The microstratigraphy of middens: capturing daily routine in rubbish at Neolithic Çatalhöyük, Turkey

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The microstratigraphy of middens: capturing daily routine in rubbish at Neolithic Çatalhöyük, Turkey

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Microstratigraphy — the sequencing of detailed biological signals on site — is an important new approach being developed in the Çatalhöyük project. Here the authors show how microscopic recording of the strata and content of widespread middens on the tell are revealing daily activities and the selective employment of plants in houses and as fuel. Here we continue to witness a major advance in the practice of archaeological investigation.

Keywords: Çatalhöyük, Neolithic, Chalcolithic, microstratigraphy, micromorphology, phytoliths, middens

Introduction

Çatalhöyük is a tell site in the Anatolian region of Turkey with an occupation spanning the early Neolithic to Chalcolithic. The site consists of two mounds — the larger, mainly Neolithic east mound, and the smaller Chalcolithic west mound (Figure 1a). The east mound covers an area of 13.5ha, with the highest point reaching *c.* 20m. Çatalhöyük is internationally recognised as one of the largest early settled villages in the world with exceptionally well preserved mud-brick architecture, faunal and botanical remains, and

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elaborate burials, wall paintings and sculptures. As such, it is a key site in understanding the Neolithic, for example the origins of complex settlements, the development of agriculture and domestication, and changing human-environment relationships (Hodder 2006).

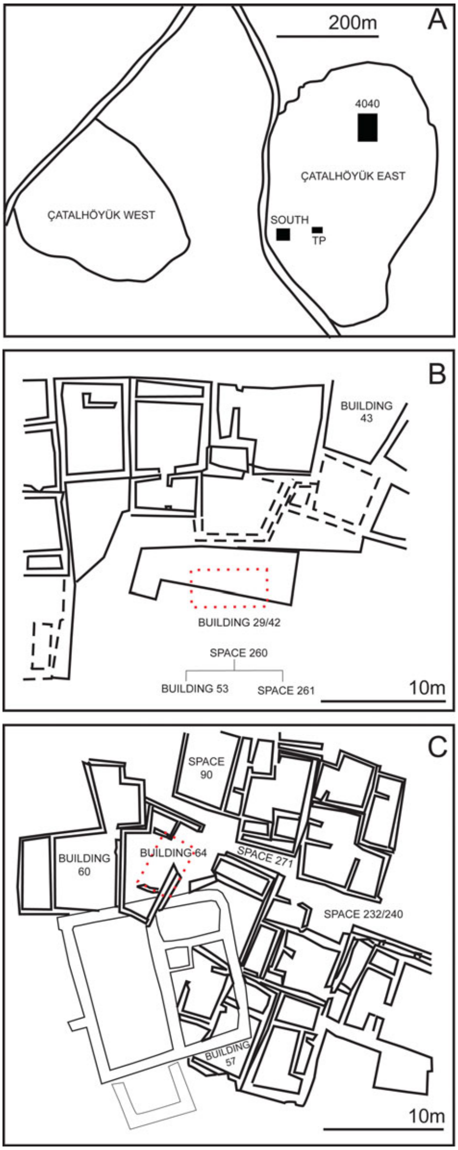

Figure 1. a) Site plan showing the three major excavation areas; b & c) simplified plans of excavated areas of buildings in the South and 4040 areas respectively, showing the location of the middens investigated. South Area midden located in Space 132, 4040 Area midden located in Space 279. For detailed plans see the Çatalhöyük online database (http://www.catalhoyuk.com/database/catal/).

Micromorphology at Çatalhöyük

Micromorphology has become an increasingly important analytical tool in understanding site formation processes and the use of space (Matthews *et al.* 1997), particularly within settlements, where it can be used to investigate the life histories of buildings at high temporal resolution (Matthews 2005; Shahack-Gross *et al.* 2005; Karkanas & Efstratiou 2009), and to understand the formation processes of deposits such as middens which are difficult to resolve at the macroscale (Simpson & Barrett 1996; Shillito *et al.* 2008). Buildings at Çatalhöyük were kept remarkably clean and have little evidence of *in situ* activity (Hodder & Cessford 2004). Micromorphology has contributed significantly to understanding the use of space by examining microscopic indicators of activity, and has demonstrated, for example, the frequent sweeping of floors and removal of micro-debris, cyclical re-plastering of walls and floors, and possible floor coverings in Buildings 1 and 5 (Matthews 2005).

Found within and between groups of buildings are extensive midden deposits, which can be up to 5m wide and over 1m high. Middens are typically composed of many individual fine layers, which are impossible to distinguish during excavation (Yeomans 2005). Studies of midden faunal assemblages have highlighted the complex histories of discarded materials (Martin & Russell 2000). Micromorphological studies of early middens in the South Area, Spaces 181 and 115 (Levels VIII and pre-XII, 6790 to pre-7070 cal BC respectively), have demonstrated the potential of the technique for distinguishing between layers and the potential of middens as indicators of activities that are absent in buildings, such as animal penning (Matthews 2005).

This study has also highlighted difficulties with the use of micromorphology on certain deposits due to the emphasis on visible components and the two dimensional nature of the samples (Matthews 2005). For example, decayed organic remains have a similar amorphous appearance to coprolites, and can only be identified further using biomolecular geochemical methods (Bull *et al.* 2005; Matthews 2005). Phytoliths, an abundant component (Rosen 2005), can also be difficult to identify depending on their orientation (Matthews 2010). Conversely, geochemical and phytolith analyses can provide identifications of these components but are unable to distinguish between different micro-contexts, and provide a general overview rather than activity-specific signals (Jenkins 2005).

