Contextual analysis of the use of space at two Near Eastern Bronze Age sites

Micromorphological analysis of occupational sequences

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1 Introduction

The objective in this element of the Leverhulme Trust Project is to analyse the microstratigraphy of floors and occupation deposits, both in the field, and at higher resolution under the microscope in large thin sections of resin impregnated deposits, 13.5 x 6.5 cm, 25-30 μm thick, in order to detect evidence for spatial and temporal variation in site formation processes and uses and concepts of space in different sociocultural and micro environmental contexts within complex urban settlements.

The principal contribution of micromorphology is that it not only enables simultaneous analysis of the nature of diverse sediments and artefactual and bioarchaeological remains, but also provides precise details of their depositional and contextual relationships which are themselves valuable sources of sociocultural and environmental information.

This report is arranged in ten sections, each of which considers both Tell Brak and Kilise Tepe. In Section 2 we examine methods of micromorphological analysis, and in Section 3 discuss practical details and issues, including presentation of data in the report and comparisons with archaeobotanical and archaeozoological data. In Section 4 we review the mean trends observed in analysis of charred plant remains in thin section, for comparison to archaeobotanical data. In Section 5 we examine the nature, abundance and size of the diverse non-charred plant remains and dung present in thin-section. We consider evidence for individual depositional units and variation according to deposit type, context type and temporal phases. In Section 6 we discuss the diversity of both charred and non-charred plant remains present in thin section samples*. In Section 7 we review the nature of bone remains present in thin section, both for mean trends and individual depositional units and multiple variables. In Section 8 we briefly consider pottery and other remains in thin section. In Section 9 we discuss the nature of variation in micromorphological characteristics of each deposit type, and microstratigraphic sequences. In the conclusions in Section 10 we compare and assess the results from both sites, and their correlation with results from archaeobotanical and archaeozoological analyses. Sections 5,6 and 9 were prepared for individual site reports for Kilise Tepe and Tell Brak and have slightly different formats for each site.

2 Methods of analysis

2.1 Micromorphology

2.1.1 Development of micromorphological studies of uses of space

Micromorphological analysis of intact sequences of deposits in resin-impregnated thin sections was first developed in the study of soils in the 1930's and first applied in archaeology to study of palaeosols in the 1950's. Technological and methodological developments in the 1970's and 1980's have enabled more widespread application of the technique (Courty *et al*. 1989).

Goldberg was one of the first to suggest that 'thin sections could be used to evaluate such actions as trampling and compaction in streets. The resulting fabrics and textures should be different from those of other activity areas such as kitchens, storerooms, Holy Places, and market squares' (1983: 147-8).

Micromorphological studies of occupation sequences and uses of space have since included analysis of deposits within caves (Goldberg 1987; Courty *et al*. 1991), and settlements (Courty *et al.* 1989; Weiss *et al.* 1993; Matthews and Postgate 1994; Courty *et al*. 1994; Macphail 1994; Macphail and Goldberg 1995, Matthews *et al*. 1997a and b). Analysis of plant remains in particular is being developed (Wattez and Courty 1987; Schiegl *et al.* 1996; Matthews *et al.* forthcoming), and experimental and ethnoarchaeological research undertaken (Davidson *et al*. 1992; Goldberg and Whitbread 1993).

Ethnoarchaeologists and geoarchaeologists have argued that all component materials in depositional sequences, including sediments, are potentially informative about cultural behaviour and settlement history. In particular, during ethnoarchaeological research in Iran Kramer observed that:

'The floor of each area within a house compound is peculiar to that kind of area and therefore diagnostic of primary function... it is likely that an excavator could readily distinguish between roofed and unroofed areas, [and] identify stables, storerooms, kitchens and living rooms... by evaluating variations in floors' (1979: 148-9).

Anthropological studies illustrate that spaces defined by architectural units are endowed with meaning through practice, through the activities conducted within spaces which is both informed by and therefore representative of sociocultural behaviour and conceptual schemes (Bourdieu 1977; Moore 1986; Wilson 1988). Carsten and Hugh Jones have observed that within the house there is often a 'maze of spatial conventions whose invisible lines get easily scuffed and trampled by ignorant...foreign feet' of anthropologists (Carsten and Hugh Jones 1995: 4).

Microstratigraphic analysis within architectural units offers potential for detecting and interpreting such conventions and realms of human behaviour by enabling high resolution analysis of spatial and temporal variation in surfaces and the often sparse traces of activities on them. The McKellar hypothesis states that it is the smaller artefactual remains which are 'more likely to become primary refuse' even in areas which are periodically cleaned (Schiffer 1983: 679).

2.1.2 Micromorphology: analytical procedures

Micromorphological analyses and interpretations employ many of the principles and theories used in contextual archaeology and sedimentology. Interpretation of microstratigraphic sequences both in the field and in thin section is based on internal and comparative analysis of the type, frequency, morphology and structural relationships of components and boundaries of depositional units in each sequence, and their spatial, temporal and sociocultural contexts within settlements.

A wide range of components and depositional and post-depositional attributes are recorded in thin section (Table 1; Bullock *et al*. 1985; Courty *et al*. 1989). The significance of each of these attributes to interpretation of depositional sequences and human behaviour and concepts is discussed in Matthews 1995 and in press. The attributes examined include analysis of:

1. the nature and significance of the boundary between depositional units (e.g. natural, human)
2. deposit thickness (e.g. thin lens/thick deposit)
3. deposit internal organisation and nature of deposition, including particle size in thin section and sorting, microstructure (pattern of voids), geometric relationship between coarse and fine materials (e.g. embedded/coated), nature of the fine material (organic/mineral), groundmass (birefringence pattern)
4. nature of artefactual, bioarchaeological and mineral inclusions within each unit (e.g. type, abundance, size in thin section, shape, internal structure)
5. inclusions orientation and distribution (e.g. multiple lenses of accumulated deposits with components which have parallel orientation patterns and linear distributions related to periodic accumulation, in contrast to unoriented components in massive dumped deposits)
6. post-depositional alterations (e.g. effects of abrasion, burning, salts, insect/root activity, organic decay)

2.2 Comparison of micromorphological and archaeobotanical and archaeozoological analyses

A number of points should be borne in mind in comparison of micromorphological results with those from archaeobotanical and archaeozoological analyses. These largely arise due to the smaller number of samples selected for micromorphological analysis, and to differences in size between micromorphological thin sections and flotation samples. These are discussed further in the following Section 3, which considers practical details.

Only c.30-50% of deposits selected for archaeobotanical and archaeozoological analyses at each site have been sampled, due to the expense and time involved in preparation of each thin section sample, at currently c. £50-100 per sample in the UK. The micromorphological samples were selected from a wide range of different deposit types including packing, floors, occupation deposits and fills, and from contexts including domestic, administrative, ritual and craft areas. As a consequence the sample representation within and across these groups is small, and has not been subject to the correspondence analyses conducted for archaeobotanical remains. Instead, the results have been presented as scatter diagrams, bar charts, and in tables. General clusters and trends have been observed, many of which appear to vary according to deposit and context type, and contribute towards our understanding of many of the initial issues and questions raised in the project design, and discussed in this report.

3 Practical details

3.1. Field analysis and sample collection and preparation

A total of 104 thin section samples were analysed within the context of this Leverhulme project. This includes four more samples than in the project outline. 40 were collected from Kilise Tepe (Table 2), 64 samples from Tell Brak (Table 3). More samples were collected from Tell Brak than Kilise Tepe, because of the greater range of Bronze Age levels exposed by excavation at Tell Brak.

Most of these samples were collected by Wendy Matthews in the final weeks of excavation during each of the 1995-97 excavation seasons. The samples collected therefore, largely represent deposits selected for analysis in the Leverhulme project which were either being excavated during the final weeks, or which were still present in main excavation sections or in plinths of stratigraphy left by the excavators in selected areas.

All field sections selected for micromorphological analysis were photographed, drawn at 1:5 and described in detail (Matthews 1995 after Hodgson, 1976; Limbrey, 1975; Bullock *et al*., 1985; Courty *et al.,* 1989,). Block samples of undisturbed occupation sequences were cut out of the section face with a Swiss army knife, and wrapped tightly in tissue and tape for transport. In the Geoarchaeology Laboratory in Cambridge the micromorphological block samples were impregnated with a crystic polyester resin which takes six weeks to harden, and ground and polished into large thin sections (13.5 x 6.5cm) of standard geological thickness (25-30_m thick) (after Guilloré, 1985; Murphy, 1986).

Spot samples of c. 50g of deposits were collected from individual depositional units adjacent to micromorphological blocks for possible targeted scanning electron microscopy and organic and inorganic analyses, in the future. Bulk samples of c. 200-500g were selected from each flotation sample as archive samples, and have been sampled for phytolith analysis in the first instance (see Madella this report).

3.2 Thin section analysis

The thin sections were examined using a large field polarising macroscope (at magnifications of x5.3 - x70) and polarising microscope (at x40 - x400). The natural auto-fluorescence of plant remains and other components was examined in fluorescent light (excitation wavelength 480 nm).

The thin sections were described using standard micromorphological procedures in an Access database (Table 1; Bullock *et al*., 1985; Courty *et al*., 1989; Matthews, 1995). These descriptions are detailed and include specific technical information.

3.3 Issues arising during comparison of micromorphological and archaeobotanical and archaeozoological data

3.3.1 Sample size in thin section

Thin section samples are small (13.5 x 6.5cm, 30µm thick), particularly when compared to flotation samples (10-60 litres). It is frequently suggested that such as small sample size in thin section cannot be considered representative of entire depositional units. A number of steps however are built into micromorphological analyses and procedures to try and assess the representativeness of each sample.

i) thin section observations are always compared to observations of deposits in the field, which are recorded by photographs, drawings, observations and descriptions
ii) specific types of deposit occur repeatedly within many field sequences and thin sections, associated often with consistency in the uses of each space (Matthews and Postgate 1994). The

percentages of depositional components, as well as a whole range of other depositional and micromorphological attributes, also consistently recur, adding greater confidence to assessment of representativeness of samples of deposits in thin section

iii) as illustrated in the following discussions, distinctive and general trends are being detected in thin section analysis, which suggest that the variations in patterns of attributes observed are significant

It should be added, that many other samples examined in chemical, mineralogical and phytolith analyses are also small, often less than 1-10 grams, and ensuing results also need careful consideration.

3.3.2 Density measurements

Densities of charred plant remains in thin section have been calculated by visual estimation of the percentages of each class of components within single depositional units by area in thin section, by visual comparison to area percentage charts (Bullock 1985, Fig. 24). Computer aided image analysis was not used in this project as its application to analysis of heterogeneous components in thin sections of archaeological deposits is problematic, although some studies are developing its application (Aycott *et al*. 1997, Bryant 1996). Some of the problems in computer aided image analysis include difficulties in computer recognition of and distinction between individual components of diverse origin but with similar optical properties, such as black opaque minerals and charred plant remains. Other difficulties occur in computer recognition of only the area occupied by anatomical elements of plant fragments, rather than the total area which each fragment occupies within single depositional units. This can be corrected for by manual delineation of each component, but this was considered too time consuming to achieve the objectives of this project.

Density by area measurements used in micromorphology are not the same as density by volume measurements used in archaeobotanical and archaeozoological analyses, although general and relative variations in densities may be considered.

3.3.3 Size in thin section measurements

The size in thin section and shape of components in thin section may be misleading due to the random location and orientation of thin section slices through individual components (Bullock *et al*1985, 26). Measurements in thin section can only record random two dimensional slices through three dimensional components and features. In this project the maximum and minimum size in thin section of component fragments in thin sections was recorded. Analyses of fragmentation indices are based on maximum size in thin section of plant and bone fragments in thin section. Minimum size in thin sections, particularly of charred plant remains are less meaningful as charred flecks occur in each deposit analysed. Although these measurements may be misleading, general trends are emerging.

3.3.4 Identification of plant and bone remains in thin section and analysis of diversity

3.3.4.1 Problems

One of the greatest limitations in the small size of thin section samples is the ability to assess the diversity of plant and bone remains present in depositional units. Some general trends are detectable (Sections 4-7), but much of the detailed information on the range of species present is lacking due to smallness of samples and sparsity of plant remains in some deposits. Study of anatomy of bone fragments in micromorphological thin sections has not been developed, although it is possible to distinguish between fragments of bird, fish and mammal bone. Further analyses of bone anatomy should be explored in future in collaboration with zoological anatomists.

Some of the problems in identifying plant remains in thin section were assessed in a three year micromorphological project which included collaboration with plant anatomists at Kew, and was supported by the Natural Environment Research Council (Matthews *et al* 1997a and b, Matthews *et al.* forthcoming). These problems include:

a) lack of comprehensive plant anatomy reference collections and atlases for Western Asia
b) confusing similarities in the anatomy of some plant remains, including different grass parts and species in particular, and some woods. For example, *Celtis* and *Ulmus* (Ulmaceae) share tall multiseriate rays and a more or less identical pattern in T.S. of tangential bands of large early wood vessels combined with tight groups of small latewood vessels. *Populus* and *Salix* (Salicaceae) are also very similar, but may in some instances be distinguished in perfect T.L.S. on the basis of homocellularity (*Populus*) or heterocellularity (*Salix*) of the ray tissue.

c) the nature of the single, random and fragmentary orientation of plant remains in thin section. Wood identification frequently requires systematic observation of features in three planes (transverse section (T.S.), transverse longitudinal section (T.L.S.) and radial longitudinal section (R.L.S.)) to achieve a positive identification of individual specimens. Many charred and siliceous fragments of grasses are often transverse in thin section, lying flat within deposits. Multiple views, particularly of epidermises, are required in identification of Monocotyledons and phytoliths.

3.3.4.2 Integrative interdisciplinary studies

Correlation of micromorphological and archaeobotanical analyses, including study of phytoliths, can furnish multiple lines of evidence which may enhance potential interpretations of plant remains within settlements, and human-plant relationships. Some of the benefits of such integrative interdisciplinary approaches are briefly outlined here.

a) Micromorphology enables simultaneous analysis of diverse plant materials within single depositional units. The range of plant remains preserved in thin section includes not only charred plant remains, but pseudomorphic voids (impressions) in sediments of plant remains which have since decayed, siliceous remains, and calcitic ashes. Previous micromorphological analyses of occupation deposits have revealed that charred plant remains only represent a small and varying percentage of the total plant remains preserved in archaeological deposits (Matthews and Postgate 1994, Matthews *et al.* 1997b). Charred plant remains only represent plants which have been subject to low temperature burning or reducing conditions, generally between 200-400 C (Boardman and Jones 1990; Colledge this report). Micromorphology can help in the assessment of the history of plant remains prior to deposition, especially burning, and subsequent taphonomy.
b) Many fragile plant remains are preserved in thin section, including articulated siliceous remains and phytoliths, which if oriented favourably, can aid identification.
c) Micromorphological analysis of plant remains within single depositional units and their precise associations with other bioarchaeological, artefactual and mineralogical remains can potentially enhance interpretation of use and discard of plant remains, and sociocultural and ecological perceptions and practices
d) It is also possible in thin section to assess nature of post-depositional effects on plant remains including organic decay, and distinction between the effects of trampling and post-depositional disturbance by insects/roots of salts for example.

