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# ENVIRONMENTAL ARCHAEOLOGY

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## Summary

Environmental archaeology is concerned with the human ecology of the past, the relationship between past human populations and their physical, biological and socio-economic environment. The techniques of the discipline are the analysis and interpretation of biota (animal and plant remains) within the depositional environment of the archaeological site and its surrounds (sediments and soils). It encompasses a range of interconnecting sub-disciplines, including primarily geoarchaeology (the study of soils, sediments and geomorphological features), zooarchaeology (the study of animal remains), and archaeobotany (the study of plant remains).

## 1. Introduction

Environmental archaeology is a diverse subject concerned, broadly, with the human ecology of the past and encompassing the study of a wide range of biological and geological materials. This brief review aims to: set out the aims and scope of environmental archaeology; outline some of the key methods and applications employed; and present case studies on the different scale and integration of such methods.

There has been debate in the academic literature over the definition of environmental archaeology. In part this has been due to a conflation of definitions based on the aims of the studies and the methods of the studies, and whether it is the methods used which define the discipline, or the aims of the studies. The techniques of the discipline are the analysis and interpretation of biota (animal and plant remains) within the depositional environment of the archaeological site and its surrounds

1 (sediments and soils). In the study of biota, we are in a sense talking about ‘ecofacts’, although  
2 these can themselves be made into ‘artifacts’ (e.g. animal long bones have been used for knife  
3 handles), and may themselves also act as sedimentary particles. The aims of the discipline are to  
4 advance understanding of the human ecology of the past. As K.D. Thomas has written, this seeks to  
5 understand the relationship between past human populations and their physical, biological and  
6 socio-economic environment.  
7

8 Environmental archaeology as a mature discipline in its own right is a relatively recent  
9 development, however, its roots lie articulated with the development of other ideas and disciplines  
10 including, in particular, understanding of stratigraphy (18<sup>th</sup> century), the antiquity of humans and  
11 early archaeology (19<sup>th</sup> century), vertebrate comparative anatomy (19<sup>th</sup> century), evolution (19<sup>th</sup>  
12 century), ecology (early 20<sup>th</sup> century), and molecular biology (later 20<sup>th</sup> century).  
13

14 Environmental archaeology encompasses a range of overlapping and interconnected sub-disciplines.  
15 Those covered below are geoarchaeology (the study of soils, sediments and geomorphological  
16 features), zooarchaeology (the study of animal remains), and archaeobotany (the study of plant  
17 remains). The study of human remains is not covered; while this is sometimes considered within the  
18 remit of environmental archaeology, it is to a large extent a discipline of its own (and space does  
19 not allow discussion of it here). Other disciplines that will be touched on below are those of the  
20 rapidly expanding biomolecular fields of DNA research and stable isotope studies - again,  
21 disciplines in their own right, but increasingly offering insights into past human-animal, human-  
22 plant and plant-animal relationships.  
23

## 24 **2. Geoarchaeology**

### 25 **2.1. Introduction**

26 **Geoarchaeology** is a sub-discipline of archaeology that first developed in the 1960s and normally  
27 refers to work carried out using Earth science approaches and techniques, but to address  
28 archaeological aims and objectives. Geoarchaeology is distinct from **archaeological geology** as the  
29 latter is the use of archaeological information in the resolution of geological problems. For example  
30 a geoarchaeological project might comprise the geomorphological mapping of an area to predict the  
31 most likely locations for past human settlement, while an archaeological geology study may use  
32 artifacts preserved in a stratigraphic sequence as dating control in understanding the chronology of  
33 landscape change. The remaining parts of this chapter only discuss geoarchaeology.  
34  
35  
36

37 While the word ‘geoarchaeology’ is a relatively recent term, geoarchaeological work (albeit not  
38 originally defined as such) has a much longer history. For example K Bryan and E Antevs (both  
39 geologists) studied the stratigraphy of the south-western United States in the 1930-1950s. In this era  
40 before the advent of **radiocarbon dating** they were able to provide relative ages of Cochise and  
41 Clovis period sites by correlating artifact-bearing strata with landforms and beds thought to have  
42 formed in particular climate episodes. Geoarchaeology (as opposed to archaeological geology)  
43 developed rather later in Europe than in North America, although arguably the first  
44 geoarchaeological text book was by the British soil scientist I Cornwall in 1958 (Soils for the  
45 archaeologist). There are many examples of geoarchaeological studies in the 1960s, albeit primarily  
46 undertaken by geologists. A good example of the latter was H Wright’s study of the context of  
47 Bronze Age activity in Messenia, Greece which was undertaken as part of a larger archaeological  
48 survey. In contrast to the situation before the 1970s and typified by the examples above, present day  
49 geoarchaeologists are predominantly archaeologists who have received training in the Earth  
50 sciences.  
51

1 While the definition of geoarchaeology provided above would appear to be tight, there is some  
2 debate on exactly which Earth science approaches constitute geoarchaeology and which are other  
3 sub-disciplines of archaeology. For example G. Rapp and C. Hill in their text book  
4 *Geoarchaeology: the Earth-Science approach to archaeological interpretation*, include  
5 chapters/sections on geophysics, aerial photography and bioarchaeology. A. Brown in *Alluvial*  
6 *archaeology* does much the same. However, another key geoarchaeological text, *Geoarchaeology:*  
7 *a North American perspective* by M. Waters, has a much narrower focus and discusses only  
8 geomorphology, stratigraphy, sedimentology, pedology and depositional environments. This latter  
9 geologically orientated range of subjects is also considered to be geoarchaeology in K Butzer's  
10 landmark study, *Archaeology as human ecology*. In part because bioarchaeology is discussed under  
11 zooarchaeology and archaeobotany below, while geophysics is considered elsewhere in this  
12 encyclopedia, the present text examines only those topics considered by Waters and Butzer to be the  
13 component parts of geoarchaeology.

14

## 15 **2.2. Materials**

16

17 Geoarchaeologists study **strata** and **landforms**. Therefore unlike either zooarchaeology or  
18 archaeobotany where taphonomic factors affect preservation, meaning that a site might contain no  
19 sub-fossil remains of animals and/or plants, strata on an archaeological site, are almost invariably  
20 present. Moreover even where there is no archaeological stratigraphy, for example because a stream  
21 channel has migrated across a site and left archaeological features and/or artifacts as a lag above the  
22 bedrock, the location still has a geomorphological story to tell. For these reasons geoarchaeology is  
23 of ubiquitous relevance to all archaeological fieldwork projects.

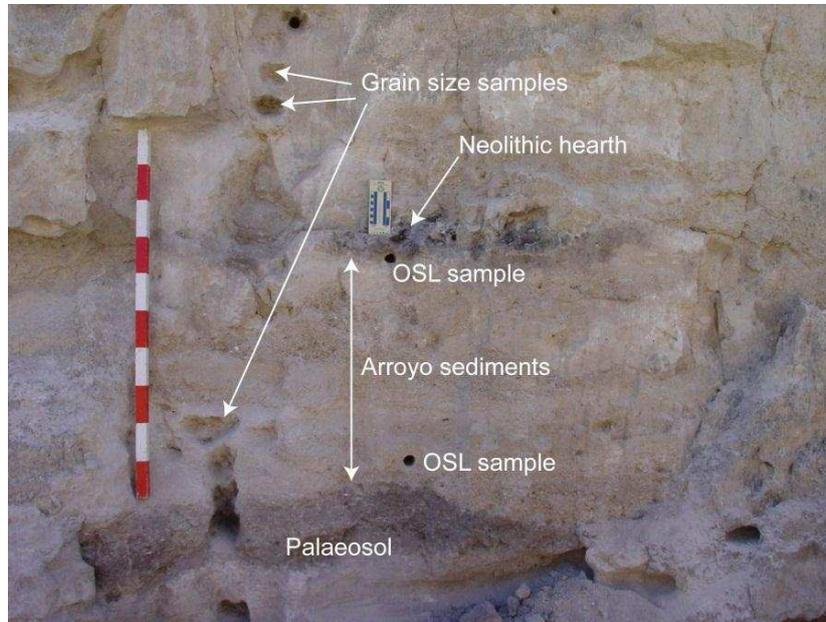
24

25 'Strata' on archaeological sites (and those off site locations that provide indirect evidence of human  
26 activity) comprise **sediments** and **soils**. Sediments are the product of the weathering → transport →  
27 deposition cycle. Therefore grain size and structural properties of sediment beds (layers) are  
28 collectively dependent on the geological source, and the mechanism and energy of transport. The  
29 mode of transport determines the depositional environment in which a sedimentary bed forms, for  
30 example running water leads to the formation of alluvial sediments, wind leads to the accretion of  
31 aeolian sediments, tidal processes to intertidal sediments and people to archaeosediments. Changes  
32 of source material and/or transport conditions will result in a sediment bed with different properties  
33 to the original forming. A succession of such beds is called a **sequence**. A geoarchaeologist is able  
34 to 'read' the properties of the sediments in a sequence and the boundaries ('bounding planes' or  
35 'contacts') between the different sedimentary beds to reconstruct changes both from one  
36 depositional environment to another (for example alluvial to aeolian), but also from one part of a  
37 depositional environment (sub-environment) to a second (for example a beach to dune in the case of  
38 a marine marginal depositional environment).

39

40 Soils develop within sediments and form a stable terrestrial surface downwards, thereby  
41 'overprinting' existing strata with pedogenic (soil forming) features. As soils mature they develop  
42 as distinct and universally recognized **horizons** (soil layers) designated by a combination of capital  
43 and lower case letters. For example the Ah horizon is the humus-rich, biologically active surface  
44 zone, the Bt horizon is a largely mineral layer containing high concentrations of clay that have been  
45 washed down from the A horizon, while the C horizon is the so-called parent material, i.e. the  
46 unmodified sediment/rock in which the soil has developed. Soils mature at different rates and in  
47 varying ways depending upon the climate prevailing during their development, properties of the  
48 parent material and vegetation. However, given that the properties of soil horizons and their  
49 component parts are determined by these external factors, geoarchaeologists are able to interpret  
50 soil properties in terms of past environments and relative age. Often, however, it is **palaeosols** (i.e.  
51 fossil soils that have been isolated from present day soil-forming regimes) rather than those

1 presently forming that provide the most useful geoarchaeological evidence. Palaeosols can be  
2 buried beneath sediments (Figure 1), are relict (i.e. present at the surface, but isolated from soil  
3 forming processes), re-exposed at the surface, or fused (i.e. joined with a presently forming soil)  
4 and can be interpreted in exactly the same way as present day surface soils.  
5



6  
7  
8 Figure 1. An arroyo/gully infill sequence containing a Neolithic hearth and sealing a palaeosol from  
9 Zaragoza province, northern Spain.