The integrated microstratigraphic approach

To overcome these limitations, the integration of microscopic and analytical techniques is necessary, which can be called the microstratigraphic approach to characterising deposits (Weiner 2010). Targeted geochemical analyses such as infra-red spectroscopy (FT-IR), and scanning electron microscopy (SEM-EDX) for identifying inorganic materials (Berna *et al.* 2007; Shillito *et al.* 2009) and, less commonly, gas chromatography/mass spectrometry (GC/MS) for organic materials have been successfully integrated with micromorphology (Simpson *et al.* 1998). Integration of phytolith analysis with micromorphology is also increasingly becoming the standard approach (Albert *et al.* in press). It enables the simultaneous observation of the context and associations of deposits from individual depositional events (Matthews *et al.* 1997; Matthews 2005), as well as the identification of specific components within deposits that are problematic in thin section. For example, in buildings the integration of high resolution geochemical analysis of individual plaster layers is providing further information on the possible sources for different types of plasters (Matthews *et al.* 2010), and comparison of phytoliths from extracted samples and in thin section has contributed to understanding taphonomic impacts on conjoined phytolith size (Shillito 2011).

Fine layers in midden deposits at Çatalhöyük have not previously been examined using this microstratigraphic approach. The present study thus integrates micromorphology with geochemical (FT-IR, SEM-EDX and GC/MS) and phytolith analyses to examine cycles of deposition and activities, such as pyrotechnology, agriculture, diet and resource use. By comparing earlier and later middens it is possible to examine longer-term variations in formation processes.

Microstratigraphic analysis of middens

Three middens were examined from early to mid level deposits (South and 4040 areas, approximate to Mellaart Level V/VI, 6550–6350 cal BC) as well as the latest levels of the site (TP Area, Level III-0, 6410–6230 cal BC). The South Area midden is located in Space 261, underlying Building 53 and stratigraphically above Building 85 (Brown 2006)

(Figure 1b). The 4040 Area midden is located in Space 279, in a large central pit area, created following the abandonment of Building 64, associated with Building 60 (Yeomans 2006) (Figure 1c). The TP Area midden is located below Buildings 33 and 34 (Czerniak & Marciniak 2004) (Figure 1a).

The excavation areas and sections studied are illustrated in Figure 2. Twenty-one blocks were collected in the field by cutting from the midden face and wrapping securely with tissue and tape. Where possible, continuous sequences of finely stratified layers were sampled, as well as selective sampling that targeted features of interest such as *in situ* burning layers. The spatial extent and macroscopic features of different layers were observed to enable the microscopic observations to be related back to their macroscopic context.

Intact blocks of undisturbed sediments were firstly 'micro-excavated' in the laboratory, taking care to sample as closely as possible from individual layers. These sub-samples were collected for geochemical and microbotanical analysis, which could be directly linked to observations in thin section. After sub-sampling, blocks were oven dried at 40°C followed by impregnation with resin under vacuum. The large format of the sections (140 × 70mm) has the advantage of covering long, undisturbed sequences and reduces the number of slides that need to be prepared to obtain an overlapping sequence. Identifications and descriptions were made according to standard references (Bullock *et al.* 1985; Courty *et al.* 1989) where appropriate, and through comparison with reference collections.

Phytoliths were extracted following a method based on Rosen (2005). Following thin section observations, selected sub-samples were further characterised using FT-IR (Shillito *et al.* 2009) to aid interpretation of their composition. Thin section and phytolith observations were carried out using a Leica DMLP polarising light microscope at magnifications from ×40 to ×400, using plane (PPL) and cross polarised light (XPL). Inclusions suspected to be coprolites were analysed by GC/MS to identify species on the basis of faecal sterols and bile acids (Bull *et al.* 1999). Analysis indicates a wide range of deposit types, or microfacies (examples are presented in Figure 3). A summary of inclusion types observed in middens and their depositional characteristics is presented in Table 1.

Finely stratified ash and phytolith-rich deposits

The midden deposits are dominated by the presence of ash, which occurs both as pure fine layers and associated with fragments of bone, minerals and aggregates. Unit 12504 in the South Area, for example, consists almost entirely of such ash deposits. The variation in the colour from dark grey to almost white is observed in thin section to be a result of the percentage of microcharcoal, also observed in ash-rich deposits at Tel Dor, Israel (Berna *et al.* 2007). The presence of grass-derived microcharcoal in the dark grey ash indicates low temperature burning (Boardman & Jones 1990), and phytolith analysis of these layers indicates they consist entirely of grasses and reeds. Conversely, the pale grey ash layers in this unit consist largely of fine grained calcite from the burning of wood (Canti 2003) with sand-sized mineral inclusions.

Phytoliths are abundant, well preserved and ubiquitous throughout the middens due to the spreading and mixing of ash (Rosen 2005), of which they are a common component along with microcharcoal. Micro-excavation and extraction of phytoliths has overcome problems

