ENVIRONMENTAL ARCHAEOLOGY

Robin Bendrey
Department of Archaeology, University of Reading, Reading, UK

Aurélie Salavert
UMR7209 (CNRS, MNHN): Archéozoologie, Archéobotanique, Muséum National d'Histoire Naturelle, Paris, France.

Keith Wilkinson
Department of Archaeology, University of Winchester, Winchester, UK

Keywords: archaeobotany, archaeology, environment, ecology, economy, geoarchaeology, zooarchaeology.

Contents

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

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

Environmental archaeology encompasses a range of overlapping and interconnected sub-disciplines. Those covered below are geoarchaeology (the study of soils, sediments and geomorphological features), zooarchaeology (the study of animal remains), and archaeobotany (the study of plant remains).

The study of human remains is not covered; while this is sometimes considered within the remit of environmental archaeology, it is to a large extent a discipline of its own (and space does not allow discussion of it here). Other disciplines that will be touched on below are those of the rapidly expanding biomolecular fields of DNA research and stable isotope studies - again, disciplines in their own right, but increasingly offering insights into past human-animal, human-plant and plant-animal relationships.

2. Geoarchaeology

2.1. Introduction

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

While the word 'geoarchaeology' is a relatively recent term, geoarchaeological work (albeit not originally defined as such) has a much longer history. For example K Bryan and E Antevs (both geologists) studied the stratigraphy of the south-western United States in the 1930-1950s. In this era before the advent of radiocarbon dating they were able to provide relative ages of Cochise and Clovis period sites by correlating artifact-bearing strata with landforms and beds thought to have formed in particular climate episodes. Geoarchaeology (as opposed to archaeological geology) developed rather later in Europe than in North America, although arguably the first geoarchaeological text book was by the British soil scientist I Cornwall in 1958 (*Soils for the archaeologist*).

There are many examples of geoarchaeological studies in the 1960s, albeit primarily undertaken by geologists. A good example of the latter was H Wright's study of the context of Bronze Age activity in Messenia, Greece which was undertaken as part of a larger archaeological survey. In contrast to the situation before the 1970s and typified by the examples above, present day geoarchaeologists are predominantly archaeologists who have received training in the Earth sciences.

While the definition of geoarchaeology provided above would appear to be tight, there is some debate on exactly which Earth science approaches constitute geoarchaeology and which are other sub-disciplines of archaeology. For example G. Rapp and C. Hill in their text book *Geoarchaeology: the Earth-Science approach to archaeological interpretation*, include chapters/sections on geophysics, aerial photography and bioarchaeology. A. Brown in *Alluvial archaeology* does much the same. However, another key geoarchaeological text, *Geoarchaeology: a North American perspective* by M. Waters, has a much narrower focus and discusses only geomorphology, stratigraphy, sedimentology, pedology and depositional environments. This latter geologically orientated range of subjects is also considered to be geoarchaeology in K Butzer's landmark study, *Archaeology as human ecology*.

In part because bioarchaeology is discussed under zooarchaeology and archaeobotany below, while geophysics is considered elsewhere in this encyclopedia, the present text examines only those topics considered by Waters and Butzer to be the component parts of geoarchaeology.

2.2. Materials

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

'Strata' on archaeological sites (and those off site locations that provide indirect evidence of human activity) comprise sediments and soils. Sediments are the product of the weathering → transport → deposition cycle. Therefore grain size and structural properties of sediment beds (layers) are collectively dependent on the geological source, and the mechanism and energy of transport. The mode of transport determines the depositional environment in which a sedimentary bed forms, for example running water leads to the formation of alluvial sediments, wind leads to the accretion of aeolian sediments, tidal processes to intertidal sediments and people to archaeosediments. Changes of source material and/or transport conditions will result in a sediment bed with different properties to the original forming.

A succession of such beds is called a sequence. A geoarchaeologist is able to 'read' the properties of the sediments in a sequence and the boundaries ('bounding planes' or 'contacts') between the different sedimentary beds to reconstruct changes both from one depositional environment to another (for example alluvial to aeolian), but also from one part of a depositional environment (sub-environment) to a second (for example a beach to dune in the case of a marine marginal depositional environment).

Soils develop within sediments and form a stable terrestrial surface downwards, thereby 'overprinting' existing strata with pedogenic (soil forming) features. As soils mature they develop as distinct and universally recognized horizons (soil layers) designated by a combination of capital and lower case letters. For example the Ah horizon is the humus-rich, biologically active surface zone, the Bt horizon is a largely mineral layer containing high concentrations of clay that have been washed down from the A horizon, while the C horizon is the so-called parent material, i.e. the unmodified sediment/rock in which the soil has developed.

