From Concepts of the Past to Practical Strategies: The Teaching of Archaeological Field Techniques

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Chapter 13 ✦ Archaeological Science in Field Training

Dorian Q Fuller

Defining Archaeological Science

Archaeological science is the application of methods from various natural sciences to the study of archaeological materials and questions. Archaeological fieldwork increasingly incorporates scientific analyses of materials, such as animal bones, charcoal and sediments. All archaeologists need to understand, at least at a basic frontline level, how to make decisions about sampling during excavations.

The term 'archaeological science' may be divided further into different categories. Some archaeological science can be done after fieldwork, on material in museum or artefact collections, whereas other kinds of archaeological science require planning on the part of excavators and specific approaches to collecting samples while in the field (Table 1). Indeed, failure to collect certain kinds of samples results in much information being destroyed through excavation. It is these aspects of archaeological science which are at risk from destruction by ill-informed archaeologists, including those sub-disciplines often termed 'environmental archaeology,' which should be a component of training. The failure to collect samples for plant remains, microfauna or sedimentological samples can rarely be remedied after excavations. By contrast, archaeological sciences that look at the material composition of artefacts (such as ceramic petrography or metallurgical analyses) can normally be designed subsequent to excavations; and indeed such studies often utilise objects in museum stores.

As the importance of archaeological science in archaeology has evolved, so has the inclusion of archaeological science teaching as part of basic fieldwork training. This is especially true of archaeobotany and archaeozoology. It is possible to see the development of environmental specialist reports as having developed from the use of external consultants, to externally trained specialists producing report appendices, to archaeologists having received some specialist training, the latter often providing key evidence for archaeological research questions. The importance of archaeological science should be reflected in the way archaeologists are trained.

The teaching of archaeological science is necessary at both undergraduate and postgraduate levels. As answers to archaeological research questions increasingly call upon laboratory specialist studies, it is necessary for field archaeologists to have a basic understanding of archaeological science techniques, the potential contribution of results and their limitations. Of crucial importance is an understanding of how to collect samples so as to most effectively utilise sciences to answer archaeological questions. For these reasons some inclusion of introductory archaeological science should form a part of fieldwork. At the Institute of Archaeology, University College London (UCL), this normally includes on-site discussion of sampling for plant and animal remains and sediments to supplement classroom lectures. Students receive hands on training of basic sample processing techniques such as flotation and the sorting of wet-sieve heavy residues. The aim is to provide an understanding of the principles and processing involved in dry-sieving, wet-sieving, and flotation, their potential contributions and the nature of appropriate size of samples. Sampling for phytoliths and sediment analyses are also discussed. Some basic principles relating to different sampling are listed at the end of this chapter, and a more detailed discussion of flotation with reference to its impact in Chinese archaeology is presented by Zhao in Chapter 14. In an ideal world, every field project would have specialists on site, but this is not always practicable due to time demands on specialists, especially for time-consuming lab work. A generation ago western archaeological science specialists called for the need to include specialists on field projects (*eg* Shackley 1980), but we need more background training in scientific specialisms as a standard part of the repertoire of all excavators. The most time-effective and cost-effective way to include sampling in a field project is for excavators on the ground to take charge, that is to be able to make decisions about collection and initial processing of samples. This can then reduce the already lengthy, and costly, laboratory time for processing. (Table 1)

The Evolution of Archaeological Sciences

A history of archaeological science can be written as an evolutionary story passing through three phases (following Weber 2001; Fuller 2002).[1] The timing of the development of these phases differs between different regions.

The first phase is the origin of archaeological sciences and can be characterised as that of the occasional scientist-consultant. This involved the avocational pursuit of professional scientists who had other interests and concerns, and goes back to the beginnings of modern archaeology in the 19th and early 20th century. Finds that were not artefacts were sometimes noted and collected. Records were largely descriptive and consisted of lists, like a kind of 'stamp collecting,' and as such was equivalent to the typological 'antiquarianism' identified by historians of archaeology (*eg* Trigger 2006). Archaeologists tended to include analyses of plant or animal remains incidentally in research after excavations had finished. They found they had boxes of bones, a shoe box full of charcoal from an obvious charcoal layer, or a

Table 1 | Three Subdivisions of Archaeological Science and Their Relevance for Fieldwork Training

Rôle of archaeological sciences	Definition	Examples	Importance for Basic Training
Adjunct studies of archaeological finds, supplemental artefact studies	Application of chemistry/ materials sciences methods to examining artefact production and distributions.	Archaeometallurgy, ceramic petrology, Lithic petrographic analysis, chemical provenience studies	These provide a supplement to conventional artefact analysis and typology; normally can be sampled in post-excavation studies.
Study of organic 'non-artefact' finds categories ('Ecofacts')	Application of taxonomic and biogeographic knowledge from biological science to study of archaeological finds of plant/animal remains.	Archaeozoology, Archaeobotany	ESSENTIAL knowledge of sampling and analytical potential; without targeted sampling these finds that will normally be lost
Study of site deposits, for formation processes, including dating and stratification (archaeological or geological)	Application of geological techniques, or physical/ chemical analysis to archaeological deposits or inclusions therein.	'geoarchaeology', sedimentology, soil chemical analysis (phosphates, etc), soil micromorphology, radiometric data (C-14, etc.)	ESSENTIAL knowledge of sampling and basic interpretation, essential part of excavation planning, site interpretation and/or evidence destroyed via excavation

visible residue that could be scraped off a potsherd. Such materials were then handed over to someone whose main work was in a non-archaeological field. Thus the box of charred plant pieces would be sent to an agronomic institute or a botanist at a herbarium, or bones sent to a zoologist at the natural history museum. Examples abound, from the first archaeobotanical analysis of wooden pieces and charcoal from Wheeler's excavations at Harappa, that were sent to the chief wood anatomist at the Dehra Dun Forestry research institute (see Fuller 2002), to the plant remains from the Tomb of Tutankhamun that went to the Kew Gardens herbarium (see Hepper 1990), or the animal bones from Neolithic Hemudu that went to the Hangzhou Natural History Museum (see Zhejiang Provincial Institute 2003). At this stage remains were examined by botanists or palaeobotanists, zoologists or palaeontologists, whose research focus was on taxonomy, evolutionary history and the like, but not on cultural history, or social research. These experts provided taxonomic species lists, often with useful descriptions of the basis for identifications, but less often any quantitative analysis, or any serious consideration of how these remains related to archaeological contexts, to the spatial and temporal structuring of activities producing these remains across a site. The cultural practices that produced these assemblages were rarely considered. The lack of systematic sampling might call into question any such conclusions in any case.