10  
11 Landforms are surface or sub-surface morphological features either developed by deposition of one  
12 or a series of sediment beds (in which soil formation may or may not have occurred), or sculpted  
13 from such layers or the bedrock by erosional processes. The study of landforms is called  
14 **geomorphology**. Landforms occur at a variety of scales ranging from isolated hollows resulting  
15 from the fall of a tree to river terraces that might have a linear extent of tens to hundreds of  
16 kilometers. The environment in which a landform has developed can be reconstructed by a  
17 geoarchaeologist on the basis of its morphology together with the properties of the sediment beds  
18 that comprise it. For example talus is deposited in conical and lobate forms at the entrances to caves  
19 as it is a combined product of water moving through the cave and gravity.  
20

### 21 **2.3. Approaches**

22  
23 The spatial scale at which analysis is undertaken differentiates the methods and approaches of  
24 geoarchaeology. Scale also determines the objectives of geoarchaeological studies, with those  
25 carried out over large spatial areas concerning themselves with landscape change and prospection  
26 for archaeological sites, while those undertaken at smaller scale investigate site formation  
27 processes.  
28

### 29 **Regional**

30  
31 Regional scale geoarchaeology examines the development of landscapes at scales of a few square  
32 kilometers and more. Such studies are often termed ‘off site’ given that archaeological sites are not  
33 the main focus and are frequently component parts of regional archaeological survey. The main  
34 purpose of regional geoarchaeological studies is often to reconstruct the palaeolandscape  
35 (topography, depositional environment etc.) for a given chronological period (e.g. as part of an

1 archaeological survey of the area), to determine the effect of human impact on landscape change  
2 (e.g. as a result of deforestation, agriculture or industrial activities) and to develop predictive  
3 models suggesting where archaeological sites of different periods and types might be found. Typical  
4 methods used in such investigations include:

5 **1. Desktop study of cartographic (e.g. topographic and geological maps), aerial (photographs  
6 and LiDaR) and satellite sources.** Such data are used to develop a preliminary  
7 geomorphological map/model for field checking. Where cartographic data are poor, non-existent  
8 or classified, data acquired from satellite sensors can be used to model topography (e.g. as  
9 acquired by the Space Shuttle Tomography Mission [SRTM], the Advanced Spaceborne Thermal  
10 Emission and Reflection Radiometer [ASTER] Global Digital Elevation Model [GDEM] sensor  
11 in the Terra satellite or available from commercial platforms such as Satellite Pour l'Observation  
12 de la Terre [SPOT]), can be used to provide vegetation and geological information (e.g. LandsAT  
13 and ASTER), while panchromatic (i.e. visible light spectra) imagery from high resolution sensors  
14 (e.g. Quickbird, Ikonos as well as CORONA satellite photographs) can be used as vertical air  
15 photographs to better understand the morphology of the landscape.

16 **2. Field geomorphological survey.** Activities of this type are carried out to enhance a working map  
17 initially produced in the office, and are undertaken either on foot or in a vehicle. The location and  
18 extent of distinctive landforms are plotted onto either a topographic map (typically of 1/10,000 or  
19 larger scale) or vertical aerial photograph and using standard geomorphological mapping symbols.  
20 Global positioning system (GPS) receivers are often used to provide spatial control in the  
21 mapping, while the integration of GPS receivers, personal data assistants (PDA)/tablet computers  
22 and geographical information systems (GIS) software now makes the exercise an entirely digital  
23 one. A combination of the spatial relationship between landforms, their morphology and their  
24 stratigraphy when exposed in section (see below), can provide an indication of how and when  
25 they formed.

26 **3. Field examination of exposures.** A geomorphological survey will usually encounter vertical  
27 sections that have been cut through landforms as a result of natural processes such as channeling  
28 (e.g. by streams) and slippage (e.g. by coastal erosion or as a result of earthquakes), or by people  
29 (e.g. to construct roads, agricultural terraces etc.). The strata in such exposures are described and  
30 photographed, while they might also be sampled for the purposes of dating, laboratory-based  
31 geoarchaeological studies (see below) and the investigation of biostratigraphy (Figure 1).  
32 Descriptive data collected in the field frequently provide the most relevant information on the past  
33 landscape represented by a landform. Color (using a Munsell Soil Color Chart), grain size, and  
34 structural properties such as sorting (i.e. how broad a range of grain size classes are represented),  
35 bedding (thickness, orientation, upwards trends) and lamination are all described using standard  
36 schemes for each stratigraphic layer. Deposits forming in different depositional (sub-)  
37 environments have been studied in the present landscape and frequently have unique  
38 combinations of the morphological and structural properties outlined above. Therefore  
39 uniformitarian principles are used to reconstruct the environments represented by strata exposed  
40 in section. Particularly diagnostic layers exposed in multiple sections can be used as a means of  
41 correlation and relative dating of landforms.

42  
43 Landscape changes over time can be pieced together using these approaches, while human influence  
44 on these processes can be reconstructed from biological, geochemical (see below) and artifactual  
45 evidence preserved in the strata. It is often possible to model the location of potential undiscovered  
46 archaeological sites from landscape reconstructions using as an analog the known distribution of  
47 archaeological sites of a given period and their relationship with geomorphological features.

48  
49 **Macro**

1 Macro-scale geoarchaeology is carried out on archaeological sites. As was noted above, the main  
2 objective of such studies is to reconstruct the processes that caused the formation of the site (**site**  
3 **formation processes**) and which have since affected the site following its abandonment (**post-**  
4 **depositional processes**). Understanding such processes also helps in the study of **taphonomy**, i.e.  
5 the extent to which artifactual and biological materials are preserved in the archaeological record. In  
6 addition to determining site formation and post-depositional processes active on a site, macro-scale  
7 geoarchaeological studies are also concerned with correlating strata, both between excavation areas  
8 and with off-site stratigraphic sequences (e.g. as investigated by a regional survey). Correlations of  
9 this type help date the site stratigraphy (even if only in relative terms) and set it within a regional  
10 framework.

11  
12 The basis of macro-scale geoarchaeology is the vertical sections exposed in the walls of  
13 archaeological excavation trenches. Strata are described in exactly the same way as outlined for  
14 regional studies above, except that there is a much greater emphasis on recording the presence,  
15 quantity and morphology of artifacts and features that have resulted from human activity. For  
16 example a layer containing stone artifacts with their long axis pointing in one direction may indicate  
17 that the stratum formed as a result of fluvial reworking of a knapping floor. In addition to  
18 descriptive data collected during fieldwork, samples can also be collected for the following analyses  
19 (Figure 1 and 2):

- 20 **1. Grain size measurement.** While it is possible to provide an approximate determination of the  
21 grain size in the field by eye (for particles >2mm, i.e. gravels), use of a hand lens (for particles  
22 0.063-2mm, i.e. sands) and by ‘finger texturing’ for finer particles, such approaches are neither  
23 quantitative nor accurate. Grain size classes assigned in the field also lack detail (e.g.  
24 descriptions such as ‘sandy silt’ and ‘medium-coarse sand’ are usually assigned) and can only  
25 be used to attribute a stratum to a broad depositional sub-environment (e.g. ‘floodplain’,  
26 ‘beach’, ‘dune’). Laboratory approaches to grain size analysis are varied, but typically comprise  
27 sieving a disaggregated and dry sample through a nest of sieves at half phi ( $\phi$  - a logarithmic  
28 scale in which the mesh in every second sieve halves in size [Table 1]) to determine the grain  
29 size distribution of sands. Approaches that rely on Stokes’ Law (i.e. the speed at which spheres  
30 in a liquid settle from suspension depends upon their radius and density) are employed to  
31 measure silt and clay grain sizes. The <0.063mm fraction of a sample is therefore placed in  
32 suspension in a 1000ml cylinder and either aliquots are removed by pipette, dried and weighed;  
33 or hydrometer readings are taken at times corresponding to those at which particles of different  
34 sizes settle out of suspension. The grain size distribution of fine sands, silts and clays can also  
35 be measured by mechanical means and the most common of these is laser granulometry in  
36 which a laser beam is passed through a suspension containing the sample and the angle by  
37 which the beam is deflected is measured (the angle of diffraction increases with particle size).
- 38 **2. Magnetic susceptibility measurement.** The magnetic properties of a sample are dependent on  
39 the geological source from which particles in the sample are derived, whether and the degree to  
40 which particles have been heated and finally if soil formation has taken place. Magnetic  
41 susceptibility measurements can therefore provide an indication of sediment source, whether  
42 pedogenesis has occurred and evidence for certain human activities (e.g. burning, pottery  
43 discard etc). Mass specific magnetic susceptibility measurements are usually made on dried 10cl  
44 samples that have been passed through a 2mm sieve (i.e. on particles <2mm), while the samples  
45 are often continuous blocks of 10-20mm thickness removed from a vertical section, a cohesive  
46 sample (e.g. a monolith tin) taken from such a section, or a borehole core (Figure 3). Volume  
47 magnetic susceptibility readings can also be taken in the field using a probe sensor or on  
48 borehole cores using a core sensor.
- 49 **3. Organic carbon measurement.** Loss-on-ignition measurements are carried out in a muffle  
50 furnace on 1-30g samples in order to determine the organic carbon content of a soil or sediment.  
51 The loss in mass of a sample following exposure to temperatures of 450-850°C is a result of

1 combustion of organic material and its conversion to carbon dioxide. Some authors have argued  
2 that loss-on-ignition measurements over estimate organic carbon content as some minerals (e.g.  
3 carbonate) break down during high temperature firing. Therefore chemical means of organic  
4 carbon measurement are also sometimes used, for example measuring weight loss consequent  
5 on digestion of a sample with hydrogen peroxide. The organic content of a soil or sediment  
6 relates to the position of a sample in a soil profile (e.g. O and A horizons have high organic  
7 contents, most B horizons do not), depositional sub-environment (e.g. fills of oxbow lakes  
8 contain high quantities of organic material, those in active channels do not) and human activity  
9 (humans commonly produce/are associated with large quantities of organic material). As with  
10 mass specific magnetic susceptibility, samples for organic carbon measurement are usually  
11 taken as continuous blocks of soil/sediment of 10-20mm thickness.

12 **4. Micromorphology.** See under ‘Micro’ below.

13 **5. Geochemistry and mineralogy.** The mineralogical properties of a soil and sediment primarily  
14 reflect those of the geological source, although heating can also change mineral composition.  
15 While chemical properties also reflect the source of sediment/soil particles, they are more  
16 transient and are affected by natural post-depositional processes and human activity. Therefore  
17 mineralogical studies are usually undertaken to determine where a sediment unit originates from  
18 (in the same way that mineralogy is used in archaeometric studies to find clay sources  
19 corresponding to ceramics found on a site). Various methods are employed including heavy  
20 liquid separation of minerals in the silt size fraction for manual identification under an optical  
21 microscope and X-ray fluorescence (XRF) measurements made of clay-size particles.  
22 Geochemical measurements are usually made on acid-digested samples and by using  
23 spectrometers (i.e. either using atomic absorption spectrometry [AAS] or inductively-coupled  
24 plasma mass spectrometry [ICPM-S]). However, geochemical measurements can also be made  
25 directly on individual particles using a microprobe when they are viewed under a scanning  
26 electron microscope (SEM). As with magnetic susceptibility and organic carbon measurements,  
27 geochemical studies are normally carried out on multiple sub-samples taken stratigraphically  
28 through a section. However obtained, geochemical measurements are employed to evaluate  
29 human activity during sediment deposition/soil growth, to examine post-depositional changes  
30 and to source a sediment.



32  
33  
34 Figure 2. Monolith samples taken through a peat filled cut-off meander of the river Kennett,  
35 Berkshire, England.

1



Figure 3. Using a Bartington MS2 magnetic susceptibility meter and MS2C dual frequency sensor.