Studies of taphonomy of bone can also be aided by micromorphological analysis of

a) nature and hardness of underlying substrate
b) extent of trampling
c) history prior to deposition including effects of burning, abrasion, and digestion. A range of bone fragments have been identified embedded in omnivorous/carnivorous coprolites (Section 5.6).
d) Post-depositional alterations such as effects of salts, and extent of organic staining

Micromorphological and archaeozoological data are compared and discussed in Section 7.6.

3.4 Issues relating to deposit type classifications

Two deposit classifications have been employed in consideration of results from micromorphological analyses. The first classification considered in each section relating to variation in deposit type, is that assigned by the site directors to the site excavation unit which is generally the same depositional unit as the flotation unit. The second classification is that assigned after thin section analysis of the microstratigraphic units present in each thin section sample. This second classification system follows the same categories of deposit classifications as those assigned by the excavators, but attributes them to the single depositional units that are detectable in thin section. The unit number and deposit classification assigned to a thin section often only refers to one of the units present in a thin section. Other micro-depositional units have to be defined and classified separately during micromorphological analysis.

In particular, occupation sequences (excavation deposit class 5/5c) often in thin section can be analysed separately as individual layers of floor plaster (5a) and accumulated occupation deposits (5b). Similarly many fill deposits on floors (4) can often be distinguished as fill (4) and thin lenses of accumulated deposits on floors (5b) in thin section. Thin residual lenses of phytoliths in pits at Kilise Tepe were often characterised separately from the thick deposits which subsequently infilled the pits. One sequence characterised as indeterminate fill (4) and 'brown soil' during excavation resolved into a sequence of very fine plaster floors (5a) which could be described individually during section-cleaning with a palette knife and in thin section. Conversely, a yellow clay floor (5a) observed in the field proved to be an accumulation of a series of white and yellow plaster floors and intervening calcitic ash deposits (deposit types 5a and 5b), during examination under the microscope.

Both deposit type classifications have been presented in this report in all tables and some figures, particularly in consideration of mean abundance and size in thin section of charred plant remains and bones, in order to enable comparison with results from wet-sieving and flotation. Site deposit type classifications and values are written in plain text, micromorphological deposit type classifications and values in italics.

Context type classifications were not allocated to units from Kilise Tepe by the excavators due to the uncertainty in interpretation of some spatial contexts, and are only considered for Tell Brak.

3.5 Presentation of results in this report

3.5.1 Tables

Several types of tables are presented in this report in order to illustrate different data. Tables 4-12 present detailed observations of plant and bone remains abundance, size in thin section, preservation, and diversity in thin section for comparison with the archaeobotanical and archaeozoological results, bearing in mind reservations discussed in Section 3.3. Table 24 summarises the size and diversity of plant remains at tell Brak and Kilise Tepe, by individual depositional unit. Table 16 lists the variation in deposit types observed in thin section at Kilise Tepe. Tables 13 and 17-20 present summary micromorphological observations on each microstratigraphic unit composition, origin, deposition, post-depositional alterations and interpretation. Tables 14-15, and 21-23 detail the character of key characteristics of microstratigraphic sequences and interpretations of uses and concepts of space, which are summarised in Table 25. The micromorphological tables of data are taken directly from the lab notes entered into Access, and may contain shorthand text, and a few typos. It was not possible due to time constraints to alter each of these entries. These tables have been included here for information as they are, rather than exclude them from the final Report.

3.5.2 Figures

The graphs presented in this report include:

a) Bar charts of mean abundance and size in thin section by site and micromorphological deposit types (see Section 3.4), and site horizontal and vertical context types (R.J. Matthews and Postgate this report), which can be compared to those in archaeobotanical and archaeozoological reports.
b) Bar charts of diverse plant remains and dung present in each depositional unit analysed
c) Scatter plots of abundance and size in thin section of plant and bone remains for each microstratgraphic unit. The scatter plots of each unit are coded according to the classification system employed in all aspects of this project with reference to deposit type, and horizontal and vertical (chronological) contexts. In these scatter plots however, these codes have been combined into one composite code for each microstratigraphic unit in order to enable analysis of multiple variables influencing the nature of floors and deposits within complex settlements including deposit type, spatial and socio-cultural contexts and time.

3.5.3 Photomicrographs

Photomicrographs of deposits from both sites are available in the site archives.

In conclusion therefore, this report has tried firstly to enable comparison with archaeobotanical and archaeozoological data, and secondly to furnish other information based on micromorphological information to aid understanding of deposition within complex settlements and human uses and concepts of space.

4 Discussion of results: charred plant remains in thin section - mean trends

Detailed micromorphological characterisations of plant remains are presented in Table 4 for Tell Brak, and Table 5 for Kilise Tepe.

4.1 Charred plant remains abundance in thin section

The mean abundance of charred plant remains in thin section was compared to overall sample means and classification group means for samples from different deposit types and horizontal and vertical contexts. The mean for the whole sample group was compared to the mean of a) the deposit type means and b) the context type means. The aim in this comparison was to assess the possibility of the mean for the whole sample group being influenced by over-representation of sample numbers in particular deposit type or context type groups.

4.1.1 Charred plant remains mean abundance in thin section at Tell Brak

The overall mean abundance for charred plant remains in thin sections of deposits within the settlement at Tell Brak is 11.04%, by visual area within single depositional units.

For deposit class discussions only, site deposit type classifications and values are written in plain text, micromorphological deposit type classifications and values in italicised text (see Section 3.4).

4.1.2 Mean charred plant remains abundance in thin section - by deposit class Tell Brak

(Figures 1-2)

The deposit class mean abundance values are less than the overall sample group mean abundance value (11.04%), according to both the site and micromorphological deposit type classification systems (9.87%/*6.7%* respectively), but are much lower for micromorphological classifications at *6.7%*.

Accumulated occupation deposits (5b) have charred plant remains abundance values above the overall site mean, according to both deposit type classifications (site deposit class: 15%, micromorphological deposit class: *13.96%*). According to site deposit type, mixed floors and occupation deposits (5c) and miscellaneous/mixed samples (8-9) have mean abundance values also above the overall site mean (15% and 11.67% respectively). According to micromorphological deposit classifications however, only midden/refuse deposits (*2: 13.4%*) and in-situ fire-installation deposits (*6c: 11.75%*) have mean abundance values above site mean, in addition to occupation deposits.

The lowest mean abundances of charred plant remains include mixed plaster/fill and occupation sequences (5d: 3.5%; *5c: 1%*), floor plasters (5a: 6.88%; *5a:4.25%*) and construction/fill deposits (4: 7.88%; *4: 3.33%*), for both deposit type classifications. Other deposits in thin section with low mean abundance of charred plant remains include naturally laid deposits (*1: 2%*) and miscellaneous deposits (*8: 6.79%*).

4.1.3 Mean charred plant remains abundance in thin section - by horizontal context Tell Brak

(Figure 3)

The overall sample and context type mean values for abundance of charred plant remains in thin section are similar (11.04% and 11.68% respectively).

Four of the nine context types examined have mean abundance values above the overall site sample mean. The highest mean values occur in unroofed spaces both within buildings (F: 20%) and outside buildings (C: 17%). Ritual spaces within buildings (K:16.44%) and unroofed craft areas outside buildings (B: 13.7%), also have mean values above the site mean.

The lowest mean abundances of charred plant remains in thin section occur in samples from corridors/passage ways (I: 4.33%) and surprisingly kitchens (H: 5.24%). Streets/lanes (D: 9.29%), and in miscellaneous/uncertain contexts (X: 8.33%) also have mean abundance values below site average.

4.1.4 Mean charred plant remains abundance in thin section - by vertical context (period) Tell Brak

(Figure 4)

Four of the five vertical contexts or periods that were excavated have mean abundance values above the overall site sample mean. Only deposits sampled from the late third millennium BC have mean abundance below the site mean (IV: 5.68%).

4.1.5 Summary discussion and comparison to archaeobotanical analysis of mean charred plant densities

There is some correlation between concentrations of charred plant remains in micromorphological and flotation samples. In both sample groups, middens and occupation deposits have charred plant remains concentrations above the site mean, whilst construction material and fill deposits have concentrations below the site mean. Samples of in-situ fuel examined in thin section, however, have higher mean concentrations than those from flotation.

For context type classes, the highest mean concentrations of charred plant remains occur in unroofed spaces both within buildings and outside buildings, in both data sets, whilst comparatively low concentrations occur in streets or lanes. Other mean trends for context type classes however, differ. In particular, lenses of charred plant remains in ritual spaces have considerably high concentrations of charred remains in thin section, yet have the lowest densities in flotation samples. These lenses are less than 1 mm in thin section, and are too thin to excavate separately. They were excavated and sampled for flotation together with multiple layers of thin floor plasters prepared from natural sediments, which have considerably diluted percentages of charred remains present in occupation deposits. The thinness of these lenses, however, does accord with the overall assessment of flotation results, which show that ritual spaces were well-maintained. Conversely charred plant remains mean densities in 'kitchens' are comparatively high in flotation samples, but surprisingly low in micromorphological samples.

Analyses of other plant remains preserved in thin section, illustrate that although charred densities in flotation and thin section samples are perhaps surprisingly low in fire-installations, 'kitchens' and streets, concentrations of plant remains generally are high, preserved as impressions of plant remains, siliceous plant remains, and calcitic ashes (Section 5-6).

Mean charred plant remains densities for different periods differ markedly between micromorphological and flotation samples. Four of the five vertical periods excavated have mean abundance above the overall site sample mean in thin section samples, but less than the site mean in flotation samples. The lowest densities occur in the late third millennium BC in thin section, but in Ninevite 5 and E-M Uruk periods in flotation samples.

4.1.6 Charred plant remains abundance at Kilise Tepe

The overall site sample mean abundance of charred plant remains at Kilise Tepe is 9.51%.

For deposit class discussions only, site deposit type classifications and values are written in plain text, micromorphological deposit type classifications and values in italics (see section 3.4)

4.1.7 Mean charred plant remains abundance in thin section - by deposit class Kilise Tepe

(Figures 5-6)

For site deposit type classifications, occupation sequences (5) and miscellaneous/mixed deposits (8-9) have concentrations above site mean at 15% and 25% respectively.

For micromorphological deposit type classifications, highest concentrations of charred plant remains occur in-situ burnt deposits on floors, more than four times the site sample mean (*38.75%*:9.51%). Accumulated occupation deposits on floors which had not been burnt in-situ, have values just above site sample mean at *10.3%*. The lowest charred plant remains abundance in thin section occurs in residual lenses in pits (*7: 3.83%*), construction materials and fill (*4.29%*) and in floor plasters (*5.5%*).

4.1.8 Mean charred plant remains abundance in thin section - by vertical context (period) Kilise Tepe

(Figure 7)

Mean abundance of charred plant remains varies considerably by vertical (chronological) context. Four periods have abundance above the site mean: Early Bronze Age II (period 9: 12%), Middle Bronze Age (7: 16.5%), Early Iron Age (4: 10.8%), and Iron Age (periods 2/3/4: 18.2%). Mean abundance for four other periods, however is remarkably low, in Early Bronze Age II (8: 2.5%), Late Bronze Age a-c (6: 2%), Late Bronze Age d-f (5: 3%) and Later Iron Age (2: 4%).

4.1.9 Summary discussion and comparison to archaeobotanical analyses of mean charred plant remains densities at Kilise Tepe

Mean abundance of charred plant remains in micromorphological deposit classifications show general trends which are similar to those which might be predicted archaeologically with highest concentrations in burnt deposits on floors, and above site mean concentrations in other occupation deposits on floors. Values for unburnt pit linings/residual materials, construction materials and fills and floor plasters are predictably low. These results suggest mean abundance of charred plant materials in thin section can aid identification of attributes which may be characteristic of different deposit types.

Mean charred plant remains abundance varies remarkably for different periods, as these include a range of different deposit and context types.

There are correlations between trends in mean abundance of charred plant remains in thin section and densities in flotation samples. In-situ burnt deposits, not surprisingly, are above the site means in both data sets. Charred plant remains concentrations in accumulated occupation deposits are also similar, falling just below site mean in flotation samples, but just above site mean in thin section samples. Construction materials and fill deposits in both data sets are less than the site mean, but are much lower in thin section samples than in flotation samples.

Charred plant remains in pit fill deposits, however, are much more abundant in flotation samples, than micromorphological samples. This is almost certainly because many of the thin section analyses are based on the thin residual lenses of siliceous plant remains on the bottom and edges of many pits, not the indeterminate thick layers of fill within pits.

There is little correlation in trends for mean abundance by vertical context between flotation and micromorphological samples. Micromorphological abundance values do not suggest increasing density with decreasing age, in contrast to those from flotation.

4.2 Charred plant remains preservation indices in thin section

Preservation indices in thin section are perhaps more difficult to assess than for archaeobotanical remains retrieved by flotation. Plant remains diversity in the small sample size in thin sections, in albeit large thin sections, is so uncertain and low, that the charred plant remains selected for archaeobotanical analysis cannot be considered in the micromorphological analysis.

Preservation indices in thin section are based on assessment of all extant charred plant remains and consideration of a range of variables including fragment size in thin section, distortion by burning, and abrasion. Plant taphonomy and post-depositional alterations are recorded for each unit in the Access database and are presented in Table 4 in this report. Post-depositional alterations to deposits generally are discussed in section 6.3.

A general scale of 1-3, from poor to moderate and good preservation, has been applied to samples from Tell Brak and Kilise Tepe, with intermediary classes of 1-2 and 2-3, where a range of preservation conditions are present.

4.2.1 Preservation indices in thin section Tell Brak

Mean percentages of samples in each preservation index are illustrated in Figures 8-9.

4.2.2 Preservation indices in thin section - by deposit class Tell Brak

(Figures 8-9)

The only deposit types with well preserved plant remains (preservation index 3) are midden deposits (*2: 25% of samples by micromorphological deposit type*) and occupation deposits (5b: 18% and *5b: 5%*).

Many samples have poor (1) to poor-moderately (1-2) preserved plant remains. These categories include all charred plant remains in construction/fill (*4: 100%*) and floor plasters (*5a: 100%*), and *67%* of samples in fire-installations.

4.2.3 Preservation indices in thin section at Kilise Tepe

Mean percentages of samples in each preservation index are illustrated in Figures 8-9.

4.2.4 Preservation indices in thin section - by deposit class Kilise Tepe

(Figures 10-11)

Well preserved charred plant remains (index 3) occur in 50% of in-situ burnt deposits and floor plasters, and in 7% of construction/fills. 40-50% of samples from plaster floors and construction/fill, however, are also poorly preserved (index 1).

Occupation deposits and pit fills at Kilise Tepe occur in all preservation classes, suggesting other factors are influencing preservation, such as context type. Preservation in pit fills is also varied, suggesting diverse origins of charred plant remains.

4.3 Charred plant remains fragmentation indices in thin section

Analysis of maximum fragment size in thin section may provide another approximate indication of nature of preservation of plant materials in thin section, although the significance of this varies markedly according to the type and species of plant remains represented in the largest fragment size in thin sections. Fragments of well preserved charred wood and figs for example will be much larger than well preserved cereal grains, irrespective of state of preservation. The randomness of thin section slices will also affect apparent largest size in thin section of components (Section 3.3.1).

Size in thin sections of charred plant remains can be compared to those of siliceous plant remains and impressions of plant remains in order to assess differences in pre-depositional, depositional and post-depositional histories (Figures 12-18).

