# Chapter 12

# Pollen

*by Charles Turner, Barbara Silva and Francis Wenban-Smith*

## INTRODUCTION

There were three main phases of pollen investigation at the site: (1) as part of the initial field evaluation; (2) during the main fieldwork programme; and (3) post-excavation assessment and analysis. As mentioned previously (Chapter 3), several samples were evaluated during the initial field evaluation of December 2003, some of which were found to apparently contain moderately abundant and well-preserved pollen remains, although concerns about the taphonomy were raised (Oxford Archaeology 2004). This positive result was one of the factors in recognising the site as important and justifying more thorough investigation, with a focus on pollen analysis through the sequence. Therefore, one strand of investigation in the following larger-scale excavation was recovery of monolith series through the deposits that were thought to be pollen-bearing, with the intention of constructing detailed pollen diagrams through the site sequence.

The site was visited by a range of specialists in late March 2004, following discovery of the elephant skeleton, and it was decided then to carry out some on-the-spot sampling to further evaluate for pollen preservation: firstly, in the vicinity of the newly discovered elephant; secondly, in other clayey horizons in the Phase 5 clay-laminated sands that were at that time thought to be polleniferous; and thirdly, in as-yet-uninvestigated horizons of Phases 6 and 9. Analysis of this second set of samples established reasonable preservation and countable quantities of pollen in the same brown organic-rich deposit (context 40078) that contained the elephant skeleton. However pollen remains were not found in samples from any other deposits, including those from Phase 5, where pollen had initially been identified in the original phase of evaluation. Therefore, a set of duplicate analyses was carried out, processing and analysing parts of the same samples as used for the initial pollen evaluation. The results of this re-analysis again came back negative, suggesting that some of the positive results of the initial evaluation, particularly those that had apparently shown pollen in excellent condition, were probably due to modern contamination rather than being ancient pollen. Further pollen investigation took place towards the end of the excavation in July-August 2004, when the very dark and organic-rich context 40158 was exposed in the central part of the site, forming the Phase 6 deposits at the base of the synclinal 'skateboard ramp' (Fig. 3.22). The results of these analyses are reported on together (Turner, below).

Following completion of fieldwork, a much more systematic investigation took place, assessing for pollen remains throughout previously unevaluated horizons, namely Phases 1, 2 and 7 (lower part) of the site sequence. In addition, a vertical series of samples was taken from a monolith series through the full thickness of the Phase 6 clay and assessed for pollen. Although pollen presence had been confirmed in context 40158 and in the particular thin brown organic-rich bed (context 40078) associated with the elephant skeleton, the prevalence and preservation of pollen through most of the (several metres thick) Phase 6 deposits remained uncertain. These Phase 6 assessment samples were closely spaced in the nearest monoliths to the elephant skeleton, samples <40364> and <40365>, where the sequence above and below the elephant horizon was preserved, hoping to put the pollen profile from the elephant horizon in context within a longer pollen sequence. The results of this more detailed assessment are discussed further by Silva (below). This chapter on pollen analysis then concludes with a review of the more significant results of the various pollen analyses carried out, and discussion of the implications for climate, environment and dating.

## INITIAL FIELD EVALUATION

Five samples were selected for initial evaluation in December 2003 from the central part of the main west-facing section at Log 40011, where the greatest range of phases of the site sequence (as understood at that time) was exposed (Fig 12.1a). Two samples were assessed from Phase 4, which was particularly clayey here, and which was thought to perhaps be a basal lake clay from the start of an interglacial period, and one from each of the overlying Phases 5, 6 and 7. The samples were analysed at Oxford Archaeology North, and this summary is taken from the evaluation report (Oxford Archaeology 2004a, Appendix 1).

Samples were prepared using the standard techniques of Potassium Hydroxide, acetolysis and hot Hydrofluoric Acid treatment (Faegri and Iversen 1989). The residues were mounted in silicone oil and examined with an Olympus BH-2 microscope using x400 magnification routinely and x1000 for critical grains. Counting

Table 12.1 Initial pollen evaluation results from December 2003 fieldwork (Oxford Archaeology 2004a, Appendix 1), all counts based on examination of two slides

| *Phase [original deposit group]* | *Context* | *Sample* <> | *Sampling notes* | *Results* |
|---|---|---|---|---|
| Phase 7 [6] | 40043 | 40006 | - | A single pollen grain (Poaceae) |
| Phase 6 [5] | 40039 | 40007 | From upper dark brown/purple brecciated level, the presumed palaeo-landsurface | Eight grass (Poaceae) pollen grains and 29 indeterminate grains |
| | 40100 [originally 40029] | 40008 | From purer, thicker blue-grey clay to south of Log 40011 | Not analysed |
| Phase 5 [4] | 40025 | 40009 * | From olive-grey clay lamination | Eighty six pollen grains were identified on the two slides from this sample. The pollen preservation was excellent. Pollen from herbaceous plants dominated the assemblage and included grass (Poaceae), nettle (*Urtica*), goosefoot family (Chenopodiaceae) and stitchwort family (Caryophyllaceae) grains. Some birch (*Betula*) alder (*Alnus*) and hazel (*Corylus*) pollen |
| | | 40010 | From olive-grey clay lamination | Not analysed |
| Phase 4 [3] | 40026 | 40011 | Top of grey/orange clay | Not analysed |
| | | 40012 * | Middle of grey/orange clay | Nineteen pollen grains, mainly from herbaceous taxa, were identified on the two slides from this sample. These included pollen from grasses (Poaceae), nettles (*Urtica*), plantains (*Plantago*) and Ericales. Single grains of birch (*Betula*) and oak (*Quercus*) were also recorded. Pollen preservation was again excellent |
| | | 40013 | Bottom of grey/ orange clay | Not analysed |
| | 40027 | 40014 | Middle of lower, more sandy/ pebbly clay | Not analysed |
| | | 40015 * | Bottom of lower, more sandy/ pebbly clay | Fifty two pollen grains, mainly from herbaceous taxa, were identified on the two slides from this sample. They included pollen from grasses (Poaceae), nettles (*Urtica*), dead nettle family (Lamiaceae) and rock-rose (*Helianthemum*). Some birch (*Betula*), elm (*Ulmus*) and pine (*Pinus*) pollen was also recorded. Pollen preservation was again excellent |

Subsequent re-analysis of the samples marked * established that the apparently positive results might be due to modern contamination (see Table 12.2)

continued until a sum of at least 50-100 pollen grains from land pollen types had been reached on two or more complete slides, to reduce the possible effects of differential dispersal under the coverslip (Brooks and Thomas 1967). If pollen was very sparse, counting continued until two complete slides had been assessed. Pollen identification was carried out using the standard keys of Faegri and Iversen (1989) and Moore *et al.* (1991) and a small reference collection. Because the samples were only being assessed, pollen grains not identified rapidly were recorded in either larger categories eg Asteraceae (Daisy-type) and Lactuaceae (Dandelion-type) or as undifferentiated grains. Indeterminate grains were recorded using groups based on those of Birks (1973).

The results (Table 12.1) indicated low pollen frequency, as might be expected at the start of the climatic amelioration after a period of glaciation, but excellent preservation in three particular samples: <40009> (Phase 5), <40012> (Phase 4) and <40015> (Phase 4), where pollen grains were also more abundant. Contamination was ruled out because the samples were taken from freshly exposed faces several metres below the present day land surface, the laboratory equipment was carefully cleaned, and it was thought unlikely for any atmospheric contamination to have taken place in late December, when the samples were collected, or in January, when the slides were prepared. It was therefore recommended that more detailed sampling should take place.

## ANALYSES DURING FIELDWORK

*by Charles Turner*

Following from discovery of the elephant skeleton, a specialist meeting was convened on-site on 23rd of March 2004, during which several samples were collected