Table 1. Wentworth (1922) grain size classes

Diameter	Phi ( $\Phi$ )	Description	Diameter	Phi ( $\Phi$ )	Description
256mm	-8.0	Cobbles	354 $\mu$ m	+1.5	Medium sand
	-7.5		250 $\mu$ m	+2.0	
128mm	-7.0		177 $\mu$ m	+2.5	Fine and very fine sand
	-6.5		125 $\mu$ m	+3.0	
64mm	-6.0	88 $\mu$ m	+3.5		
45.3mm	-5.5	Pebbles	63 $\mu$ m	+4.0	Silt
32mm	-5.0		44 $\mu$ m	+4.5	
22.6mm	-4.5		31 $\mu$ m	+5.0	
16mm	-4.0			+5.5	
11.3mm	-3.5		16 $\mu$ m	+6.0	
8mm	-3.0			+6.5	
5.66mm	-2.5		8 $\mu$ m	+7.0	
4mm	-2.0			+7.5	
2.83mm	-1.5		4 $\mu$ m	+8.0	
2mm	-1.0			+8.5	
1.41mm	-0.5	Very coarse and coarse sand	2 $\mu$ m	+9.0	Clay
1mm	0.0			+9.5	
0.707mm	+0.5		1 $\mu$ m	+10.0	
0.5mm	+1.0				

9

10 **Micro**

11

12 Micro-scale geoarchaeology refers to the examination of single or small numbers of archaeological  
 13 layers and is synonymous with **micromorphology** (often inaccurately termed ‘soil  
 14 micromorphology’). As with analyses carried out as part of macro-scale geoarchaeology,  
 15 micromorphological studies are a response to hypotheses generated from an examination of site  
 16 stratigraphy. Questions to be addressed by micromorphology are typically the same as those asked

1 of macro-scale studies, although often more detail is expected of micro-scale studies. Thus the  
2 processes that caused the formation and subsequent modification of an archaeological layer – or a  
3 stratum that is suspected of recording evidence for human activity - are the primary concern of  
4 micromorphology. Micromorphological studies are often also carried out to confirm field  
5 interpretations of layers such as palaeosols, floors, hearths, processing surfaces etc.  
6

7 Micromorphological samples are taken in Kubierna tins, i.e. rectangular stainless steel frames  
8 measuring 10-20cm in length and 5-10cm in width. These are inserted into a vertical section and  
9 their outer face sealed with a lid. Upon extraction a second lid is used to cover the inner face of the  
10 frame. In the laboratory the outer face lid of the Kubierna tin is removed and the sample is then air  
11 dried. The tin is then filled with resin and that allowed to cure (solidify and harden). Once cured a  
12 thin section is made of the resin-impregnated sample. Finally the thin section is studied under  
13 various types of light using a petrological microscope. Description of thin sections is often  
14 undertaken using a standard system that was developed by P Bullock and colleagues (1985) and  
15 which uses a combination of semi-quantitative and qualitative terms. However, fully qualitative  
16 descriptions targeted at directly addressing archaeological questions are also employed.  
17

## 18 **2.4. Conclusions**

19  
20 The text above has made it clear that geoarchaeology is a field discipline, with laboratory studies  
21 being a secondary element intended to confirm/reject/provide supporting evidence for  
22 interpretations that are made in the field. Very rarely are samples taken in the field for purposes  
23 other than to address field hypotheses. The degree to which fieldwork is important differentiates  
24 geoarchaeology from the other sub-disciplines of environmental archaeology reviewed below.  
25 Zooarchaeologist and archaeobotanists study animal and plant remains recovered from  
26 archaeological deposits, but the material studied by geoarchaeologists is the sediment/soil matrix  
27 and that can only be fully understood in the field.  
28

## 29 **3. Zooarchaeology**

### 30 **3.1. Introduction**

31  
32  
33 Zooarchaeology is the study of subfossil and fossil (non-human) animal remains from  
34 archaeological sites. Although zooarchaeology is often used as shorthand term for vertebrate  
35 zooarchaeology, here it is used to cover the archaeology of all animal remains. Some common  
36 classes of animal remains studied, which will be discussed below, include: (non-human)  
37 vertebrates; mollusks; insects; parasites.  
38

### 39 **3.2. Vertebrates**

#### 40 **Introduction**

41  
42  
43 Vertebrates, animals with backbones, are divided into five classes: mammals, birds, reptiles,  
44 amphibians, and fishes. Bones and teeth are the most commonly preserved body parts, and on the  
45 majority of sites these tend to be dominated by mammal skeletal elements. Studies of vertebrate  
46 remains allow a range of insights into human-animal relationships including, in particular, the  
47 investigation of past human activities (economies, societies, beliefs), past human-animal  
48 relationships, and the environments of landscapes inhabited by the humans and animals.  
49

50 Early interest in animal remains began around the start of the 19<sup>th</sup> century AD. In Europe,  
51 observations by a number of individuals, such as the English John Frere and French Jacques

1 Boucher de Perthes suggested that remains of humans found alongside extinct animals could be of  
2 great antiquity, contra the biblical chronology of creation that was accepted at the time. Accepted  
3 from the mid-19<sup>th</sup> century, such early work on animal remains, alongside the work of geologists and  
4 scientists such as Charles Lyell and Charles Darwin, first gave insights into the great antiquity of  
5 human origins.

6  
7 One of the early pioneers was the Swiss veterinarian L Rütimeyer. In the 1860s he described animal  
8 bones from Neolithic lakeside dwellings in Switzerland, and was perhaps the first to distinguish  
9 between bones of wild and domestic species. The origins of food production formed a major early  
10 focus for zooarchaeological research. Advances came around the turn of the 19<sup>th</sup> and 20<sup>th</sup> centuries,  
11 with J Ulrich Duerst, who studied domestication and morphological change with studies of cattle  
12 and sheep in Russian Turkestan, and E Hahn, who suggested that many animals were first  
13 domesticated in the Near East. In the mid-20<sup>th</sup> century, the zoologist Charles Reed, working with  
14 the archaeologist Robert Braidwood in the Near East, set the ground work for rigorous  
15 investigations into the origins of domestication which would influence many of the researchers who  
16 followed. Through the 20<sup>th</sup> century AD, animal bones from archaeological sites were being used in  
17 an increasingly diverse range of studies to explore questions from reconstructing past environments  
18 to the activities of humans at sites.

19

## 20 **Survival and recovery of remains**

21

22 Vertebrate remains from archaeological sites are dominated by the hard parts of the skeleton: bones  
23 and teeth. In addition to these, in exceptional circumstance, such as anoxic, desiccated, or frozen  
24 conditions, keratinous and soft tissues can also be preserved in situations where bacterial attack is  
25 limited, such as the bodies recovered from the waterlogged and acidic peats of European bogs. Bird  
26 egg shell can also be recovered, and is best preserved in alkaline conditions

27

28 Key factors influencing the recovery of vertebrate remains include the qualities of the remains  
29 (especially their size and robustness), which affect their ability to survive the burial environment,  
30 and the method of recovering the remains. There are two main methods for recovering vertebrate  
31 remains from archaeological sites, via hand-picking (collection by the excavating archaeologist) and  
32 by sieving (passing a bulk-sample of collected sediment through a sieve).

33



34

35

36 Figure 4. Wet sieving and flotation of samples being undertaken at the Early Neolithic site of  
37 Sheikh-e Abad by the Central Zagros Archaeological Project. © Prof. R. Matthews.

38

1 Hand-picking bones can introduce biases to the recovered assemblage, as it often favors the remains  
2 of larger animals over smaller ones. The analysis of assemblages of solely hand-excavated bones  
3 can therefore produce results that are biased relative to the remains that are ‘available’ in the ground  
4 during the excavation. The development and application of sieving techniques from the 1960s and  
5 1970s allow for greater control on what archaeologists recover. Bulk samples of sediment taken  
6 from the site are wet or dry sieved through meshes of standard size, such as 1mm, 2mm, and 4mm  
7 mesh size (Figure 4). Sieving is essential for recovering the bones of smaller animals – such as  
8 rodents, frogs, small birds, and fish – but also for accurately interpreting body-part representations  
9 of the larger animals (as it is the smaller skeletal elements that are often under-represented by hand-  
10 excavation).

## 11 **Recording, analysis and interpretation**

12  
13  
14 Identification of vertebrate remains is undertaken using osteological reference collections of  
15 modern skeletons of known species, age and sex. A good reference collection, containing **taxa**  
16 appropriate for the geographical region and period of the past under study is crucial for correct  
17 identification of the remains (Figure 5). For many of the common taxa encountered during  
18 archaeological research, osteological manuals have been published which outline key identification  
19 criteria. These are important tools for aiding identifications, especially for taxa with very similar  
20 skeletons, such as goats and sheep.



21  
22  
23  
24 Figure 5. Modern cod bones in a comparative osteological reference collection.

25  
26 Closely linked to issues of recovery and identification is quantification. Some taxa have more  
27 skeletal elements than others, which could relatively over-represent them if a simple comparison of  
28 numbers of fragments was made. Further, the skeletons of different taxa exhibit differential ability  
29 to survive the burial environment. A red deer humerus is significantly more robust than a house  
30 mouse humerus, for example. Likewise, fish scales also vary considerably in size and robustness.  
31 Further, not all vertebrate skeletons are composed of bone: jawless fishes (the Agnatha), such as  
32 lampreys, do not possess mineralized skeletons.

33  
34 Vertebrate zooarchaeological remains tend to be disarticulated and fragmentary – this can occur  
35 through a range of anthropogenic and natural taphonomic processes - although complete or partially  
36 complete skeletons are also found. They may have been affected by butchery techniques, disposal  
37 practices, preservation conditions and other taphonomic factors, such as chewing and dispersal of  
38 bones by scavenging animals. Differential preservation at sites can also affect the species ratios

1 recovered, for example in sites with poor bone preservation the bones of smaller animals can be  
2 more susceptible to destruction than those of larger beasts.

3  
4 Zooarchaeologists use a range of methods to quantify bones recovered from archaeological sites.  
5 The two most commonly used quantification units for vertebrate remains are the number of  
6 identified specimens per taxon (**NISP**) and the minimum number of individual animals (**MNI**)  
7 necessary to account for the set of identified bones. Whereas NISP is an observational unit, MNI is  
8 derived as it may or may not consider inter-specimen variation (e.g. the age or size of specimens).  
9 NISP quantifications tend to exaggerate the importance of **taxa** whose elements are more readily  
10 identified and minimize the importance of those represented by only a few specimens, whereas  
11 MNI tends to exaggerate the presence of rarer animals. It should be stressed that there is no single  
12 'correct' method of quantification, as the various methods all provide estimates of abundance  
13 suffering from different biases.

14  
15 Vertebrates can provide valuable data on past climate and habitat. The various species of small  
16 terrestrial vertebrates can be used to characterize local habitats. Small mammals, amphibians and  
17 reptiles all have different preferred habitats and tolerances, and analyses of their remains can give  
18 an idea of the local habitats around a site. The climatic tolerances of many animals are wide, but the  
19 composition of species at a site or sites can give an idea of climatic conditions (although biases due  
20 to **taphonomy** and human selection must be considered). This can be seen, for example, in the  
21 different faunas recorded from successive glacial and interglacial periods in Europe. Further,  
22 knowledge on mammals as climatic indicators has been used to particularly good effect as a  
23 chronological tool, as evolutionary changes in some animals are well known. They can be used to  
24 date site stratigraphy as has been well-demonstrated at the Middle Pleistocene site of Boxgrove in  
25 southern England by M Roberts and S Parfitt.

