Multivocality and Multiproxy approaches to the use of space: lessons from 25 years of research at Çatalhöyük

Lisa-Marie Shillito

School of History, Classics and Archaeology, Newcastle University

Lisa-marie.shillito@ncl.ac.uk

Abstract

Understanding site formation processes are essential before we can make inferences about human behaviour, and a key part of the inferential process is the integration of multiple, diverse lines of evidence. The term 'multi proxy' has become increasingly used in studies of use of space, particularly in geoarchaeology, to describe an approach multiple methods are combined to reduce the impact of equifinality of interpretation. Since the early 1990s this integration has been an aim of the reflexive methodology at the Neolithic settlement of Çatalhöyük. Methods including sediment micromorphology, microartefact patterning and geochemical analyses of floors and wall plasters, phytoliths and starch, alongside artefact studies, macrobotanical and zooarchaeological analysis have all provided insights, but there is still a gap between macroscale and microscale approaches, and integration has not always been successful. Considering the history of analytical approaches at this site provides an opportunity to reflect on how we acquire and interpret archaeological science data, and the relationship between multi proxy and multivocality.

Introduction

'progress in inferential theory is apt to be a function of the willingness of archaeologists themselves to confront head on the need to integrate diverse lines of evidence'

Schiffer 1988.

Central to archaeology is the process of inference, reaching a conclusion on the basis of our observations of the archaeological record via analogy and/or the application of a uniformitarian stance. In order to do this we must understand what factors have created and influenced the things we are observing. The record is complex with many variables, and understanding these falls under the heading of formation processes. Schiffer divides these into cultural and natural formation processes, both those which we hope to identify (i.e. the nature of human activity in the past) and those which obscure (modifications to objects and materials when they move from a systemic to an archaeological context). Archaeologists must consider the formation processes and taphonomy of archaeological deposits before we can make cultural interpretations (Schiffer 1983, Schiffer 1985, Schiffer 1987), as these modify or limit the interpretation that can be made.

Binford's definition of middle range theory suggested that correlations between material culture and behaviour in the present could be used as a basis for interpreting specific behaviours from material culture in the past. The aim is not to explain the behaviour, simply to infer the presence of a specific behaviour. The explanation of behavioural patterns, beyond evolutionary adaptations, is a concern of post-processual or interpretive archaeology, which argues that our explanations of archaeological data are inherently subjective. Middle range theory and post-processual archaeology have been seen as in opposition, but in fact can be and should be complementary (Kosso 1991). As Trigger (1995) suggests, a combination of processual and post-processual theory can greatly enhance the analytical power of archaeology, providing both the necessary restraints on interpretation, and acknowledging that there can be more than one way to explain any given archaeological data.

Fundamental to the process of inference, and subsequently explanation, is the accuracy and thoroughness of the observations on which the inference is based, how these observations are produced, and the process by which we assess and synthesise diverse lines of evidence to produce meaningful statements about people in the past. This process is constrained by the limitations of the evidence itself, the limitations of the methods and equipment used, and crucially, our perception of it. These all form part of the 'way of working' throughout the research process.

As the amount of observations and evidence increases, the more refined our interpretations become. Evidence increases with further study, and refinement of analytical methods, driven by technological progress but also led by questions the research hopes to address. Similarly, the concept of context is central to archaeological investigation, with the essence of what we define as a single context, and thus our units of analysis, being linked to the ability of the investigator to identify and define multiple relationships (Llobera 2011).

The development of ‘microarchaeology’, thin section micromorphology in combination with various geochemical analyses and often microfossil analysis, has shown that what we can see in the field is only a fraction of the archaeological record, and that activity signals, and the processes that modify them, often occur at the microscopic level (Matthews et al 1996). It has provided the potential to examine the microscopic traces of artefacts and the sediments in which they are contained, to the level of a layer of dust trapped underneath reed matting (Shillito 2012). It has shown that our perception of a ‘single context’ in the field is oversimplified, and that the methods we use to define this can influence the outcome. Thus what is defined as a single context during excavation, using the the trowel, does not always fit with a single context when the same deposits are observed using the microscope (Shillito 2015). Formation processes and post-depositional modifications may only be visible under the microscope. But understanding the context is essential for synthesising the evidence. How do we know materials are related? How do we synthesis and interpret the data? How are the connections made?

Micromorphology has become a central focus in ‘multi proxy’ archaeological research, a term used to describe approaches in which multiple lines of evidence are used simultaneously to address a research question, particularly within geoarchaeology. Micromorphology provides a means of visualising the relationships between materials - an ‘excavation under the microscope’. The term ‘multi proxy’ is used frequently in Quaternary science and palaeoecological research to describe studies which use multiple environmental proxies, to gain a better overview of complex systems, than can be achieved through a single proxy analysis (Birks and Birks 2006), usually in reference to the analysis of sediment cores. Whilst early approaches focused exclusively on pollen, it is now routine to look at several proxies simultaneously. Multi proxy archaeology integrates several analytical methods during the process of sampling and analysis, so that results from several analyses can be directly compared (e.g. various geochemical techniques, particle size analysis, pollen, plant macrofossils). This avoids the problem of lack of comparability if, for example, each analysis was conducted on a different sediment core. Whilst cores may be collected from the same lake, it is recognised that the spatial variability complicates the linking of records.

This contrasts with traditional ways of working in archaeology which typically separate materials for analysis. The development of archaeology as a discipline has created different specialist identities, such as archaeobotany, zooarchaeology, human osteoarchaeology and artefacts (itself divided into categories such as lithics and pottery). These determine to a large extent how we approach analysis. Jones (2002) calls this the ‘explosion’ of a site, where the constituent elements that make up the site are disengaged from each other.

The potential of a multi proxy approach is that it provides a more complete characterisation of the archaeological material record, and the specific relationships between different categories of materials, and thus focuses the range of possible interpretations. By examining multiple lines of evidence together, we can better define specific activities which produce an ‘assemblage’ of signals, and identify modifications – the gap between the systemic and archaeological contexts (Schiffer 1972). Shahack-Gross et al. (2005) for example use a combination of mineralogical, micromorphological and phytolith analysis to identify alternating layers of ‘floors’. One layer that was identified as a plaster floor in the field, was seen to be a mix of micro-laminated phytoliths, in association with dung spherulites and phosphate nodules. This combination of markers strongly supports an interpretation of animal penning in the building, which would not be possible without the combination of evidence being analysed together. Furthermore, the combination of methods enabled identification of a large volume reduction due to degradation of organic material.

Çatalhöyük

Çatalhöyük was inscribed on the UNESCO World Heritage List in 2012, and is thought to be one of the earliest ‘urban’ centres in the world, with deposits first starting to accumulate in the aceramic Neolithic c.7100 BC (Bayliss et al. 2015), and continuing until c.6000 BC (Marciniak et al. 2015). Since 1993 it has been excavated every year under the direction of Ian Hodder. Hodder’s excavation was planned as a 25 year project, with the eventual aim of presenting Çatalhöyük as a heritage attraction. The central research direction currently is to understand the symbolism and paintings within a wider environmental and socio-economic context. The continuous occupation provides an important case study to examine the long term processes that led to urbanisation, including technological change, development of agriculture and domestication, and the position of the site within the wider region in terms of trade and other relations. These high level goals are underlain by a process of data collection that are enviable in their extent and range. At a lower level, ‘use of space’ within and between buildings, can be linked to most, if not all, of these themes.

As well as the long lived nature of the occupation, spanning the early pre-pottery Neolithic to Chalcolithic, the exceptional level of preservation of buildings and occupation deposits makes it an ideal case study for the reconstruction of past behaviours and the potential to apply a wide range of techniques. In theory the preservation means that past activities should be more readily reconstructed, compared to sites which have undergone greater post-depositional transformation. There is less of a gap between the systemic and the archaeological, particularly in the deeply buried parts of the site, where deposits have escaped the post-depositional processes that are observed in deposits closest to the surface (Shillito and Matthews 2013). Hundreds of buildings remain with intact walls and floors, along with a rich artefactual and eco-factual record that offer a huge scope for combining multiple integrated methodologies to investigate the household. As Campbell (2008) notes, the aims of the Çatalhöyük excavations have been to develop the practice of archaeology as much as the research outcomes, with ‘integration’ being a cornerstone of the ‘reflexive methodology’ that Çatalhöyük is known for. The aim of the reflexive methodology was to move away from the traditional approaches that separate material and send it off for different specialists to examine in isolation, to facilitate interdisciplinary discussions, and appropriate sampling strategies, where materials are considered together in their depositional context (Hodder 2000). Specialists have direct access to the context of the materials they are examining, which should avoid the ‘de-contextualisation’ process (Jones 2002). A related feature of research at

Çatalhöyük is multivocality – multiple voices in the process of doing and interpretation of archaeology, rather than the hierarchical approach where the excavation director has the final say in the overall interpretation of a site. Ideally it is an ongoing collaborative process, to formalise the type of engagement that may or may not occur informally within a team (Farid 2015).