4.3.1 Comparison of the fragmentation indices in thin section Tell Brak

The overall mean maximum size in thin section of charred plant remains in all samples analysed from Tell Brak is 2.69 mm.

4.3.2 Fragmentation indices in thin section - by deposit class Tell Brak

(Figures 12-13)

Deposit class means for both site deposit classifications and micromorphology deposit classifications are both close to the site sample mean (2.79 and *2.69* respectively).

General trends in charred plant remains mean size in thin sections however, differ considerably between site deposit type classifications and micromorphological deposit type classifications, and are conversely above or below site sample mean in the alternative classification.

In micromorphological deposit classifications four of the eight classes have charred plant size in thin sections which are above the mean size in thin section of charred plant remains in thin section. These include naturally laid deposits (*1: 8mm*), midden deposits (*2: 3.45mm*), accumulated occupation deposits (*5b: 2.73mm*) and in-situ fuel deposits in fire-installations (*6c: 2.64mm*). The latter are very close to the site mean.

The smallest mean size in thin sections of charred plant remains in thin section samples occur in floor plasters (*5a: 1.02mm*) and construction/fill (*4: 1.43mm*).

4.3.3 Fragmentation indices in thin section - by horizontal (spatial) context Tell Brak

(Figure 14)

Six of the eight context type classes have deposits with charred plant remains maximum size in thin sections above the site sample mean. Only four deposits, however, have size in thin sections above the *context type* mean. These four include streets (D), unroofed areas outside buildings (C, except craft areas B), unroofed areas inside buildings (F) and kitchens (H), and range in size in thin section from 3.86-4.5 mm.

The smallest size in thin sections of charred plant remains occur in corridors or passage ways within buildings (I: 0.67mm) and in ritual spaces (K: 0.67mm).

4.3.4 Fragmentation indices in thin section - by vertical context Tell Brak

(Figure 15)

Three of the five periods sampled at Tell Brak have maximum charred plant size in thin sections above the site mean. These include the Middle Uruk period (II: 4.79mm), Late third millennium (IV 3.5mm) and the second millennium (V: 3).

The lowest mean maximum size in thin sections of occur in the Early Middle Uruk period (I: 1.96mm) and in Ninevite 5 period (III: 1.33mm)

4.3.5 Summary of the preservation and fragmentation analyses in thin section and comparison to results from archaeobotanical analyses at Tell Brak

Preservation of charred plant remains in thin sections of deposits of construction/fill and floor plasters is poor, probably due to reworking and abrasion of charred plant remains during manufacture and infilling activities. These two classes also include the smallest mean size in thin section of charred plant remains in thin section. This is in contrast to the preservation of siliceous plant remains in plasters, probably present as added vegetal stabilisers, which were still fresh and pliable and less susceptible to fragmentation than fragile charred plant remains. Charred plant remains are also poorly preserved in in-situ fuel in fire-installations due to effects of heat and possibly a range of pre-depositional histories including plant remains digested in dung which is a frequent source of fuel, and possibly trampling and sweeping of plant remains prior to use as fuel.

There is currently no explanation for the marked differences in size in thin section distributions between site deposit classifications and micromorphological deposit classifications, as trends in mean abundance do not differ so markedly.

The size in thin section of charred plant remains in in-situ fuel deposits is very close to site mean in thin section, perhaps suggesting that origin of at least some charred plant remains in other settlement deposits is from charred fuel.

The large size in thin section of plant remains above site and context mean in some unroofed areas inside and outside buildings, and in streets and kitchens, may suggest rapid accumulation of refuse in these areas. In the field many of these areas clearly included rich refuse deposits. The dirtiness of streets is variable at other sites. At the Aceramic Neolithic site of Asıklı Höyük the pebble street adjacent to possible ritual area is scrupulously maintained and kept clean, in contrast to rich midden areas elsewhere at site (Esin 1999; Matthews 1998). Socio-cultural perceptions of different public areas and networks of communications through sites will influence dirtiness of streets and open areas. Indeed the smallest fragments of charred plant remains at Tell Brak occur in corridors and passage ways within buildings, and in ritual areas, in particular in Ninevite 5 temple where fine fragments of charred plant remains accumulated on latest floor.

Different measures were used to calculate fragmentation indices in micromorphological and archaeobotanical analyses due to the nature of each technique and the samples studied (Section 3.3.1). Nevertheless, for purposes of this study analysis of general trends shows that there is a strong correlation in the results from both analyses.

Both midden deposits and in-situ fuel in fire-installations have charred plant remains which are less fragmented than the site mean in flotation samples, and have large maximum sizes in thin sections above site mean in thin section samples. This likely due to discard of some plant remains in middens before they have been subject to trampling on floors, and to lack of disturbance of in-situ fuels in fire-installations. The effects of burning in fire-installations have however resulted in poor preservation indices in archaeobotanical and micromorphological analyses, but not overall fragmentation and size in thin sections.

Charred plant remains in occupation deposits in both sets of data are close to the overall site mean, in contrast to those in construction materials in which charred plant remains are highly fragmented, by abrasion from mixing and pugging of deposits during manufacture.

In both data sets, fragmentation is high in corridors and passage ways (I), and low in unroofed areas inside buildings (F). For other contexts, however, there is slightly more variation between results from analysis of charred plant remains in flotation and thin section samples. In streets and lanes, charred plant remains are highly fragmented in flotation samples, but are larger than the site mean in thin section samples. Similarly in kitchens charred plant remains are smaller in flotation samples than in thin section samples.

Conversely charred plant remains are better preserved in unenclosed unroofed areas outside buildings in flotation samples, than in micromorphological samples. It has been suggested that larger maximum size in thin section of plant remains in unroofed areas in thin section may be due to rapid burial.

Fragmentation of plant remains by vertical context is similar for both data sets for firstly, the Middle Uruk period, where plants have lowest fragmentation index in flotation samples, and largest maximum fragments size in thin section in thin section. Secondly, the E-M Uruk period and Ninevite 5 periods both have a high fragmentation indices in flotation samples and low mean maximum size in thin section. There are differences, however, in results for the late third millennium BC and 2nd millennium BC. Both of these periods have fragments size in thin sections above site mean for thin section samples, but below site mean for flotation samples. There are no obvious chronological trends in either data set to suggest that longer periods of burial have a detrimental effect on preservation or fragmentation of charred plant remains.

4.3.6 Comparison of the fragmentation indices in thin section Kilise Tepe

The overall mean maximum size in thin section of charred plant remains in thin sections of deposits from Kilise Tepe is 7.56 mm.

4.3.7 Fragmentation indices in thin section - by deposit class Kilise Tepe

(Figures 16-17)

Only two of the six micromorphological deposit type classifications have mean maximum size in thin section above the site sample mean. These are accumulated occupation deposits (*5b: 10.21 mm*) and in-situ burnt deposits (*6: 15.38 mm*), which are more than twice the size in thin section of site mean.

The smallest fragments occur in construction materials and fill (*4: 4.98 mm*).

4.3.8 Fragmentation indices in thin section - by vertical context Kilise Tepe

(Figure 18)

The largest mean maximum size in thin section of charred plant remains occurs in LBA d-f (5: 18.75mm). Other periods with mean maximum fragment size in thin sections above site mean include EBA II (9: 15.04) and Iron Age (2/3/4: 9.6). The smallest mean maximum fragment size in thin sections occur in LBA a-c (6: 1mm).

4.3.9 Summary of the preservation and fragmentation analyses in thin section at Kilise Tepe

The good preservation (index 3) of charred plant remains in 50% of floor plasters at Kilise Tepe and 7% of construction/fills at Kilise Tepe is surprising. 40-50% of samples from both of these deposit types however, are also poorly preserved (index 1). The poorly preserved charred plant remains in plasters have been subject to fragmentation similar to that at Tell Brak during mixing and pugging of plaster mixes. One of the differences at Kilise Tepe is that there are a number of building levels which have been destroyed by fire. Plant remains, probably present as deliberately added stabilisers (Norton 1986), are very well preserved in burnt construction materials, similar to the unburnt siliceous plant remains and impressions of plant remains in construction materials at Tell Brak.

Occupation deposits at Kilise Tepe occur in all preservation classes, suggesting other variables are influencing preservation, such as context type. Preservation in pit fills is also varied, suggesting diverse origins for charred plant remains.

5 Discussion of results: diverse plant remains in thin section - analysis of individual depositional units and multiple variables

5.1 Introduction

Approaches to analysis of thin section data in this project have involved both lumping and splitting of data. In order to assess effects of interaction between variation in deposit type and spatial and temporal contexts, each single depositional unit in thin section data for plant remains and bone has been examined in a number of exploratory ways, which are discussed in this section of the report. Presentation and discussion of data unit by unit in the database, tables and figures, is also helping in preparation of final excavation reports for both Tell Brak and Kilise Tepe as the specific information from each unit is being integrated with information from excavation and analyses of other material remains.

5.2 Charred plant remains in thin section

In Section 4 of this report mean densities and size in thin sections of charred plant remains were examined for each variable. In Section 5 individual densities and size in thin sections of charred plant remains are examined both for individual and multiple variables, and for each depositional unit. This is also enabling examination of variation within trends such as abundance and size in thin section, which are so apparent in mean values.

5.2.1 Charred plant remains abundance and size in thin section in thin section - by deposit type and spatial and temporal contexts at Tell Brak

(Table 4. Figures 19-23)

By deposit type, the most abundant charred plant remains in individual depositional units (50%) occur in ritual deposits and unenclosed, unroofed space: craft activity (one example). The largest maximum size in thin section (15mm) occurs within a building in a kitchen context, the smallest (<2mm) in ritual areas.

Packing and fill deposits generally have the smallest and least abundant charred plant remains. Ritual packing has the least and smallest charred plant remains, suggesting source materials are 'cleaner/purer' than in kitchen areas. Charred plant remains are not abundant (<10%) in non-occupation deposits. Miscellaneous deposits generally have fragments >2mm in size in thin section.

By context type, within buildings, in ritual contexts (K) charred plant remains range in abundance from <1%-50% according to whether they occur in construction materials (low: K4a and K4c) or thin lenses of occupation deposits (generally high: K5b), but are always small (<2mm) with the exception of one sample (3mm). Kitchen contexts (H), by contrast, include largest size in thin section of plant remains (generally >2mm-15mm), and are not as abundant (<20%). The scatter plots are mutually exclusive for the abundance and size in thin section of charred plant remains in samples examined for this project. Mixed, miscellaneous or uncertain context types (X) have a scatter plot distribution close to the boundary between ritual and kitchen contexts (Figure 21: X), suggesting they are difficult to distinguish or interpret and classify both during excavation and microscopic analyses. Charred plant remains in unspecified or other rooms are generally not as fragmented as in ritual areas.

In unenclosed, unroofed spaces outside buildings, the most abundant charred plant remains occur in accumulated occupation deposits in craft activity areas (B) , these remains however, are consistently small, <2mm, due to abrasion by intensity of activities and trampling. The largest size in thin section of charred plant remains occurs in accumulated refuse deposits in 'other' spaces outside buildings (C), although other refuse deposits in these contexts are smaller (<3mm).

Charred plant remains in street deposits generally have moderate maximum size in thin sections (>2mm), and are moderately abundant (5-20%), perhaps due to use of these areas for some refuse disposal. Corridor and passageway deposits have very fragmented (<1mm), and sparse (<10%) charred remains, probably due to trampling and sweeping of these areas.

5.2.2 Charred plant remains abundance and size in thin section in thin section - by deposit type and temporal contexts at Kilise Tepe

(Table 5. Figures 24-26)

The highest concentrations of charred plant remains occur in occupation deposits on the latest floors in sequences which had been subject to destruction by burning, Deposit type 6. These charred plant remains constitute up to 40-60% of deposits by area in thin section. Some final occupation deposits, however, include some of the lowest concentrations of charred plant remains (2-5%), representing variation in i) uses of different rooms and areas of the settlement, at least prior to and during destruction (1388), and ii) burning conditions. 70% of the plant remains on the floor in H20c (1853) were burnt at higher temperatures and/or in more oxidising conditions, and are present as calcitic ashes, for example.

The largest plant remains in thin section are charred figs in collapse/fill deposits on a floor in I20-J20c (1388), measuring 37mm. They are associated with large aggregates of building materials.

The second largest size in thin section category in thin section is 8-15mm, and includes:

1) well preserved charred remains of vegetal stabilisers burnt in-situ within floor plasters (1836). Many of these stabilisers are stem fragments, which are triangular in transverse section. Some of these charred remains may have shrunk by almost one third in thickness, based on the size in thin section of pseudomorphic voids impressions surrounding charred vegetal stabilisers burnt in-situ within plaster floors.

2) plant epidermises in a thick layer on floors in H20c (5412) and I14a/b (3459)
3) charred coniferous and dicotyledonous wood fragments in pit fills (3067 and 3478)
4) charred coniferous and dicotyledonous wood fragments in fill deposits with burnt structural materials and midden-like deposits (4278, 5412, 3458)

5.3 Siliceous plant remains in thin section

The anatomy of some plants includes siliceous cell walls or silica bodies/phytoliths, especially Gramineae. Siliceous plant remains occur in many deposits at both Tell Brak and Kilise Tepe. Silica cells and plant skeletons coated by occluded carbon from charring have been counted as charred plant remains in order to record pre-depositional histories and taphonomic processes of plant remains. Siliceous plant remains with no occluded carbon occur in many deposit types sampled, but do not occur as frequently nor as abundantly as charred plant remains.

5.3.1 Siliceous plant remains abundance and size in thin section in thin section - by deposit type and spatial and temporal contexts at Tell Brak

(Table 4. Figure 27)

At Tell Brak, siliceous plant remains, with no occluded carbon, are most abundant in in-situ fuel in fire-installations, comprising up to 60% of deposit by area in thin section. They are also abundant (20-30%) in streets and unroofed spaces outside buildings. The largest remains occur in accumulated occupation deposits in unroofed space (6-8mm), one room 'other' (5mm), and in an FI in unenclosed, unroofed area. The smallest and least abundant siliceous remains occur in ritual area (2%, <0.2mm) with the exception of one sample (10%, 2mm).

5.3.2 Siliceous plant remains abundance and size in thin section in thin section - by deposit type and temporal contexts at Kilise Tepe

(Table 5. Figure 28)

At Kilise Tepe, siliceous plant remains, with no occluded carbon, are only present in seven out of twenty-eight thin section samples of accumulated occupation deposits, and occur in concentrations of less than 20%. Concentrations of siliceous plant remains may be higher in some areas not sampled for the Leverhulme Project, based on observations in the field. These contexts include areas of more oxidised burning of thick layers of plant remains on floors, where lenses of white siliceous plant remains represent plants from which occluded carbon has probably been burnt off.

The largest and most abundant siliceous remains in thin section occur in pit linings (3067 and 3478) and lenses within fills (3478), at up to 50%, and 10mm in size in thin section. Only one other context has more than 10% siliceous plant remains: dung rich deposits in I19a (5526), but these are comparatively small at <2mm. Contexts with articulated siliceous remains of more than 2mm in length in thin section, other than pits, include:

1) fill deposit with heterogeneous aggregates (5310)
2) vegetal stabilisers within plaster floors (1836)
3) thick layer of burnt plant epidermises on a floor (3459)

To view the full captions for these figures in the electronic copy, please ensure that the graph is selected and small black boxes are visible in the corners, then select View/Header and Footer.