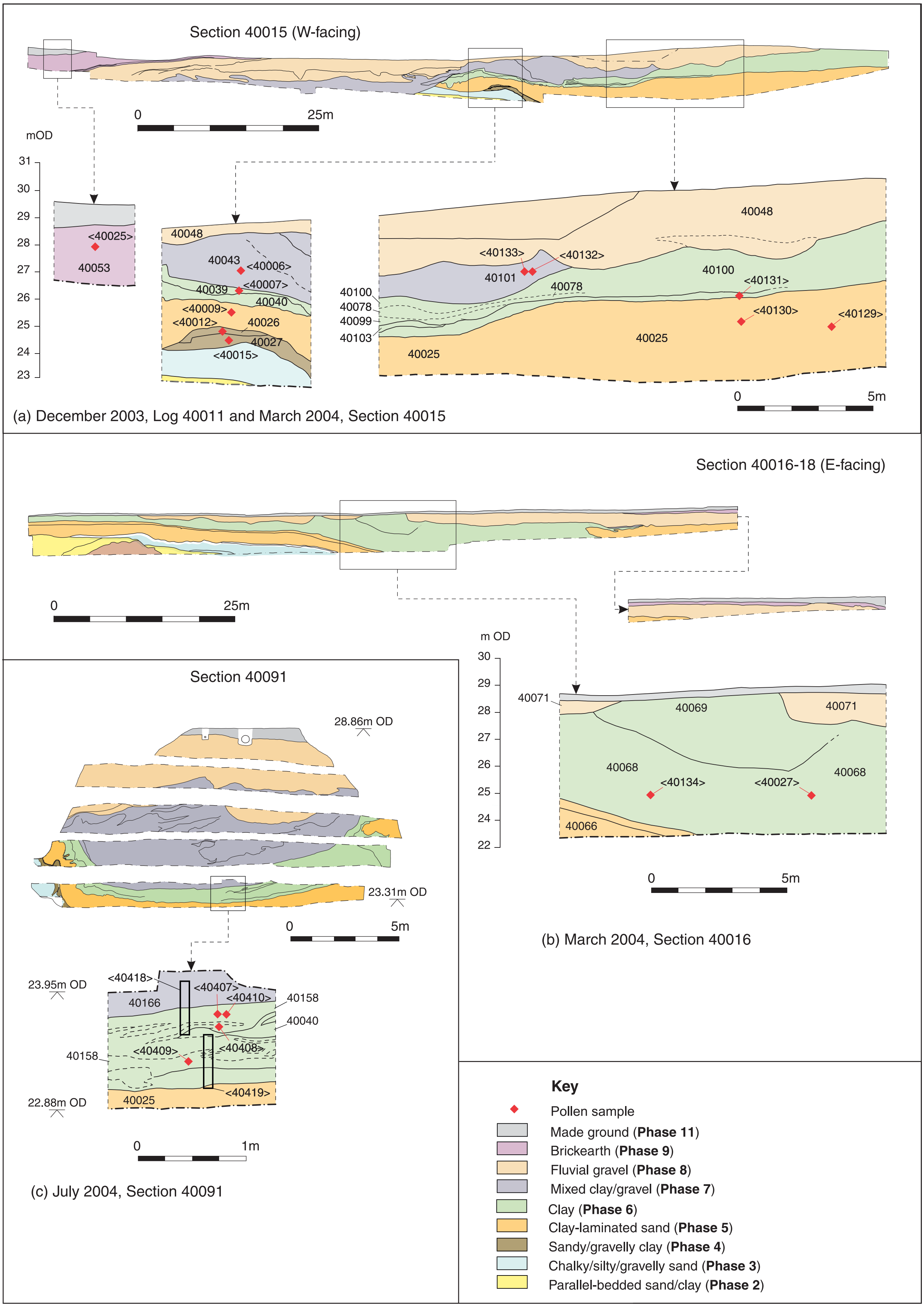


Figure 12.1 Pollen sampling locations during fieldwork

for immediate pollen analysis (Table 12.2; Fig. 12.1). Two samples, <40132> and <40133>, were collected from the same dark brown organic-rich clayey bed (context 40078) that contained the elephant, from amongst the scatter of the elephant bones to remove any doubt as to their association with the elephant (Fig. 12.1a). Three more samples, <40129>, <40130> and <40131>, were collected from particularly clayey beds *c* 10-20mm thick in the upper part of the Phase 5 deposits (context 40025) in the main west-facing section 40015 (Fig. 12.1a). These appeared in the field to have been subjected to fairly rigorous oxidation processes and not to have good potential for pollen preservation, and so it was decided to verify the apparently positive results from the initial evaluation. Two samples were collected from the main east-facing section 40016 (Fig. 12.1b), one from the tufaceous channel (<40134>, from context 40070 and the other from the upper part of the overlying grey clay of Phase 6 (<40027>, from context 40069. The former of these was highly calcareous, with relatively abundant molluscan and small vertebrate remains and, when a sample of this material was sieved, it also produced discrete pebbles of grey silty clay, which were then also prepared for pollen analysis. One sample, <40025>, was collected from the Phase 9 brickearth (context 40053) capping the sequence at the north end of the site (Fig. 12.1a). Standard methods were used to prepare the samples for pollen analysis, including treatments with 10% NaOH, 7% HCl, 70% HF and Erdtman acetolysis (Faegri and Iversen 1989) as well as treatment with sodium pyrophosphate ($NaP_2O_7$) (Bates *et al.* 1978).

The results of these analyses were mostly negative (Table 12.2). All the samples from the Phase 5 clay-laminated sands were devoid of any trace of fossil pollen. Indeed, apart from the exotic *Lycopodium* spores routinely added during sample preparation, the slides prepared from these samples contained no, or virtually no, organic residues (ie nothing that absorbed safranin stain). This finding was entirely consistent with the field evidence that these thin silt layers had been subjected to oxidation processes incompatible with pollen survival. Likewise, the samples from Phase 9 (context 40053), the upper part of Phase 6 (context 40069) and the clay pebbles from the tufaceous channel-fill (context 40070) also contained no pollen whatsoever.

Since the negative results from Phase 5, samples <40129>-<40131> conflicted with the positive result from the initial evaluation of the same deposit, sample

Table 12.2 Pollen analyses during the 2004 excavation; samples marked * were re-analysed from the initial evaluation (see Table 12.1)

| *Phase of analysis* | *Site sequence Phase* | *Context* | *Sample/s <>* | *Sampling notes* | *Results* |
|---|---|---|---|---|---|
| March-April 2004 | 9 | 40053 | 40025 | From thicker brickearth at north end of main west-facing section 40015 | No pollen |
| | 6 | 40069 | 40027 | From upper part of thick grey clay in central part of main east-facing section 40016 | No pollen |
| | 6b | 40070 (clayey pebbles) | 40134 | Clayey pebbles sieved from context 40070 were investigated for pollen | No pollen |
| | 6 | 40078 | 40132<br>40133 | From darker brown organic-rich clay bed containing *Palaeoloxodon* skeleton | Countable quantities of fossil pollen and spores, although assemblages have been affected by differential destruction (Table 12.3) |
| | 5 | 40025 | 40129<br>40130<br>40131 | From grey clay-silt laminations within otherwise sandy/gravelly deposits at south end of main west-facing Section 40015 | No pollen |
| May-July 2004 | 5<br>4 | 40025<br>40026<br>40027 | 40009*<br>40012*<br>40015* | Re-analysis of further sediment from same samples as initially assessed – see Table 12.1 | No pollen |
| July-August 2004 | 6 | 40158 | 40407<br>40408<br>40409 | Three small pollen samples from very dark organic-rich bed in Section 40091 | Some amorphous non-cellular organic detritus; no pollen apart from some very corroded conifer grains, probably *Pinus*, and possibly of derived Tertiary origin |
| | | | 40410 | Slightly larger sample for plant macro remains from same level as <40407> | Single *Azolla* spore, but no Pleistocene pollen or other identifiable plant macro-fossils |

<40009> (Table 12.1), a duplicate analysis was carried out on surviving sediment from the original sample. This was conducted alongside re-analysis of surviving sediment from the two other original samples that had also produced apparently positive results, samples <40012> and <40015> (Table 12.1). All three duplicate analyses came back entirely negative, suggesting that the initial positive results may have been due to laboratory contamination at some stage in the preparation process.

The only samples that produced any Pleistocene pollen were the two samples <40132> and <40133> from immediately beside the elephant. Here there were countable quantities of fossil pollen and spores (Table 12.3), although it is clear that in both cases the assemblages have been affected by differential destruction. Also present on the slides were a few fragments of cypselas (ie achenes) of the hemp agrimony *Eupatorium cannabinum*. The most important thing to realise about both these samples is that their palynomorph assemblages have undergone considerable differential destruction, through corrosion probably caused by both biological oxidation of pollen grain walls by bacteria and by direct chemical oxidation when drying out of the sediments introduced aerobic conditions. Differential destruction/preservation of pollen grains and spores has been extensively studied by Havinga (1964; 1967; 1985). The general conclusions of this and other work are summarised by Birks and Birks (1980). Resistance to corrosion depends substantially on the sporopollenin content of the outer walls (exines) of pollen grains and spores. It is clear that taxa noted by Havinga as having a high percentage content of sporopollenin, namely fern spores, pine *Pinus*, lime *Tilia*, alder *Alnus* and hazel *Corylus,* are precisely those which are best represented in the Southfleet assemblages. Other taxa, which would also be expected to be present, even abundant, in temperate forest assemblages, such as oak *Quercus*, elm *Ulmus*, ash *Fraxinus* and some herb pollen types, are barely represented or absent; and these are taxa which contain lower sporopollenin percentages in their pollen exines. It is also pertinent that the pollen and spore taxa that survive and are countable also have distinctive features or shapes (eg, the wings of *Pinus*, the arci of *Alnus*, the sunken pores of *Tilia* and the size and heavy sculpture of *Polypodium* spores). This tends to make them instantly recognisable, even when somewhat corroded.

It follows that, although the Southfleet pollen assemblages (Table 12.3) have been calculated as conventional percentages based on the sum of total land pollen, excluding spores (though corroded grains *etc*, are given as percentages of all grains) it is meaningless to make direct comparisons with percentage data shown in pollen diagrams from interglacial sites such as Hoxne (West 1956) or Marks Tey (Turner 1970), where the pollen was well-preserved. However, the Southfleet pollen assemblages do make it clear that context 40078 was deposited (and the *Palaeoloxodon* was active) under fully temperate vegetational and climatic conditions probably in or immediately adjacent to a swampy alder carr. This is suggested not only by the presence of relatively abundant *Alnus* pollen, but also the preservation of frequent *Alnus* sieve plates derived from the breakdown of wood fragments within 40078. Larger fragments thought to be derived from rotted wood were also noted in the sediments during excavation but did not prove to retain sufficient cellular structure for identification (see Appendix 4). The few surviving traces of *Quercus*, *Ulmus*, *Tilia* and *Corylus* pollen, as well as *Pinus*, suggest that higher and drier ground in the wider site vicinity supported the typical mixed, largely deciduous forest that normally characterises the early-temperate substage of interglacial periods. However, the less frequent shrub taxa of the forest, such as holly *Ilex*, ivy *Hedera* or Type X are not represented, being either too poorly preserved or too sparsely produced to survive and be found in these weathered assemblages.

