Environmental Archaeology

Appendix 2 - Commonly Studied Environmental Remains: preservation, recovery and significance

Summary

This document is part of a suite of documents about environmental archaeology practice. It is an appendix to the main text: Environmental Archaeology: A Guide to the Theory and Practice of Methods, from Sampling and Recovery to Post-excavation (third edition), and should be read in conjunction with that document. It contains examples of 20 types of environmental remains, discusses how they are preserved, and how their study can be incorporated into archaeological projects.

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Front cover: Charred oat grains from High Tarns medieval site, Cumbria.

Contents

Introduction

Appendix 2 is intended to support archaeological project managers, local authority archaeologists and archaeological consultants in understanding the key relevant information for the main specialisms employed in archaeology in England today. It does not cover every type of biological remains that can be applied to the archaeological resource, but does cover commonly used methods and approaches.

From the outset there have been examples of individuals using the earth sciences or biological sciences to study archaeological remains associated with past human activity. Well-known examples of this include the use of vertebrate anatomy by William Buckland to identify the bones of extinct mammals in caves in Kirkdale Cavern, Yorkshire, in 1822, the use of geological sciences to propose ancient dates for Palaeolithic tools by John Frere in 1797, and the use of pollen studies by Harry Godwin from 1940 onwards to propose changing landscapes and environments through time (Evans and O'Connor 2005, 2-3). Since then, particularly from the 1960s onwards, these methods have developed into the distinct field of environmental archaeology, which itself has undergone further development over time, both through methodological improvements and developing philosophical and theoretical approaches.

In England, the incorporation of archaeology into the planning system from 1990 (known as Planning Policy Guidance 16: Archaeology and Planning, or PPG16), and the increase in archaeological work this generated, resulted in a huge increase in developer-funded environmental archaeology services. This not only opened up employment opportunities for archaeological scientists, but also created datasets that challenged academic paradigms, leading to refinements and improvements in archaeological science practice. This mutual support and development between academic and developer-funded research continues to this day.

Many commercial archaeology units have at least one environmental specialist, typically with a background in zooarchaeology or archaeobotany. They may also have several individuals with a range of specialist skills, depending on the nature of the region in which they work and the size of projects they generally undertake. These individuals may be responsible for associated tasks as well, such as coordinating the outsourcing of specialist analyses or taking a lead in the choice of materials for radiocarbon dating.

Developments in archaeological science, and the increasing complexity of the approaches and methods used to study archaeological remains, have meant that where once a single specialist might reasonably have undertaken different strands of work there is now often the need to consult multiple individuals with distinct specialist skills. For example, the field of archaeobotany can encompass work on charred plant remains (typically seeds and cereal grains), waterlogged macroscopic remains (which can include delicate preserved vegetative remains), charcoal and waterlogged wood. Within the broad field of archaeobotany, these specialisms all exist as discreet fields of study in their own right, with their own distinct approaches to sampling, identification, quantification and analysis. Similarly, zooarchaeological assemblages of diverse remains of fish and bird bone may present identification and quantification challenges in addition to those seen in mammal bone assemblages from the same site.

In all cases it is the responsibility of the specialists to be clear where they may need the input of additional support (either direct additional specialist input, or advisory support) in order to address properly the research potential of the material they are working on. Likewise, project managers should ensure all staff members are competent and have the necessary training, skills, expertise and knowledge to undertake the work assigned to them.

The increasing subspecialisation within environmental archaeology does not mean that individuals cannot cross subspecialist boundaries. However, it does mean that all practitioners need to stay aware of new developments within their fields, engage in continuous professional development (CPD), and understand when they will need to call upon experienced peers, or utilise resources such as specialist reference collections, to help them complete their work to a high professional standard. There are also a number of special interest groups that provide supportive environments for CPD and networking. These groups are particularly important for individuals working as independent specialists or in small units, where they may be the only environmental archaeologist employed by their organisation.

For all archaeological projects it is recommended that early contact is made with an experienced specialist to discuss the sampling and recovery of biological remains. In addition, there needs to be clarity as to what outputs are needed, or are indeed even feasible, for the project. This can include all stakeholders being clear on:

- the resources required for assessment or full analysis;
- the different outputs required for assessments and full analyses;
- what resources may be required for the publication of results;
- what resources may be required for the production of findable, accessible, interoperable, reusable (FAIR) datasets/archives (Wilkinson 2016);
- how specialist input may address project-specific, regional and national research agendas;
- whether further subspecialist input is required for successful completion of the project.

An overview of the different types of environmental remains commonly studied is presented on the following pages, arranged in an easily comparable short format utilising the same subsections:

- Introduction
- Preservation
- Recovery
- Archaeological significance

Recommended reading has also been provided in a bibliography.

Further advice on the recovery and study of these remains and the use of other subspecialisms and other archaeological techniques can be sought from the Historic England Science Advisors.

Multiproxy approaches

The use of multiple lines of evidence to study archaeological sites and environments is now well established (for example see Fig 4 in the main guidelines text, Brown et al. 2023; Fig 11, Knight et al. 2024). Some of these multiproxy approaches work well because different biological remains may be preserved under similar conditions and in similar archaeological contexts. For example, a medieval latrine fill could usefully be studied with a combination of archaeobotanical, zooarchaeological (particularly fish bone), pollen, insect and parasite analyses. In other situations, different lines of evidence can be combined because the biological remains preserve under different conditions and thus, should one element be poorly preserved, it may be compensated for by others. This is why studies in estuarine environments may utilise diatoms, ostracods and foraminifera (see Table 1 in appendix 2 of this guidance).

In cases where multiproxy approaches are undertaken, careful coordination of specialists is required, including an understanding between all project stakeholders of how the outcomes of the different studies will contribute to the aims and objectives of the project.

Table 1: The use of biological remains in reconstructing past wet environments.

	Temperature	Salinity	Nutrient status	Water availability	Oxygen concentration	Substrate	Acidification
Testate amoebae	no	yes	yes	yes	no	no	yes
Diatoms	yes	yes	yes	yes	yes	no	yes
Ostracods	no	yes	no	yes	yes	yes	no
Foraminifera	no	yes	no	no	no	yes	no
Chironomid larvae	yes	no	no	yes	no	no	no

1. Charred plant remains

Introduction

Charred plant remains are ubiquitous on archaeological sites from all periods. This class of material can include charred seeds, grains, stems, buds and tubers. It also includes charcoal, but analysis of this is a separate field of study (see Section 3). Plant remains can be charred through a variety of mechanisms, which can reflect cultural activities. These can include accidental burning of cereal grains in a corn-dryer, charring of hazelnuts (commonly found in large numbers on prehistoric sites), or burning resulting from catastrophic fires in houses or other structures. Deliberate activities can include the burning of floor sweepings and stable waste to dispose of them, and the use of animal dung or turves as fuel.

Preservation

The charring process makes the organic plant materials resistant to the natural chemical and biological processes that would normally degrade and destroy them. However, they are vulnerable to physical erosion (e.g. trampling). Depth of burial and the stability of the burial medium is a factor in their preservation. They may be widely dispersed within certain contexts such as ditches, or can be concentrated within features such as pits or kilns. Dumps of burnt material or in-situ burning can also occur. These taphonomic factors need to be borne in mind when considering where and how to sample.

Recovery

Charred plant remains are normally recovered in sediment samples, which typically should be 40–60 litres in volume, or 100% of the sediment from smaller contexts. Samples should be taken from within a single context, using clean tools and a clean receptacle. It is recommended that sediment be recovered from across different parts of a context (rather than as a single flotation sample).

Samples from dry land sites are usually processed by flotation, with the flot collected in a 300µm sieve, and the heavy residue collected in a 0.5–1mm nylon mesh. These samples are distinct from waterlogged remains, which are dealt with in Section 2.

Archaeological significance

Charred plant remains can reveal information on the economy, local environment around an archaeological site, and patterns of waste disposal related to cereal production and use. They can provide evidence of plants used as construction material (such as thatch and turves), the use of cultivated and wild plants as food for humans or fodder for domestic animals, and the use of plant material such as chaff as fuel. An understanding of these remains also provides evidence of site-formation processes, including evidence for contamination and reworking.

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Figure 1: Charred oat grains from High Tarns medieval site, Cumbria.

2. Waterlogged plant remains

Introduction

In temperate environments plant remains on archaeological sites are most commonly preserved via charring and waterlogging. Though complementary, these different forms of preservation generally produce very different types of archaeobotanical and archaeological information. Waterlogged remains not only preserve seeds and grains of plants, but also vegetative elements such as leaves, stems and roots. This material can include plants used as flavourings, vegetable foods and dye plants that are rarely preserved through charring.

Waterlogged plant remains also provide detailed evidence of different habitats, from heathland to hay meadows.

Preservation

Waterlogged preservation relies on the exclusion of oxygen (anoxic conditions), and thus the cessation or slowing down of the biological and chemical processes that would normally degrade and breakdown organic materials.

The Roman settlement at Vindolanda, Northumberland, Anglo-Saxon and Anglo-Scandinavian deposits in York, and Roman and medieval remains in London, are some of England's best-known examples. However, waterlogging can occur at any site, and even in apparently well-drained sites the presence of waterlogged deposits in deeper ditches or pits should be anticipated.

Recovery

Sampling waterlogged deposits typically involves taking samples of 5–10 litres. Waterlogged deposits require specific processing methods, typically disaggregation in water followed by washing the deposit through sieves with a mesh of 250µm (0.25mm). Because of the delicate nature of these remains, they should be transported to a specialist as soon as possible.