5.4 Impressions of plant remains in thin section

Impressions of plant remains which have since decayed may be preserved in deposits with fine material of either mineral origin as in many structural materials, or organic origin, such as coprolitic or dung rich deposits. These impressions of plant remains, preserved in surrounding fine material, are also known as pseudomorphic vegetal voids or casts. Their origin as impressions or casts of plant remains has been confirmed either by presence of silica skeletons lining impression walls, or from charring of floor plasters or oven plasters for example, where charred remains of plants are preserved within spaces or voids in surrounding sedimentary material. Many of these impressions or casts are linear or curvilinear in shape, from stems and leaves of Monocotyledonous plants such as grasses or leaves. In floor plasters which have been charred, other more irregular or rounded impressions of fragmented plants are preserved, from their inclusion as fresh plant fragments, probably as stabilisers in structural materials, for stabilisers in structural materials, and preservation by subsequent charring. Where plant remains are not preserved, it is not always certain whether such rounded and irregular voids or spaces within sediments are impressions of plants which have since decayed, or channels and chambers from root activity. Many of these latter shapes tend to be recorded in the section on post-depositional alterations, and are not counted as pseudomorphic voids of plant remains to avoid any over-representation of this class of material.

5.4.1 Impressions of plant remains abundance and size in thin section in thin section - by deposit type and spatial and temporal contexts at Tell Brak

(Table 4. Figure 29)

At Tell Brak, impressions of plant remains which have since decayed are most abundant in accumulated occupation deposits in one room (30%), and are generally abundant in unenclosed unroofed:craft activity, kitchens and one corridor/passageway. The largest impression occurs in one kitchen miscellaneous deposit. Other large impressions occur in refuse packing/fill in a room (23mm), and occupation deposits in one street, room, and unenclosed unroofed area (10-12mm). These impressions are most frequent in street deposits (occurring in 8/8 samples) as at Abu Salabikh (Matthews and Postgate 1994). Possible sources of impressions of plant remains in accumulated deposits include loose coverings of leaves on floors, discard of unburnt fresh or decaying plant remains, and erosion of vegetal stabilisers from exterior wall faces, particularly in courtyards and streets, as observed at Tell Brak after heavy rain.

5.4.2 Impressions of plant remains abundance and size in thin section in thin section - by deposit type and temporal contexts at Kilise Tepe

(Table 5. Figure 30)

Pseudomorphic voids (impressions) of plant remains which have since decayed are preserved in occupation deposits with fine material of either mineral origin as in many structural materials (1850, 1836), or organic origin, including dung rich deposits (5526).

Of the fifteen deposits in which pseudomorphic vegetal voids occur, six are classified as fill, two as sequences of floor plasters, four as occupation deposits, and three as pits. The only deposits in which pseudomorphic vegetal voids are larger than 4mm, are plaster floors, where they may be up to 12mm in length. Well preserved 'casts' are common in structural materials from many sites in the Near East, particularly in plasters and mud bricks, and are visible with the naked eye. These 'casts' often represent stabilisers which have since decayed, but may also occur in occupation deposits in lanes and adjacent to grinding stones, as at Tell Brak and Tell Abu Salabikh (Matthews and Postgate 1994).

5.5 Calcitic ashes in thin section

Calcitic ashes are clearly distinguishable from fine silica cells and charred flecks in thin section, as small pale grey particles which are birefringent in cross-polarised light, some of which may be identifiable by scanning electron microscopy (Wattez and Courty 1987).

5.5.1 Calcitic ashes abundance and size in thin section in thin section - by deposit type and spatial and temporal contexts at Tell Brak

(Table 4. Figures 35-52)

At Tell Brak calcitic ashes occur outside buildings in some occupation deposits in unenclosed unroofed areas: craft activity and other (<10%), and streets/lanes (10%). Within buildings calcitic ashes occur in occupation deposits in some unroofed spaces (20%), kitchens (surprisingly <2%), ritual areas (<5%), and other rooms (<30%). In in-situ fuel in fire-installations concentrations may be as high as 40% of extant deposits.

5.5.2 Calcitic ashes abundance and size in thin section in thin section - by deposit type and temporal contexts at Kilise Tepe

(Table 5. Figure 31)

It is sometimes difficult to distinguish dispersed calcitic ashes in mineral rich deposits in thin section at Kilise Tepe. This is due in part to the highly calcareous nature of some of the mineral sediments at the site. Many calcitic ash particles are also small in size in thin section (silt size in thin section) and occur in differential and irregular clusters, or dispersed through deposits. In these circumstances, it has not been possible to measure the size in thin section or articulation of calcitic ashes in thin section in a way which would provide a meaningful index of depositional processes and agencies.

Calcitic ashes occur in greater concentrations in occupation deposits, at up to 40-80% (2825, 4535, 1258, 1853) than in fill deposits, at less than 30%. Some ash deposits include remarkably well preserved calcitic pseudomorphs of plants and other organic remains, suggesting that these deposits were either burnt in-situ or had not been subject to much disturbance during re-deposition, such as rake-out from an adjacent FI (1853). Some ashy deposits include spherulites from dung, in various stages of transformation, probably from effects of heat during extensive burning of the area (2825).

5.6 Dung in thin section

Charred and uncharred herbivore dung has been identified in a range of deposit types. Both charred and uncharred dung occur with and without spherulite inclusions, which are believed to form in the gut of animals during digestion (Brochier 1992, Canti 1997, Matthews *et al.* 1996). Factors affecting presence or absence of spherulites are not understood, but may relate to differences in animal age or species, mineral substrate, plant species and season, and research is ongoing (Canti 1999).

5.6.1 Dung remains abundance and size in thin section in thin section - by deposit type and spatial and temporal contexts at Tell Brak

(Table 4. Figures 32-33)

Charred, siliceous and ash remains of dung occur in a range of contexts outside buildings at Tell Brak, including craft areas, unenclosed unroofed areas and streets and lanes (2-22%, one example 70%). Most of it is herbivore. Dung also occurs in accumulated deposits in some rooms and fire-installations as fuel. The frequency and abundance of dung in thin section does suggest that the predominance of barley grains and glume wheat chaff in the majority of flotation samples from Tell Brak, may at least in part, relate to the presence of fodder or dung in samples (Colledge this report).

5.6.2 Dung remains abundance and size in thin section in thin section - by deposit type and temporal contexts at Kilise Tepe

(Tables 5-6. Figure 34)

All of the dung identified at Kilise Tepe is herbivore. Most of it is finely comminuted and resembles sheep/goat dung. The large size in thin section of siliceous remains and pseudomorphic voids in some lenses of dung in 2818 suggest some of this dung may be derived from larger ungulates, such as cattle (Courty *et al.* 1991, table 1).

Uncharred dung is much more common than charred dung, present in 8 out of 11 instances. Dung only occurs in two fill deposits (1858 and 3458) at less than 2-10%. Three deposits with concentrations of dung at 30-80% have been identified in I19a and I19c/d (2818, 2825, 5526). As discussed below, these deposits appear to represent accumulations of animal stabling or penning. Dung concentrations are less than 10% in all other deposits, and occur in two other occupation sequences and four deposits within pit linings and fills.

6. Discussion of results: diverse plant remains in thin section - in single depositional units

Problems relating to identification of plant remains have been discussed above in section 3.3.4. Bearing in mind such reservations, plant materials, parts and types identifiable in thin section have been recorded for each depositional unit analysed, and presented in a series of figures for each site.

6.1 Diversity and size in thin section of plant remains - in single depositional units at Tell Brak

(Table 4. Figures 35-52)

Analysis of all of the diverse plant remains present in thin section is altering some of the assessments of plant remains presence in occupation deposits. In contrast to flotation results, the highest concentration of all plant remains occur in in-situ fuel deposits in fire-installations, at 60-80% of deposits by area in thin section, only 2-10% of these plant remains are represented by charred plant remains. Many plants in burnt fuel are preserved as siliceous remains or calcitic ashes. Total plant remains abundance are also high in one deposit unenclosed, unroofed space, craft activity (67%), although in other samples in this context type are generally less abundant at <20-30%. Moderate concentrations of diverse plant remains also occur in unenclosed, unroofed spaces, other (45%), one street deposit (30%), within building unroofed space (50%), some ritual contexts (50%), six out of thirteen occupation deposits in other rooms (30-65%), and one refuse deposit in a room. Perhaps surprisingly low concentrations in kitchen areas within buildings (<4%). As suggested in interpretation of charred plant remains distributions, many of these trends and patterns are indicative of perceptions and practices of cleanliness in different areas and rooms within settlements, as much as the nature of activities themselves. This is particularly apparent in kitchens, where plant remains are extensively used as food and fuel, but were often cleaned carefully, for hygiene and pest control. Analysis of types of floors and micromorphology of deposits is adding further information to help distinguish between uses and concepts of space within settlement (Section 9, below).

6.2 Diversity of plant remains in single depositional units at Kilise Tepe

(Table 5. Figures 53-64)

6.2.1 Identification of plant remains in thin section - in single depositional units at Kilise Tepe

6.2.1.1 Identification of charred plant remains in thin section - in single depositional units at Kilise Tepe

(Table 7)

Identified charred plant remains at Kilise Tepe are listed in Table 6 and include the following:

Parts: grass stem and leaf epidermis, wood and bark, twigs, shrubby stems, parenchyma, seeds, fruit, fibres.
Types: coniferous and dicotyledonous wood, including willow/ poplar (Salicaceae), fig fruit, Gramineae, cereal grains including einkorn.

Charred plant remains occur in almost all deposit types and samples at Kilise Tepe. The greatest diversity of plant types occurs in fill deposits of heterogeneous origin (1858), deposits on floors mixed with heterogeneous aggregates (1388), and heterogeneous pit fills (3083). The absence of cereal grains in occupation deposits on floors in deposit type 5b, is just one indication of the small size in thin section of thin section samples in comparison to much larger flotation samples in which cereal grains are more widely represented (Colledge this report). The only deposit types in which unidentifiable charred flecks only occur are fill/packing deposits with lowest concentrations of plant remains (4231,1258 and 4246), thin 'soot-like' sequences on floors (1836), and the phytolith rich lining of one pit (3067).

6.2.1.2 Identification of siliceous and other plant remains in thin section - in single depositional units at Kilise Tepe

(Table 8)

Table 8 lists the frequency of occurrence of siliceous, desiccated and pseudomorphic void remains of plant types in different deposit types. Counts of occurrence highlighted in bold indicate deposits in which these remains add new information on presence of plant types not represented by charred remains. Comparison of Tables 6 and 7 clearly illustrates that at current levels of identification, charred plant remains yield information on a much greater diversity of plant types, both in thin section and from flotation. No siliceous, desiccated or pseudomorphic void remains of wood, cereal grains or figs have been identified, but are abundantly represented by charred remains in thin section. Similarly, problems in identifying siliceous remains, discussed above (section 3.3.4), currently mean that siliceous remains in this study have not been identified to species or anatomical parts such as leaf, stem and inflorescence.

The siliceous remains from Kilise Tepe do not resemble those from Tell Brak and Çatalhöyük which were studied in collaboration with Mr Tim Lawrence and Dr David Cutler of the Plant Anatomy Section, Jodrell Laboratory, Royal Botanic Gardens, Kew. Identifiable remains from Kilise Tepe include Gramineae and fibres.

Analysis of these siliceous, desiccated and pseudomorphic void remains of plants in thin section, however, provides new information in particular on the occurrence of uncharred plant epidermises. Ten deposits with uncharred plant epidermises were identified in addition to the twenty-two with charred epidermises. Four of these new deposits were fill deposits, two were occupation deposits on floors, and two pit linings.

Six deposits with siliceous and ash remains of dung were identified in addition to five in which charred dung was identified. It is still not certain whether GC/MS traces of coprostanols and bile acids from dung in early settlement sites survive, nor whether any traces present are either ancient and in-situ, or modern contaminants.

6.2.2 Variation in diversity of plant remains in thin section - by deposit type for single depositional units

(*Tables 5, 14-17. Figures 61-64*)

Figures 61-64 attempt to illustrate the diversity of different plant materials, parts and types in each depositional unit. In these figures presence is counted as 1 in each unit. The detailed information to accompany these figures is presented in Tables 5 (plant remains) and 14-17 (plants and other micromorphological characteristics).

The greatest diversity in plant materials, parts and types occurs in the following deposits:

1) Burnt occupation deposits and heterogeneous fill, type 4.2b (1858) and 6b2/4.4 (1388)
2) Deposits rich in dung, type 5.1b (2825, 5526)
3) Discarded deposits in I14a/b, deposit type 5b3/5a1 (3474)
4) Heterogeneous fill within pits, type 7b-c (5501, 3067, 3478, 3083)

Some of the lowest diversity in plant materials, parts and types occurs in:

1) stored deposits burnt in-situ on floors (4511)
2) fill deposits with <5% plant remains
3) plaster floors (1850)
4) pit linings (3067 and 3478)

There is no correlation between plant diversity and plant abundance.

6.2.3 Variation in plant remains according to context type

Given the interesting patterns emerging from variation in plant and bone remains according to context type at Tell Brak, it would be instructive to apply these criteria to analyses of plant and bone remains from Kilise Tepe.

6.3 Post-depositional alterations of plant remains in thin section

In general, deposits at Kilise Tepe have been subject to less post-depositional disturbance than at Tell Brak. Soil faunal pellets, clusters of microfaunal eggs, bacteria and organic staining, however, do occur in a range of deposits. Reprecipitated salts are also less frequent. Deposits at Kilise Tepe exhibit more variation in structure under the microscope, than was perhaps evident to me in the field.

Calcareous spherules c. 50-200um in diameter are generally more common at Kilise Tepe than at Tell Brak. These spherules generally occur in concentrations of <2%, but in some instances occur in concentrations and lenses of up to 50%, associated in some instances with organic staining (5412) and dung (5526). They also appear to occur in a series of stages of calcification and recrystallisation, as observed at Tell Brak. The origin of these spherules, however, requires further research. Dr R.I. Macphail has suggested they may be biogenic in origin (pers comm.). Similar spherules have been observed at Tell Brak, both within Leverhulme samples, and in samples examined by Dr M.A. Courty. Some of these spherules, may have formed by condensation in hot water and are found for example in modern kettles, or as Courty recently suggests, may also have formed in a hearth from burning plants or lime (Courty pers comm.). Other spherules, distinguishable only by SEM examination, may be associated with evidence for environmental disturbance at the end of the third millennium BC (Weiss *et al.* 1993, Courty pers comm.).

Some of the plant remains on the latest floors at Kilise Tepe have been subject to post-depositional charring during burning and destruction. It is these instances in which charred plant remains, not surprisingly, are abundant and well preserved, and desiccated remains occur (see above).

The preservation of plant remains may vary within one deposit according to different pre-depositional and depositional histories of different plant remains. One common example of this can be observed in plasters or mudbricks. Pseudomorphic vegetal voids from uncharred plant remains added as stabilisers are generally very well preserved due to the intact cellular structure of these fresh or dried materials during manufacture, and the lack of post-depositional alteration by trampling etc. By contrast, charred plant remains present in source materials or plaster and mud brick preparation areas have often been fragmented during mixing and preparation of structural materials, and tend to occur as dispersed flecks, due to the fragile structure of many charred materials (Figure 56, 1836). Similar patterns are observable in pit linings where siliceous remains from fresh plant/dried plant remains are better preserved than charred flecks included in lining (Figure 60 3067, 3478). Where charred, siliceous and desiccated remains all are in-situ and have not been subject to post-depositional trampling, plant remains from the same types of plant are of similar length and preservation (Figure 58, 3459 and 5412).