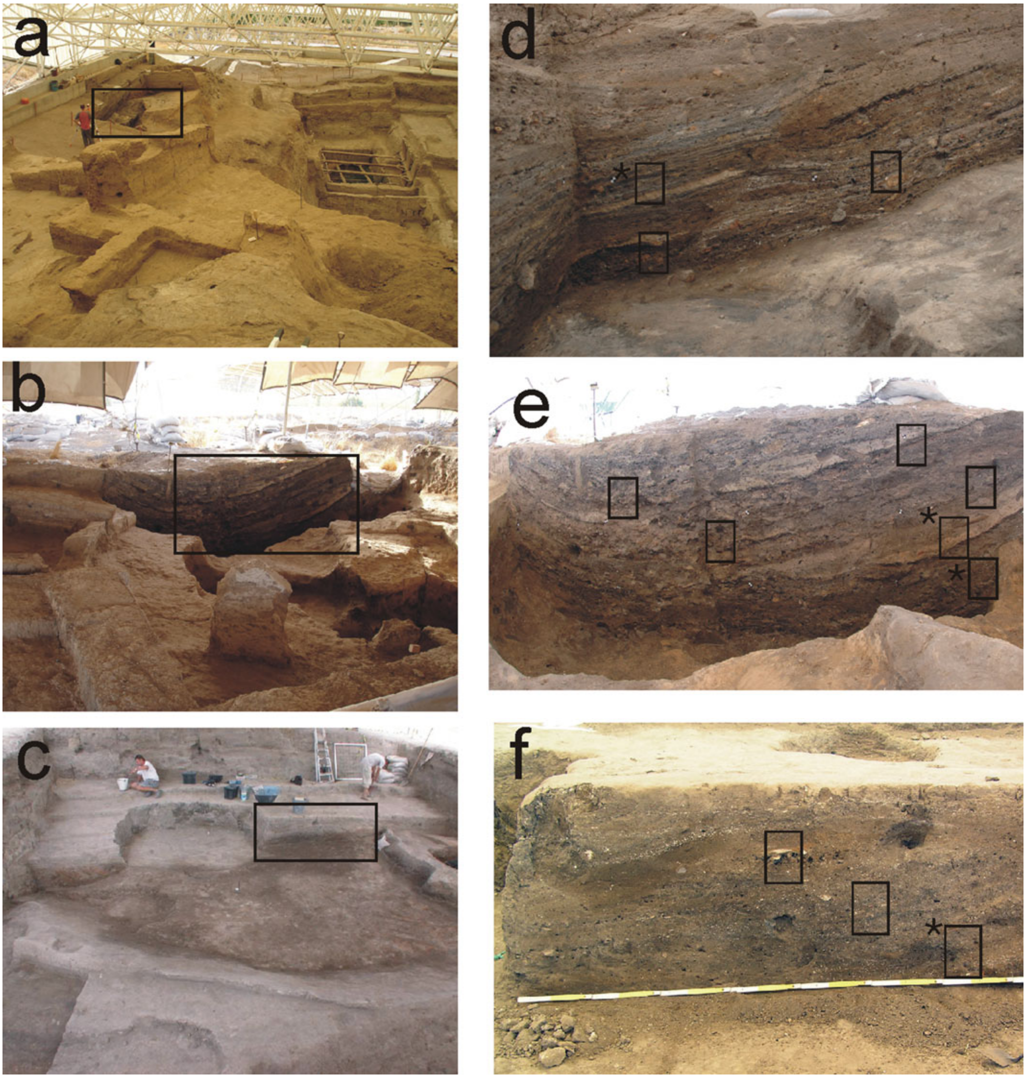

*Figure 2. Photographs of the excavation areas and midden sections studied, showing the location of the thin section samples: a) South Area excavation in 2006; b) 4040 Area excavation in 2006; c) TP Area excavation in 2004. Slides prepared from blocks marked * are shown in Figure 3 (photographs c, d and e are reproduced courtesy of the Çatalhöyük image database (http://www.catalhoyuk.com/database/catal/).*

with identification recognised by Matthews (2005), and analysis shows a dominance of wild grasses and reeds, whilst comparison with micromorphology shows the diverse range of contexts for the phytoliths. In addition to the different ashes described above, phytoliths also occur as inclusions in animal dung in all three middens (Figure 3n) with types identified including reed and grass leaves and stems, similar to the early midden deposits in Space 181 (Matthews 2005). The integration of micromorphology and extracted phytolith analysis demonstrates the similarity in the appearance of phytoliths from animal dung and