Çatalhöyük has seen what is arguably one of the most extensive programmes of microarchaeological research and investigations of use of space over the past 25 years, and early archive reports discuss the specific focus on 'integration' between methods (Matthews 1998, Rosen 1998, Middleton 1998), with initial sampling strategies devised by Matthews. It is interesting then that Beggren et al (2015) in their review of reflexive methods at Çatalhöyük note that "archaeology as a discipline becomes ever more fragmented into specialised areas of knowledge" and caution that we maintain an overview of all the lines of evidence. To what extent then has this integration been achieved? What are the implications for interpretation of data? The history of analytical approaches to use of space at the site can be divided broadly into three phases, and is an opportunity to reflect on the lessons that can be learnt about how we acquire, synthesis and interpret scientific archaeological data.

Use of space

"Our choice of strategies for investigation is partially dependent on the archaeological, logistical, social, and political contexts in which we practice household archaeology and the extent to which the practice of different methodologies has been hindered or enabled and encouraged" Tringham 2012:87.

'Use of space' in archaeology is a broad concept that sits within household archaeology and the investigation of intra-site relationships, which can be categorised under middle range theory, and the building of hypotheses directly linked to empirical data (Tringham 2012). As such, investigations of the use of space in archaeology are a good example for exploring the practice of archaeological interpretation, how we generate and synthesise different strands of data, and how we make the links between empirical data and higher level theories about societies. Many of the broader research themes at Çatalhöyük can be linked back to the household, and identification of activity areas.

Many different lines of evidence can be pursued to investigate use of space, and can give their own stories of a range of possible activities. But human behaviour is complex and rarely produces a discrete signal. Trying to investigate 'use of space' in archaeology is therefore a complex process that requires understanding of many different aspects of the archaeology from the visible to the invisible – the buildings themselves, the floors within them, the organic and inorganic remains within those buildings, and the chemical signals. At this level of analysis, we are trying to make that direct link between material evidence, in its many forms, and specific activities. The integration of evidence is difficult but essential to bridge material specific categories and exert controls on our interpretations. The constraint of evidence and refinement of methodology limits the bias of our interpretations (Trigger 1995). However, as Shahack-Gross (2011) notes, there has been no household study that has successfully integrated all aspects, the macroscopic and the microscopic, artefacts and molecular, in order to understand activity areas.

Jones (2002) notes that different sciences have different practices which affect the kind of knowledge generated. Within geoarchaeology, there is an inherent recognition that multi proxy approaches provide a more nuanced picture, and the use of multiple methods in tandem is common, such as thin section micromorphology with phytoliths and FT-IR for example (e.g. Shahack-Gross et al. 2003, 2004, Albert et al. 1999, Sulas and Madella 2012, Shillito et al. 2011). This is perhaps due to the fact that geoarchaeology as a specialism has less of an obvious focus on one category of material, in the same way that zooarchaeology and archaeobotany do with animal and plant remains respectively, and the diversity of soils and sediments as a material category. Its close links with palaeoecology and Quaternary science, where multi proxy methods are a standard approach in the analysis of sediment cores (Birks and Birks 2006), may also contribute to the multi proxy perspective. The knowledge generated is different to that of 'single proxy' practice.

By applying a multi proxy approach, is it possible to better understand the formation processes – from habitation and abandonment to post-abandonment? At Çatalhöyük it is well recognised that artefact based reconstruction of use of space is not possible, because the vast majority of artefacts are obviously not in situ in terms of their systemic context (though see later discussion of B52). Post-depositional process and abandonment are the source of the majority of 'signals' (Diehl 1998). This is made even more problematic by the fragmentary nature of the archaeological record, where only a fraction, if any, material record of activities may remain. In archaeology we therefore look increasingly to the sediments themselves as material culture (Owoc 2003, Boivin 2003). The popularity of methods such as spatial geochemistry are the result of a recognition that artefacts are rarely suitable for reconstructing 'in situ' activities.

The floor, or occupation surface, has been a focus in use of space studies, in that it supposedly can be a repository of primary activity residues, though this assumption has been extensively critiqued (e.g. Hayden and Cannon 1983, LaMotta and Schiffer 1999, Shahack-Gross 2011), and it is recognised that factors such as the composition of the floor play a huge role in their potential to record activities (Schiffer 1996). When trying to reconstruct activities, what we are measuring are the formation processes, the material signals and, crucially, how they have been modified, which are 'read' to decipher possible activities. How do we measure these things together, and how do we know which features relate to each? Experimental archaeology and ethnoarchaeology can provide insights here, for example the research of Banerjea et al. (2015) which applies sediment micromorphology to house floor deposits from three experimental houses (Butser Ancient Farm andSt Fagans, UK; Lejre, Denmark). The observations of 'known' activity areas revealed interesting insights into the types of residues that form from specific activities, but also how materials are transported and deposited, and how they are altered after deposition. A particularly relevant observation for studies into use of space, was the transport of micro residues on the soles of feet, leading to the deposition of material in locations away from the site of the actual activities. The interpretation of foot traffic as a transport mechanism has been suggested in an archaeological example by Regev et al (2015), who identified spreads of ash on floors. Conversely, an ethnoarchaeological case study by Milek and Roberts (2015) demonstrates deliberate spreading of ash material on floors to dry the surfaces and act as an insecticide.

Examining how floors and other activities areas have been approached at Çatalhöyük, the way the data has been generated and presented, can highlight both problems and potentials. Research can be divided into three phases. During the early phase of excavation in the 1990s, the team was relatively small, and archive reports make explicit mention of integrated approaches. Buildings were studied by specialists including thin section micromorphology (Matthews 1995), geochemical patterning through ICP (Middleton 2004), phytolith studies (Rosen 2005) and microartefact distributions (Cessford 2003). Initially floors were considered to be 'primary activity areas' (Matthews and Hastorf 2000). Intensive micro-excavation and sampling was conducted with the aim of detecting high resolution activity signals and different functions between rooms, but later abandoned as it became apparent that the effort required did not deliver results that could be linked to in situ activities (Farid 2015). A second phase, noted by Rountree (2003) began in the early 2000s, when many new project members joined, and a new phase of work started. Some methods were abandoned, whilst others were expanded (Anderson et al. 2014a, 2014b), and new methods such as starch analysis were introduced (Hardy 2007, van der Locht and Hardy 2009). A third phase since 2013 can be identified, where interestingly aspects of micro-excavation have been reintroduced, and where integration is becoming more effective (Garcia-Suarez 2013, 2014).

Changing Approaches to activity areas at Çatalhöyük

Phase 1

In the early 1990s there was an initial focus of all specialists on buildings 1 and 5. The sampling strategies were devised largely by Matthews (1993, 1994, 1995, 1996). Microartefact floor patterning was applied with the aim of identifying in situ activity, and perhaps the multi-function and changeability in the use of rooms, and whether this is at all related to the architectural segmentation of space (Cessford 2003, Hodder and Cessford 2004). The source of microartefact data is heavy residue flotation by-products from standard 30L samples, and is itself 'multi proxy' in that it examines all components of the heavy residue as an assemblage, including microfaunal, botanical, lithic debitage, eggshell, amongst others. However the materials are removed from their depositional context, separated for quantification, and re-combined for analysis.

Microartefact studies have been highlighted as having greater potential as primary refuse, as they are likely to escape the cleaning and deliberate removal that frequently occurs with larger material (Hull 1987, LaMotta and Schiffer 1999, Ullah et al. 2015). The main conclusion from this work however is that microdebitage patterning is not a reliable tool for identification of 'in situ' activity, as was initially hoped. By comparing the density of microartefacts in floors and walls (and assuming the latter would not relate to primary activity), the analysis showed that walls actually have microartefact densities close to or sometimes greater than those of floors, suggesting that an in situ activity signal is unlikely. Cessford (2003) suggests that microartefact densities are in fact a result of the construction process, and became mixed into the wall and floor material as part of the constructional materials. The conclusion is that analysis of 'trapped' microdebitage from discrete features such as post holes may be more representative of activities occurring in the building. He also highlights the problem of using microartefact density, when this may simply be the result of duration of occupation. This problem has been referred to as the 'cumulative palimpsest' or time-averaging of deposits from multiple activities being superimposed in a certain area (Bailey and Galanidou 2009).

Preservation of intact floors at the site would deem it ideal for studies of floor geochemistry, which has seen extensive applications elsewhere (particularly the lime plastered floors of Mesoamerica e.g. Terry et al. 2004, Barba 2007, Middleton et al. 2010), however it has been relatively limited at Çatalhöyük following the first phase. Studies by Middleton (2004) proposed that chemical signals are an important means of identifying use of space that cannot be obtained through 'traditional' (i.e. artefact based) approaches. Middleton and Price (1996) used ICP-AES to examine bulk chemical signals in the floors of B1 and B5. In Building 5 Middleton (2004) focuses on a 'single floor' and proposes distinctions between 'clean' and 'dirty' on the basis of geochemical patterning - a concentration of P for example near storage bins, proposing a 'general traffic' area, food storage area, and 'ash scatter' zone on the basis of P, Na, Mn and K along with architectural features. These studies are highly cited in spatial geochemistry studies.

