University of Reading
School of Archaeology, Geography
and Environmental Science

# INVESTIGATING NEOLITHIC ECOLOGY AND SETTLEMENT NETWORKS IN THE KONYA PLAIN

## Integrated micro-contextual analysis of buildings and open areas at Çatalhöyük East, Boncuklu Hüyük, and Pınarbaşı

Thesis submitted for the degree of
DOCTOR OF PHILOSOPHY

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## Declaration:

I confirm that this is my own work and the use of all material from other sources has been properly and fully acknowledged.

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# ABSTRACT

This PhD research focuses on the investigation of local developments in sedentism, ecological strategies, and site networks in Central Turkey through the microstratigraphic study of buildings, middens, and open areas at the Neolithic sites of Boncuklu Hüyük (9th-8th millennium BC cal), Çatalhöyük (8th-6th millennium BC cal), and Pınarbaşı (9th-7th millennium BC cal).

To examine the relationship between Neolithic subsistence economy and settlement dynamics at high resolution it is necessary to investigate the nature, distribution, and periodicity of accumulated micro-residues derived from daily activities, as well as the technological choices expressed in floor construction materials. Thus, a geoarchaeological study appears as the most suitable approach to this problem, as it provides us with the tools to explore questions of ecology and society at multiple analytical scales, tying environmental data from the surrounding landscape to excavated on-site evidence for subsistence.

This research has entailed, firstly, the microstratigraphic excavation of a building at Çatalhöyük to experiment with field, recording, and sampling strategies of finely laminated sequences. Second, a micromorphological study of house floors, middens, and open areas at the three sites has been conducted to identify the origin, deposition, and periodicity of components indicating particular human activities such as storage, food procurement and cooking practices, and the ecological and social variations of these. Thirdly, construction floor materials have been characterised through XRF, XRD, and FTIR methods. Finally, SEM-EDX and IR microscopy have contributed to the characterisation of specific deposits related to domestic activities such as food and fuel management.

The combination of these highly resolved spatial and chronological datasets has offered robust explanations for each community's economic, ecological, and social basis. The results address the relationship between Neolithic communities and their environments, giving a more precise understanding of the full range of landscape exploitation strategies used by early farmers in the wetland/dryland setting in which these sites existed. This integrative approach is essential to confirm the different path to sedentism that scholars are currently positing for Central Anatolia, and models for local diversity more widely.

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# 1

# INTRODUCTION

*The first chapter reviews the main issues of this investigation and highlights the aims and objectives of the research conducted in this thesis. A critical evaluation of key themes in Near Eastern Neolithic research including the origins of agriculture, sedentism and settlement organisation, building materials, and architecture, is expounded in this chapter. Issues concerning the socio-economic dynamics of neolithisation in the Konya Plain are discussed within the framework of the study sites investigated. Finally, the research questions, aims, and specific objectives of this investigation are examined alongside the methodological approach used in this study and its contribution to previous geoarchaeological works in the Konya Plain.*

## 1.1 The Neolithic Transition: a significant milestone

One of the most intensively discussed topics in modern times is that of the human relationship with the environment. With climate change threatening to alter all aspects of human life, including health, housing, and culture, the development of feasible solutions and adaptations to a new environmental scenario has become a major popular concern. Unsurprisingly, this subject has long been a recurrent research focus of archaeological investigations, the discipline most clearly devoted to exploring and understanding the human condition over time and space (Butzer 1982; Robinson *et al.* 2006; Roberts *et al.* 2011). The archaeological record reveals the diversity of community responses to changes in the physical environment occurring over millennia, highlighting the need for flexibility and resilience in complex adaptive systems and offering important insights that are relevant to the contemporary human experience (Bar-Yosef 2011; Flohr *et al.* 2016; Özdoğan 1997). The study of human ecological strategies is a topic of particular importance and subject of contested debate when dealing with periods of change in economic practices, such as the emergence of agriculture and sedentism during the Neolithic period (Zeder 2009; Belfer-Cohen and Goring-Morris 2011). Social dynamics are inherent to these discussions, as they are a key component in human adaptations and ecological choices. Throughout our history as a species, human groups have been systematically involved in interaction spheres that have served to promote the exchange of knowledge, resources and technologies in such a way as to increase the ecological repertoire available to any local group. Recent ethnographic studies on Hazda communities, a population of hunter-gatherers in Tanzania, demonstrate that the construction of social networks is a key element in cooperative behaviour (Apicella *et al.* 2012). Such socio-cultural networks were probably present at an early point in human history, increasing flexibility in ecological strategies and ultimately allowing for a diversification in resource exploitation and the maintenance of resilience.

These concepts of ecological strategies and social dynamics are especially important in Neolithic research due to the transformation in human interactions with the landscape witnessed during this period. Interestingly, although the recently proposed geological epoch, the 'Anthropocene' (Crutzen and Stoermer 2000), defined as "the present time interval, in which many geologically significant conditions and processes are profoundly altered by human activities […] including colonisation, agriculture, urbanisation and global warming" during the last International Geological Congress (Zalasiewicz 2016) is generally considered to begin in 1800 AD with the onset of the Industrial Revolution in Europe or, alternatively, 1945 AD with the start of the nuclear age, some voices claim that it is the dawn of the Neolithic period that set the beginning of this new era (Ruddiman 2003; Glikson 2014). This argument is based on the evidence for major environmental alterations occurring during this period, including the burning of forests to clear areas for crops, resulting in increased emissions of $CO_2$ to the atmosphere (Head 2016), and the massive extraction of alluvial sediments for mud-brick production (Biçakçi 2003). Investigating Neolithic socio-economic transformations then, has the potential of shedding light into the complex and interwoven nature of the relationship between human cultures and environmental conditions, a topic of worldwide significance that applies to modern ecological and humanistic enquiries and that is the focus of this thesis.

### 1.1.1 Research context on origins, ecology, and landscape

There has been much debate in recent years regarding the universal understanding of the Neolithic as a stable and definite period of human history strongly defined by the concepts of agriculture and domestication (Asouti 2013a; Zeder and Smith 2009; Price and Bar-Yosef 2011). A widely accepted assumption, in particular, entails that the Neolithic represents a crucial transition between two opposite human lifestyles: nomadic hunter-gatherers versus settled agriculturalists and herders (Baker 2006; Cohen 1977). Current research is challenging this interpretation and some scholars are beginning to suggest that this traditional view of human ecology is too rigid and that the gathering of wild resources was still important during this period (Asouti and Fuller 2012). Nonetheless, there is an ongoing debate on the extent of reliance on wild versus domesticated resources, with some scholars arguing for agricultural production as a key component of the Neolithic economy (Fairbairn 2005), and others placing a more equal importance of wild food resources (Atalay and Hastorf 2006).

One of the most important means to re-frame the Neolithic transition is to break apart its monolithic status by demonstrating its spatial and temporal variability. Evidence has shown agriculture and animal domestication to be a contingent emergence in a number of different ways in various areas around the world (Davidson 1989; Piperno and Fritz 1994; Belfer-Cohen and Goring-Morris 2011), and scholars have recently began to stress the inadequacy of overarching explanations and universal models, as these are unable to accommodate all the variability displayed by the growing archaeological record (Zeder and Smith 2009). Therefore, in studying transformations in ecological strategies during the Neolithic, special attention must be given to the local environment in which these changes are framed and, in particular, to the extension and interactions between dryland and wetland habitats, key to cereal cultivation (Roberts and Rosen 2009). Archaeological investigations at local and regional scales would encourage interpretative frameworks closely based on existing empirical information, focusing on the complex interplay of a range of temporal- and geographic-specific environmental, economic, and socio-cultural factors, contributing to the understanding of what is increasingly being recognised as a set of long, complex, and independent developmental trajectories to Neolithic lifestyles in different regions of the world (Asouti 2013a).

The Near East, a region roughly encompassing the lands between the Nile Valley and Mesopotamia including the Arabian Peninsula, Anatolia, modern-day Iran, and Cyprus, has long been the target of archaeological research aimed at exploring the earliest emergence of agriculture and sedentism (Bar-Yosef and Valla 1990; Childe 1928; Flannery 1969; Kuijt 2002; Miller 2001). This has been encouraged by the status of this region as a source of many of the world's major crop plants and livestock species (Vavilov 1992; Kislev and Bar-Yosef 1988; Lev-Yadun *et al.* 2000) which, in addition to its great time-depth and biological diversity, has served to classify this area of the globe, and in particular the Fertile Crescent, as an agricultural centre of origin and dispersal (Harlan 1971; Diamond 1997). This has been explained by the confluence of various environmental factors favourable to agriculture, including geological, biological and cultural characteristics (Wright 1976). Over time, however, the theory of a few agricultural centres has been modified in favour of a multiple-origins hypothesis (Fuller *et al.* 2011; Zeder and Smith 2009), partly in the light of novel plant genetic and morphological evidence that has demonstrated that many of our most important crops, such as wheat and lentils, have been domesticated multiple times, with single domestication events occurring outside the Fertile Crescent (Armelagos and Harper 2005; Heun 1997).

The Central Anatolian region, in particular, despite being situated within the distribution zone of major domesticated animal species, namely cattle, pig and ovicaprines (Martin *et al.* 2002), and having been identified as the origin of a number of plant domesticates (Özkan *et al.* 2002), has been viewed by some scholars as an area peripheral to major Neolithic developments occurring elsewhere in the Near East (Cauvin 2002), a discourse founded on the apparent absence of a strong Epipalaeolithic tradition in this region. Therefore, the Neolithic of Central Anatolia was originally conceptualised as an intermediate phase between the initial development of sedentary lifeways in the Fertile Crescent and its subsequent spread and adoption across Anatolia and Europe, hence denying participation in the so-called 'nuclear zone' of economic and socio-cultural transformations. Intensive archaeological research in Central Anatolia over the last thirty years, however, has put the region in the spotlight by revealing fundamental differences between the early village communities settled in this area from at least 8500 cal. BC and those of the Fertile Crescent, pointing to the status of this region as a distinct area of early neolithisation (Özdoğan 1999).

The few sites that have been extensively excavated in Central Anatolia, comprising Aşıklı Höyük, Canhasan, Çatalhöyük, and Boncuklu between others, have provided richly detailed contextual data that has made it possible to examine the specific microscale factors that shaped the trajectory towards agricultural settlements in this part of the world. Nevertheless, in spite of this rich body of data, there are still aspects of this transition that remain inadequately understood. Some of the sites in Central Anatolia, in particular Aşıklı Höyük and Çatalhöyük, are amongst the largest known in the Near Eastern Neolithic, each hosting populations that would have reached thousands of individuals (Hodder and Cessford 2004; Cessford 2005; Özbaşaran 2012). Although it was initially thought that these 'mega-sites' were located in virtually empty landscapes, devoid of contemporary and preceding settlements (Düring 2007; Hodder 2005c), in the case of the Çatalhöyük hinterland, an archaeological survey led by Douglas Baird in the south-western Konya basin identified six possible Epipalaeolithic sites, six settlements spanning the Aceramic Neolithic, and one Ceramic Neolithic site, Pınarbaşı B, occupied towards the end of the Catalhöyük East sequence (Baird 2005; Watkins 1998). Ongoing investigations at some of these sites, in particular the Aceramic village of Boncuklu Hüyük, have the potential to create important new insights into the first appearance of sedentary agricultural communities in this region, the presence of local traditions, and the historical context of the large settlement at Çatalhöyük (Baird *et al.* 2012a).

### 1.1.2 Settlement configuration and social complexity

A research topic that has been insufficiently studied in the past concerns the clustered spatial organisation of the largest settlements within the Central Anatolian Neolithic and its influence on the articulation of society. These sites, formed by domestic buildings constructed atop one another that were accessed through a roof entrance and clustered into neighbourhoods that were not divided by streets, were continuously occupied for centuries, and their complex settlement patterns contrast with the small-scale early Neolithic sites in the Levant (Belfer-Cohen and Bar-Yosef 2002). Although a number of scholars have addressed the issue of societal organisation and its reflection in the architectural and spatial constitution of Neolithic settlements in Anatolia (Cutting 2005; Düring 2005), these studies comprise mainly the analysis of site plans and feature distributions, focusing the attention on building continuity and thus creating an unfavourable bias against buildings with shorter developmental trajectories, commonly smaller and containing less features than the average built environment at these sites. Therefore, the functional and social roles that these small buildings played in the constitution of large settled communities has not been critically examined, nor has archaeological data from these built environments been meaningfully integrated into the frequently inflexible definitions of households and social groups (Hodder and Pels 2010).

An underlying problem is the fact that Neolithic researchers have only recently begun to tackle systematically the social issues involved in the formation, organisation and reproduction of sedentary local communities during this period (Düring 2007; Kuijt 2002; Price and Bar-Yosef 2011). Traditionally, investigations have focused on topics related to the ecology, economy, and technology of early village groups, in a paradigm that considered the Neolithic mainly as an economic transition from hunter-gatherer societies to agriculturalists induced by demographic pressures (Cohen 1977; Bocquet-Appel 2008), climatic changes (Bar-Yosef and Belfer-Cohen 2002; Bar-Yosef 2011; Richerson *et al.* 2001), or a combination of both factors (Flannery 1969). In these lines of research, the key issues explored addressed climatic fluctuations and their impact on the availability of local resources, and the identification of morphological and genomic changes in plant and animal species related to domestication processes. New interpretations of the Neolithic transition in the Near East were launched in the 1980s, directing the attention to the social context of household life (Byrd 1994), community (Hodder 1987; Hodder 1990), and religion/symbolism (Cauvin 2002). These alternative views shifted the point of debate from questions concerning domestication mechanisms to social arrangements and their variations through time and space, conceiving the Neolithic as a cognitive transition that implied the development of new structures of thought upon which food production existed. This new emphasis resulted in a focus on houses and households, the latter perceived as the most important social institution of this period, linked to new symbolic systems and economic means of production (Byrd 2000; Flannery 2002; Hodder and Pels 2010). The main problem with these perspectives is that they tend to disregard other levels of social interaction. Although Neolithic households appear to have been transcendental social institutions, acting as the key organisational units of economic production and consumption, and most sites seem to be devoid of communal buildings, the existence of corporate institutions is hinted at by the high degree of symbolic elaboration of some built environments, in particular the display of animal remains such as cattle skulls and horns, suggestive of food sharing (Bogaard *et al.* 2009), and the deployment of disarticulated human remains (Bonogofsky 2004; Hodder and Meskell 2011). However, even though the adoption of agriculture, the development of household identities, and the flourishing of elaborate material symbolism appear to have been interrelated processes, a strong focus on behaviours shared by and between communities has resulted in attempts to construct a rather monolithic understanding of Neolithic social and economic systems (Baird 2012a). Furthermore, the tendency of drawing too much attention to the spatial and architectural homogeneities of domestic buildings within and between settlements may have masked differentiations promoted by variable landscape and social practices.

This research, therefore, proposes to examine the economic, social, and cultural dimension of Neolithic houses through the high-resolution analysis of occupation surfaces and accumulated residues in buildings and open areas at three Central Anatolian settlements spanning from the 9$^{th}$ to the 7$^{th}$ millennium BC. Stratigraphic sequences are viewed in this investigation as more than just records of activities and uses of space, but as an important category of material culture that embodies social practices, technological knowledge, and ecological choices. As such, their study is deemed fundamental for understanding the variable relationship between humans and the built environment, and the social complexity of Neolithic settlements.

#### 1.1.2.1 Household and community space

Domestic built environments have been the focus of archaeological research for several decades, partly due to the valuable information they provide on household activities, family structure, and the changing use of space (Banning 2003; Watkins 2004; Souvatzi 2012). In the case of Neolithic communities in the Near East, interpretations have often been articulated around the concept of autonomous households as the principal elements of social and economic organisation, each occupying discrete buildings that showed a high degree of spatial standardisation (Byrd 2000).

However, the house-household analogy that identifies the domestic building as part of an apparently stable social order appears as a problematic research focus, albeit one that has been adopted in many studies (Steadman 1996). In fact, the relationship between the house as a physical unit and the people who occupied and used it would have been subjected to changes determined by factors such as kinship structures, social practices, and economic systems. In addition, domestic buildings might not have been associated to specific households but rather used and managed by more than one individual and social unit (Souvatzi 2008). The view that Neolithic houses were inhabited by family groups based on kinship is an assumption that needs to be demonstrated in particular cases, as does the complex relationship between built environments, social entities, and units of production and consumption (Deetz 1982; Allison 1999). This leads, however, to considerable difficulty in the definition of a household in archaeological terms, usually strongly bounded by the identification of material houses.

Another important point to consider is the multiple temporalities of architecture and how changes at the seasonal, annual, and life-time scales can have an impact on the nature and management of domestic activities and the engagement of individuals and social units with the built space (Matthews 2012b). High-resolution studies focused on the systematic analysis of microstratigraphic sequences and small-sized material residues of human activities, often conducted at the microscopic level and therefore closer to the short timescales that created the data, have made important contributions to our understanding of household and community practices at an unprecedented level of detail (Boivin 2000; Karkanas and Efstratiou 2009; Matthews 2005b; 2005a; 2012c; Weiner 2010). The value of these studies, however, transcends their ability to inform us on the precise loci and nature of domestic practices across time and space to provide key insights into household behaviour and relationships between social actions and the material, thus contributing to our understanding of how past societies were articulated. Domestic built environments are viewed here as the loci where individual identities, ideological concerns, and economic interests intersect and define the trajectory of communities (Barański *et al.* 2015a). While the difficulty of using architectural materials and activity micro-remains as evidence of the size and composition of a household and its relationship with the built environment is acknowledged, the patterns produced by these forms of archaeological evidence are deemed to be informative on the importance of houses in constructing and maintaining socio-economic frameworks and ideologies within the community.

Thus, the concept of household adopted in this research is conceived as "[…] a social group cooperating in a sphere of social, economic, and ideological practices consisting minimally of production, distribution/consumption, transmission, and social reproduction" (Souvatzi 2012: 18). Importantly, this moves away from the notion of kinship as the defining parameter of households, mainly understood as family units, and the interpretation of houses as the material constructs of individual autonomous households that has long permeated the views of Neolithic communities in the Near East (Banning 1998; Watkins 2012).

The large settlement at Çatalhöyük East, in the Konya Plain of south-central Turkey, was one of these communities. This site, world-renowned for the outstanding preservation of its bioarchaeological assemblage and elaborate art, displays a highly agglomerated settlement pattern and distinctive mud-brick architecture. Building interiors are characterised by a strict division of space that shows remarkable continuity both throughout the settlement and over time, a uniformity that has been interpreted as dictated by social regulations (Hodder and Cessford 2004). Interestingly, recent research at this site based on the dental morphology of human remains buried beneath buildings floors has shown the absence of biological affinity between individuals buried together (Pilloud and Larsen 2011). This implies, at least to some

**Figure 1.1** *Top left image*: experimental Neolithic house at Çatalhöyük displaying a traditional rectangular plan; the entrance at floor-level was made for visitors' accessibility purposes. *Top centre image*: interior of the Çatalhöyük experimental house looking north towards the 'clean' area of the building, where plastered platforms and wall-paintings are commonly found. The crawhole connects the main room with the ante-room, commonly used for cereal storage. *Bottom left image*: recreation of the interior of a Neolithic Çatalhöyük house at the Museum of Anatolian Civilizations in Ankara. The south-western corner of a typical house is represented, with the food preparation area located around the oven, and the ladder entrance above it. *Top right image*: experimental Neolithic house at Boncuklu Hüyük, showing an oval plan. *Bottom right image*: interior of the Boncuklu experimental house looking towards the sunken, 'dirty' area of the building where the hearth is normally found. Notice the roof smoke-hole immediately above the fireplace.

degree, that households were probable flexible entities, based on rights and practices rather than kin, and linked to specific buildings by complex social ties (Hodder 2013a).

One of the main goals of this research is to draw attention to the multiple forms in which built environments occurred at the Neolithic site of Çatalhöyük by investigating architectural floor materials, formation processes, and activities in the insufficiently studied small-sized buildings, the study of which is vital to complete our understanding of socio-economic systems at this settlement. The archaeological evidence from these buildings, usually interpreted as annexes to larger buildings nearby and considered too small to have functioned as autonomous units, has been widely overlooked in previous studies. Assumed to be socially and economically dependent on larger houses, the possibility that they could have hosted individual households with at least a certain degree of autonomy has not been considered yet. The role of these small-sized buildings within the settlement is still under question and is therefore a key focus in this research, with some scholars arguing that they were the scenario of specialised activities, while others interpret them as Neolithic pied-à-terre, seasonal residences for individuals who wanted to be part of the important community at Çatalhöyük (Hodder, pers. comm.).

However, in order to understand how houses and households were embedded in larger communal associations, they cannot be studied in isolation. Therefore, it becomes necessary to contextualise built environments by investigating settlement areas that were potentially the scenario of wider social interactions, such as courtyards and unroofed spaces, also examined in this thesis. Open spaces in Neolithic settlements are commonly referred to as middens, that is, refuse areas frequently rich in bioarchaeological and artefactual remains (Schiffer 1987). The study of middens is key in investigating ecological strategies and daily practices, as these spaces often contain a wide range of deposits relating to fuel and cooking activities, food processing, industrial activities such as plaster manufacture, and penning practices (Matthews *et al.* 1997; Needham and Spence 1997). Archaeo-stratigraphic sequences in open spaces from a number of Neolithic sites in Central Anatolia have been observed to contain extensive layers formed by ashes and charred plant remains interpreted as relating to large-scale burning activities (Baird *et al.* 2012b; Shillito *et al.* 2011b). In addition to these, researchers at the site of Çatalhöyük have detected evidence for *in situ* craft activities in middens, including wood working debris (Matthews *et al.* 1996), abundant obsidian flakes (Carter *et al.* 2006; Carter 2012), mud-brick production (Love 2012), lime burning (Matthews 2005b), and remains of pottery manufacture (Akça *et al.* 2009). Understanding the formation processes of open sequences entails the identification of single depositional episodes within these contexts and the examination of the composition of the layers to determine the activity sets and discard practices represented by them. In particular, the detection in ashy contexts of different fuel sources such as woods, grasses, reeds, and dung, indicative of landscape use, is only possible through the application of microscopic techniques due to the finely laminated stratigraphy commonly encountered in these Neolithic external areas (Shillito and Matthews 2013).

Another category of open area, in between what could be categorised as private and public space, comprises building tops. These were both passage routes and the scenario of a range of outdoor activities in agglomerated settlements such as Çatalhöyük (Matthews 2012c). The analysis of floor sequences from flat roofs and upper storeys is highly significant for the investigation of spatial boundaries and behaviour due to the possibility that they contain residues from activities that were not performed on the ground floor of buildings. Unfortunately, the preservation of remains from the uppermost parts of buildings is rare, a fact that, together with the difficulty of detecting possible roofing during excavation due to the variability of the architectural materials used for its construction, has contributed to the low archaeological visibility of these sequences.

To sum up, the investigation of open spaces alongside interior sequences is critical to a comprehensive interpretation of ecological strategies, uses of space, and social dynamics within settlements, especially if we consider the sparsity of finds on most Neolithic building floors (Matthews 2005b). To this end, this research concentrates on examining the material remains of houses, middens, and suspected roof fragments, placing the emphasis on their spatial patterning and multiple temporalities to throw light on settlement dynamics involving economic practices, household organisation, and units of consumption.

#### 1.1.2.2 Building materials and architecture

Building materials are strongly related to the social dimension of settlements, as they are both the deliberate product of human actions and a determinant factor of building form, durability, and the ways people organised their physical living spaces. However, it is not only the building structure per se that may reflect and affect behavioural patterns and cultural traditions, as the location and form of interior features and decorations, as well as the materials used in their production, can be equally revealing on these issues. Architectural structural elements and surfaces are the physical manifestation of spatial and social boundaries for particular fields of action within a settlement (Steadman 1996; Watkins 2004). The selection, manufacture, and placement of specific materials is therefore not merely a functional or technological process, but also the means for the representation of social roles and identities.

The Near Eastern Neolithic has been defined by the extensive extraction of clay for the sun-dried mud-brick architecture that characterises early sedentary settlements during this period (Biçakçi 2003). Building materials commonly comprised mudbricks, mortars, structural elements of organic origin such as wooden posts and beams that are often difficult to observe on site, pisé-like constructions, make-ups, and plasters. The production of the inorganic materials entailed first the collection of appropriate sediments from surrounding alluvial sources, followed by the modification of their physical properties such as plasticity, cohesion, and strength by adding water and stabilisers. The latter commonly included plant remains, herbivore dung, minerals, and often, extracted midden layers of high organic content. The final processing of the materials would have involved moulding, compaction, direct shaping, or firing (Cammas 2003; Houben and Guillaud 1994). This complex preparation required good organisation and skills, technical knowledge, and a substantial amount of labour.

The technology and social aspects involved in Neolithic mudbrick and mortar manufacture have been the subject of meticulous examination by a number of scholars at Çatalhöyük (Love 2012; 2013; Tung 2005; 2013). These studies, based on the compositional variations of these structural elements across neighbouring buildings, have shown mudbrick production to be an independent process for every household. The sediments used in mudbrick manufacture, in particular, appear to have been locally procured within the catchment area surrounding the site, with variations in material composition being the result of independent manufacture practices rather than of differential access to raw materials (Doherty 2013). Love (2013) argues, however, that in the latest levels of occupation at Çatalhöyük there is a broader pattern of sharing resources and knowledge. A comparative study of the composition and manufacture processes of building mudbricks at the early Neolithic site of Boncuklu, situated immediately to the north of Çatalhöyük, is currently in progress (S. Love, pers. comm.) and will contribute to expand our current knowledge of the selection and use of raw materials for wall construction in Central Anatolia during this period.

Rooftops have been considered extremely significant architectonic elements to understanding key aspects of daily life at the clustered site of Çatalhöyük, such as the nature of external activities and the location of passage routes communicating different areas of the settlement (Mellaart 1967; Hodder 2006). Nevertheless, in spite of the extraordinary preservation of buildings at this site, the evidence for roofs is sparse. Stevanović (2013) deduced, after analysing a range of fired clays bearing wood imprints from two burnt buildings at Çatalhöyük, that building tops were probably made of a wood framework covered with plant matting and several layers of clay that served to create a flat surface where a wide variety of activities would have been performed. In this regard, Matthews (2012c) identified remains of ovens and cooking residues in the collapsed roofing of Building 3, whereas Cutting (2005) has suggested the possibility that roof space played an equally active role in domestic practices as house interiors. This, however, does not appear to have been the case at the neighbouring Neolithic sites of Boncuklu and Pınarbaşı, both of which displayed an open settlement plan. At these sites building access was at floor level, and roofs, consisting of broadly the same raw materials as those used at Çatalhöyük, namely wooden beams and plant matting encased by a thick layer of clay (Baird *et al.* 2012a; 2014; Baird 2003), do not appear to have been the scenario of daily activities.

It is important to bear in mind, however, that while the structure of a building, formed by mudbrick and mortar walls, wooden posts, beams, and the core of the roof, is the product of a single temporal event, although likely spread to a considerable length of time, the floor stratigraphy of a building reflects multiple production and depositional events as well as the impact of human activities on these surfaces, all of which results in a detailed physical record of the histories of people and place (Boivin 2000; Matthews *et al.* 2004; Robb 2010). Therefore, the microscopic study of floor plasters and the occupation residues accumulated on top of them can provide important insights on continuity and change in ecological and social actions, household strategies and roles, and wider relations at high-resolution timescales (Karkanas 2006; Karkanas and Efstratiou 2009; Macphail *et al.* 2004; Matthews 1995; Matthews 2012a).

In Central Anatolia, micromorphological analyses at Aşıklı Höyük have revealed the alternating use of calcareous and non-calcareous mud plasters in building floors (Mentzer and Quade 2013). At Çatalhöyük, previous works conducted by Wendy Matthews (1996; 2005b; 2005a) have highlighted the use of a wide range of different materials in multiple floor re-paving episodes. The occurrence of hard floors made of fired lime in the earliest levels at the site has been claimed by Matthews (2005b) and Matthews *et al.* (2013) based on micromorphological observations of floor sequences. The production of hard-lime plasters, which commonly involves the use of large quantities of fuel sources for the firing process, has been suggested to occur at a household scale on the edge of the settlement (Cessford and Near 2005). Both marls and backswamp clays, however, were occasionally modified to make floor plasters and pisé-like constructions. Floors made of pebbles have also been documented in the latest levels of occupation at the site (Tung 2013).

The materials and periodicity of the wall plasters found in building interiors at Çatalhöyük have been investigated by Matthews and colleagues (2013) using thin-section micromorphology and spectroscopic mapping. These analyses have shown that foundation plasters were prepared using a marl source, whereas the lighter finishing coats consist of softlime sediments, extracted from sources located 6.5 km away from the site.

These sequences of plastered surfaces in the walls and floors of a building reflect cyclical events of house maintenance and individual life-histories associated with household practices and identities (Matthews 2005a). Micromorphological evidence and radiocarbon dating of Neolithic built environments at Çatalhöyük have demonstrated that these were typically occupied for fifty to one hundred years, with later buildings often having slightly shorter occupation spans (Cessford 2001; Cessford *et al.* 2005; Matthews 2005a). These buildings were characterised by a great degree of dynamism, being subjected to renovations, abandonment, and reconstructions on a regular basis. Amidst the remarkable consistency in the types of sediments selected for plastering at Çatalhöyük, certain materials, such as the red paint used in mural art and in walls associated with burial platforms and individual inhumations in buildings (Hodder 2005b; Stevanović 2012b), appear embedded with symbolic overtones. The fact that these coloured plasters and painted motifs are usually encountered in very few of the layers that constitute the plastered sequences of house walls, formed by up to 300 plaster applications probably done on an annual or seasonal basis (Matthews *et al.* 1996), suggests that these materials relate to the temporality of particular rituals and important events in the life-history of buildings (Boivin 2000).

The present study aims to expand the current knowledge of the selection, manipulation, and use of sediments as architectural materials by Neolithic communities in Central Anatolia through the micro-analysis of selected floor plasters, surface deposits, and suspected roofing materials at Çatalhöyük East, Boncuklu Hüyük, and Pınarbaşı A and B. Although extensive micromorphological and geochemical applications to both wall and floor plaster sequences have already been undertaken at the site of Çatalhöyük (Matthews *et al.* 2013; Anderson *et al.* 2014b; Anderson *et al.* 2014a), recently exposed structures displaying unusual spatial and architectural patterns, such as Building 114 in the North Area of the site, provide an opportunity to challenge the conclusions reached in previous studies based in other types of built environments, in addition to a testing-ground for new hypotheses on the use and diversity of Neolithic building materials. Furthermore, the high-resolution micro-analysis of building sequences from the sites of Boncuklu Hüyük and Pınarbaşı, also located in the Konya Plain within the immediate vicinity of Çatalhöyük, will contribute to the development of a wider understanding of the biographies of architectural materials, as well as to the investigation of the possible temporal continuities in the selection, technology, and symbolic significance of specific sediment types used in the manufacture of building materials throughout the Neolithic period in Central Anatolia.

### 1.1.3 Research perspectives and methodology

Issues related to the evolution of social landscapes, settlement organisation, and household differentiation, are the central subjects of this research, which aims to contribute to our understanding of the socio-cultural framework of the Konya Plain throughout the Neolithic period. The basis of the analysis consists of two elements: undisturbed occupation sequences from building interiors, and the microstratigraphy of open areas. The examination and comparison of the depositional histories of these two different types of space is expected to improve our understanding of the processes that led to their configuration, use, and abandonment, critical to the interpretation of socio-economic dynamics, ecological strategies, and concepts of space at any settlement. Significantly, this study puts domestic built environments into perspective by including open areas in the analysis, the latter conceived not only as places of discard but as the key location of group activities and social interactions (Shillito *et al.* 2011b).