The resultant material must then by stored wet and kept refrigerated to prevent the growth of moulds and algae. Processing in a flotation tank and drying the resultant material will irreversibly destroy this material. Project archaeobotanical specialists must ensure they have the requisite skills and experience to study such remains.

Archaeological significance

Waterlogged plant remains will contain a range of plant species and materials not usually recovered in charred plant assemblages. From latrine contexts, vegetative parts (such as onion epidermis) and cereal bran may be recovered. Dye plants such as madder may also be recovered.

Waterlogged features such as the fills of waterholes or palaeochannels provide evidence of environmental change and different natural habitats, revealing how the landscape has changed over time. Such studies are always best carried out in combination with studies for other environmental proxies, such as insects, molluscs, pollen and other microfossils.

The study of waterlogged plant remains can also be an important factor in the assessment of preservation conditions on an archaeological site.

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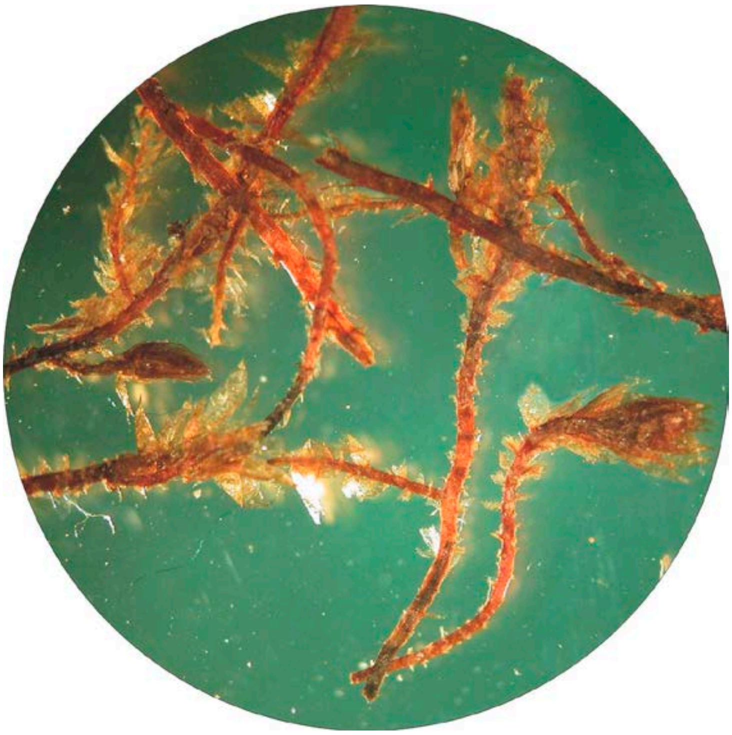

Figure 2: Moss fragments from the upper organic mound, Silbury Hill, Wiltshire dating to the late Neolithic.

3. Wood charcoal

Introduction

The presence of charcoal in a deposit may be the first indication of human activity when conducting archaeological survey or evaluation work. Charcoal forms from the incomplete burning of wood and thus can be found on any site where people have used fire or where wildfires have occurred.

The cell structure of wood is preserved in charcoal, and specialist examination can identify groups of wood taxa or individual species and a range of other archaeologically significant details (e.g. insect and fungal damage, ring curvature, number of rings). Charcoal studies play a significant role in the understanding of the organisation of domestic, industrial and ecological processes.

Preservation

Charcoal can be preserved in all sediment types and a range of depositional environments. It can be present as small, fine fragments barely visible to the naked eye, or clearly visible in deposits producing many kilograms of >4mm charred wood fragments.

If not subjected to physical stresses, charcoal (like other charred plant material) is durable and survives well in the archaeological record. However, this durability means that it can be reworked and redeposited within contexts. An understanding of the taphonomy of the charcoal in an assemblage is therefore essential.

Recovery

Charcoal can be collected via the same flotation samples used for general archaeobotanical sampling. In some cases deposits should be sampled using a grid, e.g. at charcoal production sites, or where burnt structures are being investigated.

Charcoal analysis is conducted using high-power microscopy (×10 to ×400), with even higher magnifications required in some cases. It also requires the recording of a range of features, including the presence of bark, ring curvature and fungal hyphae. It is therefore essential that those undertaking the charcoal analysis have the requisite experience and equipment.

Archaeological significance

The controlled use of fire is significant for so many activities that the study of charcoal is an important element of many archaeological subdisciplines. Charcoal analysis can provide direct information on fuel consumption, past ecological diversity, and human management of woodlands via coppicing. As well as the use of fire as a domestic heating fuel, the use of wood or charcoal as fuel at metal-working sites, for producing materials like lime, or to fuel structures such as Roman bath-houses, means it is an important factor in the study of many significant human economic and social processes.

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Figure 3: Wood charcoal from Tintagel, Cornwall showing insect frass within chambers made by a wood boring beetle.. Photographed using a Keyence VHX7000 3-D digital microscope (AHRC Award AH/V011758/1).

4. Waterlogged Wood

Introduction

Before the Industrial Revolution (AD 1750-1900) wood was probably the most widely utilised natural product in most societies, as a fuel, for building, and as raw material for a broad range of objects. In England wood preserved by charring in the form of charcoal is present on most archaeological sites. Waterlogged or anoxically preserved wood is less common, but where present can form the largest artefactual element of a site (e.g. as at Vindolanda, Northumberland, and Must Farm and Flag Fen, Cambridgeshire).

The sampling, conservation and identification of this wood is treated in this guidance as a specialism in its own right. Although the analysis of wood shares many of the approaches used in charcoal analysis, they are distinct fields of study.

Preservation

Wood can include large structural timbers as well as delicate artefacts. The resilience of this material depends on the consistent exclusion of oxygen by a fine clay/silt burial medium, a high water table, or both.

Historic England's guidance (2016) Preserving Archaeological Remains, and its associated case studies, presents a range of conditions under which wood survives. A key preservation consideration during excavation is that apparently well-preserved wood can be structurally unstable as a result of degradation at a cellular level.

Recovery

On sites where wood is expected to be present, advance discussions with an experienced wood specialist are essential. This will ensure that the recovered wood is not biased by an inappropriate collection strategy, and that appropriate resources are allocated for its conservation and study. It will also mean that packing and storage is suitable (wrapping tightly in cling film/plastic is a common but inappropriate technique that can damage the cell structure).

Wood type identification is conducted using high-power microscopy (×10 to ×400), with higher magnification required in some cases.

Archaeological significance

The archaeological significance of wood can be broadly conceptualised as structural and artefactual.

As well as helping understand construction techniques, structural wood from buildings, boats or bridges can provide dates via dendrochronology that cannot be surpassed by any other dating technique.

Where artefacts are preserved they may provide insight into items that were once commonplace in a past society but that are typically not preserved. The Vindolanda writing tablets, and their impact on our understanding of Roman Britain, is one such example.

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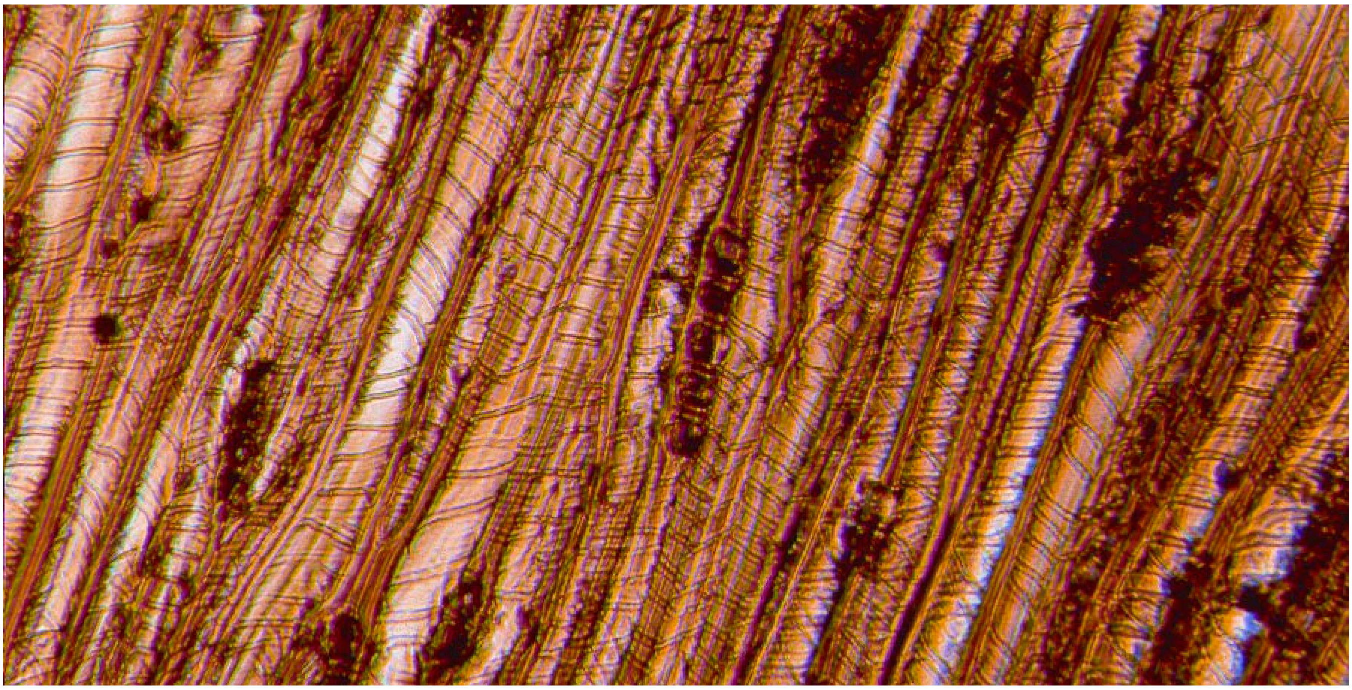

Figure 4: *Taxus* (yew) from Roman deposits at The Lanes, Carlisle, where good evidence for woodworking was revealed.

