce) may indicate that the sediments are no later than the earlier part of the Devensian. This would restrict the time frame of deposition of these sediments to approximately 380ka to 70ka which would correspond to the Lower and Middle Palaeolithic archaeological periods.

OSL (Optically Stimulated Luminescence) dating of these sediments would potentially refine this dating further. Further coring would be required in order to obtain a suitable sample. If this is the case then sediments identified by the Stage 1 assessment but not available for Stage 2 and Stage 3 assessment should also be investigated for their archaeological potential.

Stage 4 work is recommended. If no further coring is undertaken then analysis of pollen and ostracods is recommended, including more tightly spaced samples from within Unit 2. This should identify any subtle changes within these sediments and provide a sound basis for publication of the results in a suitable journal.

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Acknowledgements

This assessment was commissioned by AMEC Wind Energy on behalf of Centrica Renewable Energy Limited. Jack Russell carried out the foraminifera and ostracod assessments and compiled this report. Dr Robert Scaife carried out the pollen and diatom assessments. John Gribble managed the project for Wessex Archaeology.

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Stage 3 Subsample assessment

1. INTRODUCTION

1.1. PROJECT BACKGROUND

1.1.1. Wessex Archaeology (WA) was commissioned by AMEC Wind Energy, on behalf of Centrica Renewable Energy Limited, to undertake the Stage 3 subsample assessment of samples taken from borehole BHID25, collected during the geotechnical surveys for the proposed Lynn and Inner Dowsing Offshore Wind Farms.

1.1.2. The core logs generated by the geotechnical contractors for these vibrocores and borehole cores were assessed by WA in 2005 during a Stage 1 desk-based assessment. This Stage 1 assessment established the likely presence of horizons of archaeological interest within the cores, broadly characterised them and recommended that Stage 2 archaeological recording was required (WA 2005).

1.1.3. Stage 2 archaeological recording of selected cores entailed the splitting of the cores, with half of each core being cleaned and recorded. The Stage 2 report described the results of the archaeological recording and indicated Stage 3 work was warranted (WA 2006).

1.2. CHARACTERISTICS OF THE AREA

1.2.1. The sedimentary sequence of the area set out in WA 2005 and WA 2006 can be summarised as follows:

- **Unit 1**: Recent seabed sediments: brown gravelly sand or sandy gravel, with shell inclusions and flint content.
- **Unit 2**: Glacial till: firm to stiff brown, sometimes speckled white, slightly sandy or gravelly clay; silty lenses.
- **Unit 3**: Glacial till: variation of sometimes clayey, sometimes silty sand and gravel layers.
- **Unit 4**: Bedrock: Chalk.

1.2.2. A blanket deposit of Devensian till, the Bolders Bank Formation, appears from available data to be the prevailing sediment near the seabed surface within the Lynn and Inner Dowsing Offshore Wind Farm areas. The formation is internally largely structureless on geological seismic profiles and consists of red-brown, calcareous, gravelly, sandy clay with erratics which are predominantly of chalk, red-brown sandstone and grey mudstone. The formation is up to 25m thick (BGS Sheet, Spurn).

1.2.3. Seismic profiles interpretation and micromorphological studies imply that the Bolders Bank Formation is a composite of subglacial and supraglacial deposits. It appears to be the lateral equivalent of the Hunstanton Till of East Anglia and the tills of Holderness north of Spurn Point, both of which it resembles lithologically (Cameron et al. 1992, 113; BGS Sheet, Spurn).

2. PROJECT AIMS AND OBJECTIVES

2.1. AIM

2.1.1. The aim of the Stage 3 subsample assessment of the cores was to assess the samples taken by WA for the presence and preservation of pollen, diatoms, ostracods and foraminifera.

2.2. OBJECTIVES

2.2.1. The objectives of the study were :

- to assess the potential of the sampled sediments to inform further on chronology, local and regional environments, hydrological regimes and potential archaeological layers;
- to assess the need for further work.

3. METHODOLOGY

3.1. INTRODUCTION

3.1.1. The subsampled sediments are from sedimentary **Unit 2** within borehole BHID25. This unit has been further subdivided into three subunits on the basis of the original borehole descriptions (Fugro 2004) and the archaeological descriptions (WA 2006):

Unit 2i. Grey sandy silty clay. 18.5m to 19.05m below OD

3.1.2. From the geotechnical description this unit would appear to have a maximum thickness of 0.55m and forms the base of **Unit 2**. A small section of **Unit 2i** (18.70m to 19.05m below OD) was archaeologically recorded (WA 2006). It is distinguished from **Unit 2ii** by dark, possibly organic bands (**Figure 1**).

