Archaeology under the microscope

Lisa-Marie Shillito[1]
[1]School of History, Classics and Archaeology, University of Edinburgh, Edinburgh, EH8 9AG
Email: lisa@palaeo.eu

Most archaeologists are aware that what we can see in the field is only a fraction of the archaeological record. This is perhaps especially obvious to anyone who has excavated a Near Eastern tell site, ashy midden deposits, or multiple superimposed hearth deposits in caves. The photograph in Figure 1, showing hundreds of finely stratified layers in a midden at the Neolithic site of Çatalhöyük (Turkey) illustrates this quite nicely.

Figure 1: *Finely stratified ash and organic layers in a midden at Çatalhöyük* (Image Copyright: Lisa-Marie Shillito)

Although single-context archaeology is often regarded as a ‘gold standard’ in excavation methodology (for a great discussion of this see Colleen Morgan’s blog; Morgan 2010), excavating a true ‘single’ context is limited firstly by our ability to visually resolve an individual layer, and secondly by our tools. I remember during one field season, Shahina Farid (former field director of the Çatalhöyük Project and Senior Research Associate at UCL) remarked that we can only dig at the resolution that a trowel will allow. You could even say, thirdly, that we are limited by time - how long would it take to excavate multiple single layers, less than 1mm thick, or to sieve these deposits to recover remains such as charred plants and animal bones? In reality therefore, we have to assign artificial ‘single’ contexts to these types of complex deposits.

Obviously there are problems here. How can we distinguish between individual daily activities if we group together multiple layers from several events, artificially labelled as a single unit? As discussed by Goldberg *et al.* (2009), if we are to move beyond broad interpretations of human behaviour, we need to examine the archaeological record on the scale at which human activities occur and are recorded – often this is the microscale. Daily activities produce signals which may be all but invisible to the naked eye, but which can be seen clearly by looking at deposits under the microscope.

One approach which addresses this problem is through the application of ‘microarchaeology’. This term was used by Weiner (2010) to describe a combination of microanalytical techniques that aim to examine past human activity at a high spatial and temporal resolution. The past few decades have seen a steady increase in the application of these microanalytical methods to archaeology, many of which were first developed outside the discipline, for example in soil science or geology (Matthews *et al.* 1997).

In the past few years in particular, methods such as thin section micromorphology, combined with microbotanical and geochemical analyses, have become increasingly recognised as providing an essential insight into several aspects of the archaeological record. An example of the resolution of this approach is the identification of individual layers of wall plasters at the site of Çatalhöyük in Turkey, revealing the seasonal redecorating habits of the Neolithic population (Matthews 2005).

Similarly, we can identify single episodes of dust accumulation on floors, where microscopic debris became trapped underneath matting - a scenario familiar to anyone who has swept underneath a rug on hard flooring (Figure 2). And it is not just in buildings - this approach can also be used to identify formation processes of midden deposits (Shillito 2011; Shillito *et al*. 2011).

However, microscopic analysis still has its limitations. We can only identify activities which leave a visual signal, and even then there are some materials, particularly organic remains, which are almost impossible to identify using visual methods. By combining the microscopic analysis with chemical analysis, we can overcome this problem.

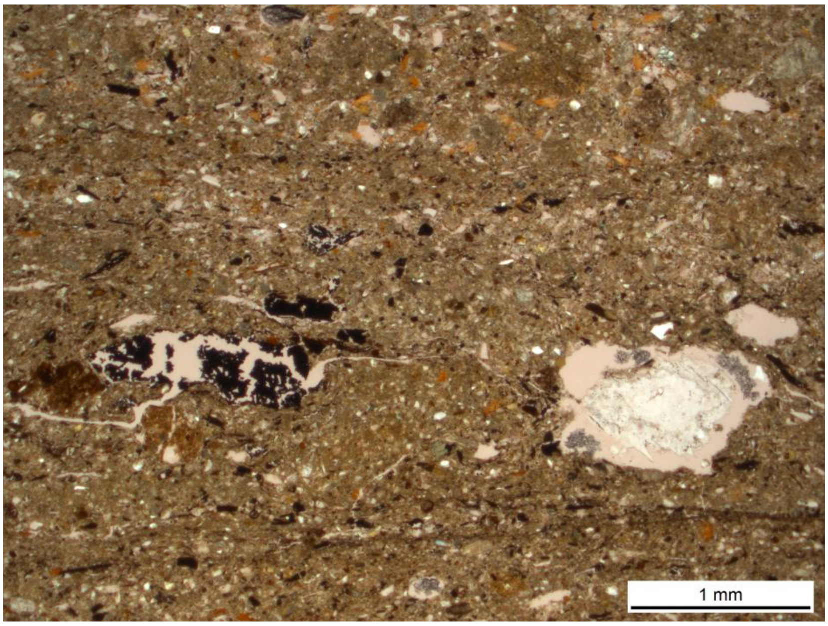

Figure 1: *A layer of dust in a sequence of plaster floors at Kamiltepe* (Image Copyright: Lisa-Marie Shillito)