Given the preservation of pollen and spore assemblages in samples <40132> and <40133>, it was thought likely that further samples from the same stratum in other nearby faces of the excavation would also be likely to yield such assemblages. Therefore, four extra samples, <40407>-<40410>, were taken on a field visit in late July 2004, from the very dark organic-rich bed of context 40158, in the south-facing section 40091 of Trench B (Table 12.2; Fig. 12.1c). This context was thought to be equivalent stratigraphically to the elephant horizon of context 40078, and also appeared to have good potential for pollen preservation. This hope was strengthened by the presence of a distinctive fragment of a megaspore of the water fern *Azolla filiculoides* in sieved residues from sample <40410>. All four samples yielded varying amounts of organic detritus, mostly amorphous rather than cellular, and occasional, often crumpled and/or corroded, bisaccate conifer pollen grains. Most might be ascribed to *Pinus* (of undeterminable age), but some certainly appear to be reworked Tertiary palynomorphs, as do a few small, indeterminate tricolpate pollen grains. However, none of these samples yielded clear, let alone countable, Pleistocene pollen assemblages. Even pollen taxa like *Alnus* or Pteropsida (Filicales) spores, both relatively frequent in samples <40132> and <40133>, relatively resistant to destruction and easily identifiable even when poorly preserved, appeared to be absent from these pollen preparations. Sample <40410> had originally been collected for processing for plant macrofossils, but even when a much larger sample was sieved and examined, only two minute fragments of wood were seen and no further sign of *Azolla*.

The presence of *Azolla filiculoides*, however sparse the evidence, is nevertheless of stratigraphical importance. If we discount the early Middle Pleistocene ('Cromer Complex') interglacials as too old to be taken into account here, *A. filiculoides* apparently persisted in the European fossil record beyond the Elsterian/Anglian glacial Stage for a further two interglacial intervals: the Hoxnian/Holsteinian Interglacial, usually correlated with Marine Isotope Substage 11c in the deep-sea stratigraphy, and the Dömnitz Interglacial (Menke 1968; Erd 1970) which corresponds to part of MIS 9. In

Table 12.3 Pollen spectra from two samples from brown organic-rich band (context 40078) associated with *Palaeoloxodon* remains

| | *Sample <40132>* | | *Sample <40133>* | |
|---|---|---|---|---|
| | *No. of grains counted* | *Percentage of total land pollen* | *No. of grains counted* | *Percentage of total land pollen* |
| **Trees & shrubs** | | | | |
| *Betula* | 1 | 1% | | |
| *Pinus* | 8.5 | 10% | 4.5 | 20% |
| *Ulmus* | 1 | 1% | | |
| *Quercus* | 1 | 1% | 1 | 4% |
| *Tilia* | 3 | 3.5% | 1 | 4% |
| *Alnus* | 64 | 73% | 12 | 45% |
| *Corylus* | 8 | 9% | 5 | 20% |
| **Herbs** | | | | |
| Poaceae | 1 | 1% | 3 | 11% |
| **Total land pollen** | 87.5 | | 26.5 | |
| **Spores** | | | | |
| Pteropsida (Filicales) | 130 | 149% | 16 | 60% |
| *Osmunda* | | | 1 | 4% |
| *Polypodium* | 1 | 1% | | |
| **Crumpled & broken grains** | 40 | (14%) | 9 | (15%) |
| **Corroded grains** | 19 | (3%) | | |
| **Exotic** | 86 | | 40 | |
| ***Eupatorium cannabinum* cypsela fragments** | 2 | | | |
| **Sieve plates derived from *Alnus* wood** | 70 | 3 | | |

Britain *A. filiculoides* has been regularly recorded from Hoxnian sites such as Marks Tey (Turner 1970) and Hoxne itself (West 1956). More recently it has been recorded from Cudmore Grove, East Mersea (Roe 1999; Schreve 2001a) and Hackney Downs, London (Green *et al.* 2006), both sites that are generally believed to correlate with MIS 9 (Roe *et al.* 2009). After that interval *A. filiculoides* appears to have become extinct in Europe (though its megaspores are sometimes reworked into Eemian or Holocene deposits) until it was reintroduced from North America back into Europe in historical times, so that it is again widespread today.

It is possible to speculate a little further on the age of these deposits, from the pollen profiles of the two polleniferous samples, <40132> and <40133>, from context 40078. The absence of any trace of fir *Abies* and also hornbeam *Carpinus*, though the latter but not the former might be relatively susceptible to corrosion, make an early-temperate rather than a late-temperate substage of an interglacial, as defined by Turner and West (1968), more probable. In south-east England *Alnus* expands during the Hoxnian Interglacial to its highest percentages in pollen diagrams in subzone Ho IIb, but remains abundant also in Ho IIc and then through zone Ho III, the late-temperate substage. By contrast, at Cudmore Grove, thought to correlate with MIS 9 (Roe 1999), *Alnus* appears to have low values in the early-temperate zone II and much higher ones in the late-temperate (zone III), although this may simply be the result of a hiatus in the stratigraphy, cutting out the later part of zone II. On the balance of the palaeobotanical data, it is therefore probable that the lower parts of Phase 6 at Southfleet, where sampled for pollen in context 40078 by the elephant skeleton, represent the early-temperate zone of the Hoxnian Interglacial, Ho II (MIS 11c).

## POST-EXCAVATION ASSESSMENT AND ANALYSIS

*by Barbara Silva*

Once the excavation was finished, a much more systematic investigation for pollen preservation was carried out, focusing on horizons which had not yet been fully investigated. It was hoped that the darker bed (context 40057) of the Phase 1 'tilted block' sequence might contain pollen evidence, and therefore that pollen analysis could provide some information on this otherwise enigmatic sequence. Consequently eleven samples were chosen through the Phase 1 sequence, as well as seven through the overlying Phase 2 deposits (Table 12.4; Fig. 12.2a, b). Fifteen samples were assessed from the monolith sequence through the Phase 6 grey clay south of Trench D, where the major flint concentration had been found (Table 12.5; Fig. 12.2c). Eleven samples were assessed through deposits of Phase 6b, the tufaceous channel-fill, focusing upon the slightly browner and more organic-looking fine silty sand of context 40144, which looked more promising than other deposits of the channel-fill sequence for pollen preservation (Table 12.6; Fig. 12.3). Fifty-seven samples were

Table 12.4 Pollen assessment: Phases 1–2, Section 40016

| *Phase* | *Site area* | *Context* | *Source sample* <> | *Type* | *Site sample/ sub-sample* <> | *Pollen sample no.* | *Pollen concentration* | *Pollen preservation* | *Pollen taxa* |
|---|---|---|---|---|---|---|---|---|---|
| 2 | South (E) | 40065 | 40095 | Monolith | 40095/A/12-13cm | 91 | n/a | n/a | Not present |
| 2 | South (E) | 40065 | 40067 | Spot | 40067 | 92 | n/a | n/a | Not present |
| 2 | South (E) | 40065 | 40078 | Monolith | 40078/A/49-50cm | 93 | n/a | n/a | Not present |
| 2 | South (E) | 40064 | 40076 | Monolith | 40076/A/34-35cm | 94 | n/a | n/a | Not present |
| 2 | South (E) | 40064 | 40073 | Monolith | 40073/A/17-18cm | 95 | n/a | n/a | Not present |
| 2 | South (E) | 40064 | 40098 | Monolith | 40098/A/18-19cm | 96 | n/a | n/a | Not present |
| 2 | South (E) | 40064 | 40097 | Monolith | 40097/A/12-13cm | 97 | n/a | n/a | Not present |
| 1 | South (E) | 40059 | 40063 | Spot | 40063 | 98 | n/a | n/a | Not present |
| 1 | South (E) | 40059 | 40094 | Monolith | 40094/A/25-26cm | 99 | n/a | n/a | Not present |
| 1 | South (E) | 40059 | 40093 | Monolith | 40093/A/24-25cm | 100 | n/a | n/a | Not present |
| 1 | South (E) | 40059 | 40092 | Monolith | 40092/A/45-46cm | 101 | n/a | n/a | Not present |
| 1 | South (E) | 40058 | 40085 | Monolith | 40085/A/5-6cm | 102 | very low | moderate | *Rumex* |
| 1 | South (E) | 40058 | 40084 | Monolith | 40084/A/26-27cm | 103 | n/a | n/a | Not present |
| 1 | South (E) | 40058 | 40083 | Monolith | 40083/A/57-58cm | 104 | n/a | n/a | Not present |
| 1 | South (E) | 40057 | 40082 | Monolith | 40082/A/40-41cm | 105 | n/a | n/a | Not present |
| 1 | South (E) | 40057 | 40082 | Monolith | 40082/A/57-58cm | 106 | n/a | n/a | Not present |
| 1 | South (E) | 40057 | 40061 | Spot | 40061 | 107 | n/a | n/a | Not present |
| 1 | South (E) | 40057 | 40081 | Monolith | 40081/A/20-21cm | 108 | n/a | n/a | Not present |