Unit 2ii. Greyish brown sandy silty clay. 17.10m to 18.50m below OD

3.1.3. From the geotechnical descriptions (Fugro 2004) this unit would appear to have a maximum thickness of 1.4m in borehole BHID25. A short section of this unit (17.70m to 17.93m below OD) was available for archaeological recording (WA 2006). This unit is stratigraphically above **Unit 2i**. It is sedimentologically distinct from **Unit 2i** in that it lacks the dark, possibly organic bands and contains occasional chalk and flint inclusions (**Figure 1**).

Unit 2iii. Very dark greyish brown clay. 11.90m to 17.10m below OD

3.1.4. From the geotechnical descriptions (Fugro 2004) this unit would appear to have a maximum thickness of 5.2 metres in borehole BHID25. Three short sections (12.20m to 12.45m, 13.20m to 13.69m and 14.70m to 14.59m below OD) of this unit were

archaeologically recorded (WA 2006). This unit is stratigraphically above **Unit 2ii** and below **Unit 1** (**Figure 1**).

3.1.5. The table below describes the sediments and depths at which the subsamples were taken from within **Unit 2** in borehole BHID25:

Subsample Type: Pollen (p) Diatom (d) Foraminifera (f) Ostracod (o)	Depth of subsample below seabed (m)	Depth of subsample below OD (m)	Section of borehole below OD (m)	Description of sediments (WA 2006)
p,d	**0.54**	**12.24**	12.20 - 12.45	10YR 3/2 Very dark greyish brown clay, firm and stiff, with frequent chalk (2-10mm) and occasional flint inclusions (10-20mm). Big patch of white chalk at 12.28-12.39, firm and stiff. Big patch of yellowish brown, loose medium sand with big gravel inclusions (40mm) at 12.37-12.45. **Unit 2iii**
p,d	**1.89**	**13.59**	13.20 - 13.63	10YR 3/2 Very dark greyish brown clay, firm and stiff, occasionally slightly sandy, with frequent subrounded gravel inclusions (chalk, flint, red sandstone etc., 4-40mm) and rare tiny black (mineral?) flecks. **Snit 2iii**
p,d	**2.60**	**14.30**	14.20 - 14.59	10YR 3/2 Very dark greyish brown clay, firm and stiff, frequent subrounded gravel inclusions (chalk, flint etc., 5-45mm), rare small black (mineral?) flecks. **Unit 2iii**
p,d,f,o **p,d,f,o**	**6.08** **6.17**	**17.78** **17.87**	17.70 - 17.93	2.5Y 3/2 Very dark greyish brown sandy silty clay, firm and stiff, well sorted. No inclusions (apart from intrusive small chalk and flint particles at the sides). One brownish sandy band at 17.83-17.84. **Unit 2ii**
p,d,f,o **p,d,f,o** **p,d,f,o**	**7.05** **7.17** **7.30**	**18.75** **18.87** **19.00**	18.70 - 19.05	2.5Y 3/1 Very dark grey sandy silty clay, completely crossed by slightly arched horizontal black organic (?) bands (c.3mm wide), especially dense between 18.95 and 19.05. Well sorted, firm. **Unit 2i**

3.1.6. The sediments from which the samples were taken were from those sections made available for Stage 2 archaeological recording (WA 2006). **Figure 1** shows the positions of those sections which were made available and the positions of the samples assessed as part of this report.

3.1.7. The samples were chosen from sediments most likely to contain environmental indicators. In particular **Unit 2i**, the sediments with dark, possibly organic bands were investigated (7m-7.35m; 18.70m-19.35m below OD)

3.1.8. The sediment subsamples were assessed for pollen (**Appendix I**), diatoms (**Appendix II**), foraminifera (**Appendix III**) and ostracods (**Appendix IV**).

4. RESULTS

4.1. INTRODUCTION

4.1.1. The following environmental assessments were undertaken:

- Pollen (**Appendix I**)
- Diatoms (**Appendix II**)
- Foraminifera (**Appendix III**)
- Ostracods (**Appendix IV**)

4.1.2. No diatoms were recovered from the sediments. This may be due to preservational conditions **(Appendix II**). Foraminifera were recovered in very low numbers. The foraminifera recovered were all planktonic fossil types common in the Cretaceous period. Given the presence of chalk (**Unit 4**) and chalk fragments present within the sediments (**Unit 3**, **Unit 2ii** and **Unit 2iii**) it is likely that these foraminifera are derived from the chalk (**Appendix III**).