It was in the context of these forays into archaeological materials that scientists became interested in archaeology, and came to increasingly specialise in archaeological science or to train students to do so. For example, Hans Helbaek, a self-trained archaeobotanical founder in Europe (*eg* Helbaek 1959), or Vishnu-Mittre, in Lucknow, India, a palaeobotanist working on Jurassic spores and pollen, who was asked to look at archaeological plant remains (*eg* Vishnu-Mittre 1961) and came to specialise in these, and to supervise PhD students in archaeobotany only (see Fuller 2002). Similarly, K A Chowdhury, who had been the senior wood anatomist at Dehra Dun, where Wheeler had sent his Harappan charcoal (Chowdhury and Ghosh 1951), in retirement returned to university teaching of botany where he trained two generations of archaeobotanists in India (Chowdhury *et al* 1977; see Fuller 2002). In England Geoffrey Dimbleby left the Forestry school in Oxford to pursue research on how humans had modified vegetation in the long-term, as Professor of Human Environment at the Institute of Archaeology (*eg* Dimbleby 1967). As well as founding archaeobotanists such as Helbaek and Dimbleby, this period saw the first publications defining the archaeological studies of sediments or animal remains (*eg* Cornwall 1956, 1958; Zeuner 1946, 1963).

The research questions that could be answered at this stage were limited. Lists of taxa were used to infer the presence of specific kinds of environment and lists of species were taken to represent food habits. While domestication was discussed (*eg* Helbaek 1959; Chowdhury 1969; Vishnu-Mittre 1970) clear methodologies for distinguishing wild from domesticated forms of plants remained poorly developed, and the evolutionary transition from one to the other was minimally theorised.

The second phase represents the professionalisation of the archaeological sciences, or a 'scientification' of archaeology. Increasingly, archaeologically focused scientists began to ask more complex questions of the data, to demand more archaeological information and more samples. In broad terms, this professionalisation correlated with the increasing interest amongst archaeologists in asking questions about cultural process, the so called 'New Archaeology'. As interest in drawing on scientific disciplines outside archaeology grew, so did interest in more complete sampling and analysis (*eg* Brothwell and Higgs 1969; see Trigger 2006: pp392-418). It is in this context that sieving and flotation entered archaeology. Although flotation of soil samples in laboratories had been carried out in the 1950s (see Pearsall 2000: pp19-20), the first flotation carried out in the field took place in the early 1960s with the Koster Site excavations in Illinois, directed by Stuart Struever (1968), one of the voices of the 'New Archaeology', and Hans Helbaek's (1969) involvement in the Deh Luran plain survey in Iran. By the early 1970s systematic collection methods were widely encouraged, including flotation for plants (*eg* French 1971; Jarman *et al* 1972; Williams 1973; Stewart and Robertson 1973; Limp 1974; Keeley 1978) and sieving for animal bones (*eg* Thomas 1969; Clason and Prummel 1971; Payne 1972; Cherry 1975).

During this period (*c*1960-1975) the first archaeological science specialists emerged. Although mainly natural scientists, they often came to be based in, or closely affiliated with, archaeology departments and institutes, where they increasingly had students of their own. Archaeologists were expected to float or to sieve material, and specialists were needed for field projects, to be involved in planning (*eg* Shackley 1980: ppvii-viii), not simply brought in to work on bits of material already collected. It was also during this period that the first discussions of phytoliths from the past were published, although these were still seen largely in terms of micro-fossil environmental indicators akin to pollen (*eg* Rovner 1971; Dimbleby 1977), or as archaeological indicators of plant presence as during the scientist-consultant phase (*eg* Watanabe 1968, 1971).

There were three important developments. First, with the new collection techniques, dataset sizes of bones and seeds increased greatly, requiring more laboratory time and dedicated specialists. New patterns emerged as new questions loomed. The larger datasets provided a basis for statistical analyses and the use of more quantitative measures of ecological groups, and metrical data that might track domestication. Indeed it was during this period that studies of plant and animal domestication become more widespread and systematic (*eg* Ucko and Dimbleby 1969; Brothwell and Brothwell 1969; Flannery 1973; Reed 1977). Second, these new professionals were in a position to train interdisciplinary students, who could gain background in both natural science and archaeology. After the adoption of flotation the number of archaeobotanists greatly increased (Watson 1997). Third, specialists increasingly demanded to be involved in excavation projects, from planning to execution. This improved sampling strategies and helped to assure data quality. However, as collection techniques of data samples have become well-known, even commonplace, there is now less need to have a trained laboratory specialist in the field doing sieving or flotation.

This third phase consisted of two linked developments. First, the various branches of the archaeological sciences began to be practiced by specialists who trained primarily as archaeologists but with a specialisation within archaeology. This was possible because the scientists outside archaeology had been associated with archaeological departments for some time. Second, an awareness of formation processes that underpin the preservation of their samples and structure interpretation had developed. In the wake of flotation and sieving, bones and plant remains, rather than being conceived only as the remains of past organisms, came to be seen as the products of past human activities, structured by those activities and the intervening transformations of the archaeological record.