The methodology applied entails three multiscalar components: first, the microstratigraphic excavation and geoarchaeological sampling of a small built environment, approximately 9 $m^2$ in extension, conducted at the site of Çatalhöyük to explore in unprecedented detail the use and spatial distribution of this type of built environment, frequently classified as secondary annexes to larger buildings on the sole basis of their reduced size (Mellaart 1967; Tringham and Stevanović 2012); second, the high-resolution contextual analysis of architectural surfaces and traces of activities at three settlements spanning the Aceramic to the Ceramic Neolithic, namely Çatalhöyük (8th-6th millennium cal BC), the herder campsite of Pınarbaşı (9th-7th millennium cal BC), and the early agricultural site of Boncuklu Hüyük (9th-8th millennium cal BC), all located in the south-west of the Konya Plain and within the vicinity of the Çarşamba river, undertaken through the micromorphological observation and description of a number of domestic and open contexts at each of these settlements; third, the application of a series of X-ray and spectrometry techniques to a selected range of spot samples and bio-archaeological inclusions from specific deposits within the studied stratigraphic sequences to determine their chemical compositions, depositional pathways, and preservation state. Taken together, these methods, described in more detail in Chapter 3, have the potential to create important new insights into the development of the Neolithic in Central Anatolia, and in the Konya Plain in particular, which may be of relevance beyond this period and region.

An important aspect of this study is the development and application of a novel excavation and recording methodology that would result in an improved identification, documentation, and understanding of the information from individual microlayers (those less than 1 cm in thickness) that form the bulk of the stratigraphic record of most buildings and open areas at the study sites. Although these thin deposits, often millimetric in thickness, are acknowledged to contain important information related to seasonal and life-cycle changes, they are excavated in large arbitrary units which do not represent actual units of deposition (Farid *et al.* 2000). It is proposed here that the integration of strategic baulks and sections into the excavation methodology contributes to a better understanding of the depositional and post-depositional histories of the sites and enables the application of a range of field and laboratory sedimentological characterisations, including enhanced sampling for thin-section micromorphology, X-ray Fluorescence (XRF), X-ray Diffraction (XRD), Fourier Transform Infrared Spectroscopy (FTIR), and Scanning Electron Microscopy with Energy Dispersive X-rays (SEM-EDX), techniques that have the potential of making important contributions to the identification of environmental micro-residues present at these settlements, and to expand upon what has been learnt from more traditional methods of enquiry.

This is, however, not only a study in methodology, as the principal issues addressed in this investigation are social ones. The central questions asked are: Can we reconstruct in detail the histories of individual buildings and open spaces? Can we identify different levels of community organisation at the study sites and, if so, how were they interrelated? Is there evidence of the existence and development of local settlement networks in this part of the Konya Plain throughout the Neolithic period? These questions are approached through the high-resolution contextual analysis of interior and exterior occupation surfaces, a part of material culture that, in spite of being both the scenario and a construct of human practices, is surprisingly seldom considered for the examination of social issues in the past (Karkanas and Goldberg 2007). This is probably due to the fact that, until recently, socio-cultural investigations in archaeology have been undertaken on the basis of a paradigm, that considers only the characteristics of artefacts and bioarchaeological finds, as well as their spatial arrangements, as informative on these issues, thus neglecting the potential contribution of the sediments, also produced by humans, in which those finds are embedded. Stratigraphic studies of sediment sequences are essential for the interpretation of depositional processes, human-induced modifications, and the cultural history of sites, shedding light into the behaviour of their inhabitants (Schiffer 1983; 1987). The focus is not only on the identification and quantification of non-recovered micro-residues, but on the understanding of their particular context, and the relationships between sediments and finds (Goldberg and Macphail 2006).

Therefore, this research targets not only building materials, specifically, manufactured floors and other surfaces, but the social occupation and environmental performance of buildings and open spaces, going beyond previous studies focused on architectural forms based on plans of single buildings and simple descriptive analyses (Allison 1999; Souvatzi 2008) that result in static models of behaviour and use of space. Investigations of settlement dynamics should consider not only spatial patterns and socio-cultural principles, but also the multiple temporalities entailed in human occupation (Lucas 2005). The definition of timescales is a fundamental aspect of community studies that is often very difficult to address, especially since archaeological interpretations of deposits, building phases, and site levels, are usually formulated at a much grosser scale than the short-term processes that led to their existence (Foxhall 2000). Furthermore, when attempting to reconstruct activities occurring within a given space, it is important to bear in mind the McKellar hypothesis (McKellar 1983), which postulates that it is the smallest residues that are more likely to be discarded as primary refuse in activity areas, especially when these are frequently cleaned, a statement that has been later supported by ethnoarchaeological and experimental research (Schiffer 1987). In reality, few macroscopic archaeological artefacts can be said to have been found *in situ* within a site, and a substantial proportion of these cases are often related to single events of abandonment or post-abandonment activities, including ritual and refuse (Hodder 1999a). This evidence illustrates the need for a high-resolution methodological approach which can aid in the identification of short- and long-term spatial and temporal changes in settlement layout and socio-economic practices, enabling fine-tuned interpretations of behaviour at timescales that are closer to the temporal life-cycles and practices that led to them (Boivin 2000; Matthews 2005b; 2012b).

In conclusion, this research deals with the Neolithic communities of the Konya Plain and seeks to identify some of the mechanisms that were involved in the creation and reproduction of social groups during this period through the high-resolution study of depositional sequences at the three key sites. This might help us gain a better understanding of the settlements and societies of the Central Anatolian Neolithic, and contribute to the study of the constitution of communities, use of space, and ecological practices in the Near Eastern Neolithic as a whole. What follows is a critical overview of previous research on questions related to the emergence of agriculture and sedentism in Central Anatolia, and in the Konya Plain in particular, delving into ecological strategies, settlement organisation, and socio-cultural change, including a consideration of how the present investigation aims to extend and build upon this.

## 1.2 Issues concerning the emergence of agriculture and sedentism in the Konya Plain

Central Anatolia is a region of key importance for understanding the development of Neolithic innovations and their spread from the Near East to other geographic territories. The area began to attract significant archaeological attention after the initial excavations at Can Hasan and Hacılar (French 1962; Mellaart 1961), and the subsequent spectacular finds at Çatalhöyük (Mellaart 1967) during the 1960s. In the following decades archaeological work intensified, leading to the discovery and further excavation of several Neolithic settlements that, despite the outstanding results they have yielded, remain considerably scattered across the region, especially when compared to the myriad of sites assigned to this period that have been excavated in the Levant (Özdoğan 1999). Scholarly attempts to expand the Neolithic record of Central Anatolia comprise geomorphological surveys (Roberts *et al.* 1996), and archaeological landscape surveys led by Todd (1998), and Baird (1996; 2002), the latter restricted to the Konya Plain and resulting in the identification of over thirty sites spanning from the Epipalaeolithic to the Chalcolithic period. In spite of these efforts, the emergence of the Neolithic in Central Anatolia has tended to be viewed from the perspective of two or three large sites, with Çatalhöyük and its exceptionally complex wall art and architecture occupying a prominent place in archaeological investigations within this regional context. Excavations at this 'mega-site' resumed in 1993 under the direction of Ian Hodder, and the project has since then attracted numerous specialists from widely diverse research disciplines (Hodder 1999b; Hodder *et al.* 2007). However, to be fully understood, this large, aggregated community has to be put in a broader historical and contemporary context (Baird 2002).

Interestingly, the virtual absence of Upper Palaeolithic sites in the Konya Plain has been used as evidence to support diffusion, acculturation, and colonisation theories that view the emergence of the Anatolian Neolithic as derived from the Levant and regions farther to the south-east (Özdoğan 1999). However, the small number of early settlements found in this region dating to *ca*. 9000-7500 BC and contemporary with the later Pre-Pottery Neolithic A and B in the Levant share very few features, with oval buildings and microlithic chipped stone assemblages dominating the Central Anatolian record (Baird 2012a). This has encouraged some researchers to stress the importance of indigenous settlement in this part of the Near East, as archaeological evidence appears to indicate cultural continuity between Epipalaeolithic groups in Central Anatolia and the earliest Neolithic in this region (Düring 2010). In this line of thinking, a number of scholars have suggested, on the basis of mudbrick and stone tool

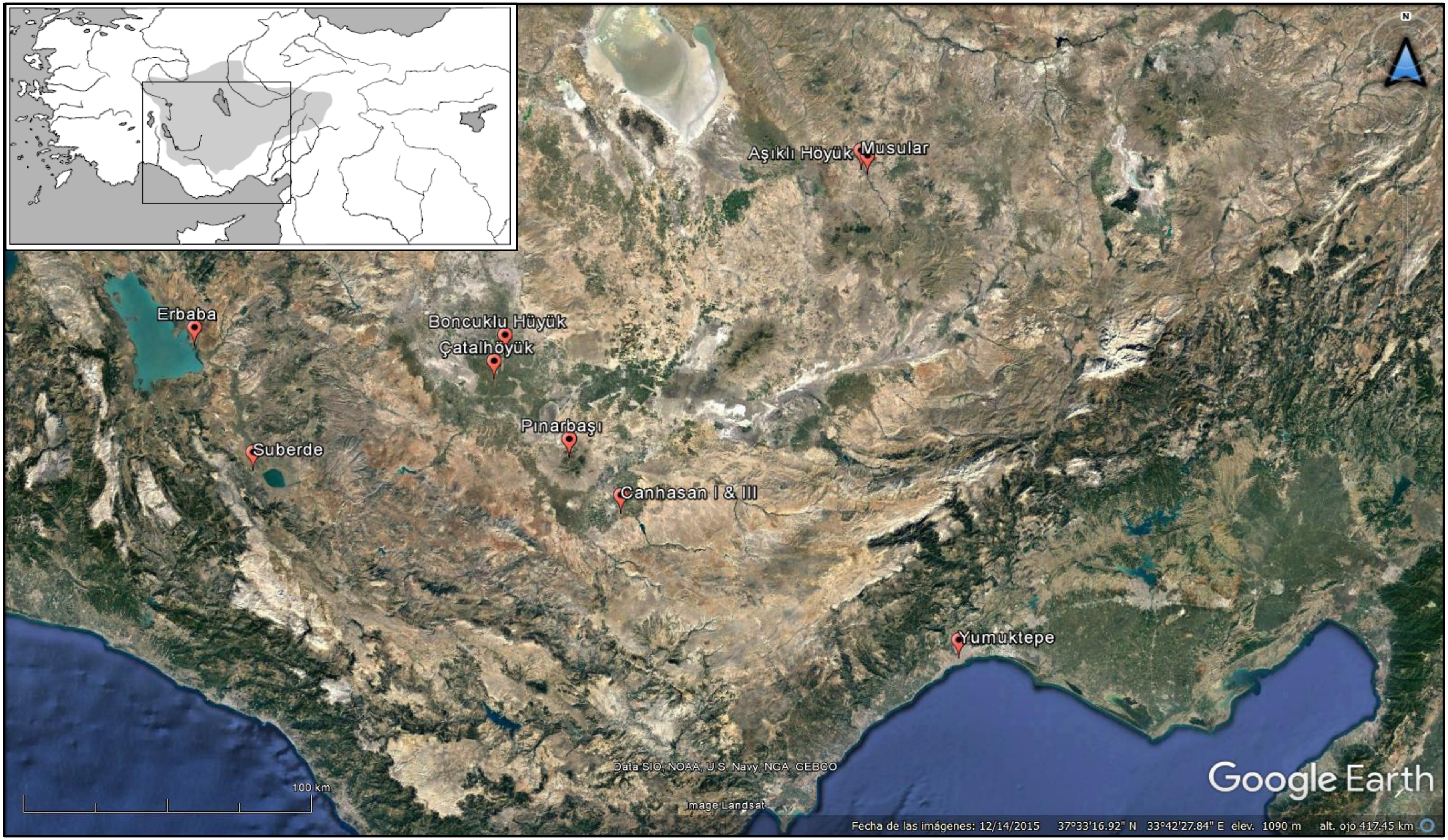



**Figure 1.2** Map of South-Central Anatolia, with key Neolithic sites indicated.

technologies, that the large settlements at Çatalhöyük and Aşıklı Höyük might had developed from small earlier sites in the plateau (Duru 2002; Baird 2002).

The extent to which major questions about the origins and development of the Neolithic in the Konya Plain remain unresolved rests partially on the very few sites that have been discovered and excavated, a situation that contrasts with the Neolithic settlement of Upper Mesopotamia and the Levant, where over four hundred sites have been investigated (Özdoğan 1999), providing enough data to support the formulation of wide-ranging hypotheses and theoretical assessments (Bar-Yosef and Valla 1990). In spite of this caveat, with the growing body of evidence indicating that the Neolithic was a diffused phenomenon that unfolded over a vast geographical area and developed along local path trajectories (Özdoğan 1995), it appears essential to address the relationship between neighbouring communities to confirm the different culture-historical paths to sedentism that scholars are currently positing for Central Anatolia, and current models for local diversity more widely. In the specific case of the distinct Konya Plain record, newly excavated early settlements such as Boncuklu Hüyük are contributing to re-define the parameters of this debate (Baird *et al.* 2011a).

### 1.2.1 Socio-economic dynamics during the neolithisation of the Konya Plain

The Konya Plain, due to its long history of archaeological research, great time-depth, and landscape setting, appears as an ideal region for the investigation of the resource exploitation patterns and social dynamics involved in human behavioural ecology. The most prominent settlement in this area is the site of Çatalhöyük (8th-6th millennium BC cal) which, since its initial excavations in the 1960s (Mellaart 1965; 1967) has become recognised as an internationally significant site due to the exceptional preservation of its wall art and the richness of its bioarchaeological assemblage. These characteristics have made the settlement a unique site within the Neolithic of Turkey, and have served to promote the investigation of the Neolithic occupation at Çatalhöyük in isolation, with little discussion as to how it relates to the broader local and regional pictures (Asouti 2005a). Although there have been several attempts aimed at placing the large community at Çatalhöyük into a wider socio-economical perspective (Baird 1996; Boyer *et al.* 2006), these studies have been carried out at a gross scale, and comparative microcontextual approaches for the investigation of settlement dynamics and socio-ecological strategies in this region have not yet been undertaken.

Before Çatalhöyük emerged as a megasite, the early agricultural communities of the Konya Plain were organised in small settlements scattered across the wetlands. Boncuklu Hüyük was one of these villages, characterised by its dispersed oval houses with paintings, bucrania, and sub-floor burials reminiscent of the ritual complexity of the later settlement at Çatalhöyük (Baird *et al.* 2014). The more than plausible contemporaneity of this site with the 9th millennium BC cal habitation of Pınarbaşı, as inferred from the similarities in their lithic assemblages (Baird *et al.* 2012b), opens an intriguing scenario where the community at Boncuklu was involved in the adoption of cultivation, as the presence of processed cereal plant remains on site appears to indicate, while that at Pınarbaşı maintained an alternative lifestyle, relying primarily on gathered resources (Baird 2003; Fairbairn *et al.* 2014). In spite of the uncertainty surrounding the identification of crop species in a context of early plant domestication, it appears as clear that in this region different paths to agriculture and sedentism were possible within the same environmental setting.

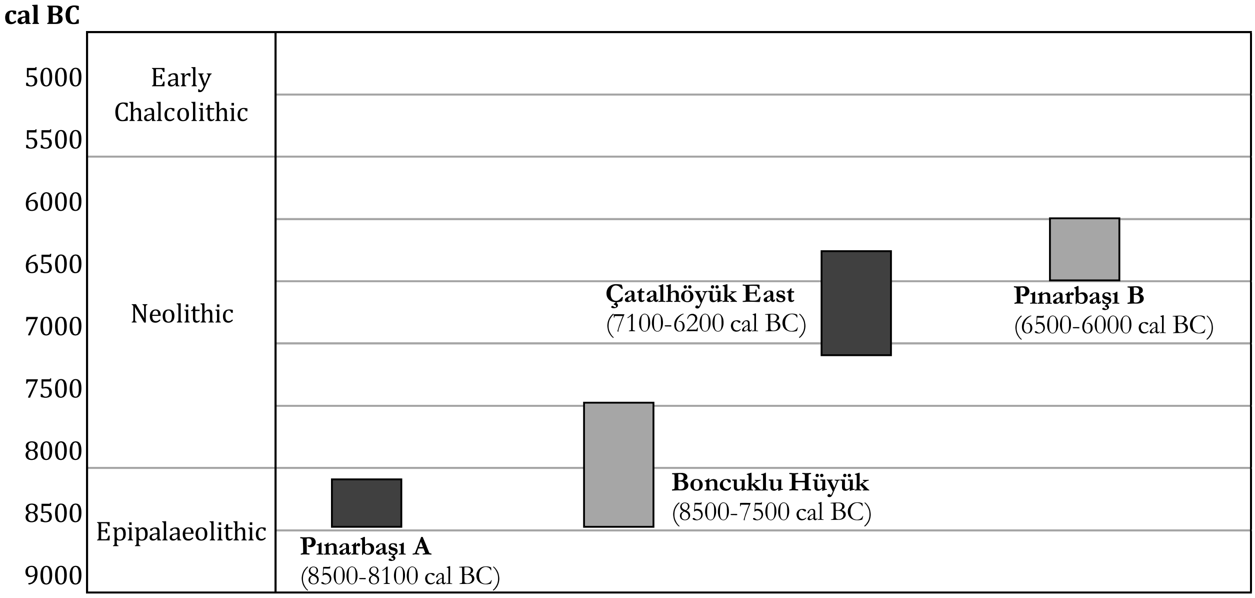



**Figure 1.3** Timeline of human occupation in the Konya Plain for the study sites. Data collected from Baird (2012b); Baird *et al.* (2011b); Baird *et al.* (2012b); Bayliss *et al.* (2015); Watkins (1996).

This situation contrasts with the lasting view of early Neolithic communities in the Near East as relatively egalitarian groups that lived in standardised domestic structures, such as the pier houses of the Levant Pre-Pottery Neolithic or the rectangular buildings of Çatalhöyük East, and relied heavily in crop production for their subsistence (Byrd and Banning 1988; Byrd 1994). These theories led to a rigid perception of early village life in which little cultural change occurred in several hundreds of years, as interpreted from the continuity in symbolic manifestations, the organisation of domestic space, and the almost uniform socialisation of individuals with their houses (Goring-Morris and Belfer-Cohen 2013; Hodder 2006).

Again, these models appear flawed when we examine the evidence from Çatalhöyük East, a Neolithic settlement continuously occupied for approximately a thousand years. Here, different lines of evidence suggest that the population of this site was eventually compelled to develop social and technological mechanisms to cope with the challenges posed by a landscape gradually evolving to drier and more arid conditions, at least partially due to the impact of human activities (Asouti 2005b; Boyer *et al.* 2006; Hodder 2014a). However, one cannot understand these changes in social organisation and landscape exploitation at Çatalhöyük in isolation, without attempting to explore what was happening in other contemporary sites within the region to estimate the extent of the 'uniqueness' of this large settlement. Therefore, the investigation of another Late Neolithic site would provide a more conclusive indication of the full range of socio-economic strategies present in the Konya Plain at this time.

The 7$^{th}$ millennium occupation at the Pınarbaşı rockshelter, contemporary with the latest levels of occupation at Çatalhöyük East, is characterised by its large concentrations of herded sheep/goat and the rare presence of cultivated cereals and legumes (Baird *et al.* 2011b). Although it is not clear whether the community at Pınarbaşı was distinct from that of the megasite, and faunal studies indicate seasonal occupation of the rockshelter based on the high numbers of caprine neonate remains found (Baird *et al.* 2011b), frequent contact between the two population groups would be expected due to the proximity of these sites.

The application of high-resolution techniques undertaken in this study to investigate micro-traces within houses and open areas at both settlements, closer to seasonal and life-cycle changes such as periodical site abandonments, will aid in the identification and comparison of resources and activities, adding further information to the socio-cultural connection of these two settlements and their ecological interests in the wider landscape.

Overall, the archaeological evidence from the Konya Plain points to a distinctive local path in the spread and development of Neolithic lifeways, placing us in a unique position to explore the transformation of neighbouring communities adopting a sedentary lifestyle over a wide temporal frame, something rarely achieved in the archaeological record. Significantly, in order to examine the nuances of cultural change and the diversity of ecological adaptations, it is important not only to explore the link between the remains of subsistence resources at a particular site and its immediate environmental setting, but also to situate this within the social geography of the area under study. This appears as essential to be able to address the relationship between Neolithic communities and their environments on one side, and between different settlements and individual households on the other, giving a more precise understanding of the full range of landscape exploitation strategies used by early farmers.

The detailed microstratigraphic study of occupation sequences and environmental remains at the neighbouring sites of Çatalhöyük, Boncuklu, and Pınarbaşı conducted in this thesis is expected to add significantly to our understanding of the social dynamics and patterns of landscape use involved in the adoption of cultivation by forager communities from their neighbours in this part of Central Anatolia. The combination of macroscopic and microscopic elements, in particular, constitutes the main strength of this research, allowing to approach the complex dynamics of human behaviour from a building, settlement, and local scale to understand variations in socio-economic strategies. Altogether, this investigation will make a meaningful contribution to our current knowledge of cultural adaptations of Neolithic communities in the area, their possible interactions, and the inter-relationships between these settlement foci.

#### 1.2.1.1 Household networks and socio-cultural change at Çatalhöyük

Results from the first years of the Çatalhöyük Research Project, devoted to the survey, excavation, sampling, and analysis of the settlement and its surrounding landscape, stressed the marked temporal continuity and cultural uniformity of the site, supported by the sparse evidence found for social and economic differentiation (Hodder 2005a). Over recent years, however, the research focus has shifted towards the investigation of the social geography of the settlement, moving past the study of the individual house and its occupants that characterised the early stages of the project. This new trajectory has led to the identification of a major cultural shift during the occupation of the site between Mellaart levels VI and V, dated to approximately 6500-6400 cal BC (Hodder 2013b). The socio-economic changes linked to this transition appear to have occurred immediately after the highest point of population density at around 6500 cal BC, which seems to have been associated with an increase in human fertility, as it has been interpreted from the analysis of the human skeletal remains buried beneath the floors of houses dated to this time period (Hillson *et al.* 2013; Larsen *et al.* 2013). This major shift was also accompanied by a gradual transformation of the environment around the site caused by both climatic change and human intervention, entailing a marked increase in dryness and a reduction of the wetlands (Boyer *et al.* 2006; Bar-Yosef Mayer *et al.* 2013; Asouti 2013b).

The upper levels of the Neolithic occupation at Çatalhöyük also display evidence of an increased focus on sheep/goat and domesticated cattle, as seen in the animal bone assemblage (Russell *et al.* 2013). This change was probably accompanied by a shift in animal management strategies from pooled herds to segregated animal herds with greater landscape mobility, as the increased diversity of sheep/goat isotopic values in the upper levels seem to indicate (Pearson 2013; Henton 2013). This evidence correlates with the human femoral midshaft data collected from skeletal remains, that indicate a higher degree of mobility within the Çatalhöyük population in the upper levels (Larsen *et al.* 2013). This was probably associated to the increased emphasis on caprine herding across a wider diversity of environments and the extraction of other forms of resources, such as stone beads used in the manufacture of personal ornaments (Bains *et al.* 2013). In addition, there is a significant decrease in the material elaboration of burials in these later stages of the Neolithic occupation, a trend that has been corroborated by the discovery of multiple burials and a tomb structure in the uppermost excavation area at the site, the TP Area (Marciniak and Czerniak 2007a).

Similar changes have been detected in other forms of material culture. The chipped stone industry, for instance, displays a major techno-typological switch from level VI onwards, involving the production of artefacts from pressure-flaked prismatic blades, as opposed to the detachment of flakes from irregular multi-platform cores using direct percussion, a practice that was common in earlier levels. Due to the considerable skill that this later technique requires, the shift in the lithic industry has been interpreted as evidence for craft specialisation (Conolly 1999). Similarly, a gradual change in the pottery assemblage starting at around 6600 cal BC has been identified by Doherty and Tarkan Özbudak (2013). This consisted in a switch in manufacture towards the use of non-local clays collected from volcanic regions to the west, in contrast with the local clays that were predominantly used in the early stages of occupation at the site.

All these changes resulted in a trend towards increased house size and independence across the whole site, a pattern that appears to be related to processes leading to a gradual accumulation of wealth by individual households (Marciniak and Czerniak 2007b). Building continuity decreased, and the houses, occupied for shorter periods and displaying little evidence of the history-making practices and ritual features commonly found in earlier levels, became larger and more complex, accommodating several storage and work-rooms under the same roof. These changes also affected the settlement plan, which shows more open spaces between houses in the upper levels, possibly a consequence of a more fragmented and dispersed occupation. Nevertheless, evidence of social differentiation remains slight, although signs of incipient craft specialisation have been identified in the stone bead and chipped stone assemblages (Hodder 2013b). Overall, it appears as if the socio-economic focus at Çatalhöyük shifted from social and ritual obligations established to reinforce cooperative networks between households, to independent households managing their own resources and relations in the later levels of occupation.

This research aims to contribute to these issues through the micro-stratigraphic examination of the occupation sequence of three buildings assigned to Mellaart levels VII-V (*ca*. 6600-6400 cal BC) in order to investigate possible discontinuities in the choice of floor construction materials, variations in the spatial organisation of interior spaces, changes in the range of activities performed within buildings, shifts in fuel source preferences, and signs of economic specialisation and house differentiation. Furthermore, geoarchaeological research on the late Neolithic occupation of the Pınarbaşı rockshelter will aid in understanding the Çatalhöyük transition in a wider local context, providing further evidence of the diversity of ecological strategies operating in the Konya Plain during this time period.

## 1.3 Aims and objectives of this research

In light of the archaeological background previously discussed in this chapter, a number of aims and objectives have been outlined for this thesis.

The first aim is to develop an integrated high-resolution methodology for the excavation, documentation, and microanalysis of the finely stratified occupation sequences commonly found in Central Anatolian Neolithic sites. It is argued here that recording the vertical dimension of the stratigraphic units found within a building or an open area will improve the understanding of its internal configuration and changes through time. Further, optical and geochemical characterisations of the excavated deposits will allow the extraction of all the contextual and compositional information related to ecological and maintenance practices from the occupation layers. In order to achieve this goal, the following objectives have been set:

- The microstratigraphic excavation of a domestic building at Çatalhöyük, involving the strategic use of plinths and baulks, will be carried out as a testing ground for assessing the potential application of targeted multiscalar geoarchaeological methodologies.

High-resolution field records will be achieved through the use of 3D photogrammetry techniques at various excavation stages, and selective micromorphological and pXRF sampling of deposits. Each stratigraphic layer will be excavated and documented as a single deposit, regardless of its thickness.

- The depositional sequences of buildings and open areas at the three study sites will be analysed with the aid of thin-section micromorphology and state-of-the-art X-ray and spectroscopic techniques in order to maximise the amount of compositional information gathered from deposits and key inclusions related to specific practices.

The exploration of the socio-economic significance of small-sized buildings at Çatalhöyük is one of the main aims of this research. This involves an investigation of the range and nature of activities taking place in these built environments along with the building technology, spatial conventions, and maintenance practices operating in this type of built environments. The specific objectives related to this aim include:

- To study architectural surfaces and features from the macro- to the micro-scale to shed light into choices of building materials and technologies, maintenance practices, and intensity of occupation and renewal.
- To analyse biological micro-residues within buildings through thin-section micromorphology and chemical micro-analytical techniques in order to detect records of ecology and social strategies, such as the occurrence of specialised or highly repetitive activities.

The last aim of this research is to examine the role of domestic buildings as key in the construction and maintenance of the socio-economic fabric at the Neolithic settlements of Boncuklu, Çatalhöyük and Pınarbaşı. Evidence of household practices in the construction, occupation, abandonment, and possible re-occupation of built environments can shed light into the importance of the house as the loci where individual and communal interests are negotiated. An integrated approach has been adopted in this research that incorporates evidence from within and beyond individual buildings, neighbourhoods, and sites. The multiscalar and multidisciplinary methodology used allows the examination of multiple lines of evidence at high spatial and temporal resolutions, resulting in the integration of data from multiple viewpoints and cohesive interpretations. In relation to this aim, the following objectives have been formulated:

- To investigate building technology, spatial conventions and site formation processes at each of the three case studies through the study of architectural surfaces and features with thin-section micromorphological and geochemical characterisations of sediments and materials.
- To identify and compare ecological strategies as inferred from the range and use of mineral, plant, and animal resources at Boncuklu, Çatalhöyük and Pınarbaşı through the analysis of micro-residues in both buildings and open areas with micromorphological, SEM-EDX and IR microscopic techniques. Fuel sources, alongside fire activities will be studied in particular to characterise different types of fire installations and associated human practices.
- To examine the demarcation and social meaning of different settlement spaces by analysing the spatial distribution of activities through micromorphological and geochemical studies to assess differences relating to variations in specialised uses of space, correspondence between activities and chemical residues, and the impact of changes in spatial organisation on the formation of these residues.
- To investigate midden use and formation as key to understanding the relationship between built and non-built space in Neolithic settlements. The range of activities in external areas will be examined through the combination of micromorphology and high-precision geochemical techniques (IR microscopy and SEM-EDX) on specific components to offer a robust depositional and contextual explanation of midden formation processes and the use of open spaces.

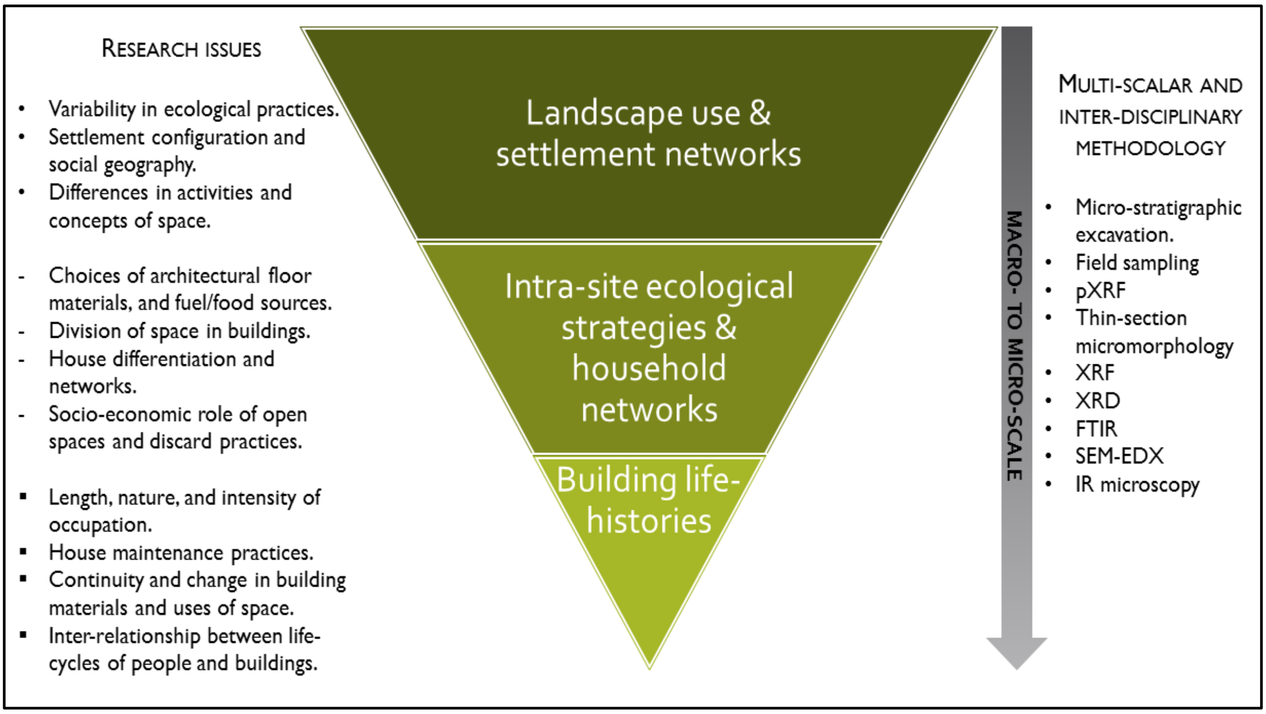



**Figure 1.4** Graph illustrating the multiple scales of the present project, comprising research topics on one side, and methodological approaches on the other.

The physical and palaeoenvironmental context of the Konya Plain is presented in Chapter 2 together with a detailed description of the three study sites, Çatalhöyük, Boncuklu, and Pınarbaşı, that will be investigated to shed light into key issues of the Central Anatolian Neolithic.