4.1.3. Pollen was recovered in sufficient quantities for assessment from five of the eight assessed samples. These samples are all from the base of **Unit 2** (**Unit 2i** and **Unit 2ii**) (**Figure 1**, **Appendix I**). The pollen assemblages are low in abundance and are homogenous. The samples include pine (*Pinus*), birch (*Betula*), grasses (Poaceae), sedges (Cyperaceae) ferns (*Dryopteris/Pteridium*) and freshwater algal cysts (*Pediastrum*). These are indicative of an open herbaceous environment surrounding a depositional environment of standing or slow flowing freshwater. They are indicative of a cold stage within the Pleistocene, with the presence of spruce (*Picea*) suggesting an earlier Devensian (Oxygen Isotope Stage (OIS) 5a and 5c) age at the latest (**Appendix I**)**.**

4.1.4. Ostracods were recovered from five samples at the base of **Unit 2** (**Unit 2i** and **Unit 2ii**) and were all indicative of cold freshwater habitats. Together they are indicative of a depositional environment on the margins of a glacial lake (**Appendix IV**). The occurrence of "*Leucocythere batesi*" and *Limnocythere falcata* are of biostratigraphic value and indicate that the sediments date from a cold period from the Hoxnian (Marine Isotope Stage (MIS) 11) to Devensian (MIS 3).

4.2. DISCUSSION

4.2.1. It has been suggested that the black, possibly organic bands within in the lower part of **Unit 2** (**Unit 2i**) are varves. The term "varves" is usually used to describe: "*annual sediments deposited in glacial melt water lakes. These consist of a coarser layer, representing summer deposition, and a finer layer, representing winter deposition*." (Whitten & Brooks 1972). The sediments as described by Wessex Archaeology 2006 are not therefore varves in that they do not comprise a coarser and finer layer of deposition. Given the sedimentary descriptions and pollen and ostracod

content of the sediments they are better described as glacial lacustrine sediments. It is interesting to note that the ostracod and pollen assemblages are no different in the sediments with darker organic bands (**Unit 2i**) and those without (**Unit 2ii**). **Unit 2ii** therefore also comprises glacial lacustrine sediments. Organic material was noted in the foraminifera/ostracod samples in both **Unit 2i** and **Unit 2ii** (**Appendix IV**).

4.2.2. The bands within **Unit 2i** were also noted not to cross the sediment in an unbroken line across the width of the borehole and had a somewhat broken, lenticular and mottled appearance. This may be due to the influence of freezing on the sediments.

4.2.3. The main component of **Unit 2** is **Unit 2iii,** a glacial till, which represents the advance of an ice sheet. The description of this unit (WA 2006) and comparison with the described offshore geology suggests that it is part of the Bolders Bank Formation (WA 2006; BGS 1991; Cameron et al 1992) which has been ascribed a Devensian date (Cameron et al. 1992).

4.2.4. Using the ostracod fauna, the glacial lacustrine sediments at the base of **Unit 2** (**Unit 2i** and **Unit 2ii**) biostratigraphically correlate to a cold stage between the Hoxnian (MIS 11) to early Devensian (MIS 5a) date (**Appendix IV**). The presence of spruce (*Picea*) would suggest **Unit 2i** and **Unit 2ii** were deposited no later than the earlier part of the Devensian (OIS 5a). This means the deposition of **Unit 2i** and **Unit 2ii** occurred during a cold stage approximately from 380,000 to 70,000 BP, which would correspond to the Lower and Middle Palaeolithic archaeological periods.

4.3. RECOMMENDATIONS

4.3.1. OSL (Optically Stimulated Luminescence) dating of these sediments would potentially refine this dating further. This would aid the interpretation of the archaeological significance of these sediments. Further coring would be required in order to obtain a suitable sample. If further geotechnical investigations are planned for the Lynn and Inner Dowsing OWFs sediments identified by the Stage 1 assessment but not available for Stage 2 recording (WA 2006) and Stage 3 assessment should also be investigated for their archaeological potential.

4.3.2. Even if no further coring is undertaken then Stage 4 analysis of pollen and ostracods is still recommended. This involves the analysis of more tightly spaced samples from within Unit 2 of the existing core section/s. The organic bands (**Unit 2i**) should also be investigated for their plant macrofossil and insect fauna. The plant macrofossils could add information on the more local vegetational environment. Insects, if present, could provide information on climate and, as such on the chronology of the sediments. Together, these analyses would have the potential to identify any subtle changes within these sediments, provide a more detailed environmental account and provide a sound basis for publication of the results in a suitable journal. The sedimentological descriptions of the glacial sediments should also be compared to the described onshore sequences which may correlate to these offshore formations.

4.3.3. Given that the sediments investigated here account for a very small percentage of the total recorded during geotechnical work, and that other core sections recorded in the geotechnical logs (Fugro 2004) showed considerable potential for the survival of palaeoenvironmental and archaeological evidence (WA 2005), it is also

recommended that any future cores from the area undergo an archaeological assessment before they are destructively tested.