5. Mammal bone

Introduction

Mammal bone is found on archaeological sites of all periods, from the earliest stages of human evolution to modern times. Its study is integral to research into patterns of hunting, domestication, changing economies and craft work. On some sites, particularly those with urban deposits, mammal bone may be the most commonly occurring archaeological material. Thus, for project planning it is important to consider appropriate sampling and recovery strategies, as well as subsequent assessment and full analysis.

The effective recovery of fish bone and bird bone requires specific strategies, which are covered in Sections 7 and 9, respectively.

Preservation

Bone is best preserved in deposits that are pH alkaline to neutral. In England these environments are more common in the east Midlands and south-central areas. However, local site formation can create environments conducive to bone preservation in any part of the country. In urban areas characterised by Roman, medieval and post-medieval archaeology, waterlogging as well as local preservation conditions caused by human activity can lead to increased levels of preservation. In rural areas middens (particularly shell middens) can create localised conditions that allow excellent preservation in regions with otherwise poor levels of bone preservation. This may occur even where most of the shell has degraded away.

Recovery

It is important to remember that hand collection of mammal bone will lead to biases in favour of larger animals, as well as the larger bones from those animals. For this reason, on-site sieving is necessary, and the resources needed for this should be considered as part of project planning.

Animals can also be deposited whole (as burials) or as body parts (e.g. joints), and these associated bone groups (ABGs) require special treatment in a comparable manner to human inhumations (see Section 6).

Consideration should be given to how site collection strategies can help or hinder subsequent analysis. For example, mandibles with teeth should be recovered and stored carefully to prevent the teeth from falling out, to allow sampling for isotope analysis to be undertaken and accurate age at death data obtained

Archaeological significance

The study of mammal (vertebrate) remains is can address thematic and period-specific research questions from the Palaeolithic to the modern period.

It is important at the project planning stage to consult with a zooarchaeologist who can advise on relevant and pertinent research questions that may be answered. The sheer quantity of bone that can be recovered requires consideration of how its collection, assessment and analysis will be resourced within the project.

The significance of the zooarchaeological resource is not determined solely by the size of the assemblage. Even small assemblages can be used to address previously neglected or poorly studied regional or period-specific questions.

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Figure 5: Cat skull from a skeleton found in a ditch outside Richborough Roman amphitheatre.

6. Human remains

Introduction

Unburnt human remains may be found in contexts from all periods, from the Palaeolithic onwards. Cremated remains may occur from the Neolithic until about the 7th century AD. On prehistoric sites, interments generally occur in small numbers, but larger cemeteries become more frequent in the historic periods; some post-medieval burial grounds may contain tens of thousands of graves. Disturbance of deliberately placed human remains requires permission under secular law. Interventions in burial grounds under Church of England jurisdiction require instead ecclesiastical legal permissions. Because they are the remains of once-living people, ethical good practice must be observed in the treatment of human remains.

Preservation

Soil pH and particle size are key variables in the survival of human skeletal remains. When soils are acidic and/or free-draining survival may be poor such that only dentition (or dental enamel) may survive, or no hard tissue may remain. Where natural soils are hostile to bone survival, remains may nevertheless survive well in urban contexts, presumably because of anthropogenic alteration of soils and sediments. The gross condition of bone is not necessarily a good indication of survival of any biomolecules. Cremated bone is highly resistant to destruction and survives in soils where unburnt bone does not. Cremated bone generally contains no organic biomolecules.

Recovery

For an articulated burial, once the remains have been exposed and recorded, and any soil samples taken (e.g. for recovery of parasite remains; see Section 19), the bones should be lifted by hand (see also Case Study 9). Remaining soil in the grave should then be removed as bulk sediment for the recovery of small bones, bone fragments, small artefacts, etc. Depending on the site, measures may need to be taken to recover remains of organic items such as coffin wood, floral tributes, etc. Skeletonised remains pose no special health risks, but precautions may be needed in enclosed environments or if there is substantial soft tissue survival. Deposits containing cremated bone need to be 100% sampled to recover the bone and associated material.

Archaeological significance

The study of human remains can shed light on the demography, diet, health and disease, growth, migrations, genetic relationships, physique, activity patterns and the funerary practices of our forebears. For most osteological work it is essential that site reports are not only descriptive but aimed at addressing site and regionally specific research questions. Destructive analyses (ancient DNA, isotopes and other, newer, techniques) of human remains are increasingly being incorporated into threat-led archaeology. Isotopic and spectroscopic analyses are expanding the information that can be obtained from cremated remains, particularly regarding the process of cremation. However, any work involving destructive sampling is only justified if it addresses compelling and specific research questions.

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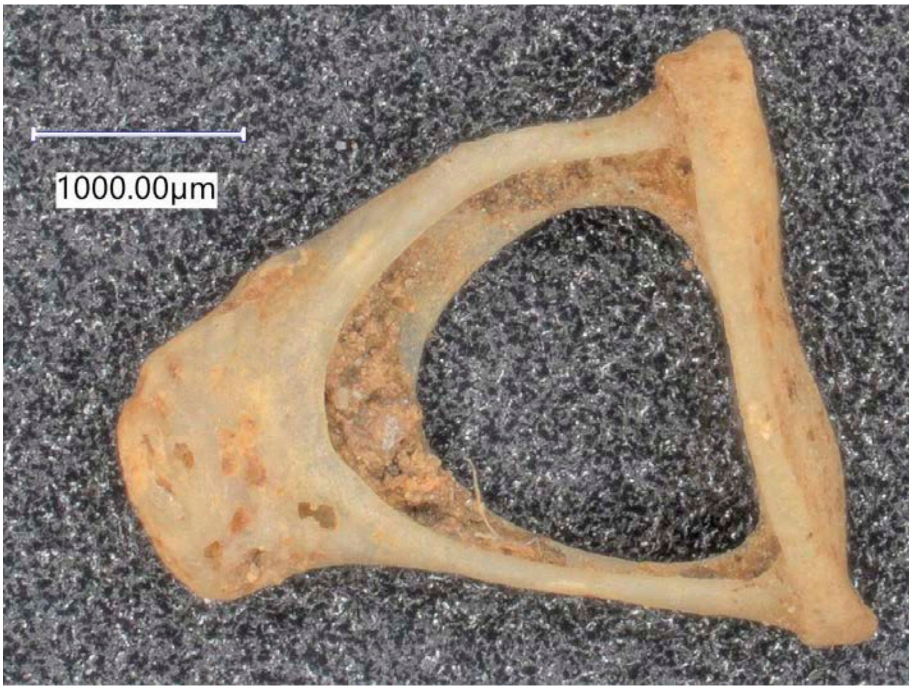

Figure 6: Human ear bone (stapes) from Stanwick, Northamptonshire. Image taken with AHRC funded Keyence VHX7000 3-D digital microscope (AHRC Award AH/V011758/1).

7. Fish bone

Introduction

The study of fish remains from archaeological sites is a distinct and specialised field, and not merely a subset of the study of the more commonly occurring mammal bone.

The volume of fish consumption and the types of fish being consumed varies greatly between different archaeological periods. Thus, fish bone assemblages play an import role in research on social and economic changes from prehistory to the modern period. The capture, processing, transport and consumption of fish also requires a range of technologies (particularly maritime technological developments) and patterns of activity. Archaeological fish bone studies play an important part in these studies.

Preservation

Fish bone is best preserved in neutral to alkali sediments, and on sites with waterlogging and/or anoxic preservation. Midden deposits, and urban pit and well deposits, also frequently preserve large assemblages of fish bone. Bony fish (such as cod) preserve better than cartilaginous fish (such as rays and skates), while other elements, such a dermal denticles, can be distinct finds from rays and skates. Elements such as otoliths, dermal denticles and fish scales can also be preserved in a range of conditions.

The presence of fish bone can favour preservation by mineral replacement, as fish remains provide a readily available source of phosphate.

Recovery

The size of fish bone means representative samples will always be best recovered via the sieving of sediments, and via sorting material from dried heavy residues. Case Study 8 from Roman Chester is an example of the importance of both sieving for fish bone and the correct identification of such remains. A mesh size of 2-1mm is recommended to ensure good recovery, although a 0.5mm mesh may be recommended to recover tiny fish bones.

On sites where fish bone is anticipated those individuals sorting heavy residues from soil samples should be made aware of the range of biological elements that can be present.

Archaeological significance

The process of catching and processing fish can involve complex freshwater, estuarine and marine technologies, such as hooks, nets, fish-traps, and various forms of vessels ranging from simple boats to complex sea-going ships. Understanding where and how fish can be caught thus links to research on diet, economy and trade. Archaeological evidence can also contribute to the understanding of past fish distributions, and human impacts on fish populations. The development of deep-sea fishing, inland transport of fish, and the farming of fish in artificial ponds, are all of particular cultural significance.

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Figure 7: Fish bone fragments.

8. Microfauna

Introduction

Microfauna are animals smaller than rabbits. They include micromammals, such as mice, rats and voles, and herpetofauna, such as snakes and lizards (reptiles), frogs and toads (amphibians). Microfauna may not be recovered during evaluation or excavation unless they occur in considerable numbers. Their size and unfamiliarity mean a full range of microfauna can only be retrieved by careful sampling and recovery. Recognisability is key to recovering microfauna, and is often an issue when dealing with lizards, snakes, frogs and toads. These animals are intimately affected by changes in palaeoenvironment, and by anthropogenic actions, so are effective proxies for past environments or environmental change.