A closer look at ICP analysis of B5 reveals some of the difficulties with interpreting geochemical signals. Middleton's analysis shows a high concentration of P near the bins of Space 157 and in Space 156. One observation is that the chemical signals do not seem to align with walls, appearing to be more of a spread across areas. The low level of P around a Fire Installation area is unexpected. The group 4 'ash scatter' is not located near a hearth. It could be that these signals relate instead to debris from the wall packing material identified in Space 156, which frequently consists of mixed ash, charcoal and other debris. Against the walls (F231 and blocking F249) Berggren (1998 a, 1998b) identified a concentration of small animal bones, and an accumulation of material containing charcoal and phytoliths (3880) piling up against F249, all of which create P signals and could be the origin of the ICP signals. As with microdebitage, there is also a problem of intensity versus duration, geochemical signals are also 'averaging' a lifetime of use signals.

Many geochemical studies focus on increased levels of P, which is correlated generally with food preparation and refuse disposal (e.g. Fernandez et al. 2002). Middleton et al (2010) does note that the interpretation of bulk chemical residues is problematic, given the lack of specificity of the signals such as P, and calls for a holistic approach that combines other evidence to identify whether we are observing a single process of cumulative activity. Later work (Middleton et al 2010) notes that the equifinality of P means that going from detection of chemical patterns to the identification of behaviour is not straightforward, and highlights the importance of integrated geochemical methods that combine organic and inorganic chemistry in the analysis of floors.

The advantage of sediment micromorphology is that it has the potential to distinguish between individual episodes of deposition within a single area, even if the floors are too fine to excavate and sample individually (Matthews et al 1996), and gives a coherent framework to the different lines of evidence (Campbell 2008). Whilst ICP and microdebitage provide an averaged picture of 'use signals' over the lifetime of the building, micromorphology can look at variation over time within a single building, from construction to abandonment i.e. this is a method that can potentially 'unpack' the cumulative palimpsests, and examine variability rather than the average. Micromorphology is unique in that it examines the depositional relationships between different categories of materials, requiring the analyst to look at all materials simultaneously, without them ever having been removed from their depositional context. This enables a direct observation of the specific relationships between categories of materials that is not possible after they have been physically separated. Early micromorphology work at Çatalhöyük was conducted by Matthews, applying an approach developed for other urban sites in the near east (Matthews et al. 1996, Matthews 1998). The aim of long term study of depositional sequences using micromorphology has been to investigate the use of space and behaviour at Çatalhöyük, ideally in collaboration with traditional architectural analysis and distribution of artefacts and bioarchaeological remains (Matthews 1998). In reality, the different sampling strategies and processes of research have meant the latter has only rarely been possible, and ultimately the datasets were presented separately.

Micromorphological studies demonstrated that the type, thickness and frequency of floors and associated occupation deposits at Çatalhöyük varies spatially within single rooms, and also through time and the life-history of a building. Such variations can provide important insights on socio-cultural behaviours. The 'clean' and 'dirty' areas within B1 and B5 suggested by ICP are resolved in greater detail – the clean areas with high Ca for example being seen to be surfaces frequently replastered with calcareous sediments, whilst 'dirty' areas contain variable sediments with heavy trampling and organic material. Floors in B49 for example are seen to be remarkably clean for the majority of the building life, until towards the end of use, when we see an accumulation of organic debris (Matthews et al. 2005). This could therefore mean that bulk geochemical analyses reveal an 'end of life' signal rather than a lifetime average. Cessford (2003) noted that microdebitage and micromorphology seem like they should complement each other, but that the problem of scale means these data are not directly comparable i.e. microdebitage is bulk samples from a whole section of floors, whereas micromorphology focuses on a limited area, and analyses successive individual floor layers. A general comparison with micromorphology data (Matthews 1996) revealed that only certain floor 'types' had in situ activity, and these activities were represented by extremely thin lenses which would be impossible to excavate and separate from the materials of the floors themselves. This is not necessarily a problem however. Milek and Roberts (2013) sampled the floors of a Viking house in Iceland in 1m grids for heavy residue, with a 200ml sub sample of this being used for geochemical analysis. Micromorphology samples were taken from exposed sections in each of the grid squares. This enabled an effective comparison between the data sets, in particular it enabled the source of the geochemical signals to be better understood.

Phytolith studies were also originally designed to complement geochemical analysis (Rosen 1998), but rather than looking at spatial patterning on floors, the phytolith work became more targeted early on, focusing on storage bins and other contexts where the input of time is likely to be more informative (Rosen 2005). Interpretation of the phytolith remains has problems related to taphonomy, as it is often unclear what processes are responsible for the presence of phytoliths (Shillito 2011). Again, analysis of B1 and B5 would have been enhanced by presenting this analysis alongside micromorphology, where trampling evidence could have refined interpretation.

Ethnographic work has similarly shown that phytolith assemblages from diverse sources can appear similar and need to be considered alongside other proxies to understand their origin (Shahack-Gross et al. 2004). A study into the use of space at the Neolithic site of Makri in Greece concluded that, like the patterns in microartefacts at Çatalhöyük, phytolith assemblages from most floors did not reflect activities, but were already embedded in them, as they comprised material used to construct the floors (Tsartsidou et al. 2009). Micromorphology at Makri notes the presence of potential phytolith 'mats' (Karkanas and Efstratiou 2009) and shows the highly localised nature of phytoliths relating to room use. The activity of house construction and maintenance is more visible than how the space was subsequently used. This observation is also seen in ethnographic research, where floor residues are related to building maintenance events rather than activities (Milek 2012). The physical structure of the floors in thin section indicates processes such as trampling, and artefact distributions were seen to be a result of this trampling, cleaning and abandonment rather than primary deposition. Milek concludes that only very select activities have the potential to leave archaeological traces. A study by Shahack-Gross et al. (2004) on abandoned Maasai settlements likewise concluded that whilst some activities could be detected (namely detection of features associated with ash), other features such as house floors were not detected.

Whilst the initial aims of sampling at Çatalhöyük were to avoid fragmentation, the post-excavation process still occurred according to material categories. There is some limited cross referencing between microartefact studies to chemical residue work and phytolith analysis, however the relationship between the datasets is unclear without careful scrutiny of multiple publications. Why were these analyses been so poorly integrated, when the aims were to compare the data from different approaches? One reason could be the operational processes, which make it difficult, and sometimes impossible, for these analyses to be conducted on site (e.g. in comparison with macrobotanical and zooarchaeological material). The process of publication and data presentation was therefore 'staggered'. The lack of visual plotting of data may also have been a problem.

The ability to integrate is limited by the problems that Birks and Birks (2006) identify for multi proxy studies in palaecological contexts. Whilst sampling was initially devised by Matthews, analysis occurred separately, and presented in different ways at different scales, meaning it is difficult to compare different data. The initial publication of the different datasets occurred on very different timescales, with some analyses being included in journal articles (e.g. micromorphology – Matthews et al. 1997; ICP – Middleton et al.; microresidues – Cessford 2003), and others appearing only in the site monographs (phytoliths).

Phase 2

In the second phase of research, some techniques such as ICP were abandoned, whilst others were refined. As Farid (2015) notes, there was shift to larger numbers of isolated teams, with work conducted largely by PhDs and postdocs with lab heads not present for an extended period of time. Micromorphology was expanded with the aim of integrating complementary geochemical approaches that could enhance the information that could be gained from thin section analysis. In contrast to earlier studies, these methods were integrated during the actual process of data collection by a single researcher, rather than conducting them separately and trying to bring them together after analysis. Rather than using bulk techniques like ICP, these studies have tried to integrate micromorphology directly with geochemical fingerprinting techniques, such as micro FT-IR and XRD, to characterise individual floor layers (Anderson et al 2014a, 2014b) and GC/MS to investigate organic residues (Wiles 2008). By 'pinpointing' an object visually with micromorphology, we can be much more precise about the origin of a geochemical signal, which removes the 'averaging' effect of bulk techniques. Results indicated distinct differences between layers in terms of materials used, but there are no clear activity signals in the geochemical data.

The focus of micromorphology studies has shifted from identifying 'use of space' through in situ activity signals, to characterising variations in materials within a building, and how this may relate to use of the wider landscape resources, and cycles of building maintenance. Such temporal cycles have been observed in ethnographic studies, and show a real link between floor construction and lifecycles of different social groups (Boivin 2000).

Another consideration is linking these 'micro' methods with macroscopic techniques. The main focus of these specialist analyses as a whole has been wider questions related to long term changes in plant economy and domestication, trade and technology, based on material from middens. A reason for this is that most of the buildings at Çatalhöyük do not have 'in situ' artefacts as buildings were meticulously cleaned prior to abandonment (Twiss et al. 2008). More recently the work of Bogaard and others has turned back to the household, due to the unique circumstances of B52 which has the preservation of 'in situ' remains due to the burning of the building. The assemblages from this building have been interpreted as a snapshot of use at a specific moment in the history of the building (Twiss et al. 2008). Using GIS to spatially plot the distribution of animal and plant remains, Bogaard et al (2009) identify what are interpreted as assemblages of consumption and ritual located in different rooms, showing the strength of presenting data together. It is unclear whether the burning of B52 was deliberate. Carter (2011) argues that a deliberately burnt building does not necessarily reveal actual patterns of activity, and that they may represent a 'staged' scenario rather than a systemic context of materials.