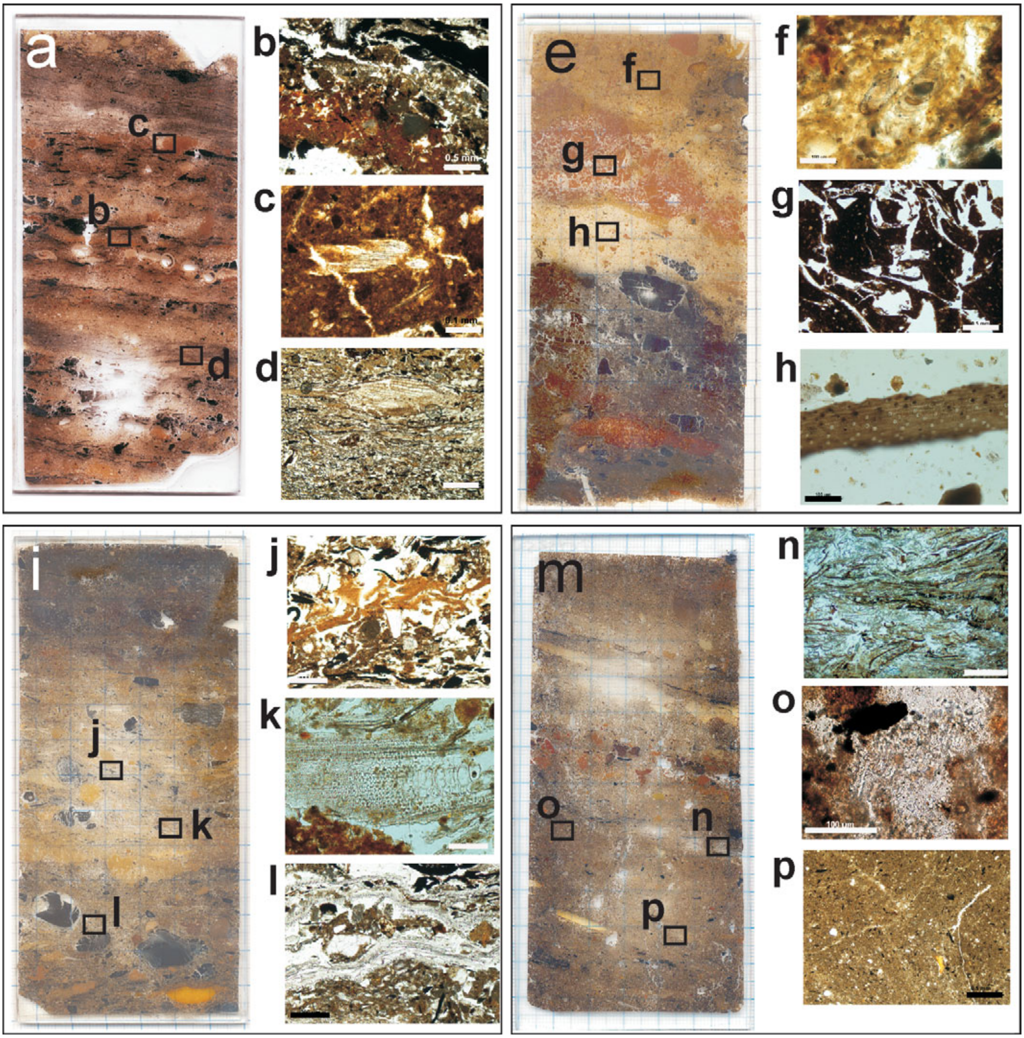

*Figure 3. Examples of thin sections from each of the excavation areas and microscope photographs of different deposit types observed in the sections (the number in brackets refers to the length of the scale bar): **a)** scan of thin section (South Area, field unit 12504 s17, sequence of finely laminated ashes); **b)** PPL. A 0.5mm thick lense of yellowish decayed organic remains overlain by partially disturbed ash and microcharcoal from low temperature burning (0.5mm); **c)** PPL. A coarse building aggregate with a pseudomorphic void from decayed plant temper – the phytoliths can be seen within the void (0.1mm); **d)** PPL. Microlaminated charred plant remains, with large sections of preserved plant tissue in the form of conjoined phytoliths (200µm); **e)** scan of thin section (4040 Area, field unit 13103, s25 and s26,* in situ *burning deposits); **f)**. PPL. Calcitic ash from high temperature* in situ *burning, the presence of reed buliform cells can be seen embedded in the ash (100µm); **g)** PPL. The appearance of the orange clay material embedded in the large ash deposits, again the presence of abundant pseudomorphic voids indicates the use of plant temper (0.5mm); **h)** PPL. An example of a reed stem phytolith extracted from the ash layer (100µm); **i)** scan of thin section (4040 Area, field unit 13103, s26, organic layers underlying* in situ *burning deposits); **j)** PPL. Yellow-orange amorphous organic material, identified as human coprolite by GC/MS (200µm); **k)** PPL. Highly articulated phytoliths from the* in situ *decay of plant material, possible cereal husk (100µm); **l)** PPL. Laminated, highly articulated phytoliths from the* in situ *decay of plant material (200µm); **m)** scan of thin section (TP Area, field unit 8932 s7, occasional laminated deposits within massive midden); **n)** PPL. Microlaminated, partially charred herbivore dung (1mm); **o)** PPL. Unorientated fragment of conjoined reed phytolith embedded in a mixed ashy/organic matrix (100µm); **p)** PPL. Finely grained clay aggregate with grass derived microcharcoal and small bone inclusions. The lack of pseudomorphic voids and small mineral inclusions indicate a different use of temper in this later deposit (0.5mm).*

non-dung deposits after extraction, and further highlights the importance of integrating the two methods for a reliable interpretation.

Phytoliths also occur infrequently in thin section as plant temper in building aggregates within pseudomorphic voids, for example in Unit 12504, Space 261 (Figure 3c), and in Spaces 279 and 261 as lamina of highly articulated phytoliths with an orientation parallel to the base of the deposits (Figure 3k & l). In household contexts, such deposits have been interpreted as decayed organic matting (Matthews 2005; Karkanas & Efstratiou 2009). In middens these are also interpreted as occurring from the *in situ* decay of whole plant remains, perhaps from the discard of broken basketry or matting, or the raw materials from such activities. In the 4040 Area a laminated phytolith layer with possible penning deposits would support the hypothesis of Matthews (2005) that such areas may have had some sort of covering. In one instance in Space 261 (Unit 12519) a highly articulated layer of phytoliths, less than 2mm thick, was identified as wheat husk remains in the extracted samples, perhaps from crop processing, and is a good example of the high resolution specificity of microstratigraphy, and its ability to detect individual events (Monks 1981).

Organic layers

Embedded throughout the middens are distinct orange inclusions. These are also present in the middens from Space 181, where they are identified in thin section as faecal deposits and amorphous organic deposits of uncertain origin, perhaps decayed food remains (Matthews 2005). Several of the organic inclusions in all three middens in this study have been identified as human coprolites on the basis of organic residue analysis by GC/MS, which has enabled a distinction between human and animal that is not possible through micromorphology alone (Matthews 2005). An example from Space 279, Unit 13103, is shown in Figure 3j, with the corresponding GC trace of faecal sterols in Figure 4. One example of a suspected coprolite (Space 261, Unit 12504) associated with hackberry pericarps, was identified as having a plant rather than faecal origin, which highlights the importance of integrating geochemical methods.

Massive ash and mixed deposits

At the macroscale 'massive' deposits are observed occurring periodically between the fine laminations. These consist of two types of deposits; homogenous mixed redeposited material (Figure 3m) which is particularly common in the TP midden, and *in situ* burning events characterised by rubified sediments underlying large ash layers (Figure 3e), absent from the TP midden but occurring throughout the sequences in Spaces 279 and 261. Two examples, unit 12524 in the South Area and 13013 in the 4040 Area, are described as repeated lime-burning deposits in the field (Brown 2006; Yeomans 2006), however, their micromorphology is distinct from the lime-burning deposits in Space 181 (Matthews 2005) and other lime-burning experiments (Karkanas 2007) and an alternative activity is likely.