Preservation

When exposed to weathering or chemical and biological soil processes, microfauna bones are rapidly dispersed by bioturbation and other forms of surface and subsurface transport. This means large concentrations of microfauna may only be recovered from archaeological contexts where mass mortality has occurred, e.g. as a result of predation, consumption or natural landslip, which produces initially large concentrations of bones. Concentrations may, however, be recovered from contexts that favour preservation, such as where rapid burial has occurred, or in cesspits, middens, ditches and chalk pits.

Recovery

Hand-picking microfauna bones produces size bias, so sampling and sieving are needed to recover the full range of taxa present. Site sampling and recovery strategies should consider whether microfauna will contribute significantly to site interpretation, and be planned accordingly. Microfauna are often recovered as a by-product of flotation for archaeobotanical remains, and they should be sorted from both flot and heavy residue. Sieve size should be fine enough to recover juvenile bones, with a recommended minimum of 1mm, although smaller teeth and slow worm osteoderms require a 0.5mm mesh.

Archaeological significance

Even small numbers of microfauna can be highly significant archaeologically, reflecting changing patterns of diet, trade, migration, occupation and land use. Microfauna may live alongside people and accompany them as commensals, and are always affected by human land-use change. Because they are short-lived animals sensitive to environmental change, the composition and populations of local microfauna respond rapidly to natural and anthropogenic change. Changes in palaeoenvironment and land use affect microfauna at a landscape scale, and even small-scale changes, such as in building layout and structure, affect the numbers and species found at a site.

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Figure 8: Microfauna bone assemblage. © Paul Clarkson

9. Bird bone and eggshell

Introduction

Bird bone is distinct from mammal bone, being typically lighter resulting from adaptations for flight. Therefore its preservation on archaeological sites is comparatively less common. The recovery of bird bone and bird eggshell assemblages should always be regarded as significant.

Bird bone assemblages can present significant research potential, but also significant complexity compared to mammal bone assemblages. The identification of wild bird remains in Britain needs to account for over 600 species, compared to just over 100 mammal species.

Preservation

Like mammal bone, bird bone and eggshell are best preserved in deposits that are alkaline to pH neutral, either naturally or as a result of the alteration of deposits by human activity, such as in sites with deep stratigraphy or local preservation by middens. In addition, where mineral-replaced preservation is encountered, eggshell is often well preserved.

Recovery

Bird bone is best recovered by sieving deposits. Hand collection will invariably lead to biases in favour of the larger bones from larger species. Recommended sieve sizes can range from 4 to 1mm, depending on the type of site and the nature of the remains being recovered.

In cases where whole or partial bird skeletons are identified, these should be treated as associated bone groups (see Section 5), recovered and bagged whole, and not mixed with the general assemblage.

Eggshell may be recovered from the residues of sieved samples, and also from flots. If eggshell is observed during excavation it should be treated as a delicate artefact, and recovered with its surrounding sediment.

Archaeological significance

Within the broad field of zooarchaeology the study of birds is a distinct subdiscipline. Human–bird interactions include the use of birds as food, as animals with significant religious symbolism, as commensal animals, as pests, and as high-status animals both as food (e.g. swan and heron in the medieval period) and as companion animals (e.g. the various birds of prey kept for hawking). Bird bones from archaeological sites can also inform modern conservation studies of contemporary bird populations.

Allied to this, the study of eggshell is important for understanding how domestic bird populations were managed for their meat and/or eggs.

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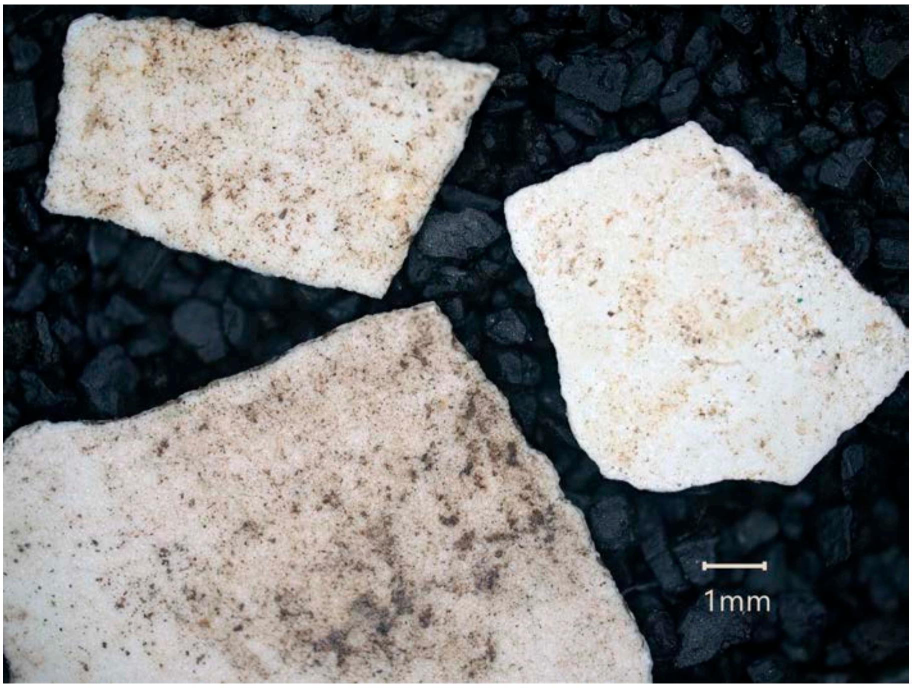

Figure 9: Egg shell fragments. Image taken with AHRC funded Keyence VHX7000 3-D digital microscope (AHRC Award AH/V011758/1).

10. Marine shell

Introduction

Marine shells can be found on a range of archaeological sites. For inland sites, particularly Roman and medieval sites, the presence of European flat oyster (*Ostrea edulis*) is a common and readily recognised mollusc species because of its size and colour. Examples of other mollusc species that can be present are limpets, whelks, dog-whelks and razor shells. Sea urchins are often included in this category, although they are echinoderms, not molluscs.

Sampling for shells is distinct from other classes of zooarchaeological material. Their dentification and analysis comprise a distinct specialist skill, and an archaeomalacologist should be consulted when significant deposits are encountered.

Preservation

Like animal bones, marine shells will be best preserved in deposits that are pH alkaline to neutral. However, large deposits of shell in otherwise acidic sediments can create localised conditions that support the preservation of shells, as well as other materials such as animal bones and artefacts.

The preservation of shells in either shell-rich deposits (such as middens) or as scattered finds across a site will require different collection approaches that minimise the breakage of the shells, as well as different approaches to the type of archaeological questions these different assemblages can answer.

Recovery

When sampling marine shells, limiting collection by hand recovery does not provide useful results.

Deposits that are rich in shells (e.g. middens) should not be treated as a homogenous mass. Large deposits may need to be sampled on a grid that covers the extent of the context, with layers collected in discreet spits (5–10cm thick). In other cases, shell-rich deposits can be sampled with whole-earth samples (20–50 litres, ideally enough to recover 200–600 shells).

The approaches to shell recovery depend on the rarity of such deposits (high significance should be given to prehistoric and early medieval assemblages) and the density of the shells (shell-poor deposits from Roman and later medieval sites have less archaeological significance).

Archaeological significance

The consumption of marine invertebrates occurs in all archaeological periods. However, there is a noticeable global increase in midden deposits from the mid-Holocene. The reasons for this are not fully understood, but rising sea levels may have been a factor. The consumption of marine shellfish at sites distant from the coast may be linked to high status or elite dining, particularly in the Roman and medieval periods.

As well as food consumption, marine shell can be used as a raw material for artefacts or be symbolically important, e.g. finds of scallop shells from medieval graves reflecting the pilgrimage of St James. They can also be used in construction, including the production of mortars.

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Figure 10: Dog-whelks from Le Yaudet, Brittany, showing the characteristic breakage pattern for extracting the gland for producing the dye, Tyrian purple. Whole, unbroken shells are pictured on the left. © Greg Campbell

11. Land and freshwater molluscs

Introduction

The garden snail is probably the most commonly encountered land mollusc. However, there are over 100 species of land and freshwater molluscs in Britain, many of which are only a few millimetres in length, and most of which are difficult to spot in the wild.

Molluscs build straight or coiled shells (gastropods) or paired shells (bivalves), and live in a wide range of conditions in water (fresh, brackish and salt) and on land. Each part of the land and coast usually has a characteristic range of snail species, and some species live only in specific conditions (such as damp woodland, short-turfed grassland, and brackish channels). This makes these remains very useful for reconstructing past environments, especially as they preserve well in deposits where pollen preservation is poor.

Preservation

Shells normally preserve well in regions where the underlying rock produces neutral or alkaline soils, and in waterlogged deposits. They rarely survive in regions with more acidic soils, where pollen is generally well preserved, and conversely can be utilised in regions where pollen evidence is typically poorly preserved. Even in regions with acidic soils, however, preservation can occur where the deposits have been rendered neutral or alkaline by calcareous additions (sometimes by the shells themselves).

The concentration of molluscs within a deposit can vary greatly. Rapidly infilling deposits will contain fewer shells per volume of sediment than those that fill in over a longer period of time. Preservation normally improves with depth of burial. These factors need to be taken into account when sampling.