A strength of microstratigraphic approaches is the ability to observe taphonomic processes which are otherwise unseen, and indicates exactly where signals are coming from. However, despite the convincing arguments put forth by Matthews with regards to plant remains (2010), there has never been a true integration between microstratigraphic analysis and archaeobotany at Çatalhöyük. One question that could have been resolved through micromorphology in the earlier discussion of B52 for example, is whether dung fuel was present that could have acted as an accelerant. Bogaard et al state that dung reduced to ash in the fire is 'invisible', yet this material can be easily observed in thin section through the distinctive morphology of the ash crystals, and presence of calcareous spherulites (Matthews 2005, Canti 1999). The problem here again is the operational process of these different methods. Whilst botanical analysis is conducted almost exclusively on-site on a unit by unit basis, micromorphology requires collection of samples to be exported and prepared before analysis can take place. Results may not be available in time to be incorporated into other studies. It is unfortunate that the microarchaeology of B52 has not been studied.

Floors are just one aspect of buildings with the potential to reflect activity and the use of space; the analysis of hearths and other features within the buildings has also seen a suite of methods. Understanding activities within a site requires a holistic approach that considers the movement and cycling of materials around the site, from storage and use, to disposal, and re-use. Examination of the buildings can therefore not occur in isolation from the analysis of midden deposits and other external areas. Microanalysis has shown direct links between material within buildings, and that seen in the midden deposits, with materials such as floor sweepings being seen in the latter (Matthews 2005). These clues enable us to reconstruct patterns of movement, and the high resolution nature of microanalysis offers the potential to determine activity patterns in annual, seasonal, or even daily cycles. This is the scale at which individuals interact with and perceive the landscape, and the scale of the household 'experience'. At Çatalhöyük, external areas include spaces between building clusters, where midden accumulates, and it is also thought that activities occurred on the roofs of the buildings (Matthews 2005). There are no 'streets' in the way that we generally use this term, though the external spaces certainly functioned in a similar way.

Middens can be seen both as 'indirect' indicators of activity, being the end product of activities that presumably occur in houses (Hodder and Cessford 2004), but also as locations of primary activities – the presence of 'fire spots' of various sizes attests to the use of the midden as an occupation surface (Bogaard et al. 2014, Shillito et al. 2011). Matthews' work recognised the limitations of only using 'visual' methods such as micromorphology, and as methods developed later studies of middens, like buildings, aimed to integrate microbotanical and geochemical methods with micromorphology (Shillito and Matthews 2013, Shillito et al. 2011). The aim here was to better understand the formation processes, and therefore the activities that are represented.

Middens are more complex than floors, in that they have a high spatial heterogeneity, and are composed of diverse materials. A method of 'microsampling' thin section blocks before impregnation was developed, so that the data could be directly compared (Matthews et al. 2004, Shillito et al. 2011, Shillito 2011). Whilst useful for providing a highly detailed and specific 'excavation under the microscope', these studies have been limited by the ability to integrate other proxies (Shillito et al. 2011), particularly plant macroremains. Middens comprise a large volume of ash i.e. plant remains in another format, and by themselves are only part of the available evidence. Such work also needs to be better contextualised by broader phytolith studies, such as the work of Ryan (2011), which has provided a more in depth analysis of broader patterns of phytolith change over time. But how do we combine these two approaches?

Phase 3

Shillito and Ryan (2013) demonstrated the advantages of integrating phytolith analysis and micromorphology to identify changes in the use of space in an outdoor area, which shifted from being a 'typical' finely stratified midden, to an area of intense trampling and activity. By integrating micromorphology directly with phytolith analysis of selected deposits, a detailed characterisation of specific layers was achieved, which was able to identify trampled surfaces alongside the plant and dung component of ash rich deposits. Although successful to an extent, this study also shows the limitations of sampling strategies that were devised separately - only a small number of samples were comparable. These external areas were obviously not cleaned in the same way the internal areas of buildings were, and could perhaps be the focus of future attempts to understand use of space through multiproxy approaches.

Starch analysis was also introduced towards the end of this phase (van de Locht and Hardy 2009, Hardy et al.). Starch for example in B.77 sp.336, shows the 'expected' pattern of clean floors, with starch only being recovered in significant quantities near storage bins (Hardy et al. 2014), confirming a function that is readily observable from architectural features, but providing additional information of the types of products stored within the bins. Despite starch being analysed from the same buildings as micromorphology, little cross referencing in the publication of the data. Again, a result of operational processes and lack of extended presence of researchers on site.

Relationships between 'multiproxy' and 'multivocal'

"despite the best intentions, this ideal was not fully realised" (Farid 2015: 66).

Whilst Çatalhöyük has seen the application of an enviable suite of methods over the past 25 years, we have seen that the integration of these methods has been sporadic, despite early reports stressing the aims of integration. Micromorphology (and associated geochemical work), despite its potential as a linking tool and its ability to resolve individual activities, is one of the most poorly integrated analyses. And yet, when we look at these data it is clear that the greatest interpretative power comes when they are considered together. Farid notes that lab heads not being present, and relying on a rotation of students for sample collection and analysis was a hindrance (2015). This is certainly the case in the second phase of research, where in my own experience it was difficult as a new team member to fit in to a large, very busy and overwhelming process. The time it takes to become familiar with a huge project and huge numbers of researchers, means it can easily become too late to plan sampling in a complementary way, until it is too late for effective integration.

There is also some tension between multiproxy and multivocal aims. Multivocality encourages all who have an interest to be involved in the process of data production and interpretation. An example from the second phase of research is the three chapters on architecture, each conducted independently and involving various types of analysis of mudbricks (Tung 2013, Love 2013, Stevanovic 2013). These three different narratives could be seen as multivocality, in the process of data production,, but each is based on a different set of analyses and data, with no dialogue. The fact that the data itself is contradictory indicates a problem with individual or limited proxy approaches. What would be revealed if these data were brought together? A further chapter on other architectural materials (Matthews et al. 2013) provides building biographies at a different scale. It is near impossible to integrate the data from these different studies, to see whether the different analyses could have worked together.

As well as the ethical argument, Hodder’s multivocality is also epistemic - inclusive practice will enrich our understanding of the past, though it is stressed that competing narratives need to fit the evidence. Wylie notes “if multivocality is to be sustained as an operational practice…it will be crucial to establish grounds on which to warrant (and contest) both the claims about the past…and reflexive claims (2007, p203).

It is not just the timescale of the operational processes, but also perhaps the ‘ownership’ of the data from different proxies that makes integration difficult. It may not be a coincidence that the only studies where data are published together are those conducted by a single researcher, or a small team. Whilst multivocality requires data sharing, it is inevitable that methods which are quicker and which produce data that is easier to understand, will dominate.

One approach that was developed to facilitate data sharing was the priority samples approach, where certain bulk units are selected for focused analysis by all the specialists. This method is heavily focused on macros, and not suitable for micro approaches. Micro analyses routinely identify multiple micro-units within a single context, with huge variability within a small area, and may have for example hundreds of data points with a ‘single’ unit. Data cannot be easily linked with the microstratigraphic observations as the samples analysed are often from different contexts, or from different microstrata within the same context. The important message than can be taken from this exampleis that the sampling strategies for different methods need to be devised together.

The reflexive approach at Çatalhöyük, whilst envisaged as on ongoing discussion, has been to bring the data together after specialist analysis has been conducted, through the use of discussion groups, and joint writing of chapters, based around priority units, for 'formalised' interpretation. In reality materials were still separated (Berggren and Nilsson 2015).

In some ways the project was ahead of its time. The absence of cross referencing and integration between individual reports noted by Campbell (2008) in phase 1 is perhaps due to practical issues of collaboration in the analysis and writing process, at a time when digital communication was not as common. In the early 1990s presentation of micromorphology data was also difficult, as digital cameras were not routinely available, and production of analogue images was time consuming and expensive. The lack of spatial plotting of data made it difficult for others to understand the data, and the relatively slow production meant that data was not available in time to be incorporated into other studies. We begin to see this integration happening in phase 2, but it is not until relatively recently that micromorphology has been directly included in thematic discussions. Now, the possibility of digital cameras in the field changes this, as does recent advances in procedures for producing thin section slides in the field (Asscher and Goren 2016).

It is virtually impossible to be fully involved with materials that cannot be analysed in the field. Berggren and Nilsson, in their review of reflexive methodology (2015) also note that in practice teams and labs have different priorities, focusing on their own questions which may or may not be linked to the broader project goals, meaning integration can be difficult to achieve when time is limited. Whilst multivocality encourages multiple interpretations of the data, multiproxy aims to reduce the range of possible interpretations by integrating different lines of evidence, and the requirements of sampling that are needed to properly integrate data. Birks and Birks suggest a requirement of successful multi proxy analysis is an overall leader who manages the process of integration (2006), but this contradicts the multi-vocal aims at Çatalhöyük.