4.3.4. Sub-bottom profiler marine geophysical data for the Lynn and Inner Dowsing Offshore Wind Farms could help determine the extent of the glacial lake identified within borehole BHID25 and any other archaeologically interesting palaeogeographical features in the area. This data should now be analysed as part of the Stage 4 work.

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APPENDIX I: POLLEN ASSESSMENT

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Introduction

A series of eight pollen samples of Pleistocene age have been analysed in an attempt to ascertain the broad age of the material and its depositional environment, especially in relation to its glacial or its interglacial status. This material, comprising fine grained and possibly varved sediments, offered potential for pollen and diatom analysis. Pollen was found to be generally well preserved in the finer grained sediments but, however, absolute numbers present were small. This is attributed to deposition in a cold stage (glacial) environment where the habitat was open and comprised grass and sedge dominated herbaceous communities.

Pollen Method

Vibrocores from this off-shore site have been described and sampled for pollen in the laboratory (Dr. P. Paddenberg, Wessex Archaeology). Sub-samples of 2ml were processed using standard techniques for the extraction of the sub-fossil pollen and spores (Moore and Webb 1978; Moore *et al.* 1992). Micromesh sieving (10u) was also used to aid with removal of the clay fraction from these largely minerogenic sediments. The pollen and spores were identified and counted using an Olympus biological research microscope fitted with Leitz optics. A pollen sum of up to 200 grains per sample level was counted where preservation allowed. Other, miscellaneous microfossils including substantial numbers of algal *Pediastrum* and pre-Quaternary palynomorphs were also recorded. Data are presented in pollen diagram form, adn where appropriate, in tables. The former have been plotted using Tilia and Tilia Graph (**Figure 1**). Where percentages are given, these have been calculated as follows:

Sum =	% total pollen (tlp).
Spores =	% tlp + sum of spores.
Misc.=	% tlp + sum of misc. taxa.

Taxonomy, in general, follows that of Moore and Webb (1978) modified according to Bennett *et al.* (1994) for pollen types and Stace (1992) for plant descriptions. These procedures were carried out in the Palaeoecology Laboratory of the School of Geography, University of Southampton.

The Pollen Data

Five of the eight samples contained pollen and spores. These, as anticipated, come from the laminated (varved ?) sediments only and not the under and overlying glacial till. Overall, the pollen assemblages are herb dominated but with a limited taxonomic diversity. There are correspondingly few trees and shrubs. Due to the homogeneous nature of the samples, no local pollen assemblage zones have been designated. However, the assemblages are diagnostic and the broad vegetation categories are characterised as follows.

Trees and shrubs; There are few tree and shrub pollen. *Pinus* (Pine) and *Betula* (birch) are most consistent with values to 3%. Of note are occasional records of *Picea* (spruce). A single grain *Corylus* type (Coryloid) is darker and degraded and thought to be derived from earlier material.

Dwarf Shrubs; There are small numbers of *Empetrum nigrum* (crowberry).

Herbs; Poaceae (Grasses; to 60%) and Cyperaceae (sedges; to 60%) are dominant in all samples, forming the principal components throughout. Overall herb diversity is low with occasional/sporadic occurrences of herbs of open grassland.

Spores: There are small numbers only of monolete forms - *Dryopteris* type (ferns) and *Pteridium* (bracken) in the basal level. *Botrychium lunaria* (moonwort) is the most diagnostic taxon present, being a plant of short turf grassland.

Miscellaneous: Of specific note are the substantial numbers of freshwater algal *Pediastrum* cysts (to 55% sum + misc.). Pre-Quaternary palynomorphs are more abundant in the under and overlying till.

Interpretation and discussion

Although pollen is well preserved, the absolute numbers are somewhat small and the taxonomic diversity is low. This is wholly in keeping with pollen assemblages from extreme cold stage environments where habitat pollen production may be many orders of magnitude less than tree and shrub dominated interglacial periods. These sediments are also of minerogenic character, rather than peat, which may also be a factor where rapid deposition occurs in contrast to slow build up of humic material.

The stratigraphical position of these fine grained sediments within till (chalky boulder clay) and the pollen spectra portraying an open herbaceous environment, suggest that deposition occurred during a cold (glacial) stage. Dating to a specific cold stage may, however, be problematic unless the age of the overlying till can be ascertained. A Devensian, last glacial, age is perhaps unlikely and an Anglian/Wolstonian age may be more appropriate. In this case, pollen does not offer any dating solutions and only the character of the environment of deposition can be deduced from the data obtained.