The development of self-critical and archaeologically focused specialisations was part of a wider move in archaeology to be concerned about formation processes (Schiffer 1972; see Paddayya 1980; David and Kramer 2001: pp14-31). This is part of what Clarke (1973) characterised as the 'loss of innocence,' and constitutes the development of what Binford (1978) termed 'Middle-Range Theory' or Hodder (1982) called 'relational analogies,' that is relationships between variables observed in the present which can be used to infer processes in past behaviour, even in different cultural contexts. It developed through experimental and ethnographic studies of what people did which left behind potentially preservable traces. In archaeozoology, this is associated with studies of butchery and the impact of animal scavengers on bone assemblages (*eg* Brain 1969; Binford 1978, 1981). In archaeobotany, the main foci were on traditional crop-processing (*eg* Hillman 1973, 1981, 1984; Miller 1984; Jones 1987; Hastorf 1988), and the problem of seed sources, whether modern intrusive (normally uncharred) seeds in the soil or indeed ancient ones (Keepax 1977; Minnis 1981; Lopinot and Brussell 1982; Green 1985; Pearsall 1988). Charring experiments also looked at issues of size distortion and differential preservation (*eg* Stewart and Robertson 1971; Wilson 1984; Boardman and Jones 1990). Similar ethnographically informed frameworks for interpreting wood charcoal assemblages have also emerged (*eg* Hastorf and Johannessen 1991; Asouti and Austin 2005). These developments represent an increased awareness of the archaeological nature of the plant and animal remains that specialists study. It is now possible to classify samples of remains in relation to their archaeological context, and their likely information, into three parallel grades, as suggested for typical charred archaeobotanical evidence by Hubbard and Clapham (1992) and extended to faunal remains (Wilkinson and Stevens 2003: p168). (Table 2)

In this period, archaeological science practitioners came to address a wider range of research questions. While concerns with reconstructing past environments and domestication of plants and animals continued to be prominent, with improved methodological foundations it became possible to ask questions about past human activities and traditions that involved plants and animals. Archaeobotanists began to consider issues of crop husbandry, that is how agricultural activities were organised socially and technologically (*eg* M. Jones 1981, 1985, 1988; Hillman 1981, 1984; Pearsall 1983; Stevens 2003) and how social differences within society may have impacted the access to particular foods (*eg* Hastorf 1991, 1993; Hastorf and Johannessen 1991, 1993; Welch and Scarry 1995). Archaeozoologists have come to look at the distribution of different animal body parts of varying utility (*eg* Binford 1978; Metcalfe and Jones 1988; Marshall and Pilgram 1991), and social patterning across sites and between sites (*eg* Schulz and Gust 1983; Maltby 1985; Luff 1994; Welch and Scarry 1995). Phytoliths also became important, indicating not just the presence of crops but patterns in the use of plants and plant-related activities (*eg* Rosen 1999; Pearsall 2000: pp392-399, pp468-491; Madella 2003; Harvey and Fuller 2005; Piperno 2006). There are now increasing efforts to integrate plant and animal remains with other lines of archaeological evidence, such as attempting to get at culinary practices through correlating patterns in plant processing with ceramic evidence for cooking techniques (*eg* Fuller 2005), or with other processing tools and features (*eg* Wright 2000).

The actual timing of the development of archaeological science has varied in different regional contexts. Flotation began in the Near East and North America in the 1960s, and in Europe and the Americas in the 1970s and early 1980s. In Southeast Asia and India the very first flotation was in the later 1970s, and still only occasionally practiced by a few people through the 1980s, with the result that datasets that could support analyses of formation processes such as crop-processing only became available at the end of the 1980s and into the 1990s (see Fuller 2002:

Table 2. Archaeobotanical and Archaeozoological Deposition Classes
(Based on Hubbard and Clapham 1992; Wilkinson and Stevens 2003; Fuller and Weber 2005; these are correlated with refuse classes of Schiffer 1972).

	Plants	Animals (vertebrates)
Class A. Direct relationship between context, content of assemblage and human activities. Truly *in situ* activity deposits; *de facto* refuse.	Burnt where recovered, such as accidentally burnt stores and fuel recovered in firing features.	Whole or parts of animals deliberately placed in deposits where found. Articulated, without signs of weathering, fragmentation or butchery.
Class B. Well-defined contexts that represent primary deposition with minimal mixing of activities. Primary refuse, but context where recovered does not relate directly the activities that formed or preserved assemblage.	Plant material charred in a single event but redeposited, including the dumped hearth contents, with mixed fuel waste remains of numerous cooking events.	Deposits of a single activity or continuously built up through repetition. Bones may have been butchered and cached in a recurrent way
Class C. Heterogeneous samples in which processes of deposition, destruction and mixing are unclear, with averaging through time between different activities. 'Background noise' of routine activities. Little relationship between excavated context and activities that led to accumulation of material.	Heterogeneous samples in which processes of deposition, destruction and mixing are unclear: material has been charred elsewhere, possibly in more than one place and more than one event and has been redeposited and mixed into archaeological 'fill'. *Most common form of plant remains, recovered through flotation.* (*cf* Stevens 2003; Fuller and Weber 2005)	Assemblages resulting from multiple activities spread out over space and time, including redeposition and mixing. Weathering, gnawing and element biases common. *Most common form of animal bones, recovered through sieving during excavation.*

pp257-264). In China flotation began to be employed even more recently (Zhao Zhijun 2001) and the application of the insights of crop-processing and issues of quantification and formation processes are just beginning (*eg* Jin *et al* 2005; Crawford *et al* 2005; Zhao Zhijun 2005; Fuller in press).

In some parts of the West, such as the UK, the maturation of archaeological sciences was accompanied initially by an "alienation of archaeological science, and with it environmental archaeology from the rest of archaeology" (Albarella 2000: p7). This has been attributed to shifts in archaeological theory (Albarella 2000; Wilkinson and Stevens 2003: p242; Milner and Fuller 2003), as the period in which professionalisation and 'archaeologisation' took place saw archaeologists in general favouring frameworks of functionalist cultural ecology and adaptationism, as exemplified by Higgs (1975) and Butzer (1982; and see Trigger 2006: pp392-418). As post-processual archaeologies moved towards interests in social power, symbolism and perception, less use was made of archaeozoology, archaeobotany or geoarchaeology within theoretical syntheses, during the same period that the datasets from these specialisations were on the increase. This rift was already apparent by the start of the 1980s (see Bailey and Sheridan 1981), but the importance of plant and animal remains, and geoarchaeology, to all archaeological projects regardless of theoretical orientations, has come to be recognised (*eg* Hodder 1999) and an increasing number of symbolic and social analyses of archaeological science data have appeared (*eg* Hastorf 1999; Austin 2000; Fairbairn 2000; Wilkinson and Stevens 2003; Evans 2003; Boivin 2004; Marciniak 2005; Barker 2006: pp405-410).