Charred wood and fig fragments generally feature in the larger size in thin section ranges, from 10-37mm, but also occur in all size in thin section ranges. Siliceous and desiccated remains, and pseudomorphic vegetal voids are principally from stem and leaf epidermal fragments, and tend to occur in smaller size in thin section ranges, due to differences in original plant size in thin section and articulated anatomical and structural robustness. Charred epidermal fragments burnt in-situ within plasters or on floors, however, may survive as individual articulated remains up to 12 mm in length in thin section.

7. Bone in deposits in thin section

7.1 Bone in thin section: introduction

Estimations of bone abundance in thin section will relate more to assessment of the presence of small fragments within deposits. Larger fragments of bone will not be included in the relatively small thin section samples, due to difficulties in sampling, and aims designed to examine as large a sample of deposits forming the depositional matrix of other components as possible in thin section samples.

7.2 Bone mean abundance in thin section at Tell Brak

The overall mean abundance of bone in thin section samples at Tell Brak is 0.9%, as a % by area for each deposit.

7.2.1 Bone mean abundance in thin section - by deposit class Tell Brak

The micromorphological deposit class mean abundance is *0.99%*, whilst the site deposit class mean is slightly higher at 1.17%.

Three site deposit classes have abundance values above site mean, middens (2: 1.33%), mixed floors and occupation sequences (5c: 2.75%) and miscellaneous deposits (8-9: 1.5%).

Three micromorphological deposit classes also have abundance values above site mean. Two of these are the same, namely middens (*2: 2%*) and miscellaneous deposits (*8: 1.4%*), the other is naturally laid deposits (*1: 2%*). Occupation deposit values fall just below the site mean at *0.87%*.

The lowest concentrations of bone in micromorphological deposit classes occur in floor plasters (*5a: 0.33%*), construction and fill deposits (*4: 0.6%*) and fuel in fire-installations (*6c: 0.75%*).

7.2.2 Bone mean abundance in thin section - by horizontal (spatial) context Tell Brak

The mean abundance of bone by context type class is slightly higher than the overall site mean at 1.11%.

Five of the eight context type classes sampled in thin section have bone concentrations above the overall site mean. Two of these are above the context type mean: the highest concentration is in unenclosed unroofed spaces (C: 3%), the second highest in miscellaneous deposits (X: 1.4%). Also above site mean are middens (B) and, within buildings, unroofed spaces (F) and unspecified rooms (L), all at 1%.

The lowest concentrations occur in ritual spaces (K: 0.29%) and streets/lanes (D: 0.5%).

7.2.3 Bone mean abundance in thin section at Tell Brak: discussion of results

Low concentrations of bone in ritual spaces relate to the general cleanliness of the particular spaces sampled at Tell Brak, such as the Ninevite 5 temple in HS4, which only has thin lenses of finely flecked charred remains on floors less than 1 mm thick. The low concentration in streets and lanes is surprising. How does this relate to wet-sieving finds? It may relate to lack of trampling (suggested by plant remains, sampling between bone fragments, and perhaps digestion of bone by animals such as dogs, although their faeces would produce fine fragments. It may also relate to different stages of processing. Larger fragments in streets may relate to remains from stages less removed from primary processing, whilst smaller remains within houses and some middens may relate to further processing and ?post-consumption.

7.2.4 Bone mean abundance in thin section at Kilise Tepe

The overall mean abundance of bone at Kilise Tepe is 1.03%.

7.2.5 Bone mean abundance in thin section - by deposit class Kilise Tepe

Three of the four site deposits classes sampled have abundance values above the site mean. The highest concentration occurs in mixed deposits (9: 10%). The lowest in construction and fill deposits (4: 0.54%).

According to micromorphological deposit classes, by contrast, only one deposit class has concentrations above the site mean, occupation deposits (*5b*) at *1.46%*. No bone was identified in samples of floor plasters. Concentrations were also very low in deposits burnt in-situ on floors at 0.4%.

7.2.6 Bone mean abundance in thin section - discussion of results

The comparatively high concentrations of bone in occupation sequences is as we may suspect. The low concentrations in deposits sampled on floors is rather more surprising and may relate to the specific nature of contexts sampled, but this interpretation of this data awaits the final report.

7.3 Bone mean maximum size in thin section in thin section

7.3.1 Bone mean maximum size in thin section in thin section at Tell Brak

The overall site mean maximum size in thin section of bone fragments in thin section at Tell Brak is 2mm.

7.3.2 Bone mean maximum size in thin section in thin section - by deposit class Tell Brak
The site deposit class mean maximum size in thin section in thin section is 2.91mm. The micromorphological deposit class mean is *2.2mm*.

Four of the eight site deposit classes have mean maximum size in thin sections above overall mean for the site. They include middens (2: 8.23mm), mixed floors and occupation deposits (5c: 7.12mm), mixed floors, occupation deposits and fills (5d: 2.16mm) and accumulated occupation deposits (5b: 2.12mm). These two latter classes are both very close to the site mean.

Of the micromorphological deposit classes, only three of the seven classes sampled have concentrations above the site mean. These include middens (*2: 6.88mm*), naturally laid deposits (*1: 4mm*), and miscellaneous deposits (*8: 2.8mm*). Occupation deposits (*5b*) fall close to the site mean at *1.95mm*.

The smallest mean maximum size in thin sections, in both deposit classifications of deposits occur in in-situ burnt fuel (6c: 0.33mm/*0.06mm*), floor plasters (5a: 1.3mm/*0.6mm*), construction and fill deposits (4: 0.68mm/*1.32mm*).

7.3.3 Bone mean maximum size in thin section in thin section - by horizontal (spatial) contexts Tell Brak

The overall site and context type bone mean maximum size in thin sections are close at 2mm and 2.16mm respectively. Three of the eight context type classes have mean maximum size in thin sections above the overall site average. These include unenclosed unroofed spaces (C: 8.2mm), other rooms (L: 3.43mm) and middens (B: 2.18mm). The other five context type classes all have mean maximum size in thin sections less than 1mm, streets/lanes (D), miscellaneous (X) and, within buildings, unroofed spaces, kitchens and ritual spaces. The smallest mean maximum size in thin section fragments occur in ritual spaces (K: 0.28).

7.3.4 Bone mean maximum size in thin section in thin section at Tell Brak- discussion of results

In both site and micromorphological deposit classes midden deposits have mean maximum size in thin sections above the overall site average, and occupation deposits are very close to the site mean, and floor plasters, construction and fill deposits and in-situ fuel deposits have the smallest fragments of bone.

These patterns perhaps closely follow what we might expect, with midden deposits including largest fragments relating to discard practices and perhaps lack of trampling. They also include highest concentrations.

Occupation deposits relate closely to the site mean.

7.3.5 Bone mean maximum size in thin section in thin section at Kilise Tepe

The overall site mean maximum size in thin section of bone in thin section at Kilise Tepe is 1.97mm.

7.3.6 Bone mean maximum size in thin section in thin section at Kilise Tepe - by deposit class

Pit fill deposits (7) are the only micromorphological deposit class which includes maximum size in thin section fragments above the overall site mean at *4.25mm*. Occupation deposits are very close to the site mean at *1.93mm*.

In the site deposit class pit fills are also above the overall site mean (5.1mm), along with occupation sequences (5: 2.55mm), and mixed (9: 18mm).

The smallest maximum size in thin section fragments occur in deposits burnt in-situ on floors (*6c: 0.16mm*) and in construction and fill deposits (4: 0.63mm).

7.3.7 Bone mean maximum size in thin section in thin section at Kilise Tepe - discussion of results

The largest maximum size in thin section fragments of bone in pits, suggests they were discarded in these contexts before they were subject to extensive trampling on surfaces. The small size in thin section of fragments in deposits burnt in-situ on floors, concurrent with low concentrations, may relate to the specific nature of activities within these contexts, or perhaps the nature of activities prior to abandonment or destruction. Full interpretation awaits integration of all excavated evidence in the final site report. Many of these deposits by contrast include high concentrations of charred and siliceous Graminaea stem/leaf fragments (grasses/cereals).

7.4. Bone in deposits in thin section from Tell Brak - analysis of individual depositional units and multiple variables

7.4.1 Bone in deposits in thin section from Tell Brak: all contexts

(Tables 9, Figure 65)

- The largest fragment (37mm) occurs in domestic deposits with wide range of inclusions in HS1
- The second largest fragment (26mm) occurs in unroofed space dump (20095.359 Unit 5) HN charred
- Fragments larger than 5mm include room in HS6 (20096.433 Unit 2.1) dump of floor sweepings and FI rake-out; (20096.406 Unit 6) HS1 packing of anthropogenic debris; (20096.430 Unit 11) ?rodent tooth (large) HN massive infix/collapse in disturbed deposits

7.4.2 Bone in deposits in thin section from Tell Brak: unroofed contexts

(Table 9, Figure 66-67)

- Refuse deposits (C2) include the largest fragments in each abundance class
- □ • ⌐ least abundant and most finely fragmented occur street or lane deposits (1% <3mm)

7.4.3 Bone in deposits in thin section from Tell Brak: roofed contexts

(Table 9, Figure 68-69)

- □ • ⌐ □least abundant and smallest fragments occur in ritual contexts and corridors or passage ways (kick zone etc). NB some other room deposits also occur in this category of deposits (1% <3mm)
- □ • ⌐ □most abundant (3%) occurs in occupation deposits in kitchen context (?) and in HS6 (20096.433 Unit 2.1) dump of floor sweepings and FI rake-out

for largest and smallest see 'all contexts' above

7.4.4 Bone in deposits in thin section from Tell Brak: effects of burning

(Table 9)

- □●□▲ • • ●□ ?⌐⌐ ▲ • ⫽●□20095.357 Unit 4 one large fragment (20mm) exhibits all characteristics of unburnt, lightly burnt and moderately burnt bone (B5b) HS4.1
- Charred bone is notably present in thin section 20095.359 Unit 5

7.4.5 Bone in deposits in thin section from Tell Brak: preservation

(Table 9)

Eight principal types of morphological alterations were observed, and are listed below:

1. cracking
2. splintered
3. abraded external morphology
4. calcite/sprite crystals
5. orange brown organic staining
6. low birefringence (?type of bone or effects of post-depositional alterations?)
7. semi-digested
8. weathered/dissolution

The occurrence of each of these types is summarised for unroofed and unroofed spaces according to different horizontal context types in Table 10.

Bone in unroofed contexts is often associated with organic staining. Bone from kitchens and some rooms is often cracked and splintered. Bone in packing and floor materials derived from natural sediments is often uncharred and exhibits pale birefringence and signs of weathering.

7.5 Bone in deposits in thin section from Kilise Tepe - analysis of individual depositional units and multiple variables

(*Tables 11-12. Figures 70-72 abundance and size in thin section, 73-76 size in thin section and occurrence in each unit)*

Bone concentrations in all deposit types are low, at less than or equal to 2% of each deposit by area in thin section. There is one exception to this, in ashy deposits unit 4535, type 5b3, where there is a large well preserved bone fragment, >18mm in size in thin section, and taking up c. 10% of deposit in thin section. Three of the nine fill deposits with bone include moderately well preserved fragments which are subangular in shape, and larger in size in thin section than fragments in other deposits, at 3-6.3 mm (4231, 1852, 5310). These fill deposits derive from discarded refuse.

Bone is poorly preserved in thin section samples from all other fill, floor and occupation deposits. In these deposits bone is small in size in thin section, <2 mm, often fractured, sub-rounded to subangular in shape, and occasionally exhibits signs of dissolution. Bone within pits is larger in size in thin section and moderately preserved, at 3-13mm in size in thin section.

Burnt bone is generally as common, or more common than unburnt bone in all deposit types (Table 12). Bone in the latest occupation on floors is slightly larger and more abundant than bone in underlying occupation deposits.

7.6 Comparison between micromorphological and archaeozoological analyses

General trends in archaeozoological analyses are considered here in a comparison of the two analytical approaches. Several reservations need to be borne in mind in these comparisons. The report on archaeozoological materials considers each of the trends in much greater detail accounting for variation according to animal species and size in thin section for example, which is not possible due to small sample size in thin sections and current difficulties in identification of bone in thin section. It is generally the <2mm size fraction which is present in thin section, and may be compared to more general trends relating to <2mm and greater than 2mm size fractions in archaeozoological analyses.

7.6.1 Comparison between micromorphological and archaeozoological analyses - Tell Brak

The highest mean abundance of bone in both archaeozoological and micromorphological data sets, despite their differences, occur in middens and miscellaneous deposits. Concentrations in both types of analyses are also comparatively high, close to site mean at Tell Brak for micromorphological deposits.

In both data sets high concentrations of bone occur in unenclosed unroofed spaces (C), other rooms unspecified (L), and low concentrations in ritual areas (K) and perhaps surprisingly 'kitchens' (H). The highest concentrations occur in unroofed spaces within buildings (F) in wet-sieved samples, but in midden deposits in thin section samples.

In considering size in thin section of fragments in both data sets, there is some correlation between proportions of fragments <2mm from wet-sieved samples and mean maximum fragment size in thin sections in thin section. In particular, there is some similarity in higher incidence of smaller bone fragments in construction materials, and lower incidence in middens. Data from archaeozoological results proved difficult to interpret on the basis of deposit class alone.

7.6.2 Comparison between micromorphological and archaeozoological analyses - at Kilise Tepe

The highest bone densities in deposits which had been wet-sieved occur in in-situ burnt deposits, by contrast to micromorphological data, where this category includes some of the lowest. As mentioned in the archaeozoological report, these high concentration values relate to only two of the six of these deposit types sampled, only one of which was above the overall site mean. One is an unusual FI which includes many large mammal horn core fragments.

Both micromorphological and archaeozoological mean concentrations of bone show comparatively high values for pit fills, and low values for construction materials. Density of bone in occupation deposits is slightly lower than site mean in wet-sieved samples, but slightly higher in micromorphological samples.

Both data suggest high densities in pits relate to different discard practices. In particular archaeozoological analyses have identified greater densities of both large and unidentified mammal bone remains in pits. The low concentrations in construction materials in both data sets relate to materials selected and perhaps removal of larger bone fragments, form materials which are often from natural sediments with little anthropogenic debris generally, although a range of mammal, bird, reptile, fish and crustacean bones are present in wet-sieve samples, with notably high proportions of small mammal and reptile bones.

The comparatively low concentrations of bone in occupation sequences from wet-sieving and average concentrations in micromorphological samples, suggest some 'cleaning' of surfaces, in comparison to concentrations in pits. Consideration of variation in occupation sequences according to different context types at Tell Brak, has illustrated how this may vary according to human uses and concepts of space.

It has not been possible to identify bone remains to species in thin section (section 3.3.4), so it is not possible to compare diversity of bone with that from archaeozoological data.

Both micromorphological and archaeozoological data show no evidence of lower concentrations of bone in later levels, although archaeozoological data suggest there may be more reworked bone from earlier deposits in Byzantine levels. The proportions of different deposit and context types represented in each period, however, will also affect apparent preservation in different levels.