Goldberg and Aldeia (2016) recently reviewed the role of micromorphology in archaeology, suggesting that observations and data from microstratigraphy are typically underutilised, due to problems of both the producers and consumers. They and others have noted that data presentation of micromorphology can be dull and incomprehensible. At Çatalhöyük it is incredibly impressive that Matthews was able to link descriptive and photographic data despite technological limitations, and at least with the second phase (Shillito and Matthews 2013, Shillito et al. 2011, Matthews et al.), authors moved away from text heavy descriptions to give greater emphasis to visual/spatial presentation of data. This could be why the most recent phase of microarchaeology is becoming more integrated - the "dynamic dialogue' suggested by Goldberg and Aldeia (2016) has parallels with Hodder's idea to have specialists on site, and Aroa Garcia-Suarez has been involved in excavation as well as micromorphology.

Many of the limitations of integrating data that have been discussed come about from the nature of excavations at Çatalhöyük. Initially planned as a process of excavation and data collection, the lack of an overarching strategy for archaeological science, and especially for the integration of different datasets at a different degrees of resolution, has meant that sampling for different techniques has passively developed over time, driven by the agendas of individual researchers and teams rather than an overall ‘vision’ for how these methods might complement each other. New developments that have come along in recent years have been difficult to retrofit onto data and approaches from the early days of excavation. Without clear questions, we run the risk of collecting data that is not informative for the questions we are asking.

Whilst there is some conflict here between multivocality and multiproxy, they could be seen as two ways of looking at the same thing. Multiproxy in the process of data gathering, under a ‘soft’ direction to manage comparability, and multivocality in the process of interpretation. Multiproxy enables a better comparison of data and can focus interpretations. But meaning of these signals still requires interpretation. It is this part of the process that needs multiple voices. Perhaps the hybrid approach suggested by Atalay, stressing that different stories can be true at the same time, but constraining the stories through the most robust consideration of evidence. Processes described by Hodder, lend themselves to a focused, question driven archaeology, with those questions driven by communities as well as scholarly interest. Reflecting on this reminded me of the phrase Ante-disciplinary Science’, a reflection on organisational models for team science. Though focusing on biomedical research, the issues are similar to those of archaeological science. The push for ‘interdisciplinary research teams’, with individuals of ‘proper credentials’ from different disciplines is seen as problematic, the author instead advocates for interdisciplinary individuals, who are able to synthesise and think in new ways, and create new fields, a reorganisation of the discipline (Eddy 2005).

Hodder (2008) emphasises that it is “duty to contest interpretations which violate material data”, doing so requires an ability to understand the nature of the evidence. Jones (2002 p30) argues that in order to critique scientific facts, it is necessary to carry them out yourself, or at least to have experience and understanding of how the facts are produced. Otherwise the process of data creation cannot be easily criticised. Killick (2015) goes as far as suggesting that there is a “refusal to learn basic principles of technology” for some types of techniques. If we do not understand the basics of how a method works, and where the data is coming from, it is impossible to come up with our own interpretation of that data. We have to rely on the interpretation of others. What are the implications of this for multivocality?

Whither multi proxy?

You want to go where a question takes you, not where your training left you” (Eddy 2005)

Is a multi proxy approach always necessary? When/how should they be combined, with each other and with macros? It is clear that ‘multi proxy’ approaches can offer a great deal of insight, and are an important means of reducing the equifinality of interpretations, but it depends on the questions. Certainly we do not need ‘all the methods, all the time’. Different analytical techniques are not always applicable in different contexts. Analyses at Çatalhöyük have shown that some methods arguably do not produce useful data, or tell us things other than what we hoped. We need to be willing to change our focus on a particular method, and focus on the question being asked. Indeed, the strength of multiproxy analysis is its ability to provide multiple data around a particular question.

Studies at Çatalhöyük and elsewhere have shown that 'over exposure' of new methods can lead to them being discredited when answers are not as clear as was hoped. A recent critique of geochemical mapping (Oonk et al. 2009) discusses the problems in distinguishing archaeological signals from modern ones, and how best to integrate geochemistry with other methods. The authors suggest caution in the use of geochemistry as a 'mapping' tool, and Çatalhöyük shows that other methods are more effective in terms of the detail they can provide. However, as Canti and Husimann (2015) note, such problems can be overcome by asking the right questions, both in terms of what is meaningful archaeologically, but also with regards to the level of detail a method can provide. Spatial geochemical mapping is arguably not very informative if our interest is in defining activities, but it can provide focus for other techniques. The use of 'spot tests' to target areas of interest is proposed as a screening method for more time consuming techniques such as ICP and GCMS (Middleton et al. 2010), and pXRF also provides possibilities for rapid screening. All of this would enable the most productive sampling for micromorphology.

A third phase of micromorphology and high resolution geochemistry work began in 2013. Although the full results of this are not yet available, the aims of the work are to have a greater integration between micro methods and macros (Garcia-Suarez 2013, 2014, 2015). A new pilot study (Madella 2014) also proposes to address the use of space question brings together geochemical (ICP), starch and phytolith proxies, lipid and protein residues, with spatial analysis. A renewed interest in geochemical patterning is welcomed, especially the simultaneous application of techniques rather than separate sampling strategies. This new approach builds on previous research at Çatalhöyük, where such an approach was aspired to but not achieved. Whilst it is unclear how this will account for the taphonomic problems identified by Middleton and Cessford in linking these data to specific activities, and distinguishing materials versus activities, it will enable a real multiproxy data comparison, and allow us to assess which of these methods is most informative.

It is clear that whichever techniques we choose, it is essential that they are integrated from the beginning if we want to be able to meaningfully compare the data. Çatalhöyük can be compared with the Central Zagros Archaeological Project (CZAP), chosen as it is one which the author has experience of, and was also designed by a PI with experience of Çatalhöyük (Matthews et al. 2013). The Central Zagros Archaeological Project, designed as a 4 year project, aimed specifically to use a multi proxy approach at the micro and macro scale. The sampling strategies of the CZAP project were designed to address a set of specific questions, including use of space within buildings and the wider settlement. The smaller team size and a focused set of aims and objectives enabled a sampling strategy to be designed which had a real integration of the different methods. Thin section micromorphology blocks were sub-sampled at a high resolution for geochemical analysis, and ash layers were sampled at a high resolution alongside block collection in the field. A combination of phytolith analysis, and organic geochemical analysis enabled an identification of stratified layers of human and animal dung. Likewise, phytolith analysis could distinguish between animal dung layers and other types of ash deposits – a distinction that could only be made through combining with thin section micromorphology. The experience of working at Çatalhöyük, combined with the smaller team size and focused direction undoubtedly played a role in the efficiency. Integration between micromorphology, phytoliths and organic geochemistry provided a very powerful suite of evidence for the change in use of space of a building, and some of the earliest evidence for animal penning (Matthews 2013, Shillito et al 2013). This type of focused study would not be possible with a more exploratory approach, or if the sampling for different methods occurred separately. CZAP makes it clear that reflexive methods are possible, and powerful, and a very efficient way to get the most out of smaller scale projects.

New GIS approaches have seen the biggest drive to multi proxy approaches. We are better able to visualise the relationships between data, including that not generated by ourselves (Forte et al 2015). The 3D digging project established in 2009 has created 3D models of houses, and has the potential to map multiple datasets, and hopefully these will eventually incorporate microstratigraphic data. It is interesting to see that the early inspiration for the project came from microstratigraphic analysis, and the problem of creating artificial units (Forte et al. 2012). The visualisation of in situ relationships is something that micromorphology has long aimed to promote, but has been limited. If geoarchaeology wants to be integrated into routine analysis, we need to focus on ways of addressing different scales, and understanding of our data (Aldeia and Goldberg 2016).

The GIS model is almost like a thin section, but at the macroscale, and with a spatial dimension. It is possible that in future geochemical mapping could be plotted alongside microstratigraphy, enabling a better comparison between the spatial resolution offered by the former, and the focused and high resolution temporal detail offered by the latter, whether this data tells us about materials or activities. It is frustrating that such possibilities have arisen towards the end of excavations, but at the same time indicates exciting possibilities for the future in archaeology. Such visualisations perhaps will enable a better understanding of the data for those who did not produce it, which in turn will enable a 'data constrained' multivocality.

Conclusions

So what are the key lessons for archaeological epistemology that we can learn from the history of multivocality and multi proxy approaches to use of space at Catalhoyuk? Central to archaeological theory is interpretation, and the process by which we collect, synthesise and assess the evidence is crucial to interpretation. The diversity of materials we work with and the nature of most archaeological training, means there is a tendency to gravitate towards particular disciplines, which impacts the practice of archaeology and how we design archaeological projects. Interpretation cannot be separated from the methodological process, it is a dynamic system where all parts are interlinked, and the process of archaeology needs to reflect this.

Raab and Goodyear argue that 'middle range theory' is primarily methodological, and does not deal with the problems of cultural dynamism. Yet archaeology is a methodology, a way of using the material evidence of the past to address questions that are also the concern of present day anthropology, geography. The nature of archaeological knowledge cannot be separated from the method of doing archaeology. The closer we look, the more complex things get, and 'middle range' remains a useful concept to show how interpretation links to data

Part of the aims at Catalhoyuk were to show the strengths of materials being considered together and that multivocality is achievable and necessary (Farid). The history of how this has been approached in relation to activity areas demonstrates that interpretation depends heavily on our way of working, and that the hardest part of multiproxy analysis is putting it into practice. How do we best collect and integrate evidence, and how can teams of specialists (and other stakeholders) work together in this process? In earlier phases, the process of doing multiproxy analysis was hindered by methods of data collection that meant data was not always comparable, but also the practicalities of interpretation and publication. In the 1990s the project was ahead of its time, and we are only just realising the potential of digital technology for recording and visualization that can help deal with complex multiple data. However we also need to ensure that everyone gets fair acknowledgement for their contributions in a profession where 'reward' is highly centred on individual achievement, a related but separate discussion.