Table 12.5 Pollen assessment: Phase 6 (grey clay, south of Trench D), Section 40015

| *Phase* | *Site area* | *Context* | *Source sample* <> | *Type* | *Site sample/ sub-sample* <> | *Pollen sample no.* | *Pollen concentration* | *Pollen preservation* | *Pollen taxa* |
|---|---|---|---|---|---|---|---|---|---|
| 6 | South (W) | 40100 | 40196 | Monolith | 40196/A/5-6cm | 1 | n/a | n/a | Not present |
| 6 | South (W) | 40100 | 40196 | Monolith | 40196/A/21-22cm | 2 | n/a | n/a | Not present |
| 6 | South (W) | 40100 | 40196 | Monolith | 40196/A/41-42cm | 3 | n/a | n/a | Not present |
| 6 | South (W) | 40100 | 40195 | Monolith | 40195/A/0-1cm | 4 | very low | moderate | *Ranunculus* |
| 6 | South (W) | 40100 | 40195 | Monolith | 40195/A/16-17cm | 5 | n/a | n/a | Not present |
| 6 | South (W) | 40100 | 40195 | Monolith | 40195/A/32-33cm | 6 | n/a | n/a | Not present |
| 6 | South (W) | 40100 | 40194 | Monolith | 40194/A/4-5cm | 7 | n/a | n/a | Not present |
| 6 | South (W) | 40100 | 40194 | Monolith | 40194/A/25-26cm | 8 | n/a | n/a | Not present |
| 6 | South (W) | 40100 | 40194 | Monolith | 40194/A/45-46cm | 9 | n/a | n/a | Not present |
| 6 | South (W) | 40100 | 40193 | Monolith | 40193/A/5-6cm | 10 | n/a | n/a | Not present |
| 6 | South (W) | 40100 | 40193 | Monolith | 40193/A/15-16cm | 11 | n/a | n/a | Not present |
| 6 | South (W) | 40100 | 40193 | Monolith | 40193/A/30-31cm | 12 | n/a | n/a | Not present |
| 6 | South (W) | 40039 | 40193 | Monolith | 40193/A/33-34cm | 13 | n/a | n/a | Not present |
| 6 | South (W) | 40039 | 40193 | Monolith | 40193/A/41-42cm | 14 | n/a | n/a | Not present |
| 6 | South (W) | 40039 | 40193 | Monolith | 40193/A/49-50cm | 15 | n/a | n/a | Not present |

Table 12.6 Pollen assessment: Phases 6a–6b (tufaceous channel), Trench XIII and Section 40064

| *Phase* | *Site area* | *Context* | *Source sample* <> | *Type* | *Site sample/ sub-sample* <> | *Pollen sample no.* | *Pollen concentration* | *Pollen preservation* | *Pollen taxa* |
|---|---|---|---|---|---|---|---|---|---|
| 6b | Central (E) | 40144 | 40311 | Bulk | 40311/A | 23 | very low | poor | Poaceae |
| 6b | Central (E) | 40144 | 40321 | Monolith | 40321/A/5-6cm | 24 | n/a | n/a | Not present |
| 6b | Central (E) | 40144 | 40321 | Monolith | 40321/A/14-15cm | 25 | n/a | n/a | Not present |
| 6b | Central (E) | 40144 | 40321 | Monolith | 40321/A/23-24cm | 26 | n/a | n/a | Not present |
| 6a | Central (E) | 40103 | 40321 | Monolith | 40321/A/44-45cm | 27 | n/a | n/a | Not present |
| 6b | Central (E) | 40143 | 40250 | Spot-sed | 40250/A | 85 | n/a | n/a | Not present |
| 6b | Central (E) | 40143 | 40249 | Spot-sed | 40249/A | 86 | n/a | n/a | Not present |
| 6b | Central (E) | 40143 | 40248 | Spot-sed | 40248/A | 87 | n/a | n/a | Not present |
| 6b | Central (E) | 40070 | 40281 | Monolith | 40281/A/4-5cm | 88 | n/a | n/a | Not present |
| 6b | Central (E) | 40070 | 40281 | Monolith | 40281/A/12-13cm | 89 | n/a | n/a | Not present |
| 6a | Central (E) | 40103 | 40281 | Monolith | 40281/A/22-23 | 90 | very low | moderate | *Pinus*, Poaceae |

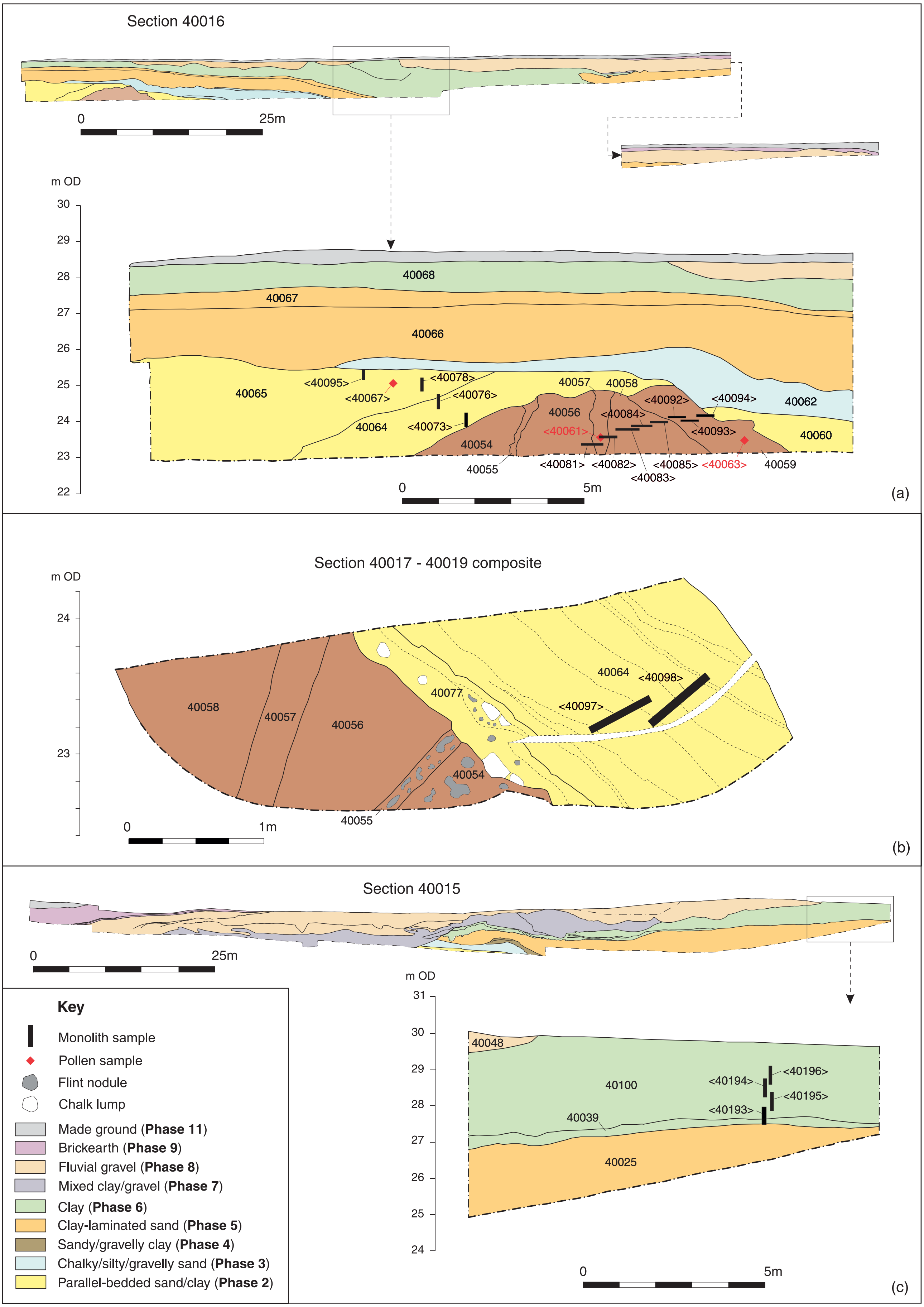


Figure 12.2 Pollen sampling locations, post-excavation assessment and analysis: (a) Phases 1–2, Section 40016; (b) Phase 2, Section 40017; (c) Phase 6, south of Trench D, Section 40015

Table 12.7 Pollen assessment: Phases 6a–6 (elephant horizon and surrounding grey clay), Section 40085