Chemical analysis can be divided broadly into inorganic and organic methods. Inorganic methods include techniques such as infra-red spectroscopy (FT-IR) and X Ray Fluorescence (XRF), which can characterise the elemental and structural composition of materials such as mudbricks, plaster and stone. Organic techniques include Gas Chromatography Mass Spectrometry (GC/MS), which separate out and identify different components in complex mixtures of organic materials such as fats, oils and resins. Although organic techniques are more time consuming and expensive, the information they can provide is much more specific and in many cases can identify the exact origin of decayed material, for example distinguishing between layers of trampled animal dung and human latrine deposits (Shillito *et al.* 2011).

Microarchaeology at the University of York

The Department of Archaeology in York has several strengths, but is particularly strong in the fields of bioarchaeology and cultural heritage management, with period strengths in early prehistory and historical archaeology. In addition to this, the department is committed to the integration of humanities and science-based approaches in all aspects of the discipline.

The application of organic geochemical techniques is well established at the University of York, and is one of the major research areas of the BioArCh group. BioArCh have applied GC/MS and associated methods particularly to pottery samples, where they have been used recently to identify the types of foods that were being processed in Jōmon pottery (Craig *et al.* 2013). With pottery analysis, we can combine the analysis of 'invisible' chemical residues with microscopic analysis of plant remains in burnt food crusts, to provide a more complete picture of what the vessels may have been used for (Saul *et al.* 2012).

This 'microarchaeological' approach is being further developed through major research projects in the Department, such as the ERC InterArchive project (investigating microscopic and geochemical signals in burials), and is also included as an important part of the ERC POSTGLACIAL project at the Mesolithic site of Star Carr. The Department Research Committee has also supported the development of this methodology through funding pilot projects at important prehistoric sites such as Paisley Caves (USA) and Çatalhöyük (Shillito and Ryan in press).

Learning and teaching – the importance of practical approaches

Thanks to generous funding from the University Teaching Committee, the Department of Archaeology in York is now able to offer students access to facilities and training in this area, through a new microscope facility based in the BioArCh laboratories (Figures 3 and 4). 'Archaeology Under the Microscope' is a strategic learning and teaching project which aims to build upon existing strengths in the Department.

In response to module evaluation data, it was recognised that a key skill area, training in the use of modern microscopic facilities, was an under-represented area in the teaching of archaeological science and laboratory skills. The aim of 'Archaeology Under the Microscope' is to address this through developing a state of the art microscope laboratory and digital reference collection that can be used for teaching across undergraduate and postgraduate curricula, enabling students to become more involved in departmental research.

Figures 2-4 (L-R): *Converting space in BioArCh into a microscope laboratory; one of the new Leica DM750P microscopes with integrated digital camera* (Image Copyright: Lisa-Marie Shillito)

The importance of practical laboratory teaching in science subjects is well documented (Hofstein and Lunetta 2004), and competency in practical skills is also shown to be essential for employment in the archaeological workplace (Lydon 2002; Croucher *et al.* 2008). An integrated approach of practical microscopy training and digital image resources was used for example by Kumar *et al.* (2006) in teaching histology, and evaluation indicated that students strongly supported this integrated approach. The project produced a collection of reference images that could be accessed remotely by students, enabling them to revise materials demonstrated during practical sessions, in their own time.

A similar collection of reference images are currently being produced in York alongside a physical collection of microscope slides. These images will be archived with the York Digital Library (YODL), an online repository for multimedia resources at the University of York. YODL provides access to over 69,000 resources, including images, past exam papers and theses. The reference collection will be permanently available with YODL to support research, teaching and study in archaeology and beyond.

Reference materials have been selected to complement existing teaching within the Department of Archaeology (including pottery and bone thin sections), as well as areas of current research (such as microfossil analysis) to enable new teaching to be developed in this area in future. The project was recently presented at the University Learning and Teaching Conference 2013 (Figure 5), and the microscopes are now available for use in student projects.

Figure 5: *Poster presentation at the York Learning and Teaching Conference 2013* (Photograph of author's poster reproduced with kind permission of Steve Ashby)

It is hoped that this facility will provide a foundation that can be built upon in the future, and become an important teaching and research resource that will keep York at the cutting edge of archaeological investigation. Further information and case studies can be found on the author's blog at castlesandcoprolites.blogspot.co.uk/.

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