### 1.3.1 Research questions and hypotheses

In consideration of the aims and objectives outlined in the previous section, a number of research questions and interrelated hypotheses have been set out below. These are organised according to site, as the particular nature of the Neolithic occupation at each case study demands the formulation of specific hypotheses to address their differences and similarities. The main research areas that are the focus of this investigation, Neolithic ecology and settlement networks in the Konya Plain, are thus explored through the contextual comparison of the geoarchaeological data obtained from each site (see Figure 1.5 below) in order to critically examine the existence of local socio-economic traditions during the Neolithic in Central Anatolia.

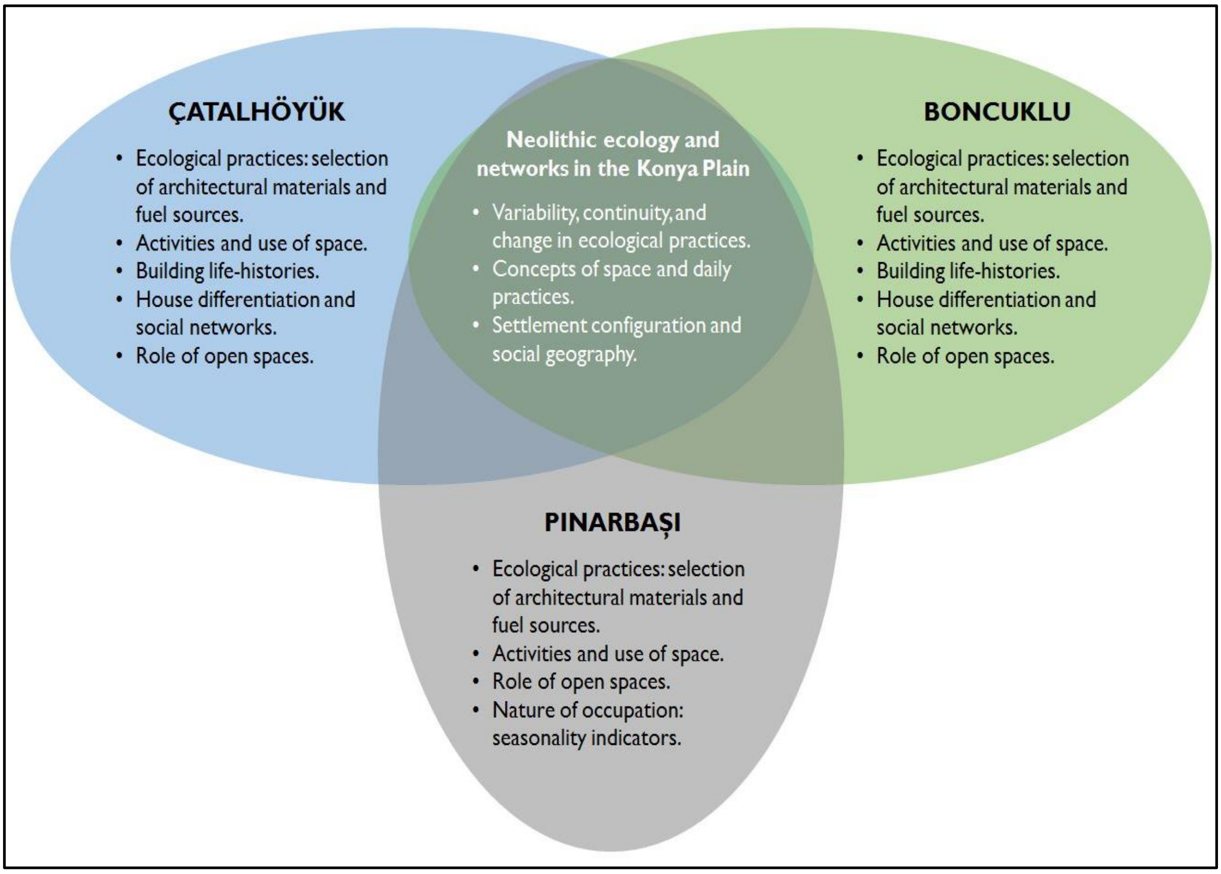



**Figure 1.5** Graph illustrating the main topics examined in this research.

The first main goal of this thesis is to develop an integrated methodology for the study of formation processes, materials, activities, and post-depositional processes by linking excavation strategies and field observations with high-resolution optical and elemental characterisations of occupation deposits to provide a more robust interdisciplinary interpretation of archaeological stratigraphy. The following research questions and associated hypotheses are related to this major goal:

1. How can we improve the excavation, recording, and analysis of finely stratified occupation sequences from archaeological sites?

   $H_1$ – The micro-stratigraphic excavation of occupation sequences, involving the use of field sections, baulks, and plinths to document the vertical dimension of the stratigraphic units forming the occupation sequence of buildings, results in better documentation and improved understanding of their depositional histories.

   $H_2$ – The combined use of thin-section micromorphology and elemental characterisation of deposits and specific components through XRF, XRD, FTIR, SEM-EDX and IR microscopy reveals important information on the origin of archaeological sediments, depositional pathways, and taphonomic alterations. Sub-sampling of sediment blocks before impregnation, involving the extraction of spot samples from every distinguishable deposit, ensures that the results from chemical micro-analyses can be directly correlated to specific field and micromorphological units and observations.

Research questions and associated hypotheses relating to the investigation of intra-site variability in ecological strategies and household networks at Çatalhöyük are:

2. Is there significant variability in spatial boundaries, maintenance practices, and range of floor architectural materials and environmental resources present in different buildings across the site?

   $H_1$ – Every large house at Çatalhöyük displays a structured use of domestic space that was standard across the site, with small-sized buildings acting as secondary built environments associated to adjacent larger structures.

   $H_2$ – All domestic built environments at Çatalhöyük, regardless of their size or degree of symbolic elaboration, were continuously occupied during their lifetime and display similar patterns of maintenance activities.

   $H_3$ – Every identified floor plaster type can be found in each studied building, indicating the occurrence of strong socio-economic conventions at the site and the absence of restricted household access to specific architectural sources.

$H_4$ – The nature and frequency of food, fuel, and craft micro-residues found accumulated on the floors and fire installations of buildings do not suggest the existence of task-specific houses nor of differential access to resources by contemporary households.

3. Were open spaces, including rooftops and middens, a common scenario for the performance of domestic or communal activities?

   $H_1$ – *In situ* micro-remains observed in thin-section can be used to elucidate the type and frequency of human activities performed in open spaces.

Research questions and associated hypotheses relating to the investigation of intra-site variability in ecological strategies and household networks at Boncuklu include:

4. Are there any marked differences between standard and non-standard structures regarding organisation of space, intensity of occupation, maintenance practices, and range of floor architectural materials and environmental resources present?

   $H_1$ – The occupation of standard buildings, which display a more rigid organisation of internal space than non-standard buildings, was more lasting and intense than that of non-standard structures.

   $H_2$ – Standard buildings, which were more architecturally and symbolically elaborate than non-standard buildings, were plastered more frequently and with better materials than other types of built structure, and were also more carefully maintained by their occupants.

   $H_3$ – The nature and frequency of food, fuel, and craft remains found accumulated on the occupation surfaces and fire installations of standard and non-standard buildings do not suggest differential access to resources by different households.

5. Were middens spatially organised at Boncuklu? What types of activities were performed in open areas?

   $H_1$ – External areas display a marked spatial organisation with regard to the type of activities performed in them, including waste disposal, food processing, crafts, and fires.

   $H_2$ – Ecological strategies at Boncuklu entailed the exploitation of a wide range of environments, as reflected by the diversity of discarded and *in situ* plant and animal micro-remains found accumulated in open spaces.

   $H_3$ – The nature and frequency of crop processing residues found in middens will contribute to establishing the relative importance of cereal versus wild resources at Boncuklu.

Research questions and associated hypotheses relating to the investigation of ecological strategies and periodicity of occupation at Pınarbaşı are:

6. What is the nature, range, and use of environmental resources at this site? Can we detect seasonal indicators that suggest a periodical occupation of Pınarbaşı during the Neolithic?

   $H_1$ – The occupation residues found at Pınarbaşı are representative of a non-diversified, local environmental exploitation strategy focused on pastoral activities, practically devoid of microscopic traces of crop processing and consumption.

   $H_2$ – The archaeo-stratigraphic sequence of Pınarbaşı shows strong seasonal indicators and periods of site abandonment, suggesting the temporality of its occupation.

The investigation of ecological practices, uses of indoor and outdoor spaces, and building life-histories at each of the study sites is expected to shed light into wider issues of the Central Anatolian Neolithic, such as the range of landscape exploitation strategies practised by different communities, and the institutionalisation of houses as key elements in the constitution of society. Research questions and associated hypotheses relating to a wider contextual understanding of Neolithic ecology and settlement networks in this area include:

7. Are there marked differences in ecological practices between the three case studies with respect to the selection of floor architectural materials and fuel sources?

   $H_1$ – Floor plasters at Çatalhöyük display a better technological preparation and more variability in selected sediments and added stabilisers than those at Boncuklu and Pınarbaşı.

   $H_2$ – Fuel sources at Çatalhöyük are more diverse and are collected from wider landscapes than those found at Boncuklu and Pınarbaşı. Further, fuel selection at Çatalhöyük is related to the performance of specific activities (i.e. cooking, pottery firing, plaster manufacture), and the seasonal availability of certain fuel types.

8. Are there similarities in the organisation of space within buildings and open areas between the three case studies? What type of daily activities were performed indoors as opposed to open spaces? What does this evidence tells us about settlement configuration and social geography at these sites?

   $H_1$ – The demarcation and symbolic meaning of different building areas is particularly strong at Çatalhöyük, whereas domestic built environments at Boncuklu and Pınarbaşı display evidence of more relaxed social conventions in relation to internal spatial organisation.

   $H_2$ – Buildings at Çatalhöyük were plastered more frequently, and were generally more carefully maintained, than their counterparts at the other two sites.

$H_3$ – Open areas at Çatalhöyük and Boncuklu display highly structured spatial organisation patterns and were the scenario of a wide range of communal activities, in marked contrast with middens at Pınarbaşı, mainly used as discard locations.

$H_4$ – At Boncuklu and Pınarbaşı middens are more extensive but less continuously used than at Çatalhöyük. In the latter, it is possible to distinguish individual (possibly daily) discard events due to the high intensity of midden use, something not possible at the other two sites.

## 1.4 Methodological considerations

Traditionally, archaeological methods have entailed the extraction of finds and environmental remains from their depositional contexts, while macroscopic observation of stratigraphic units in the field have often failed to identify small-scale depositional events formed by layers that are often only a few millimetres in thickness (Courty *et al.* 1989; Matthews *et al.* 1997). This research aims to address these problems through the application of an integrated methodology focused on *in situ* and spot microanalyses of depositional contexts to target individual units and components, an approach that has been successfully applied to a wide range of sites in recent years (Akeret and Rentzel 2001; Albert *et al.* 2012; Anderson *et al.* 2014a; Canti 1995; Courty *et al.* 2012; Goldberg *et al.* 2009; Karkanas *et al.* 2000; Macphail *et al.* 2000; Mallol *et al.* 2010; Schiegl *et al.* 1996; Shillito *et al.* 2013a).

The archaeological queries posed in this research have determined the critical selection of a range of scientific geoarchaeological methods, described in more detail in Chapter 3, considered the most suitable due to the nature of the materials being examined. These methods include thin-section micromorphology, XRF, XRD, infrared techniques, and SEM-EDX. The interdisciplinary nature of this methodological approach allows descriptions and observations to be made at a variety of scales, drawing on the independent lines of evidence produced by these different methods to build stronger arguments (Farid 2015; Wylie 2000).

However, while the techniques selected determine the scale at which both data acquisition and observations are made, the research questions addressed also define the scale at which the archaeological record is interpreted, which poses a series of challenges. In the case of this investigation, research topics range in scale from building life-histories to settlement dynamics and broader ecological practices in the landscape. In this capacity, scale is defined as the size and duration of the unit considered in hypotheses, data collection, analyses, and interpretation (Bailey 2007; Stein 1993; Stein *et al.* 2003). The definition of timescales is an important issue in this study, as it gives information on the nature of Neolithic sites and has implications for the identification of permanent as opposed to temporarily-occupied settlements (Baird 2012b), management of resources (Fairbairn *et al.* 2005b), and seasonal fission and fusion of populations (Roberts and Rosen 2009). In this regard, it is often animal and plant remains that are used in studies of seasonality (Asouti 2003; Baird *et al.* 2011b; Fairbairn *et al.* 2005a), with cereals normally being excluded due to issues such as storage, which enables their use throughout the year. Investigations of cyclicity and periodicity are similar to seasonal studies but refer to any patterns in activity over a period of time that are not necessarily correlated to seasonal changes and the availability of environmental resources at specific points within the year (Monks 1981). The annual application of wall plasters at Çatalhöyük represents one of such cyclical or periodic patterns in activity unlikely to have been influenced by seasonal environmental fluctuations (Anderson *et al.* 2014a; Matthews *et al.* 1996; 2013).

In addition to these important definitions of scale, the concept of resolution at which the archaeological record is observed (macro- to micro-scale) is crucial (Weiner 2010). Broadly speaking, as the resolution of the study augments, its complexity increases (Stein 1993). Resolution also relates to timescales, with events reconstructed over broad temporal periods considered to be at low resolution, whereas episodes reconstructed for short-term temporal periods are interpreted at high resolution (Foxhall 2000). In this respect, geoarchaeological methods such as thin-section micromorphology, a sedimentary contextual analysis based on the microscopic study of undisturbed sediments (Fitzpatrick 1993; French 2003), contribute to unravelling complex problems related to formation processes and depositional rates at high temporal and spatial resolution. Micromorphology, which can be conceived as a progression from the study of stratigraphy and sedimentary structure at field resolution to a finer microscopic scale (Karkanas and Goldberg 2007), enables the simultaneous observation of contextual associations between organic remains, artefacts, and sediments in each individual layer. Understanding the depositional pathways of bioarchaeological remains, especially of those that are not evident to the naked eye, is of extreme importance for the reconstruction of site formation processes and activities, which eventually sheds light into patterns of resource procurement and production, organisation of space, and temporal variations in these.

Soil micromorphology has been successfully employed in different periods and archaeological-related problems. In sites characterised by mudbrick architecture, such as *tells* and *höyüks*, micromorphological studies focused on the materiality of living floors, their maintenance, and the associated occupational debris, have provided cues on differential uses of space within settlements (Matthews 1995; Matthews *et al.* 1997; Shahack-Gross *et al.* 2005), the origin of raw materials (Karkanas 2007; Karkanas and Efstratiou 2009; Karkanas and Van de Moortel

2014), and pyrotechnology (Berna and Goldberg 2007). Furthermore, micromorphology appears to be the best analytical tool for studying homogeneous-looking anthropogenic deposits like those defined as "dark earth" in Medieval sites, which have been found to consist of multiple components and depositional events at the microscopic scale (Macphail and Goldberg 1995). Animal management practices, including waste disposal and the use of faecal materials in domestic building construction have also been successfully identified through micromorphological studies, resulting in the differentiation of faecal matter from various animal species (Karkanas 2006; Shahack-Gross *et al.* 2007).

Micromorphology is often combined with other instrumental techniques to further decipher the nature of non-recognisable microscopic features, resulting in a more holisctic interpretation of site formation processes. For instance, IR microscopy has been very successful in determining mineralogy within the context of uncoverslipped thin-sections and revealing temperature estimates of combustion for heated bones and clays (Berna *et al.* 2007; Shahack-Gross *et al.* 2014). IR microscopy has been further utilised to gather information on the composition of specific components in thin-section that are often difficult to assess based on optical properties, such as organic aggregates and ashes (Shillito 2009a; 2009b; Weiner *et al.* 1993; 2002), and millimetric layers such as fine paint coatings on walls, impossible to distinguish or sample at the macroscale (Anderson *et al.* 2014a; 2014b). In addition to these studies, Mentzer (2012) successfully applied FTIR techniques to bones in order to determine maximum burning temperatures, as heat exposure causes progressive changes in bone mineralogy.

The measurement of the chemical characteristics of sediments has become a major focus of research in archaeological investigations, with the earliest approaches being mostly phosphate-based (Canti and Huisman 2015). Recent studies, focused on XRF, XRD, FTIR, and ICP-MS methods, have expanded this original focus by also targetting other elements to gather additional compositional information. These techniques have been used in scientific archaeology in studies of provenance, production, mineralisation, and preservation of both sediments and artefacts (Anderson *et al.* 2014a; Berna *et al.* 2007; Brysbaert 2008; Friesem *et al.* 2011; Nazaroff *et al.* 2013; Shillito 2009a). Other investigations have shown the potential of these methods for spatial analysis through the mapping of chemical traces left in sediments within buildings, which can lead to the distinction of specific activity areas (Middleton and Price 1996; Middleton *et al.* 2005). More recently, some authors have set out to improve this methodology by combining site and off-site sampling to identify anthropogenic elements and refine interpretations (Oonk *et al.* 2009). However, the main problem presented by these studies is the lack of contextual analyses focused on understanding site formation processes and the preservation of the micro-environment, a drawback that hinders the production of a complete assessment of the complex chemical relationship between elemental concentrations and human activities. Recent studies have achieved a greater integration of multi-element chemical analyses of archaeological deposits with other geoarchaeological methods such as loss-on-ignition, magnetic susceptibility, and thin-section micromorphology by conducting parallel measurements and sampling of targeted contexts (Milek and Roberts 2013).

Stimulated by these new possibilities of obtaining additional information from archaeological deposits, portable or handheld XRF devices (pXRF) are currently widely used for multi-elemental sediment analysis in fieldwork contexts (Emery and Morgenstein 2007; Shoval and Gilboa 2015). This method, although fast and flexible, is invariably more inaccurate and less precise than laboratory instruments (Donais and George 2013), and its widespread application in archaeology has recently been the subject of controversy (Killick 2015; Shackley 2010). This is based on the observation that when multi-element sediment analyses in the field are undertaken with pXRF devices, variations in sampling conditions including moisture content, surface roughness, and deposit heterogeneity might seriously affect measurements (Gauss *et al.* 2013). Nevertheless, although data reliability can be a problem, as readings frequently have larger errors with direct sediment measurement, pXRF has been used in the field during the 2013 excavation at Çatalhöyük to quickly gather compositional information on key depositional contexts to assess their potential for laboratory chemical characterisations and micromorphological studies.

Another important method focused on the chemical characterisation of sediments and finds is SEM-EDX. Although not as widely used in geoarchaeology as the techniques discussed above, this method has the advantage of allowing the chemical characterisation of the sample as well as the production of extremely detailed images of the materials analysed at very high magnifications (Skoog *et al.* 2007). While the main disadvantage of EDX detection systems is that they have a poorer resolution and sensitivy than most laboratory (Wavelength Dispersive) XRF instruments (see discussion in Chapter 3), the small analytical spot size of SEM-EDX systems makes them suitable for the analysis of microscopic materials such as phytoliths and other plant elements (Quade *et al.* 2014; Tsutsui *et al.* 2016), ashes (Canti 2003), faecal spherulites (Canti 1997), fine coats of pigments (Anderson *et al.* 2014b), and organic microresidues detected in micromorphological slides (Shillito 2009a). As one of the most versatile analytical techniques available to archaeologists for the investigation of a wide range of inorganic and organic materials, SEM-EDX is currently being extensively used in artefact studies, including provenancing of obsidian finds (Poupeau *et al.* 2010), production mechanisms of glass objects (Heck and Hoffmann 2000), and the exploration of metallurgical traditions (Giumlia-Mair *et al.* 2000). Other applications that are more relevant to geoarchaeology comprise the evaluation of diagenetic alterations of buried bones (Turner-Walker and Syversen 2002), and the investigation of sedimentary processes through the exploration of the textural surfaces of sand-size grains occurring in diagenetic environments (Krinsley and Margolis 1969).

In addition to these analytical techniques, at the beginning of this investigation it was acknowledged that, although these geoarchaeological analyses were to be undertaken in the laboratory, the integration of the obtained results with field data would require careful planning and on-site interpretation skills on the part of excavators. In archaeological science, an informed understanding of when, where, and how to collect samples in order to effectively utilise scientific methods for answering relevant archaeological questions is of crucial importance to avoid destroying evidence that can only rarely be retrieved after fieldwork (Fuller 2008). For these reasons, we decided that the best way to integrate the field and laboratory components that form the present geoarchaeological study was for the specialist to be included in the excavation process, a resolution that eventually entailed taking charge of the excavation of a small building in one of the key study sites to experiment with field approaches and develop an improved collection mechanism and processing of sediment samples to ensure data quality (see section 5.2 of this thesis).

It was thus reasoned that the integration of these methods would allow the characterisation of depositional contexts and components that would eventually result in an improved understanding of site formation processes, human activities, and taphonomy at the three case studies. Therefore, two fundamentally different laboratory analytical approaches to stratigraphic analysis have been applied to depositional sequences from Çatalhöyük, Boncuklu, and Pınarbaşı: one involving the analysis of dissagregated materials, consisting of XRF, XRD, and FTIR analyses for the investigation of compositional properties, and another one focused on the study of undisturbed sediment samples through thin-section micromorphology, SEM-EDX, and IR microscopy. Elemental studies, although allowing the rapid characterisation of archaeological deposits, have frequently suffered from a lack of contextual analysis, especially when dealing with microstratigraphic sequences, with samples being removed from their original context, which often entails focusing the attention on the sample itself rather than on the depositional context (Canti 1995). The integration of these analyses with the study of undisturbed archaeological stratigraphy has been achieved through the sub-sampling of collected micromorphological blocks, or the sampled field section when possible, a strategy that has made possible to correlate all the results obtained through the range of techniques applied in this research. This has resulted in the production of a wealth of information at high spatial and temporal resolutions related to the Neolithic occupation of the three study sites.

## 1.5 Structure of the thesis

This introductory chapter has presented the broad research context of this thesis in the light of the geographical, temporal, and archaeological setting of the case studies, considering previous investigations and theories along with the rationale for the methodological approach used in this study and its potential contribution to the issues being examined. The research questions tackled in this thesis have also been stated, in addition to the specific aims and objectives of this multiscalar project. In the following chapter, a detailed overview of the Neolithic landscape of the region under study is presented according to the latest palaeoenvironmental and geological reconstructions of the ancient Konya Plain, alongside a summary of the history of excavations, chronostratigraphic sequence, architectural traditions, and uses of space within buildings and open areas at each of the three study sites investigated. Chapter 3 includes a thorough discussion of the methodological strategy used, comprising field methods – excavation approaches and recording techniques as well as geoarchaeological sampling, and laboratory procedures for each microanalytical technique, stating sample production, analysis, and processing of results. This chapter finishes with a brief discussion of how these multiscalar and multidisciplinary methods are being integrated in order to address the research questions of this study. Results are presented by site, incorporating data from all the applied techniques to facilitate the subsequent discussion of specific contexts through the integration of results obtained from various analytical methods. The sites are organised chronologically: Chapter 4 discusses Boncuklu Hüyük, the earliest settlement considered here, Chapter 5 displays the data collected from contexts in Çatalhöyük East, and Chapter 6 revolves around the latest Neolithic occupation at Pınarbaşı. In each of these chapters, results are presented in order of scale, starting with excavation outcomes and macroscale observations in the field, followed by data resulting from the micromorphological examination of archaeological deposits, and finally geochemical characterisations of architectural materials and open contexts through FTIR, XRF and XRD, and identification of specific inclusions and aggregates with the aid of IR microscopy and SEM-EDX techniques. The discussion in Chapter 7 brings together key results from the integration of all multiscalar methods to focus on the microstratigraphic sequences of specific buildings and open areas within the three study sites, stressing how this research has contributed to the understanding of formation processes, activities, social dynamics, and ecological strategies at each of the settlements investigated. Finally, the wider implications of this research to our current state of knowledge of the development of Neolithic settled communities in the Konya Plain are discussed in Chapter 8 through the inter-site comparison of the evidence generated for landscape exploitation and concepts of space at Boncuklu Hüyük, Çatalhöyük, and Pınarbaşı. The main conclusions of this study can also be found in this chapter, which contains a final section of future work that has been identified from this research.

# 2

# THE CASE STUDIES

*This chapter includes a summary of the environmental and archaeological context of the Neolithic period in the Konya Plain. The landscape and environmental settings, history of excavations, chronology of occupation, and current state of knowledge regarding specific aspects that are relevant to the focus of this research, such as division of space within buildings and the nature of open spaces, are discussed in detail for each of the three study sites.*

# 2.1 Geology and Late Quaternary landscapes of the Konya Plain

Any investigation of socio-economic dynamics and resource use in the past must give consideration to the environment within which human activities were framed. Because one of the focuses of this thesis is the exploitation of natural resources and Neolithic ecological strategies, a brief report of the geological setting and palaeoenvironmental context of the Konya Plain is of significance to this research. Therefore, a brief account of previous investigations in the area, including localised geoarchaeological studies around Çatalhöyük (Roberts 1982; Roberts *et al.* 1996; 2007b), are provided in the sections below.

## 2.1.1 The physical context

The Konya Plain is one of the five most prominent plains that form the Great Konya Basin, the second largest lacustrine depression of the high plateaus of Central Anatolia (De Meester 1970). A relatively level geographical area, the Konya Basin is an inland drainage plateau that extends over one million hectares and has an altitude of 1000 m above sea-level (Kuzucuoğlu *et al.* 1998). The inland drainage system is maintained by a number of rivers and sub-surface sources that introduce water to the Konya Basin from surrounding hills and mountains, which enclose the plateau and prevent any superficial draining to the sea (Fontugne *et al.* 1999). These uplands comprise mainly limestone and volcanic rock formations frequently denuded of soil and vegetation, with footslopes consisting of colluvium deposits (Kuzucuoğlu *et al.* 1998).

In the south-central area of the Konya Basin lies a large depression corresponding to a former lake, surrounded by structural terraces (Roberts *et al.* 2001). During most of the Late Pleistocene this area was occupied by a 20 m deep sweet-water lake, radiocarbon dated 23 to 17 ka BP (Roberts *et al.* 1979). As a result, alluvial soils currently dominate much of the central part of the Konya Basin, with dune systems and gravel ridges, shorelines of the former Pleistocene lake, standing out in an otherwise level basin. This lake eventually became gradually infilled by calcareous materials, although younger beach and lacustrine sediments, in addition to palaeosols, indicate the occurrence of temporary shallow lakes, marshes, and playas in this region during the Holocene (Fontugne *et al.* 1999; Kuzucuoğlu *et al.* 1998; Roberts 1982). Coarse and medium textured sediments were deposited on the flat shores by upland rivers, ultimately forming the May and Çarşamba bajadas parallel with the mountains, while fine components were deposited in local minor depressions and washed towards the centre of the basin where they formed heavy calcareous clay deposits (Driessen and de Meester 1969).

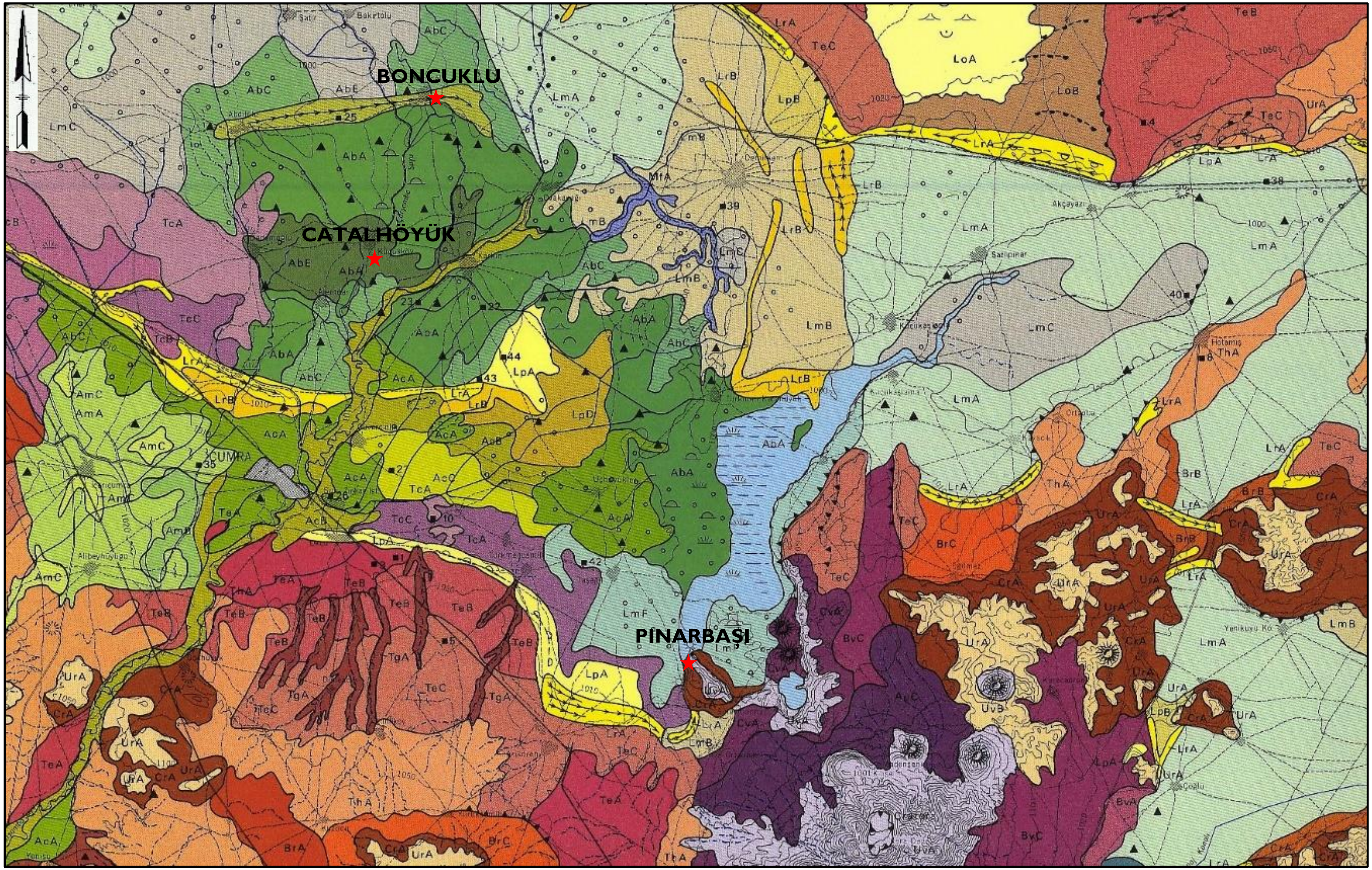



**Figure 2.1** Section of soil map produced by Driesen and de Meester (1969) after an extensive survey of the Konya Plain displaying the modern distribution of soil types. Scale 1: 200,000. Map legend included in the next page.