The best preserved fragments in both wet-sieved and micromorphological samples occur in pits and room fill deposits, where bone may have been discarded earlier in stages of use than in occupation sequences, and may not therefore have been subject to as much abrasion by trampling for example. The largest fragments in both data sets occur in pit fills, in construction materials and fills, and occupation deposits.

8. Pottery and other inclusions

(Tables 14-17)

At Kilise Tepe pottery occurs in three fill deposits in thin section. The pot fragment in Unit 1852 is large, at 32 mm. The pot fragment in Unit 1836 is small and subrounded, 7mm. Unit 3458 includes pot fragments in midden-like deposits.

Pottery also occurs in pit fill (3067) as small subrounded particles in refuse deposits.

Other components identified in thin-section include basalt grindstone fragments (pit fill, 3083), aggregates of plaster, mudbrick, naturally laid deposits, including natural clays and water-laid deposits (2390), and calcareous rock fragments.

9. Contextual variation in microstratigraphic sequences

9.1 Introduction

There are four principal stages in thin section analysis of occupation sequences and evidence for uses of space. These entail analysis of:

1. materials and technology of floors and surfaces
2. impact of activities on floors and surfaces
3. nature and abundance of component sediments and artefactual and bioarchaeological remains in occupation deposits and their precise depositional and contextual relationships
4. post-depositional alterations

9.2. Contextual variation in microstratigraphic sequences at Tell Brak

Discussions and interpretation of the origin, deposition, and post-depositional alterations of each depositional unit which correlates with flotation unit numbers are presented in Table 13. Contextual variation in each of these sets of attributes is emerging at Tell Brak, and is summarised in Tables 14-15.

9.2.1 Nature and technology of floors and surfaces in thin section at Tell Brak

Different source materials and technologies were employed in the preparation of surfaces and floors in different context types. Aggregate hard core and/or few prepared surfaces were laid in courtyards and open areas. Poorly prepared plaster floors with some anthropogenic debris were laid in rooms associated with facilities for food preparation, cooking and storage. Moderately well prepared plaster floors with little anthropogenic debris were laid in rooms for sitting/sleeping and reception. These were often laid as couplets of floors with either a heterogeneous base and an orange silty clay finishing coat, or an orange plaster floor with a white plaster finishing coat. Multiple sequences of fine plaster floors were laid in ritual contexts, such as the temple in HS4.

9.2.2 Impact of activities on floors and surfaces in thin section at Tell Brak

The impact of activities on surfaces and floors also varies according to context. Surfaces in courtyards and rooms with domestic facilities are the most heavily trampled and include sub-horizontal cracks in underlying substrates and dislodged aggregates in overlying occupation deposits. Some compacted lenses of silt and impressions of mats have been identified, particularly in rooms with well-prepared floor plasters and few accumulated occupation deposits.

9.2.3 Deposition of sediments and artefactual and bioarchaeological remains at Tell Brak

The nature and depositional arrangement of components in occupation deposits provides a second independent set of attributes for analysis of variation in uses of space. Deposits rich in diverse plant remains and burnt aggregates occur in open areas and rooms with domestic installations for food preparation and cooking. A wide range of charred woody plant remains were identified in the open area in HN. Fragments of bone are often much less abundant than plant remains in thin section. Some fragments of bone in the open area in HN are larger than elsewhere in thin section and have been charred black. Other residues from activities identified in thin section include: grindstone fragments, often in sweepings in rooms with evidence of food preparation, courtyards and lanes associated with fine pseudomorphic voids from plant remains which may have been ground; pottery and stone bowl fragments; and a range of burnt and unburnt aggregates from fire-installations, architectural materials, anthropogenic debris and natural sediments.

Few naturally laid deposits have been identified in depositional sequences within the settlement at Tell Brak. Where they do occur, they are often associated with phases of negative demographic growth or abandonment, or are present in unroofed areas close to wall edges and entrances or as subrounded aggregates in trampled deposits. Wind-laid deposits often comprise sand size in thin section aggregates of finer sediments, which would be broken down in other routine particle size in thin section analyses and difficult to detect or interpret.

9.2.4 Post-depositional alterations of deposits at Tell Brak

The principal agents of post-depositional alteration are reprecipitation of gypsum and dehydrated gypsum (celestite and anhydrite), and bioturbation. These effects are most apparent in unroofed contexts and in depositional sequences close to the surface of the mound. Microbial filaments have been identified in deposits in domestic rooms.

9.3 Contextual variation in microstratigraphic sequences at Kilise Tepe

Five principal deposit types have been sampled at Kilise Tepe:

Deposit type 4	Fill deposits
Deposit type 5a	Flooring and surfaces
Deposit type 5b	Occupation deposits
Deposit type 6	In-situ materials on floors
Deposit type 7	Pit linings and fill

A number of sub-types within these general groupings have been identified and are listed in Table 16.

Summary micromorphological characteristics of each deposit type are presented in Tables 17-20. Key characteristics of microstratigraphic sequences are listed in Tables 21-23.

9.3.1 Flooring and surfaces, Deposit type 5a

(Tables 17, 21. Figures 54 abundance of plants in each unit, 56 size in thin section of plants in each unit, 62 diversity of plants in each unit).

Three principal groups of substrate have been identified within the occupation sequences sampled.

Type 5a1. No deliberately laid floor
This type of surface appears only to occur in one of the samples studied, Unit 3474. This sequence includes periodic accumulation of aggregates and lenses of ash and charred plant remains, perhaps from discard of general 'domestic' refuse. The sequence has been uniformly rubified by post-depositional burning from destruction.

Type 5a2. Packing
The second group of substrate types includes a range of packing or levelled deposits. These packing deposits were not covered with a finishing coat of plaster in six out of the ten sequences sampled with these materials. Four sub-types were distinguished within this group.

The first type, 5a2.1, comprises unoriented randomly distributed structural aggregates and plaster fragments which had accumulated on top of a floor in K19c, R6, to a depth of 85mm. This deposit appears to derive from eroding/collapsed structural materials. The entire deposit and underlying floors have been uniformly rubified by the conflagration which subsequently engulfed this building. Dense concentrations of charred einkorn occur on top of this aggregate deposit, perhaps from secondary use of the building as a storage area, or from collapsed storage pots or a hopper either on the roof or a second storey.

The second type, 5a2.2, comprises unoriented sandy silt loam packing/fill with heterogeneous aggregate inclusions, and is the most commonly occurring type of packing, associated with a variety of overlying deposit types.

The third type, 5a2.3, consists of compacted burnt and unburnt aggregate hard-core. Similar deposits were observed at Abu Salabikh in street and courtyard contexts. The hard-core at Kilise Tepe occurs in association with courtyard-like deposits in J18a and I19c/d, Units 2370, 2391 and 2818.

The last type of packing, 5a2.4, is well prepared sandy silt loam with added vegetal stabilisers, and few heterogeneous aggregates. This packing is associated with use of mats or moderate-fine floor plasters, and cleaner overlying occupation deposits.

Unit 4246 was classified as fill, type 4.5, and comprises loose heterogeneous aggregates. The friable character of this deposit, evident in the field, is due to extensive bioturbation, and includes soil faunal pellets. Due to the stratigraphic location of this deposit, below a yellow plaster floor, it may better be classified as levelled material/packing.

Type 5a3. Floor plasters
Three distinctive types of mud plaster floor were identified in thin section. The first, type 5a3.1, is made from the coarsest sediments of this group, a sandy silt loam. These sediments have not been well pugged or mixed and include unworked aggregates. 2-5% of the deposit comprises pseudomorphic vegetal voids impressions, probably from added stabilisers which have since decayed.

Plaster floors types 5a3.2 and 5a3.3 are made from similar source materials, a calcareous silty clay loam. Type 5a3.2, however, includes coarser inclusions of unworked aggregates of yellow clay, silty clay loam and calcareous rock fragments. It has also been less well mixed, and includes fewer added vegetal stabilisers. One silt loam lens is orange in colour and rare. It occurs in a sequence of plasters of type 5a3.3.

Plaster floor Type 5a3.3, is one of the finest prepared mud plaster floors which I have examined in thin section. The deposits are extremely well pugged, and added vegetal stabilisers are comparatively fine, and comprise up to 10% of deposits, and would have provided good tensile strength and flexibility. These plaster floors were applied in two locations in H20c, Units 5412 and 1836. Both of these areas were kept very clean. Accumulated deposits are less than 0.4mm thick.

Frequency of application
Only one to three applications of packing or plaster flooring are present in many of the occupational sequences at Kilise Tepe. This pattern is also commonly encountered at Tell Brak. Exceptions to this include probable courtyard areas where there are multiple layers of packing and overlying debris.

Areas with multiple layers of plaster flooring are rarer. Where they do occur they usually comprise multiple applications of fine plaster floors which were kept very clean. The only sequence of this kind sampled at Kilise Tepe occurs in H20c, Level 8, Unit 1836. These floors were well applied and continue over a step/platform within the room. The plasters on the walls are thinner, but were also applied in multiple layers. These had been baked hard during burning of this building. It would be interesting to sample these plasters in the future for comparison to sequences on walls in earlier sites such as Çatalhöyük where there also multiple applications of fine plaster/wash on the walls. The fineness and depth of application of plasters within this building suggest the building and the space within it were well tended and of special import.

9.3.2 Impact of activities on floors
The boundaries between floors/surfaces and overlying occupation deposits are described in brief in table 21. Nine types of boundaries have been identified within this sample group. These types are indicated in [ ] brackets in summary microstratigraphic tables 22-23. Some boundaries may exhibit at least two types of impact, such as mat/rug impressions during use and vertical cracks from rapid shrinking and drying of substrate during destruction burning, as in H20d and H20c, below Units 5310 and 1858.

1) Irregular diffuse boundaries with dislodged aggregates. Five of this type were observed, four of which occur in association with packing with or comprising aggregates, and one poorly prepared floor on top of packing. The boundary at the base of the deposit with charred figs also comprises dislodged and depressed aggregates and disturbed ?floor plaster.
2) Irregular boundaries with sub-horizontal cracks have been associated with trampling (Davidson *et al.* 1992), and occur in association with dislodged aggregates in J18a.
3) Irregular inter-bedded boundaries where underlying substrate and occupation deposits have been mixed, occur twice, in association with dung rich deposits in I19a.
4) Some boundaries are so irregular, underlying substrate deposits appear almost 'flame-like' or like peaked waves. These deposits often occur where substrate was trampled in moist conditions, then overlain by often organic rich deposits, which were not subject to extensive trampling, as in deposition of ashes in H20c, Unit 1852, and in some street deposits at Abu Salabikh, where ash was thrown into the street. This boundary type, also occurs in association with dung rich deposits at Kilise Tepe, in Unit 5526.
5) Some boundaries are undulating with little distinctive impact.
6) Some surfaces subject to burning exhibit vertical cracks from rapid shrinking during heat from destruction fires, as in H20d below Units 1258 and 1858.
7) Boundaries with small regular peaks may have been formed from impressions of overlying mats/rugs (Matthews 1995), and occur in H20d below Unit 5130 and in H20c below Unit 1858. Compacted sediments in curvilinear aggregates may originate from base of mats on moist surfaces, as observed in modern tents and dig houses, and in thin sections of ED1 dump deposits at Jemdet Nasr.
8) Some plaster floors in particular have been truncated prior to laying of subsequent floors. Evidence for truncation and repair of floors has been identified in H20c, below Unit 1838, and in H20d below Unit 5310. Ethnoarchaeological research in Turkey has documented frequent plastering and truncation of floors (Nurcan Yalman pers comm)
9) Two contexts have smooth knife edge boundaries between floors and deposits, H19a/b, below Unit 4278, and H20c, in the multiple sequence of fine floors in Unit 1836.

9.3.3 Occupation deposits, Deposit type 5b

(Tables 18, 21. Figures 26,28, 30,31,71, abundance and size in thin section of plants and bone, 55 abundance of plants in each unit, 56 size in thin section of plants in each unit, 62 diversity of plants in each unit, 83 size in thin section of bone in each unit).

Many occupation deposits on floors can be distinguished from fill deposits by partial strong parallel or undulating orientation and occasionally linear distribution from periodic discard, accumulation and compaction.

Six different types of occupation deposit have been identified, principally on the basis of the nature of the inclusions. The nature of inclusions is often one of the most sensitive indicators of the nature of activities, and thereby of different depositional impacts and agencies. The nature of inclusions within occupation deposits often directly affects microstructure and related distribution of coarse and fine materials.

The different sets of deposits identified include:

5b1 layers rich in uncharred dung, probably from penning of herbivores, including smaller ruminants and larger ungulates
5b2 deposits with fine pseudomorphic voids from ?winnowing
5b3 deposits rich in calcitic ashes
5b4 deposits with finely fragmented charred remains
5b5 thin lenses of deposits with a) calcareous sediments b) charred remains

Deposits burnt on floors have been classified as in-situ deposits, deposit type 6, and are discussed in the following section.

The largest plant remains occur in plaster floors. The second largest occur in deposits of plant remains burnt in-situ on floors. Bone occurs in five out of eight units. It occurs in low concentrations at 1-2% and is poorly preserved. Bone is not burnt in Unit 2370, where plant remains are also uncharred. Bone in deposits which have been burnt on floors also exhibits signs of burning, except in regions where heat has not penetrated. Bone observed in thin section in Unit 3473 occurs in structural aggregates.

5b1 Dung rich deposits
Three deposits include moderate-high concentrations of dung, at 30-80%. These sequences are similar to ethnoarchaeological samples of herbivore stable deposits from Konya and Aksaray regions. Both the Kilise Tepe and modern deposits have strong parallel orientation and distribution patterns which suggest accumulation through time. The dung is not unoriented and randomly distributed as in modern samples of dung cakes, nor as we may expect in shovelled heaps of stored dung. Underlying dung rich deposits in these sequences are more fragmented and compacted from trampling than in uppermost deposits from the latest use of the courtyard. Similar sequences of deposits have been detected within the Neolithic site of Çatalhöyük (Matthews *et al.* 1996) and Asıklı Höyük in an open area (Matthews 1998).

In Unit 5526 at least 60% of the deposit comprises non-charred dung with organic staining. The dung includes spherulites, 5-15 um in diameter, which are the same as those detected in modern samples from both the gut and dung of a range of herbivores around the world, and also occur in ancient dung (Brochier 1992 , Canti 1997, Matthews *et al.* 1996). The large size in thin section and arrangement of the siliceous remains and pseudomorphic voids in some dung fragments in Unit 5526 resemble dung from larger ungulates such as cattle, rather than sheep/goat (c.f. Courty *et al*. 1991, table 1). Positive identification of dung, however, requires collection of additional reference material. It is possible that the animals which produced the dung could be identified from chemical signatures detectable by GC/MS, if any coprostanols or bile acids survive in the organic stained deposits (Evershed and Bethel 1996). Also present in deposits in 5526 are organic staining, larger calcareous spherules of different biogenic origin, and clusters of micro-faunal eggs. These larger spherules range in size in thin section from c.100-250um, and occur in different stages of recrystallisation and calcification associated with post-depositional changes in sediments. Lenses of trampled sediments also occur within this depositional unit. Other plants remains include uncharred fibres, and charred coniferous wood, derived either from occasional discarded refuse or deposits brought in on the hooves of animals. The pinkish colour observed in the field is due to the presence of organic staining.