26  
27 Analyses of butchered and fragmented animal remains left behind by humans can give detailed  
28 insights into their past activities, diets and industries. Such analyses can provide information on, for  
29 example, resources available to hunting and gathering groups. The types, seasons and extents of  
30 territory and habitat use may be explored through consideration of the range of wild species present  
31 at sites. Questions of territorial use can also be answered through recent advances in isotopic  
32 analyses. Studies of isotope ratios preserved in animal tissues can be used to reconstruct the origins  
33 and movements of animals, for example analyses of strontium isotope ratios ( $^{87}\text{Sr}/^{86}\text{Sr}$ ) ratios in  
34 tooth enamel (which is resistant to chemical changes in the ground) can be used to explore  
35 movement in relation to the underlying geology where the animal consumed food and water while  
36 the tooth was growing. Such analyses may also help understand past trade in animals, as animals  
37 and animal products will have moved around to differing degrees based on the complexities and  
38 extents of human economies and networks. Further, seasonality may be investigated through the  
39 study of skeletal parts which grow incrementally, such as fish otoliths.

40  
41 The economies of farming societies can be studied through analyzing how they raised and used  
42 domestic livestock. Husbandry techniques can be explored through constructing age and sex  
43 profiles of these herds. Identification of sex is possible with certain skeletal elements, and metrics  
44 can often be used for animals that exhibit sexual dimorphism. Metrics are also used to explore the  
45 differences in animal size and shape between individuals and also populations (Figure 6).

46  
47 Analyses of the proportions of males to females in a population and the different proportions of  
48 ages in the archaeological assemblage can be used to investigate the products for which a past herd  
49 might have been kept. This is based on the assumption that different proportions of males and  
50 females will be culled from a herd at different ages if a particular product (e.g. milk or meat) is  
51 being favored. The multiple and complex ways humans used animals in the past can be detected

1 from evidence on the bones: butchered food waste can inform on human diet, pathologies to the  
2 skeleton can inform on the use of large domestic mammals for transportation, worked body tissues  
3 show use as raw materials (e.g. bone, antler, ivory and horn sheath), and so on.  
4



5  
6  
7 Figure 6. Measurement of horse metacarpals with digital calipers.  
8

9 Ideas may also be transmitted and understood through animals and their remains. Animals have also  
10 been used in ritual and social display in the past. This can be seen, for example, in the deposition of  
11 complete horses in the burial mounds (kurgans) of Iron Age nomadic cultures of the Eurasian  
12 steppe. Also, in complex societies, social status can be conferred through access to different types  
13 of food, such as the meat of deer and also cetaceans (sea mammals) in the English medieval period.  
14 Zooarchaeologists must study the contexts of finds, and recognize patterns in the data, to understand  
15 the past. In the latter cases, the associations of Iron Age horses with funerary monuments and deer  
16 remains with medieval castles are the site-level contexts.  
17

### 18 3.3. Mollusks

#### 19 Introduction

20 Mollusks are invertebrate animals. They live on land and in water habitats (fresh, brackish and salt  
21 water). It is the mollusks' shells, the hard calcium carbonate exoskeletons, that are studied by the  
22 discipline of malacology. There are five classes of mollusks which possess a shell: chitons, most  
23 univalves, tusks, bivalves, and some cephalopods. Most mollusks have symmetrical paired shells  
24 (bivalves) or asymmetrical straight or coiled shells (gastropods).  
25  
26  
27

28 The study of mollusks can be used to reconstruct human activities, past land-use, environmental  
29 conditions and change, human behavior and impact on the natural environment, and for the study of  
30 site formation processes. Assemblages of mollusks can provide an idea of the general nature of the  
31 conditions at a site. Their shells are used to reconstruct past environments and human use of the  
32 land and coast. This is based upon an understanding of the different species' ecological  
33 requirements, for example, land mollusks can be used to reconstruct local vegetation but in broad  
34 terms (e.g. woodland, grassland, arable, etc) and freshwater snails used to reconstruct speed of flow  
35 and nature of aquatic habitats.  
36

37 In the earlier 19<sup>th</sup> century, coastal shell middens were recognized as products of human activity by  
38 researchers such as the Dane Japetus Steenstrup and the British biologist Charles Darwin. From the  
39 mid-19<sup>th</sup> century research took on a more sophisticated approach, examining aspects of human

1 adaptation, environmental reconstruction, and palaeoenvironmental change, as illustrated by the  
2 Danish interdisciplinary kjoekkenmoddings (kitchen middens) study group composed of the  
3 biologist Streenstrup, the archaeologist Worsaae, and the geologist Forchhammer.

#### 4 5 **Survival and Recovery of Remains**

6  
7 Mollusk shell is usually best preserved in calcareous soils, but can also be found in regions with  
8 acidic geology if the deposits in which they are found are neutral or alkaline. The valid  
9 quantification and interpretation of mollusk shells rests upon an adequate and representative sample  
10 of shells being recovered and examined by the specialist for the analysis proposed. Sampling  
11 decisions are based upon the stratigraphy and nature of the deposit(s) at the site(s) and the research  
12 objective(s). Samples for mollusk shells analysis are normally taken through a sequence of deposits.  
13 Samples are usually taken as vertical columns from the section face of soil or sediment. Such  
14 samples are useful for palaeoenvironmental and land use reconstructions, and as mollusk taxa  
15 reflect local vegetation it is useful to take samples from multiple locations around a site. Samples  
16 are processed and shells extracted in the laboratory. As discussed above for animal bones, hand-  
17 excavation would bias recovered samples towards the larger shells, and in some contexts large  
18 whole-earth samples for sieving are taken, for example where there are large quantities of mollusk  
19 shells that have been collected and deposited into middens.

#### 20 21 **Recording, Analysis and Interpretation**

22  
23 Identification is based on shell morphology and is undertaken with comparison to modern reference  
24 material and published guides (as described for vertebrate remains).

25  
26 Mollusk shells are typically quantified by counting distinct morphological zones, such as the shell  
27 apex in gastropods, or the hinge in bivalves. This produces a count of the minimum number of  
28 individuals (**MNI**). Other quantification methods exist, including by calculating numbers of  
29 identified specimens (**NISP**) and by weight. Analyses of completeness and fragmentation of the  
30 shells can inform on **taphonomy** and the formation processes of the assemblage.

31  
32 Environmental reconstructions are based on the analysis of taxa with particular climatic or habitat  
33 ranges. Plotting of the frequencies of identified non-marine molluscan taxa throughout a sequence  
34 by their preferred habitat can be used to present general interpretations on environmental change,  
35 for example evidence for woodland clearance might be seen in a shift from shade-demanding  
36 species to taxa that inhabit open conditions. It is groups of mollusks identified together that are used  
37 to interpret particular environments for a given sample. The archaeological data must be interpreted  
38 with an understanding of the taphonomy of the sample(s) and the response of modern mollusks to  
39 changes in cultural landscapes.

40  
41 Subsistence practices – including diet, seasonality, technological developments and trade – have  
42 been explored through analyses of (mainly) marine mollusks. Such analyses can demonstrate  
43 human exploitation strategies, the sources of shellfish used for food, the techniques employed in  
44 their collection, and the impact of human consumption on molluscan communities. In addition to  
45 their use as food, analyses of mollusk shells can also demonstrate their use for other purposes, such  
46 as personal adornments (e.g. beads). Sea conditions, such as temperature and local salinity, can be  
47 reconstructed from marine mollusk shells via analyses of stable isotopes. Such analyses have been  
48 able to demonstrate the season of harvest of the mollusks, and also the past climate.

#### 49 50 **3.4. Insects**

## 1 **Introduction**

2

3 Insects are invertebrate animals and the most diverse class of life on earth. They inhabit all of the  
4 world's terrestrial, freshwater and intertidal ecosystems, and a wide range of artificial (man-made)  
5 habitats. Many species have very specific ecological requirements and are sensitive to  
6 environmental and temperature changes. Assemblages from ancient deposits can thus be used as  
7 proxy data for past habitats and climatic or environmental conditions. As well as providing data on  
8 a regional scale, insects can provide information on local environmental conditions, including the  
9 function of archaeological features.

10

11 Although the use of insects in archaeology has its origins in the 1930s and 1940s, with the work of  
12 the Swedish entomologist C. Lindroth and others, it is in the second half of the 20<sup>th</sup> century that  
13 many of the founding principles were established. Beetles (Coleoptera) are by far the best studied  
14 group of insects in archaeology. Importantly, work in Britain by R. Coope established that  
15 throughout the Quaternary, they had remained stable in their morphology and their environmental  
16 requirements through time. It is this stability that is fundamental to their use for reconstructions of  
17 past climate and environmental conditions.

18

## 19 **Survival and Recovery**

20

21 Insects have exoskeletons of chitin, a nitrogen-containing protein that is insoluble in water, alcohol,  
22 most acids and bases, but which oxidizes and decomposes in air. Chitin is robust and preserves well  
23 under waterlogged anoxic conditions, including in the fills of pits, ditches and wells, lake  
24 sediments, palaeochannel alluvium, and peats.

25

26 Sampling decisions are based upon the stratigraphy and nature of the deposit(s) at the site(s) and the  
27 research objective(s). Insect remains can be collected by taking bulk samples (of around 20 liters or  
28 more in volume) from archaeological or off-site contexts, or by taking samples (of at least 5-7 liters  
29 each) through a sequence of deposits from an exposed section (taking care to respect stratigraphic  
30 boundaries). Ultimately, sample size can be determined in relation to the concentration of insect  
31 remains within a particular deposit. Extraction of insects from samples is undertaken in the  
32 laboratory.

33

## 34 **Recording, Analysis and Interpretation**

35

36 Identification of insect remains is made by comparison with modern reference material and standard  
37 published entomological guides. Quantification is typically based on counts of exoskeletal sclerites  
38 to produce a minimum numbers of individuals (**MNI**).

39

40 Analyses are based on detailed knowledge of modern insects and their ecological preferences. Many  
41 insect species are **stenotopic**, occupying specialized and narrow environmental niches; whereas  
42 others are **eurytopic**, having broader habitat ranges. It is the former that are most useful in the  
43 reconstruction of past environments. Various methods can be used to interpret insect assemblages.  
44 The 'mosaic' approach is often applied, ranging from the discussion of the representation and  
45 habitats of certain taxa to the classification of groups of species sharing certain habitat preferences.

46

47 Detailed reconstructions of human environment and living conditions can be made from insects  
48 assemblages recovered from urban archaeological sites, as has been pioneered at York, England, by  
49 H. Kenward, P. Buckland and colleagues. Data may also be obtained on ancient crop infestations,  
50 and on personal hygiene (from lice and fleas). On rural sites, insect assemblages can inform on the

1 character of woodland, the quality and speed of flow of water, land use, and the occurrence of  
2 domestic animals.

3  
4 Chironomidae (non-biting midges) are an insect family commonly studied as a temperature proxy.  
5 Their larvae are largely aquatic and sensitive to changes in water temperature, making them useful  
6 for palaeoclimatic reconstructions.