# LEGEND

**U UPLANDS**
Ur LIMESTONE UPLAND SOILS
UrA Shallow loamy or rocky

Uv VOLCANIC UPLAND SOILS
UvA Angular pumice and ash
UvB Volcanic cones

**C COLLUVIAL SLOPES**
Cr LIMESTONE COLLUVIAL SOILS
CrA Angular steep sandy or loamy

Cv VOLCANIC COLLUVIAL SOILS
CvA Angular steep pumice and ash

**T TERRACES**
Te FLAT TERRACE SOILS
TeA Loamy or clayey, softlime over limestone
TeB Loamy or clayey over limestone
TeC Eroded loamy or clayey, locally stony

Th UNDULATING TERRACE SOILS
ThA Angular-cobbly, clayey over limestone

Tc SOFT LIME SOILS
TcA Loamy or clayey over soft lime
TcB Loamy or clayey over concreted soft lime
TcC Loamy or clayey over limestone

Tg TERRACE GULLY SOILS
TgA Clayey over limestone, inc. rocky slopes

**B BAJADAS**
Br LIMESTONE BAJADA SOILS
BrA Reddish-brown clayey
BrB Brown loamy or clayey
BrC Sloping eroded gravelly loamy or clayey

Bv VOLCANIC BAJADA SOILS
BvA Locally vertic clayey
BvB Gravelly sandy or loamy with duripan
BvC Sloping angular-cobbly sandy or loamy

**A ALLUVIAL PLAINS**
Ab FORMER BACKSWAMP SOILS
AbA Grayish swelling clayey
AbC Brownish swelling clayey
AbE Aeolian clayey (ridge)

Ac ÇARŞAMBA FAN SOILS
AcA Clayey
AcB Loamy, locally sandy
AcC Loamy, over sandy subsoil

Am MAY FAN SOILS
AmA Loamy, locally clayey
AmB Loamy, locally sandy
AmC Gravelly or sandy

Au SOILS OF MEDIUM-SIZED FANS
AuC Volcanic angular-cobbly

**L LACUSTRINE PLAINS**
Lm MARL SOILS
LmA Clayey with shell fragments
LmB Stratified loamy with shell fragments
LmC Clayey with shell fragments, dark gray
LmF Clayey, locally gypsiferous and cemented

Lr SANDRIDGE SOILS
LrA High
LrB Low

Lp SANDPLAIN AND BEACH SOILS
LpA Dark grayish-brown sand
LpB Pale brown sand with shell fragments
LpC Carbonatic sand with dark volcanic surface
LpD Reworked, complex stratified

Lo OLD SANDPLAIN SOILS
LoA Undulating deep
LoB Nearly flat shallow, over terrace

**M MARSHES**
Mf MARSH SOILS
MfA Carbonatic clay or soft lime

## Symbols / İşaretler

Mainroad (asphalt)
Esasyol (asfalt)

Secondary road
Tâli yol-iz

Railway
Tren yolu

Town or village
Kasaba veya köy

Contour line (metres above sea level)
Tesviye münhanesi (yükseklik çizgisi)

Dam
Baraj

Soil boundary
Toprak sınırı

Uncertain soil boundary
Kati olmayan toprak sınırı

Escarpments
Dik eğimler

Steep, higher than 10 m (cliffs)
10 m'den daha yüksek dik yokuş (uçurumlar)

Steep, lower than 10 m
10 m'den daha alçak dik yokuş

River or canal
Çay veya kanal

Spring
Kaynak

Marshland
Bataklık arazi

Doline
Obruk (dolin)

Volcanic cone
Volkan konisi

Ridge
Sedde

Small sand dunes
Küçük kum kümeleri

Small clay dunes
Küçük kil kümeleri

Small marl dunes
Küçük marn kümeleri

Hummocks
Tümsekler

The volcanic massifs of Karacadağ and Karadağ define two small sub-basins on which human settlements were established after the lake waters began to recede due to increased evaporation caused by the warmer and moister climatic conditions of the early Holocene in Central Anatolia (Boyer *et al.* 2006). One of these sub-basins is the Konya Plain, located towards the west of the Great Konya Basin and surrounded by the Toros Mountains to the south, composed of Upper Cretaceous limestone, and the Anatolides to the north and west, formed by Palaeozoic limestone and schist (Driessen and de Meester 1969; Inoue *et al.* 1998).

As rivers flowed into the undulating marl plain formed by the dried out Pleistocene lake, alluvial sediments were deposited across the Konya Plain resulting in the formation of alluvial landforms, the largest of which is the Çarşamba alluvial fan, that covers an area of approximately 474 $km^2$ (Boyer *et al.* 2006; Roberts *et al.* 1999). On the extensive flat area created by this alluvial feature a number of early Neolithic sites are located, including Çatalhöyük and Boncuklu (see Figure 2.1). Driessen and de Meester (1969) identified five major soil types in this plain: softlime, marl, sandridge, backswamp, and sandplain soils.

Softlime soils are unconsolidated Neogene deposits consisting of over 80% carbonates of calcium and magnesium that have been reworked and mixed with modern sediments. In some places, such as the shores of the palaeolake, softlime soils originated from the reworking of Neogene limestone contain some loam or clay, but rarely gypsum. Locally, these whitish to light grey deposits are covered by shallow backswamp sediments that have fanned out over the plain (De Meester 1970). The absence of marine fauna in the limestone bedrock of the Çumra area indicates that these are freshwater deposits (de Ridder 1965).

Marl soils have a variable content of calcium and magnesium carbonates, ranging between 50% to 80% (Driessen and de Meester 1969). These deposits derive from the bottom of the palaeolake, where aquatic vegetation caused the precipitation of carbonates in the water. Locally, marl soils are covered by Çarşamba fan deposits. Partly for this reason, the depth of marl across the plain can vary considerably between sites (Boyer *et al.* 2006). Marl soils range in colour from dark greyish-brown to white, and have a particle size between clay and silt. These deposits commonly include shell fragments (mainly *Dreissenia*), indicative of their lacustrine origin (Driessen and de Meester 1969).

Sandridges, remnants of ancient lakeshores and beaches, are prominent features of the lacustrine plain, measuring between 50 and 400 m in width and standing 5 to 20 m higher than their surroundings (De Meester 1970). The carbonate content of these deposits varies between 10% and 25%, and frequently display inclusions of *Dreissenia* shells and layers of fine to coarse gravel (Driessen and de Meester 1969). Sandridges are dark greyish-brown in colour, ranging in particle size from sandy-loam to sand.

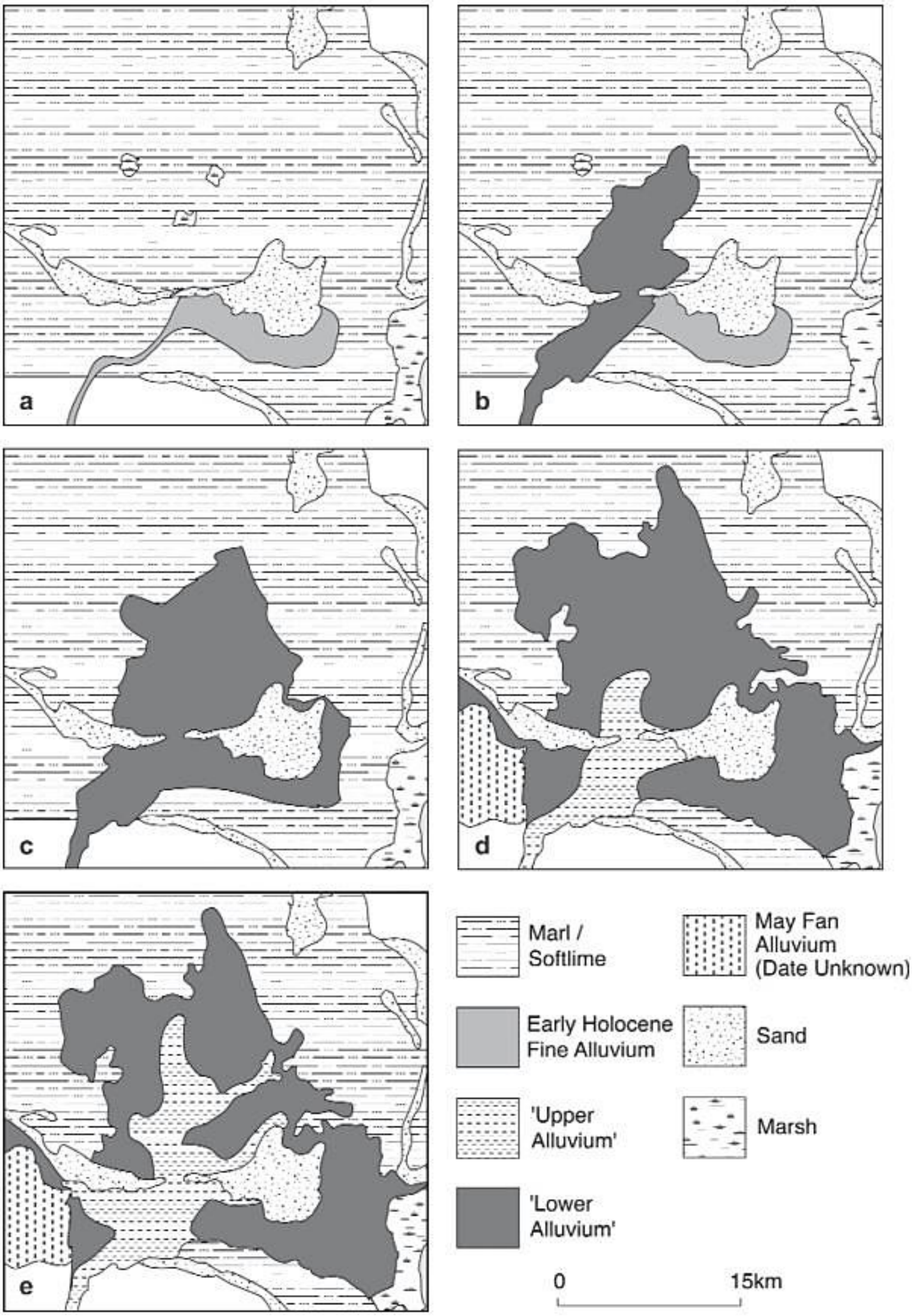



**Figure 2.2** Inferred pattern of changing Holocene sedimentation across the Çarşamba fan: a) 9600 cal BP; b) 9000 cal BP; c) 8000 cal BP; d) 4000 cal BP; e) present day. Source: Boyer *et al.* (2006, Fig. 5).

Alluvial plain sediments deposited by the rivers May and Çarşamba are here referred to as backswamp soils because they originate from the former backswamps of the rivers and associated streams flowing from the surrounding uplands. These soils are relatively deep (approximately 2-1.5 m below the modern surface), and have coarser textures towards the fan apices while becoming gradually loamy and clayey near the borders across the northern and eastern parts of the Çumra region (Driessen and de Meester 1969). The average carbonate content of these soils varies between 5% and 20%, with smectite clay predominantly forming the fine fraction. Backswamp soils display a wide range of colours, including dark yellowish-brown, light brownish-grey, dark grey, and brown. Gypsum salts in addition to iron and manganese mottling has been observed to occur in the subsoil, caused by variations in the water table (Driessen and de Meester 1969).

Finally, calcareous sandplain soils, originally part of the ancient lakebed and comprising 5-40% carbonates mixed with shell fragments, were identified overlying marl and softlime deposits. These soils range in texture from loamy sand to loam, displaying a colour that varies from brown to light brownish-grey (Driessen and de Meester 1969).

The site of Pınarbaşı, located towards the centre of the Konya Basin, approximately 25 km to the southeast of Çatalhöyük, occupies the base of a cliff at the foothills of the volcanic massif of Karadağ. The site is surrounded by a small spring-fed lake to the east, seasonally flooded alluvial depressions to the north, and limestone terraces, colluvial slopes, and bajadas to the west and south.

Driessen and de Meester (1969) identified three types of terrace soils in this area: a) flat terrace soils, loamy in texture and varying in colour from dark brown to yellowish-/reddish-brown, containing a well-developed gypsic horizon; b) undulating terrace soils, clay-loam soils with a pronounced calcic horizon and no traces of gypsum, commonly reddish-brown in colour and containing abundant angular rock fragments; and c) terrace gullies, consisting of sandy loam and gravelly soils developed on the slopes and rims of limestone gullies.

The colluvial slopes of the limestone mountains occur locally in the south-western parts of the Konya Plain. The soils developed in these areas have a loamy texture and contain abundant limestone rock fragments of various sizes, ranging in colour from dark brown to yellowish brown (De Meester 1970).

The bajada soils, which cover extensive areas towards the south of the Konya Plain, developed on sediments transported through erosion gullies from the uplands into the basin. They comprise poorly-sorted loam deposits sloping towards the basin and merging locally into colluvial soils (Driessen and de Meester 1969). Whereas reddish-brown limestone bajada soils are common in the south-western area of the Konya Plain, immediately to the east and south-east of the site of Pınarbaşı and around the Karadağ Massif, volcanic bajada soils are predominant. These soils developed on reworked volcanic ash and pumice, limestone debris, and eroded materials from the volcanic outcrops. Loamy to locally gravelly in texture, these soils vary in colour from deep dark brown to dark yellowish brown, and are commonly devoid of gypsum salts.

### 2.1.2 The palaeoenvironmental context

The climate of the Konya Plain is semi-arid with cold winters, wet springs, and hot and dry summers. With annual precipitations in the range of 200-300 mm and a relative humidity below 50%, this region is today one of the most arid environments in Anatolia (De Meester 1970). Much of the Konya Plain is currently under irrigation, evident in the channelling of watercourses, to secure agricultural productivity. However, water supply is limited and the area has no internal drainage, which causes salinization in the lowest areas of the plain. Heavy grazing by sheep currently prevents grass regrowth, resulting in only a poor cover of steppic vegetation comprising drought-resistant species and shrubs occurring scattered along the plain (Boyer *et al.* 2006). Arboreal cover in the form of open deciduous oak forests is restricted to the slopes of Karadağ (Asouti 2003).

Interestingly, palaeoenvironmental records from lake sediment cores indicate the prevalence of much wetter conditions at the end of the Pleistocene. Geoarchaeological works in the Konya Plain have documented a steady rise in humidity during the early Holocene, reaching a maximum at *ca*. 6500 cal BP (Roberts *et al.* 1979). This warmer and moister climate led to the formation of alluvial fans and wetland habitats that would have provided attractive resources to the first Neolithic settlers in this region.

#### 2.1.2.1 The geomorphological and geoarchaeological evidence

The geomorphology around the site of Çatalhöyük has been extensively investigated through intensive surveying and geoarchaeological work conducted by the KOPAL (Konya Basin Palaeoenvironmental Project) team in the late 1990s and early 2000s (Roberts *et al.* 2007b). The main goals of this research, which involved both coring through the site and excavating trenches in the alluvial sediment sequences surrounding it, were to reconstruct the palaeoenvironmental history of this region by relating data on geomorphology and past vegetation to the archaeological occupation of the settlement (Baird 2002; Boyer *et al.* 2006; Roberts 1982).

These investigations on the surroundings of Çatalhöyük concluded that the site was located at the centre of an active alluvial fan and that the settlement was flooded on a seasonal basis, possibly in spring after the melting of snow in the Taurus Mountains, as interpreted from the identification of anthropogenic deposits sealed by backswamp clays in the sediment cores analysed (Baird 2002; Boyer *et al.* 2006; Roberts *et al.* 1996; 2007b). Marshlands and scattered stagnant pools would have formed around the settlement, with riparian trees growing on hummocks. Above the backswamp deposits, possible alluvium/colluvium sediments, in addition to buried soil horizons, were detected, indicating drier periods at the end of the Neolithic (Roberts *et al.* 1999).

According to this model, it has been argued that the backswamp soils surrounding Çatalhöyük in the Neolithic were ill-suited for farming (Asouti and Hather 2001; Fairbairn *et al.* 2002; Roberts *et al.* 1999), and that the dry sandy ridges situated approximately 12 km away from the site were the main crop growing locations for the inhabitants of this settlement (Fairbairn *et al.* 2005b; Rosen 2005; Rosen and Roberts 2005). This would have entailed a predominant pattern of mobility for the population at Çatalhöyük in order to work on remote cereal fields, to graze animals on upland pastures, and to collect wood from the terraces and mountains to the south of the plain. Based on this landscape reconstruction of the Konya Plain, Roberts and Rosen (2009) proposed a model of Neolithic economic and social organisation involving a single nucleated settlement, i.e. Çatalhöyük, with fission and fusion of population on a seasonal basis (see Figure 2.3 in the next page). According to these authors, this strategy would have enabled the intensive exploitation of a wide landscape region for a diversity of natural resources, although this interpretation implies the prioritisation of wetland resources over agricultural production, and the view of cultivation and herding as separated activities. This model has been challenged in recent times on a combination of new archaeological, sedimentological, and environmental evidence, and it now appears that the idea that Çatalhöyük was located in an area unsuitable for agriculture is not completely correct.

The picture emerging from the more recent coring program around Çatalhöyük is that of a series of narrow channels of low stream power filling up small depressions in the landscape and depositing a wide variety of clayey sediments (Doherty 2013). This new interpretation conceives the immediate environment of the site as a fragmented wetland habitat supported by a less evolved alluvial system, in contrast with the previously accepted scenario of a large

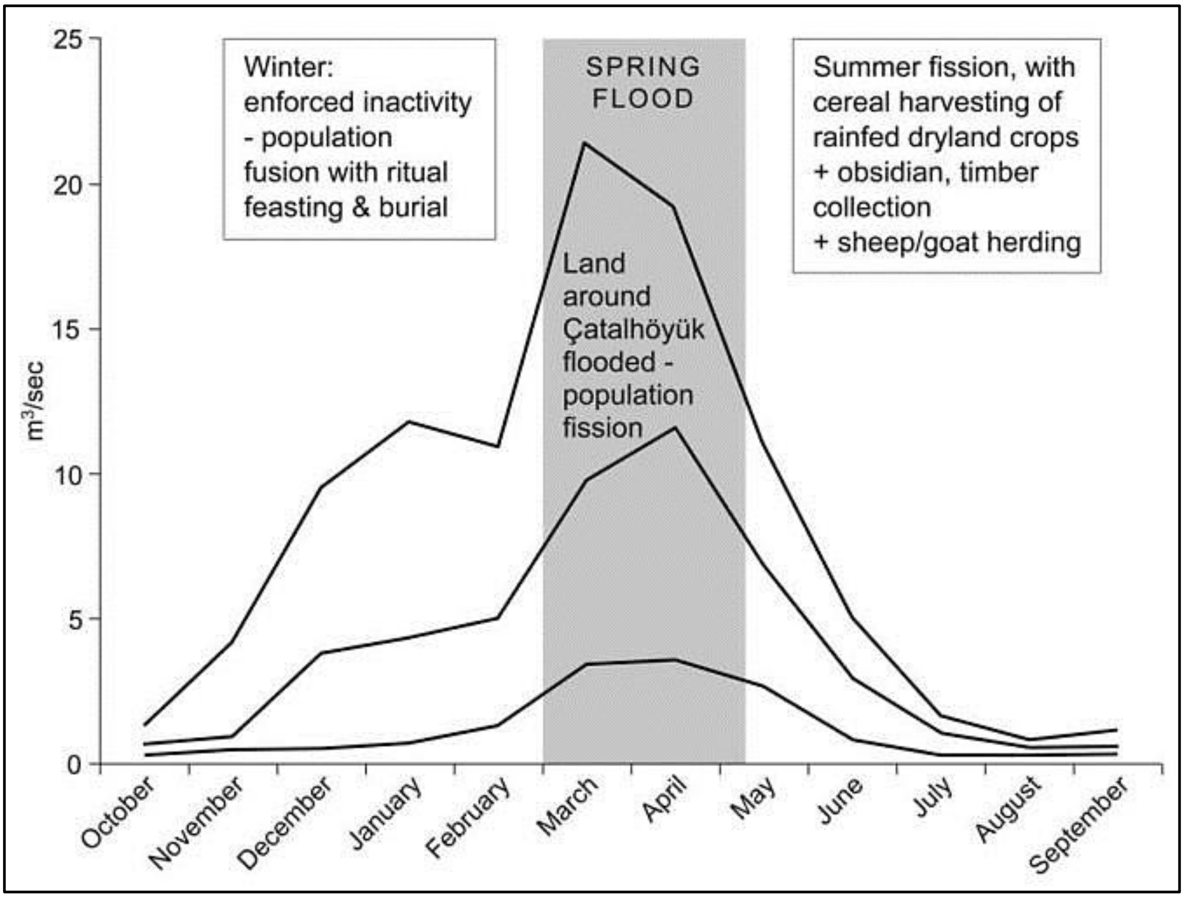



**Figure 2.3** Graph representing the Çarşamba river flood regime with lines showing maximum, mean, and minimum monthly water flows for the period 1964-1980. The annotations correspond to possible seasonal fission and fusion of Catalhöyük's population, and associated activities performed in the wider landscape. Source: Roberts and Rosen (2009: Fig. 3).

seasonal flood caused by a major channel (Boyer *et al.* 2006). This mosaic landscape allowed the exploitation of cultivation plots on dry ground within the vicinity of the settlement, the grazing of sheep herds, the extraction of clays for the manufacture of pottery and architectural materials, and the utilisation of wild food and fuel resources (Charles *et al.* 2014). Within time, gradual climate change and human activities resulted in an increasingly dry landscape and a decrease in the extension of local wetlands, as suggested by archaeological evidence from shells (Bar-Yosef Mayer *et al.* 2013), charcoal (Asouti 2013b), and fish remains (Van Neer *et al.* 2013). The massive extraction of both alluvial and colluvial sediments around the mound, in particular, probably affected local drainage and ground-water levels, thus contributing to the transformation of the local landscape during the Neolithic period (Doherty 2013). Therefore, the environment around Çatalhöyük changed considerably throughout the occupation of this settlement, forcing its inhabitants to cope with variations in resource availability.

The site of Boncuklu, originally situated in a reed-dominated marshland, has recently been the focus of a palaeoenvironmental investigation comprising both surveying and mapping of the immediate surroundings of the site (E. Asouti, pers. comm.). This ongoing research revealed a

Byzantine gravelly surface at approximately 1.3 m below the current surface, overlaying natural marl deposits into which small pits containing abundant Neolithic artefacts had been excavated (Baird *et al.* 2012b). It is expected that this multi-proxy study will result in an accurate reconstruction of the forager-cultivator environment exploited by early settlers at Boncuklu.

### 2.1.2.2 The evidence for past vegetation

The climatic and environmental conditions of the Konya Basin at the time of Neolithic occupation has been investigated on a regional scale from a combination of proxies derived from lakes, caves, and coring surveys (Bar-Matthews *et al.* 2003; Boyer *et al.* 2006; Roberts *et al.* 2001). These studies detected a rapid increase in moisture levels after the Younger Dryas, *ca.* 12000 BP, which continued to rise until 8500 BP, coinciding with the late Neolithic occupation of the Konya Plain. Inferences on vegetation based on off-site pollen records suggest the development of grass-steppe and riverbank taxa in the plain following the end of the Younger Dryas, in addition to an increase in the levels of arboreal pollen (Bottema and Woldring 1984; Eastwood *et al.* 1998; Vermoere *et al.* 2002). During the period running up to and overlapping with the beginning of the Neolithic occupation in this region, *ca.* 10,500 BP, increased climatic moisture resulted in an expansion of grassland-steppe vegetation across the lowland plain in addition to a marked development of deciduous woodland in the uplands, dominated by oak (*Quercus*) with small quantities of elm (*Ulmus*), maple (*Acer*), and hazel (*Corylus*). In the period from 9400 to 8500 BP, pollen data indicate a shift from grass-steppe to a combination of forest/grassland steppe, comprising shrubby plants such as chenopods and ephedra, and including an increase in riparian taxa, represented by *Salix*, *Tamarix*, *Populus*, and *Platanus*.

In addition to these studies of off-site proxies, archaeological materials collected from Neolithic sites, particularly wood charcoal, have the potential of shedding light into palaeoenvironmental conditions and plant cover present within the catchment of Neolithic settlements (Asouti 2003; Asouti and Hather 2001; Asouti and Austin 2005; Charles *et al.* 2014; Fairbairn *et al.* 2002). At Çatalhöyük, in particular, the Aceramic levels show an abundance of Salicaceae-willow/poplar, *Ulmus*, *Fraxinus*, and *Celtis* (hackberry), with additional inputs from dry woodland species such as *Amygdalus* (almond), and *Pistacia* (terebinth) used as wood fuel. Asouti (2005b) interpreted these patterns as indicative of the presence of both riparian and dry woodland habitats within the vicinity of the site. Later on and corresponding to the earliest excavated mudbrick architecture at Çatalhöyük, oak charcoal frequencies increase, peaking at approximately 8500 BP, and decreasing thereafter to be substituted by juniper as the predominant wood species during the Late Neolithic occupation of the site (Asouti 2013b). A progressive reduction of *Celtis* and wet woodland taxa during this later period has also been observed. All in all, both oak and juniper woods were probably collected from the dry upland zone to the south of the Konya Plain throughout the occupation of Çatalhöyük (Asouti 2013b; Charles *et al.* 2014). In addition, phytolith evidence on past vegetation indicates an increase in *Phragmites* (reeds) in the mid-later occupation of the site. This is an invasive species whose predominance during this period might reflect the expansion of human disturbance in wetland areas around Çatalhöyük, possibly associated with the quarrying of extensive zones for the extraction of clays, marls, and gravels (Doherty 2013; Ryan 2013).

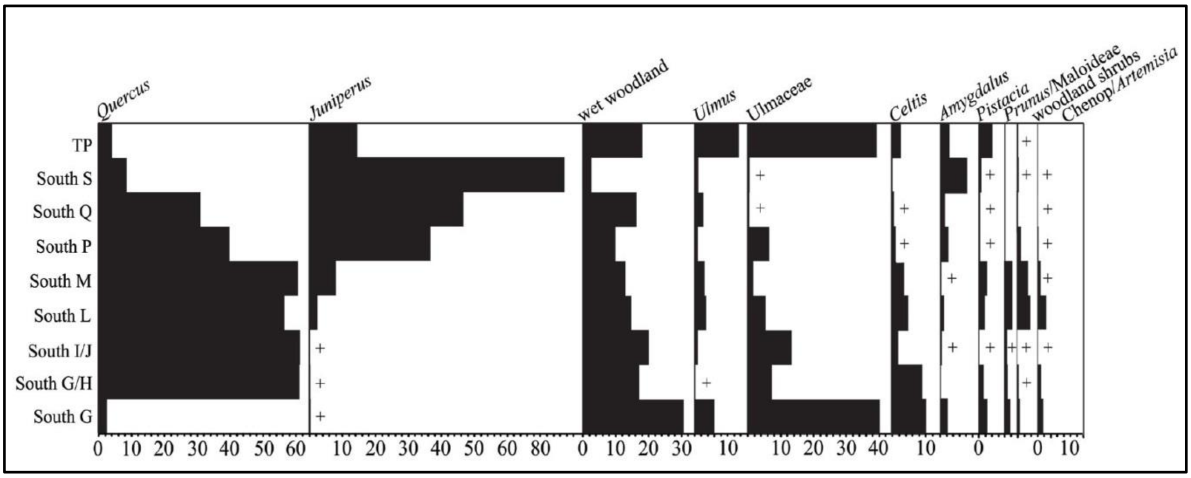



**Figure 2.4** Percentage fragment counts of wood taxa identified in the South and TP Areas of Çatalhöyük. Source: Asouti (2013b: Fig. 8).

Oak and juniper remains have also been found at the earlier site of Boncuklu, primarily in post-hole contexts (Kabukcu and Asouti in press). In contrast with Çatalhöyük, however, riparian taxa such as *Celtis*, *Amygdalus*, *Pistacia*, and *Maloideae* appear in very low frequencies in the palaeobotanical assemblage of Boncuklu, strongly dominated by reed fragments. This pattern is probably a consequence of the location of Boncuklu, situated in a wetland/ marshland habitat that included regularly flooded areas as well as permanent water bodies.

Similarly, the plant assemblage from the Epipalaeolithic occupation at Pınarbaşı indicates the presence of wetland species, represented by seeds and leaves, as well as high quantities of *Amygdalus* and *Juniperus* woods used as fuel (Asouti 2003). A small component of wet woodland vegetation included *Fraxinus*, Salicaceae, and *Celtis*. The later, 7$^{th}$ millennium occupation also contain abundant plant remains from wetland species, with *Juniperus* becoming less ubiquiteous and both *Amygdalus* and *Pistacia* dominating the wood assemblage (Baird *et al.*

2011b). The proportion of species derived from wet and dry habitats suggests that Pınarbaşı was located on an ecotone between wetlands with marginal reedbeds, and drier habitats.

## 2.2 Boncuklu Hüyük

The Neolithic site of Boncuklu Hüyük – which translates as 'mound with beads', so-called by the local villagers due to the glittering caused by prehistoric stone and shell beads scattered on the surface of the settlement following the spring rains (D. Baird, pers. comm.) –, was discovered in 2001 during the last phase of the Konya Plain Survey Project (Baird 1996), which aimed at mapping all the ancient settlements in the surveyed area to aid in the understanding of the long-term history of the region. Before Boncuklu was identified as an important archaeological site, the inhabitants of the nearby village of Hayıroğlu used the mound as a threshing area where they removed the grain from their harvested crops. These activities damaged the latest archaeological deposits in few places, and the tracks through the site can still be seen today. In spite of this, the location of the settlement, situated 20 km away from Pınarbaşı and 9.5 km north of Çatalhöyük, together with its rich bioarchaeological assemblage, makes Boncuklu a key site for understanding sedentary communities in the Konya Plain.

**Figure 2.5** View of the Boncuklu archaeological mound during excavation from its south-western edge, looking north.

This mound settlement stands 2 m above current plain level and covers an area of approximately 1 ha (Baird *et al.* 2012b). Initial surface explorations revealed decorated stone artefacts very similar to those found in the early occupation levels of the Pınarbaşı rockshelter, and a microlith-dominant assemblage comparable to that of the Late Aceramic Neolithic levels at Çatalhöyük, Suberde, and Can Hasan III (Baird *et al.* 2011a). The stratified sequence at this site spans part of the 9th and 8th millennia cal BC (*ca.* 8500-7500 cal BC), a chronology based so far on a small number of radiocarbon dates obtained from the excavated phases (D. Baird, pers. comm.). However, the latest levels of occupation are truncated, and they have not been dated except by broad techno-typological comparisons of lithic assemblages.

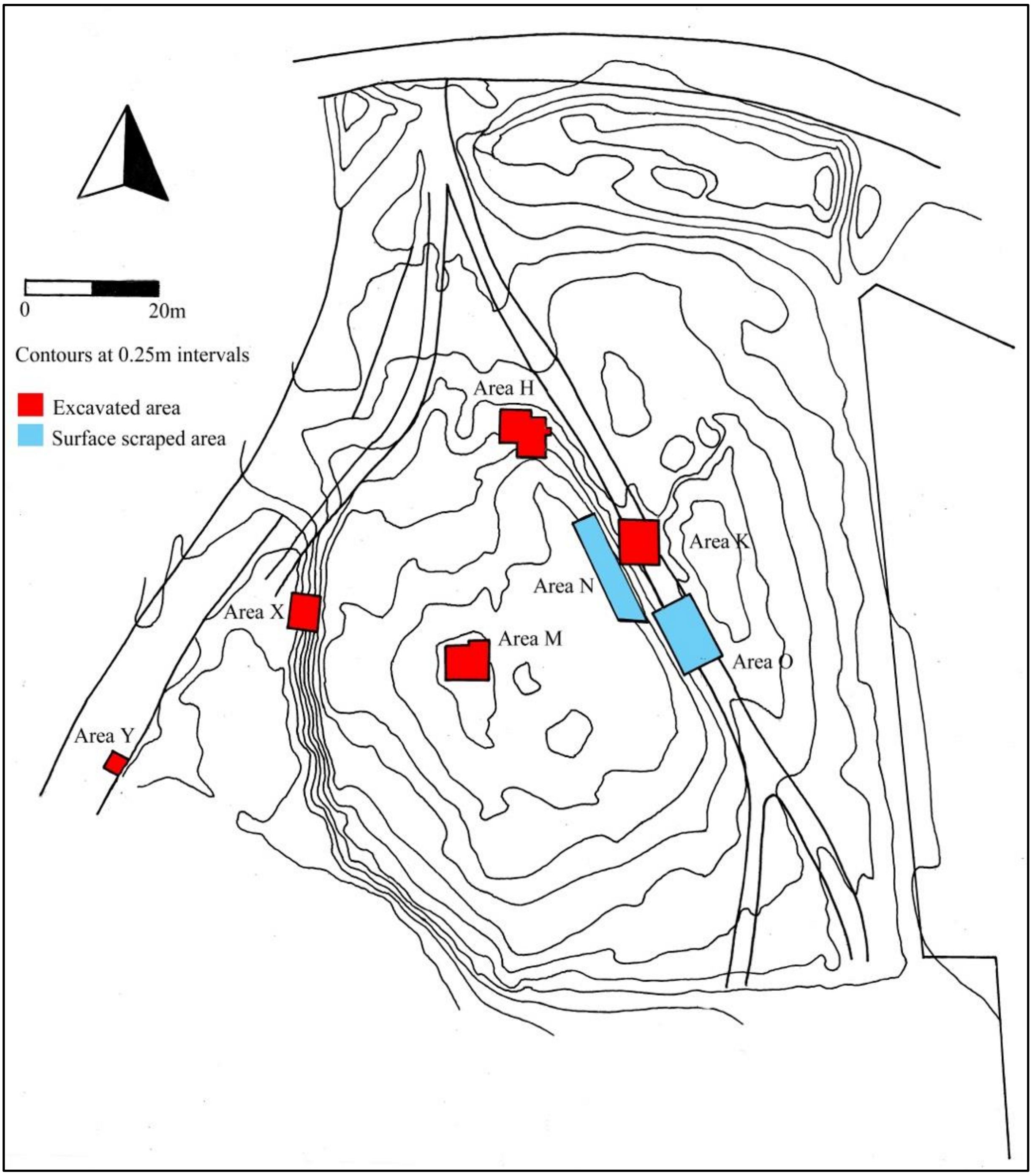



**Figure 2.6** Site plan and excavated areas. The darker lines represent modern bulldozed field tracks (Baird *et al*. 2012: 239).