The pollen data suggest a very open herbaceous habitat which was largely dominated by Poaceae (grasses) and Cyperaceae (sedges), the latter in wetter areas and perhaps adjacent to the freshwater depositional hollow. In addition, there are a number of other herbs which may come from the grassland including the low growing fern, *Botrychium lunaria* (moonwort), *Anemone* types and *Plantago lanceolata* (ribwort plantain).

The depositional habitat was one of standing or very slow flowing freshwater. The presence of varves, as well as being indicative of a cold stage environment with seasonal freeze and thaw, also suggests a water filled depression (lake?). Palynologically this is evidence by substantial numbers of cyst of algal *Pediastrum.* This sedimentary basin was surrounded by a wet, grass-sedge community, possibly with *Caltha palustris* (marsh marigold), *Thalictrum* (meadow rue) and *Valeriana officinalis* (valerian). Growing on the wetter fringes.

Throughout the sequence, there are a very small number of tree pollen present. These comprise the typical glacial-Boreal taxa, *Pinus* (pine) and *Betula* (here, tree birch). These are

anemophilous and high pollen producers and as such, are thought to be of long distance, extra-regional origin. *Picea* (spruce) is occasionally present and is diagnostic of earlier interglacial periods and from interstadial periods within glacial periods. Not a native of the Holocene, the most recent occurrences of this conifer are from the earlier part of the Devensian, interstadial periods (OI 5a. and 5c.) from South Oxfordshire and the Midlands.

Summary and Conclusions

The following principal points have been obtained from this preliminary study:

* Pollen is present in the laminated ?varved sediments but not, unexpectedly, in the over and underlying till, except for derived geological palynomorphs.

* The pollen is well preserved but with low a.p.f. (absolute pollen frequency).

* The pollen assemblages are dominated by herbs, predominantly grasses and sedges, but with a low taxonomic diversity. An open herbaceous environment is thus demonstrated.

* There are small numbers of birch and pine and occasional spruce pollen which are considered to be from extra regional sources (i.e. long distance transport component).

* The above palynological features clearly demonstrate that the sediments were deposited in a cold stage. The small species diversity indicates an extreme cold, arctic environment. This is in accord with the stratigraphical location of these fine sediments intercalated between till. The laminated/varved nature of these sediments also implies a seasonal, but harsh freeze thaw, periglacial, permafrost environment.

* The presence of algal *Pediastrum* and the lamination of the sediments suggests a low energy, freshwater environment of deposition. This may have been a small lake or water filling a glacially scoured topographic hollow or other feature.

* It has not been possible to suggest an age for the sediments based on these pollen assemblages. This may be achieved by more accurate characterisation of the associated till deposits. Presence of spruce (*Picea*) suggests an early Devensian age at the latest, although an earlier glacial phase is readily possible.

Suggestions for additional work

This fine grained sediment unit has proven surprisingly interesting yielding information on a cold (glacial) stage environment. Clearly, there are problems in the dating of this sequence which could be from a one of number of cold stages within Pleistocene. There is obviously no human component to this study. Given these factors, if some further information on the tills can cast light on the age of the sediments by inference, then additional pollen work could provide interesting information on what are rare sediments. If additional work is required e.g. for publication, the following aspects are suggested:

* Intermediate samples from within the cores need to be analysed. Given the largely homogeneous pollen spectra, these need not be at close intervals unless additional phases of vegetation change are identified. Extra samples could be selected from the more humic, laminated levels.

* Pollen counts. Although counts of 500 or more grains are often required, apf values here would negate this and a realistically lower number only may be achieved where preservation permits.

* Insects and testate amoebae might provide corroborative palaeoenvironmental data- especially the former.

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APPENDIX II: DIATOM ASSESSMENT

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Five samples taken from the fine grained laminated alluvial or fluvial sediments which were analysed for pollen have also been examined for presence or absence of diatoms. If present, these microfossils were expected to provide a valuable indication of the freshwater status of the environments in which the sediments were deposited.

Preparation

Samples were analysed from depths of 6.08, 6.13, 6.17, 7.05 and 7.30m
depth. Digestion and disaggregation of the humic/organic material was carried out using Hydrogen Peroxide. Samples were then dried on microscope cover-slips and mounted on microscope slide using Naphrax mounting medium. Examination was carried out at high power x400 and x1000 using a biological microscope.

Results

All slides were carefully scanned but unfortunately, no diatoms were observed in any of the above samples. Clearly preserving conditions were unsatisfactory. This is probably a function of the coarseness of the sediments.

APPENDIX III: FORAMINIFERA ASSESSMENT

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Introduction
Five sub-samples taken from borehole BHID25 have been assessed for the presence and preservation of foraminifera. The sediments are sandy clayey silts which are over- and underlain by glacial till. Foraminifera were present in one of the five samples.