| *Phase* | *Site area* | *Context* | *Source sample <>* | *Type* | *Site sample/ sub-sample <>* | *Pollen sample no.* | *Pollen concentration* | *Pollen preservation* | *Pollen taxa* |
|---|---|---|---|---|---|---|---|---|---|
| 6 | Central (E) | 40162 | 40340 | Monolith | 40340/A/0-1cm | 28 | n/a | n/a | Not present |
| 6 | Central (E) | 40162 | 40340 | Monolith | 40340/A/12-13cm | 29 | n/a | n/a | Not present |
| 6 | Central (E) | 40162 | 40340 | Monolith | 40340/A/24-25cm | 30 | n/a | n/a | Not present |
| 6 | Central (E) | 40162 | 40340 | Monolith | 40340/A/39-40cm | 31 | very low | poor | *Betula* |
| 6 | Central (E) | 40162 | 40340 | Monolith | 40340/A/54-55cm | 32 | n/a | n/a | Not present |
| 6 | Central (E) | 40162 | 40340 | Monolith | 40340/A/69-70cm | 33 | n/a | n/a | Not present |
| 6 | Central (E) | 40162 | 40342 | Monolith | 40342/A/3-4cm | 34 | n/a | n/a | Not present |
| 6 | Central (E) | 40162 | 40342 | Monolith | 40342/A/18-19cm | 35 | n/a | n/a | Not present |
| 6a | Central (E) | 40103 | 40342 | Monolith | 40342/A/30-31cm | 36 | n/a | n/a | Not present |
| 6a | Central (E) | 40103 | 40342 | Monolith | 40342/A/33-34cm | 37 | n/a | n/a | Not present |
| 6a | Central (E) | 40103 | 40342 | Monolith | 40342/A/48-49cm | 38 | n/a | n/a | Not present |
| 6a | Central (E) | 40103 | 40342 | Monolith | 40342/A/66-67cm | 39 | n/a | n/a | Not present |
| 6 | Central (E) | 40162 | 40344 | Monolith | 40344/A/0-1cm | 40 | n/a | n/a | Not present |
| 6 | Central (E) | 40162 | 40344 | Monolith | 40344/A/9-10cm | 41 | n/a | n/a | Not present |
| 6 | Central (E) | 40162 | 40344 | Monolith | 40344/A/18-19cm | 42 | n/a | n/a | Not present |
| 6 | Central (E) | 40162 | 40344 | Monolith | 40344/A/27-28cm | 43 | very low | poor | *Plantago* |
| 6 | Central (E) | 40162 | 40344 | Monolith | 40344/A/39-40cm | 44 | n/a | n/a | Not present |
| 6 | Central (E) | 40162 | 40344 | Monolith | 40344/A/48-49cm | 45 | n/a | n/a | Not present |
| 6 | Central (E) | 40162 | 40344 | Monolith | 40344/A/60-61cm | 46 | very low | poor | *Alnus*, Poaceae |
| 6 | Central (E) | 40162 | 40345 | Monolith | 40345/A/0-1cm | 47 | n/a | n/a | Not present |
| 6 | Central (E) | 40162 | 40345 | Monolith | 40345/A/12-13cm | 48 | n/a | n/a | Not present |
| 6 | Central (E) | 40162 | 40345 | Monolith | 40345/A/24-25cm | 49 | n/a | n/a | Not present |
| 6 | Central (E) | 40162 | 40345 | Monolith | 40345/A/36-37cm | 50 | n/a | n/a | Not present |
| 6 | Central (E) | 40162 | 40345 | Monolith | 40345/A/48-49cm | 51 | n/a | n/a | Not present |
| 6 | Central (E) | 40162 | 40345 | Monolith | 40345/A/63-64cm | 52 | n/a | n/a | Not present |
| 6 | Central (E) | 40100 | 40352 | Monolith | 40352/A/3-4cm | 53 | very low | poor | Poaceae |
| 6 | Central (E) | 40099 | 40352 | Monolith | 40352/A/12-13cm | 54 | n/a | n/a | Not present |
| 6 | Central (E) | 40099 | 40352 | Monolith | 40352/A/18-19cm | 55 | very low | poor | Poaceae |
| 6 | Central (E) | 40099 | 40352 | Monolith | 40352/A/21-22cm | 56 | n/a | n/a | Not present |
| 6 | Central (E) | 40099 | 40352 | Monolith | 40352/A/27-28cm | 57 | n/a | n/a | Not present |
| 6 | Central (E) | 40099 | 40352 | Monolith | 40352/A/33-34cm | 58 | n/a | n/a | Not present |
| 6 | Central (E) | 40099 | 40352 | Monolith | 40352/A/42-43cm | 59 | very low | moderate | *Picea* |
| 6 | Central (E) | 40099 | 40352 | Monolith | 40352/A/51-52cm | 60 | n/a | n/a | Not present |
| 6 | Central (E) | 40099 | 40353 | Monolith | 40353/A/0-1cm | 61 | n/a | n/a | Not present |
| 6 | Central (E) | 40099 | 40353 | Monolith | 40353/A/9-10cm | 62 | n/a | n/a | Not present |
| 6 | Central (E) | 40099 | 40353 | Monolith | 40353/A/21-22cm | 63 | n/a | n/a | Not present |
| 6 | Central (E) | 40099 | 40353 | Monolith | 40353/A/36-37cm | 64 | n/a | n/a | Not present |
| 6a | Central (E) | 40103 | 40353 | Monolith | 40353/A/44-45cm | 65 | very low | poor | Cyperaceae, Poaceae |
| 6a | Central (E) | 40103 | 40353 | Monolith | 40353/A/53-54cm | 66 | n/a | n/a | Not present |
| 6 | Central (El) | 40100 | 40364 | Monolith | 40364/A/0-1cm | 67 | low | moderate | Pinus, *Corylus*, *Alnus*, *Tilia*, Poaceae |
| 6 | Central (El) | 40100 | 40364 | Monolith | 40364/A/6-7cm | 68 | low | moderate | *Alnus*, *Picea*, *Corylus*, Poaceae, Polypodiaceae |
| 6 | Central (El) | 40100 | 40364 | Monolith | 40364/A/12-13cm | 69 | n/a | n/a | Not present |
| 6 | Central (El) | 40100 | 40364 | Monolith | 40364/A/18-19cm | 70 | low | moderate | *Betula* |
| 6 | Central (El) | 40078 | 40364 | Monolith | 40364/A/27-28cm | 71 | n/a | n/a | Not present |
| 6 | Central (El) | 40078 | 40364 | Monolith | 40364/A/30-31cm | 72 | very low | moderate | Asteraceae |
| 6 | Central (El) | 40078 | 40364 | Monolith | 40364/A/33-34cm | 73 | n/a | n/a | Not present |
| 6 | Central (El) | 40078 | 40364 | Monolith | 40364/A/36-37cm | 74 | n/a | n/a | Not present |
| 6 | Central (El) | 40078 | 40364 | Monolith | 40364/A/39-40cm | 75 | n/a | n/a | Not present |
| 6 | Central (El) | 40078 | 40364 | Monolith | 40364/A/42-43cm | 76 | n/a | n/a | Not present |
| 6 | Central (El) | 40078 | 40364 | Monolith | 40364/A/45-46cm | 77 | n/a | n/a | Not present |
| 6 | Central (El) | 40099 | 40364 | Monolith | 40364/A/49-50cm | 78 | n/a | n/a | Not present |
| 6 | Central (El) | 40099 | 40364 | Monolith | 40364/A/52-53cm | 79 | n/a | n/a | Not present |
| 6 | Central (El) | 40078 | 40365 | Monolith | 40365/A/0-1cm | 80 | n/a | n/a | Not present |
| 6 | Central (El) | 40078 | 40365 | Monolith | 40365/A/6-7cm | 81 | n/a | n/a | Not present |
| 6 | Central (El) | 40099 | 40365 | Monolith | 40365/A/17-18cm | 82 | n/a | n/a | Not present |
| 6a | Central (El) | 40103 | 40365 | Monolith | 40365/A/29-30cm | 83 | n/a | n/a | Not present |
| 6a | Central (El) | 40103 | 40365 | Monolith | 40365/A/38-39cm | 84 | n/a | n/a | Not present |

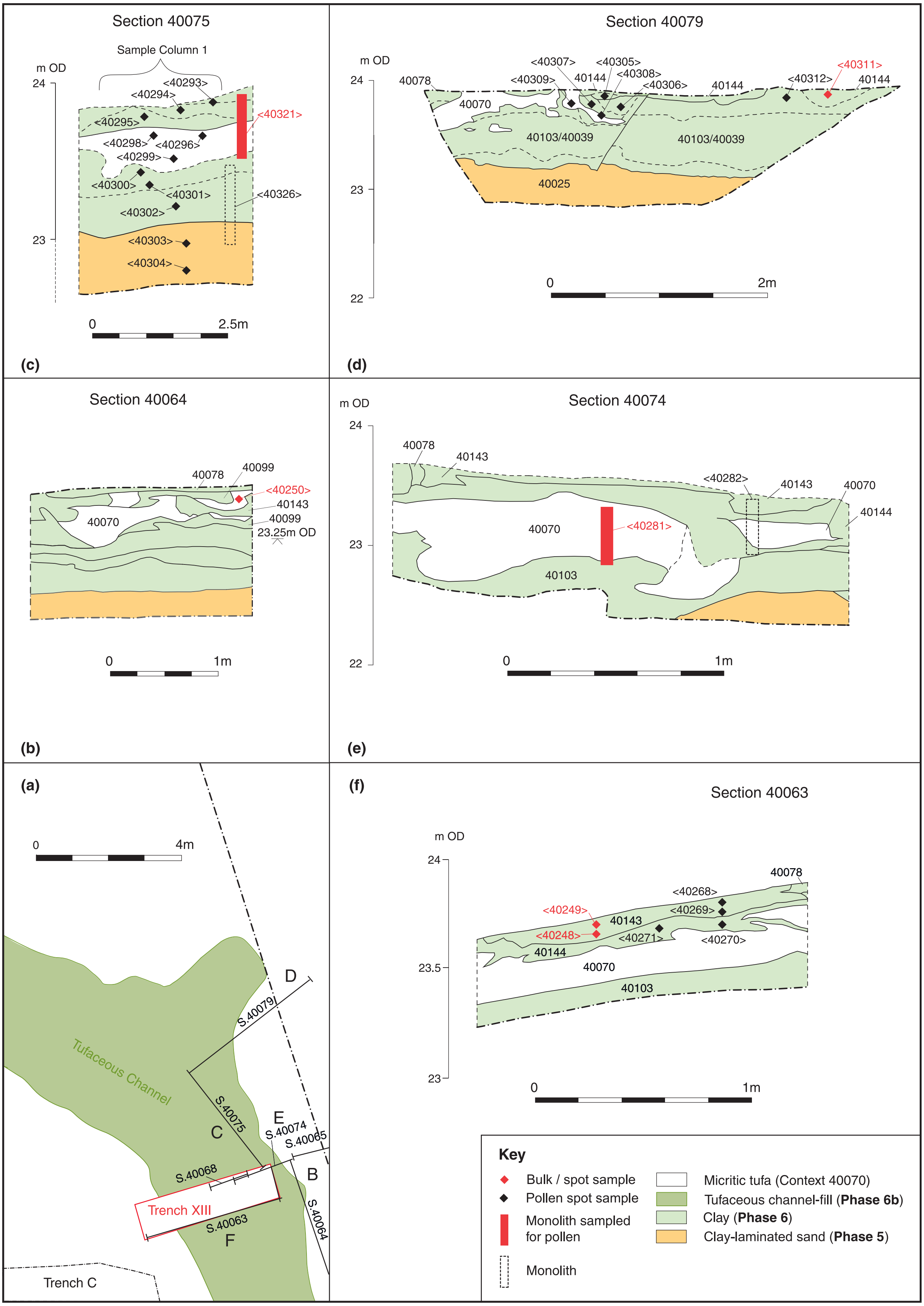


Figure 12.3 Pollen sampling locations, post-excavation assessment and analysis, Phases 6a–6b: (a) thumbnail of sampling locations; (b) Section 40064; (c) tufaceous channel, Section 40075; (d) tufaceous channel, Section 40079; (e) Trench XIII, Section 40074 (south-facing); and (f) Trench XIII, Section 40063 (north-facing)