Table 1. Summary of microscopic inclusion types observed in midden deposits and their significance for interpreting activities (PPL: plane polarised light; XPL: cross polarised light).

Inclusion	Description	Variations	Significance
Bone			
Unburnt	PPL: yellow appearance, varies from microscopic fragments to large inclusions with visible cell structure XPL: first order grey	Size and shape, roundness, preservation	Indicates waste from activity involving animal resource. Pre-depositonal burning may indicate cooking/hearth remains.
Burnt	PPL: yellow to orange appearance, varies from microscopic fragments to large inclusions with visible cell structure XPL: bright orange		Post-depositional burning may be a result of *in situ* burning in midden as part of a different activity.
Plant material			
Charred	PPL: black charcoal fragments, often with cell structure intact	Size and shape, roundness, preservation, species	Plant burning activity, fuel, low temperature/short duration.
Partially charred	PPL: brown-black		Partially charred plant material rather than fully burnt may indicate accidental burning.
Phytoliths	PPL: siliceous, semi-transparent impressions of plant cells XPL: dark, non-birefringent	Plant part/species, articulation, multi or single cells	Plant decay *in situ* or burning *in situ* if associated with ash or rubified deposits. Fuel type, resource use, crafts, crop processing.
Pseudomorphic voids	PPL: colourless, voids spaces where plant material was once present but has decayed *in situ*, leaving an impression of its former shape in the surrounding fine material. Often seen as impressions in building materials.	Size, shape	Plant decay *in situ*. Use of different materials as temper.

Table 1. Continued

Inclusion	Description	Variations	Significance
Coprolitic material/dung			
Amorphous, non-burnt	PPL: yellow/orange, smooth, amorphous XPL: dark, often non-birefringent.	Size, shape, spherulites, plant and bone inclusions	Faecal waste deposition — cleaning, health.
Charred <650–750°C	PPL: dark brown/black or ash XPL: spherulites		Dung burning activity. Different fuel types.
Discrete	PPL: rounded, orange, bone inclusions XPL: dark		Faecal waste deposition — cleaning, health.
Spherulites	PPL: not visible XPL: distinctive spherical with extinction cross <5–20μm.		Ruminant dung. Spherulites without dung matrix may be a result of fully combusted dung.
Ash			
Plant origin	PPL: pale grey amorphous crystals XPL: Small rounded calcite crystals typical of plant ash, birefringent	Crystallinity, morphology of ash crystals, temperature of burning	Burning activity. High temperature, extended time of burning.
Dung origin	PPL: pale grey/white large ashy shape XPL: third order blue birefringence, spherulites		
Shell	PPL: white, linear and curved fragments XPL: high interference colours, striated, often seen as inclusions within aggregates and building material	Size, shape	Possibly indicates origin of aggregates through identification of shell species and comparison with local natural sediments such as lake marl.

Table 1. Continued

Inclusion	Description	Variations	Significance
Aggregates and building material			
Type 1	Brown, coarse, large mineral inclusions, with plant voids.	Size, shape, plant and other inclusions	Indicates activity involving aggregates and source of materials used. Small size and rounded shape may indicate sweepings, burnt sweepings from hearth area, unburnt from floors. Very large aggregates may be from demolition activity.
Type 2	Reddish brown, less coarse, smaller mineral inclusions with plant voids.		Coarser material suggests mud-brick
Type 3	Fine grained, pale silty grey aggregate with plant voids.		Fine grained material suggests fine plaster
Type 4	Unclear origin — no plant voids to suggest anthropogenic		Fine grained material suggests fine plaster.
Minerals — major types present			
	Quartz and calcite as well as other small fragments of mica and feldspar. Mineral fragments often seen within aggregates, or as a post depositional feature such as gypsum crystals Autigenic phosphate from decaying organic matter	Size, shape, roundness	Pre- and post-depositional origin of deposits

In thin section these large ash layers consist of calcitic plant ash with embedded reed and grass phytoliths associated with occasional animal dung spherulites (Canti 1999), suggesting the presence of dung fuel (Figure 3f). Extracted phytoliths are a mix of grass/reed derived and amorphous forms from wood. At the macroscale, large orange aggregates were seen embedded in the ash layers which are identified in thin section as burnt clay deposits with