Recovery

Mollusc studies for reconstructing land use and environmental change usually require specialist samples taken in vertical columns. Each sample should be a minimum of 2 litres where feasible. Columns should be taken from multiple features across a site where available, in order to gain as full a picture as possible.

Extraction of the molluscs involves drying the sediment, followed by gentle disaggregation using boiled water and a wash-over technique for the shells that float. The resultant residue is then mixed with further boiled water, sometimes with the addition of hydrogen peroxide to break up the remaining sediment. Molluscs are commonly also recovered from flots and residues. However, these samples may be unrepresentative of the total population of snails in the deposit and should not be used as an alternative to specialist mollusc samples.

Archaeological significance

Molluscs from alluvial sequences give important information on floodplain development and regional land-use change. Periglacial and tufa deposits are particularly useful in understanding environmental change during the Palaeolithic and Mesolithic periods. Mollusc studies can also trace the change in balance between woodland, cultivated land and pasture in the Neolithic period. Studies from Wessex have shown that the earliest prehistoric monuments were constructed in forest clearings, and subsequently later monuments were built in areas of already developed arable land. Molluscs have also been a key component in the study of colluvium associated with Bronze Age cultivation.

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Figure 11: An assemblage of land molluscs. © Matt Law

12. Insects

Introduction

Insects are invertebrates with a chitin exoskeleton and jointed limbs. They can be recovered with a range of other arthropods such as arachnids. Examples of insects and spiders found archaeologically include beetles, true bugs, mites, flies, fleas, caddis flies and chironomids. Of these, beetles are the most commonly studied, although mites and chironomids are often more numerous within an assemblage.

Some insect species occupy very narrow ecological and environmental niches, and this makes them particularly useful for understanding environmental changes, or habitats on an archaeological site, e.g. distinguishing between a stable or house deposit, or between a water well and a latrine pit.

Preservation

Insects are best preserved in deposits that are anoxic and fine grained, such a waterlogged silty clays or peaty deposits. Natural features such as fen and bog peat, lake sediments, palaeochannel alluvium and flood deposits may all be suitable, as well as anthropogenic structures such as pits, ditches, wells, stable and house floor deposits.

The remains of insects also can be preserved through calcium phosphate mineral replacement, particularly in latrine contexts and deeper features where there is a throughput of water. Occasionally, insects can be preserved through charring but such remains are very delicate. Traces of insect infestation of wood, including their faeces (frass), preserve within charcoal.

Recovery

Sampling for insects can be conducted via extraction of samples from sections, via geoarchaeological cores, or subsamples from whole earth samples. To recover enough insects for statistical analysis samples typically need to be 2–10 litres. It is best to discuss with the insect specialist in advance how much material they need to answer the project question.

Extraction of insect remains uses paraffin flotation, and most specialists will prefer to process their own samples. The maximum mesh size used in processing is 300µm. A minimum mesh size of 180µm is needed to ensure full recovery of mites. General specialist samples collected for insect remains (c. 10 litres in volume) can be subsampled for the recovery of plant macrofossils and/or pollen.

Archaeological significance

Insects provide evidence for a range of environments, from the landscape surrounding a site to an individual deposit. They are useful for general palaeoenvironmental reconstruction, providing details of past hygiene (e.g. lice and fleas) and living conditions, and providing evidence of crop infestation. In rural situations, they are particularly useful for showing the character of woodland, the quality of water and/or the occurrence of domestic animals. In urban situations with deep organic stratigraphy very detailed reconstructions can be made of human environment, craft and industry, and living conditions. Insects are best studied alongside other environmental proxies such as macroscopic plant remains and pollen.

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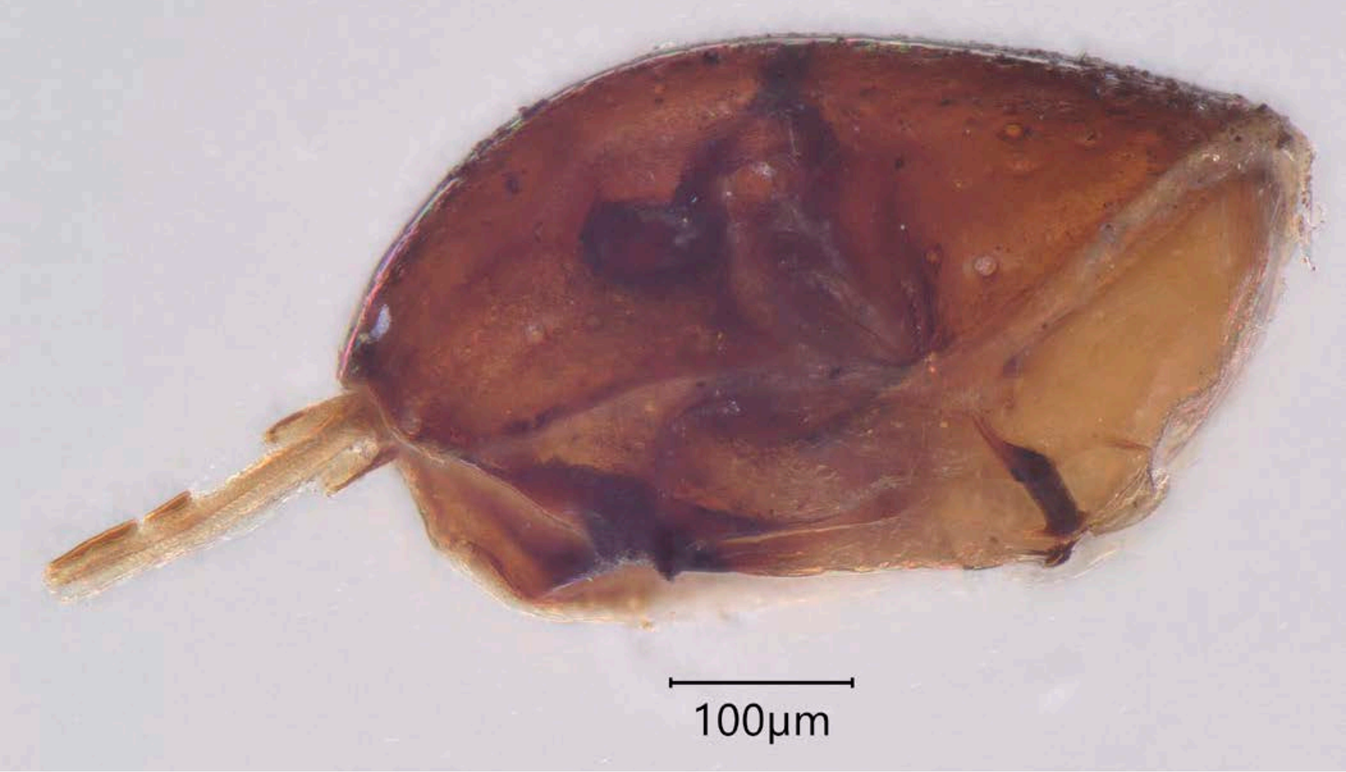

Figure 12: A flea from excavation at Combe Haven, East Sussex, dated to the middle Bronze Age it is currently the earliest example of a flea found in Britain. Image taken with AHRC funded Keyence VHX7000 3-D digital microscope (AHRC Award AH/V011758/1).

13. Mineral-preserved and mineral-replaced remains

Introduction

The terms mineral-replaced remains and mineral-preserved remains can be easily confused but are separate forms of archaeological preservation.

In the case of mineral replacement, the biological tissue of both plant and insect remains are replaced by metal salts, most usually calcium phosphate.

In the case of mineral preservation, the material is preserved as a result of the toxic nature of metal corrosion products, which inhibit the normal decay processes.

In both cases that material is preserved in a form that is atypical of its normal appearance, and thus these remains require specific identification skills as well as an understanding of the preservation processes involved.

Preservation

In mineral-replaced remains the conditions for preservation are often those with a high phosphate content, and slightly alkaline conditions where there is a throughput of water to allow the metal salts to replace the soft tissues. Thus, deposits from latrine contexts, drains and middens can often preserve such remains.

Mineral-preserved remains result from the presence of metal corrosion products. This can be seen in the plant packing material from the Pewsey hoard (see Case Study 3). Recent work on the same material has shown that organic residues can also be preserved metal corrosion. Cloth, hair, wood and leather have been preserved by mineral preservation.

Recovery

Mineral-replaced plant and insect remains can be recovered using flotation samples, but the majority of the remains will be present in the residues rather than the flots. This means that sorting of residues down to 0.5mm will be required, and this additional resource should be considered as part of project planning. Furthermore, the identification of this material is complicated by the fact the mineral-replaced items may not look like typical examples of the biological organism.

For mineral-preserved remains the lifting and examination of the objects should only be done under the supervision of a suitably experience conservator, to prevent delicate remains being damaged through inappropriate cleaning.

Archaeological significance

Both mineral-replaced and mineral-preserved remains are of archaeological significance as they can preserve material that under normal biological and physical process would degrade over time, such as organic materials associated with inorganic objects (either as packing or as an element of the object itself).

In cases where midden, latrine or drain deposits are likely to be encountered, the project's environmental archaeologist should be asked whether the presence of mineral-replaced remains has been considered in the sampling and recovery strategy.