Soils mature at different rates and in varying ways depending upon the climate prevailing during their development, properties of the parent material and vegetation. However, given that the properties of soil horizons and their component parts are determined by these external factors, geoarchaeologists are able to interpret soil properties in terms of past environments and relative age. Often, however, it is palaeosols (i.e. fossil soils that have been isolated from present day soil-forming regimes) rather than those presently forming that provide the most useful geoarchaeological evidence. Palaeosols can be buried beneath sediments (Figure 1), are relict (i.e. present at the surface, but isolated from soil forming processes), re-exposed at the surface, or fused (i.e. joined with a presently forming soil) and can be interpreted in exactly the same way as present day surface soils.

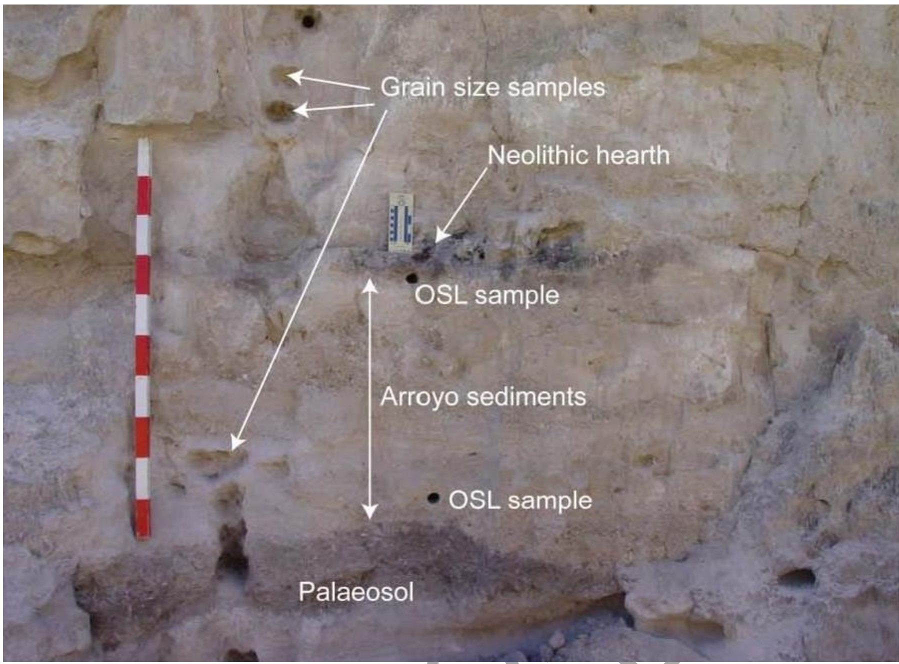

Figure 1. An arroyo/gully infill sequence containing a Neolithic hearth and sealing a palaeosol from Zaragoza province, northern Spain.

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

2.3. Approaches

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

Regional

Regional scale geoarchaeology examines the development of landscapes at scales of a few square kilometers and more. Such studies are often termed 'off site' given that archaeological sites are not the main focus and are frequently component parts of regional archaeological survey. The main purpose of regional geoarchaeological studies is often to reconstruct the palaeolandscape (topography, depositional environment etc.) for a given chronological period (e.g. as part of an archaeological survey of the area), to determine the effect of human impact on landscape change (e.g. as a result of deforestation, agriculture or industrial activities) and to develop predictive models suggesting where archaeological sites of different periods and types might be found. Typical methods used in such investigations include:

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

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

3. **Field examination of exposures.** A geomorphological survey will usually encounter vertical sections that have been cut through landforms as a result of natural processes such as channeling (e.g. by streams) and slippage (e.g. by coastal erosion or as a result of earthquakes), or by people (e.g. to construct roads, agricultural terraces etc.). The strata in such exposures are described and photographed, while they might also be sampled for the purposes of dating, laboratory-based geoarchaeological studies (see below) and the investigation of biostratigraphy (Figure 1). Descriptive data collected in the field frequently provide the most relevant information on the past landscape represented by a landform. Color (using a Munsell Soil Color Chart), grain size, and structural properties such as sorting (i.e. how broad a range of grain size classes are represented), bedding (thickness, orientation, upwards trends) and lamination are

all described using standard schemes for each stratigraphic layer. Deposits forming in different depositional (sub-) environments have been studied in the present landscape and frequently have unique combinations of the morphological and structural properties outlined above. Therefore uniformitarian principles are used to reconstruct the environments represented by strata exposed in section. Particularly diagnostic layers exposed in multiple sections can be used as a means of correlation and relative dating of landforms.