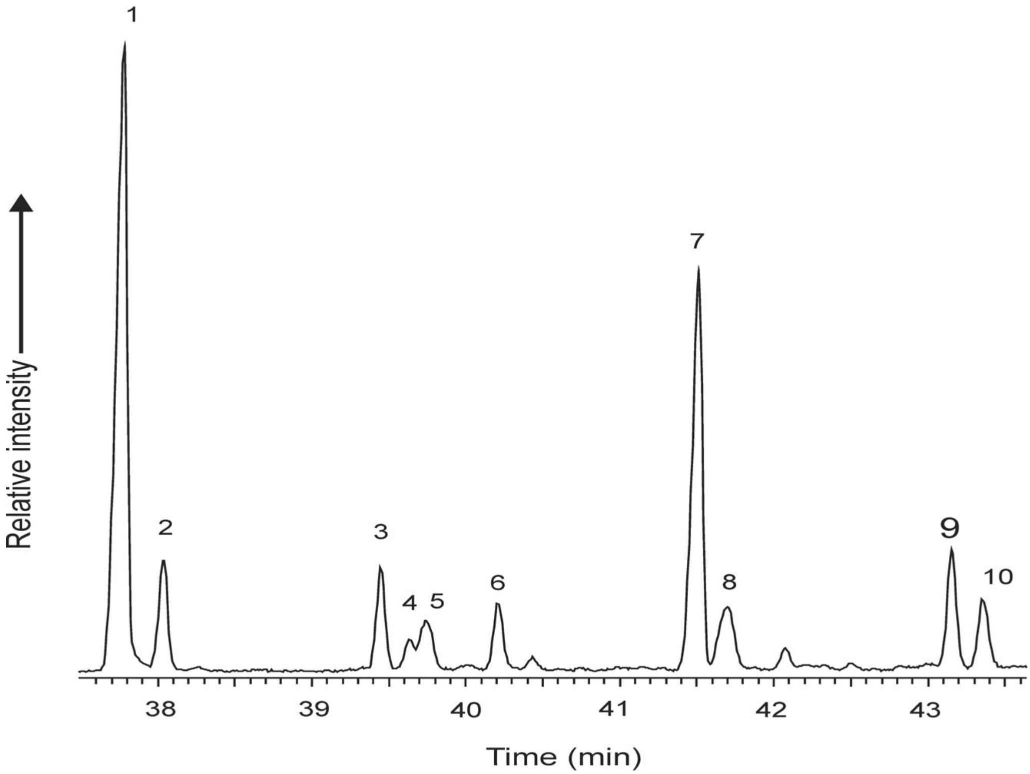

Figure 4. GC trace for coprolite sample 13103s27, showing faecal sterols ***1)*** *coprostanol;* ***2)*** *epicoprostanol;* ***3)*** *cholesterol;* ***4)*** *5α-cholestanol;* ***5)*** *5β-campestanol;* ***6)*** *5β-epicampestanol;* ***7)*** *5β-stigmastanol;* ***8)*** *5β-epistigmastanol;* ***9)*** *sitosterol;* ***10)*** *5α-stigmastanol.*

pseudomorphic voids from the use of plant temper, characteristic of constructional materials (Matthews 2005). Other inclusions embedded in the ash are rounded to sub-rounded reddish clay aggregates, and small shell and bone fragments. The reddish aggregates are not seen in the more frequent finely layered ash from domestic activities and may give a clue to the activity represented here. Such aggregates are present in cave ash deposits in Israel where they are suggested to be burnt soil particles (Berna & Goldberg 2007), and are also present in kiln deposits from the Bronze Age site of Tel Brak, Syria (Matthews 2001). A possible suggestion is that these may be related to ceramic production rather than lime-burning. A bonfire kiln would fit with the quality of ceramics found at Level VI (Açka *et al.* 2009).

Redeposited material is distinguished by the lack of parallel orientation and lamination of deposits, with the inclusions being embedded in a mixed ash and organic rich groundmass (Matthews 2005). Such material is observed in packing between buildings and under floors, similar to observations of 'informal' floors at Neolithic Makri, Greece (Karkanas & Efstratiou 2009), though at Çatalhöyük these are interpreted as packing for the preparation of a plaster surface rather than actual floors (Matthews 2005). These layers in middens are in the region of 50–100mm thick compared to fine layers that may be less than 1mm, and are rare in Spaces 279 and 261. The mixing of material makes interpretation more difficult, and these are considered more a cumulative palimpsest, or aggregation of several different activities into one deposit (Bailey 2007). However, despite being highly mixed, the components are similar to those seen in the fine layers, with inclusions such as coprolites, phytoliths and burnt animal dung.

Discussion

Microstratigraphic analysis indicates that some deposits occur more frequently than others. The most striking pattern in the South and 4040 areas is the high frequency of finely laminated ashes and organic materials compared to larger infrequent, but repeated, *in situ* burning on the midden surface (Figure 2d & e). The fine layers are interpreted as relating to frequent activities such as hearth rake out and floor sweeping, and the variation in their composition suggests possible variability in fuel use for different activities that require further investigation.

In the TP Area there was no evidence of *in situ* burning deposits, though it should be noted that the area excavated is much smaller. Conversely, the TP midden appears to have more massive redeposited layers with less frequent finely stratified layers suggesting a difference in the nature of discard in the later levels of the site, with periods of intense reworking and less frequent fine laminations relating to individual activities.

The large volume of ash, comprising much of the total volume of middens, is significant in enabling us to understand the use of plant resources in the past. The charred macrobotanical record consists only of materials preserved by burning at less than 500°C or for a short duration (Boardman & Jones 1990). Light components such as grasses and chaff are lost most readily from the charred plant record (van der Veen 2007). By incorporating the micromorphological and geochemical study of ash deposits, and of impressions of plants that have since decayed, we get a better overall picture of the nature of plant and fuel resource use (Matthews 2010). The integration with phytolith analysis enables the positive identification of the non-wood component of plant fuel, and a distinction can be made between dung-derived material.

Certain inclusions such as husk phytoliths and hackberry pericarps have previously been suggested as possible seasonal indicators due to their production at specific times of the year (Fairbairn *et al.* 2005; Rosen 2005). Microstratigraphic observations have demonstrated these occur as distinct clusters within microlayers rather than being ubiquitous, which is encouraging for using these as seasonal markers, at least of processing activities, as storage of plant remains may blur the time signals that they represent (Monks 1981). Other possible indirect seasonal indicators are the *in situ* burning events — if these relate to activities such as pottery production, perhaps either during the winter, when there was more time for craft activities (Fairbairn *et al.* 2005), or in the summer when it was drier. However, further analysis of such deposits and a more detailed program of ^{14}C dating is needed to explore the issue of seasonality and periodicity further (Stein & Deo 2003).