7  
8 Quantitative palaeoclimatic reconstructions are also made using the Mutual Climatic Range (MCR)  
9 method developed by T.C. Atkinson and colleagues in the 1980s. This is achieved by using the  
10 mutual intersection of modern climatic ranges of species in the fossil record, on the assumption that  
11 modern climatic ranges are applicable to the past. Beetles (Coleoptera) are particularly useful for  
12 the MCR method as they are the most commonly recovered and studied insect, and many species  
13 have fairly well-defined climatic tolerance ranges.

### 14 15 **3.5. Parasites**

#### 16 17 **Introduction**

18  
19 Parasites are organisms that live in or upon another organism and derive their nutriment directly  
20 from it. Animal parasites are almost invariably invertebrates although of many different orders and  
21 families. **Endoparasites** live inside the tissues or body of their host; **ectoparasites** live externally  
22 on the body. Although there were earlier studies, archaeoparasitology largely developed in the  
23 1970s and especially 1980s. The study of parasites from archaeological material can inform us  
24 particularly on living conditions (especially sanitation), changing human-animal-plant-parasite  
25 relationships, and levels of disease and infestation.

#### 26 27 **Survival and Recovery of Remains**

28  
29 Remains of parasites from archaeological contexts mainly consist of eggs of intestinal worms and  
30 sometimes their larvae, or of the chitinous exoskeletons of ectoparasites, such as fleas (see  
31 discussion on insects above; the rest of this section will discuss endoparasites).

32  
33 Intestinal worms are the most commonly studied parasite. Their remains can survive well in  
34 archaeological strata (the eggs are robust and resistant to decay as their reproductive cycle needs  
35 them to survive in the faeces of one host in order to enter the intestines of another). Endoparasite  
36 eggs are small (up to ca. 60  $\mu\text{m}$  in length) and are most often found in wet deposits, but can occur in  
37 dry ones too. These eggs can be recovered from faecal remains found on archaeological sites,  
38 especially from latrines and cesspits. Such sediments are composed of large quantities of coprolites  
39 that have (incompletely) disintegrated during the process of decay. Parasite ova have also been  
40 identified from both mummies and also European bog bodies. In contexts where soft tissue does not  
41 survive, but we have the complete skeleton, of a human or an animal, the area of the pelvic region  
42 can be sampled for parasite remains. Coprolites (preserved faeces) are useful sources of  
43 archaeological parasites. Sampling of coprolites and latrine deposits can be undertaken for parasite  
44 eggs, larvae, and also DNA.

#### 45 46 **Recording, Analysis and Interpretation**

47  
48 Parasite egg analyses are normally presented as the number of eggs per gram of sample, however  
49 given the issues of variability in egg-production between infections and taphonomic variation in the  
50 archaeological remains, semi-quantitative methods may also be appropriately used, as proposed by  
51 M. Dainton.

1  
2 A major problem in the study of parasites is that in many cases the eggs are not necessarily  
3 identifiable to species, which limits their interpretation. A further problem lies in our ability to  
4 assess the true parasitic load of an individual at the time of death. Diagenetic factors affecting the  
5 remains make it difficult to assess the epidemiological consequences of an identified infection.  
6

7 Studies of parasite remains from archaeological contexts can contribute to a range of interpretations.  
8 This can include indicators of the health of individuals, as when mummies, bog bodies or coprolites  
9 are sampled. Information on the health of populations may be drawn from studies on amorphous  
10 faecal deposits (e.g. latrines). Parasite remains are also particularly useful for identifying  
11 contamination by human and animal faecal waste.  
12

### 13 **3.6. Conclusions**

14  
15 The animal kingdom is and has been an integral part of human ecology at every level of existence,  
16 from the need to subsist on (wild or domestic) animals for their very existence, to ‘hosting’  
17 parasites that lived within and on their own bodies. The study of all these categories of animal  
18 remains provides useful insights into the contexts (environments and climates) and details  
19 (economies and actions) of human ways of life. Zooarchaeological research bears witness to the  
20 diverse range of human-animal relationships that have existed in the past and depending on the  
21 particular archaeological material under study can give insights from the level of the individual to  
22 that of the population.  
23

## 24 **4. Archaeobotany**

### 25 **4.1. Introduction**

26  
27  
28 Archaeobotany studies the interactions between human societies and the plant kingdom from the  
29 botanical remains discovered on archaeological sites. The discipline is a continuation of  
30 palaeobotany which is itself a branch of palaeontology that studies plant remains from geological  
31 contexts. Palaeobotany is concerned with the evolution of plants through time, and understanding  
32 the environment and climate from the Palaeozoic to the Quaternary (~540 to ~2 million years ago).  
33 Thus, compared to the hundreds of millions of years of time covered by palaeobotany,  
34 archaeobotany is concerned with a very restricted period. Archaeobotany becomes a full discipline  
35 when there is interaction between people and the environment. Archaeobotany can be split into  
36 several sub-disciplines dedicated to their own problems and material, each of which is interested in  
37 different anatomical elements of varied taxonomic groups. Some groups are little studied because  
38 their anatomy has very few identifiable elements and/or they have a low resistance to taphonomic  
39 processes thereby preventing their preservation over time (e.g. fungi, algae, etc). In contrast to these  
40 groups, the vascular plants are one of the most studied taxonomic groups, especially angiosperms  
41 (hardwoods) and gymnosperms (conifers), as their remains are both durable and relatively easy to  
42 identify.  
43

44 The types of vegetal remains most studied are:

- 45 1. pollen and spores
  - 46 2. wood
  - 47 3. seeds and fruits
  - 48 4. phytoliths
- 49

### 50 **4.2. Palynology**

1 **Definition**

2

3 Palynologists (from ancient Greek palunein, "sprinkle", and logos, "word, speech") study pollen  
4 and spores (Figures 7 and 8) collected in natural and archaeological contexts. Pollen is produced  
5 during the reproduction process of seed-bearing plants (**Spermatophyta**). Spores are the spreading  
6 elements in fungi, algae, mosses and ferns. Palynologists seek to reconstruct past flora and also the  
7 human impact on vegetation.

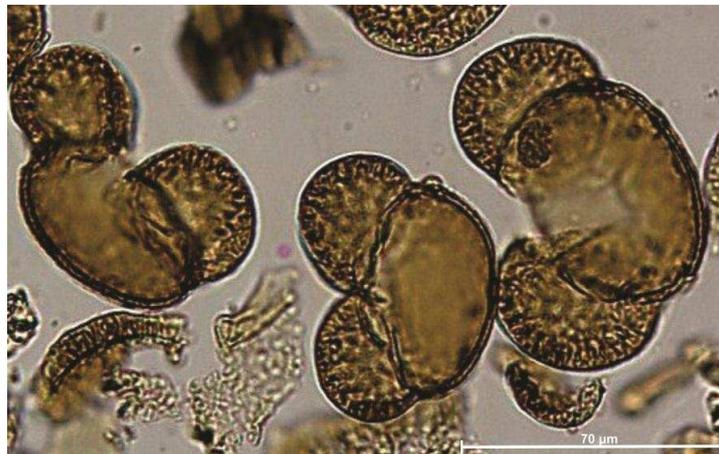
8

9 **Short History**

10

11 The fertilizing role of pollen has long been known. But it was not until the 16<sup>th</sup> century and  
12 especially in the 17<sup>th</sup> century when botanists became interested in pollen thanks to the invention of  
13 the microscope. In the 19<sup>th</sup> century, descriptive studies allowed the identification of the plants that  
14 produced such pollen or spores, from which developed multiple applications, such as  
15 **melissopalynology** and **aeropalynology**. At the end of the 19<sup>th</sup> century, geologists in northern  
16 Europe became interested in pollen grains contained in bogs, mainly to understand climate change.  
17 This work led to the first palynological diagrams.

18



19

20

21

22

Figure 7. Fossil pollen grain of Pinus (Pine). © M. Court-Picon.



23

24

25

26

Figure 8. Fossil pollen grains of Quercus (Oak), Tilia (Lime)  
and Ulmus (Elm). © M. Court-Picon.

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## **Excavation and Recovery**

Three main types of deposits are sampled for palynological studies:

1. natural environments such as peat
2. lakes and rivers
3. archaeological sites

In natural sediments, sampling is mostly carried out by mechanical or manual coring. On archaeological sites, samples are taken from vertical sections in monoliths, or by collecting spot samples in zip-lock bags. Cores and monoliths are sub-sampled in the laboratory and the sub-sample is chemically treated to remove organic and mineral remains to leave just pollen grains and spores.

## **Identification of Remains**

Pollen grains and spores have a wide variety of shapes and sizes. The size of a fossil pollen grain varies from 5 to 500 micrometers. Moreover, the membrane of the pollen, the “exine”, is extremely robust and can be preserved over time and in most sediments. The pollen exine has a number of morphological characteristics (size, thickness, ornamentation, and apertures) that also allows the identification of the **taxon**. Once samples are prepared chemically, they are mounted on microscope slides using silicon oil, glycerol or glycerol-jelly. The identification and counting of pollen grains and spores contained in each sample are performed under light microscopy (X 250 to 1000). The pollen grain is identified with the help of regional comparative atlases and modern reference collections. The results for the entire sequence sampled are presented in a pollen histogram.

## **From Quantification to Environmental Reconstruction**

Pollen histograms allow the interpretation and discussion of vegetation dynamics and climate, sometimes over long periods. To reconstruct ancient vegetation, it is important to fully understand the production and dispersion of pollen grains and spores in modern plants. The palynologist uses knowledge of modern ecology to interpret the results and takes the following into account:

1. that the various plants recorded as palynomorphs do not have the same production of pollen or the same mode of pollination. Pollen is transported by wind, insects, or may simply drop around the plant. The pollen sources can be therefore of local or distant origin. For example, pine has a long distance pollination strategy and therefore the identification of its pollen does not mean that pine forest was adjacent to the sampling area;
2. knowledge of the ecological characteristics of the taxa: if they are associated with wet or dry environments, require light, or are favored or cultivated by people, etc;
3. the proportions of tree pollen as compared to herbaceous pollen which might indicate a more or less wooded environment.
4. with pollen the class to which the plants can be identified varies – sometimes it will only be family (e.g. Chenopodiaceae), sometimes genus (e.g. Quercus), sometimes species (e.g. *Plantago lanceolata*)

Pollen samples are frequently collected away from archaeological sites because natural sediment is often less affected by post-depositional processes than deposits forming on an archaeological site. However, studies in specific archaeological contexts (such as tombs, storage structures, or coprolites) can provide information about the funeral rituals, food and plant processing.

## **4.3. Anthracology (or Charcoal Analysis)**

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## Definition

Wood is the secondary xylem tissue resulting from the secondary growth of the tree. The xylem transports raw sap. Charcoal (i.e. the product following burning of wood) is regularly found on archaeological sites and is studied by the discipline of anthracology (from the Greek anthrax, "coal, carbuncle"). Anthracology can provide considerable information on the nature of the woodland environment and also on human use of arboreal resources:

1. charcoal from domestic fires is usually the result of wood gathering in the vicinity of the site. Their study provides an indirect picture of vegetation exploited and allows a reconstruction of palaeoenvironment and its changes over time, which is influenced by both human activities and climate.
2. the study of timber or fuel in specialized contexts, such as those used in metallurgical furnaces or for firing pottery, provides information on species selection as well as the management of timber resources.
3. the identification of tree species grown for their fruit or their wood allows the anthracologist to address issues related to horticulture and arboriculture.