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

Macro

Macro-scale geoarchaeology is carried out on archaeological sites. As was noted above, the main objective of such studies is to reconstruct the processes that caused the formation of the site (site formation processes) and which have since affected the site following its abandonment (post-depositional processes). Understanding such processes also helps in the study of taphonomy, i.e. the extent to which artifactual and biological materials are preserved in the archaeological record.

In addition to determining site formation and post-depositional processes active on a site, macro-scale geoarchaeological studies are also concerned with correlating strata, both between excavation areas and with off-site stratigraphic sequences (e.g. as investigated by a regional survey). Correlations of this type help date the site stratigraphy (even if only in relative terms) and set it within a regional framework.

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

1. **Grain size measurement**. While it is possible to provide an approximate determination of the grain size in the field by eye (for particles >2mm, i.e. gravels), use of a hand lens (for particles 0.063-2mm, i.e. sands) and by 'finger texturing' for finer particles, such approaches are neither quantitative nor accurate. Grain size classes assigned in the field also lack detail (e.g. descriptions such as 'sandy silt' and 'medium-coarse sand' are usually assigned) and can only be used to attribute a stratum to a broad depositional sub-environment (e.g. 'floodplain', 'beach', 'dune'). Laboratory approaches to grain size analysis are varied, but typically comprise sieving a disaggregated and dry

sample through a nest of sieves at half phi (φ - a logarithmic scale in which the mesh in every second sieve halves in size [Table 1]) to determine the grain size distribution of sands. Approaches that rely on Stokes' Law (i.e. the speed at which spheres in a liquid settle from suspension depends upon their radius and density) are employed to measure silt and clay grain sizes. The <0.063mm fraction of a sample is therefore placed in suspension in a 1000ml cylinder and either aliquots are removed by pipette, dried and weighed; or hydrometer readings are taken at times corresponding to those at which particles of different sizes settle out of suspension. The grain size distribution of fine sands, silts and clays can also be measured by mechanical means and the most common of these is laser granulometry in which a laser beam is passed through a suspension containing the sample and the angle by which the beam is deflected is measured (the angle of diffraction increases with particle size).

2. **Magnetic susceptibility measurement**. The magnetic properties of a sample are dependent on the geological source from which particles in the sample are derived, whether and the degree to which particles have been heated and finally if soil formation has taken place. Magnetic susceptibility measurements can therefore provide an indication of sediment source, whether pedogenesis has occurred and evidence for certain human activities (e.g. burning, pottery discard etc). Mass specific magnetic susceptibility measurements are usually made on dried 10cl samples that have been passed through a 2mm sieve (i.e. on particles <2mm), while the samples are often continuous blocks of 10-20mm thickness removed from a vertical section, a cohesive sample (e.g. a monolith tin) taken from such a section, or a borehole core (Figure 3). Volume magnetic susceptibility readings can also be taken in the field using a probe sensor or on borehole cores using a core sensor.

3. **Organic carbon measurement.** Loss-on-ignition measurements are carried out in a muffle furnace on 1-30g samples in order to determine the organic carbon content of a soil or sediment. The loss in mass of a sample following exposure to temperatures of 450-850^{o}C is a result of combustion of organic material and its conversion to carbon dioxide. Some authors have argued that loss-on-ignition measurements over estimate organic carbon content as some minerals (e.g. carbonate) break down during high temperature firing. Therefore chemical means of organic carbon measurement are also sometimes used, for example measuring weight loss consequent on digestion of a sample with hydrogen peroxide. The organic content of a soil or sediment relates to the position of a sample in a soil profile (e.g. O and A horizons have high organic contents, most B horizons do not), depositional sub-environment (e.g. fills of oxbow lakes contain high quantities of organic material, those in active channels do not) and human activity (humans commonly produce/are associated with large quantities of organic material). As with mass specific magnetic susceptibility, samples for organic carbon measurement are usually taken as continuous blocks of soil/sediment of 10-20mm thickness.

4. **Micromorphology**. See under 'Micro' below.

5. **Geochemistry and mineralogy**. The mineralogical properties of a soil and sediment primarily reflect those of the geological source, although heating can also change mineral composition. While chemical properties also reflect the source of sediment/soil particles, they are more transient and are affected by natural post-depositional processes and human activity. Therefore mineralogical studies are usually undertaken to determine where a sediment unit originates from (in the same way that mineralogy is used in archaeometric studies to find clay sources corresponding to ceramics found on a site). Various methods are employed including heavy liquid separation of minerals in the silt size fraction for manual identification under an optical microscope and X-ray fluorescence (XRF) measurements made of clay-size particles.