Archaeological excavations at Boncuklu started in 2006 under the direction of Douglas Baird with two main research foci: 1) to investigate the cultural antecedents of Çatalhöyük within its local context, and 2) to document the emergence of early sedentary communities in Central Anatolia (Baird *et al.* 2012b). At the heart of the project is the exploration of the mechanisms by which agriculture and herding appeared in the Plateau, whether spread from the Levant by colonising farmers, or adopted by indigenous forager communities (Bellwood 2009). Initially, three trenches were opened: Area H, of 16 x 13 m in dimension; Area K, extending over 6.5 x 7 m; and Area M, occupying 5.5 x 7 m. The latter consists of midden deposits formed by gradually accumulated plant remains, animal bones, artefacts, and sparse fragments of human skulls. *In situ* fire installations were encountered, suggesting the performance of activities in these discard areas. In later years two additional trenches, namely Area N, which was 14 x 4 m in dimension, and Area O, 10.7 x 7 m in size, were opened. A smaller trench, Area Y, was excavated in order to investigate natural deposits and collect palaeoenvironmental samples. A section through the edge of the site was also excavated in Area X, which confirmed the hypothesis that the Neolithic settlement of Boncuklu had originally been founded on a marl rise (Baird *et al.* 2012b).

### 2.2.1 Architecture and organisation of space within buildings

All standard buildings at Boncuklu, that is, those consisting in an oval structure demarcated by mudbrick walls, in some cases with posts along their interior edges, display a major division in floor area. Typically, the eastern half or two thirds of the building are characterised by flat, marl-based plaster surfaces with a distinct lip marking the boundary between this clean floor area and the sunken sequence of occupation surfaces in the north-western part of the built environment. These undulated surfaces are rich in preserved occupation residues apparently derived from the continuous use of the hearth, also located in the north-western area of the building and, in some cases, lined with flat river pebbles (Baird *et al.* 2012b). Formations of concentric plaster material, apparently accumulated and distorted, are commonly found around fire installations, interpreted as drip holes formed by the action of rain entering the edge of the smoke-hole above the hearth. Occasionally, linear arrangements of small plastered stakeholes or postholes can be found. Entry into houses was not through the roof, unlike buildings at Çatalhöyük and Aşıklı, but by means of a door at ground level in the southeastern end of the structures.

Burial pits are commonly located under the clean plaster floors in the south-eastern area of buildings, along with wooden posts interpreted as bearing symbolic significance (Baird *et al.*

2012b). The dead were consistently interred in buildings during their occupation, after which the floor area was patched, and occasionally painted red.

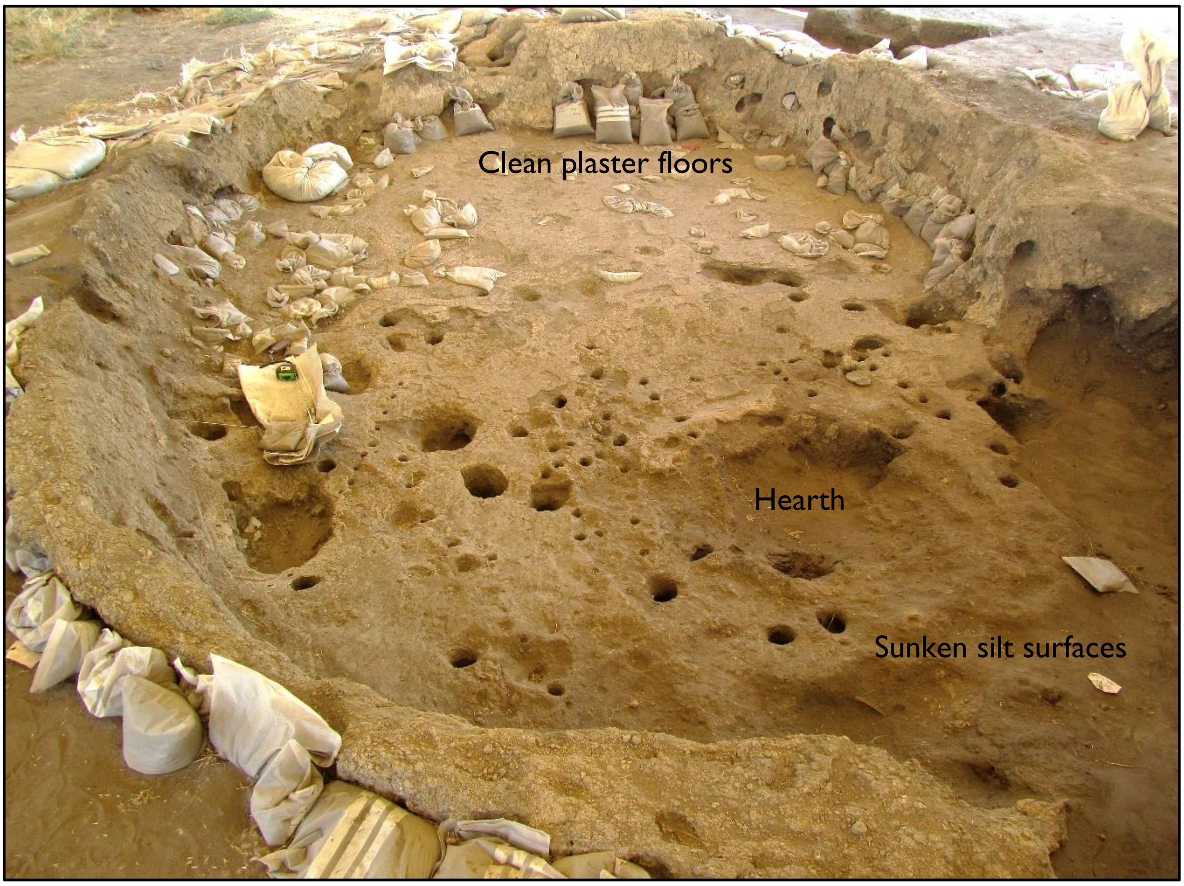



**Figure 2.7** Building 6 in Area N under excavation, looking towards the south-east. The hearth pit and surrounding dirty area are visible on the bottom right corner of the image (north-western part of the building), whereas clean plaster floors can be distinguished towards the top (south-eastern area).

Building continuity, involving the repeated reconstruction of essentially the same house on the same spot over several decades or even centuries, is manifested at Boncuklu in the sequences of standard Buildings 2, 9, 7, 3, 1.1, and 1.2 in Trench K, and Buildings 8, 5, and 4 in Trench H (Baird *et al.* 2012b). This evidence suggests that building continuity, similarly to the roughly contemporary settlement of Aşıklı Höyük and the later occupation at Çatalhöyük, was a significant aspect of Neolithic lifeways at Boncuklu.

However, not all the built structures excavated at this settlement have these characteristics. Buildings 16 and 23, excavated in Area M and, like the domestic residences previously discussed, displaying evidence of long-term continuity and re-building events, appear devoid of the marl plaster floors commonly found in the south-eastern area of standard structures. These non-standard buildings have silty floors, temporary hearths, and a variable number of small shallow pits often containing abundant phytolith remains, possibly left by decayed baskets (Baird *et al.* 2015). Significantly, dense layers of reed phytoliths cover some of the silt surfaces towards the southern half of these structures, possibly the remains of task-specific activities. The unusual architectural configuration of these buildings is further manifested by the occurrence of multiple postholes, as if their roofs, apparently formed by reeds and a thin wooden structure encased in clay material, suffered multiple modifications (Baird *et al.* 2013b). The dynamic nature of these buildings points to the possibility that they were communal constructions used by several households for storage, cooking, or industrial activities.

### 2.2.2 Social practices and open spaces

In contrast to other Neolithic sites in Central Anatolia, buildings at Boncuklu were not organised in clustered neighbourhoods but freestanding, with midden areas surrounding built structures and displaying a much less restricted spatial patterning than open spaces at the later site of Çatalhöyük. The central part of the site is characterised by extensive open areas where a range of activities were carried out and midden deposits accumulated. Non-standard buildings with light superstructures and variable floor configurations occur in this central space, whereas residential built environments were grouped together in small clusters around the peripheries of the settlement (Baird *et al.* 2013b).

Discarded materials accumulated under diverse circumstances in the various open spaces of this site. While most areas display evidence of massive dumpings of unconsolidated materials, some open spaces consist of finely laminated and compacted deposits of ash, charred and silicified plant fragments, bones, lithics, and faecal matter (Baird *et al.* 2012b). These remains suggest the regular performance of a wide range of activities in these open spaces, including butchery, animal skin working, and tasks related to the processing of plant materials, such as basketry/matting preparation. *In situ* burning in middens has been observed in the form of temporary fire spots and formal stone- or clay-lined hearths that were repeatedly used. In addition, circular pits up to 1 m in diameter were cut in these spaces, some of which contained fragments of human skulls (Baird *et al.* 2015).

Interestingly, open spaces between buildings also display a significant amount of evidence for the performance of ritual practices. Decorated stones, plaster vessels, fragmented human skulls occasionally painted with ochre, and a number of articulated burials have all been found in midden contexts, suggesting the important role played by open areas in communal ritual, in addition to food production and craft activities (Baird *et al.* 2012b). The deposition of human skulls within pits excavated in midden areas, in particular, indicates distinctive treatment and possible circulation of human heads.

Figure 2.8 Excavation of open spaces in Area M, looking east.

### 2.2.3 Discussion

In spite of its many contrasts, archaeological evidence from Boncuklu displays very significant continuities with the later settlement at Çatalhöyük. Building continuity, a common feature of built environments at Çatalhöyük, is manifested at Boncuklu in Structure 1 in Trench K. Six buildings, reconstructed atop one another, were unearthed in this area, all of which display virtually the exact same pattern of spatial structure. The presence of plaster installations and paintings on the north wall of buildings, in particular, bears a resemblance with the investment in decoration features, including bucrania, reliefs, and wall paintings, seen in most buildings at Çatalhöyük (Baird *et al.* 2012b).

The stone assemblage from Boncuklu, dominated by obsidian, is strikingly similar to the one from the 9$^{th}$ millennium occupation at Pınarbaşı, containing abundant microliths and incised decorated stones featuring a wide range of complex designs (Baird 2012a). This implies at least a certain degree of contemporaneity of the earlier Boncuklu phases with the Pınarbaşı occupation.

A considerable range of animals was exploited at Boncuklu, as indicated by the zooarchaeological analysis of animal remains. However, the high incidence of bone fragmentation at this site has rendered only 8% of the whole animal bone assemblage identifiable to genus/species (Baird *et al.* 2012b). Wetland species such as birds, fish, and tortoises are present in high numbers at Boncuklu, whereas mammal remains are dominated by cattle and boar/pig, which contrasts with the caprine-dominant faunal assemblage at Çatalhöyük (Russell and Meece 2005). Few bones belonging to equids, cervids and sheep/goat have also been encountered. Altogether, the faunal assemblage from Boncuklu appears to indicate the exploitation of a mosaic of habitats, such as wetlands, grasslands, and woodlands.

Although carbonised plant inclusions are extremely common in all contexts at Boncuklu, they are made of very small fragments below 5 mm in diameter, with diagnosed wood charcoals being very rare (Baird *et al.* 2012b). Plant macrofossils of crop species have been found preserved in small quantities, including emmer wheat (*Triticum dicoccum*), einkorn (*Triticum monococcum/boeoticum*), and hulled barley (*Hordeum vulgare/distichum*), representing less than 25% of the whole palaeobotanical assemblage at this settlement (Baird *et al.* 2012b). Nuts and fruits are common, comprising fragments of hackberry, terebinth, and wild almond. The non-domestic seed flora is very abundant and broad, containing wetland taxa, such as *Carex*, and grasses, including *Graminae* and various Caryophyllaceae (Baird *et al.* 2012b). Overall, the plant macrofossil assemblage from Boncuklu suggests a low focus on crop species. However, cereals were probably used for food and, occasionally, fuel sources, in combination with a wide range of wild plants.

## 2.3 ÇATALHÖYÜK

Çatalhöyük, a 9,000 year-old tell site in central Turkey declared World Heritage Site by the UNESCO in 2012, is situated along the eastern bank of the former Çarşamba river, which has diminished considerably from prehistoric times and runs nowadays through a rural channel bordering the settlement. The site comprises two low hills, the Neolithic East Mound, that dates approximately from 7100 to 6000 cal BC (Bayliss *et al.* 2015), and the West Mound, occupied in the Early Chalcolithic period and situated opposite the now dry riverbed. The settlement is mainly known due to the wealth of art and symbolism displayed by the built structures of Çatalhöyük East, and its international significance is manifested by its large size (*ca*. 13.5 ha), and dense population of approximately 3,500 to 8,000 people (Cessford 2005; Hodder 2014a). The well-preserved architecture, stratigraphy, and bio-archaeological remains in this Neolithic mound give a unique insight into early village life. In spite of the many years of excavations at Çatalhöyük, the site continues to yield new insights into important research questions dealing with the early formation of settled villages, and the origins of agriculture and domestication in Central Anatolia.

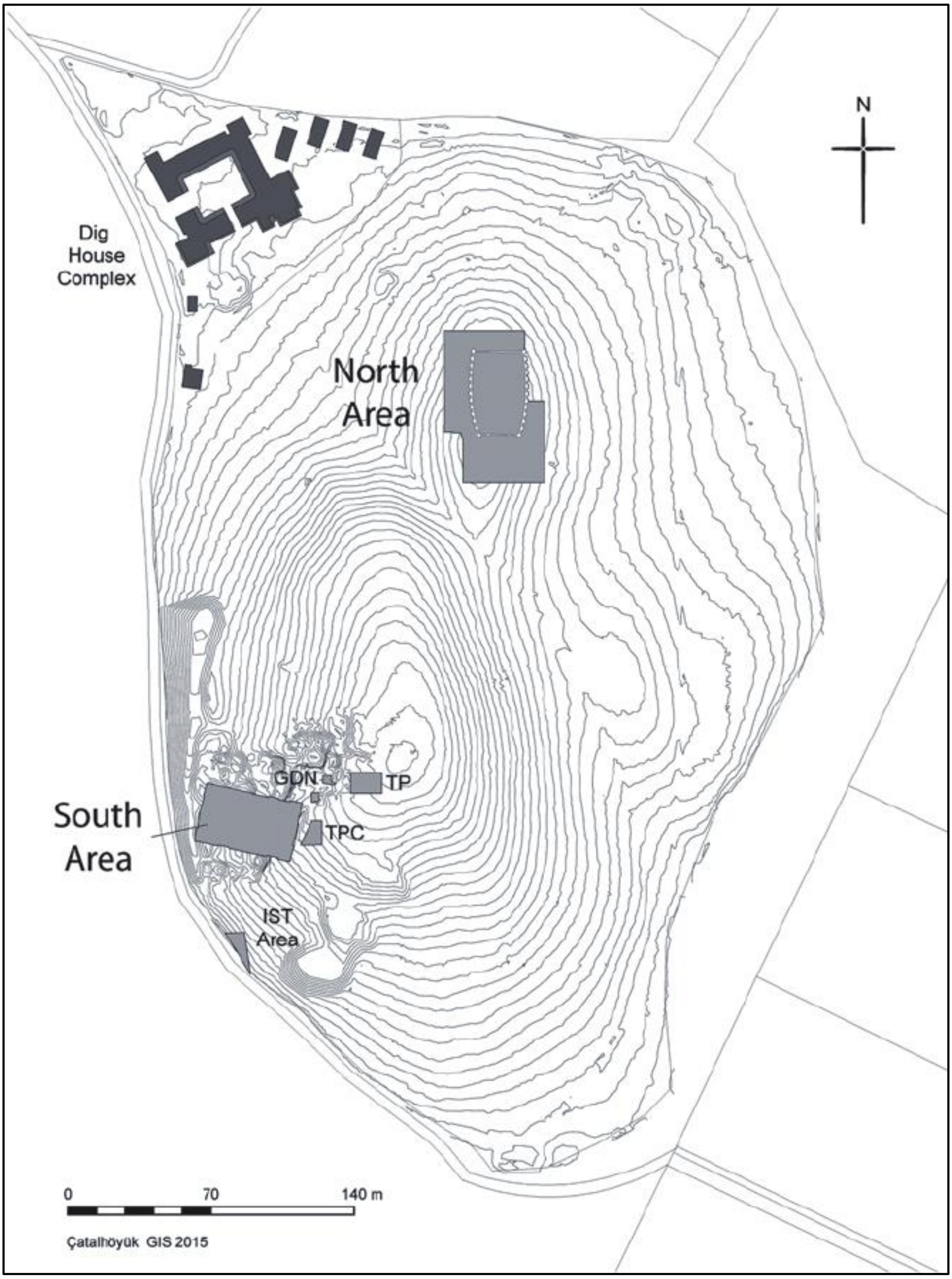



**Figure 2.9** Site plan of Çatalhöyük East displaying current and former excavation areas (Source: Camilla Mazzucato for Çatalhöyük Research Project).

### 2.3.1 History of excavations

The site of Çatalhöyük was discovered in the late 1950s by Mellaart, French, and Hall during an archaeological survey of the Konya Plain (Mellaart 1967). The first excavations in the East Mound, which measures approximately 275 by 400 metres and stands 17 metres above the Konya Plain, began in 1961 under the direction of James Mellaart, and works continued in 1962, 1963, and 1965 (Mellaart 1998). Large areas of the settlement were exposed and an estimate of four hundred rooms were excavated in these early years, bringing to light spectacular finds such as vivid wall paintings, mouldings, figurines, and a considerable number of burials. The variability in symbolic elaboration displayed within building interiors was interpreted by Mellaart as evidence for the existence of two types of structures: houses and shrines. The later term was used to refer to buildings with large amounts of symbolic features, such as wall paintings, bucrania, figurines and reliefs, implying that Mellaart considered this type of built environments as having primarily a religious function. This categorisation has currently fallen in disuse as later evidence has demonstrated that all the buildings were lived in, that is, they all show evidence of domestic occupation, as seen in the dense patterning of artefacts and the micro-remains of activities observed through thin-section micromorphology (Matthews 2005a; 2005c).

In 1993 the large-scale archaeological project led by Ian Hodder started, involving meticulous excavation practices as well as elaborate documentation and sampling procedures for the application of state-of-the-art analytical methodologies that allow for the extraction of a wealth of fine-grained data from the archaeological record. Initially, the research focus was directed towards the detailed understanding of particular buildings, shifting in later years to wider questions regarding the social geography of the settlement, the occurrence of major socio-cultural changes during its occupation, and the dynamics of power and religion in early settled life (Hodder 2006; 2013b).

This important project, which was originally scheduled to last for twenty-five years, will come to an end in 2018. In these years, several areas across the East Mound were opened for excavation, including its south-western flank (South Area), next to the 1960s deep excavation trenches, and the northern peak (North Area, see Figure 2.9). Further work in other areas of the East Mound has been conducted by a number of different teams, including the TP (Team Poznań) and TPC (Team Poznań Connection) Areas, an extension of Mellaart Area B where the latest Neolithic deposits have been revealed (Marciniak 2015; Marciniak and Czerniak 2007a); the GDN (Gdańsk) Area, overlapping with Mellaart Area A, where Late Neolithic architecture has been re-exposed for detailed structural examination (Barański 2013); the IST

**Figure 2.10** Main excavation areas at Çatalhöyük. From top to bottom: North Area, South Area, and TPC Area. Bottom image by J. Quinlan.

(Istanbul) Area, located to the south of the mound and comprising Late Neolithic deposits extending beyond the edge of the upstanding mound (Özbaşaran and Duru 2013); the BACH (Berkeley Archaeologists at Çatalhöyük) Area, situated within the North Area and comprising Building 3 and three adjacent spaces to the south of it (Tringham and Stevanović 2012); and the KOPAL (Konya basin Palaeoenvironment project) Area, formed by a number of small trenches stretching along the north slope of the East Mound excavated with the aim of obtaining in-depth information on the character of the occupation and natural deposits beyond the edge of the site (Roberts *et al.* 2007b). In spite of the various teams and research scopes, all the recent work at this settlement has been undertaken under a unified recording and sampling methodology set by the Çatalhöyük Research Project in order to facilitate data exchange and interpretation (Farid and Hodder 2013; Hodder 1997; Hodder *et al.* 2007).

### 2.3.2 Chronostratigraphic sequences

The accurate dating of the Neolithic settlement at Çatalhöyük has long been a significant goal of the current research project (Hodder 2006; Hodder and Farid 2013; Hodder and Ritchey 1996). Recent theories on the development of early agricultural societies are increasingly emphasising the polycentric nature of this process, in which locally developed ecological strategies coexisted with regional traditions in material culture (Özdoğan 2010), thus making the definition and interpretation of chronological change during the Neolithic still a relevant aspect of current archaeological research in Central Anatolia.

Scientific dating involving Accelerator Mass Spectrometry (AMS) and Optically Stimulated Luminescence was undertaken by Cessford *et al.* (2005), who estimated the start of the site at around 7400-7300 cal BC. However, technical problems at the Oxford Radiocarbon Accelerator Unit related to bone pre-treatment methodologies meant that these dates were approximately 100-300 years too old (Bronk Ramsey *et al.* 2004; Bayliss and Farid 2007). The new radiocarbon dating program, initiated in 2006, was originally conceived within a Bayesian statistical framework, an approach that has dated the start of Çatalhöyük at 7100 cal BC, at least 200 years later than previously estimated (Bayliss *et al.* 2015). This research has been focused on two areas of the mound: the latest Neolithic deposits of the TP Area (Marciniak *et al.* 2015), and the deep, vertical stratigraphic sequence of the South Area (Farid 2013). The recently excavated spaces in the North Area that are the main focus of this investigation have unfortunately not been dated with this innovative radiocarbon methodology yet, and their chronological framework has been estimated after a careful examination of their stratigraphic relationships and associations with previously dated buildings and trenches in this area.

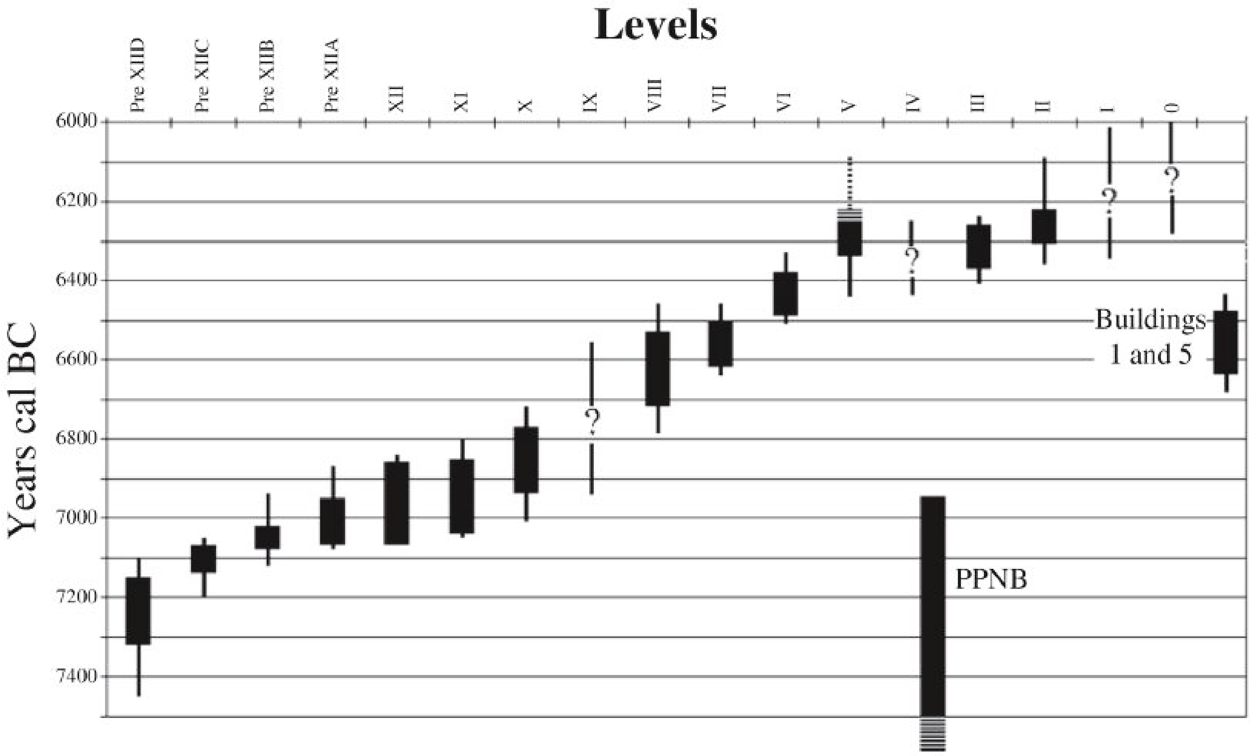



**Figure 2.11** Radiocarbon dates of Mellaart levels at Çatalhöyük (Cessford *et al.* 2005). Although the date for the start of the settlement has been recently revised by Bayliss *et al.* (2015) and estimated at 7100 cal BC, the assigned radiocarbon dates of the excavation levels have not been reviewed at the time of writing.

Based on the site stratigraphy exposed during the 1960s excavations, Mellaart distinguished fifteen building levels, numbered from top to bottom 0-XII. Levels V-O have been generally considered to belong to the Late Ceramic Neolithic, whereas levels XII to VI are usually assigned to the Early Ceramic Neolithic. Current estimations of the dates that each level represents can be seen in Figure 2.11.

One of the main challenges of the current research project relates to the chronological sequencing of the site, a problem manifested in the fact that at Çatalhöyük there are no large-scale occupation horizons that stretch across large areas of the settlement, making the grouping of buildings and open areas into levels an extremely difficult task (Farid 2013). Buildings are constructed and re-built on an individual basis, and there is very little inter-connection between houses, as each follows its own sequence. Further, as the excavation works directed by Ian Hodder exposed more of the stratigraphic complexity of Çatalhöyük, a new system of levels was introduced based on relationships detected in the Harris Matrices of each individual excavation area (Hodder 2013b). A summary of the current understanding of the Çatalhöyük level system, based on ceramic and chipped stone data, is displayed in Table 2.1. In this regard, it is worth noting that a South Area level is not directly equivalent to any other identified level in another Area sequence and vice versa, as the trenches are not linked.

| Mellaart | Hodder | | Approximate C14 age BC |
|---|---|---|---|
| | TP/TPC | | |
| | South T | 4040 J | |
| 0, I, II, III, IV | South S | 4040 J | 6,400 - 6,000 |
| | South R | 4040 I | |
| | South Q | 4040 H/I | |
| (V) | South P | 4040 H | |
| VIa | South O | 4040 G | 6,500 - 6,400 |
| VIb | South N | 4040 G | |
| VII | South M | 4040 G | 6,700 - 6,500 |
| VIII | South L | 4040 F | |
| IX | South K | 4040 F | |
| X | South J | | |
| XI | South I | | 7,100 - 6,800 |
| XII | South H | | |
| Pre XII | G1, G2, G3, G4 | | |

**Table 2.1** Current understanding of the relationships between Mellaart and Hodder levels in the South and North (4040) Areas (Source: after Hodder 2013: 10).

A major cultural and economic transition at the site, occurring at around 6500-6400 cal BC, has been detected by a number of researchers through the observation of changes in lithic industries (Conolly 1999), ceramic traditions (Doherty and Tarkan Özbudak 2013), and the configuration of settlement space (Düring 2001), between other aspects. By examining the evidence from accumulated microresidues and floor construction materials in a series of buildings dated *ca.* 6700-6400 cal BC, this hypothesis is further investigated in the present study to determine the occurrence of corresponding changes in activities, concepts of space, and resource use – in particular fuel materials and sediments for floor manufacture –, that could be linked to the wider technological and ecological shift identified in other types of material culture during this narrow period.

### 2.3.3 Architecture and organisation of space within buildings

On a site without streets, distinguishing buildings from one another is not straightforward. At Çatalhöyük space numbers are allocated to defined internal and external areas, and as such they can refer to rooms or courtyards. A building number is allocated where more than one internal space can be demonstrated to belong to one structure. That is, if there is more than one space beneath one roof. At Çatalhöyük this definition can be applied because part walls were not used and each building has its own set of outer walls. Built environments often display a high degree of conformity when it comes to internal spatial divisions, and commonly fall into a restricted size range of approximately 10 to 40 $m^2$, with an average of about 27 $m^2$. At room level we can distinguish three categories: main rooms, which contain fire installations and have one or more platforms; anterooms or siderooms, frequently used as storage areas and devoid of substantial architectural features, averaging 5 $m^2$ in size; and indeterminate rooms, spaces that fall outside the two previous categories and that have a size range beyond that of a normal distribution. Most buildings at Çatalhöyük contain either a single main room, or a main room with one or two anterooms, interpreted as single-household residences. There are, however, very few exceptions to this rule, such as buildings with two main rooms, sometimes sharing an anteroom (Düring and Marciniak 2006).

Building interiors at Çatalhöyük are remarkably standardised in the configuration and orientation of furnishings and architectural features, including hearths, ovens, platforms, and compartments (Hodder and Cessford 2004). At the south end of the main room one could find hearths, ovens, the ladder entrance, and small storage features (Matthews 2005b). Burials normally occur beneath platforms located in the north-eastern part of the main room, in pits excavated through the floor during the occupation of a building, after which the burial site was closed and the floor was patched. These platforms were kept remarkably clean and most


**Figure 2.12** Building 77 under excavation, displaying the typical spatial boundaries of a Çatalhöyük house. The fire installations and associated cooking areas are located in the south of the main room, whereas the plastered platforms for sitting and sleeping, often containing burials, are situated along the east and north walls of the construction. Elaborated wall paintings and mouldings, frequently associated with burials, are commonly found on north walls. The sideroom was typically accessed off the main room and used for crop storage. (Photo by J. Quinlan).

likely served for sitting and sleeping. Multiple interments in a single location were common, with new burials often disturbing the human remains of earlier burials, which were sometimes placed aside or re-arranged. Although Mellaart (1962; 1964) initially suggested that burial locations within buildings were age- and gender-specific, this spatial differentiation has not been observed in the recent excavations (Hodder and Cessford 2004). The high degree of spatial and architectural standardisation of buildings at Çatalhöyük would seem to suggest that they were economically independent entities and that economic pooling was focused primarily on the household.

A range of activities seems to have been performed on the roofs, likely during the warmer months of the year, as the micromorphological examination of collapsed remains in Building 3 has revealed (Matthews 2012c). A fire installation was found on top of this roof and clean and dirty areas were identified, suggesting a similar division of space to that found in interior main rooms. Although the idea that Çatalhöyük buildings could have had substantial upper storeys has been dismissed by some scholars on the ground that the often slumping and leaning walls would have lacked the structural strength to support them (Düring 2006), there is some evidence that buildings would have been double-storey in the South Area of the site by 6400 cal BC, and two-storey houses have been commonly found on the Chalcolithic West Mound (Hodder 2013b). However, these buildings appear to have had substantial wooden structural components to support the upper storey (Harrison *et al.* 2013; Stevanović 2013).