Furthermore, the anthracologist can help select appropriate material for **radiocarbon dating**. The identification and selection of short-lived species can help provide a reduced margin of error compared to long-lived species (such as oak, which can live for many centuries).

Several other disciplines study wood brought by humans to archaeological sites. Xylology focuses on wood which is not preserved by carbonization, and studies the tree species from which architectural timbers, tools or other objects are made, and the techniques by which they were shaped. Dendrology studies the tree growth, particularly the thickness and the density of tree rings. It allows understanding of the different parameters which influence the growth of wood, that is to say environmental conditions, including temperature, rainfall, soil type and light availability. Human activities can also leave traces in the wood structure, for example as a result of forest clearing or tree pruning. Pedaanthracology studies charcoal outside archaeological contexts. It analyses material derived from burnt vegetation in order to interpret past ecosystem dynamics.

## Short History

The first people to take interest in the study of prehistoric charcoal were the Italian G. Passerini and the Swiss O. Heer during the second half of the 19<sup>th</sup> century. The analysis of prehistoric charcoal in Germany in the late 19<sup>th</sup> century, followed by work in France and Hungary, marks the beginnings of the discipline of anthracology. The use of **reflection microscopy** by A Freitz in 1931 to study charcoal enabled statistical analysis by allowing the identification of a greater number of fragments. In the 1940s, British researchers posed the main questions of the discipline, including investigating the palaeoecological representation of charcoal compared to actual vegetal stands. In France, anthracological methods applied to archaeological sites were largely developed thanks to J.-L. Vernet and his students at Montpellier.

Since the 1990s, new analytical techniques have tried to respond to issues related to the human management of fuel wood and forest:

1. reconstitution of wood diameters allows us to understand strategies of firewood gathering and the state of the past forest.
2. eco-anatomy of charcoal informs on changes in tree growth.
3. experimentation allows us to understand the role of taphonomy in the composition of charcoal assemblages.

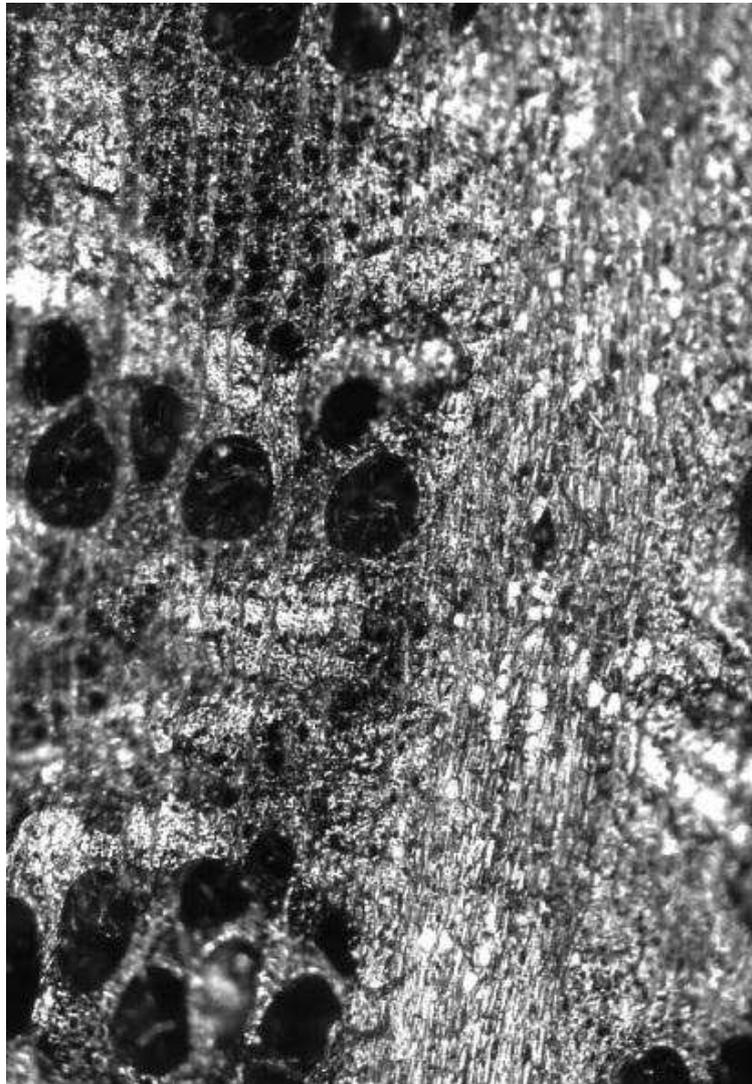
- 1 4. ethnoanthracology informs on current modes of forest use and that of territorial exploitation  
2 for wood gathering to help the interpretation of anthracological assemblages.  
3

#### 4 **Excavation and Recovery**

5

6 In anthracology, the contexts that may indicate the collection of wood over a long time are the most  
7 appropriate for giving the best representation of the past environment, such as areas where  
8 fireplaces/hearths have been emptied and of ash spreading. Charcoal fragments are recovered from  
9 sediments by sieving (dry or wet) or by flotation. They are analyzed using a reflection microscope,  
10 under magnifications of 50 to 1000 times. Identifications are based on the cellular structure (or  
11 anatomy) of wood, which is characteristic for each **taxon** (Figures 9 and 10). A collection of  
12 modern wood and a wood anatomy atlas support the work of identification. The results can be  
13 expressed in different ways:

- 14 1. the proportion of each species over time with the relative number of charcoal fragments in an  
15 anthracological spectra.  
16 2. a list of taxa with their relative proportion to provide a reconstruction of the vegetation during a  
17 period of given time.  
18



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21 Figure 9. Modern charcoal of Quercus (oak). Magnification X50. © A.Salavert.  
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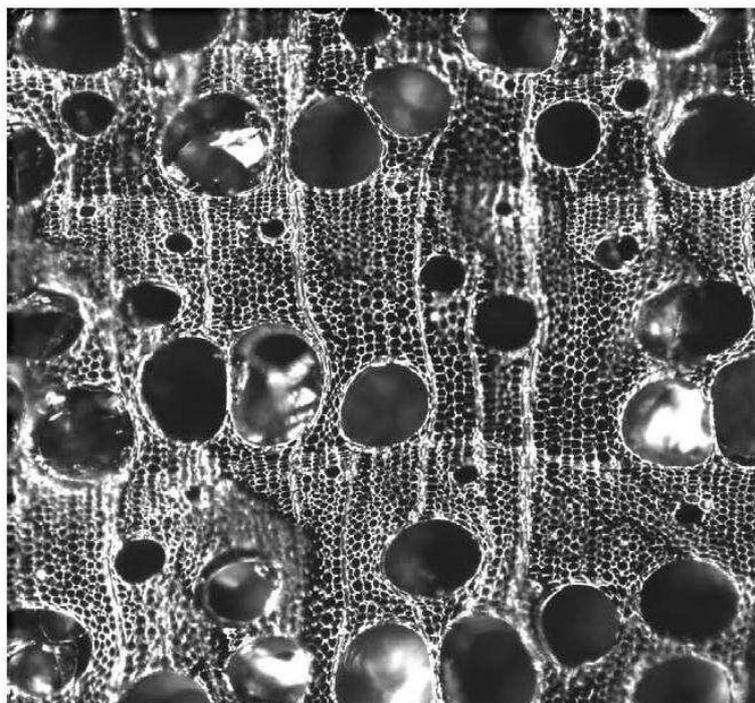


Figure 10. Modern charcoal of Fraxinus (Ash). Magnification X100. © A.Salavert.

#### From Quantification to Environmental Reconstruction

Knowledge of the modern ecology of tree species is used to interpret the anthracological spectra. If the methodological bases of the discipline are followed (i.e. appropriate field sampling, quantification of results, etc), the spectra can provide a good picture of past vegetation, more precisely the proportion of each tree species for each period covered by the study. However, the anthracological spectra cannot provide direct information on the proportion of wooded areas, open spaces, inhabited or cultivated zones etc, around a site. Human filters, such as the selection of firewood, can influence the composition of the charcoal assemblage. The arguments for a good palaeoecological representation of anthracological spectra are:

1. the reproducibility of the observations: two archaeological levels of the same period but spatially separated on one site giving very similar results
2. the analysis reveals high species diversity according to the potential of the environment and periods studied, even if the specialist is aware that the anthracological spectrum does not deliver all the species that were present
3. the ratio of dominance between species observed in the anthracological spectrum is similar to the ratio in present vegetation.

The anthracologist must therefore reproduce analyses over a certain period and/or region to understand palaeoenvironmental dynamics and identify climatic or human causes of such changes.

#### 4.4. Carpology (or seed analysis)

##### Definition

Carpologists (from the Greek carpos, "fruit, carpel") study seeds and fruits found in archaeological sediments. Also included are all the elements resulting from the transformation of the flower or inflorescence after fertilization of the ovule (fragments of **rachis**, **glumes**, stems, etc.) and the

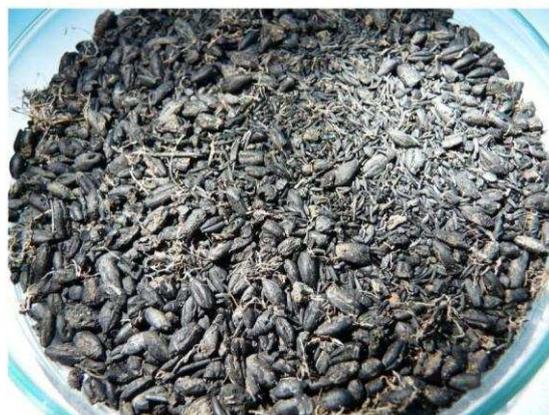
- 1 organs involved in the asexual reproduction of certain plants such as bulbs and rhizomes. On  
2 archaeological sites, seeds and fruits are most often found waterlogged, charred or mineralized.  
3 Plant remains can survive in desiccated conditions or can be preserved in the form of prints in  
4 ceramic or mudbricks. In Europe, charring is the most common mode of preservation. It can be  
5 accidental (fire) or intentional (burning of domestic or agricultural waste, ritual deposits, fire, etc).  
6 Waterlogged material is widespread and preserves plants (particularly wild and fragile seeds) better  
7 than carbonization. A variety of issues are addressed by carpology:  
8 1. the history of food plants - in particular wild and domestic species - and cooking practices.  
9 2. the history of agricultural practices, from land preparation to crop storage.  
10 3. the processes of domestication of plant species, and the morphological and genetic changes  
11 caused by their human selection.  
12 4. some aspects of the medicinal and ritual uses of plants (such as offerings or funerary deposits).

### 13 14 **Short History**

15  
16 In 1926, the British botanist C. Kunth published a study on dried seeds and fruits found in tombs of  
17 ancient Egypt. The beginnings of the discipline were laid down by O. Heer, in the second half of the  
18 19th century, with the study of waterlogged remains of **palafittes** (pile dwellings) in Switzerland.  
19 Carpology was then mainly developed and structured in Britain. In 1944, a synthesis of the first  
20 carpological results obtained on archaeological sites in Britain and Ireland was presented. The  
21 International Workgroup for Palaeoethnobotany was created in 1968, bringing together mainly  
22 European carpologists. New methods have been developed in recent years, notably geometric  
23 morphometrics.