Method
Sediment was wet sieved through a 63µm sieve to extract the coarser fraction. The fine sediment was dried and then sieved through 500µm, 250µm, 125µm sieves. Foraminifera were picked out under 10-60x magnification and transmitted and incident light using a Meiji EMT microscope.

Results
Foraminifera were present in samples at 7.05m and 7.17m but not in samples at 6.08, 6.13 and 7.30m. Abundance of foraminifera per sample was very low and preservation was poor. At 7.05m seven reworked fossils planktonic foraminifera were recovered. At 7.17m four reworked fossil planktonic foraminifera were recovered.

Discussion
The taxa recovered are fossil marine forms which have been reworked and are of little palaeoenvironmental value. The lack of foraminifera from these samples (and the presence of ostracods) is an indication that the sediments are of freshwater origin.

Further work
No further samples should be assessed/analysed from this sequence for foraminifera

APPENDIX IV: OSTRACOD ASSESSMENT

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Introduction

Five sub-samples taken from vibrocore BHID25 have been assessed for the presence and preservation of ostracods. The sediments are sandy silty clays which are overlain by deposits of glacial till. The help of Dr John Whittaker is acknowledged, in particular with the identification of "*Leucocythere batesi*" and provision of access to unpublished material (Whittaker 2007).

Method

Sediment was wet sieved through a 63µm sieve to extract the coarser fraction. The fine sediment was dried and then sieved through 500µm, 250µm, 125µm sieves. Ostracods were picked out under 10-60x magnification and transmitted and incident light using a Meiji EMT microscope. Where possible, fifty specimens per sample were picked out and kept in card slides. Identification and ecological interpretation follows Athersuch et al. (1989), Meisch (2000) and Whittaker (2007).

Results

Ostracods were present in all of the five samples. Abundance of ostracods per sample from borehole BHID25 is summarised in **Table 1**. Abundance of ostracods was medium to high, and preservation was moderate.

At 6.08m abundance of ostracods was high and preservation was moderate. The assemblage is dominated by *Limnocytherina sanctipatricii* and *"Leucocythere batesi"*. *Limnocythere falcata* and *Eucypris* sp. were also present. Many broken specimens were recovered. There was a notable lack of instar stages and most valves recovered were adult forms.

At 6.13m abundance of ostracods was moderate to high with a total of 67 recovered. The most abundant taxon was *Limnocytherina sanctipatricii*. *"Leucocythere batesi"* and *Candona neglecta* were also present. The majority of the valves were broken and of those identified were mostly adult forms.

At 7.05m abundance of ostracods was moderate with 35 specimens recovered. The assemblage contained adult forms of *Limnocytherina sanctipatricii*, *"Leucocythere batesi"* and *Cytherissa lacustris*. 26 broken and unidentified specimens were recovered.

At 7.17m abundance of ostracods was moderate with 25 specimens recovered. The assemblage was dominated by adult forms of *Limnocytherina sanctipatricii*, and also contained *Cytherissa lacustris* and *Candona candida.*

At 7.30m abundance of ostracods was moderate with 32 specimens recovered. The assemblage was dominated by *Candona candida* and also contained *Candona neglecta, Limnocytherina sanctipatricii* and *"Leucocythere batesi"*.

Organic plant macrofossils including *Potomageton,* seeds and twigs were recovered from 6.08, 7.05 and 7.30.

Discussion

The assemblages are very similar in nature, with many broken specimens and mostly dominated by *Limnocytherina sanctipatricii.* All of the species recovered are non-marine and are known to inhabit freshwater. *Limnocythere sanctipatricii* is known from still, freshwater bodies and is often, but not exclusively associated with cold freshwater lakes (Meisch 2000). This species has a range from Cromerian (MIS 15-13) to Recent. Of greater biostratigraphic value is the presence of "*Leucocythere batesi",* another cold freshwater indicator with a known range from the Hoxnian (MIS 11) to Devensian (MIS 5-3) periods (Whittaker 2007). *Limnocythere falcata* also has a known range from the Hoxnian (MIS 11) to Devensian (MIS 3) periods.

Other species included *Candona candida, Candona neglecta, Cytherissa lacustris* and *Limnocythere falcata*. All of these taxa occur in fresh waterbodies throughout the Pleistocene (Meisch 2000). *Candona neglecta* prefers cold freshwaters but can tolerate temperature increases. *Cytherissa lacustris* is known from the sublittoral and profundal zones of cold deep lakes (Meisch 2000).

Of note is the very high numbers of broken valves and presence of predominantly adult forms. This strongly suggests that the assemblages are allochthonous. The generally good preservation would seem to suggest however that these assemblages have not travelled far. It would be reasonable to assume that these assemblages have originated from the margins of a glacial lake of any cold period between the Hoxnian (MIS 11) to Devensian (MIS 3 periods).