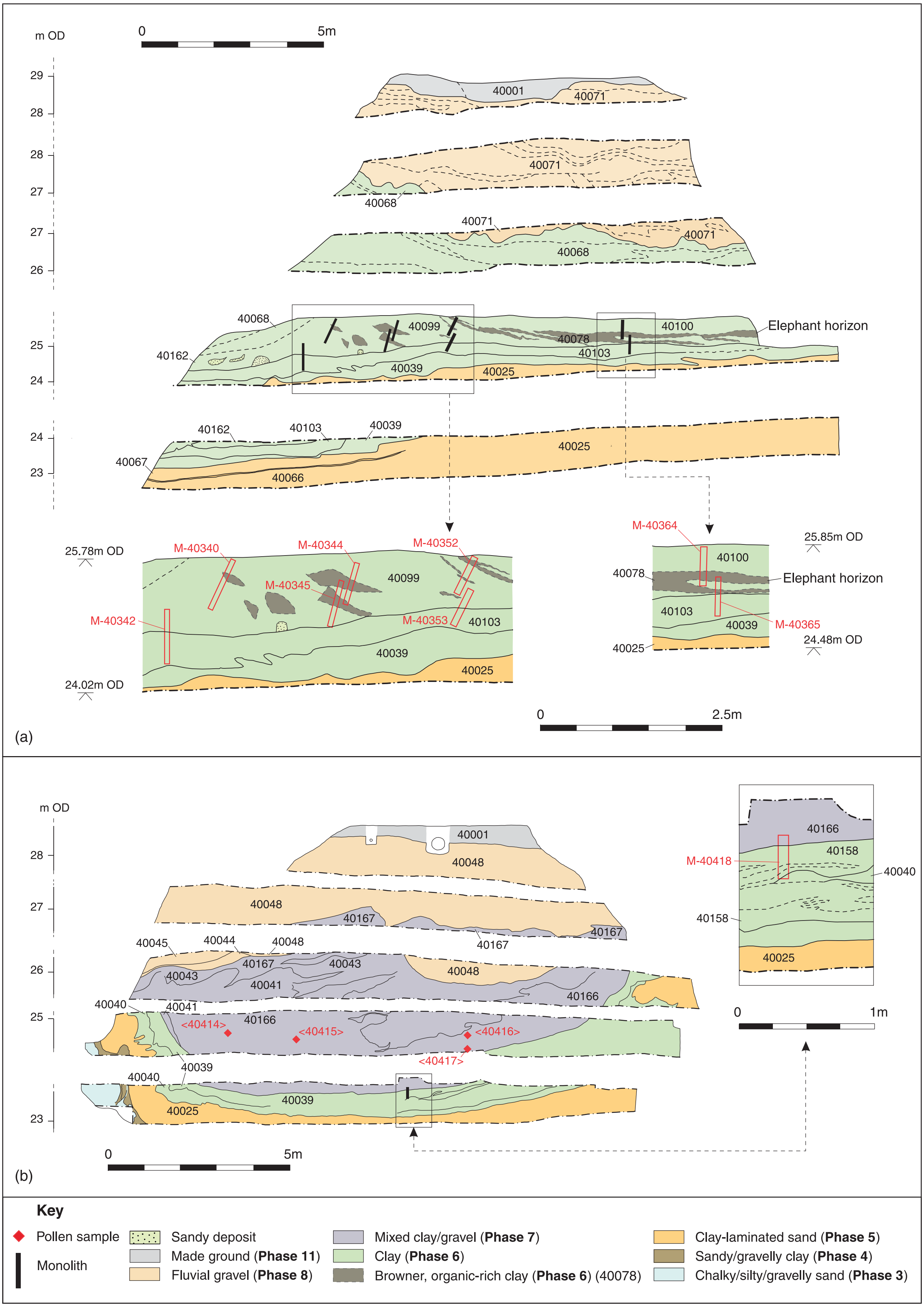


Figure 12.4 Pollen sampling locations, post-excavation assessment and analysis, Phases 6–7, including elephant horizon: (a) Trench C, Section 40085 (monoliths <40340>, <40342>, <40344>, <40345>, <40352>, <40353>, <40364> and <40365>); (b) Trench B, Section 40091

Table 12.8 Pollen assessment: Phases 6–7 (Trench B), Section 40091

| *Phase* | *Site area* | *Context* | *Source sample <>* | *Type* | *Site sample/ sub-sample <>* | *Pollen sample no.* | *Pollen concentration* | *Pollen preservation* | *Pollen taxa* |
|---|---|---|---|---|---|---|---|---|---|
| 7 | Central (N) | 40166 | 40414 | Bulk | 40414/A | 16 | n/a | n/a | Not present |
| 7 | Central (N) | 40166 | 40415 | Bulk | 40415/A | 17 | n/a | n/a | Not present |
| 7 | Central (N) | 40166 | 40416 | Bulk | 40416/A | 18 | n/a | n/a | Not present |
| 7 | Central (N) | 40166 | 40417 | Bulk | 40417/A | 19 | n/a | n/a | Not present |
| 7 | Central (N) | 40166 | 40418 | Monolith | 40418/A/0-1cm | 20 | n/a | n/a | Not present |
| 6 | Central (N) | 40158 | 40418 | Monolith | 40418/A/5-6cm | 21 | very low | poor | *Pinus*, *Pediastrum* |
| 6 | Central (N) | 40158 | 40418 | Monolith | 40418/A/14-15cm | 22 | low | moderate | Chenopodiaceae, *Ulmus*, *Alnus*, Poaceae, *Betula*, Polypodiaceae |

assessed from the monolith sequence through the Phase 6 clay in section 40085. These included samples from the lower parts of the clay (Phase 6a) below the elephant horizon, a deep sequence of samples through the clay above the elephant horizon, and two monoliths through a lateral equivalent of the elephant horizon, less than 5m from the elephant skeleton (Table 12.7; Fig. 12.4a). Finally, seven samples were assessed through the very dark context 40158 (Phase 6) seen in the south-facing section 40091 of Trench B and the overlying fine silty sand of context 40166 (Table 12.8; Fig. 12.4b).

In total, 108 samples were assessed for pollen preservation. Preparation of the samples was carried out in a clean laboratory environment, with every care taken to minimise cross-contamination and the incorporation of modern pollen. The methodology used is summarised in the accompanying figure (Fig. 12.5). The slides were scanned to provide an assessment of the key pollen and

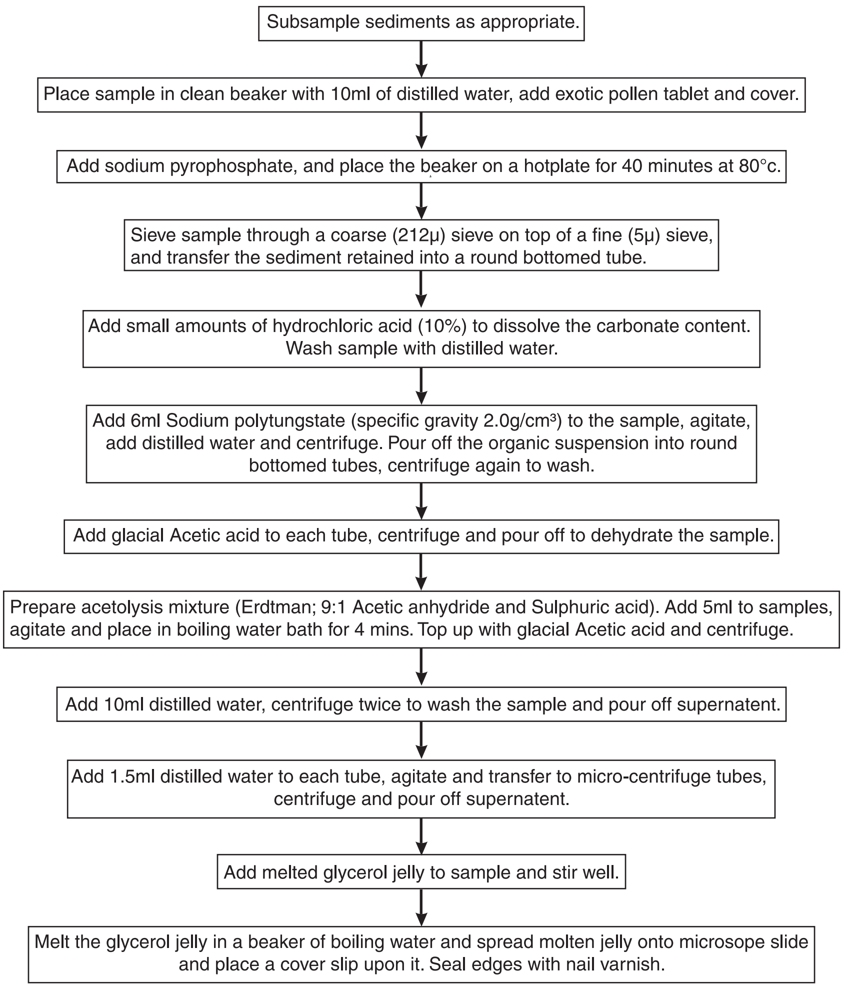


Figure 12.5 Pollen slide preparation method (Branch 2000, modified from Moore, Webb & Collinson 1991)

spore taxa, pollen and spore concentrations and preservation, and results are given for each group of assessed samples in the summary tables (Table 12.4 – Table 12.8). Pollen and spores were absent, or only present in very low quantities, in almost all of the samples processed.