### 24 25 **Excavation and Recovery**

26  
27 Plant remains are collected during excavation, usually from bulk sediment samples. Two kinds of  
28 deposits, that complement each other during interpretation, can be sampled:  
29 1. primary deposits result from one or a few specific actions ("closed set", such as a burned  
30 granary).  
31 2. secondary deposits result from progressive accumulation of ecofacts ("heterogeneous sets", such  
32 as layers of rubbish (detritus) of past societies that have built up over time).  
33 The processing method is chosen depending on the preservation of the material and the type of  
34 sediment. Botanical material can be recovered by wet sieving and **flotation** (Figure 4) and also dry  
35 sieving.



37  
38  
39 Figure 11. Assemblage of carbonized seeds, mainly cultivated cereals, from Early Neolithic  
40 contexts (central Belgium). ©A.Salavert.

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The analysis and identification of seeds and fruits is carried out using a low-power binocular microscope, allowing magnifications of around 3 to 50 times. The morphology of seeds and fruits is compared to that of modern comparative collections as well as descriptions in the specialized literature (Figure 11). The results of the analysis produces a list of taxa cross-referenced with the number of remains of each, the type of remains (such as cultivated cereal, weeds, fruit tree, etc) and the archaeological contexts. Quantification of the remains is used to perform statistical analysis, from the calculation of percentages to multivariate analyses.

## 10 **From Quantification to Environmental Reconstruction**

11  
12 Carpalogists never have a complete view of the vegetation of the past landscape for several reasons:

- 13 1. the preservation and identification of a **taxon** depends on many factors including the type of  
14 preservation and the contexts of discovery. Waterlogged sites have the advantage of favoring  
15 the preservation of a greater diversity of plants and a better preservation. The identification of  
16 plants is most often more precise (i.e. to a higher taxonomic level) than that of charred remains.
- 17 2. the quantity of seeds of a plant in an archaeological deposit may be overrepresented if it belongs  
18 to a taxon that produces many seeds.
- 19 3. in heterogeneous assemblages, one cannot know if the plants recovered in the deposit have  
20 actually grown together.
- 21 4. the filter of human activities, such as the influence of agricultural practices on weed  
22 communities, should not be overlooked.

23  
24 Two branches of modern ecology – autoecology and phytosociology – are mainly used to interpret  
25 the results of seed analyses and to try to reconstruct past environments. Autoecology studies the  
26 requirements of each species in the light of key ecological factors: climate, light, soil and water  
27 conditions. However, many species have wide ecological ranges and are not characteristic of a  
28 particular habitat. Phytosociology describes and classifies plant communities by analyzing the  
29 relations that unite plants and their habitats. A group of plants is much more typical of a specific  
30 habitat than an isolated species. The methods of autoecology and phytosociology offer many  
31 opportunities for archaeobotanists to reconstruct past agricultural conditions. Knowledge of modern  
32 communities of weeds can serve as models, particularly those observed in non-mechanized  
33 agricultural systems. Indeed, weed communities depend mainly on farming techniques.  
34 Archaeological weeds, therefore, directly inform on past husbandry practices. For an archaeological  
35 period, and a given region, it is best to first identify the weed communities based on a primary  
36 deposit (e.g. a burned granary) so as to allow the establishment of direct links between crops and  
37 weeds. The reconstructed communities will then inform on the nature of the growing environment  
38 and methods of cultivation: nature and richness of soil, water conditions, the sowing seasons, and so  
39 on.

## 40 41 **4.5. Phytolith Analysis**

### 42 43 **Definition**

44  
45 Phytoliths (from the Greek phuton "plant" and lithos "stone") are microscopic particles of silica that  
46 form both in and around plant cells (Figure 12). Due to its mineral composition, they are well  
47 preserved in soil/sediment even after the complete decomposition of the organic components of the  
48 plant. Although a type of phytolith can rarely be linked to a specific plant species, their morphology  
49 is characteristic of major plant groups (such as grasses, palms, or conifers) and can, in some cases,  
50 be identified to genus. The shape of phytoliths depends on the cells in which they are deposited.

1 The analysis of phytoliths can provide insights into the nature of past vegetation formations (e.g.  
2 grassland, temperate or tropical forest) and on the climatic conditions of the past. In the process of  
3 photosynthesis not all plants fix carbon in the same way. The three photosynthetic pathways are C3,  
4 C4 and crassulacean acid metabolism (CAM), of which the first two are the most common. C3  
5 plants (so named as the initial product of photosynthesis is a 3-carbon molecule) are dominant in  
6 temperate regions and at higher altitude while C4 plants (producing a 4-carbon molecule) are  
7 characteristic of tropical, hot and humid, and arid regions. Studies of plant phytoliths can therefore  
8 provide information on major climatic fluctuations. Furthermore, given that phytoliths vary  
9 according to the location of formation (leaf, stem, etc), the abundance of some forms at a specific  
10 location may represent specific activities requiring different parts of the plant (seeds, straw, chaff),  
11 for example animal penning, threshing or storage of crops. Thus, the phytoliths, brought  
12 intentionally by humans onto archaeological sites can inform on farming practices, livestock, and  
13 fireplace location, in the absence of, or in addition to, charred macro-remains.

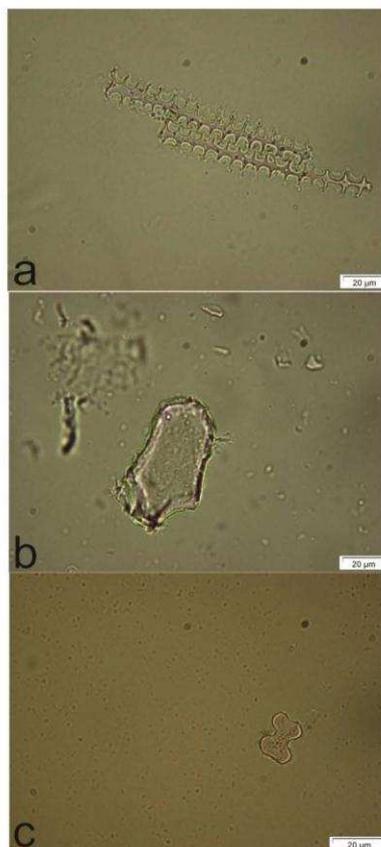
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### 15 **Short History**

16

17 The first classification of phytoliths was by Darwin who became intrigued by the abrasive dust that  
18 damaged his ship, the Beagle, during a mission off the coast of Cape Verde. He sent samples to  
19 Erhenberg, a German doctor, who was passionate about microscopy. In the 19<sup>th</sup> century therefore,  
20 phytoliths were identified, named and their vegetal origin known. They were recognized as  
21 palaeoecological markers. In the mid-20<sup>th</sup> century the study of phytoliths was further developed by  
22 American and British researchers, and in the 1980s the study of phytoliths was applied to  
23 archaeological sediments.

24



25

26

27 Figure 12. Archaeological phytoliths. a: dendritic type (cf. *Hordeum*); chaff. b: bulliform  
28 (*Phragmite*), leaf; c: bilobate (*Dichanthium*, *Panicoideae*), leaf. © E.Messenger.

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## **Excavation and Recovery**

Phytoliths are studied from both natural and archaeological contexts. In archaeological research, one gram of sediment is enough to conduct an analysis of phytoliths. In the laboratory, they are extracted from the sediment through a series of physico-chemical treatments. The residue is mounted on microscope slides. Identification is then carried out using a light microscope (X 200 to 600) and on the basis of their morphology with the help of a modern reference collection. The results are presented in terms of relative abundance.

## **From Quantification to Environmental Reconstruction**

Contrary to pollen, seeds or charcoal, phytoliths are not the fossil of a single type of tissue, organ or even cell. This presents a major obstacle to the interpretation of phytolith spectra in terms of both:

1. multiplicity, with each plant capable of producing several different types of phytoliths
2. and redundancy, as the same morphotype may be produced by several different taxa

Despite the issue of redundancy, the main morphotypes may nevertheless be linked to major vegetation groups. Multiplicity meanwhile has the advantage of allowing determination of the organ that has produced the phytoliths. This has important applications in archaeology with the possibility of differentiating between the leaf, culm and chaff of cereals for example.

## **4.6. Conclusion**

The sub-disciplines of archaeobotany are at the interface between biology and archaeology, and have complementary approaches to understanding environmental dynamics. The majority of the sub-disciplines recover their proxies from archaeological sediments which introduce important human filters into interpretations. Indeed, seeds, charcoal, pollen or phytoliths are brought by humans onto the sites. Thus, to interpret archaeobotanical results, researchers must consider climatic and human factors. The scale of analysis is also variable, both geographically and chronologically. For example, an assemblage of seeds from a burnt granary provides information on a harvest event, while a core sub-sampled for palynology can preserve several thousand years of vegetation change from a broader geographic scale. Archaeobotany is a discipline at the heart of the discussion on the co-evolution of society and past environments and has an important place in current debate on the destruction of ecosystems and biodiversity loss.

## **5. Integration and Scale of Studies**

Integration of the different fields of environmental archaeology discussed above can return detailed and important understanding of past human ecology. It is through such interdisciplinary studies that the application of environmental archaeology is at its strongest. As is clear from the accounts above, the interaction of humans and their environments occurs over different areas and time scales, both of which are continuous variables but which can be grouped into broad categories (e.g. Table 2).

We can illustrate the different ways in which environmental archaeology is studied and integrated at differing time and spatial scales via a few brief case studies. The following examples focus on the origins, spread and practices of Neolithic economies – ones which exploited domestic plants and animals – a process also known as Neolithization.

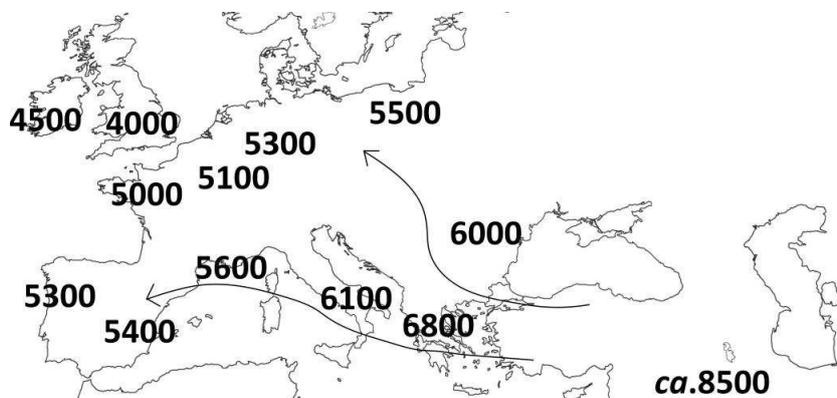
1 Table 2. Spatial scales of human-environment interactions, after Branch et al. (2005) and Dincauze  
 2 (2000).  
 3

Spatial units	Area (km <sup>2</sup> )
Site, Activity area (e.g. house)	<1
Locality	1 – 10 <sup>2</sup>
Site catchment (sub-region)	10 <sup>2</sup> – 10 <sup>4</sup>
Region; Major physiographic unit	10 <sup>4</sup> – 10 <sup>7</sup>
Hemispheres; Continents	<10 <sup>8</sup>
Earth	5.1 x 10 <sup>8</sup>