Both formation processes and behaviour can be most effectively understood through multi proxy approaches, where all available lines of evidence are considered together, throughout the whole research process, not just at the point of interpretation. Later multiproxy approaches at Çatalhöyük have shown that formation processes of floors and activity surfaces, are simply not related to the activities that were occurring in them. The signals that we read are the result of other processes, such as construction and maintenance. Thus 'use of space' is not, as initially hoped, any easier to determine through micro approaches as through traditional macro approaches. The insights from geoarchaeology show its key role as a linking tool, but we still have a way to go in determining how best to bring together data from different scales of analysis.

It is notable that early research at Catalhoyuk was not driven by questions as much as methods, and a commitment to reflexivity and multivocality (Farid). The most successful integrations have been where smaller groups have come together to address very focused questions. There are similarities again with Birks and Birks' (2006) requirements for successful multi proxy research in palaeoecology. An exploratory approach that initially focused on the practice of archaeology, rather than strict research questions (Farid 2015), has generated a huge amount of data and making this meaningful is a challenge (Berggren et al. 2015). As numbers of researchers increased, so did multiple agendas, with integration hindered by a lack of overall umbrella to archaeological science. The results of the third phase remain to be seen, though it seems that better integration may be achieved (Barański et al. 2015).

A question driven approach to research, where a team is managed closely by a PI enables more effective data integration, but runs the risk of reducing multivocality. What do we want to know about the past, and why do we want to know it? Who will it impact and how can we incorporate those views? From the phase of research design, we should ask why we are doing archaeology, and what outcomes we want to achieve for different stakeholders, beyond the academic interest. With the increased emphasis on impact in the UK setting, the ‘so what’ question is becoming more important. Catalhoyuk centred this with its focus on multivocality and involvement beyond academia

How can archaeologists and other stakeholders undertake their own interpretations of multiproxy data, if they do not understand the nature of that data (and its limitations) and how it has been generated? We can only truly understand the possible meanings of the data if we understand the nature of the data and how it has been produced. There is an aspect of training here, and also one of transparency. We need to have less emphasis on being specialists, and ensure that our data is presented in a way that makes it easy for all stakeholders to understand. Multivocality requires antediscplinary thinking, where multiple voices can access and appreciate the data. This is different to simply borrowing the conclusions from other research.

An ‘ante-disciplinary’ approach should be the central focus of developing archaeology. Our strength is the potential to take a diversity of materials and data, and to understand how that diversity can tell us something specific about the human past. Processual and post-processual archaeology are a continuum. Archaeology is both a science, in that it applies methods and concepts from science, and an art, in that it requires consideration of the data in light of human complexity. Archaeology is a process which includes both (semi) objective data gathering, and a diversity of explanations, recognising that even ‘scientific’ data are influenced by our sampling, methods, and equipment limits, as well as our own situations.

Acknowledgements

Many thanks to Dr Serena Love and Dr Chris Fowler for their invaluable comments on drafts of this paper. Thank you also to two anonymous referees for their helpful comments.

References

Albert, RM., Lavi, O., Estroff, L. Weinder, S. Tsatskin, A., Ronen, A. and Lev-Yadun, S. 1999. Mode of occupation of Tabun Cave, Mt Carmel, Israel during the Mousterian Period: a study of the sediments and phytoliths *Journal of Archaeological Science* 26: 1249-1260.

Anderson, E., Almond, M. J., Matthews, W., Cinque, G. and Frogley, M. D. (2014a) Analysis of red pigments from the Neolithic sites of Çatalhöyük in Turkey and Sheikh-e Abad in Iran. Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy, 131. pp. 373-383. ISSN 1386-1425

Anderson, E., Almond, M. and Matthews, W. (2014b) Analysis of wall plasters and natural sediments from the Neolithic town of Çatalhöyük (Turkey) by a range of analytical techniques. *Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy*, 133. pp. 326-334. ISSN 1386-1425

Asscher, Y. and Goren, Y. 2016. A rapid on-site method for micromorphological block impregnation and thin section preparation *Geoarchaeology 31: 324-331*

Bailey, G. and Galanidou, N. (2009): Caves, palimpsests and dwelling spaces: examples from the Upper Palaeolithic of south-east Europe, *World Archaeology* 41:2, 215-241

Banerjea, R., Bell, M., Matthews, W. and Brown, A. 2015. Applications of micromorphology to understanding activity areas and site formation processes in experimental hut floors *Archaeological and anthropological sciences* 7: 89-112.

Barański, M., García-Suárez, A., Klimowicz, A., Love, S. and Pawłowska, K. 2015. The architecture of Neolithic Çatalhöyük as a process: complexity in apparent simplicity. In Hodder, I. and Arkadiusz Marciniak (Ed.), *Assembling Çatalhöyük* (pp. 111-126) Leeds, W Yorks, United Kingdom: Maney Publishing.

Barba, L. 2007. Chemical residues in lime-plastered archaeological floors *Geoarchaeology* 22: 439-452.

Bayliss A, Brock F, Farid S, Hodder I, Southon JR & Taylor RE (2015) Getting to the Bottom of It All: A Bayesian Approach to Dating the Start of Çatalhöyük, *Journal of World Prehistory*, 28 (1), pp. 1-26

Berggren A. 1998a. Excavation Diary Entry 17/08/1998
http://www.Çatalhöyük.com/database/catal/diaryrecord.asp?id=174

Berggren A. 1998b. Excavation Diary Entry 10/09/1998
http://www.Çatalhöyük.com/database/catal/diaryrecord.asp?id=202

Beggren, A, Dell'Unto, N., Forte, M., Haddow, S., Hodder, I., Iassavi, J., Lercari, N., Mazzucato, C. Mickel, A. and Taylor, J. 2015. Revisiting reflexive archaeology at Catlahoyuk: integrating digital and 3D technologies at the trowel's edge *Antiquity 89*: 433-448.

Berggren, A and Nilsson, B. 2014. Going Back, Looking Forward: Reflexive Archaeology or Reflexive Method? In Hodder, I. ed. *Integrating Çatalhöyük: themes from the 2000-2008 seasons*.

Birks, H.H. and Birks, H.J.B. 2006. Multi proxy studies in palaeolimnology *Vegetaiton History and Archaeobotany* 15: 235-251.

Boivin, N. 2003. Geoarchaeology and the Goddess Laksmi: Rajasthani insights into geoarchaeological methods and prehistoric soil use. In Boivin, N. and Owoc. M.A. (eds) *Soils, Stones and Symbols: Cultural perceptions of the mineral world.* Routledge.

Boivin, N., (2000), Life rhythms and floor sequences: Excavating time in rural Rajasthan and Neolithic Çatalhöyük,World Archaeology, 31(3),367-88

Bogaard, A., Ryan, P., Yalman, N., Asouti, E., Twiss, K.C., Mazzucato, C. and Farid, S. 2014. Assessing outdoor activities and their social implications at Çatalhöyük. In I. Hodder (ed.), *Integrating Çatalhöyük: themes from the 2000-2008 seasons*. Los Angeles: Monographs of the Cotsen Institute of Archaeology, University of California at Los Angeles, pp. 123-147.

Bogaard, A., Charles, M., Twiss, K.C., Fairbairn, A., Yalman, N., Filipovic, D., Demirergi, G.A., Ertug, F., Russell, N and Henecke, J., (2009), Private pantries and celebrated surplus: storing and sharing food at Neolithic Çatalhöyük, *Antiquity* 83:649-668.

Campbell, S. 2008. Publishing Çatalhöyük: multivocality in action? *Antiquity* 316. http://antiquity.ac.uk/reviews/campbell316.html

Canti, M. and Husimann, DJ. 2015. Scientific advances in geoarchaeology during the last twenty years *Journal of Archaeological Science* 56: 96–108.

Carter, T. 2011. 'A true gift of mother earth: the use and significance of obsidian at Çatalhöyük', *Anatolian Studies* 61: 1-19.

Cessford, C. 2003. Microartifactual floor patterning: the case at Çatalhöyük. Assemblage 7 http://www.assemblage.group.shef.ac.uk/issue7/cessford.html

Diehl, M. W. 1998. The interpretation of archaeological house floor assemblages: a case study from the American Southwest. American Antiquity 63: 617-634.

Eddy, S.R. 2005. "Antedisplinary" Science *PLOS Computaional Biology* http://dx.doi.org/10.1371/journal.pcbi.0010006

Farid, S. 2015. 'Proportional representation': multiple voices in archaeological interpretation at Çatalhöyük in Chapman, R. and Wylie, A. eds. *Material Evidence: learning from archaeological practice*. Routledge. 59-78.