### 2.3.4 Social practices and open spaces

The Neolithic settlement at Çatalhöyük shows a highly clustered pattern, characteristic of other early Neolithic settlements within this region, with buildings backing onto each other and no defined streets between them (Düring and Marciniak 2006). At certain locations within the site, open areas occur between buildings, where discarded materials accumulated. These spaces were described as 'courtyards' in the early excavations (Mellaart 1967), although this term fell in disuse in later field investigations in favour of the 'midden' definition (Hodder 2006), traditionally described in the literature as an archaeological refuse deposit where domestic residues containing a rich variety of artefactual and bioarchaeological remains were gradually dumped (Schiffer 1983).

Middens at Çatalhöyük are usually completely enclosed by buildings. As it has traditionally been interpreted, the aggregated layout of Çatalhöyük suggests that, in addition to building tops, middens were used as passage routes between different parts of the site. Thus, the study of open spaces appears as highly significant to our understanding of settlement architecture and spatial organisation at Neolithic Çatalhöyük, in particular of distinctions between private and communal areas, and the movement of people and animals within the site.

The stratigraphy of open spaces at this site consists mainly of fine ashy deposits and domestic refuse, although occasional penning deposits and outdoor activity areas such as lime burning and ceramic production are also encountered, especially in the upper levels (Shillito and Matthews 2013). Middens usually show evidence of a rapid build-up of loose deposits with little disturbance by trampling. Partly due to this, the detection of outdoor activities within this agglomerated settlement has long proven challenging. Furthermore, in spite of the fact that middens are an important source of information on external activities, refuse practices, and seasonality, they are frequently excavated in arbitrary units formed by a series of grouped single layers. Therefore, the coarsely defined excavated units do not represent actual units of deposition. This makes the identification of activity areas and passage routes in the field problematic, as there are often no clearly visible macroscale indicators within the finely stratified sequences that characterise most midden deposits at Çatalhöyük to detect activities other than refuse disposal, such as paving or formally laid fire installations. Microstratigraphic approaches to midden deposits are a partial solution to the challenges posed by these contexts, since these methods allow distinguishing between deliberately laid surfaces and accumulated deposits (Matthews *et al.* 1997). At Çatalhöyük, micromorphology has been applied to the study of external sequences, finding very limited evidence for heavy trampling and deliberately constructed surfaces in the early levels at the site (Matthews 2005b). More recent microstratigraphic studies on late midden deposits at this settlement (*ca.* 6400-6000 cal BC) have revealed evidence of prepared surfaces and intense trampling at several locations within the site, similar to those observed in other late prehistoric settlements in the Near East (Matthews 2001; Matthews *et al.* 1997), pointing to the function of middens as route-ways/ courtyards during the Late Neolithic at Çatalhöyük (Shillito and Ryan 2013).

### 2.3.5 Discussion

The long-term objective of the Çatalhöyük Research Project has been to integrate the evidence for symbolic behaviour at the site within its environmental, economic, and social contexts (Hodder 2014b). The overall trajectory of the project has therefore shifted gradually from the study of individual houses to the whole community. However, as the environmental and cultural data from the site started to indicate that a major shift occurred between Levels VI and V in the Mellaart scheme, it became clear for the research team that temporal changes in the social geography of this settlement was a topic that required further investigation (Hodder 2014a).

Our understanding of the Late Aceramic period at this site remains limited. The area excavated that belongs to this chronology is reduced to a deep sounding trench, 3.8 m in depth, located towards the south-western slope of the East Mound, comprising midden deposits of various compositions. The earliest level, labelled Pre-XII-E, consists of a series of pits cut through the natural surfaces for the extraction of marl or alluvial clays (Cessford 2001). Overlying these layers midden areas displaying evidence of lime burning, probably for the production of lime floors, and penning deposits were found. In later levels of occupation, however, lime floors became rare (Matthews *et al.* 2013).

In terms of economy, the Aceramic Neolithic levels at Çatalhöyük are similar to later levels at this site. Fairbairn *et al.* (2005b) documented a range of domestic cereals and pulses in these early levels, alongside wild plants and tree food resources of various sorts. Agricultural crops appear to have been of prime importance for the economy of the site throughout its occupation, including wheat, naked barley, domestic rye, bitter vetch, lentil, pea, and chickpea. Further, the collection of a variety of wild plant resources such as hackberry, almond, acorn, fig, and plum, appears to have played a substantial supplementary dietary role in all the occupation levels (Asouti and Fairbairn 2002; Fairbairn *et al.* 2002; 2005b). Small charcoal fragments are ubiquitous at Çatalhöyük, with the most common species being juniper, oak, pistachio, and elm (Asouti and Hather 2001). Faunal remains from a large range of animals have been identified on site, including sheep, goat, and dog, and large hunted mammals such as cattle, deer, boar, horse, and bear. A variety of remains from small mammals, including fish and bird bones, and turtle shells have also been documented at this settlement (Russell and Meece 2005; Russell *et al.* 2013). The chipped stone industries of Çatalhöyük consist almost entirely (approximately 95%) of obsidian derived from two Cappadocian sources (Carter *et al.* 2005). Débitage is rarely found on site, both in buildings and open areas, which suggests that much of the knapping took place elsewhere. Finally, the occurrence of pottery at Çatalhöyük is among the earliest of the Near Eastern Neolithic, and it has been documented on site from Level XII onwards. A marked technological change, however, has been detected at around Level VII, involving improvements in temper selection and pottery firing (Doherty and Tarkan Özbudak 2013; Last *et al.* 2005).

Overall, the many socio-economic transformations identified from Level VI-V onwards in building architecture, use and configuration of external spaces, burial practices, and both environmental and artefact assemblages, which have been discussed in more detail in Chapter

1, can be summarised as entailing an intensification of independent household-based production, and a decrease in the importance of ritual ties and community structures (Hodder 2014b). Interestingly, these processes at Çatalhöyük have been observed to correlate with important transitions occurring throughout the Near East and into Europe, including the shift from Neolithic villages to new forms of settlement in Upper Mesopotamia, and the spread of farming into north-western Anatolia and Europe (Hodder 2007a; 2014a).

## 2.4 Pınarbaşı

The site of Pınarbaşı is located northeast of the Karadağ volcanic mountains, on the slope of a limestone hill. Palaeoenvironmental studies indicate the existence of a nearby marsh at the time of its earliest occupation, as well as the presence of almond and pistachio trees in its surrounding landscape (Asouti 2003; Baird *et al.* 2013a). The areas with archaeological occupation comprise the rockshelter, set against the limestone cliff face and overlooking the plain, and a small peninsula extending into the marshlands (Watkins 1996). The excavation of this site was originally undertaken by a team from the University of Edinburgh under the direction of Trevor Watkins over two field seasons (1994-1995) on two locations: Area A, situated by a small mound on the peninsula, and Area B, on the rockshelter. The excavated deposits in Area A were radiocarbon dated to the Epipalaeolithic, whereas the Late Neolithic occupation in the rockshelter was dated to *ca.* 6500-600 cal BC (Watkins 1996).

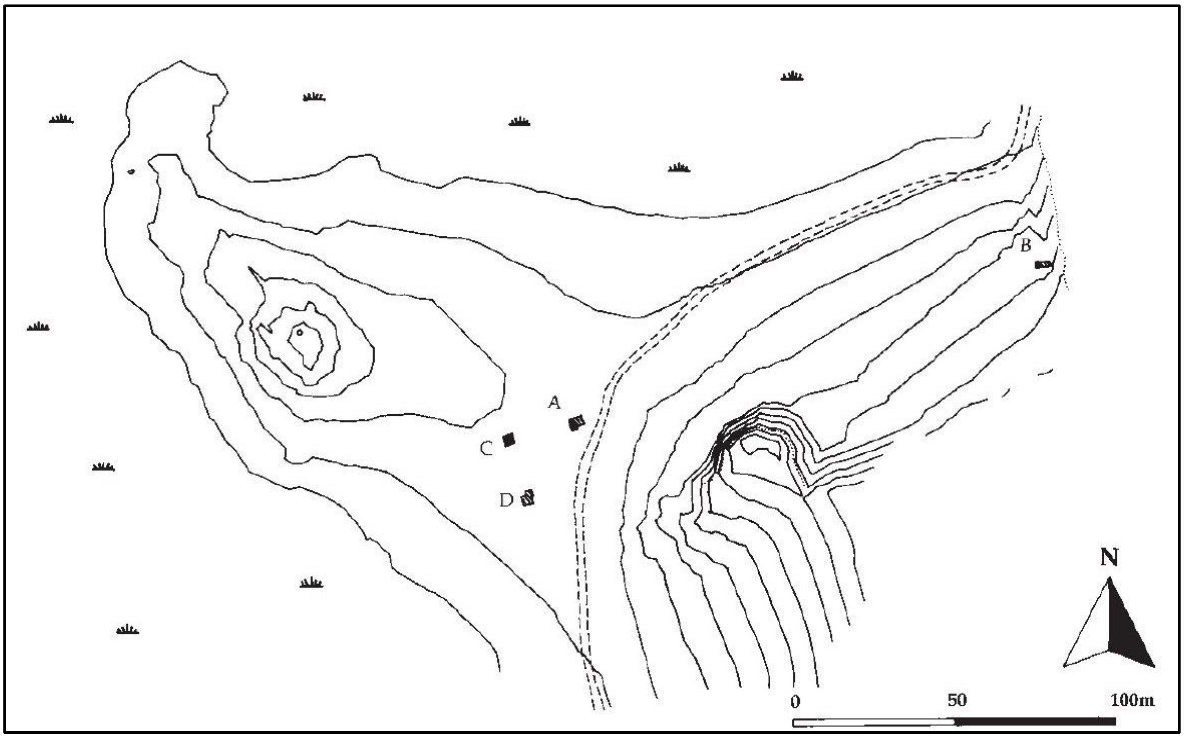



**Figure 2.13** Site plan displaying the four excavation areas. Source: Baird *et al.* (2013a: Fig. 3).

Excavations resumed in the early 2000s under the direction of Douglas Baird, involving further investigations in Areas A and B, and the opening of two more trenches on the small mound: Areas C and D. The new investigations in Area B, by the rockshelter, revealed two different occupation periods in this location. The upper part of the sequence represents a campsite used by a mobile herding and hunting group during the 7th millennium cal BC, contemporary with the late Neolithic occupation at Çatalhöyük East (Mellaart Levels V-I), whereas the lower part of the archaeological stratigraphy corresponds to a 9th millennium cal BC Epipalaeolithic occupation (Baird 2012b).

### 2.4.1 The 9th millennium occupation

The early, 9th millennium occupation of the Pınarbaşı rockshelter, which included built structures for long-term use, has been interpreted as characteristic of a sedentarising community, that is, a social group engaged in residential practices comprising the repeated occupation of the site, possibly on a multi-seasonal basis, albeit falling short of continuous, year-round occupation for numbers of years, as it would be expected of a fully sedentary community (Baird *et al.* 2013a). The deposition of human remains at this rockshelter, however, represents a significant investment on this site by its occupants.

**Figure 2.14** Collapsed daub superstructure in Area A (Source: D. Baird, pers. comm.).

The archaeobotanical evidence from the site indicates that its inhabitants were not dependent on cultivated cereals or legumes, with gathered wild plants and fruits such as almonds and pistachios dominating the assemblage. The zooarchaeological evidence, formed by hunted large mammals (mainly aurochs and equids), birds, and fish, appear to point towards a mobile group practising a 'broad spectrum' economic strategy (Baird 2012b; Flannery 1969). Approximately 90% of the chipped stone artefact found on site were made from obsidian obtained from Cappadocian sources. Microliths dominate the lithic industry, formed by specific tool types that include bladelets, scrapers, and small retouched flakes (Baird *et al.* 2013a).

The curvilinear built structures from Pınarbaşı display a considerable contrast with the broadly contemporary late 9$^{th}$ - early 8$^{th}$ millennium cal BC buildings at Boncuklu in terms of construction and elaboration. Built environments at Pınarbaşı were semi-subterranean and roofed with wattle and daub superstructures. The floors were plastered, and some appear to have been painted with red ochre. Interior furnishings included a hearth, a bench, and small pits that were likely used for cooking (Baird 2004). The thickness of the occupation deposits and succession of buildings indicate an intense, long-term settlement. Midden areas, where dumps from cooking installations gradually accumulated, are reminiscent of some aspects of open spaces at Boncuklu. The distribution of scattered stones, cooking pits, and basalt slabs in open areas appears to indicate that these were the scenario of a range of daily outdoor activities, probably related to food preparation practices (Baird 2012b; Fairbairn *et al.* 2014).

Overall, archaeological evidence from the early occupation of the Pınarbaşı rockshelter has provided no evidence for the appearance of agricultural and herding communities in this part of the Konya Plain, in marked contrast with evidence for cultivation and sheep management from the early 8$^{th}$ millennium occupation at Aşıklı Hüyük (Asouti and Fairbairn 2002; Martin *et al.* 2002). The proposed explanations for this range from the possibility that hunter-gatherer groups from Pınarbaşı practised early cultivation and herding somewhere else, specifically, around the marsh, steppe, and mountain environments of the Great Konya Basin, or that intrusive, non-local communities introduced farming and herding to this part of Central Anatolia (Baird 2012b).

### 2.4.2 The 6$^{th}$ millennium occupation

Excavations in Area B, situated by the rockshelter, revealed three phases of late 7$^{th}$ millennium occupation. The first phase comprised a series of large fire pits filled with bones and stone, apparently representing food preparation activities. The second phase consisted of a construction, lightly roofed with plant materials formed predominantly by reeds, with a central hearth contained by a wall with an oven built into it. The last phase comprised several layers of accumulated materials deposited within the structure, suggesting repeated occupation and abandonment (Baird *et al.* 2011b).

The zooarchaeological assemblage is formed by a substantial proportion of herded sheep, with significant numbers of aurochs and equids, and a small quantity of deer remains. Body-part representation for all species indicates that complete carcasses were butchered on site. The sheep remains include many foetuses and neonates, pointing to a strong seasonal signature for spring (Baird *et al.* 2011b). Overall, the scale of processing of animal products at Pınarbaşı was very large relative to the maximum extent of the occupation area, approximately 400 $m^2$, which is suggestive of the specialised use of this campsite during the Late Neolithic.

The identified plant remains suggest that plant food processing activities, including both cultivars and wild edible species, were not important at Pınarbaşı. Residues of plant foods were rare, although seeds and leaves of wetland plants have been found in moderate quantities, probably representing discards from bedding, fibres, or animal fodder (Baird *et al.* 2011b). The densities of carbonised wood remains, however, are considerably high, with terebinth and almond identified as the main species used as fuel in campfires and ovens (Asouti 2003).

**Figure 2.15** View of the rockshelter area at Pınarbaşı. Source: Baird *et al.* (2011b: Fig. 2).

The chipped stone assemblage is formed by over 90% obsidian artefacts, a proportion similar to that of contemporary levels at Çatalhöyük (Conolly 1999). Lithic reduction strategies and tool types are also similar between both sites, which could indicate a close relationship between both populations or, alternatively, the periodical use of the rockshelter by task groups from Çatalhöyük (Baird *et al.* 2011b; Roberts and Rosen 2009).

Altogether, the most notable artefact type at Late Neolithic Pınarbaşı consists of a series of plastered objects containing animal bones from the most common species found on site, namely sheep, aurochs, and equids (Baird 2003; 2004). These artefacts, possibly representing the symbolic refleshing of the bones after consumption, were deposited in clusters placed within fills in open areas.

# 3

# METHODS AND INSTRUMENTATION

*This chapter outlines the field and laboratory methodologies used in this research and describes operational procedures in detail. The strengths and limitations of each method are also evaluated within the research framework of this investigation.*

## 3.1 Methodological approach: multiscalar and multidisciplinary

An interdisciplinary and multiscalar geoarchaeological approach has been adopted for the present project, as stated in Chapter 1. To understand complex processes such as the development of household identities and shifts in the use of environmental resources we need to examine human activities at high-resolution. Exploring seasonal cycles of activities and how these are linked to the environmental and social geography of settlements is challenging at sites like Çatalhöyük and Boncuklu. Here, domestic deposits consist of a more or less continuous succession of microlayers, often millimetric in depth and impossible to distinguish and excavate individually (Farid *et al.* 2000; Baird *et al.* 2012b). This means that the remains of activities belonging to different depositional events often get lumped together during routine excavations and bulk sampling, eventually distorting the temporal signal of environmental and cultural proxies related to particular events and seasons. This research utilises a specific set of methods that aims to address such problems by studying depositional sequences at multiple analytical scales through a range of geoarchaeological techniques. Firstly, macro-scale analyses in the field with the objective of developing excavation techniques that would enable a better resolution of smaller-scale depositional events through the microstratigraphic excavation of single deposits and their meticulous documentation using photography, 3D modelling, planning, section drawing, excavation records, and portable XRF analysis. Secondly, a microscale approach with the goal of studying the fine depositional layers that are difficult or impossible to observe at the macroscale through the production and analysis of micromorphological thin-sections. Finally, in a subsequent stage, targeted geochemical techniques were applied to both spot samples and selected areas of the micromorphological slides in order to identify specific floor construction materials via x-ray (XRF and XRD) and infrared (FTIR) techniques, and to characterise specific components related to human activities through SEM-EDX and micro-FTIR analyses. The combination of these scientific methods is expected to offer robust explanations for each community's economic, ecological and social basis at unprecedented interlinked macroscopic and high-resolution scales of analysis for inter-site comparative studies in this region.

Thin-section preparation was carried out entirely by the author at the Micromorphology Preparation Unit of the University of Reading during 2013-2015. The optical analysis of the slides was conducted at the Department of Archaeology of the University of Reading, the Department of Archaeology and History of Art of Koç University, and the Mieres Institute of Technology of the University of Oviedo. IR microscopy (μ-FTIR) and SEM-EDX investigations were undertaken at the Chemical Analysis Facility and the Electron Microscopy

| Technique | Rationale | Advantages | Disadvantages |
|---|---|---|---|
| Microexcavation of archaeological deposits | Integration of micro- and macro-scale data through temporary baulks and sections left to record stratigraphic sequences and to collect micromorphological samples. | Fine-scale exploration of complex stratigraphic relationships. Visualisation, recording and sampling of interfaces between multiple contexts. Excavation of single depositional units possible. | Time-consuming. Difficult to excavate full contexts if these continue beyond a section. The presence of baulks and sections might cause problems in understanding adjacent stratigraphies. |
| Thin-section micromorphology | High-resolution contextual analysis of finely-stratified deposits, inclusions, and their associations. | Allows for the investigation of human activities and natural processes on surfaces, depositional histories and taphonomic alterations. | Complex and time-consuming sample preparation. Limitations related to the accurate optical identification of specific components and processes. |
| X-Ray Fluorescence (XRF) | Identification of dominant and trace elements in sediments and materials. | Detection of multiple elements, the distribution of which can be analysed simultaneously. | Significant sample preparation required, with some procedures resulting in the destruction of the samples. |
| Portable X-Ray Fluorescence (pXRF) | Characterisation of the elemental composition of deposits/aggregates. | Non-destructive. It can be used in the field to identify contexts of interest for further sampling. | Measurement limited to surface components only. Difficulties in detecting lighter elements. High error indices. |
| Powder X-Ray Diffraction (XRD) | Structural characterisation of crystalline mineral components. | Rapid and non-destructive elemental analysis involving little sample preparation. | Identification is limited to crystalline components. Significant processing of resulting spectra. |
| IR Spectroscopy (FTIR) | Identification of molecular bonds in deposits and aggregates. | Generally straightforward and rapid to operate. Use of ATR attachment allows the device to run without sample preparation. | The resulting spectra might be very difficult to interpret, especially for heterogeneous samples. |
| IR Microscopy (µ-FTIR) | Measurement of mineralogical composition at fixed points within a sample. | Allows IR spectra to be mapped across a sample. Possibility to run the analysis directly on micromorphological slides if not coverslipped. | Reflectance spectra recorded when run on micromorphological slides, which can be difficult to interpret. Not possible to measure spectra below 500 $cm^{-1}$. |
| Scanning Electron Microscopy - Energy Dispersive X-Ray (SEM-EDX) | High-resolution imaging and mapping of elemental composition across a sample at moderate to high magnification (50–5,000x). | Obtention of sample images containing morphological, textural, and compositional information. Possibility to run the analysis directly on micromorphological slides if not coverslipped. | Only detects surface components. Large-format micromorphological slides might not fit in the sample holder. Resin contribution to EDX results of impregnated samples might be problematic. |

**Table 3.1** Summary of the techniques used in this research (after Matthews *et al*. 2013: 116).

Laboratory respectively, both part of the University of Reading. FTIR, XRF and XRD studies were completed at the Surface Science and Technology Centre (KUYTAM) of Koç University.

The first part of this chapter outlines the field approach adopted in this research, involving both the excavation and recording process of Çatalhöyük Building 114, and the geoarchaeological sampling of selected contexts at Boncuklu Hüyük and Çatalhöyük East during the 2013-2014 field seasons. Section 3.4 reviews the micromorphological methodology of this study, comprising the production of thin-sections from the collected sediment blocks, and the optical attributes highlighted during the description and analysis of these samples under the microscope. The rationale and technical procedures of the microanalytical methods applied in this research, including infrared and X-ray techniques, are evaluated in sections 3.5 and 3.6. The chapter concludes with a brief discussion of how these methods are going to be integrated in the frame of this investigation.

## 3.2 Field Methods

What we see in the field is only a fraction of all the components forming the archaeological record. Those not visible to the naked eye are as informative and wide-ranging as the macroscopic remains, with the peculiarity that microscale analytical instruments are required to reveal them. Thus, any investigation of the archaeological record as a whole should aim at integrating both the macroscopic and microscopic records (Weiner 2010). This process starts in the field, where contexts are identified, research questions and preservation conditions are defined, and samples are collected for multidisciplinary laboratory analyses.

The main problem with integrating the macroscopic and microscopic records is that traditionally, the archaeologists studying the macroscopic record are not involved in studying the microscopic record and vice versa, which leads to a wide communicative and interpretational gap. This is especially true of field archaeologists who, despite being in the best position for understanding the macroscopic record, which forms the basis of any subsequent archaeological investigation, are rarely included as co-authors of scientific publications. The problem takes a higher dimension in large archaeological projects where multiple areas are being simultaneously excavated and dozens of specialists, each with their own, at times conflicting research agendas, participate. The members of the Çatalhöyük Research Project, in particular, were aware from an early stage of the challenges posed by the integration of multiple methodologies and research groups within the pressing environment of the archaeological excavations (Hodder 1997; 2000). To overcome these difficulties, the team developed a number of strategies aimed at building bridges between the field and the laboratory professionals working at the site involving, between other measures, priority tours of the excavation trenches by laboratory staff, and the use of computer tablets connected to the project intranet, which has facilitated the instant availability and sharing of data between team members (Farid and Hodder 2013; Taylor *et al.* 2015). Nevertheless, despite the introduction of these steps aimed at promoting 'reflexivity' and 'multivocality' within the large team of archaeologists at Çatalhöyük (Hodder 2000), the divide between research and field staff continued (Farid 2015).

The causes of this gulf between the worlds of the academic and field professionals, by no means exclusive to the team working at Çatalhöyük, are multiple and too diverse to be considered here. In the specific case of the Çatalhöyük Project, however, it has been noted that the field team is less established than the multiple laboratory teams (Farid *et al.* 2000). The former is constituted by a combination of professional excavators and archaeology students with various degrees of field experience, whose continuous participation in the project is constrained by commitments such as commercial contracts and academic calendars. This discontinuity in the excavation team has important implications for the whole project, including major variations in the nature and quality of recording and sampling, lack of familiarity with the site stratigraphy and field methodologies, and the level of interpretation and debate engagement with laboratory specialists.

Field archaeologists must, in addition to being able to systematically record and interpret contextual information during excavation and to collect a significant range of samples for further scientific analyses in an efficient manner, be familiar with the wide range of science-based analyses employed nowadays by laboratory specialists. To these already great demands, common to any current archaeological excavation worldwide, we have to add the training of inexperienced students at the sites of Çatalhöyük and Boncuklu, which devolves upon the professional members of the field team. It is thus challenging for the field archaeologist, generally trained in the humanities and adapting to state-of-the-art recording methodologies (Doneus *et al.* 2011; McPherron *et al.* 2009) to consistently engage in critical discussions with the large range of laboratory specialists present on site and, more importantly, to assess the degree of uncertainty involved in the results provided by these specialists.

On the other side, a number of laboratory members do not appear to have sufficient field experience or spend enough time at the excavation to appreciate the stratigraphic problems faced by field archaeologists, including the difficulty entailed in defining contexts. The analyses performed by all the laboratory teams are reliant on the definition of the archaeological unit and its stratigraphic relationships as recorded by the excavator but, interestingly, these field definitions are rarely challenged by laboratory specialists, even after the gathering and interpretation of analytical results (Farid *et al.* 2000). As a consequence, the presence of research specialists on site does not necessarily lead to a better integration of field and analytical/artefactual data, nor does it aid in transcending the divide between excavation and laboratory teams. Although the best strategy will pass by a fundamental restructuring of archaeological training and knowledge construction, a partial solution involves the direct participation of laboratory specialists in the excavation process, something common in small research projects (Shackley 1980). This has been the approach adopted for the multiscalar geoarchaeological investigation presented here, which includes the excavation and sampling of archaeological contexts at two Neolithic settlements in Central Turkey.

The field component of this project spanned twenty-two weeks of excavation work devoted to the integration of macro- and micro-scale approaches to archaeological occupation sequences from the moment they become exposed during fieldwork. Some of the advantages of this involvement during archaeological excavations are: 1) greater engagement in macroscopic documentation and understanding of stratigraphic sequences, resulting in the formulation of more informed research questions and the identification of key deposits for sampling and multi-disciplinary analyses; 2) the ability to integrate macroscopic field observations into the subsequent microscopic interpretations of archaeological stratigraphies; 3) the development of excavation strategies that aid in the micromorphological sampling of critical occupation sequences, such as the cross-sectioning of key features and spaces; 4) the promotion of micromorphological and geochemical studies as integral to modern investigations of archaeological sequences, contributing to resolving stratigraphic and contextual problems emerging in the field; and 5) the assimilation of microstratigraphic specialists as 'team players' (Macphail and Cruise 2001) capable of identifying and establishing meaningful research collaborations with field and laboratory archaeologists working on reconstructing past environments and behaviours.

The greatest part of the excavation work was carried out over three consecutive field seasons at the site of Çatalhöyük, which has allowed for a better understanding of the complex stratigraphy and the large range of sediment types encountered at this site than it would have been gained by studying the deposits solely at the microscale. But most importantly, the continuous involvement of the microstratigraphy specialist with fieldwork led to an iterative process in which the knowledge gathered after microanalysis was then reverted into the archaeological excavation during the next season, resulting in the rapid identification of potentially informative contexts and the formulation of new research priorities (Fig. 3.1). The observations and data collected during excavation were deemed of great importance for the successful development of this investigation, as every archaeological research, whether based on the macroscopic or microscopic records, starts in the field (Weiner 2010).

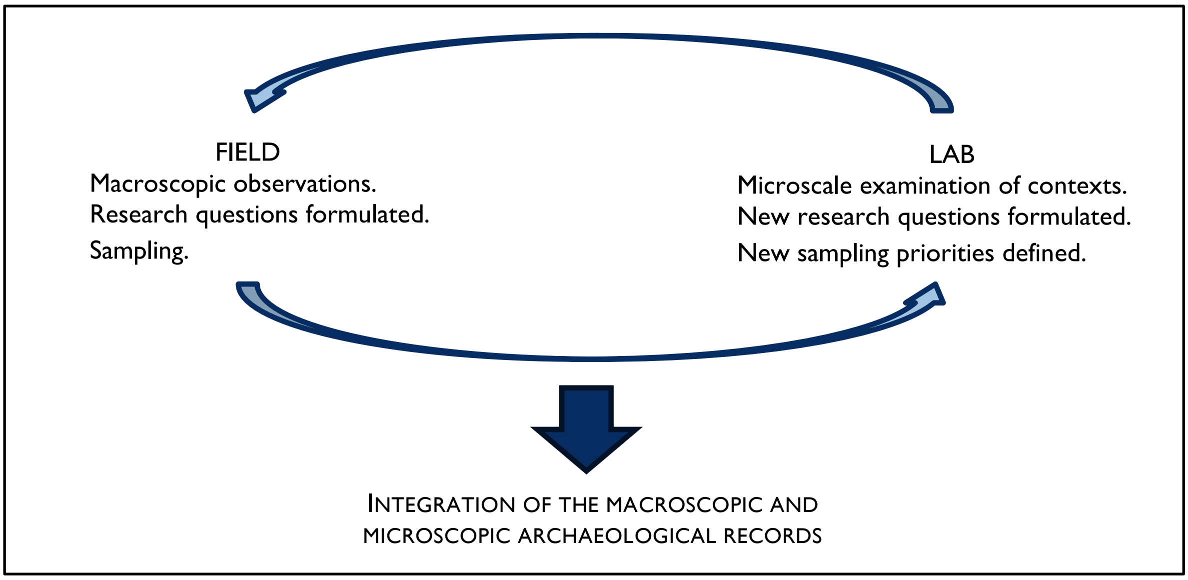



**Figure 3.1** Graph representing the iterative process at the centre of any scientific excavation methodology: question framing, data/sample collection, multiscalar analyses and, in the light of results, question re-formulation.

### 3.2.1 EXCAVATION APPROACHES AND RECORDING TECHNIQUES

Sediments not only comprise the vast majority of materials that we encounter during archaeological excavations: they were also an essential component of people's lives. Soils and sediments were part of the natural environment, but they were also elements for human engagement in the form of construction materials (mudbrick and plaster manufacture), artefactual assemblages (pottery and figurine production), and multiple scenarios of a wide variety of human activities, most of which would result in the compositional, geochemical, or geophysical alteration of the occupation deposits. Stratigraphy is, therefore, one of the most complex representations of the human past. The reality, nonetheless, is that the archaeological record, even under favourable preservation conditions, maintains little of the complexity and diversity of a settlement during its occupation. This makes reconstructing human behaviour a major challenge. At many sites, the occurrence of microlayers (those less than 1cm in thickness), places significant methodological demands on both the field and the laboratory teams in order to extract, in a reliable manner, all the valuable information embedded in the archaeological sediments. This is especially important if we bear in mind that excavation is, by essence, a destructive process.

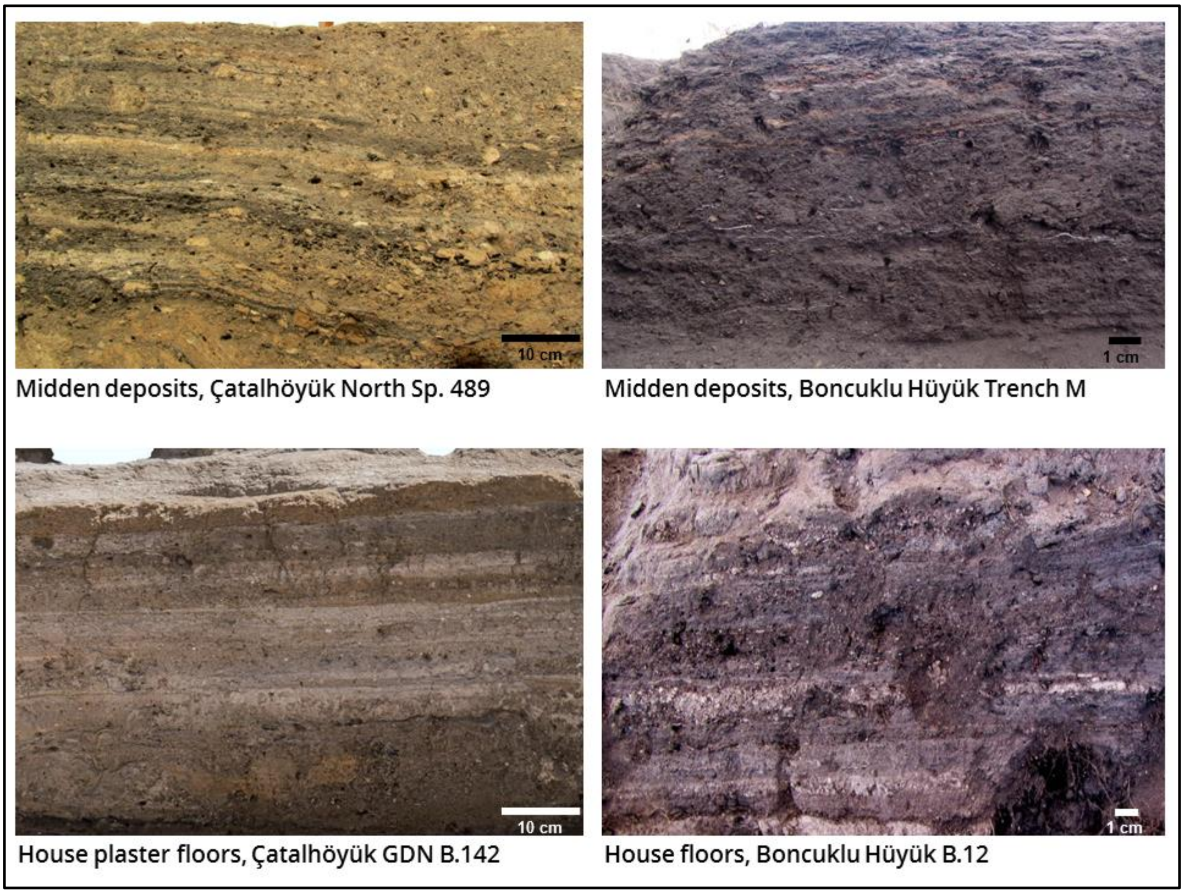



**Figure 3.2** Stratigraphic sections from Neolithic occupation contexts at Çatalhöyük and Boncuklu showing numerous microlayers (bottom left image by M. Barański).