All five samples have a similar fauna. Those from 7.05, 7.17 and 7.30 were taken from sediments that included organic bands. The faunal diversity was identical to the other samples however the abundance was less. This may be due to differing preservation.

Further work

Further intermediate samples are recommended from this sequence. Isolated sediment samples taken from the organic and minerogenic layers described from 7.00 to 7.35m might provide more information on the possible seasonal nature of these sediments.

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Meisch, C., 2000. *Freshwater Ostracoda of Western and Central Europe*. In: J. Schwoerbel and P. Zwick, editors: Suesswasserfauna von Mitteleuropa 8/3. Spektrum Akademischer Verlag, Heidelberg, Berlin. 522pp

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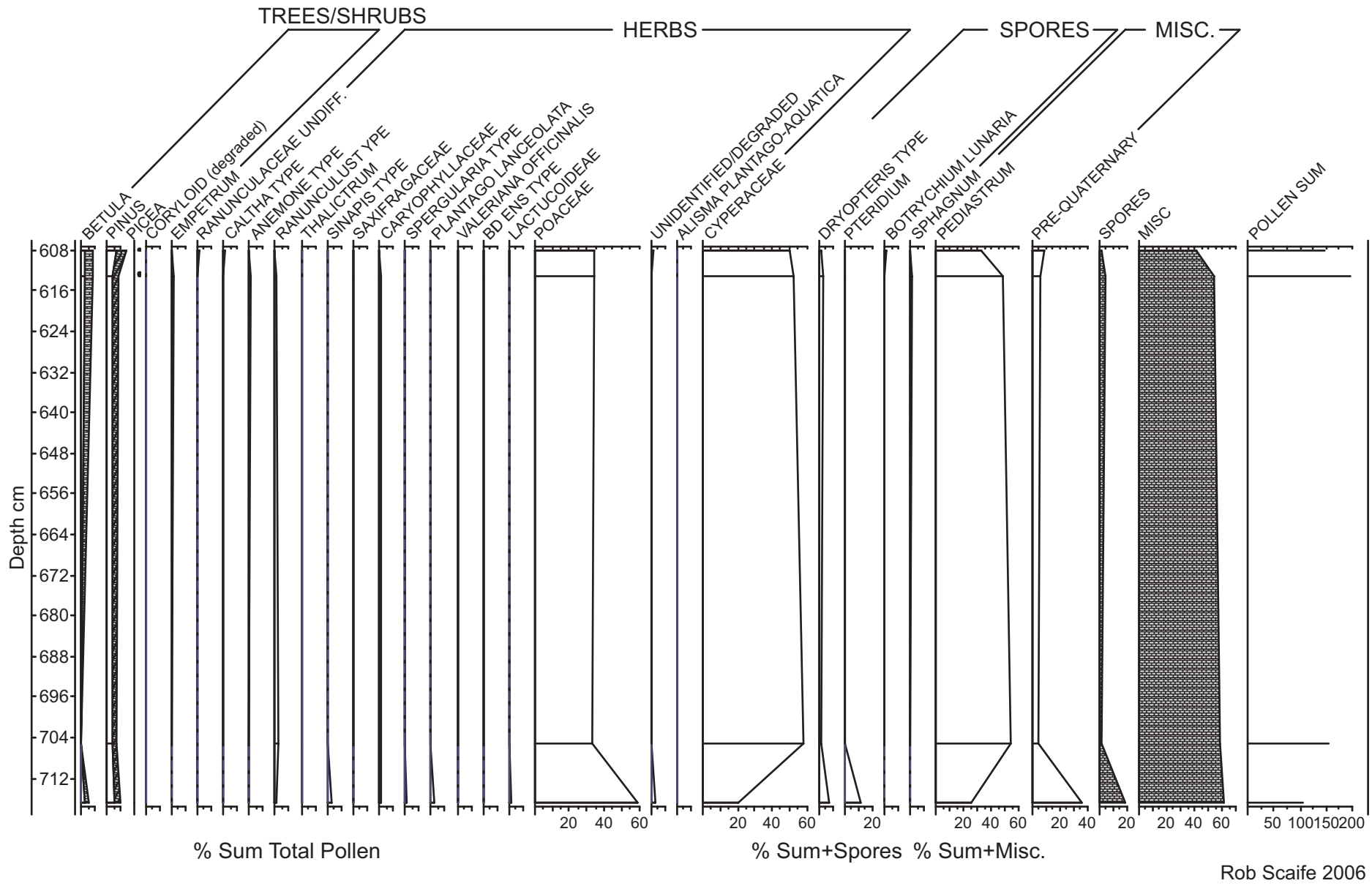
Table 1: Ostracods per sample in borehole BHID25