Fernández, F. G., Terry, R. E., Inomata, T. and Eberl, M. (2002), An ethnoarchaeological study of chemical residues in the floors and soils of Q'eqchi' Maya houses at Las Pozas, Guatemala. *Geoarchaeology,* 17: 487–519

Forte, M. Dell'Unto, N., Issavi, J., Onsurez, L. and Lercari, N. 2012. 3D Archaeology at Çatalhöyük *International Journal of Heritage in the Digital Era* 3: 351-378.

Foxhall, L. 2000. The running sands of time: archaeology and the short term. *World Archaeology*. 31: 484-498.

García-Suárez, A. 2013 Households in context: A microstratigraphical investigation of resource use and site networks Archive report 2013 p262-264. http://www.Çatalhöyük.com/downloads/Archive_Report_2013.pdf

García-Suárez, A. 2014. Micromorphology: A High-resolution Investigation of Neolithic Intra- and Inter-site Relationships Archive Report 2014. P.208-210.

García-Suárez, A. 2015. Micromorphology: High-resolution Contextual Analysis of Buildings and Open Areas. Archive Report 2015.

Goldberg, P. and Aldeias, V. 2016. Why does (archaeological) micromorphology have such little traction in (geo)archaeology? Archaeological and Anthropological Sciences

Hardy, K, van de Locht, R, Wilson, J & Tugay, O 2013, 'Starch granules and complex carbohydrates at Çatalhöyük'. in I Hodder (ed.), *Humans and landscapes of Çatalhöyük: reports from the 2000-2008* *seasons. McDonald Institute for Archaeological Research Monograph. Hodder I (ed.).* British Institute of Archaeology at Ankara

Haydon, B. and Cannon, A. 1983. Where the garbage goes: refuse disposal in the Maya highlands *Journal of Anthroplogical Archaeology* 2: 117-163.

Hodder, I. and Cessford, C. 2004. Daily practice and social memory at Çatalhöyük, *American Antiquity* 69.1, 17-40

Hodder, Ian (ed) 2000, *Towards reflexive method in archaeology : the example at Çatalhöyük*, McDonald Institute for Archaeological Research, University of Cambridge ; Oxford : Distributed by Oxbow Books, Cambridge

Hodder, I. 2008. Multivocality and social archaeology in Habu, J., Fawcett, C. and Matsunga, J.M. (eds) *Evaluating Multiple Narratives: beyond nationalist, colonialist, imperialist archaeologies.* Springer.

Hull, KL. 1987. Identification of cultural site formation processes through microdebitage analysis *American Antiquity* 52: 772-783.

Jones, A. 2002. Archaeological theory and Scientific practice. Cambridge.

Karkanas, P. Efstratiou, N. 2009. Floor sequences in Neolithic Makri, Greece: micromorphology reveals cycles of renovation. Antiquity 83, 955-967.

Killick, D. 2015. The awkward adolescence of archaeological science. Journal of Archaeological Science 56: 242-247.

Kosso, P. 1991. Method in archaeology: middle range theory as hermeneutics *American Antiquity* 4: 621-627.

LaMotta, VM and Schiffer, MB. 1999. Formation processes of house floor assemblages. In Allison, P (ed) *The Archaeology of Household Activities* Routledge.

Llobera, M. 2011. Archaeological visualization: towards an archaeological information science (AISc). *Journal of Archaeological Method and Theory* 18(3): 193---223.

Marciniak, A., M.Z. Barański, A. Bayliss, L. Czerniak, T. Goslar, J. Southon and R.E. Taylor. 2015. Fragmenting times: interpreting a Bayesian chronology for the late Neolithic occupation of Çatalhöyük East, Turkey. *Antiquity*, 89: 154–176

Matthews, W., French, C. A. I., Lawrence, T. and Cutler, D. 1996. Multiple surfaces: the micromorphology. In *On the surface: Çatalhöyük 1993-95*(Ed. Hodder, I.). McDonald Institute for Archaeological Research and British Institute of Archaeology at Ankara, Cambridge, pp. 301-342.

Matthews, W. and C. A. Hastorf. 2000. Integrating Archaeological Science in Hodder, I. ed. *Towards reflexive method in archaeology: the example at Çatalhöyük.* McDonald Institute for Archaeological Research and British Institute of Archaeology at Ankara, Cambridge

Matthews, W. (1998). Report on sampling strategies, microstratigraphy and micromorphology of depositional sequences, and associated ethnoarchaeology at Çatalhöyük *ÇATALHÖYÜK 1998 ARCHIVE REPORT* http://www.Çatalhöyük.com:8080/archive_reports/1998/ar98_06.html

Matthews, W. (2000) Microstratigrapic and Micromorphological Analysis *ÇATALHÖYÜK 2000 ARCHIVE REPORT* http://www.Çatalhöyük.com:8080/archive_reports/2000/ar00_07.html

Matthews, W., Shillito, L-M. and Almond, MJ. 2004. Micromorphology: investigation of Neolithic social and ecological strategies at seasonal, annual and life-cycle timescales. Çatalhöyük Archive Report http://www.Çatalhöyük.com/archive_reports/2004/ar04_22.html

Matthews, W. 1995. Archaeological Sediments and Soils: Analysis, Interpretation and Management. Institute of Archaeology, University College London. Pages 41-74

Matthews, W., French, C. A. I., Lawrence, T., Cutler, D. F. and Jones, M. K. 1997. Microstratigraphic traces of site formation processes and human activities. *World Archaeology*, 29**,** 281-308.

Matthews, W. 1995. Sampling report *ÇATALHÖYÜK 1995 ARCHIVE REPORT*

Matthews, W. 1996. Microstratigraphy, micromorphology and sampling report. *ÇATALHÖYÜK 1996 ARCHIVE REPORT*

Matthews, W. 1997. Report on sampling strategies, and analyses of the microstratigraphy and micromorphology of depositional sequences at Çatalhöyük, 1997 *ÇATALHÖYÜK 1997 ARCHIVE REPORT*

Matthews, W. 1998. Report on sampling strategies, microstratigraphy and micromorphology of depositional sequences, and associated ethnoarchaeology at Çatalhöyük, 1998

Matthews, R., Matthews, W. and Mohamadifar , Y., eds. (2013) The earliest Neolithic of Iran: 2008 excavations at Sheikh-E Abad and Jani. CZAP Report , 1. British Institute of Persian Studies and Oxbow Books, Oxford.

Matthews, W. (2010) Geoarchaeology and taphonomy of plant remains in early urban environments in the Ancient Near East. Quaternary International, 214 (1-2). pp. 98-113.

Matthews, W. (2012) Defining households: micro-contextual analysis of early Neolithic households in the Zagros, Iran. In: Parker, B. J. and Foster, C. P. (eds.) *Household archaeology: new perspectives from the Near East and beyond.* Eisenbrauns, Winona Lake, pp. 183-216

Matthews, W., Almond, M., Anderson, E., Wiles, J. and Stokes, H. (2013) Biographies of architectural materials and buildings: integrating high-resolution micro-analysis and geochemistry. In: Hodder, I. (ed.) *Substantive technologies at Çatalhöyük: reports from the 2000-2008 seasons*: Çatal Research Project vol. 9. British Institute at Ankara Monograph. Oxbow Books/ British Institute of Archaeology at Ankara, Oxford. ISBN 9781898249313

Matthews, W. (2012) Household life-histories and boundaries. In: Tringham, R. and Stevanovic, M. (eds.) *Last House on the Hill: BACH Area Reports from Çatalhöyük, 1997-2003.* Monumenta Archaeologica (27). Cotsen Institute of Archaeology Press and British Institute at Ankara, Los Angeles, pp. 205-224

Matthews, R., Matthews, W. & Mohammadifar, Y. (Eds). 2013. *The Earliest Neolithic of Iran: 2008* Excavations at Sheikh-E Abad and Jani. CZAP Reports Vol. 1. Oxford: Oxbow Books and British Institute for Persian Studies.

Middleton, W. (1998) Collection of Soil and Sediment Samples for the Chemical Identification of Activity Areas at Çatalhöyük *ÇATALHÖYÜK 1998 ARCHIVE REPORT* *http://www.Çatalhöyük.com:8080/archive_reports/1998/ar98_07.html*

Middleton, W. D. (2004), Identifying Chemical Activity Residues on Prehistoric House Floors: A Methodology And Rationale For Multi-Elemental Characterization of a Mild Acid Extract of Anthropogenic Sediments. Archaeometry, 46: 47–65.

Middleton, W.D., T.D. Price & D.C. Meiggs, 2005. Chemical analysis of floor sediments for the identification of anthropogenic activity residues, in *Inhabiting Çatalhöyük: Reports from the 1995–99 Seasons*, ed. I. Hodder. (McDonald Institute Monographs/BIAA Monograph 38.) Cambridge: McDonald Institute for Archaeological Research/London: British Institute at Ankara, 399–412

Middleton, W. D. and Price, D. T. 1996. Identification of activity areas by multi-element characterization of sediments from modern and archaeological house floors using inductively coupled plasma-atomic emission spectroscopy. *Journal of Archaeological Science*, 23, 637-687.