Archaeologists working on Pleistocene materials are very familiar with these challenges. At these early prehistoric sites, where post-depositional processes have accumulated over thousands of years, the temporal resolution of the stratigraphy is of utmost importance for the excavation process. Failure to respect microlayers as individual entities might result in archaeological palimpsests equivalent to hundreds or thousands of years of Palaeolithic occupation. Field approaches for dealing with the difficult tasks of distinguishing, excavating, and appropriately documenting and sampling stratigraphic units at Pleistocene sites are reliant on the research focus of each project and the specific geology of the study area, but some of the common procedures that can be observed at most of these sites include: 1) preference for grid-square and/or quadrant excavation, including the use of labelled sections; 2) consistent utilisation of total station and GIS mapping of layers and all finds over 1-2 cm in size; 3) dry- and/or wet-sieving of all excavated contexts; 4) the application of interdisciplinary scientific techniques focused on gathering every piece of information from the archaeological deposits, often performing at the microscale and involving thorough sampling; and 5) slow pace of excavation promoted by the consistent use of fine digging tools such as scalpels and knives. This last point is very relevant as archaeologists can only excavate at the resolution procured by the field tools being used. Altogether, the integration of these field procedures results in very detailed spatial mappings of finds and features throughout all archaeo-stratigraphic levels, attentive consideration and recording of the compositional characteristics of each deposit by the excavators, and a very high retrieval rate of environmental remains and scientific samples. The questions arising are: can these field methods and approaches, common in excavations of hunter-gatherer sites, be applied in an efficient way to the intricate stratigraphy of later settlements? If so, what would be the advantages and limitations of this strategy?

Some of the aforementioned field procedures were or are currently standard at the sites investigated in this research. At Çatalhöyük, Building 2 was excavated in the late 1990s following an arbitrary grid-square pattern with dissatisfying results (Farid 2007). In spite of allowing detailed stratigraphic visibility and sampling from the baulk sections, and a more precise spatial mapping of micro-remain distributions as inferred from heavy residue calculations, many disadvantages were encountered in this excavation approach to building sequences. The most critical of these was the loss of interconnectivity of the archaeological deposits, meaning that neighbouring squares were excavated at different paces, sometimes resulting in the impossibility of linking contexts from one square to the next one (Farid 2007). In addition, it was later found that the arbitrarily positioned baulks were laying at key building locations, concealing internal spatial divisions. Due to these inconveniences, this methodology was abandoned in favour of open plan excavation areas (Hamilton 2000; Farid and Hodder 2013), although cross-sectioning of features, such as hearths or ovens, and midden spaces is not uncommon in the current field project, frequently motivated by a need to better distinguish and sample the microlayers that form these sequences.

Topographic instrumentation such as theodolites and total stations, key in the mapping of archaeological layers and finds, are intensively used in modern field projects such as those at Boncuklu and Çatalhöyük. The excavation methodology of the latter has the particularity of including on-site GIS mapping of deposits and features, made possible through the availability of computer tablets in the trenches. While in the field, photographs are taken of what is being excavated, and a 3D model is created by means of a photogrammetry software (Agisoft PhotoScan). This model is then orthogonally rectified and the excavated deposits, features, finds and samples are drawn over, annotated, and uploaded into the GIS site database as digitised plans (Taylor and Issavi 2013). Generally, only certain finds, such as human bones, groundstones, knapped stone tools, figurines, and personal ornaments are mapped into the plans.

Wet-sieving, aimed at retrieving environmental remains and micro-artefacts, is a standard procedure in modern archaeological projects, with sediments from special contexts, such as burials or bin fills, being floated in their entirety. Routinely, a 30-litre flotation sample is collected from every excavated deposit at both Boncuklu and Catalhöyük, with the remaining being dry-sieved (4 mm mesh) in order to maximise the recovery of ecofactual materials.

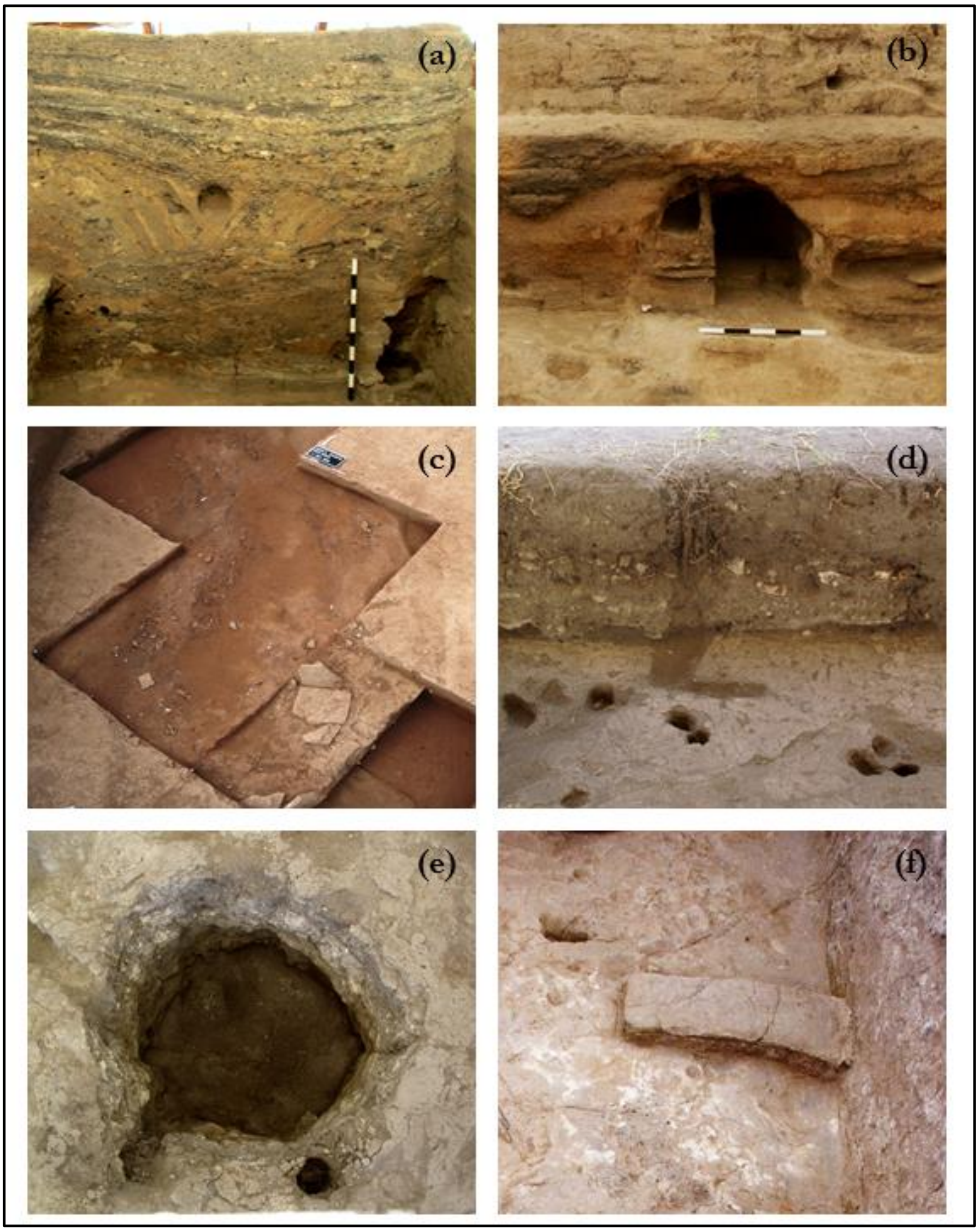



**Figure 3.3** Section types commonly used for micromorphological sampling: a) cross-section of Sp.489/511 at Çatalhöyük East; b) strategic baulk across oven feature in B.77, North Area of Çatalhöyük; c) grid-squares and quadrants at the Aurignacian site of Breitenbach, Germany; d) edge of excavation of Trench P at Boncuklu Hüyük; e) edge of burial pit within Building 21 at Boncuklu; f) small plinth in Sp.470, South Area of Çatalhöyük (photo by A. Klimowicz).

'Multivocality' and 'reflexivity' have been, since the onset of the 1990s excavations, two of the main goals of the large research project at Çatalhöyük (Hodder and Ritchey 1996; Hodder 1997). This commitment has led to the application of many revolutionary field and post-excavation methodologies, partly possible due to the continuous presence of laboratory specialists on site (Hodder 1997). It was soon assumed by the team that in order to provide answers with the smallest degree of uncertainty, all possible sources of information would have to be extracted from the archaeological record, an interdisciplinary approach that had to begin on-site through the interaction of both field and laboratory project members (Matthews and Hastorf 2000). However, although the difficulties posed by the integration of results substantiated on different lines of evidence have been addressed and dealt with in formal discussions and collaborations, it is rarely acknowledged that collecting and integrating data from different scales still poses great challenges in archaeology. For those methodologies focused on the microscale, such as microartefact spatial patterning or thin-section micromorphology, a carefully designed sampling strategy that ensures the representativeness of the samples collected in relation to the contexts being studied becomes vital to link the results obtained to activities and processes occurring at the larger scale. Nevertheless, although micromorphology allows a great amount of behavioural information to be extracted from occupation deposits, this method frequently requires the presence of vertical field sections with visible stratigraphy from where block samples can be extracted. Since the predominance of horizontal excavation strategies in archaeological field projects, typical sampling locations for micromorphological blocks are often limited to trench edges, cross-sections of areas and features, sections of grid-squares and quadrants, and edges of negative features such as burial cuts and pits (see Figure 3.3 in the previous page). If requested, however, excavators might leave small plinths or baulks unexcavated when feasible to facilitate sampling.

Furthermore, sediment block extraction is usually performed by the micromorphology specialist, partly due to the fact that a certain level of skill and knowledge is necessary to successfully accomplish the collection of these samples (Goldberg and Macphail 2003), but also because of the status of micromorphology as a side technique to archaeological projects as opposed to core methods of perceived mandatory application such as skeletal analysis of human remains or palaeobotanical studies of plant macrofossils. Thin-section micromorphology, which requires extensive sample preparation and lengthy microscope analyses that yield results several months after sampling, is still difficult to integrate within the "*always momentary, fluid and flexible*" (Hodder 1997) field process at Çatalhöyük, which encourages immediate feedback of prioritised excavation contexts in order to ensure more informed archaeological interpretations "*at the trowel's edge*" (Ibid.).

In this research, some of the practicalities and integrative challenges discussed above are being targeted for the evaluation of the field applications of microscalar geoarchaeological methods comprising micromorphological and geochemical analyses of sediments from Neolithic occupation deposits. The goals of the excavation approach presented here are closely interwoven with the general aims of reflexive and post-processual methodologies at

Çatalhöyük (Hodder 1997; 2000), which motivated the selection of a partly excavated building at this site as the scenario for this experiment. Furthermore, Çatalhöyük field methodologies already incorporate many of the meticulous excavation procedures that are common in Pleistocene projects and that inspired this approach (Farid and Hodder 2013). The main difference relies on the pace of excavation, which is much faster at Çatalhöyük, as the demands of both funders and Turkish authorities requiring the unveiling of major finds each season put a significant amount of pressure on the excavators (Hodder and Farid 2013). Nonetheless, the well-defined architectural units at Çatalhöyük provide rigorous contextual data for testing newly combined field and geoarchaeological strategies aimed at investigating continuity and change in activities at high spatial and temporal resolutions.

With all these considerations in mind, the excavation, recording, and geoarchaeological sampling of Building 114 in the North Area of Catalhöyük started in 2013 and continued during the 2014 and 2015 field seasons. The reasons for the selection of this building as the focus of this methodological experiment were threefold: 1) the absence of detailed microstratigraphic analyses of small built environments at the site meant that this was a good opportunity to test widely accepted assumptions regarding the socio-economic status of these structures; 2) it was expected, based on the evidence gathered from other excavated small buildings at Çatalhöyük, that the stratigraphic complexity of Building 114 would be limited, making this a manageable space in terms of excavation decision-making and the need for flexibility in the methodological approach; and 3) the small size of this structure implied that accomplishing the excavation of its entire occupation sequence in three field seasons was a feasible goal. The main objective of this novel approach was the full integration of micromorphological studies in field methodologies by enabling the identification, documentation, excavation and sampling of all individual stratigraphic layers. It is important to note that at Çatalhöyük, the thickness of some depositional microlayers is less than 1mm, which greatly complicates the observation and interpretation of these contexts at the macroscale (Yeomans 2005). As a result, fine layers are usually lumped together as single units during excavation, which are then used as the basis of sampling. This practice has important consequences for subsequent laboratory analyses, as the contexts and associations of artefactual and bioarchaeological remains are arbitrarily accumulated, distorting temporal and spatial patterns. As it is always feasible to amalgamate results from smaller units of excavation, but impossible to separate results from larger units, attempting to distinguish and document microlayers from the field to the laboratory is an effort that deserves consideration. In order to achieve this, stratigraphic sections and baulks were left in strategic locations during the excavation of Building 114 to record the vertical dimension of its occupation sequence and to elucidate depositional relationships and site formation processes that would then result in targeted geoarchaeological sampling. The issue of where to vertically split the area of excavation within a built environment is, however, critical to interpretation. The divisions made in the building under study included careful considerations of the complex three-dimensional characteristics of its deposits and internal spatial boundaries as they were being unearthed, and it was noticed that the exposed sections provided great insight into the life-history of the building and enabled the application of a range of field and laboratory sedimentological characterisations. This approach, however, entailed a number of disadvantages, and its application had to be discontinued as the excavation progress revealed the occurrence of complex concepts of space and multiple features within the lifetime of this small building. The implementation and results of this excavation strategy are presented and discussed in more detail within the specific setting of Building 114 in Chapter 5.

### 3.2.2 Sampling strategy

A common problem regarding all types of archaeological sampling is establishing what sizes and spatial intervals have to be considered to allow the formulation of well-grounded interpretations about the site. The objective is to have a sample that is representative of the whole context under study, a goal that can be reached through systematic sampling across different areas, but also through more targeted, question-driven sampling strategies. In the case of the intensive multi-disciplinary sampling regime at Çatalhöyük, the original purpose was to enable the study of deposits, artefacts, and environmental remains at a wide range of scales of analytical focus while avoiding the bias of under- and over-representation (Farid *et al.* 2000). For previous micromorphological analyses conducted at this settlement, it became common that floor sequences were sampled at 1-2 metre intervals, according to a grid system and the location of key features (Matthews and Hastorf 2000). At present, this systematic and uniform sampling procedure is impossible to apply at Çatalhöyük, partly because of the limited presence of stratigraphic sections since the prevalence of open excavation strategies, but also due to micromorphological studies currently having the secondary status of 'temporary research project', entailing that standardised sediment block extraction of all buildings and open areas under excavation is no longer an integral part of archaeological methodologies at this site.

Therefore, the sampling strategy of this study has been critically developed attending to the specific research questions addressed, the composition of the deposits, and the type of analysis. Attention has been paid to variations in the occurrence and preservation status of specific archaeological materials in different contexts and sites, which has significantly increased the complexity of sampling methodologies and the integration of results from the different analyses. For this reason, geoarchaeological sampling at the study sites was envisaged as a flexible procedure and the range of sediment blocks collected varies according to both research and practical issues related to the nature of the deposits exposed, primary interpretations, and perceived importance of those contexts.

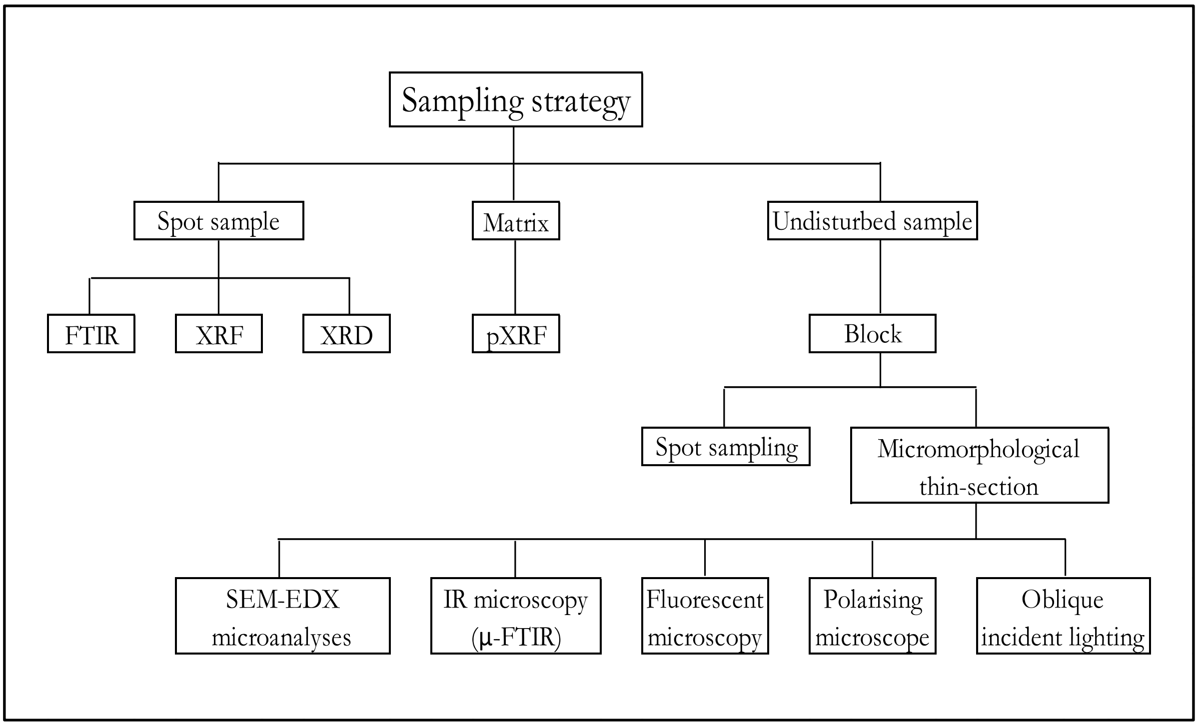



**Figure 3.4** Diagram illustrating the geoarchaeological sampling strategy adopted in this study.

The sizes of the sediment blocks collected range from approximately 15 x 8 x 8 cm for the production of extra-large thin-sections, to 12 x 9 x 8 cm for the manufacture of large slides. Micromorphological samples were extracted according to the variable depths of the stratigraphic sequences visible in field sections, and the feasibility of obtaining a complete, undisturbed block, which in some contexts (for example, in midden areas at Boncuklu, where the abundance of plant roots and unconsolidated sediments greatly complicate sample extraction) encouraged the collection of smaller, more manageable sediment blocks. These were cut from field sections using a Swiss army knife and tightly wrapped in tissue and tape, subsequently writing the top and the orientation on each block with a permanent marker. After the extraction, spot samples for secondary geochemical analyses were collected from each visible layer in the section from bottom to top, in order to avoid cross-contamination, and bagged individually. These spot samples were taken from the remaining section in the field adjacent to the back of the block that was extracted, and consequently, the elemental characterisations of these small bulk sediment samples, of approximately 5-10gr each, can be directly correlated to the micromorphological descriptions of the same deposits. Portable XRF analyses (pXRF) were carried out on key contexts visible in the exposed excavation section of Building 114 at Çatalhöyük during the 2014 field season.

#### 3.2.2.1 Boncuklu Hüyük

Sampling at Boncuklu was focused on a range of Neolithic occupation contexts: clean and dirty floors within buildings, collapsed construction materials, middens, exterior activity areas, and fire installations. During the field seasons of 2013 and 2014, a total of sixteen micromorphological blocks and associated spot samples were taken from trenches H, M, and N after discussion with the excavators, according to initial archaeological interpretations and inferred representativeness of the deposits. With regard to built environments, sampling efforts were driven by the goal to understand differences in sources of architectural materials and activities between standard and non-standard structures, described in Chapter 2. Excavation contexts in Building 12 in Trench H, and Building 16/23 in Trench M were thus sampled from every distinctive occupation area (hearths, plastered and non-plastered surfaces, and accumulated residues) to conduct a micro-contextual comparative study of their stratigraphic sequences that would shed light on the range of activities performed in these distinctive areas. Open spaces, comprising both midden deposits and external fire installations in Trenches M and N, were also thoroughly sampled for comparison with domestic contexts.

Blocks of undisturbed sediment were cut from trench sections, the edges of burial pits and post-depositional burrows, and from strategic plinths left by field team members during excavation in order to facilitate geoarchaeological sampling of potentially interesting areas.

Within a single vertical field section, specific areas for sampling were chosen after cleaning and surveying the entire exposed profile with a palette knife and a photographic puffer. Then, a block was cut from the area that seemed most representative of the whole stratigraphic sequence and that showed the least sign of disturbance by root or animal action. After the production of a section drawing, on which sampling locations were indicated, a high resolution photograph was taken of the exposed face and XYZ coordinates were obtained with the theodolite. Spot samples for geochemical analyses were collected from the section after the detachment of the micromorphological block.

| Sample | Trench | Blg | Context | Basis for micromorphological sampling | XRF | XRD | FTIR | µ-FTIR | SEM-EDX |
|---|---|---|---|---|---|---|---|---|---|
| 373 | H | 12 | Dirty floors | To investigate the composition and formation processes of multiple fine floors in dirty area of building. | √ | √ | √ | | |
| 374 | H | 12 | Floors and fills of large hearth F.171 | To study the latest phases of construction of the fire installation as well as the remains of fuel sources and activities. | | | | | √ |
| 375 | H | 12 | Dirty floors around small hearth F. 177 | To investigate construction phases, uses, and fuel sources of smaller fire installation towards the south-west of B.12. | | | | | |
| 380 | H | 12 | Dirty floors | To explore the nature and deposional patways of a deep sequence of fine ash floors (0.2-0.4 cm thickness each) in dirty area of building. | | | | | |
| 390 | H | 12 | Clean floors | To examine the composition and formation processes of multiple fine plaster floors and ocupation residues in the clean eastern half of building. | | | | | |
| 391 | H | 12 | Dirty floors around large hearth F.171 | To study the depositional history of occupation surfaces located around the main fire installation, paying special attention to remains of activities. | | | | | |
| 392 | H | 12 | Floors and fills of large hearth F.171 | To investigate the earliest phases of construction and use of the hearth, and the nature of the fill units within it. | | | | | |
| 365 | M | 16 | Collapsed structural remains | To explore the origin of construction materials and post-depositional alterations of collapsed roof remains. | √ | √ | √ | √ | √ |
| 366 | M | 16<br>23 | Collapsed structural remains and floors | To examine the stratigraphic relationship of a sequence of collapsed materials, charcoal remains (possibly derived from roof beams) and living floors. | | | | | |
| 393 | M | 23 | Dirty floors | To study the nature of the occupation surfaces, and the evidence for specific human activities in a non-standard built environment. | | | | √ | √ |
| 397 | M | 16<br>23 | Occupation residues and surfaces | To investigate the origin of plant material accumulations within the central part of a non-standard building, as well as the nature of floors and packing materials beneath. | | | | | |
| 367 | M | - | Midden | To determine the nature and depositional history of the abundant organic remains (likely omnivore coprolites) whose presence appears to be restricted to this area of the site. | | | | √ | √ |
| 376 | M | - | Fire pit within midden | To research on the formation processes of the fire pit and its use as an external hearth. | | | | | |
| 377 | M | - | Fire pit within midden | To explore the origin and deposition of several thick ash layers. To investigate the nature of communal activities in middens. | | | | | |
| 369 | N | - | External fire installation | To determine whether the deposits forming this feature are *in situ* hearth layers or rather rake-outs from dirty areas in the surrounding buildings. | | | | | √ |

**Table 3.2** List of micromorphological block samples collected at Boncuklu Hüyük and completed secondary geochemical characterisations.

#### 3.2.2.2 Çatalhöyük

Geoarchaeological sampling at Çatalhöyük was carried out during the 2013 and 2014 excavation seasons. In addition to investigating deposits within Building 114, the sampling strategy at Çatalhöyük was devised to study longer term change in the settlement. This was accomplished through the collection of micromorphological blocks from three additional built environments and several open areas, spanning Mellaart levels VII to I. One of these buildings, 77, is situated in the same neighbourhood as Building 114, with the former located immediately to the west of the latter. A sequence of clean floors and an oven were sampled, and these were used to compare the resources present with those identified in the floors and fire installations of Building 114, shedding light into variability in construction materials, diet, and fuel choices in contemporary households within the same neighbourhood. Another building, 89, located in the South Area of the site and roughly contemporary to Building 114, assigned to level VIb (6,500-6,400 yr BC), was sampled for micromorphology. Building 89 contains a deep sequence of excellently preserved clean and dirty floors, all of which were sampled to enable micro-contextual comparisons with previously sampled buildings in the North Area of Çatalhöyük.

The remaining built environments sampled for micromorphology comprise Space 489/511 in the North Area and Space 470 in the South Area of the site. The former contained large slabs of collapsed materials, identified in the field as possible roof remains or fragments of floors from upper storeys. This type of architectural materials has been rarely encountered at Çatalhöyük in the past, and thus samples were taken from several of these slabs to identify the nature of these deposits and to investigate the presence of residues derived from external (i.e. roof) activities. Space 470, a small built environment assigned to an intermediate phase between Hodder levels L and M (*ca.* 6,600 yr BC), was sampled to investigate the occurrence of industrial or communal activities within its boundaries.

Finally, four different middens spanning levels III-I (6,300-6,000 yr BC) and therefore broadly contemporary with the Late Neolithic occupation at Pınarbası B, were sampled in the TPC (Team Poznań Connection) and GDN trenches in order to investigate discard patterns, external activities, and diet during this later period of occupation at Çatalhöyük.

All the geoarchaeological samples were collected following the same field procedure described above for the site of Boncuklu, with a full list of these included in the next two pages.

| Sample | Area and level | Blg | Sp | Context | Basis for micromorphological sampling | XRF | pXRF | XRD | FTIR | µ-FTIR | SEM-EDX |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 20627-4 | Mellaart VI? (Hodder North.G) | 114 | 87 | Building fill and clean plaster floors | To investigate the nature of the infill and its depositional relationship with the plaster floors below it. | | √ | | | | |
| 20627-5 | Mellaart VI? (Hodder North.G) | 114 | 87 | Building fill and hearth rake-outs/occupation residues | To conduct a research on the depositional relationship between the building fill and the thick accumulations of ashy materials found immediately underneath. | | √ | | | | |
| 20628-3 | Mellaart VI? (Hodder North.G) | 114 | 87 | Clean plastered platform and floors | To explore the range of raw materials used in the construction of the central platform F.7114 and the plaster floors below it. | √ | | √ | √ | | √ |
| 21175-3 | Mellaart VI? (Hodder North.G) | 114 | 87 | Floors and fills of fire installation F.7345 | To investigate fireplace construction and modifications. To examine the use of fuel sources and food preparation activities. | | | | | | |
| 21364-3 | Mellaart VI? (Hodder North.G) | 114 | 87 | Lining of fire installation F.7345 and dirty floors | To study the composition and micro-stratigraphical relationship of the hearth lining and the floors around it. | | | | | | |
| 21535-3 | Mellaart VI? (Hodder North.G) | 114 | 87 | Floors and fills of fire installation F.7607 | To compare building materials, fuel sources, and fire-related activities with those of later fireplace F.7345. | | | | | | |
| 30596-3 | Mellaart VI? (Hodder North.G) | 114 | 87 | Clean plastered platform and floors | To study the sequence of construction of the central platform F.7114, its outer lip, and the floors underneath it, as well as the nature of these materials. | √ | | √ | √ | | |
| 20473-4 | Mellaart VII (Hodder North.G) | 77 | 336 | Oven floors and fills of F.7108 | To investigate types of floor construction materials and fuel sources within an intensively used oven structure. | | | | | | |
| 22087-1 | Mellaart VII (Hodder North.G) | 77 | 336 | Clean floors of platform F.6062 | To study the use and manufacture of the upper sequence of clean plaster floors in the southern area of the building. | | | | | | |
| 22087-2 | Mellaart VII (Hodder North.G) | 77 | 336 | Clean floors of platform F.6062 | To study the use and manufacture of the lower sequence of clean plaster floors in the southern area of the building. | | | | | | |
| 19835-3 | Mellaart VIb (Hodder South.N) | 89 | 379 | Clean floors | To investigate the composition and micro-stratigraphy of a sequence of clean plaster floors within the central area of the space. | √ | | √ | √ | | √ |
| 19839-1 | Mellaart VIb (Hodder South.N) | 89 | 379 | Dirty floors | To explore formation processes and impact of activities within the upper sequence of a series of dirty plaster floors located around the building hearth. | | | | | | |
| 19839-2 | Mellaart VIb (Hodder South.N) | 89 | 379 | Dirty floors | To explore formation processes and impact of activities within the lower sequence of a series of dirty plaster floors located around the building hearth. | | | | | | √ |

**Table 3.3** List of micromorphological samples collected at Çatalhöyük and performed geochemical characterisations. Table continues in the next page.

| Sample | Area and level | Blg | Sp | Context | Basis for micromorphological sampling | XRF | pXRF | XRD | FTIR | μ-FTIR | SEM-EDX |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 19393-4 | Mellaart VII? (Hodder South.L/M) | - | 470 | Occupation floors and activity residues | To investigate the formation processes and uses of this space, likely involving intensive crop processing, as the abundance of herbaceous phytolith accumulations seems to indicate. | | | | | | |
| 20988-3 | North Area - Unassigned level | 132 | 511 | Collapsed construction materials | To explore the nature of these collapsed materials, whether roof remains or fragments of floors from an upper storey, and the impact of external activities on the plastered surfaces. | | | | | | √ |
| 20988-4 | North Area - Unassigned level | 132 | 511 | Collapsed construction materials | To explore the nature of these collapsed materials, whether roof remains or fragments of floors from an upper storey, and the impact of external activities on the plastered surfaces. | √ | | √ | √ | | |
| 30407-3 | Mellaart III GDN2013.G | - | 544 | Midden | To investigate the nature of heterogeneous midden deposits situated between two Late Neolithic buildings, previously described by Mellaart as a street context. | | | | | | |
| 30823-3 | Mellaart III-IV? TPC Area | - | - | Midden | To study the nature and deposition of a sequence of thin ashy layers rich in charred flecks and displaying substantial organic staining, possibly caused by the presence of faecal matter. | | | | | √ | √ |
| 30852-1 | Mellaart III-IV? TPC Area | - | - | Midden | To examine the discarded components of a Late Neolithic midden sequence containing abundant charcoal remains and orange flecks, likely coprolitic materials. | | | | | | |
| 30855-1 | Mellaart I-II? TPC Area | - | - | Midden | To investigate the formation processes of a very ashy midden sequence rich in charred plant remains and phytoliths to enable micro-contextual comparisons with midden deposits from earlier occupation levels. | | | | | | |

**Table 3.3** *(continues from previous page)*. List of micromorphological samples collected at Çatalhöyük and performed geochemical characterisations.