BHID 25 Depth below seabed in m	*Candona candidia*	*Candona neglecta*	*Cytherissa lacustris*	*Eucypris* sp.	*"Leucocythere batesi"*	*Limnocythere falcata*	*Limnocytherina sanctipatricii*
6.08				x	xx	x	xx
6.13		x			x		xx
7.05			x		x	x	
7.17	x		x				x
7.30	xx	x				x	x

x – 1-9 specimens
xx – 10-50 specimens



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Date:	22/02/07	Revision Number:	0
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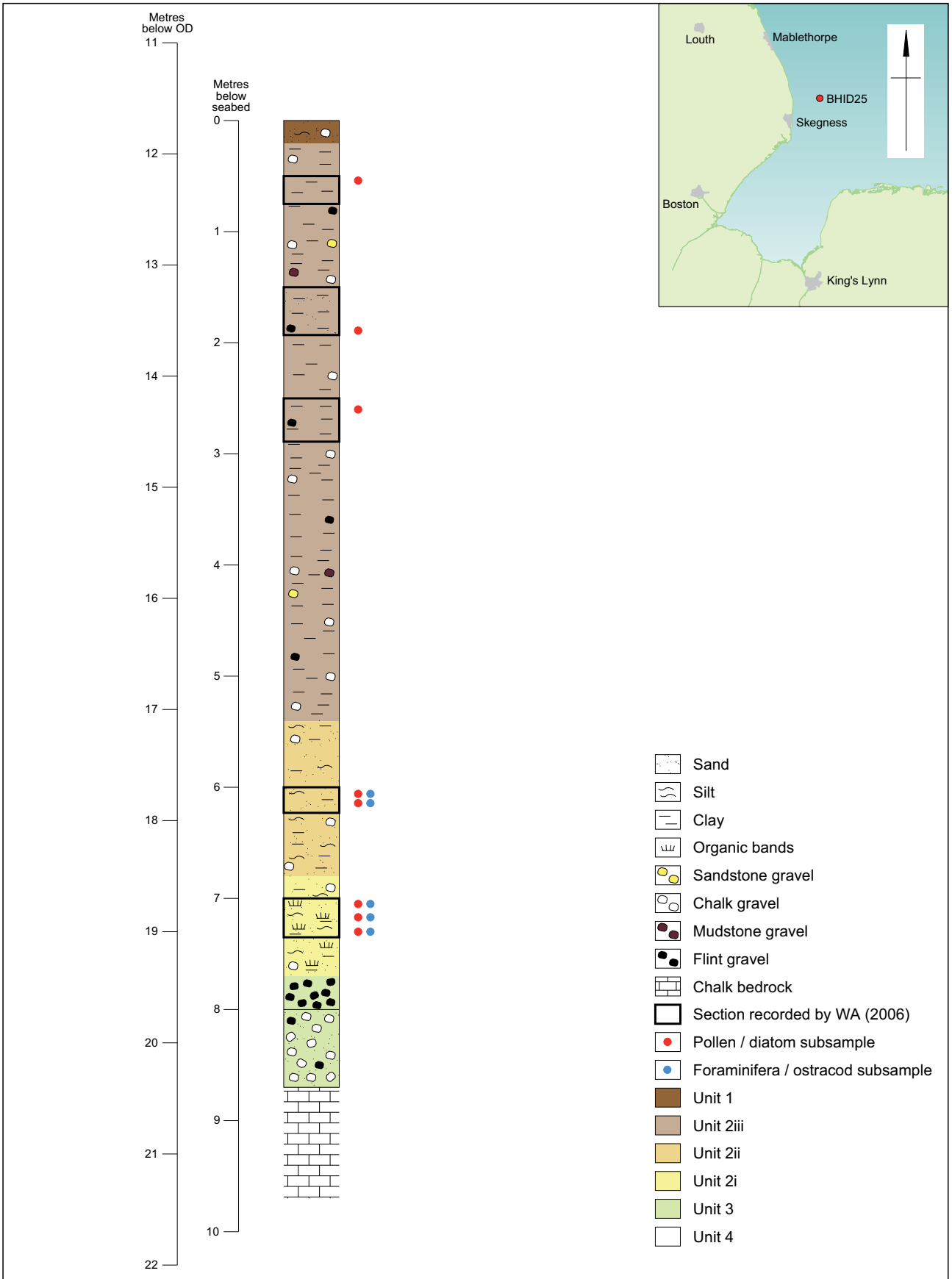
Pollen diagram

Figure 1



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Borehole BHID25 and sediment subsamples

Figure 1