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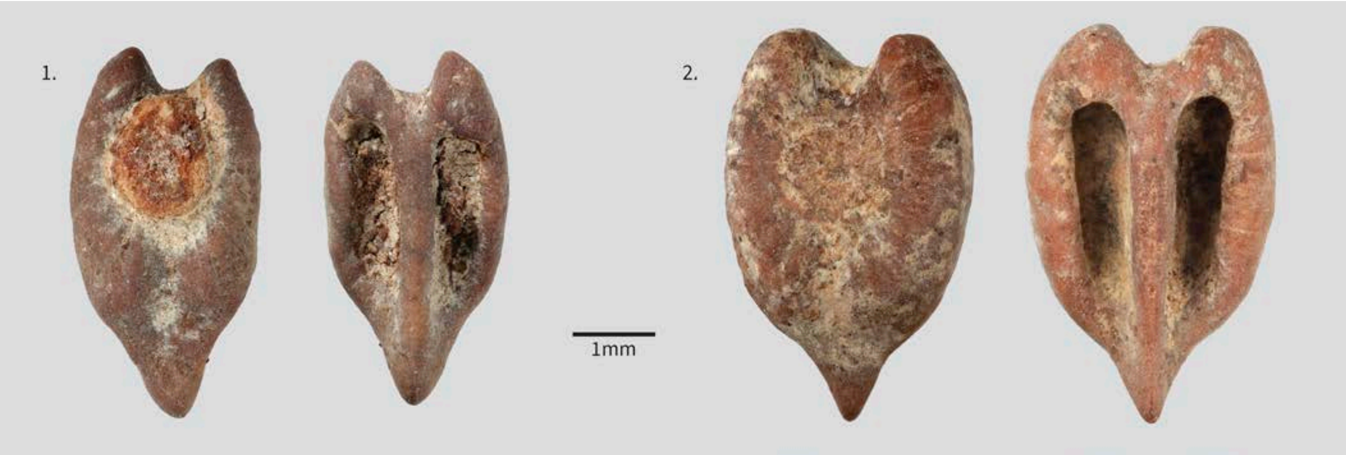

Figure 13: Mineralised grape seeds (*Vitis vinifera* L.). Image taken from Carruthers and Smith 2020

14. Pollen and non-pollen palynomorphs

Introduction

The use of pollen to study changes in past environments is one of the oldest techniques in environmental archaeology. Palynology can be used to study plant communities at context level, and up to site and regional levels. In addition, these studies are used in analyses of national and global trends of environmental change.

A range of biological remains that are similar in size to pollen also can be present in samples. This includes fungal spores, testate amoebae and algae, as well as shells, cocoons and fragments of other microscopic organisms. These are termed non-pollen palynomorphs (NPPs).

Preservation

Both pollen and NPPs are best preserved in low-oxygen, slightly acidic sediments. Deposits in low-energy depositional environments (fine-grained silts and clays) will also typically preserve the widest range of robust and delicate remains. Common sampling sites are peat bogs, waterlogged archaeological sites (including wells, pits, latrine pits, ditch sequences), foreshore deposits, and lake/pond sites.

At a site level pollen studies have been used to identify Roman vineyards in the Nene Valley, Northamptonshire, and also elements of diet not evident from the study of plant macro-fossils.

Recovery

The recovery of pollen will largely depend on the question being asked. Continuous sequences in sealed containers (cores or monolith tins) allow detailed specialist subsampling under laboratory conditions. Spot samples from sections or from excavated contexts can also be taken, depending on the project questions. These latter samples, typically 50–100g, can be collected with a clean teaspoon, placed in a sealed plastic bag or vial, and kept in cool, dark storage. It is best to get recovered samples to a specialist as quickly as possible to ensure minimal degradation of biological remains.

Archaeological significance

The application of pollen studies to archaeology is vast. Recent developments in the application of Fourier transform infrared spectroscopy (FTIR) and Raman spectroscopy offer many new possibilities in pollen identification that can only increase its usefulness. The study of NPPs is also a rapidly developing field.

The different treatment methods required for NPPs, understanding whether a pollen study will reflect the local or regional environment, and level of detail required for the study (the sample resolution), should all be discussed in advance of a project with a specialist.

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Figure 14: Pollen grains of pine (*Pinus sylvestris*). © Z Hazell

15. Phytoliths

Introduction

Phytoliths are opaline silica structures found inside the cells of many species of plant, typically 5–100µm in length. The reasons for their formation, how they can be identified to different plant species, and how they can be used to reconstruct past environments and human activity, are all ongoing fields of research. Their composition and structure make them very durable in a wide variety of depositional environments. This has made them a useful field of study in regions and sites where there is poor preservation of other plant remains or where these remains are scarce.

Preservation

Because of the inorganic material that makes up their structure, phytoliths can be preserved in a wide variety of environments and sediment types, although in very alkali environments (those above pH 9) they are likely to be either heavily degraded or completely destroyed. Some structures such as middens and burnt mounds may be particularly well suited to phytolith preservation.

The environmental and burial conditions in temperate regions such as England means samples in the order of 10g are recommend, rather than the typically recommended 0.5–2g

Recovery

Samples may be extracted from monoliths/cores, subsampled from larger whole-earth samples, or taken as spot samples across surfaces to understand vertical and horizontal differences in activity patterns. It is recommended that decisions on sampling occur after consultation with a phytolith specialist in advance of project commencement.

The extraction of phytoliths involves a series of laboratory steps that require specialist chemicals and laboratory equipment. Once extracted from the sediment the phytoliths are mounted on slides and examined using high-power microscopy (×400).

Archaeological significance

The use of phytoliths has been a significant part of archaeobotanical research in arid, semi-arid and desert environments, where the environmental stresses seem to be particularly good at encouraging the growth of phytolith structures in plants.

In temperate regions, and for England generally, more research is needed before the full potential of phytoliths is understood. In cases where charred or waterlogged remains are present their presence has been shown to complement the evidence from macro-plant analysis

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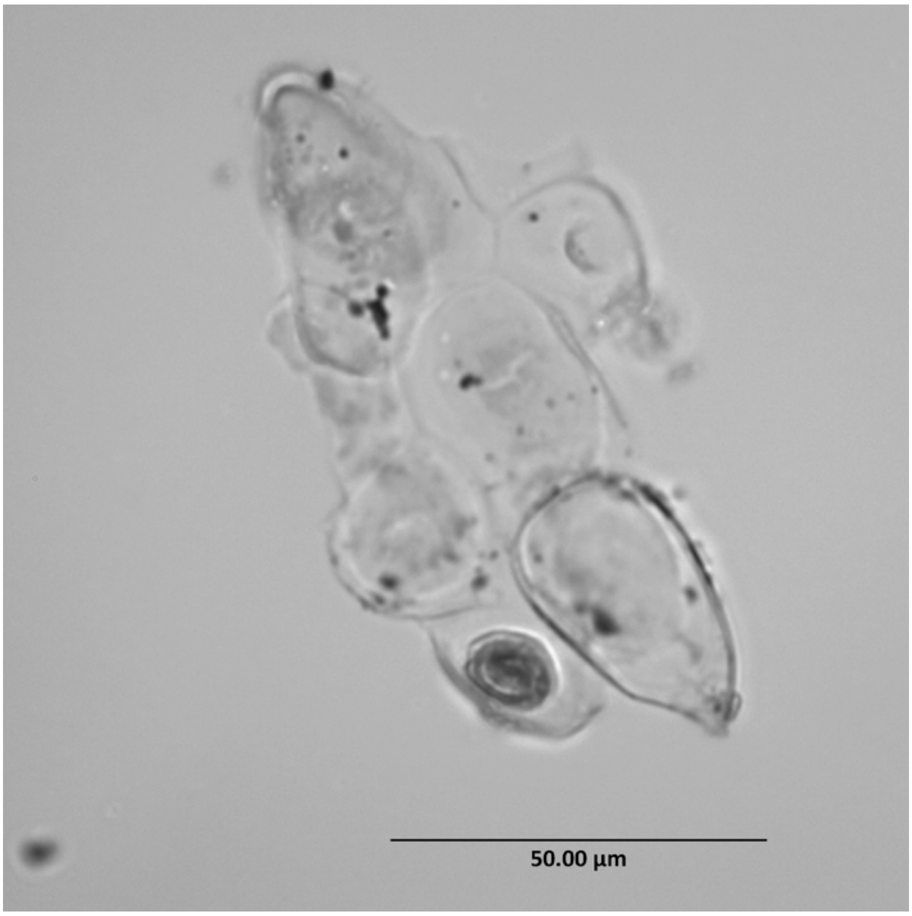

Figure 15: Flax leaf multicell phytoliths © Sigrid Osborne

16. Foraminifera

Introduction

Foraminifera are single-celled animals that produce a calcareous shell and live in marine environments. They are typically 0.1–0.4mm in size, although larger species of benthic foraminifera are also known.

They can form a significant part of the oceanic biomass, and their continuous deposition in deep ocean sediments forms the basis for many Quaternary environmental reconstructions. Notably, the evidence for glaciation cycles comes from oxygen isotope studies of planktonic foraminifera.

Foraminifera are particularly useful for the information they can provide concerning marine habitats such as levels and types of salt marsh habitat.

Preservation

The calcareous shells of foraminifera will be preserved in similar deposits to those that preserve ostracods (see Section 18). The ecological limits of the species mean foraminifera-bearing sediments will usually be in coastal or fully marine environments. Fine-grained, laminated deposits of clays and silts are the most suitable for sampling.

Foraminifera can be an important component of ancient limestone rock and other geological deposits, and therefore specialist input is needed to ensure recovered foraminifera relate directly to the archaeological time period under examination.

Recovery

It is best to discuss recovery with a specialist to ensure samples are the right size and taken from deposits most relevant to the archaeological questions being posed. Samples are best taken in either geoarchaeological columns or cores, or in sections with Kubiena tins.

The extraction of foraminifera from sediments involves dissolving the sediment in warm water and washing the sediment through a series of geological sieves (down to 75µm).