Milek, K. Floor formation processes and the interpretation of site activity areas: An ethnoarchaeological study of turf buildings at Thverá, northeast Iceland *Journal of Anthropological Archaeology* 31: 119-137.

Milek, KB. & Roberts, HM. (2013). 'Integrated geoarchaeological methods for the determination of site activity areas: A study of a Viking Age house in Reykjavik, Iceland'.*Journal of Archaeological Science*, vol 40, no. 4, pp. 1845-1865

Oonk, S. Slomp, CP. And Husiman, DJ. 2009. Geochemsity as an aid in archaeological prospection and site interpretation: current issues and research directions Archaeological Prospection 16: 35-51.

Owoc, M.A. 2003. A phenomenology of the buried landscape: soil as material culture in the Bronze Age of South-West Britain. In Boivin, N. and Owoc. M.A. (eds) *Soils, Stones and Symbols: Cultural perceptions of the mineral world*. Routledge.

Regev, L., Cabanes, D., Homsher, R., Kleiman, A., Weiner, S., Finkelstein, I. and Shahack-Gross, R. 2015. Geoarchaeological Investigation in a Domestic Iron Age Quarter, Tel Megiddo, Israel. Bulletin of the American Schools of Oriental Research, lletin of the American Schools of Oriental Research (2015), pp. 135-157

Rosen, AM; (2005) Phytolith indicators of plant and land use at Çatalhöyük. In: Çatalhöyük Project Volume IV: Inhabiting Çatalhöyük. McDonald Institute of Archaeology: Cambridge.

Rosen, AM. (2000). Phytoliths. ÇATALHÖYÜK 2000 ARCHIVE REPORT http://www.Çatalhöyük.com:8080/archive_reports/2000/ar00_17.html

Rosen, AM. 1998. Archive Report on Phytolith Studies at Çatalhöyük *ÇATALHÖYÜK 1998 ARCHIVE REPORT* http://www.Çatalhöyük.com:8080/archive_reports/1998/ar98_08.html

Rountree, K. 2003. Reflexivity in practice ÇATALHÖYÜK 2003 ARCHIVE REPORT http://www.Çatalhöyük.com:8080/archive_reports/2003/ar03_20.html

Shahack-Gross, R. 2011. Household archaeology in Israel: looking into the microscopic record, in Yasur-Landau, A., Ebeling, JR and Mazow, LB. (eds) *Household Archaeology in Ancient Israel and Beyond* Brill. P.27-36.

Shahack-Gross, R., Marshall, F., Ryan, K. and Weiner, S. 2004. Reconstruction of apatial organisation in abandoned Maasai settlements: implications for site structure in the Pastoral Neolithic of East Africa *Journal of Archaeological Science* 31: 1395-1411.

Shahack-Gross, R., Marshall, F., and Weiner, S. 2003. Geo-ethnoarchaeology of pastoral sites: the identification of livestock enclosures in abandoned Maasai settlements *Journal of Archaeological Science* 30: 439-459.

Shahack-Gross, R., Rosa-Maria Albert, Ayelet Gilboa, Orna Nagar-Hilman, Ilan Sharon, Steve Weiner 2005. Geoarchaeology in an urban context: The uses of space in a Phoenician monumental building at Tel Dor (Israel), Journal of Archaeological Science Volume 32, Issue 9: 1417-1431

Schiffer, MB. 1983 Toward the identification of formation processes. *American Antiquity* 48: 675-706

Schiffer, M.B. 1985. Is there a 'Pompeii Premise' in archaeology? *Journal of Anthropological Research*. 41: 18 – 41.

Schiffer, M. B. 1987. *Formation Processes of the Archaeological Record.* University of New Mexico Press.

Schiffer, M.B. 1988. The structure of archaeological theory *American Antiquity* 53: 461-485.

Schiffer, M. B. 1972. Archaeological context and systemic context *American Antiquity* 37: 156-165.

Schott, MJ. 1998. Status and role of formation theory in contemporary archaeological practice Journal of Archaeological Research 6: 299-329.

Shillito, L-M. 2015. The beauty and frustration of single moments, frozen in time *ThenDig* http://arf.berkeley.edu/then-dig/2015/02/the-beauty-and-frustration-of-single-moments-frozen-in-time/

Shillito L-M. 2011. Simultaneous thin section and phytolith observations of finely stratified deposits from Neolithic Çatalhöyük, Turkey: implications for paleoeconomy and Early Holocene paleoenvironment. *Journal of Quaternary Science* 26(6), 576–588.

Shillito L-M, Matthews W, Bull ID, Williams J. 2013. Biomolecular investigations of faecal biomarkers at Sheik-e Abad and Jani. *In:* Matthews, R; Matthews, W; Mohammadifar, Y, ed. *The Earliest Neolithic of Iran: 2008 Excavations at Sheikh-e Abad and Jani*. Oxford: Oxbow and British Institute for Persian Studies, pp.105-115.

Shillito, L.-M., Bull, I. D., Matthews, W., Almond, M. and Evershed, R. P. (2013) Integrated geochemical and microscopic analysis of human coprolites, animal dung and organic remains in burials. In: Hodder, I. (ed.) Çatalhöyük Excavations: Humans and Landscapes of Çatalhöyük Excavations. Çatalhöyük Research Project Volume 8. British Institute of Archaeology at Ankara. ISBN 9781898249306

Shillito, L.-M. and Matthews, W. (2013) Geoarchaeological investigations of midden-formation processes in the early to late Neolithic levels at Çatalhöyük, Turkey ca. 8550-8370 cal BP. Geoarchaeology, 28 (1). pp. 25-49. ISSN 1520-6548

Shillito L-M, and Ryan P. 2013. Surfaces and streets: phytoliths, micromorphology and changing use of space at Neolithic Çatalhöyük (Turkey). Antiquity 87(337), 684 – 700

Shillito, L.-M., Matthews, W. and Almond, M. (2013) Ecology, diet and discard practices: new interdisciplinary approaches to the study of middens – integrating micromorphological, phytolith and geochemical analyses. In: Hodder, I. (ed.) Çatalhöyük excavations: Humans and Landscapes of Çatalhöyük excavations: Çatal research project. BIAA Monograph, 8 (47). British Institute of Archaeology at Ankara, London

Shillito, L.-M., Matthews, W., Almond, M. J. and Bull, I. D. (2011) The microstratigraphy of middens: capturing daily routine in rubbish at Neolithic Çatalhöyük, Turkey. *Antiquity*, 85 (329). pp. 1024-1038

Shillito, L. M., Almond, M. J., Nicholson, J., Pantos, M. and Matthews, W. (2009) Rapid characterisation of archaeological midden components using FT-IR spectroscopy, SEM-EDX and micro-XRD. *Spectrochimica Acta Part a-Molecular and Biomolecular Spectroscopy*, 73 (1). pp. 133-139. ISSN 1386-1425

Sulas, F. and Madella, M. 2012. Archaeology at the microscale: micromorphology and phytoliths at a Swahili stone town *Archaeological and Anthropological Sciences* 4: 145-159.

Terry, R.E., Fernández, F.G., Parnell, J.J., & Inomata, T. (2004). The story in the floors: Chemical signatures of ancient and modern Maya activities at Aguateca, Guatemala. Journal of Archaeological Science, 31, 1237–1250.

Trigger, B. 1995. Expanding middle range theory *Antiquity* 69: 449-458.

Trigham, R. 2012. Households through a digital lens. In Parker, BJ. And Foster, CP (eds). *New Perspectives on Household Archaeology*. Indiana. Eisenbrauns.

Tsartsidou, Georgia, Lev-Yadun, S., Efstratiou, N and Weiner, S. 2009. Use of space in a Neolithic village in Greece (Makri): phytolith analysis and comparison of phytolith assemblages from an ethnographic setting in the same area *Journal of Archaeological Science* 36: 2342-2352.

Twiss, KC; Bogaard, A; Bogdan, D; Carter, T; Charles, MP; Farid, S; Russell, N; (2008) Arson or accident? The burning of a Neolithic house at Çatalhöyük, Turkey**.** *Journal of Field Archaeology***.** 33 (1) pp. 41-57

Ullah, II., Duffy, PD and Banning, EB. 2015. Modernising spatial micro-refuse analysis: new methods for collecting, analysing, and interpreting the spatial patterning of micro-refuse from house floor contexts *Journal of Archaeological Method and Theory* 22: 1238-1262.

Van de Locht, R. and hardy, K. 2009. Starch ÇATALHÖYÜK 2009 ARCHIVE REPORT http://www.Çatalhöyük.com/sites/default/files/media/pdf/Archive_Report_2009.pdf

Wiles, Joanne 2008 An analysis of plaster sequences from the Neolithic site of Catalhoyuk (Turkey) by microspectroscopic techniques. PhD thesis, University of Reading.

Wilk, W.L. and Rathje, W.L. 1982. Household Archaeology. *The American Behavioural Scientist* 25: 617 – 640.

Wylie, A. 2007. The Integrity of Narratives: Epistemic Constraints on Multivocality," in *Evaluating Multiple Narratives: Beyond Nationalist, Colonialist, Imperialist Archaeologies*, edited by Junko Habu, Clare Fawcett, and John Matsunaga, Springer Publications, pp. 201-212