The deposition of waste in specific localities at Çatalhöyük indicates a level of co-operation and the communal nature of some decision making. Whilst midden areas are distinct and different from clean buildings, the close proximity of middens directly adjacent to areas of habitation and the frequent reuse of the deposits in building construction suggest a different attitude to this material in the Neolithic. Particularly the identification of frequent human coprolites, often interpreted as dog on the basis of digested bone inclusions, interspersed with domestic refuse highlights an everyday activity that is not always considered when reconstructing daily routine. The recognition of smaller scale 'daily' discard versus infrequent 'massive' ash deposits also supports a household/community distinction in activities, as previously suggested through spatial analysis of faunal and macrobotanical remains (Bogaard *et al.* 2009) and examination of discard practices (Martin & Russell 2000).

Although distinguishing the activities represented by *in situ* burning is still in progress, these deposits indicates that midden surfaces were areas of activity at the site that need to be considered in addition to buildings when trying to understand use of space and periodicity of activities. It is possible that the deliberate use of fire on the midden surface was an attempt by the Neolithic inhabitants to manage the large volume of waste (Ian Hodder *pers. comm.*) but it is also possible this was an unintentional but beneficial side effect of pyrotechnological activities such as ceramic production occurring on the midden surface.

Conclusions

Micromorphology presents the opportunity to link different components of deposits, and provide a sedimentary context for environmental and artefactual remains, from which one can derive a more robust interpretation of deposits at both a high spatial and temporal scale. Furthermore, the integration of micromorphology with other microscopic and geochemical methods has overcome some of the limitations of using these techniques in isolation. The application of this microstratigraphic approach has helped unravel the complex formation processes of finely stratified middens at Çatalhöyük, and provided evidence for a range of activities which would otherwise be overlooked, including variability of fuel use and the possibility of ceramic production.

In order to fully understand these complex deposits, further integration is also needed of macrobotanical, faunal and artefactual records, and is a priority for future investigation of midden deposits. Although this data, for example ceramics, has been integrated here where possible, faunal and botanical remains are more difficult to integrate, as they represent averaged signals from excavation units which combine several of the fine layers seen in thin section (Matthews 2005). However, it may still be possible to recognise distinct activity assemblages from archaeobotanical remains (Bogaard *et al.* 2005), and hypotheses arising from these analyses can be assessed through comparison with the sedimentary context in thin section as data becomes available. This study supports the recent suggestion by Goldberg *et al.* (2009) that archaeology must examine data in the context at which individual activities occur, i.e. the microlayer, if it is to move beyond simply observing major shifts in environment and activities.

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References

Akça, E., S. Kapur, S. Özdöl, I. Hodder, J. Poblome, J. Arocena, G. Kelling & Ç. Bedestenci. 2009. Clues of production for the Neolithic Çatalhöyük (central Anatolia) pottery. *Scientific Research and Essay* 4: 612–25.

Albert, R-M, F. Berna & P. Goldberg. In press. Insights on Neanderthal fire use at Kebara Cave (Israel) through high resolution study of prehistoric combustion features: evidence from phytoliths and thin sections. *Quaternary International* 1–2. doi:10.1016/j.quaint.2010.10.016.

Bailey, G. 2007. Time perspectives, palimpsests and the archaeology of time. *Journal of Anthropological Archaeology* 26: 198–223.

Berna, F. & P. Goldberg. 2007. Assessing Paleolithic pyrotechnology and associated hominin behavior in Israel. *Israel Journal of Earth Science* 56: 107–121.

Berna, F., A. Behar, R. Shahack-Gross, J. Berg, E. Boaretto, A. Gilboa, I. Sharon, S. Shalev, S. Shilstein, N. Yahalom-Mack, J.R. Zorn & S. Weiner. 2007. Sediments exposed to high temperatures: reconstructing pyrotechnological processes in Late Bronze and Iron Age strata at Tel Dor (Israel). *Journal of Archaeological Science* 34: 358–73.

Boardman, S. & G. Jones. 1990. Experiments on the effects of charring on cereal plant components. *Journal of Archaeological Science* 17: 1–11.

Bogaard, A, M. Charles, M. Ergun, G. Jones, K. Ng, M. Polcyn & N. Stone. 2005. Macrobotanical remains. *Çatalhöyük Archive Report* 2005: 152–5.

Bogaard, A., M. Charles, K.C. Twiss, A. Fairbairn, N. Yalman, D. Filipović, G.A. Demirergi, F. Ertuğ, N. Russell & J. Henecke. 2009. Private pantries and celebrated surplus: storing and sharing food at Neolithic Çatalhöyük, Central Anatolia. *Antiquity* 83: 649–68.

Brown, D. 2006. Space 261. *Çatalhöyük Archive Report* 2006: 84–9.

Bull, I.D., I.A. Simpson, P.F. van Bergen & R.P. Evershed. 1999. Muck 'n' molecules: organic geochemical methods for detecting ancient manuring. *Antiquity* 73: 86–96.

Bullock, P, N., Federoff, A. Jongerius, G. Stoops & T. Tursina (ed.). 1985. *Handbook for soil thin section description*. Albrighton: Waine Research.

Canti, M.G. 1999. The production and preservation of faecal spherulites: animals, environment and taphonomy. *Journal of Archaeological Science* 26: 251–8.

– 2003. Aspects of the chemical and microscopic characteristics of plant ashes found in archaeological soils *CATENA* 54: 339–61.

Courty, M.A., P. Goldberg & R. Macphail. 1989. *Soils and micromorphology in archaeology*. Cambridge: Cambridge University Press.

Czerniak, L. & A. Marciniak. 2004. Excavations of the TP Area. *Çatalhöyük Archive Report* 2004.

Fairbairn, A., E. Asouti, N. Russell & J. Swogger. 2005. Seasonality, in I. Hodder (ed.) *Çatalhöyük perspectives: themes from the 1995–99 seasons* (McDonald Institute Monographs/BIAA Monograph 40): 93–108. London: British Institute at Ankara; Cambridge: McDonald Institute for Archaeological Research.