Geochemical measurements are usually made on acid-digested samples and by using spectrometers (i.e. either using atomic absorption spectrometry [AAS] or inductively-coupled plasma mass spectrometry [ICPM-S]). However, geochemical measurements can also be made directly on individual particles using a microprobe when they are viewed under a scanning electron microscope (SEM). As with magnetic susceptibility and organic carbon measurements, geochemical studies are normally carried out on multiple sub-samples taken stratigraphically through a section. However obtained, geochemical measurements are employed to evaluate human activity during sediment deposition/soil growth, to examine post-depositional changes and to source a sediment.

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

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

Micro

Micro-scale geoarchaeology refers to the examination of single or small numbers of archaeological layers and is synonymous with micromorphology (often inaccurately termed 'soil micromorphology'). As with analyses carried out as part of macro-scale geoarchaeology, micromorphological studies are a response to hypotheses generated from an examination of site stratigraphy. Questions to be addressed by micromorphology are typically the same as those asked of macro-scale studies, although often more detail is expected of micro-scale studies. Thus the processes that caused the formation and subsequent modification of an archaeological layer – or a stratum that is suspected of recording evidence for human activity - are the primary concern of micromorphology. Micromorphological studies are often also carried out to confirm field interpretations of layers such as palaeosols, floors, hearths, processing surfaces etc.

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

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

Table 1. Wentworth (1922) grain size classes

-

-

-

Bibliography

Atkinson T.C., Briffa K.R., Coope G.R., Joachim M., Perry, D. (1986) Climatic calibration of coleopteran data. In *Handbook of Holocene Palaeoecology and Palaeohydrology*. ed. B. E. Berglund, pp. 851-858. John Wiley & Sons, New York. [Paper outlining the mutual climatic range (MCR) method used for reconstructing palaeoclimatic data from fossil insect assemblages]

Berger J.-F., Guilaine. J. (2009). The 8200 cal BP abrupt environmental change and the Neolithic transition: A Mediterranean perspective, *Quaternary International* 200, 31–49. [Environmental archaeologies of Neolithization case study.]

Bouchet F., Guidon N., Katharina D., Harter S., Ferreira L.F., Chaves S.M., Reinhard K., Araujo A. (2003). Parasite remains in archaeological sites, *Mem. Inst. Oswaldo Cruz* 98, 47–52. [Paper reviewing different techniques applied to the study of paleoparasitological remains.]

Bourquin-Mignot C., Brochier J.-E ., Chabal L., Crozat S., Fabre L., Guibal F., Marinval P., Richard H., Terral J.-F., Théry-Parisot I. (1999). *La Botanique*, 208 pp. Collection “Archéologiques”, Errance, Paris.

[Handbook wriiten by a range of specialists in archaeobotany who give definitions, methodologies, problems and case studies for each sub-discipline.]

Boyd W.E. (1990). Towards a conceptual framework for environmental archaeology: environmental archaeology as a key to past environments, *Circaea* 7, 63-79. [Article contributing to the debate on the concepts and definition of environmental archaeology.]

Branch N., Canti M., Clark P., Turney C. (2005). *Environmental archaeology: theoretical and practical approaches*, 240 pp. London; Hodder Arnold. [General textbook on environmental archaeological.]

Brown A.G. (1997). *Alluvial geoarchaeology: floodplain archaeology and environmental change*, 377 pp. Cambridge University Press, Cambridge. [Text book explaining the basis for and methodologies of geoarchaeology in riverine settings.]

Bullock P., Fedoroff N., Jongerius A., Stoops G., Tursina T., Babel, U. (1985) *Handbook for soil thin section description*, 152 pp. Waine Research Publications, Albrighton, Wolverhampton. [Text book providing the standard descriptive system used by micromorphologists.]

Butzer K D. (1982) *Archaeology as Human Ecology*, 380 pp. Cambridge University Press, Cambridge. [Text book outlining geoarchaeology as an Earth science method in archaeology.]

Campbell G., Moffett L., Straker V. (2011). *Environmental Archaeology: A guide to the Theory and Practice of Methods, from Sampling and Recovery to Post-Excavation* (second edition), 47 pp. English Heritage Publishing. [Concise review of environmental archaeological approaches and sampling strategies.]

Claasen C. (1998). *Shells*. Cambridge Manuals in Archaeology, 266 pp. Cambridge; Cambridge University Press. [Comprehensive guide to archaeomalacology.]