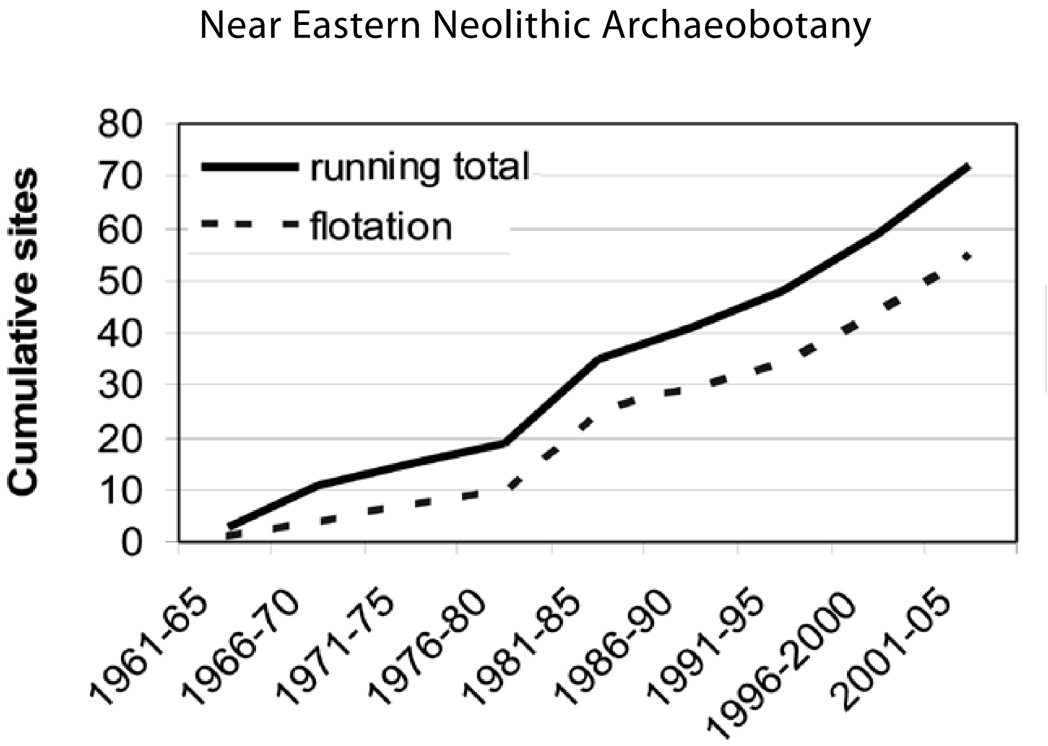
We are now at a stage where most specialists are archaeologists first, but also specialists. The specialism in plant remains, animal bones, or soil chemistry is just as archaeological as the traditional specialisation on pottery, bronzes, or the lithics of the Middle Palaeolithic. The questions asked of archaeological science data are fundamentally archaeological, about cultural history, although there remain important background issues that are not archaeological—such as taxonomic issues in certain plants or animals, or identification criteria.

The Demand for Archaeological Science: The Example of Archaeobotany

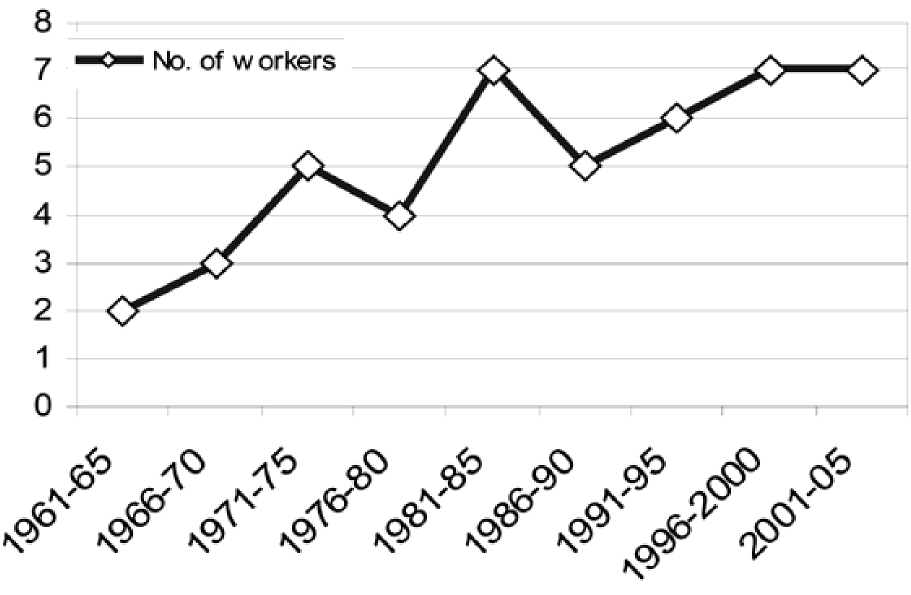
With the development of the archaeological sciences, the number of samples has increased, thus the demand for analyses has grown, with the result that there may be less time available for fieldwork.

Taking archaeobotany as an example, published archaeobotanical reports are now largely (and increasingly) derived from study of flotation samples, and the numbers of samples are also increasing. The largest numbers of active archaeological specialists, analyses and published reports are to be found in Europe (including Britain) and America, but the trend also exists in other world regions, such as the Near East, India and Africa. In the Near East, for example, the number of sites with archaeobotanical evidence has grown steadily (Figure 1A), although the number of researchers has not grown at the same rate (Figure 1B).