Goldberg, P., C.E. Miller, S. Schiegl, B. Ligouis, F. Berna, N. Conard & L. Wadley. 2009. Bedding, hearths, and site maintenance in the Middle Stone Age of Sibudu Cave, KwaZulu-Natal, South Africa. *Archaeological and Anthropological Sciences* 1: 95–122.

Hodder, I. 2006. *The Leopard's Tale: revealing the mysteries of Çatalhöyük*. London: Thames & Hudson.

Hodder, I. & C. Cessford. 2004. Daily practice and social memory at Çatalhöyük. *American Antiquity* 69: 17–40.

Jenkins, E. 2005. Phytoliths. *Çatalhöyük Archive Report* 2005: 155–6.

Karkanas, P. 2007. Identification of lime plaster in prehistory using petrographic methods: a review and reconsideration of the data on the basis of experimental and case studies. *Geoarchaeology* 22: 775–96.

Karkanas, P. & N. Efstratiou. 2009. Floor sequences at Neolithic Makri, Greece: micromorphology reveals cycles of renovation. *Antiquity* 83: 955–67.

Martin, L. & N. Russell. 2000. Trashing rubbish, in I. Hodder (ed.) *Towards reflexive method in archaeology: the example at Çatalhöyük*: 57–69. Cambridge: McDonald Institute for Archaeological Research.

Matthews, W. 2001. Micromorphological analysis of occupational sequences, in R. Matthews & N. Postage (ed.) *Contextual analysis of the use of space at two Near Eastern Bronze Age sites.* doi: 10.5284/1000206.

– 2005. Micromorphological and microstratigraphic traces of uses and concepts of space, in I. Hodder (ed.) *Inhabiting Çatalhöyük: reports from the 1995–1999 seasons* (McDonald Institute Monographs/BIAA Monograph 40): 355–98. McDonald Institute for Archaeological Research and the British Institute of Archaeology at Ankara.

– 2010. Geoarchaeology and taphonomy of plant remains and micromorphological residues in early urban environments in the ancient Near East. *Quaternary International* 214: 98–113.

MATTHEWS, W., C.I.A. FRENCH, T. LAWRENCE, D.F. CUTLER & M.K. JONES. 1997. Microstratigraphic traces of site formation processes and human activities. *World Archaeology* 29: 281–308.

MATTHEWS, W., L-M. SHILLITO, M.J. ALMOND, G. WALKER, J. BOWEN, E. ANDERSON & G. KOROMILLA. 2010. Integrated micro-contextual approaches: micromorphology and sub-surface terahertz imaging of architectural materials and paintings, and organic residue, phytolith, and geochemical analysis of middens. *Çatalhöyük Archive Report* 2010: 132–48.

MONKS, G.G. 1981. Seasonality studies. *Advances in Archaeological Method and Theory* 4: 177–240.

ROSEN, A.M. 2005. Phytolith indicators of plant and land use at Çatalhöyük. *Inhabiting Çatalhöyük: reports from the 1995–1999 seasons*. I. Hodder. (ed) (McDonald Institute Monographs/BIAA Monograph 40): 203–212. McDonald Institute for Archaeological Research and the British Institute of Archaeology at Ankara.

SHAHACK-GROSS, R., R-M. ALBERT, A. GILBOA, O. NAGAR-HILMAN, I. SHARON & S. WEINER. 2005. Geoarchaeology in an urban context: the uses of space in a Phoenician monumental building at Tel Dor (Israel). *Journal of Archaeological Science* 32: 1417–31.

SHILLITO, L-M. 2011. Taphonomic observations of archaeological wheat phytoliths from Neolithic Çatalhöyük and the use of conjoined phytoliths as an indicator of water availability *Archaeometry.* 53(3): 631–41.

SHILLITO, L.-M., W. MATTHEWS & M. ALMOND. 2008. Investigating midden formation processes and cultural activities at Neolithic Çatalhöyük, Turkey. *Antiquity* 82. Available at: http://antiquity.ac.uk/projgall/shillito317/.

SHILLITO, L.-M., M.J. ALMOND, J. NICHOLSON, M. PANTOS & W. MATTHEWS. 2009. Rapid characterisation of archaeological midden components using FT-IR spectroscopy, SEM-EDX and micro XRD. *Spectrochimica Acta Part A* 73(1): 133–9.

SIMPSON, I.A. & J.H. BARRET. 1996. Interpretation of midden processes at Robert's Haven, Caithness, Scotland, using thin section micromorphology. *Journal of Archaeological Science* 23: 543–56.

SIMPSON, I.A., S.J. DOCKRILL, I.D. BULL & R.P. EVERSHED. 1998. Early anthropogenic soil formation at Tofts Ness, Sanday, Orkney. *Journal of Archaeological Science* 25: 729–46.

STEIN, J.K. & J.N. DEO. 2003. Big sites – short time: accumulation rates in archaeological sites. *Journal of Archaeological Science* 30: 297–316.

VAN DER VEEN, M. 2007. Formation processes of desiccated and carbonized plant remains – the identification of routine practice. *Journal of Archaeological Science* 34: 968–90.

WEINER, S. 2010. *Microarchaeology*. Cambridge: Cambridge University Press.

YEOMANS, L. 2005. Discard and disposal practises at Çatalhöyük: a study through the characteristation of the faunal remains, in I. Hodder (ed.). *Inhabiting Çatalhöyük: reports from the 1995–1999 seasons* (McDonald Institute Monographs/BIAA Monograph 40): 573–85. McDonald Institute for Archaeological Research and the British Institute of Archaeology at Ankara.

– 2006. Central midden area sealing earlier buildings Space 279. *Çatalhöyük Archive Report* 2006: 27–30.