Only three samples contained an interpretable presence of pollen grains, generally moderately preserved albeit in low concentrations. One of these was sample <40418/A/14-15cm> from context 40158, from the same horizon as two earlier samples <40407> and <40410> taken and studied while fieldwork was in progress, the latter of which produced the *Azolla* spore (see above). The other two were both from different depths within monolith <40364> (0-1cm and 6-7cm) both of these representing grey clay of context 40100 that overlay the browner, more organic-rich clay of context 40078 that contained the elephant skeleton, and which had previously produced countable pollen data (see above). Curiously, the assessment samples thought to be equivalent to the elephant horizon, between 27 and 47cm depth in monolith <40364>, and between 1 and 5cm depth in monolith <40365>, produced minimal pollen remains in this phase of investigation. Nonetheless, there were general similarities in the taxa present in the polleniferous assessment samples, with similar indications of mixed woodland and alder carr in the landscape. Despite the low concentrations noted, making it unlikely that a statistically significant pollen count (ie 300 Total Land Pollen) would be practically obtainable from these samples, further analyses (and counting) were carried out for the polleniferous horizons in monoliths <40364> and <40418>.

Thus, eleven samples were analysed in more detail. These comprised seven from the upper part of monolith <40364> between 0 and 25cm from its top, representing context 40100 directly above the elephant horizon (see Table 12.9) and four from the middle part of monolith <40418> between 5 and 20cm from its top, representing context 40158. This is thought to be a broad lateral equivalent of the elephant horizon (see Table 12.10).

Overall the pollen concentrations in these samples were low (between 62 and 2051 grains/cm$^3$) (Table 12.11) and consequently the inferences made here are tentative. Generally the pollen grains identified were in fair to good condition suggesting that they had not been subject to extensive re-working. It is however likely that selective preservation of pollen grains has taken place in favour of the more robust pollen grains such as pine *Pinus*, lime *Tilia* and alder *Alnus*.

### *Monolith <40364> (context 40100)*

Pollen concentrations were moderate to very low (62-1672 grains/cm$^3$) from this context. A summary of the pollen counts is given here (Table 12.9), with a graphic diagram of the profile through the sequence (Fig. 12.6) and details of the changing concentrations through the profile (Table 12.11). This sequence is characterised by a diverse arboreal assemblage including fir *Abies*, alder *Alnus*, oak *Quercus,* lime *Tilia* and elm *Ulmus* as well as coniferous elements such as pine *Pinus* and spruce *Picea*. The presence of other taxa including hazel *Corylus,* daisy family Asteraceae and grasses *Poaceae* is also noted. Aquatic taxa are barely represented, with only *Pediastrum* (a green algae) and water lily *Nuphar*.

The similarity of the pollen data throughout the sequence suggests that the sediments were deposited relatively quickly with little evidence for vegetation succession, although a dominance of Poaceae at 21-22cm in monolith <40364> suggests a short-lived phase of local more open conditions. The pollen taxa identified tentatively suggest deposition under temperate conditions, with the regional presence of mixed woodland and perhaps alder carr growing in wetter areas. This interpretation accords with the previous investigations by Turner of the horizon of the elephant skeleton (see above; also in Wenban-Smith *et al.* 2006), apart from in the presence of *Abies*. The presence of herbaceous

Table 12.9 Summary table of the raw pollen counts from monolith <40364>

| *Taxa* | *0-1cm* | *3-4cm* | *6-7cm* | *9-10cm* | *15-16cm* | *18-19cm* | *21-22cm* |
|---|---|---|---|---|---|---|---|
| *Abies* | 0 | 2 | 0 | 0 | 8 | 0 | 0 |
| *Alnus* | 53 | 14 | 7 | 0 | 24 | 1 | 0 |
| *Betula* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Picea* | 12 | 11 | 4 | 0 | 0 | 0 | 0 |
| *Pinus* | 7 | 17 | 5 | 0 | 34 | 1 | 1 |
| *Quercus* | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| *Tilia* | 6 | 3 | 1 | 0 | 4 | 0 | 0 |
| *Ulmus* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Corylus* type | 11 | 10 | 1 | 0 | 14 | 0 | 0 |
| Asteraceae undiff | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| Caryophyllaceae | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| cf *Limonium* type | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| Cyperaceae | 1 | 0 | 0 | 0 | 5 | 0 | 0 |
| Poaceae | 20 | 0 | 0 | 0 | 15 | 0 | 19 |
| *Nuphar* | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Pediastrum* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Polypodium* | 3 | 24 | 9 | 0 | 10 | 2 | 2 |

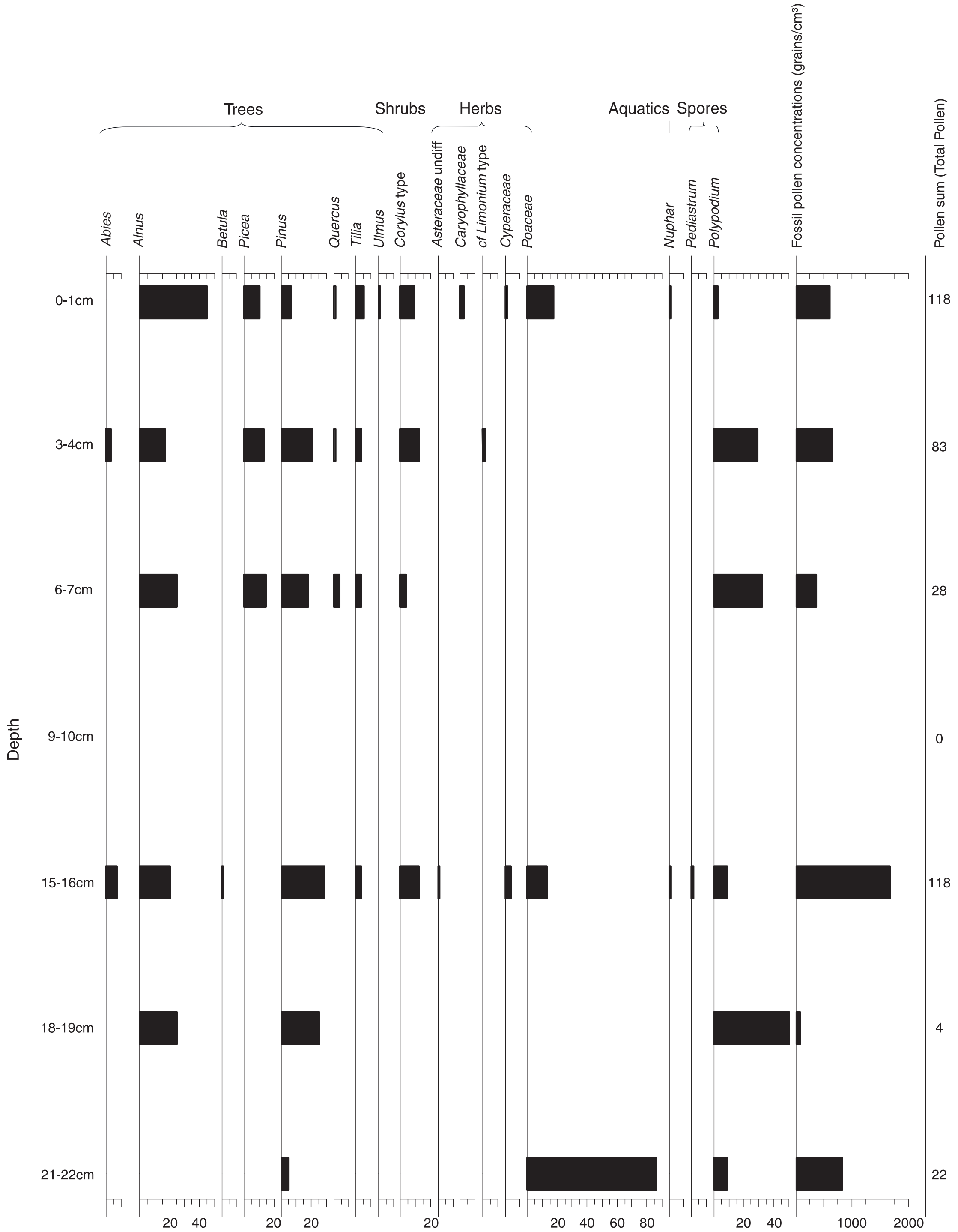


Figure 12.6 Total pollen percentage diagram for monolith <40364> (context 40100, upper part of monolith)

elements suggests that open, and possibly disturbed,areas were also present, as well as some open water inferred from the presence of *Pediastrum* and *Nuphar*.