In India and Pakistan most of the increase in the past 20 years has been



1A. The cumulative growth of the archaeobotanical record for the Near East for Neolithic and late Epipalaeolithic sites, charted in terms of the cumulative number of published reports for five year intervals. The subset of those which included flotation are indicated. Counts are derived from a database compiled by Sue Colledge (*cf* Colledge ***et al*** 2004).



1B. An estimate of the number of archaeobotanists over the same periods. This is taken to be the number of primary archaeobotanical authors contributing publications during the period. Only one author is counted for each publication. Data sources as for Figure 1A.

through flotation and involved larger assemblage sizes (Figure 2A). Over the same period there has not been a commensurate increase in the number of specialists working on this material (Figure 2B). A similar situation exists in northern Africa (Figure 3A).

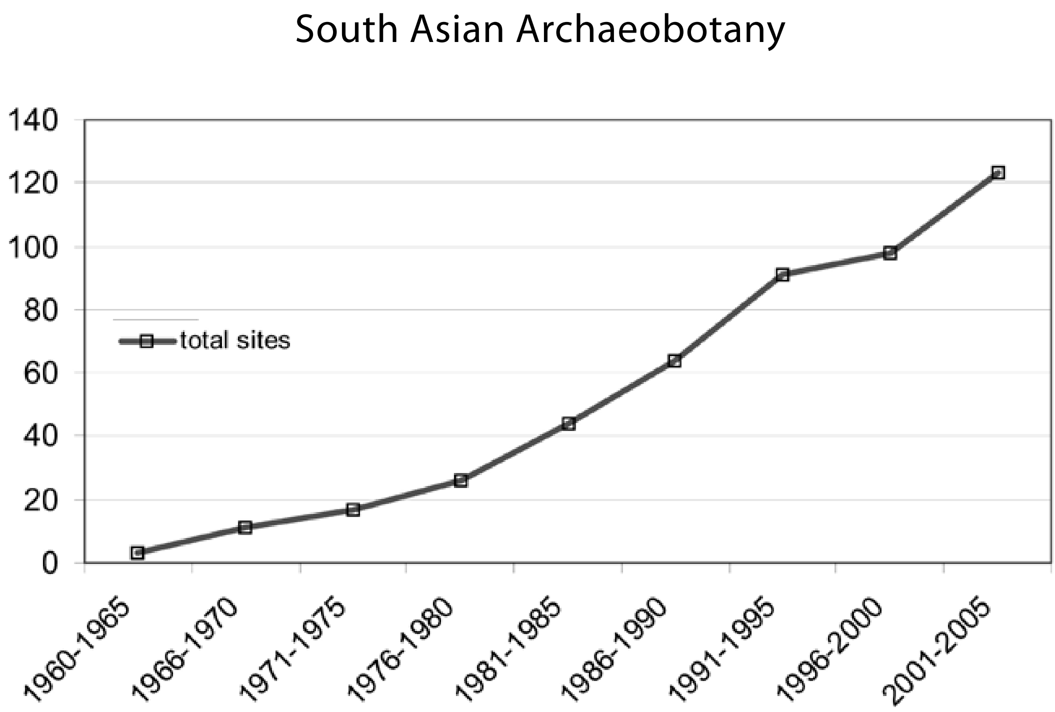
The data shows that in all these areas of the world archaeobotanical research is on the increase, whereas the number of laboratory researchers responsible for these publications is not increasing at the same rate. This suggests that field archaeologists should become increasingly self reliant in terms of basic field archaeological science, especially sampling, and be able to engage with research questions and interpretative issues arising from these specialist analyses. Therefore basic knowledge of field archaeological science should be a component of all field training.

What Archaeologists Should Know: Sampling for 'Environmental' Evidence

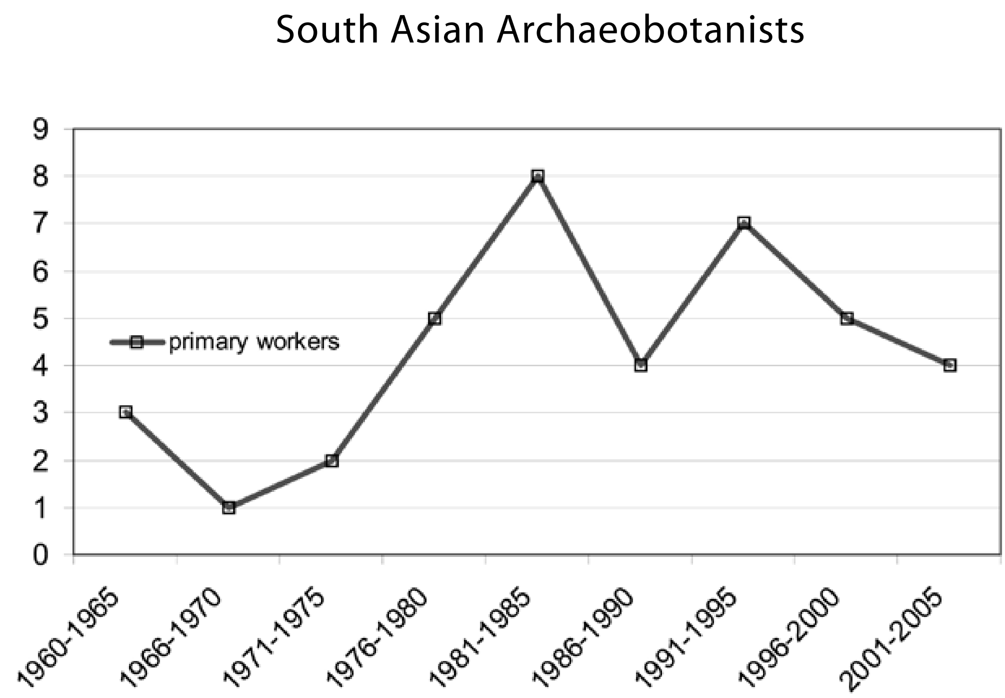
Archaeological science must be taught at an undergraduate level, including an introduction to the range of potential environmental datasets and basic concepts of formation processes and their relation to assemblage classes and context types (*eg* Table 2). Students also need to be given practical experience in different sampling collection procedures, with discussion of their potentials and limitations.