Units 2818 (lower) and 2825 also include dung. Both of these units had been burnt in-situ, and should also be compared to characteristics of Deposit type 6. Unit 2818 comprises 30% charred dung and 10% diverse plant remains, including woody stems, mixed with trampled sediments. Unit 2825 had been subject to more intensive burning. 80% of this deposit comprises calcitic ashes, to a depth of 40mm below the top surface of this unit. The underlying 8mm of deposit below these ashes had been charred.

The morphology of intact and fragmented dung pellets is still discernible within the undisturbed structure of the ash. Dung spherulites constitute as much as 60% of the deposit. Charred wood, seeds and epidermal fragments are also present.

5b2 Occupation deposits with finely fragmented uncharred plant remains
Unit 2370 comprises compacted calcareous sediments with 10% fine pseudomorphic vegetal voids, siliceous plant remains including Gramineae, organic staining and flecks of charred plant remains. The uniform presence of this deposit across area I19 suggests large scale activities. The abundance of non-charred plant remains may suggests these activities may have included something like winnowing of crops such as cereals or pulses. Identification of the siliceous plant remains requires further examination, firstly at higher magnifications, and secondly as phytolith samples extracted from adjacent sediments.

Unit 2391 occurs in the same microstratigraphic sequence as Unit 2370. These deposits are compacted and trampled, with parallel orientation, perhaps suggesting periodic accumulation. Uncharred plant remains include 5% pseudomorphic vegetal voids and 2% siliceous remains, <2mm in size in thin section, perhaps from similar activities as those in 2370. The 5% charred plant remains include moderately well preserved coniferous wood fragments with bark and a spiky plant. Heterogeneous aggregates include building materials and water-laid deposits.

5b3 Deposits rich in calcitic ashes
Units 3474 and 4535 are moderately rich in calcitic ashes, at 20-40% respectively. Unit 1853 has even higher concentrations of ash, at 70%. Plants structures are still discernible within the ash in 1853, suggesting ashes have been subject to little disturbance and may have been burnt in situ. Unit 2825 comprises 80% ash, but as this is rich in dung particles it has been grouped together with other dung rich deposits, discussed above in 5b1.

Unit 3474 comprises periodic accumulation of discarded ash, lenses of aggregates and 'domestic' debris in lenses <2-20mm thick. Charred plant remains are scattered throughout the deposit, but are also concentrated in lenses <5mm thick, at up to 50%. Unoriented discarded curvilinear aggregates of compacted sediments may be derived from the sediments adhering to the base of a mat, as I have observed macroscopically in modern dig houses and tents, and in micromorphological samples in ED1 refuse deposits at Jemdet Nasr, which have fragments of charred reed adhering to one surface. Charred remains include coniferous wood, epidermal fragments, seeds and dung. Post-depositional burning perhaps from destruction by fire has uniformly rubified all of these deposits.

Deposits in unit 4535 are not very compacted and are randomly distributed. These deposits include up to 40% calcitic ashes, mixed with charred coniferous wood fragments and burnt aggregates, perhaps from FI rake-out. These remains are also mixed with unburnt aggregates of plaster and sediment, and a comparatively large fragment of bone. Some of the ash has organic staining, other clusters of ash are unusually yellowish and greenish in colour. Some discoloration of ashes can occur from fat dripping onto fires during cooking, as observed in modern experiments (Courty pers comm.).

5b4 Deposits with finely fragmented charred plant remains
Unit 1858 comprises trampled sediments, fine plant epidermises, and charred dung, which were subject to post-depositional burning during destruction.

5b5 Thin lenses of deposits
In Unit 1836, thin lenses of occupation deposits occasionally occur in the sequence of multiple fine plaster floors in H20c. These comprise either a) calcareous sediments with unusual orange and black ?minerals, or b) thin lenses of charred flecks or 'soot'.

Unit 1258, below fill, is included in discussion and graphs for deposit type 6b

9.3.4 Plant remains in deposits burnt on floors, deposit type 6

(Tables 19,21. Figures 26-31, 34 abundance and size in thin section of plants and bone, 57 abundance of plants in each unit, 58 size in thin section of plants in each unit, 63 diversity of plants in each unit, 85 size in thin section of bone in each unit).

Six units are included in this discussion of burnt remains on floors. The accumulations of dung in units 2818 and 2825, were also burnt in-situ, but have been discussed in deposit type 5b1 with other dung rich deposits.

5b5b/6b Lens of plant remains burnt on floor
In Unit 1258, below fill, there is a thin lens of charred fibres from a ?textile burnt in-situ on the floor, and remains of charred wood, ?shrub, seed/cereal grain and ash.

6b1 Thick layer of plant remains, predominantly epidermises, burnt in-situ
Two units, 3459 and 5412, comprise 75-80% plant remains burnt on floors, in layers currently 13-26 mm thick. The bulk of these deposits may have been reduced by up to one third by charring and desiccation (see section 7.1), and further reduced by compaction within the mound. These plant remains principally comprise well preserved plant epidermises, at least some of which are Gramineae. Siliceous remains include long cells with a single line of stomata. Other plant remains include charred and desiccated seeds, including one cereal grain. One seed in Unit 5412 had been partially eaten by micro-fauna prior to burning. Desiccated remains in the centre of these lightly charred deposits are associated with organic staining. These plant remains are very well preserved, and probably represent remains of plant processing/storage, or possibly bedding. They are unlikely to represent collapsed roofing, due to the absence of collapsed or eroded structural aggregates, and the strong parallel orientation of the deposits which suggests they are in-situ.

6b2 Layer of charred seeds ?burnt in-situ
In Unit 4511 charred einkorn cereal grains were more scattered than plant remains in other units burnt on floors. The grains have been cracked and fragmented by extensive bioturbation. These charred einkorn grains lie on top of a thick layer of loose aggregates, 85mm deep, which had accumulated above a series of plaster floors. Both the einkorn deposits and underlying aggregates have been evenly rubified, strongly suggesting they were burnt in-situ in a single event. The presence of a thick layer of loose aggregates across the floor of this and other rooms, suggests this building may have been abandoned for a period of time, prior to final destruction by fire. The presence of stored einkorn may originate from secondary use of the building after abandonment or, possibly, collapse of an upper storey, hopper or roof area. The initial sequence of plaster floors and intervening layers of occupation debris includes burnt dung fragments up to 6mm in diameter, perhaps from dung fuel.

In Unit 1388 remarkably well preserved charred figs are scattered in a thick layer of unoriented burnt and unburnt structural aggregates, either from collapse or fill, >50mm thick. The figs were pierced with a central hole, probably for string, as in modern markets with dried figs in Turkey. The figs appear to have been charred prior to deposition as there is no shrinkage of charred remains from surrounding burnt and unburnt debris. The figs may have been strung out within this area or on a roof, or coiled in sacks or baskets. There are aggregates of plaster flooring at the base of this deposit.

5b3/6b3 Thick layer of ashes ?burnt in-situ
In Unit 1853 plant remains had been burnt to calcitic ashes. Calcitic pseudomorphs of diverse plant cellular structures and fibres are well preserved in the undisturbed ashes. Charred wood, Gramineae and fibres are also present. This dense concentration of plant remains had accumulated on top of trampled deposits. It is a little uncertain whether or not these plant remains were burnt in-situ as the underlying deposits have not been rubified by combustion. The remarkable preservation of pseudomorphs in the ashes, however, suggests the ashes have not been subject to much disturbance after combustion.

9.3.5 Fill deposits, Deposit type 4

(Tables 20, 21. Figures 25, 28-31, 34, 76-7 abundance and size in thin section plants and bone, 53 abundance of plants in each unit, 54 size in thin section of plants in each unit, 61 diversity of plants in each unit, 81 size in thin section of bone in each unit).

Fill deposits have been classified as five principal deposit types, with a few sub-types. These types were determined on the basis of microstructure, related distribution between coarse and fine materials and the nature of aggregate inclusions.

4.1 Fill/laid packing
The first type of fill resembles deliberately laid packing with a dense reworked microstructure (4231). This deposit comprises poorly mixed calcareous silty clay loam with rock fragments. The abundance of plant remains is low, at <5%, and finely fragmented at <2mm. Plant diversity is also low, with 2% charred flecks only and 2% pseudomorphic vegetal voids, the latter perhaps added as stabilisers.

4.2 Burnt occupation deposits mixed with a) burnt structural aggregates, and b) heterogeneous fill
This is the only class of fill deposits which clearly includes occupation deposits mixed with fill deposits (4278, 5412, 1858, 3458). One of the principal characteristics of this group is the greater abundance of plant remains at 10-25%, in contrast to all other fill deposits which have less than 10% plant remains. These plant remains are also generally the largest in fill deposits, at 3-9mm in size in thin section. Unit 1858 also includes the greatest diversity of plant remains in fill deposits, with a range of wood types, stem and epidermal fragments, seeds, ashes and charred dung.

Unit 4278 has a dusty lens of aggregates at the bottom of the fill, <5mm thick, which appear to have been rubified in-situ, perhaps suggesting a period of abandonment, before subsequent burning and destruction of the building. Overlying aggregates are highly burnt and are mixed with fragments of charred coniferous wood and calcitic ashes. The vegetal stabilisers within burnt structural aggregates have been charred.

Unit 5412 includes a lens of ashes and melted silica at the base of the fill mixed with unoriented burnt structural debris and dicotyledonous wood fragments.

Unit 1858 includes lenses of ash and calcareous sediments and fine rock fragments at the base, mixed with diverse plant remains, burnt and unburnt aggregates, some of which are large and include multiple layers of floor/roof plaster with intervening lenses of trample. Up to 60% of the deposit has been affected by bioturbation.

Unit 3458 includes dung pellets in the basal layer and scattered throughout deposit. Unoriented aggregates include structural materials and midden-like deposits with fine flecks of charred remains, fragments of pottery and bone, and subrounded burnt aggregates <1mm, probably from sweepings/FI rake-out. Plant fragments not in the midden-like aggregates are larger and better preserved, and include coniferous wood fragments up to 9mm in size in thin section.

4.3 Fill/collapse with a) burnt structural aggregates and b) heterogeneous aggregates
Due to the abundance of unoriented and randomly distributed aggregates in these deposits, plant concentrations are low, at 3-7%. These deposits include charred reed, and coniferous and dicotyledonous wood fragments, generally of moderate size in thin section within the sample group, at 6-7mm.

Unit 2818 includes moderately well preserved charred wood and reed remains scattered throughout the deposit with burnt structural aggregates.

Unit 1258 includes unburnt and burnt aggregates. The only plant remains in this deposit occur within structural aggregates. The plant remains comprise 2% charred flecks, which had been finely fragmented by pugging during manufacture, at <0.5mm in size in thin section, and 2% pseudomorphic voids from added vegetal stabilisers which are better preserved, at 4mm.

Unit 4249 includes burnt and unburnt structural aggregates with 5% well preserved charred dicotyledonous wood and epidermal fragments up to 6.5mm in size in thin section.

4.4 Fill with heterogeneous aggregates
This set of fill deposits is more compacted than type 4.3. Plant remains are few at 3-9%, and more fragmented than sub-types 2 and 3, at 0.5-3mm in size in thin section. Plant remains principally comprise wood and epidermal fragments. Pseudomorphic voids and siliceous plant remains are sparse and frequently occur as inclusions (stabilisers) in structural aggregates within fills.

Unit above1836 includes heterogeneous sediments with 2% pseudomorphic vegetal voids. Other inclusions comprise structural aggregates with sparse finely fragmented charred plant inclusions, burnt bone, and pottery fragments.

Unit 1838 comprises heterogeneous unoriented fill with finely fragmented charred remains of wood and epidermal fragments. Sparse siliceous plant remains and pseudomorphic voids, <3%, occur within building material aggregates in this fill.

Unit 1852 comprises unoriented heterogeneous fill with aggregates of poorly prepared building materials and anthropogenic debris. Plant remains are <3mm in size in thin section, and only comprise <2% charred epidermis fragments, 2% pseudomorphic voids and 5% calcitic ashes.

Unit 5310 also comprises heterogeneous fill with scattered building aggregates and sparse but moderately well preserved wood and cereal grain fragments, which are also small in size in thin section, at <2.5mm

4.5 Loose heterogeneous aggregates
Two deposits comprise loose heterogeneous aggregates due to extensive reworking by bioturbation, and include soil faunal pellets (4246, and above 2370). Plant remains are few at 3-5%, and finely fragmented at 0.5-3mm in size in thin section. The only identifiable plant remains comprise charred flecks and ash in unit 4246, and charred epidermal fragments in the unit above 2370. These deposits were noticeably friable in the field.

9.3.6 Deposits in pits, Deposit type 7

(Table 21. Figures 26, 28-31, 34, 82 abundance and size in thin section of plants and bone, 59 abundance of plants in each unit, 60 size in thin section of plants in each unit, 64 diversity of plants in each unit, 83 size in thin section of bone in each unit).

7a Phytolith lining at base of pit
In Units 3067 and 3478, the phytolith linings are currently < c. 1-2 cm thick. 40-50% of this lining comprises siliceous plant remains, which are slightly triangular in transverse section. These plant remains resemble added vegetal stabilisers in plasters. 3067 includes 2% dung with spherulites. 3478 includes 10% calcitic ashes. These siliceous remains need further specialist identification at higher magnifications. The ashes are likely to have been part of the binding materials, and may have acted as pesticide, although deposits have been subject to some bioturbation and reprecipitation of salts. Postgate has suggested that if the pits were used for storage, the plant lining may have provided additional insulation. Plant remains in 3067 are interspersed with dusty lenses of burnt and unburnt aggregates and ?dung, which perhaps accumulated/fell in the pit during use, before additional lenses of plant remains were added.

7a-b Calcareous plaster lining
At the base of 5510 there are a series of multiple layers of calcareous silt (clay) loam plasters 0.5-15mm thick. One plaster appears to have been burnt in-situ, perhaps during 'cleansing' of the pit. These plasters are separated by intervening lenses of general discard similar to that in other pit fills, 2-20mm thick, in accumulations up to 70mm thick. Unlike fill deposits which have been subject to fairly extensive bioturbation, the calcareous plasters are less disturbed with only sparse indications of bioturbation. These calcareous plasters may have acted as natural insect repellents (Panagiotakopulu *et al.* 1995), and have served to protect any stored contents within the pit.

7b Fill of pit with phytolith lenses, There are perhaps fewer plant remains within pit fills, than may be expected, at 7-12%, with one fill at 22%. Charred plant remains are moderate-well preserved, at 3.75-12mm in size in thin section, and diverse. They include coniferous and dictotyledonous wood fragments, epidermal fragments, seeds and cereal grains. Three pit fills include dung as uncharred, charred or ash remains. Unit 3478 pit fill accumulated more periodically than the massive infill represented by unit 3083. Unit 3478 includes a variety of depositional lenses including lenses of siliceous remains and dung from intermittent pit lining, well preserved charred wood and structural aggregates, and FI rake-out. Unit 3067 fill accumulated more rapidly between possibly intermittent discontinuous lenses of siliceous remains from ?linings.

7c Fill of pit without phytolith lenses
Unit 3083 was deposited as a massive single depositional event, infilling the pit. There are no intermittent lenses of siliceous remains as in Unit 3478, which was infilled more slowly. As we may expect, siliceous remains are more abundant in pit fills with lenses of phytoliths, than those without. Plant remains in pit unit 3083 without phytolith lenses are slightly more diverse, and include more ashes and stem fragments.