Archaeological significance

Foraminifera can be used as part of multiproxy studies that utilise diatom and ostracod analyses (see Sections 17 and 18). They would typically, however, only be studied where a marine component to the sediment is anticipated (for example see Table 1).

They have been used in studies where marine inundations have been interpreted as part of the site formation, such as at the Iron Age/Roman site of Stanford Wharf, Essex, the Palaeolithic site of Boxgrove, West Sussex, and the Bronze Age intertidal timber circle at Holme-next-the-Sea, Norfolk.

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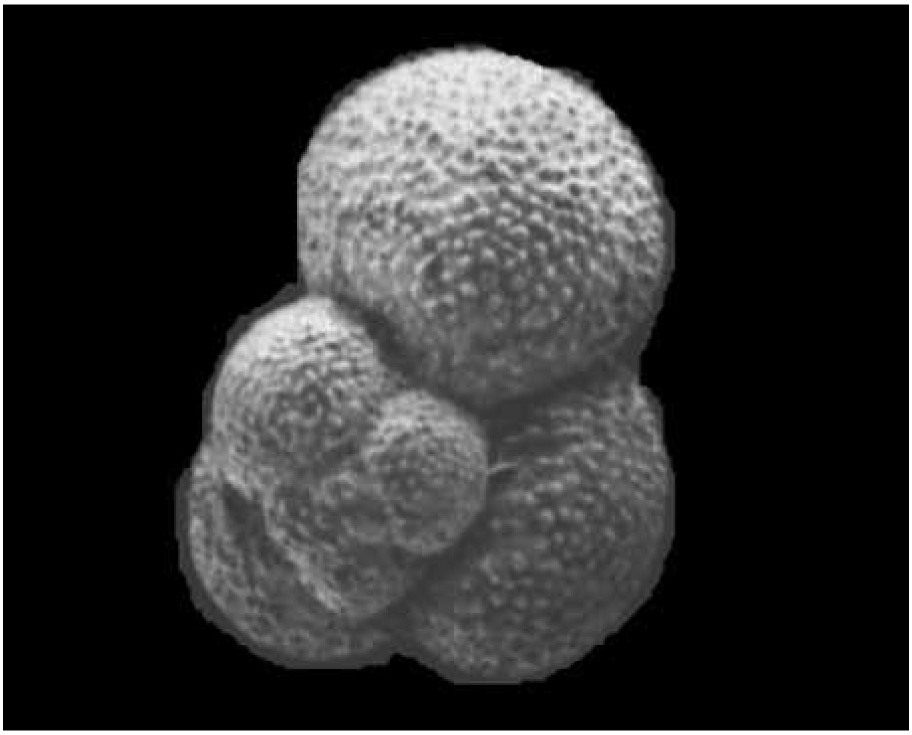

Figure 16: Test of the foraminiferan *Globigeriina bulloides*. © Department of Earth Sciences, UCL,

17. Diatoms

Introduction

Diatoms are microscopic algae that produce a siliceous cell wall know as a frustule. The recovery and identification of the frustule forms the basis of diatom analysis. Their environmental specificity means diatoms can provide an indication of water quality and depositional environment, such as temperature and salinity, nutrient and mineral levels, acidity and degree of oxygenation, and whether the site was periodically dried out (see Table 1).

Although they are most commonly found in fully aquatic environments, there are many species that live in environments that are only periodically or partly wet, such as soil, moss, and damp cave walls.

Preservation

The siliceous frustule is resistant to decay and can survive in most archaeological deposits. However, like phytoliths (which are made of a comparable opaline mineral), diatoms are likely to be damaged by strongly alkali deposits.

They can survive passage through the digestive system and thus can be recovered from both animal and human coprolites.

Their resistance to decay means they can be usefully integrated with both foraminifera and ostracod analyses (see Sections 16 and 18). This multiproxy approach may be useful to counter biases created by differential preservation and in-wash in dynamic aquatic environments.

Recovery

It is best to discuss recovery with a specialist to ensure samples are the right size and taken from deposits most relevant to the archaeological question being posed. Samples are best taken in either geoarchaeological columns or from sections with Kubiena tins.

The extraction of diatoms requires the use of chemicals, firstly to oxidise organic material, and secondly to remove carbonates, before the diatoms can be mounted on slides and examined under a high-power microscopy. This can include oil immersion microscopy (×600 to ×1000) or the use of a scanning electron microscope (SEM).

Archaeological significance

Because of their ubiquity, particularly in aquatic settings, diatom analysis can be considered for a range of archaeological features, particularly those associated with water, such as moats, cisterns, latrines and ponds. However, their use in archaeology is not limited to these features. A study from a floor deposit at the coastal Glastonbury Lake village, Somerset, was used to demonstrate a freshwater rather than marine origin for the clay that made up the floor. A study from Viking Iceland used diatom analysis to study turf-built structures and associated archaeological features.

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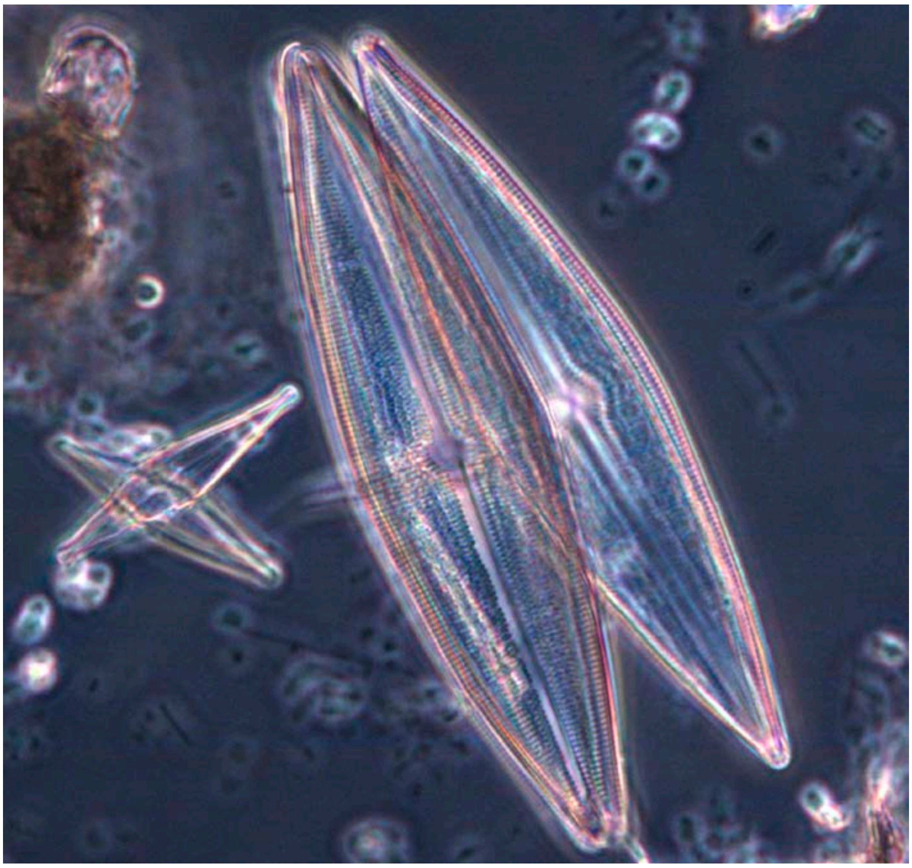

Figure 17: The diatom *Brachysira serians* showing four together in sets of two. © E Forster .

18. Ostracods

Introduction

Ostracods are small (normally ranging from 0.5 to 2mm) bivalve crustaceans with chitin valves that can become mineralised with low-magnesium calcite. Ostracods inhabit nearly all types of aquatic environments, including natural waterbodies (freshwater, brackish and marine) and wholly artificial waterbodies such as ponds and moats.

Their small size, common occurrence, and the sensitivity of different species to water conditions (temperature, pH, salinity, nutrient change), make ostracods applicable to a range of archaeological questions.

Preservation

Like molluscs and foraminifera, ostracods survive best in non-acidic sediments, and in finer grained sediments under waterlogged conditions. As a general rule the diversity and density of living ostracod populations are better suited to environments with standing or slow-flowing water that is carbonate rich.

As ostracods live in comparable environments to foraminifera and diatoms (see Sections 16 and 17), they are best integrated with studies of those organisms to provide a holistic picture. This can be particularly useful in brackish conditions where low-density foraminifera communities occur and where there is a high probability of in-washed diatom remains.

Recovery

Samples may be taken in geoarchaeological cores, from sections using Kubiena tins, or as spot samples from archaeological contexts. In cases where a sequence of samples is being taken from an archaeological section, the interval of samples should be 100mm or less. When taking samples of this nature, a minimum sample weight of 50g is recommended. The resultant sample is processed in a manner comparable to that for mollusc analysis (see Section 11), but will require a finer mesh to ensure recovery of juvenile stages of development (63µm is recommended). Extraction and processing of samples is typically undertaken by an ostracod specialist.

Archaeological significance

Ostracods can be applied to a range of studies of past climates and aquatic environments. This includes studies of water quality, changes in water salinity, as well as human impacts on lake and fluvial systems. In the latter cases this might reflect human-induced erosion or settlements on or near water bodies, which impact ostracod populations. Ostracods have also been used in provenance studies of pottery and construction materials.