On-site samples represent sources of evidence that have been influenced by archaeological formation processes, including cultural factors and human selection, and therefore, although potentially highly biased, or even misleading, in terms of their relationship to natural vegetation or animal communities they are the best source of evidence for human activities involving plants, including food production, preparation, consumption or farming. By contrast, off-site samples represent the sources of evidence normally studied in quaternary palaeoecology. In such cases buried ancient soils, or better simply sequences of sedimentary build-up at the bottom of lakes or in peat bogs, are normally preferred, which are likely to have continuous sequences of patterns that relate to regional patterns in the landscape. Off-site sampling is often done through various methods of coring sediments, or it can be done from taking segments ('monoliths') through exposed stratigraphic sections.

The range of environmental datasets studied by specialists include sediment samples, plant micro-remains, plant macro-remains and animal bones. Geoarchaeological samples include bulk sediment samples and micromorphological blocks, the latter collected to preserve in place microstratigraphy (see Goldberg and Macphail 2006). Small bulk sediments are also needed from plant micro-remains, of which phytoliths are the most widely used. Phytoliths (plant silica) are a disarticulated, non-specific plant morphotype. They are non-specific in that most phytoliths represent small fragments of plant tissues rather than pieces of discrete whole organs in the way that seeds or pollen grains are. Numerous phytolith forms are produced in a given plant and species, and there is extensive sharing of forms between different species (especially amongst grasses). While occasional morphotypes are more taxonomically diagnostic, especially when still articulated into multi-cell groups, many phytoliths are more characteristic of plant



2A. The cumulative growth of the archaeobotanical record for India and Pakistan, sites of all periods, charted in terms of the cumulative number of published reports for five year intervals. This is based on an augmented dataset of Fuller (2002: Tables 1-3, and Fuller 2006: maps).

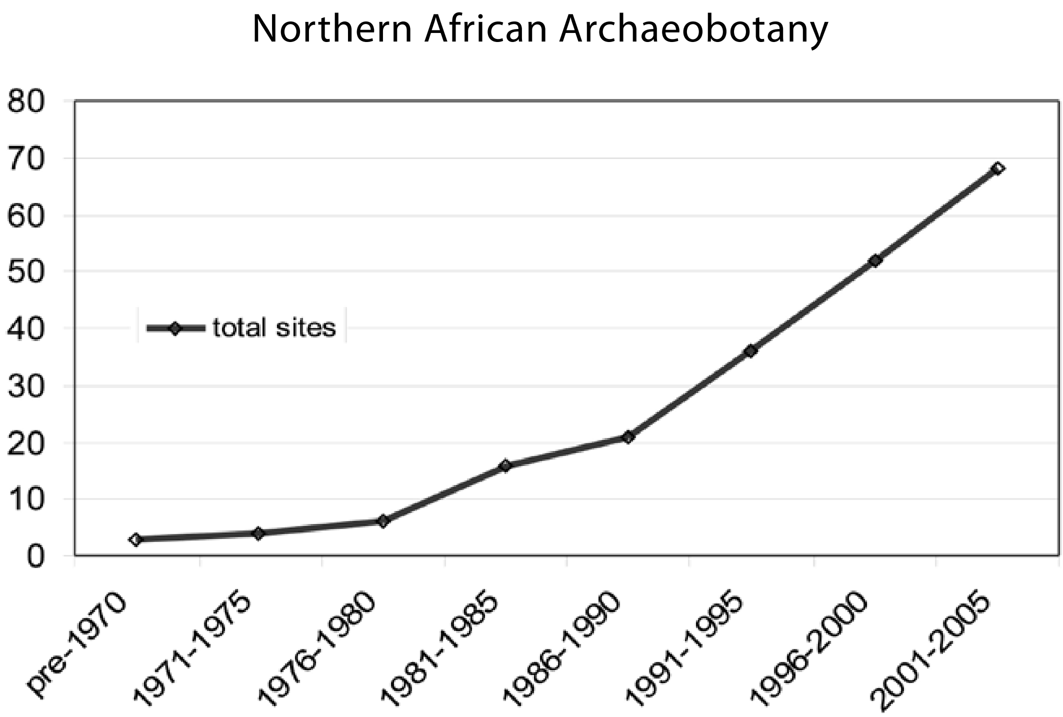


2B. An estimate of the number of archaeobotanists over the same periods. This is taken to be the number of primary archaeobotanical authors contributing publications during the period. Data sources as for Figure 2A.

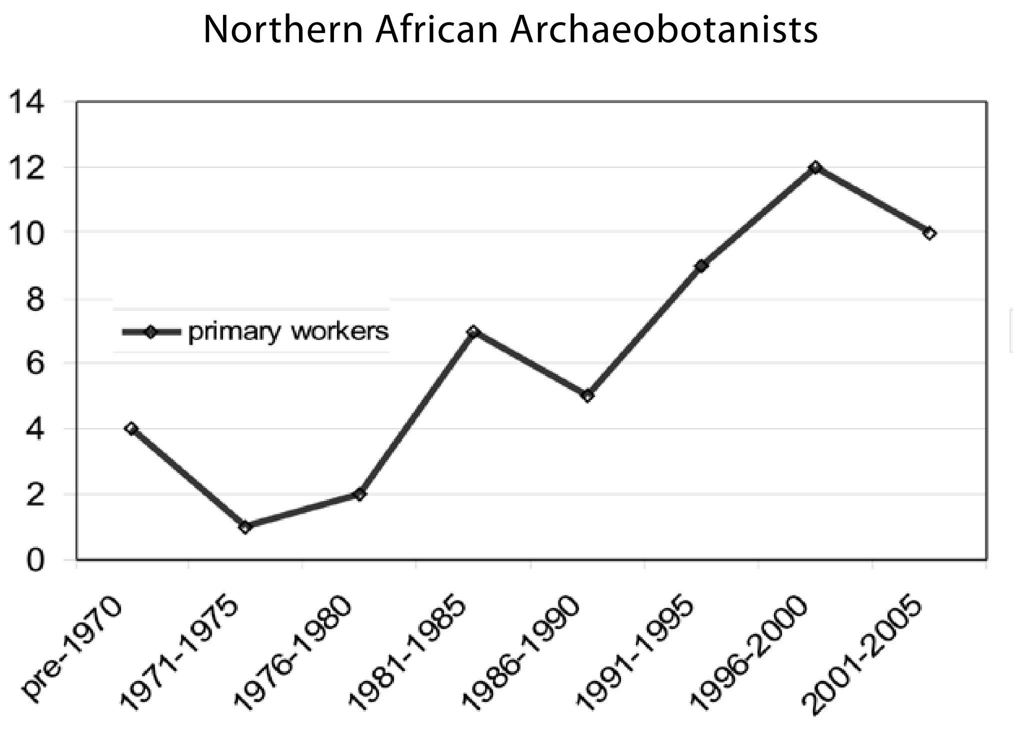
TABLE 3 | Archaeological Collection Methods for 'Ecofact' Remains