4  
 5 **Case-Studies: Environmental Archaeologies of Neolithization**  
 6

7 The origins and spread of Neolithic economies was a pivotal change in past human ecology,  
 8 whereby human subsistence shifted from reliance upon hunted and collected wild resources to the  
 9 control and exploitation of domestic plants and animals. These processes were played out at greatly  
 10 differing temporal and spatial scales, from the life-cycle of a single organism of a population, in one  
 11 location, on the path to domestication, to the dissemination of the ‘new’ farming economies around  
 12 the world, and modification of environments.  
 13

14 The early domestication of some of our now common domestic plants (e.g. the cereals einkorn  
 15 wheat and barley) and animals (sheep, goat, pig and cattle), occurred in (possibly) multiple centers  
 16 of the ‘Fertile Crescent’ in the Near East and probably developed as a gradual process over  
 17 millennia. The dissemination of these Neolithic economies beyond this core area into Europe has  
 18 been plotted by environmental archaeological studies.  
 19  
 20



21 Figure 13. Environmental archaeology at the continental scale – the main flows of domesticate  
 22 diffusion during the Neolithization of Europe (after work by A. Tresset and J.D.Vigne), showing  
 23 dates in calibrated years BC.  
 24  
 25

26 The analysis of plant and animal remains from dated sites across the Near East and Europe has  
 27 allowed the collation and comparison of data across large areas, for example as undertaken by A.  
 28 Tresset and J.-D. Vigne (Figure 13). In this way, via the identification and dating of archaeological  
 29 plant and animal bone assemblages from across Europe, the chronology and tempo of the spread of  
 30 the Neolithic can be understood (Figure 13). The evidence points to the dissemination of these  
 31 domesticates via two main routes, the Mediterranean and northwards through Central Europe,  
 32 starting in south-east Europe in the 7th millennium BC, and reaching the opposite, north-west,  
 33 corner of Europe by the 4th millennium BC. Certain species which spread as part of the  
 34 Neolithization process were not previously native to Europe during the Holocene, including both

1 animals (sheep and goats) and some plants (e.g. emmer and einkorn wheat). They had no wild  
2 predecessors in Europe, so must have been introduced from the Near East. Wild cattle and pig were  
3 present in Europe before the arrival of Neolithic economies, but analyses of ancient DNA (aDNA)  
4 have shown that these native populations were not a major part of the initial wave of Neolithization.

5  
6 Studies of climatic changes across this time period are providing an important context for the  
7 rhythm and fluidity of the dissemination of Neolithic lifeways, as discussed by J.F. Berger and J.  
8 Guilane. A climatic crisis at 6200 cal BC (the ‘8.2ky BP event’) is seen as both influencing human  
9 ecology and also potentially having an effect on the visible archaeological record from this period  
10 (particularly in the western Mediterranean) with erosion and/or sediment masking archaeological  
11 layers. This is being established through detailed geoarchaeological studies.

12  
13 At the smaller end of the analytical scale (Table 2), environmental archaeology can reveal detailed  
14 insights into the practices and immediately local environments of Neolithic communities. This can  
15 be greatly helped by good preservation conditions, as at the Neolithic lake settlement of Weier,  
16 Switzerland studied by B. O. Nielsen and colleagues. At this site, entomological and  
17 archaeobotanical evidence document the remains of a probable animal byre (stable), dating to  
18 c.3600 cal. BC. The byre deposits consisted of several compressed layers of manure, twigs and leaf  
19 fragments separated by three wooden floors. In the arthropod assemblage, dipterans, mites and  
20 beetles predominated. Lesser dung flies (Sphaeroceridae) were the predominant dipteran. Further,  
21 dipterans were represented by remains of puparia and larvae, indicating that flies were actually  
22 breeding within the deposits of the building. The presence of ruminant dung was indicated by the  
23 presence of eggs of the liver fluke (*Fasciola hepatica*) an **endoparasite** of ruminants. Cattle were  
24 the most common taxon in the animal bone assemblage at the settlement, and the presence of cattle  
25 in the byre is further indicated by the presence of the biting louse (*Damalina bovis*). In modern  
26 animal husbandry, this **ectoparasite** is more common during the winter months providing seasonal  
27 evidence for the use of the byre, also supported by indications of winter leaf foddering in the  
28 macroscopic plant remains. Associated with the archaeological and archaeobotanical evidence for  
29 plant debris and dung in the byre, the presence of decomposing organic matter is also suggested by  
30 the arthropod taxa present. However, the absence of insects associated with drier decomposing  
31 matter suggests that the byre was cleaned-out periodically for manuring of fields recorded at the  
32 site, indicating the symbiosis between animal husbandry and plant cultivation.

33  
34 Consideration of the different scales of Neolithization – how these economies disseminated,  
35 functioned and were preserved in the archaeological record – reveals examples of the physical,  
36 biological and socio-economic aspects of the human-environment interactions.

## 37 38 **6. Conclusions and Perspectives**

39  
40 Environmental archaeology comprises a range of overlapping and interconnecting sub-disciplines  
41 that, applied together, can illuminate with clarity past human ecology. As discussed above, its aims  
42 are to explore how humans lived in their physical, biological and socio-economic environment, and  
43 can be applied on a range of scales, from the context or individual to that of a global perspective.  
44 Understanding the formation of sites, the various assemblages of finds identified for study, and the  
45 interactions between geological and biological materials within these sites are essential.  
46 Archaeobotany and zooarchaeology are concerned, respectively, with the identification and  
47 interpretation of plant and animal remains – remains that are identified in the laboratory with  
48 reference to modern flora and fauna, and interpreted within the structure of the knowledge on the  
49 site/s stratigraphy and formation. In contrast, geoarchaeology is in application predominantly a field  
50 discipline, engaged in the study of strata and landforms of the sites and landscapes occupied by past  
51 humans. Focusing primarily on the geoarchaeological, zooarchaeological and archaeobotanical

1 themes outlined here, the integration of environmental archaeological approaches with the other  
2 areas of archaeological research are returning rich and invaluable insights into the past.

3  
4 As biomolecular techniques (such as analyses of aDNA) develop in power, precision and reliability,  
5 so new vistas and further possibilities will open up for research, and add detail to the data that the  
6 sub-disciplines of environmental archaeology can offer.

## 7 8 **Acknowledgments**

9  
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11 reviewing part or all of the text. Thanks are also due to Jade Whitlam and Sarah Elliott for useful  
12 discussions and comments, Prof. Roger Matthews for Figure 4, and Roz Gillis for help with Figure  
13 13.

## 14 15 **Glossary**

16  
17 **Aeropalynology:** analyzes the presence in air of different types of pollens. It has applications in medicine (allergy) and  
18 agriculture (pollination).

19 **Ectoparasite:** an organism that lives on the outside of its host rather than within the host's body.

20 **Endoparasite:** an organism that lives within another (host) organism.

21 **Eurytopic:** an organism that is able to tolerate a wide range of habitats.

22 **Flotation:** sieving process, based on density difference, to separate the macroremains of their sediment matrix using an  
23 upward flow of water; may or may not use a machine to perform this operation.

24 **Malacology:** the science dealing with the study of mollusks.

25 **Melissopalynology:** the study of the pollens contained in honey.

26 **MNI:** the minimum number of individual animals necessary to account for the set of identified remains.

27 **NISP:** the number of identified specimens per taxon.

28 **Palafittes dwellings:** houses raised on piles over the surface of the soil or a body of water.

29 **Radiocarbon dating:** analysis determining the age of organic matter (e.g. bone or wood), which measures the decay of  
30 the radioactive isotope of carbon ( $^{14}\text{C}$ ).

31 **Reflection microscopy:** has a light source illuminating from above the observed object; the light is reflected by the  
32 opaque object.

33 **Spermatophyta:** comprises the plants that produce seeds.

34 **Stenotopic:** an organism that is able to tolerate only a restricted range of habitats.

35 **Taphonomy:** the study of the transition of organics from the biosphere into the lithosphere (i.e. the processes that affect  
36 organic remains after death, including the process of fossilization)

37 **Taxon:** is any unit of classification of living things (species, genus, family, etc.).

38 **Taxa:** plural of taxon.

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27 geoarchaeology.]

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## 29 **Biographical Sketches**

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31 **Robin Bendrey** is a Post-doctoral Research Associate at the University of Reading on the Central Zagros  
32 Archaeological Project, a project investigating the origins of animal husbandry in the eastern Fertile Crescent. His work  
33 focuses on the origins and development of animal husbandry and use. He has worked in collaboration with a range of  
34 international partners on projects in countries from Europe, Northern and Central Asia and the Near East. His previous  
35 research has largely focused on the archaeology of the horse in prehistoric Eurasia. Following a PhD examining the  
36 archaeology of the horse in prehistoric Britain, he spent several years working in France for the Muséum national  
37 d'Histoire naturelle, Paris and the Centre National de la Recherche Scientifique (CNRS). He spent two years as a CNRS  
38 postdoctoral researcher investigating human-horse relationships in the nomadic societies of later prehistoric Central  
39 Asia via stable and radiogenic isotope analyses of horse tooth enamel, and one year researching the archaeozoology of  
40 the European Linearbandkeramik Culture for the ANR funded project OBRESOC. Robin also has over ten years  
41 experience as a freelance zooarchaeologist working on a range of sites across southern Britain.

42

43 **Aurélie Salavert** is assistant professor at the Muséum National d'Histoire Naturelle in Paris. Her previous research  
44 focused on the food supply and vegetal economy of protohistoric South-Levant and Egypt. She completed her PhD  
45 (2010) at the University of Paris 1-Panthéon Sorbonne. This research focused on farming practices and plant circulation  
46 as well as palaeoenvironments and forestry management of the first agro-pastoral groups of Belgium (5200-5000 BC).  
47 After some time at the Muséum national d'Histoire naturelle, researching the archaeobotany of the European  
48 Linearbandkeramik Culture for the ANR funded project OBRESOC, she worked at the Department of Palaeontology of  
49 the Royal Belgian Institute of Natural Sciences in Brussels where she mainly analyzed charcoal from archaeological  
50 sites of the Walloon region. She is now interested in the populating process and vegetation dynamics during the late  
51 Mesolithic and Neolithic periods which correspond to the transition between hunter-gatherers and farmer-herders, as  
52 well as the first agroforestry systems of temperate Europe. She is currently working on field projects in north-western  
53 Europe and the Crimean Peninsula. She is also teaching archaeobotany and environmental archaeology to Masters  
54 students at the Muséum National d'Histoire Naturelle in Paris.

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1 **Keith Wilkinson** has been a Lecturer, then Senior Lecturer and is now Reader in Environmental Archaeology in the  
2 Department of Archaeology at the University of Winchester (and its forebears) since 1997. Before that he was in charge  
3 of environmental archaeology at Cotswold Archaeology. He obtained an undergraduate degree (1989) from the Institute  
4 of Archaeology, University College London, and went on to complete a PhD (1993) at the same institution entitled *The*  
5 *influence of local factors on palaeoenvironment and land-use: evidence from dry valley fills in the South Downs*. At the  
6 University of Winchester he teaches on BA, BSc, MA and MRes programmes in archaeology, as well as supervising  
7 research students and directing the Department's consultancy [ARCA](#). Keith Wilkinson has co-authored a text book on  
8 environmental archaeology (see bibliography) and has carried out geoarchaeological research projects in Armenia,  
9 Belgium, Bulgaria, Corsica, Georgia, Greece, the Netherlands, Russia, Spain and Syria, as well as the UK.  
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