Courty M.A., Goldberg P., Macphail R.I. (1989). *Soils and Micromorphology in Archaeology*. Cambridge Manuals in Archaeology, 344 pp. Cambridge University Press, Cambridge. [Text book explaining the principles and practice of micromorphology.]

Dainton M. (1992). A quick semi-quantitative method for recording nematode gut parasite eggs from archaeological deposits, *Circaea* 9, 58-63. [Semi-quantitive method for recording parasite eggs.]

Davis S.J.M. (1987). *The Archaeology of Animals*, 224 pp. London, Batsford. [This book is an excellent introduction to zooarchaeology.]

Elias, S.A. 1994 *Quaternary insects and their environments*. Washington, DC: Smithsonian Institution Press. [Comprehensive study of insects and their environments.]

English Heritage (2007) Geoarchaeology: using Earth sciences to understand the archaeological record. http:// www.english-heritage.org.uk/ upload/ pdf/ Geoarchaeology-2007.pdf. [A brief explanation of geoarchaeology as conducted in cultural resource management projects.]

Goldberg P., Macphail, R.I. (2006). *Practical and Theoretical Geoarchaeology*, 455 pp. Blackwell Publishing, Oxford. [An explanation of the theories and models underpinning geoarchaeology, together with a number of case studies]

Jones M.K. (2005). Environmental archaeology. In Renfrew A.C., Bahn P.G. (eds.), *Archaeology: The key concepts*, pp. 79–84. London: Routledge. [Short chapter contributing to the debate on the concepts and definition of environmental archaeology.]

Lyman L. (1994). *Vertebrate Taphonomy*, 552 pp. Cambridge, Cambridge University Press. [One of the best general texts on taphonomy and also methods and pitfalls of quantifying vertebrate remains.]

Nielsen B.O., Mahler V., Rasmussen P. (2000). An arthropod assemblage and the ecological conditions in a byre at the Neolithic settlement of Weier, Switzerland, *Journal of Archaeological Science* 27, 209–18. [Environmental archaeologies of Neolithization case study.]

O'Connor T.P. (1998). Environmental Archaeology: a Matter of Definition, *Environmental Archaeology* 2, 1-6. [Article contributing to the debate on the concepts and definition of environmental archaeology.]

Pearsall D. (2000). *Palaeoethnobotany: A handbook of Procedures*, 700 pp. Second Edition, Academic Press, San Diego. [Recommended for understanding the methodologies of archaeobotanical sub-disciplines, from excavation to interpretation.]

Rapp G. J., Hill C.H. (2006). *Geoarchaeology: the Earth-Science approach to archaeological interpretation*, 274 pp. Second Edition. Yale University Press, New Haven. [A text book of geoarchaeology that explains methodologies and provides some case studies.]

Reinhard K.J. (1992). Parasitology as an interpretative tool in archaeology, *American Antiquity* 57, 231-245. [Useful review of the history and applications of palaeoparasitology.]

Reitz E.J., Wing E.S. (1999). Zooarchaeology, 455 pp. Cambridge Manuals in Archaeology. Cambridge: Cambridge University Press. [This book is an excellent introduction to zooarchaeology.]

Thiébault S. (2010). *Archéologie environnementale de la France*, 180 pp. Collection “Archéologiques de la France”, La Découverte & INRAP, Paris. [A short book, accessible to the general public, giving an overview of the contribution of archaeobotany to the understanding of past human-plant relationships and their importance in the current debates on climatic change.]

Thomas, K.D. (1990). What's in a name? Anyone can be an environmental archaeologist, *Circaea* 7, 72-6. [Article contributing to the debate on the concepts and definition of environmental archaeology – response to Boyd (1990).]

Tresset A., Vigne J.-D. (2011). Last hunter-gatherers and first farmers of Europe, *Comptes Rendus Biologies* 334, 182–189. [Environmental archaeologies of Neolithization case study.]

Waters M.R. (1992) *Principles of geoarchaeology: a North-American perspective*, 398 pp. University of Arizona Press, Tucson. [Despite the geographic scope suggested by the title this geoarchaeological text book provides a detailed background to the sub-discipline that is universally applicable.]

Whitehouse N.J. 2007. Fossil insect remains in environmental investigations. In, Murphy E., Whitehouse N.J. (eds.). *Environmental Archaeology in Ireland*. Oxbow Books: Oxford, pp. 136-163. [Concise overview of the use of insects in environmental archaeology.]

Wilkinson K.N., Stevens C.J. (2003). *Environmental Archaeology: Approaches,Techniques & Applications*, 323 pp. Stroud: Tempus. [General introduction to environmental archaeological methods and applications; Chapter 3 on geoarchaeology.]

Biographical Sketches

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

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

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