Collection *in situ* (**by hand**) of bones or plant-macro-remains	uncontrolled element through use of eye, based on experience of excavator
During excavation	biased towards larger pieces, spatially biased (haphazard). Biased against microfauna and most seed taxa.
From baulk	may be appropriate for rich sites (*eg* with desiccated remains)
Sieving (or screening)	Useful for most classes of artefacts and bones, will retain plant remains if mesh size goes down to 2mm, 1mm or less. Smaller mesh sizes will make processing slower. After sieving plant-remains will still need to be manually sorted from heavy artefacts and bone. Sieving may also damage fragile plant remains.
Dry screening	Useful procedure **for animal bones and desiccated plant remains**, if done gently. Shaking tends to fracture charcoal and large seeds. In dry, clayey soil types charcoal may be lost in unbroken clods.
Wet sieving	Preferred procedure **for water-logged plant remains, and most effective for bones, especially small bones (eg fish)**. Water pressure can pulverise dry or charred remains. Mesh sizes smaller than 1mm are difficult as fine sand clogs mesh.
Flotation	**Best option for charred plant remains.** Sometimes used for desiccated material. Not useful for waterlogged material. Flotation allows recovery of all size classes, while removing as much soil as possible, damage to remains is minimised. Mesh size usually down to 0.5 mm or 0.3mm, sometimes 0.2mm. Heavy residue from flotation can then be subjected to sieving (this is done simultaneously in most machine flotation)

part rather than plant species. It is this latter patterning that makes them useful for crop-processing studies (*eg* Harvey and Fuller 2005), and other investigations of spatial patterns in past plant use and deposition. On archaeological sites, samples for phytoliths and for various sedimentological analyses are collected and bagged from freshly exposed contexts or stratigraphic sections, bagged in bulk in relatively small quantities (on the order of 50-100 millilitres or 50 grams, which is enough to allow for replicate subsampling) and processed in a chemical laboratory (for details see Pearsall 2000; Piperno 2006). Sampling procedures are the same for pollen, and the same samples can potentially be used for phytoliths, pollen and sedimentological analyses (but sample sizes may need to be multiplied). Less usual types of discrete microfossils that see some use in archaeology, but more frequent use in palaeoecology, include various unicellular micro-organisms, generally of an algal source. These include diatoms, the most common of the micro-fossils, dinoflagellates and foramifera, all of which are typical of coastal sediments and ocean floor sediments. Diatoms also occur in fresh water and such places as rice paddy fields.



3A. The cumulative growth of the archaeobotanical record for Northern and Western Africa (excluding the Egyptian Nile valley), sites of all periods. This is charted in terms of the cumulative number of published reports for five year intervals. Counts are derived from a database compiled by Ruth Pelling (2007)



3B. This is taken to be the number of primary archaeobotanical authors contributing publications during the period. Data sources as for Figure 3A

Most central to archaeological projects, however, are samples taken for plant macro-remains and animals bones through a strategic programme of sieving and/or flotation. Various methods exist, and different methods have their advantages and disadvantages for recovering plant and animal remains (see Table 3).

Sieving separates things by size. Material smaller than the mesh, including clays, silts and usually sands pass through the screen (depending on sieve size). It can be done either dry (Figure 3A) or wet (Figure 3B). Wet screening is normally more effective as water helps to break down soil clods and clean objects to make them more visible.