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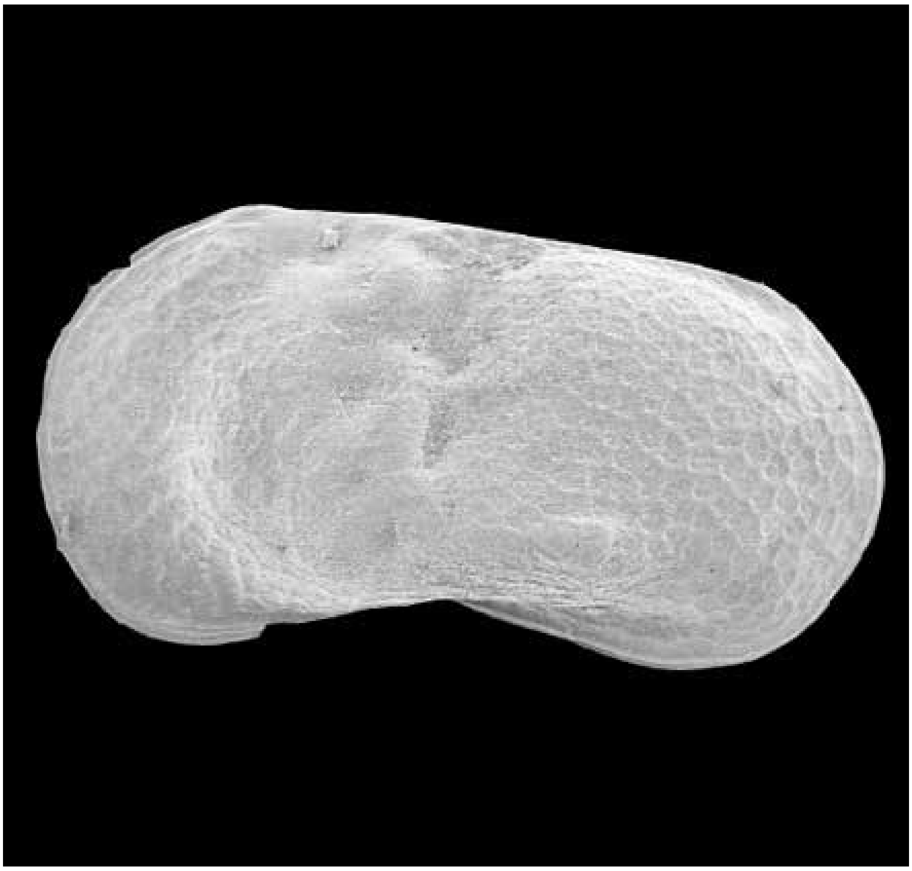

Figure 18: The ostracod *Limnocythernia sanctipatricii* (female left valve, length 850µm) © Department of Earth Sciences, UCL

19. Parasites

Introduction

The study of parasites in archaeology can relate to a broad range of organisms that derive their nutrition from feeding on living hosts. These can include single-cell protozoa, species of intestinal worms, and biting insects such as fleas. However, the focus of this section is on the remains of different species of parasitic worms known as the helminths, which include roundworms, tapeworms, flukes and thorny-headed worms.

Parasites can provide an insight into human and animal health from prehistory until the post-medieval period.

Preservation

Parasites are likely to be best preserved in anoxic and/or waterlogged deposits. However, they have also been recovered from well-drained and sandy deposits, and therefore their study can be considered for a range of sites from different archaeological periods. They may be present in any deposits where human or animal faecal waste is likely to be concentrated.

These parasites are most often found via their eggs, which are composed of a tough protein intended to protect the parasite egg during its life cycle.

Recovery

Sample sizes needed for the recovery of gut parasites are small: typically 10–20g will be sufficient. They can be taken as spot samples from a section or layer, from within a column/monolith, or subsampled from a larger sample. Spot samples and samples from columns/monoliths may be more suitable, as they allow for more precise stratigraphic control.

A number of methods are used to extract parasite remains from sediment, with the goal being to concentrate the remains so that they can be mounted on a microscope slide for examination with a high-power light microscope at ×400.

Archaeological significance

Each archaeological period will have its own unique research questions that can be addressed by archaeoparasitology. Research at Must Farm, Cambridgeshire, demonstrated both the earliest records of some parasite species, and the foraging strategies of the Bronze Age population around the site.

For some periods, particularly urban medieval sites, it can be assumed that there was a widespread presence of gut parasites in the human population as a whole, and therefore research may be best focused on using molecular techniques to examine populations rather than just focusing on the presence/absence of such remains.

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Figure 19: Eggs of the intestinal parasite *Trichuris* sp. from the Must Farm pile-dwelling settlement © Marissa Ledger

20. Testate amoebae

Introduction

Testate amoebae is a term given to describe collectively a number of distinct micro-organisms that construct protective structures or ‘tests’ around their body. These tests can be siliceous, calcareous or organic in nature. The size of tests within this group varies greatly, from 4µm to 400µm. They were initially recognised from pollen slides (as non-pollen palynomorphs, see Section 14) but have more recently emerged as a field of study in their own right. These developments have included improved taxonomic identification and the refinement of extraction techniques, which are less likely to damage the tests compared to the harsh acid treatments used in the preparation of pollen slides.

Preservation

Testate amoebae inhabit wet environments and commonly live in the water film around soil particles, as well as on the surface of sphagnum bogs and mires. Many species have specific environmental tolerances and are particularly sensitive to water availability. They also respond to other variables, including pH and nutrient status

Recovery

The study of testate amoebae relies on quantifying changes in populations through time and comparing these changes to statistical ecological models that highlight the environmental variables of relevance to the study. Thus, testate amoebae studies require sampling from continuous sequences of deposits, such as from a sealed core. Their sampling is usually undertaken in conjunction with sampling for pollen, via a series of separate subsamples because they are extracted using different methodologies.

Archaeological significance

Testate amoebae analysis is most useful for studying shifts in regional climatic change. This has been used to demonstrate increased regional surface wetness, with corresponding implications for human populations in the area.

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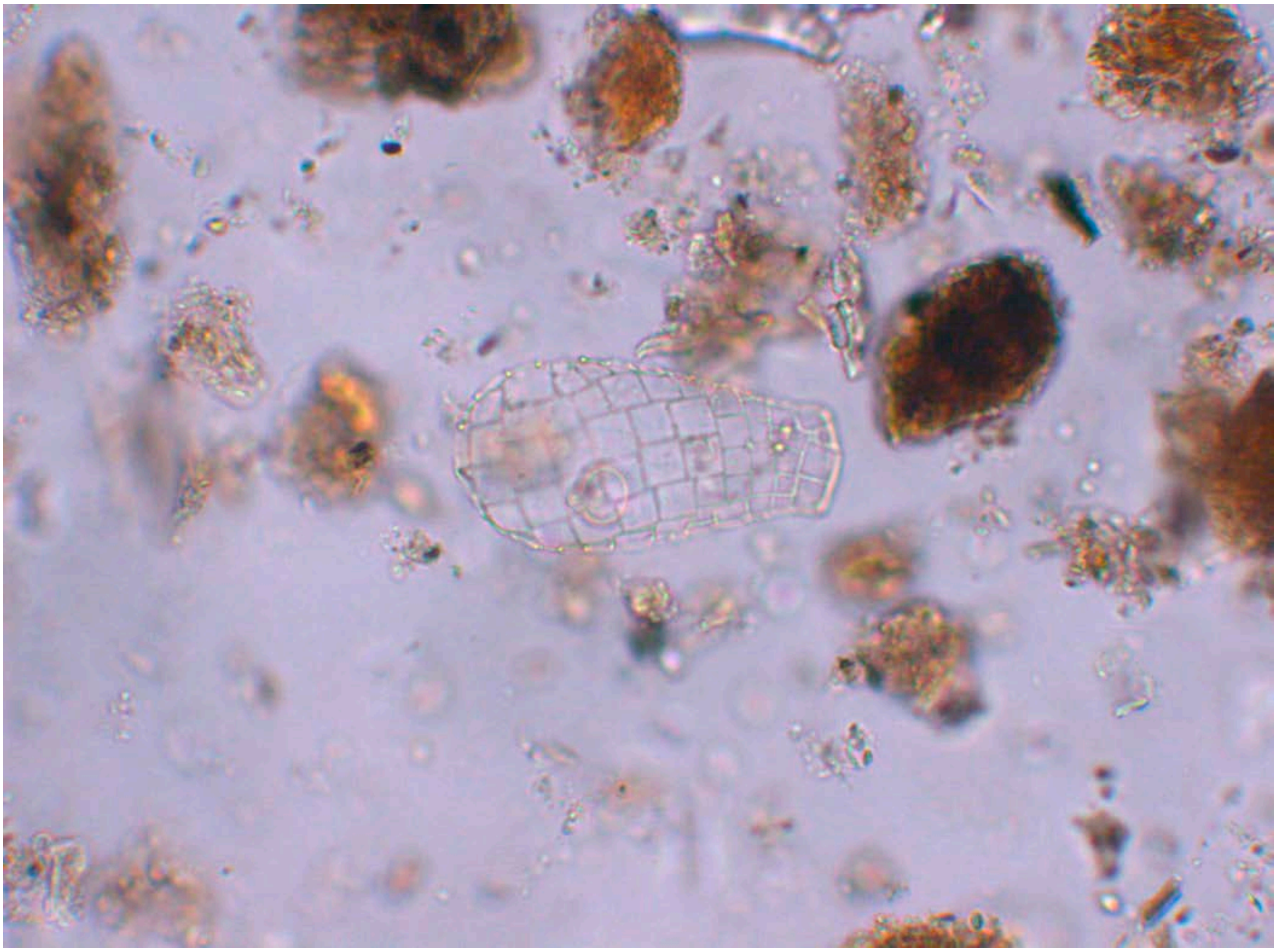

Figure 20: Testate amoebae © Z Hazell

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