9.4 Variation in characteristics of microstratigraphic sequences at Kilise Tepe

The microstratigraphic sequence and associations of all deposits in occupation sequences are presented in some detail in Table 21. Key characteristics are highlighted in the cladistic diagram in Tables 22-23.

9.4.1 Courtyard-like or food processing areas
There is a general correlation between substrates with no plaster floors or poorly prepared plaster floors and overlying occupation deposits which include residues which may be related to activities in courtyard-like or food processing areas. These sequences include:

1) residues of dung rich deposits from probable animal penning/stabling or ?storage of dung in I19a and I19c/d (2818, 5526, 2825). The sequence of dung sampled from Unit 2825 includes a moderately well prepared plaster floor. The micromorphology of the uncharred dung below burnt horizons most closely resembles samples of stable/pen deposits from Konya and Aksaray regions. Similar deposits have been encountered within the Neolithic sites of Çatalhöyük (Matthews *et al.* 1996) and Asıklı Höyük in an open area (Matthews 1998).
2) accumulations of discard from general 'domestic' refuse (3474, 2391).
3) extensive deposits with fine pseudomorphic vegetal voids from plants which have since decayed, perhaps from activities such as ?winnowing (2370, 2391).

9.4.2. Storage

Some sequences include dense concentrations of plant remains which may have been stored. These include:

1) layer of charred einkorn and adjacent pots in K19c, R6 (4511). This einkorn occurs on top of a thick layer of aggregates, perhaps from collapse/abandonment, prior to use of area for storage, and subsequent destruction by burning.
2) extensive distribution of charred figs in I20-J20c (1388). The charred figs in I20-J20c, however, were scattered throughout a thick unoriented deposit of burnt and unburnt aggregates, either from collapse or fill. The figs appear to have been charred prior to deposition as there is no shrinkage of charred remains from surrounding burnt and unburnt aggregates. The figs may have been strung out within this area or on a roof, and lie in collapsed/fill deposits, >50mm thick. There are aggregates of plaster flooring at the base of this deposit.
3) layers of plant epidermises, including Gramineae. These occur directly on top of packing in I14a/b (3459), and on top of moderately well prepared plaster floor in H20c (5412). These layers may include plants associated with storage, processing or possibly bedding. Underlying sequences of deposits between floors in H20c include plant remains, organic staining and biogenic spherules, suggesting similar activities associated with organic rich remains.

9.4.3 Food preparation and cooking

Areas with comparatively coarse plaster floors made from sandy silt loam occur in sequences with trampled deposits and residues which may be related to food preparation or cooking. Some of the storage areas may be linked with the following sequences and activities:

1) trampled sediments and plant epidermises occur H20c (1858).
2) successive accumulations of ash, charred plants, bone and aggregates from discard and FI rake-out accumulated in K19a (4353).

9.4.4 Sitting, reception or ?sleeping areas

One sequence does not have any plaster flooring but occurs in an area which was kept comparatively clean, with few detectable residues from activities. This sequence occurs in H20d (1258), where there is a thin lens of charred fibres, perhaps from a mat or rug on top of sandy silt loam packing.

All the following sequences have plaster flooring prepared from fine silty clay loam calcareous sediments. Most of the mud plasters for these floors were not very well mixed, floor Type 5a3.2.

1) one sequence includes layers of calcitic ashes, perhaps from hearth rake-out.
2) the remaining sequences include few or no detectable residues from activities. Only 1-5 plaster floors were laid in these areas, during the use of the building. This number is low in comparison to sequence in H20c (1836), and sequences within some other complex settlements such as Çatalhöyük and Asıklı Höyük, and Abu Salabikh. Many of the buildings within Tell Brak, however, also had few recurrent applications of floors.
3) One sequence of floors was truncated and repaired in H20 c (1838), from heavy use.

The sequence of floors in H20c (1836) is exceptional within this sample group, both for the quality of the floor plaster, and multiple applications. Accumulated deposits are less than 0.4mm thick and include charred 'soot-like' deposits, and thin lenses of calcareous sediments with orange and black ?minerals.

10 Discussion and conclusions

In conclusion, this report has tried firstly to enable comparison with archaeobotanical and archaeozoological data, and secondly to furnish other information based on micromorphological information to aid understanding of deposition within complex settlements and human uses and concepts of space.

The following concluding discussions relate primarily to deposit type classifications determined after micromorphological analysis (section 3.4). In many cases mean trends based on this classification are similar to those based on deposit type classification after excavation but before micromorphological analyses. Where there are differences, these have been pointed out in sections 4 and 7.

10.1 Tell Brak

There is considerable correlation between general trends emerging from analysis of charred plant remains in flotation and micromorphological samples. The nature of these correlations, and exceptions, are discussed in Section 4.

Mean abundance and maximum size in thin sections of charred plant remains in thin section appear to be roughly co-related. Increasing mean maximum size in thin section corresponds approximately with increasing abundance in micromorphological deposit classes (Figure 87). Miscellaneous deposits (8) in particular, however, do not fit in with this trend.

By deposit type, least abundant and smallest mean charred fragments occur in construction materials and floor plasters. Charred plant remains in fuel in fire-installation are comparatively more abundant and slightly larger in size in thin section (6c). The most abundant and largest size in thin section fragments occur in midden/refuse deposits (2) and in occupation sequences on floors (5b).

Analysis of individual depositional units and multiple variables is revealing more complex correlations between abundance and size in thin section, which appear to be related to complex co-variation in different deposit and context types. Charred plant remains in ritual contexts at Tell Brak, although present as comparatively dense concentrations in the Ninevite 5 temple in thin section (<40%), only occur in thin lenses of charred flecks with little interstitial sediment, perhaps related to ritual burning activities represented by extensive traces of burning in front of the altar. This pattern contrasts with nature of charred plant remains in rooms with facilities for food preparation and cooking which are less abundant, partly due to dilution by the presence of aggregates and other components, and much larger in size in thin section, occurring in thicker layers (Figures 21 and 88).

By context type, least abundant and smallest fragments of charred plant remains occur in passage ways and corridors within buildings. Other rooms and miscellaneous context types are close to the site mean for both abundance and maximum size in thin section of charred plant remains fragments (Figure 88).

Greater maximum size in thin sections and abundance of charred plant remains occur in streets and lanes, and unroofed areas outside buildings. The largest and most abundant mean charred plant remains occur in unroofed spaces within buildings (F).

There is no micromorphological evidence to suggest that abundance or preservation of charred plant remains varies according to chronological period.

10.2 Kilise Tepe

There is also considerable correlation between general trends emerging from analysis of charred plant remains in flotation and micromorphological samples at Kilise Tepe. The nature of these correlations, and exceptions, are discussed in Section 4.

Mean abundance and maximum size in thin sections of charred plant remains in thin section appear to be more closely related than at Tell Brak, with increasing mean size in thin section corresponding approximately with increasing abundance in micromorphological deposit classes (Figure 89).

By deposit type, the least abundant mean concentrations and smallest mean maximum size in thin sections of charred plant remains occur in construction materials and fills (*4*), floor plasters (5a) and residual lenses in pit fills (*7*). Charred plant remains have higher mean values and larger maximum fragment size in thin sections in occupation deposits accumulated on floors (*5b*). The most abundant mean concentrations and largest fragment size in thin sections occur in in-situ deposits burnt on floors (*6*).

There is no micromorphological evidence to suggest that abundance or preservation of charred plant remains varies according to chronological period.

10.3 Comparisons and differences between Tell Brak and Kilise Tepe

10.3.1 Comparisons and differences between Tell Brak and Kilise Tepe - plant remains and bone

(Figures 90-95)

The overall site mean abundance of charred plant remains in thin section is slightly higher at Tell Brak (11.04%) than at Kilise Tepe (9.51%). The overall site mean maximum size in thin section of charred plant remains at Tell Brak (2.69 mm), however, is much smaller than at Kilise Tepe (7.56 mm).

Mean bone abundance at Tell Brak is slightly lower than at Kilise Tepe, at 0.9% and 1.03% respectively, although both are low and comparatively similar. The overall mean maximum size in thin section of bone at Tell Brak and Kilise Tepe is particularly close at 2mm and 1.97mm respectively.

At both sites, least abundant and smallest size in thin section of charred plant remains and bone in thin section occur in construction materials. Highest concentrations and largest size in thin sections occur in refuse deposits and some occupation deposits on floors.

Table 24 compares in summary, the size in thin section and diversity of plant remains at both sites, considering individual depositional units, for comparison to consideration of site means.

10.3.2 Comparisons and differences between Tell Brak and Kilise Tepe - depositional sequences

10.3.2.1 Characterisation of different uses of space

Micromorphological analysis of variation in:

types of floors and surfaces
impact of activities on floors and surfaces
deposition of a wide range of sedimentological, artefactual and bioarchaeological remains
post-depositional alterations and characterisation

is enabling characterisation of the following types of context:

10.3.2.2 Unenclosed or unroofed areas

Unroofed areas are generally characterised by:

- traces of wind sorted deposits and water-laid crusts, although these are often reworked by trampling, except close to wall faces
- lenses of salts on surfaces, probably exposed to evaporation of water after rain
- extensive bioturbation, although this is will also be linked to abundance of organic remains in these contexts
- bone fragments are often associated with organic staining
- heterogeneous hard-core packing
- organic and refuse rich deposits
- many street and unroofed deposits include pseudomorphic vegetal voids, which perhaps include chaff from ongoing erosion of wall faces

In addition we have been able to identify specific indications for the following types of craft activities:

- large scale burning in ovens outside temple in TB HS4.1/2
- ?pottery production close to a large boundary wall in TB HS6, although no slag etc. was identified in thin section. Alternating layers of trampled sediment and FI rake-out may indicate periodicity in use.

At both Kilise Tepe and Tell Brak there is some evidence to suggest a degree of interaction between urban and rural activities concerning:

- ?penning of animals (herbivores) in KT I19, and TB HS1 and HS2 during early-mid fourth millennium and early third millennia BC
- ?processing/winnowing of grasses or cereals in KT J18a.

10.3.2.3 Within buildings

Micromorphological characterisations of different context types within buildings are emerging (Table 25). Horizontal context types were not classified at Kilise Tepe. The column for context type in the case of Kilise Tepe refers to micromorphological interpretation of occupational sequences discussed in section 9.3. Different activities are distributed within discrete areas in these complex settlements.

10.4 Assessment of micromorphological analyses and directions for future research

Micromorphological contributions to integrative multidisciplinary research in this Leverhulme Project include:

1) quantification of abundance and size in thin section of both charred and uncharred plant remains and dung, and investigation of taphonomy, notably of burning:
   - charred plant remains often constitute only a small and varying percentage of the pseudomorphic voids (impressions), and siliceous plant remains preserved in archaeological deposits. For example:

- charred plant remains only represent 2-10% of the total 60-80% plant remains in FI s at TB
- uncharred Monocotyledon epidermises are present in 30% more contexts than charred remains at KT
- uncharred dung is present in 50% more contexts than charred dung at KT
- calcareous ashes represent up to 60-80% of some deposits

2) identification of different pre-depositional histories including:
   - charred plant remains which have been fragmented by reworking of deposit during: a) manufacture of packing and plasters, or b) trampling in street deposits, and are substantially smaller than siliceous and pseudomorphic remains of plant remains which were still fresh at time of deposition, or c) FI rake-out and discard in unenclosed spaces where fragments may be <250um (Flot. mesh size)
   - effects of digestion on plants and bone in-situ in herbivore or omnivore coprolites, and identification of plant remains, including charred seeds and phytoliths within dung
   - effects of burning and abrasion

3) identification of different depositional agencies and microenvironments including:
   - massive dumping in some pits and building infills, versus multiple depositional events through time in courtyards, or fine lenses of compacted sediments within rooms
   - natural wind and water-laid deposits in unroofed areas

4) identification of effects of post-depositional alterations, which include:
   - physical disturbance and fragmentation by soil fauna and flora, reprecipitation of salts
   - organic decay represented by pseudomorphic voids, organic staining associated with dung, bone and pseudomorphic voids, microbial filaments, fungal spores

There is no evidence to suggest plants are better preserved in more recent or more deeply buried deposits (except immediately below surface, < c.20-30cm)

It is hoped that this research has shown, that although micromorphological samples are small and there are a number of methodological problems in integrating data (Section 3.3), the general and mean trends detectable in thin section do relate to much larger sample size from flotation and wet-sieving available for archaeobotanical and archaeozoological analyses.

Future integrative analyses in preparation of final reports for these and other sites, such as Çatalhöyük, will draw heavily on the experience gained during this project, and enable further assessment of the complexities of the data and characterisation of different context and deposit types, and uses and concepts of space.

The different mean trends identified in this Leverhulme Project have shown that quantitative approaches to thin section analysis are capable of detecting significant variation in deposit and context types and thereby variation in uses and concepts of space within settlements. In the future, applications of image analysis should be developed further to study of heterogeneous anthropogenic deposits, in order to assess abundance measurements in thin section based on comparison to visual percentage by area charts. Collaboration with bone anatomists may help in identification of bone fragments in thin section.

10.5 Concluding observations

There is not much evidence for small-scale craft activities in thin section samples from either Tell Brak or Kilise Tepe within individual buildings or adjacent unroofed areas, with few residues from chipped stone, pottery waste, etc. Much of the debris within refuse areas is very similar to general domestic waste. This trend within these settlements, is not simply due to the small size in thin section of thin section samples, as there is greater variety in the nature and composition of refuse layers within thin sections of middens at the earlier Neolithic site of Çatalhöyük, with more debris from craft production. Craft production in the Bronze Age may be located in other more specialized areas.

The scale of refuse in and adjacent to administrative or ritual areas is represented by greater size in thin section and depth of refuse deposits, and higher incidences of clay sealings from excavation and flotation samples, for example, than refuse deposits in unroofed spaces within or outside domestic buildings.

Dung, possibly from penned animals, has been identified in just a few cases within both urban settlements. At Tell Brak it only occurs in a courtyard in early-mid fourth millennium BC in HS1, and within house compounds with outer courtyards in the early third millennium BC in HS2. At Kilise Tepe it occurs in KT I19.

Excavation and sampling strategies for the Leverhulme Trust Project have enabled comparison of domestic and ritual contexts through several millennia. Remarkable similarities in the nature of depositional sequences from the same types of deposits and horizontal contexts have been observed through time, and consistent differences between each type. Consistent differences between sequences from different types of horizontal context such as courtyards, streets, rooms for food preparation and cooking, and ritual activities, have been identified and characterised by variation in mean abundance, size in thin section and diversity of components, and the nature of microstratigraphic sequences. Distinctive sets of attributes characteristic of different uses of space have been detected, providing keys for use in excavations at other sites.

What appears to vary according to socio-cultural context and time is the configuration and interconnectedness of areas and uses of space, characterised by these keys. Domestic buildings located unusually within compound walls, rather than free-standing along streets and lanes, have been detected at the beginning of the third millennium BC both at Tell Brak in northern Mesopotamia, and at Abu Salabikh in southern Mesopotamia. Fuller investigation of this and other emerging variations in syntax of different uses and concepts of space, requires future large-scale area excavation and sampling of urban settlements.

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