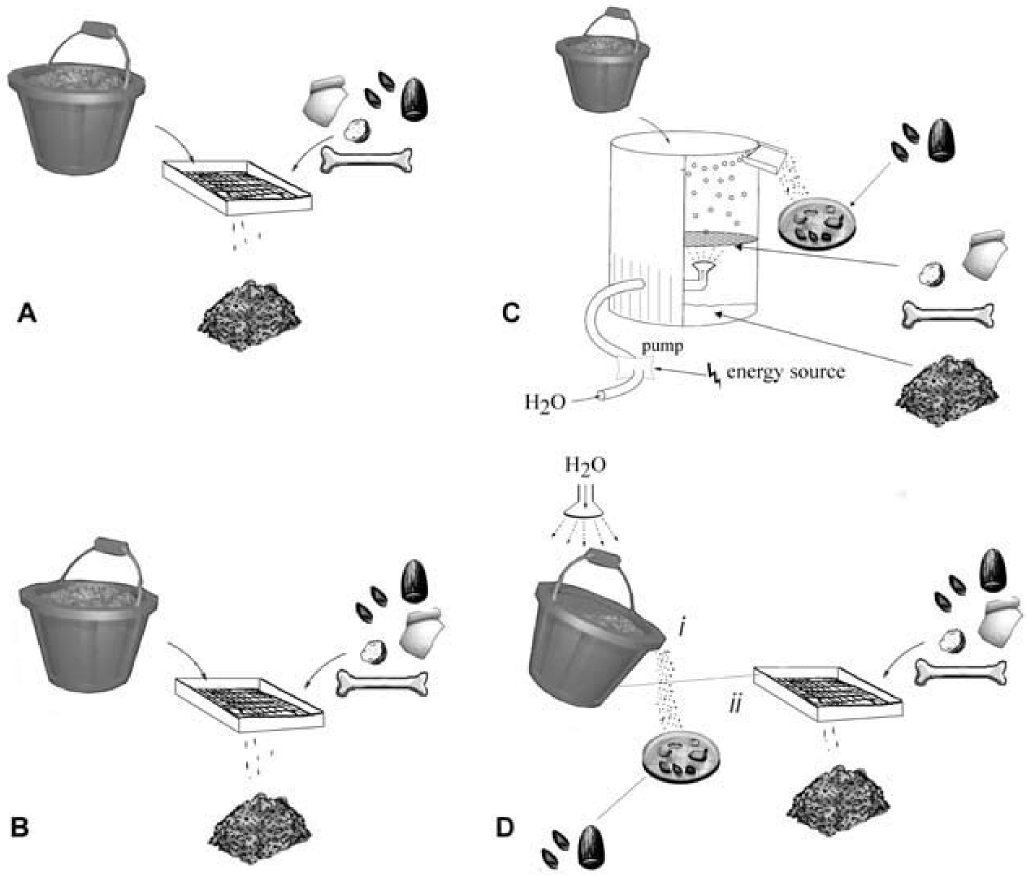
Flotation uses buoyancy to separate materials of different density. In particular plant remains, usually charred, are lighter than sand, gravel, pottery, or bone. The basic principle of flotation is that sediment is added to water and mixed so as to thoroughly break apart and wet the sediment, and then the buoyant material is poured off and collected in a fine sieve The main division in flotation systems is between machines (Figure 4C) and flotation done manually with buckets, sieves and plenty of water without using electricity or fossil fuels. Manual bucket flotation has advantages in being highly portable, cheap and can normally be carried out with locally available materials which can be found in markets in the developing world. While variants exist, a simple wash-over method of bucket flotation is reliable and portable (Figure 4D). Machine flotation has advantages in terms of the number of samples and consistency of treatment and may be preferred for established long-running excavation projects (*eg* Nesbitt 1995).

Decisions about processing method and sample size need to be tailored to a particular project, depending on resources, soil conditions and available labour. Machines are more easily run consistently by less-experienced individuals, while bucket flotation is improved through practice. In the UK large bulk samples are the norm. In some projects numerous very small samples of a few litres are collected. This is more typical of some American projects.

Flotation and sieving are straightforward activities that anyone can be trained to do. They do not require a long apprenticeship or study ability, and can easily be grasped with a day's training. The lack of an on-site specialist is no excuse to discard plant or animal remains.

Conclusion

Although the kinds of sampling discussed above are often referred to as 'environmental' samples, it is wrong to consider them only of interest for trying to reconstruct past environments. The history of archaeological sciences clearly indicates that these datasets contribute important information on past human activities, and potentially aspects of beliefs systems, in addition to environments and subsistence economies. These should be essential components of archaeological research in any region or of any period, from the palaeolithic to recent historical periods. Excavation can destroy the sediments that can be sampled for plants remains (micro- or macro-) for systematic sieved bone assemblages or for sedimentary analysis. It is therefore essential that all excavators who move, disturb and destroy the sedimentary records



4. Diagrams of the main on-site collection methods for archaeological plant and animal remains, showing the distribution of the heavy fraction (bones, stones and artefacts) and the flot (charred plant remains) in relation to sieves and spoil.

A. Dry-sieving: sample is poured on to screen and shaken to accumulate sedimentary spoil below screen and all finds on the screen.

B. Wet-sieving: as previous except that water is added to aid the removal of sedimentary spoil.

C. Machine flotation: sample is added to machine through which water is pumped mixing the sample; heavy fraction is wet-sieved within machine while flot is caught in sieve below machine's spout.

D. Bucket flotation: flotation through manual agitation and pouring is carried out as a first stage (i) and remaining sediment is emptied onto a screen for wet-sieving of heavy fraction (ii).

of the past have a basic working knowledge of the potential of these datasets and how to collect them. This should be part of fundamental undergraduate archaeological training (as is the case at UCL). MA level students, who are often specialising in a particular region, period or method, may not require repetition of this, as long as we can be sure that they already have some understanding of it. Nevertheless, it may be worth reassessing the extent to which the use of these datasets in understanding particular regional archaeologies is represented in regionally focused seminars.

One of the increasing challenges for who those who train archaeologists is the need to convey the centrality of plant and animal exploitation in past cultural practices. As a growing majority of our students in London are urban or suburban, and are increasingly distant from actual traditional production processes, surrounded by pre-packed food and artificial plastic containers and tools, there may be a tendency to be under-whelmed by the natural resources that have been the mainstays of most human economies and material culture traditions in the hominid past, *ie* perishable plant and animal parts that can be consumed or turned into objects. In our mechanised post-industrial world it may also be easy to overlook how much effort in terms of human labour time went into the collection and processing of natural resources. One approach to getting students to think about this is to have them try to replicate some of these activities, and to consider the efforts in relation to potential archaeological residues. Some discussion of the ethnographic examples is also essential to fulfilling training in the kinds of evidence that might be lost if environmental sampling is not made part of archaeological programmes. One of the major contributions of archaeology to thinking in the modern world is surely to confront us with past human societies, with access to different resources, without industrial products, supermarkets and global networks of fossil fuel transport. Fundamental to this is an appreciation of organic sources for sustenance and artefacts, studied through archaeological sciences that are dependent upon adequate sampling as part of archaeological fieldwork.

Note

[1]Some histories of environmental archaeology have followed a different three-stage model, such as the 'foundation-collaboration-integration' scheme of Rapp and Hill (Rapp and Hill 1988; also, Wilkinson and Stevens 2003: pp19-21). Their 'foundation' phase refers to the 19th century emergence of scientific endeavours such as geology, archaeology or ecology. Their 'collaboration' is essentially the first phase discussed here, while their 'integration' is herein subdivided.

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