## *Monolith <40418>*

Pollen concentrations were moderate to very low (102-2051 grains/cm$^3$) for the samples from this context. A summary of the pollen counts is given here (Table 12.10), with a graphic diagram of the profile through the sequence (Fig. 12.7) and details of the changing concentrations through the profile (Table 12.11). The discussion that follows is based on the pollen analysis of the sub-sample from 14-15cm depth, as the other levels were characterised by very low pollen content. This level is characterised by a diverse arboreal assemblage including *Alnus*, *Ulmus* and *Pinus*. The presence of other taxa including *Corylus,* Asteraceae and Poaceae is also noted.

The pollen taxa identified suggest deposition under temperate conditions, with mixed woodland and perhaps alder carr present in the landscape. The presence of Poaceae and other herbs suggests that open areas, possibly subject to disturbance, would also have characterised the landscape.

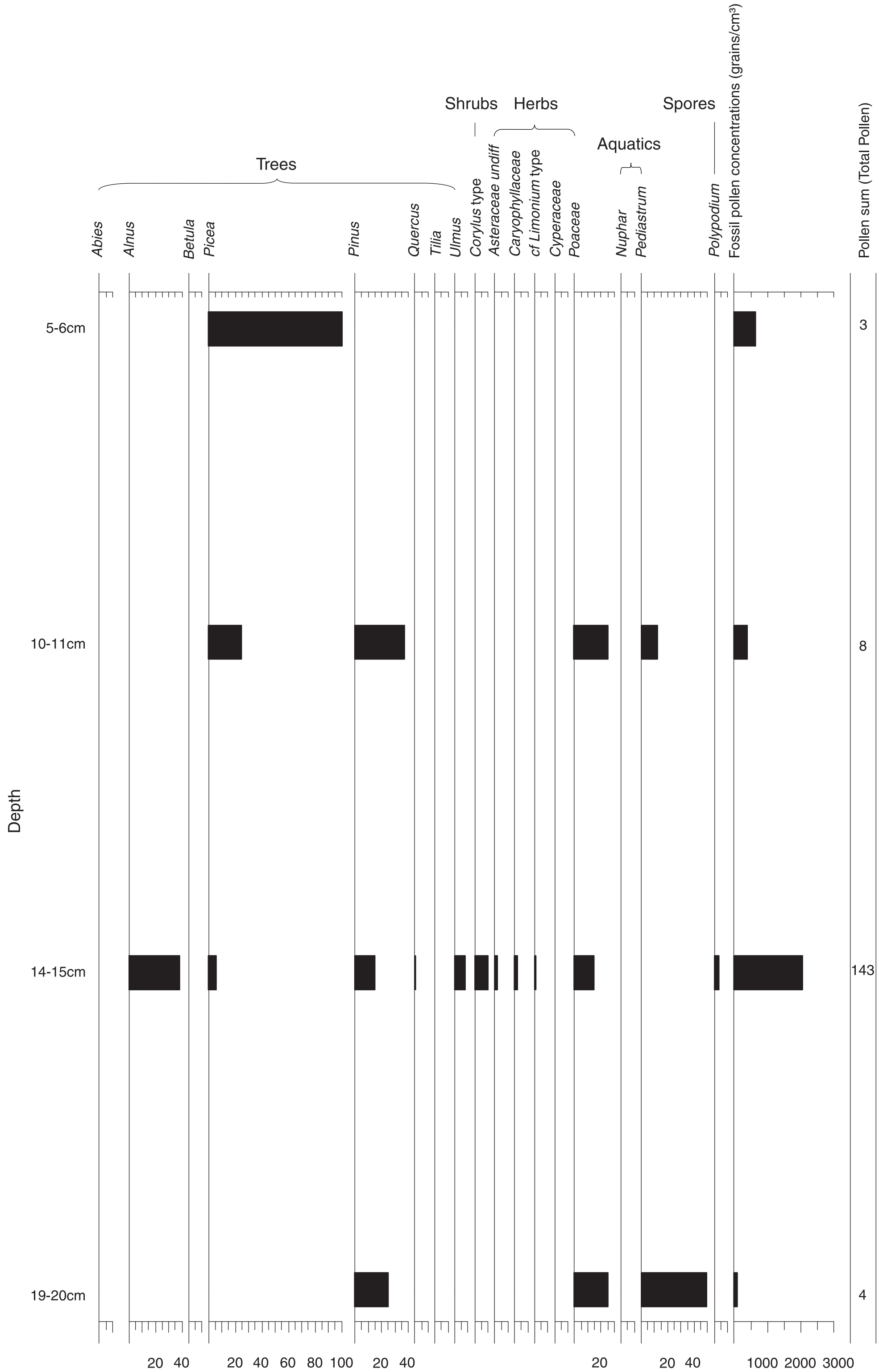


Figure 12.7 Total pollen percentage diagram for monolith <40418> (all samples from context 40158)

## DISCUSSION AND CONCLUSIONS

The interpretative potential of the pollen remains from the site is, unfortunately, constrained by its poor preservation, generally low abundance and differential preservation. Contra the results of the initial field evaluation, it is clear that there are only two horizons where pollen (other than occasional Tertiary derivations) is preserved. These are, firstly, the lower part of Phase 6, in the area of the elephant skeleton, where the grey clay of context 40100 interdigitates at its base with occasional darker brown more organic-rich beds, including context 40078. Secondly, a little (*c* 10-15m) to the north-east of the elephant, where the full thickness of Phase 6 becomes conflated to the very dark brown (almost black) organic-rich clay-silt beds *c* 0.2-0.3m thick of context 40158. The profiles from these two horizons are very similar, and indeed there is direct

Table 12.10 Summary table of the raw pollen counts from monolith <40418>

| *Taxa* | *5-6cm* | *10-11cm* | *14-15cm* | *19-20cm* |
|---|---|---|---|---|
| *Abies* | 0 | 0 | 0 | 0 |
| *Alnus* | 0 | 0 | 55 | 0 |
| *Betula* | 0 | 0 | 0 | 0 |
| *Picea* | 3 | 2 | 8 | 0 |
| *Pinus* | 0 | 3 | 22 | 1 |
| *Quercus* | 0 | 0 | 1 | 0 |
| *Tilia* | 0 | 0 | 0 | 0 |
| *Ulmus* | 0 | 0 | 11 | 0 |
| *Corylus* type | 0 | 0 | 14 | 0 |
| Asteraceae undiff | 0 | 0 | 3 | 0 |
| Caryophyllaceae | 0 | 0 | 3 | 0 |
| cf *Limonium* type | 0 | 0 | 1 | 0 |
| Cyperaceae | 0 | 0 | 0 | 0 |
| Poaceae | 0 | 2 | 20 | 1 |
| *Nuphar* | 0 | 0 | 0 | 0 |
| *Pediastrum* | 0 | 1 | 0 | 2 |
| *Polypodium* | 0 | 0 | 5 | 0 |

Table 12.11 Pollen concentrations, analysed samples from monoliths <40364> and <40418>

| *Monolith* | *Sub-Sample <>* | *Fossil pollen concentration (grains/$cm^3$)* |
|---|---|---|
| M-<40364> | 40364/A/0-1cm | 591 |
| | 40364/A/3-4cm | 647 |
| | 40364/A/6-7cm | 361 |
| | 40364/A/9-10cm | No pollen |
| | 40364/A/15-16cm | 1672 |
| | 40364/A/18-19cm | 62 |
| | 40364/A/21-22cm | 826 |
| M-<40418> | 40418/A/5-6cm | 643 |
| | 40418/A/10-11cm | 399 |
| | 40418/A/14-15cm | 2051 |
| | 40418/A/19-20cm | 102 |

lateral continuity between them so they can be considered together.

The general similarity between the pollen evidence from the two samples from context 40078 associated with the elephant skeleton, and that from monolith <40364> from context 40100, the lower part of the grey clay sealing the elephant horizon, suggests that this part of the sequence formed under reasonably stable climatic and local environmental conditions. The evidence indicates a local environment of swampy alder carr, with a mixed, mostly deciduous forest on surrounding higher and drier ground, characteristic of the early temperate substage of an interglacial. The presence of various shrubs and grasses indicates that this forest is not unbroken, but contains open areas probably maintained by herbivore grazing (see Chapter 7). A marked abundance of grasses at the base of the sequence from monolith <40364> may, however, reflect a short-lived phase of more open local environment. Then, the presence of the distinctive grain of *Abies* higher up the sequence from this monolith suggests that this part of the sequence is not contemporary with the elephant, since this distinctive and robust grain would have been recognised in the samples from beside the elephant, had it been present.

There is nothing in the pollen evidence on its own to confirm that the interglacial concerned is the Hoxnian, or MIS 11. However, all the indications support this attribution. From the elephant horizon, the presence of *Azolla*, the absence of *Abies* and *Carpinus,* and the abundance of *Alnus* are all suggestive of the early-temperate substage, zone Ho II of MIS 11. It may in fact be towards the end of zone Ho II considering that just above, in monolith <40364>, the scarce presence of *Abies* provides a faint indication that this part of the sequence may date to the very end of zone Ho II or the start of zone Ho III, when this species starts to develop a greater presence in the Hoxnian.