### 3.2.2.3 Pınarbaşı

The archaeological field project directed by Douglas Baird at the Pınarbaşı rockshelter, excavated in the early- and mid-2000s, contemplated from the onset the application of microstratigraphic techniques in order to better understand the nature of the Neolithic and Epipalaeolithic occupation phases at this site. In addition, it was expected that these studies would shed light into the occurrence of seasonal activities and any abandonment episodes within its sequence, which was partially altered by later – i.e. Bronze Age, Roman, and Byzantine – activities (Baird 2012b). A range of sediment blocks was thus collected by the excavators and the geoarchaeology specialist during the 2003-2004 field seasons with specific hypotheses in mind, in the hope that micromorphological results would eventually shed light into important research issues of great significance to the goals of the broader project. Some of the challenges that this situation posed for the present study involve lack of familiarisation with the contexts from where the samples were extracted, together with the fact that some of the sediment blocks were either too large or not conveniently wrapped, which caused problems during thin-section production.

The archaeological contexts sampled comprised mainly thick deposits rich in ashes and charred plant fragments from Area B, where three distinctive phases of late seventh millennium occupation were identified (Baird *et al.* 2011b). Multiple stratigraphic sequences corresponding to some of the large irregular fire pits unearthed in this excavation area were sampled, in addition to accumulated fills possibly deriving from a combination of dumped materials and *in situ* activities (Baird 2003). The only micromorphological block from the ninth millennium occupation of the rockshelter, collected in 2003, comes from what was originally interpreted as deep fill deposits in Area A, although these might also correspond to re-deposited debris derived from the collapsed wattle and daub superstructure (Baird 2004). A full list of samples can be found in Table 3.4 in the next page.

As spot sediment samples in association with the micromorphological blocks were not collected in the field, subsampling for secondary geochemical analyses was carried out in the laboratory before impregnating the blocks with resin, following the procedure described in chapter section 3.3.

| Sample | Area | Context | Basis for micromorphological sampling | XRF | XRD | FTIR | μ-FTIR | SEM-EDX |
|---|---|---|---|---|---|---|---|---|
| 3 | A | Fill deposits | To explore the nature and composition of loose organic layer extending over the whole trench as a fill deposit. | | | | | |
| 1 | B | Occupation residues | To investigate the nature of a white silty lens interpreted as re-deposited ash during the excavations. | | | | | √ |
| 4 | B | Fill deposits | To study the nature and deposition of Neolithic layers within the pit/structure formed by a stoney wall and a cut. | | | | | |
| 5 | B | Fill deposits and occupation residues | To investigate the formation processes of a deep sequence rich in ashes, semi-articulated phytoliths, and charcoal fragments. | | | | | |
| 7 | B | Occupation residues | To understand the origin and depositional pathways of a thick occupation unit apparently formed by a mixture of plant ash and phytoliths, possibly representing discarded fuel remains. | √ | √ | √ | | |
| 8 | B | Occupation residues | To examine the nature and deposition of a scorched occupation layer displaying abundant macroscopic fragments of charred plants. | √ | √ | √ | | |
| 11 | B | Accumulated remains | To study the origin, composition, and micro-contextual associations of a thick, discontinuous occupation layer rich in embedded charred plan remains. | √ | √ | √ | | |
| 12 | B | Fills of fire installation | To explore the range of fuel sources and activity residues present within the fills of an open-air Early Chalcolithic fire installation. | | | | | √ |
| 13 | B | Accumulated remains | To study the origin and deposition of the lower sequence of a series of compacted and homogeneous deposits containing abundant macroscopic charred plant remains. | | | | | |
| 14 | B | Accumulated remains | To investigate the origin and deposition of the the upper sequence of a series of compacted and homogeneous deposits displaying numerous thick patches of a white, plaster-like material. | | | | √ | √ |

**Table 3.4** List of micromorphological samples collected at Pınarbaşı and performed geochemical characterisations.

## 3.3 Laboratory subsampling for secondary analyses

The extraction of small bulk sediment samples, of approximately 10 g each, from the micromorphological blocks collected in the field had as an objective the direct correlation of the geochemical results (i.e. XRF and FTIR) with the observations of the deposits made under the microscope. The subsamples were extracted from the back face of the sediment blocks after meticulous cleaning with a palette knife and a photographic puffer in order to improve the visibility of the microstratigraphy and to remove any contamination. A photograph was then taken with a scale included and subsequently printed out so that the exact location of the subsamples could be marked in the photograph during the extraction of the sediment from the block face for direct comparison of micromorphological and geochemical results. The subsamples were collected using a scalpel and a spatula, and stored in sealed plastic bags. Paper labels were placed in separated bags inside the sample bags to avoid potential contamination (i.e. transfer of modern phytoliths to the archaeological sediments).

Special care was taken to extract the subsamples from distinctive individual layers, so that each deposit could be analysed separately by a range of analytical techniques. When very fine layers were encountered (under 5 mm thickness), these were either not subsampled, due to the impossibility of extracting the sediment without incurring in mixing with other differentiated deposits or, when this could be avoided, smaller samples ranging between 1.5-5 g were collected. The reduced sample size for these fine layers means that a much limited range of analytical characterisations could be conducted for the sediments.

Faecal matter, mostly present in lenses as part of midden contexts, was also the focus of laboratory subsampling when detected in the block stratigraphy. This material is identifiable mainly for its colour, orange-brown in the case of omnivore coprolites (Shillito *et al.* 2013b) and greyish to pale yellowish brown in the case of herbivore and carnivore remains (Shahack-Gross 2011). Also, faecal matter from herbivore species is commonly rich in phytoliths, a characteristic that makes it often difficult to distinguish these remains in the field when embedded in highly organic deposits containing abundant plant remains, such as those of middens (Shillito *et al.* 2011a). When faecal remains were identified within the blocks, a bulk sub-sample of 4-5 g was collected for future GC-MS analyses.

The decision of which subsamples were going to be studied by a range of analytical techniques was made after the micromorphological investigation of the thin-sections. An assessment was conducted focused on the potential that each deposit had of making a significant contribution to the research issues based on their context and microscopic characteristics. A representative sample set from each site was eventually selected based on these attributes, and further analysed with both organic and inorganic geochemical methods.

## 3.4 Soil micromorphology

Micromorphology involves the contextual description and interpretation of components, features and fabrics in undisturbed soils, sediments and other materials (e.g. ceramics, mudbricks) at a microscopic scale (Bullock *et al.* 1985; Courty *et al.* 1989). This technique, first developed by Walter Kubiëna from geological petrography in the 1930s-1940s with the purpose of studying soil genesis and classification (Kubiëna 1938), has been the subject of increasing archaeological interest in the last decades (Stoops 2009). Thin-section studies of stratigraphic sequences from cultural occupations have proven extremely successful in revealing differences between contexts which are undistinguishable at the macroscale (Matthews 2005c; Karkanas 2006; Mallol *et al.* 2010). The main strengths of this technique when applied to archaeological stratigraphy lie in its efficiency to distinguish between secondary and primary depositional features on one hand, and human activities and natural processes on the other (Courty 1992). As well as the layer sedimentological composition, it is the context and association of the materials embedded in the deposits analysed that are most informative. Although thin-sections are comparatively small samples of larger spaces, they represent a high-resolution temporal record of deposition and activities and as such, they have the potential to shed light into discontinuity and/or periodicity in human practices.

### 3.4.1 Thin-section production methodology

As informative as the micro-stratigraphic record can be, we need instruments to reveal it and, consequently, sample preparation. In the case of micromorphology, the production of slides from sediment blocks is a long and painstaking process. The thin-section manufacture procedure followed in this research was developed by the Micromorphology Preparation Unit technician John Jack (unpublished) at the University of Reading.

PHASE 1: DRYING AND IMPREGNATION

After collection in the field, the sediment blocks are carefully packed and transported in rigid boxes to avoid any physical disturbances that might alter the morphology of the samples. Once in the laboratory, the blocks are dried in an oven at 40ºC, and their weights are periodically checked. This is done to remove all traces of moisture from the samples, something imperative to ensure an adequate impregnation, as the resins used during production are not water-soluble. The duration of this stage varies from a few days to several weeks, depending on the nature of the sediments. On occasion, very argillic samples require higher oven temperatures of up to 60ºC for a full evaporation of their water content. In these cases the temperature is increased gradually to avoid severe disturbances in the blocks microstructure, such as shrinking and cracking (Fitzpatrick 1993). When the samples are losing less than 1% of their total mass they are ready to start the impregnation process.

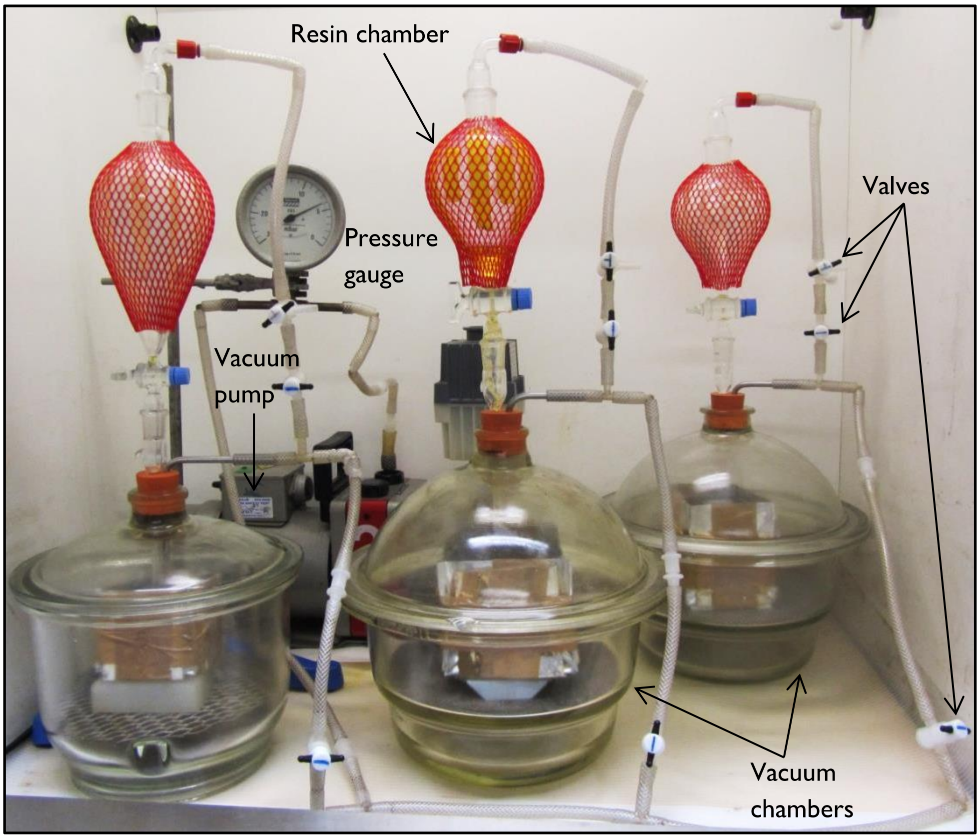



**Figure 3.5** Laboratory equipment ready for the impregnation of dried sediment blocks with epoxy resin under vacuum conditions.

Made-to-measure foil boxes are elaborated for each sediment block in order to reduce the amount of resin required for a full impregnation. The samples are subsequently placed under vacuum for twenty-four hours to remove all the air from the pores and then impregnated with a low-viscosity epoxy resin and hardener mixed at a mass ratio of approximately one-third resin (28%) to two-thirds hardener (72%). An accelerating agent is also added at a ratio of 2ml for every 100 $cm^3$ of impregnating preparation to increase the speed of polymerisation. The full equipment set up can be seen in Figure 3.5. When the samples are completely impregnated they are removed from the vacuum chambers and placed in an oven at 70ºC for eighteen hours in order to achieve complete hardening of the blocks.

PHASE 2: CUTTING AND SURFACE PREPARATION

Once cooled, a slice of approximately 1cm thickness is cut from the face of interest of each of the hardened block samples using a diamond saw. The goal is to expose undisturbed inner sections for study. The sides of the slices are then trimmed using a rock-cutting saw according to the final size of thin-section being produced. For the purposes of this research, slides of 14 x 7 cm and 10 x 8 cm have been manufactured, based on the sizes of the initial blocks and the type of materials sampled. One of the two largest surfaces of each cut slice is then selected and impregnated on a hot plate at 40ºC with a mixture of Araldite epoxy resin to fill all the superficial micro-pores in order to reduce the formation of bubbles and other artefacts during the permanent mounting of the samples. The prepared slices, temporarily mounted on glass media with an industrial adhesive, are then placed in a semi-automatic grinding or lapping instrument (a Brot grinder-polisher with diamond edge wheel for the extra-large slides, and a Logitech LP30 device for the large ones) to obtain perfectly planed surfaces. The cooling liquid used in these machines is oil-based, which prevents clays and other components from swelling and washing out, incorporating grit on the samples. The glass slides used as permanent mounting media also need to be grinded in these high-precision machines to ensure that their surfaces are completely parallel to those of the samples.

PHASE 3: PERMANENT MOUNTING AND FINAL GRINDING

After the polished surfaces of the impregnated slices and glass slides have been carefully cleaned with petroleum ether to remove all traces of oil, they are mounted together using a glue preparation. The samples are then placed under a high-pressure jig and left to cure for three days. Later, the mounted specimens are cut in a diamond saw to remove the excess of block, leaving a slice of approximately 1 mm attached to the glass. High-precision machines are used for the final grinding, allowing a uniform reduction of the samples down to a thickness of 40 μm. The amount of machine grinding at this stage would vary depending on the precision of the particular instrument, the nature of the samples, and the evenness of the mounting. The Brot machine was used for most of the specimens, whereas the Logitech LP30, which allows for finer polishing adjustments to be made, was employed for problematic samples, such as those with a high organic content or formed by a mixture of coarse and fine materials. The grinding medium for the Logitech LP30 was prepared with 9 μm aluminium oxide powder suspended in an oil-based lubricant, which results in a homogeneous, glass-like finishing of the samples.

PHASE 4: HAND POLISHING AND COVERSLIPPING

The final slides have a thickness of 30 μm, the standard measure for petrographic thin-sections (Bullock *et al.* 1985). In order to reduce the samples to this thickness without risking losing materials, hand polishing was undertaken, employing oil as surface lubricant and silicon carbide paper as grinding medium. Although the manual finishing of the samples allows for a better control of the polishing process, especially with slides that show uneven thicknesses, care has to be taken to avoid fracturing mineral grains. The slides were only coverslipped after the targeted micro-FTIR and SEM-EDX characterisations were completed.

### 3.4.2 Thin-section description and analysis

Before starting the analysis, the slides were examined on a light background with the naked eye to delimit areas of relative uniformity. Each area was then observed under the microscope for further subdivisions and, subsequently, the depositional micro-units were defined. Table 3.5 shows the main attributes recorded during the analysis of the slides and their rationale.

| MICROSCOPIC ATTRIBUTES | | DESCRIPTION | INTERPRETATIVE SIGNIFICANCE FOR ARCHAEOLOGICAL DEPOSITS |
|---|---|---|---|
| Fabric | COLOUR | As this attribute can vary depending on the type of light and the magnification used, it has been consistently recorded in PPL and 10x. | Identification of source materials and alterations. |
| | PARTICLE SIZE | Size of grains and other main constituents forming the fabric. | Origin of deposits, choice of construction materials, depositional pathways. |
| | SHAPE | Description is based on the degree of roundness, equidimensionality and rugosity of main fabric constituents. | Pre-depositional history of deposits, nature of deposition. |
| | ORIENTATION | Defined as the angle of paralellism of fabric constituents relative to each other and to a defined reference axis, in this study the deposit boundary. | Identification of depositional and post-depositional processes. |
| | SORTING | It refers to the variations in particle size within a single deposit. | Pre-depositional history of deposits, nature of deposition, choice of construction materials, post-depositional processes (e.g. earthworm activity). |
| | ABUNDANCE | Estimation of total number of fabric constituents, calculated by comparing field of view with standard charts. | Homogeneity and origin of deposits. Formation processes. |
| Micro-structure | AGGREGATION | Shape, size, accommodation, degree of separation and development, and arrangement patterns of individual aggregates (peds). | Origin and nature of deposits. Identification of natural processes such as frost action. Post-depositional conditions and alterations. |
| | VOIDS | Pore spaces, not filled with soil/sediment materials. With time they may become filled with clay, crystalline particles or other substances. | Investigation of construction material manufacture (i.e. plant pseudomorphic voids left by added stabilisers), and post-depositional processes (e.g. bioturbation, compaction, shrink-swell alterations). |

**Table 3.5** Scheme of microscopic attributes and their archaeological significance (after Bullock *et al.* 1985; Fitzpatrick 1993 and Stoops 2003). Table continues in the next page.

| MICROSCOPIC ATTRIBUTES | | DESCRIPTION | INTERPRETATIVE SIGNIFICANCE FOR ARCHAEOLOGICAL DEPOSITS |
|---|---|---|---|
| Groundmass | COARSE/FINE RATIO | The proportion of coarse fabric constituents relative to smaller fabric constituents. The limit between coarse and fine constituents has been set at 20μm for this study, the smallest particle size accurately measurable at x200. | Origin and nature of deposits and choice of construction materials. Investigation of depositional conditions. |
| | COARSE/FINE RELATED DISTRIBUTION | Distribution of coarse fabric components in relation to smaller fabric components. | Pre-depositional history of deposits, identification of depositional and post-depositional processes. |
| | BIREFRINGENCE FABRIC | Type and arrangements of interference colours in the micromass. | Composition and formation processes of deposit. Post-depositional alterations. |
| Mineral and organic components | COMPOSITION | Several categories of coarse particles have been distinguished: single mineral grains, rock fragments, inorganic residues of biological origin (e.g., phytoliths, bones), anthropogenic elements (e.g., bricks, shards), and faecal remains. | Identification of natural and potential anthropic components. Origin of deposit, depositional processes and human activities. |
| | COLOUR | Recorded in PPL, although OIL has been used in a few cases since it is unaffected by the thickness of the thin-section. | Identification of components and their alterations (i.e. burning, weathering, neo-mineral formation). |
| | SIZE | Size of components as measured with an ocular micrometre. | Pre-depositional histories of components and depositional pathways. |
| | SHAPE | General shape description including roundness and superficial rugosity of components. | Identification of components (e.g. phytolith types) and their alterations (i.e. breakage, weathering). |
| | ORIENTATION | Basic (fabric components of the same type with respect to each other), referred (fabric components with respect to a reference, i.e. the deposit boundary), and related (fabric components in relation to fabric components of another type) orientations were recorded for each component. | Depositional pathways and rates of accumulation. |
| | DISTRIBUTION | Basic, referred, and related distributions were recorded for each component. | Depositional processes and post-depositional disturbances. |
| | ABUNDANCE | The area of the deposit that is occupied by a particular component. | Indicates the proportion and significance of a specific component type in a deposit. |
| | ALTERATION | This term is used here in a broad sense to include all transformations of components, whether anthropic (pre- and post-depositional) or natural (post-depositional). | Investigation of human activities such as burning, breakage caused by trampling, etc. Post-depositional processes involving chemical and physical changes that can be indicative of burial conditions. |
| Boundaries | | Area of contact between two deposits. Type, sharpness, contrast, shape and slope angle have been described. | Depositional pathways and post-depositional alterations. Identification of human activities (e.g. trampling, sweeping, matting) and natural processes. Nature of accumulated residues on living surfaces. |
| Pedofeatures | | Fabric units distinguishable from adjacent materials by differences in component concentrations or in internal fabric. | Post-depositional processes, expecially those involving soil formation within archaeological deposits. |

**Table 3.5** (*continues from previous page*). Scheme of microscopic attributes and their significance for archaeological interpretations.

The micromorphological description and analysis of the samples was carried out with a Leica DMLP polarising microscope at magnifications 25x to 400x under Plane (PPL) and Cross (XPL) Polarised Transmitted Light, and Oblique Incident Light (OIL). Fluorescence microscopy though UV transmitted light was used for the examination of organic components present within the slides such as phosphatic aggregates and faecal matter (Babel 1975; Altemüller and Van Vliet-Lanoë 1990). Photomicrographs were captured with a DFC420 camera and enhanced using LeicaV2.3 image analysis software. Components were identified through comparison with published materials and the extensive reference collection of natural, archaeological, ethnographic and experimental slides available at the University of Reading. The samples were described using the standard terminology developed by Stoops (2003).

## 3.5 INFRARED TECHNIQUES

Infrared spectroscopy is a relatively new analytical technique that is becoming progressively widespread in its application to archaeology (Forgerit 1987; Weiner *et al.* 1993; Thompson *et al.* 2009). The main strength of this method lies in its ability to rapidly identify materials and characterise their molecular structures, whether these are crystalline or highly disordered (Farmer 1974). However, although infrared spectra are easy to obtain, they can be very difficult to interpret.

This method is based on the interaction in the infrared range (4,000 to 250 $cm^{-1}$) between the beam radiated from the analytical device and the sample. During the analysis the beam causes the chemical bonds in the sample to vibrate as it absorbs part of the radiation being emitted by the instrument. This results in less radiation reaching the detector at specific wavenumbers, which become recorded as an absorption spectrum (Weiner 2010). The spectrum will show a series of peak maxima at particular wavelengths that are characteristic of chemical bonds or functional groups. Thus, the pattern of absorbance that forms infrared spectra can be used for identifying a wide range of materials, as the analysis of each of these materials will result in a characteristic spectrum that reflects its structural attributes. In addition, variations in the peaks of known materials can be indicative of alterations in their composition, a very useful feature for determining the effects of burning or weathering on archaeological components.

Although infrared spectroscopy provides invaluable data regarding the composition and possible alterations of specific materials present within archaeological deposits, it benefits from the integration of other complementary analytical techniques that can shed light into particular attributes of the absorbance spectra.

### 3.5.1 Fourier Transform InfraRed Spectroscopy

Infrared spectroscopy has been successfully used in archaeological contexts as part of interdisciplinary scientific methodologies aimed at exploring a wide range of research issues such as the effects of heating on sediments (Berna *et al.* 2007), the identification of organic and mineral components in degraded mudbricks (Friesem *et al.* 2011), the characterisation of diagenetic alterations in fossil bone (Lebon *et al.* 2010), and the chemical examination of ochre pigments (Mortimore *et al.* 2004). Therefore, infrared spectroscopy has the potential of making a significant contribution to the investigation of the composition, sources, methods of manufacture, and alterations of archaeological floors and similar deposits.

In this research, an infrared spectrometer (FTIR) has been employed for the analysis of bulk sediments (subsamples extracted from field sections and micromorphological blocks before impregnation) in order to investigate the mineralogy of floor construction materials and deposits in open areas. These analyses were conducted at the Surface Science and Technology Center (KUYTAM) of Koç University using a Thermo Scientific iS50 FT-IR Spectrometer with an ATR (Attenuated Total Reflectance) attachment. This spectrometer has some advantages over dispersive instruments, such as greater precision and sensitivity (Skoog *et al.* 2004). The iS50 ATR attachment consists of an all-reflective diamond on top of a ZnSe wire grid polariser (Thermo-Scientific Application Note 52410) . To conduct the analysis, the diamond is cleaned with ethanol and a background spectrum of the atmosphere is obtained. The sample is then placed on the tray and the diamond is lowered at an applied pressure of 60 lbs to ensure direct contact with the material being analysed. The infrared beam is consequently directed to the monolithic diamond, passing through it and travelling to the sample. The attenuated energy that is reflected back to the infrared beam reaches the detector, producing a spectrum (Skoog *et al.* 2004). The spectra were recorded at a wavenumber range of 4000-400 $cm^{-1}$, at a resolution of 2 $cm^{-1}$, and 64 repeat scans. The background subtraction was automatically done with the OMNIC software application. As the depth of penetration of the beam into the sample depends on several factors, such as the angle of incidence or the wavelength of light being used, the spectra produced using an ATR attachment are distorted and require corrections though the application of algorithms using the OMNIC software.

The use of an ATR attachment significantly reduces the sample preparation required for FTIR analyses. It usually involves crushing and homogenising a larger amount of the sample than is needed for the analysis and then placing approximately 1gr of the ground sample on the device tray with the aid of a spatula to avoid the separation of the particles into different sizes. Although the particle size of the subsamples can fluctuate slightly due to grinding variability, affecting peak widths and heights in the spectra, the reproducibility of FTIR results is validated by the fact that peak positions and shapes do not show alterations after repeating measurements using homogenised ground samples (Chu *et al.* 2008; Regev *et al.* 2010).

#### 3.5.1.1 InfraRed Microscopy

Infrared microscopy allows for the *in situ*, non-destructive chemical micro-analysis of both organic and inorganic components in their precise depositional context, as opposed to traditional bulk FTIR methods for which the sample needs to be extracted from its surrounding matrix. This method has been used for obtaining information on the molecular structure of individual bone fragments and other matrix aggregates of interest as identified in the micromorphological thin-sections in order to investigate the origin of these materials, their possible modifications (e.g. determination of burning temperatures), and post-depositional alterations. Very fine deposits that could not be satisfactorily subsampled for bulk FTIR, such as finishing coats on floors, were also analysed using infrared microscopy to characterise and compare their elemental composition with that of other floor deposits.

This method of investigating the chemistry of materials is becoming increasingly used in archaeology due to its ability to focus the analysis on very small areas of the sample, targeting specific inclusions and materials. This is an important feature for microstratigraphic investigations of archaeological sequences as 1) it allows for the chemical study of individual components within the deposits which may be very difficult to characterise on the sole basis of their visible attributes (Weiner *et al.* 2002), 2) it increases the spatio-temporal resolution of the components targeted (Shillito 2009a), and 3) as the extraction of the material sampled is not required, the results serve to complement contextual information collected through other methods, such as SEM-EDX or thin-section micromorphology (Matthews *et al.* 2013).

The analyses were carried out at the Chemical Analytical Facility of the University of Reading using a Perkin–Elmer Spectrum 100 FT-IR Spectrometer attached to a Spotlight 400 Imaging System. This instrument uses two light beams, one visible and one infrared, which follow the exact same path through the microscope optics to the sample, allowing for the analysis of a precise area of down to 50 μm pixel size (Perkin-Elmer n.d.-b). The shared optical view enables pictures of the area analysed to be taken through the use of a video imaging camera connected to the instrument computer, and elemental mapping is also possible. The infrared beam is then collected by two Mercury-Cadmium-Telluride (MCT) detectors, specifically suited for small samples due to their high sensitivity. This type of detector, however, requires cooling by liquid nitrogen to minimise the effect of thermal noise, especially noticeable in the obscuring of the peaks in the lower wavenumber values (Perkin-Elmer n.d.-a). The computer software *Spectrum*IMAGE is used to operate the instrument and control the visualisation settings of the spectra, and a joystick to move the sample stage in the x, y and z directions.

For this research individual point spectra were recorded in the range 4000-500 $cm^{-1}$ with a spectral resolution of 2 $cm^{-1}$ and 128 repeat scans, at an aperture size of 100 x 100 μm. These analyses were carried out directly on the micromorphological slides using the imaging in transmission mode, as the glass mounting medium of the thin-sections does not transmit infrared radiation across the total spectral range. Before starting the recording of the archaeological components, a background spectrum was run for the standard brass disc to check the calibration of the instrument. Single infrared spectra (point mode) were recorded for particular inclusions in the thin-sections, phosphatic and inorganic aggregates of organic origin for the most part, and the groundmass of floor construction materials. When the latter were being analysed, special care was taken to avoid major inclusions such as mineral grains, and to focus the instrument aperture on the fine fraction of the deposit. In addition, control points of voids were recorded in order to obtain the spectrum of the epoxy resin used for thin-section production, which does transmit infrared light and can therefore obscure areas of the spectra collected from archaeological inclusions and deposits. Although point line scans and spectral maps can also be recorded over a two-dimensional area of the sample, these were not generated for this study due to the reduced time-efficiency of these techniques and the large amount of data produced (each infrared map is formed by up to several hundred thousand individual point spectra), which can be very difficult to interpret.

## 3.6 X-RAY TECHNIQUES

X-rays are a type of ionising radiation that have a much shorter wavelength than visible light and can disrupt molecular bonds, which enables the use of this form of electromagnetic radiation for investigating the crystal structure, chemical composition, and physical properties of materials (van der Heide 2011).

X-rays interactions with matter can be classified into three main phenomena: 1) photo-absorption, which involves a photon transferring all its energy to the electron with which it interacts, producing a photoelectron whose vacant position will be filled by an outer electron, ultimately causing the emission of either a characteristic photon or an Auger electron; 2) Compton scattering, consisting in an inelastic scattering of the X-ray photon by an outer shell electron; and 3) Rayleigh scattering, a type of elastic scattering meaning that the photon emitted during the interaction has the total energy of the incoming X-ray photon, thus averting energy dissipation during this process (Pavlinsky 2008; Skoog *et al.* 2004).

These effects can be used for determining the elemental composition of materials, as the strength of these processes depends on both the energy of the X-rays emitted, and the nature of the material being analysed. All the techniques described below, SEM-EDX, XRF and XRD, rely on the interaction of a source of X-ray excitation and a sample. However, detection mechanisms differ from one method to another, which makes it convenient to analyse the same sample with more than one X-ray technique in order to obtain a reliable assessment of its chemical composition.

### 3.6.1 Scanning Electron Microscopy & Energy Dispersive X-ray

SEM-EDX is an analytical method that combines the collection of high-resolution images from sample surfaces with their elemental characterisation. In practice, it involves scanning a fine beam of electrons over a specimen and detecting the signals that are emitted (Ponting 2004). This technique has been directly applied on the uncoverslipped micromorphological thin-sections to characterise the physical and chemical nature of specific organic and inorganic components embedded in the archaeological deposits. The samples analysed were selected based on the frequency with which a component was found as part of occupation deposits, its possible alterations (e.g. charring, calcination, re-precipitation), and its preservation state. A representative spectrum of natural and archaeological materials, from gypsum to bone fragments, was thus selected for this type of electron-microprobe analysis. An average of three EDX points per sample was collected to ensure the statistical significance of the results.

In order to obtain high-resolution images, low vacuum conditions are generated in the sample chamber and a finely focused beam of electrons is directed towards the specimen surface. The resolution of the SEM is determined by the size of the incident beam which, in the case of the instrument used in this analysis, FEI Quanta FEG 600 Environmental Scanning Electron Microscope, operated at an accelerated voltage of 12.50 kV, is in the order of 2 nm. The sample surface is scanned by means of the instrument digital control over the beam position on the specimen, which allows rapid movement across the surface area being analysed. Signals are then generated above the surface and subsequently received and converted into an image. Several different types of signals are produced during this process: backscattered, secondary, and Auger electrons; X-ray fluorescence photons; and other photons of various energies (Skoog *et al.* 2007). To create a SEM image, secondary electrons, originated from inelastic collisions between the electron beam and the sample, and having low energies (typically less than 50 eV); and backscattered electrons, generated slightly deeper within the sample and ejected from the nuclei of surface atoms with a broad energy spread (ranging from 50 eV up to the energy of the incident electron beam) are detected and used (Goodhew *et al.* 2000). Images obtained with backscattered electrons, however, have a lower resolution than those obtained with secondary electrons, mostly due to the larger diameter of the backscattered beam (Skoog *et al.* 2007). Variations in the signals emitted from different parts of the specimen result in a high magnification greyscale image displaying a remarkable depth of field. In general, the yield of secondary electrons is low when the surface region being analysed is completely perpendicular to the electron beam, mainly due to the shape of the volume of electromagnetic interaction within the specimen, and the geometric relation to its surface. At regions of the sample which are not exactly perpendicular to the beam, electrons are more likely to be scattered out of the specimen, rather than further into it, hence appearing brighter in the SEM image (Goodhew *et al.* 2000). As the samples analysed in this study consist of roughly polished, uncoated sediment slides that do not conduct well electricity – therefore impeding the flow of electrons and resulting in the creation of artefacts associated with the build-up of charge – the SEM images produced during this analysis display more distorted and brighter areas, with very limited topographic information, than is usual for this technique.

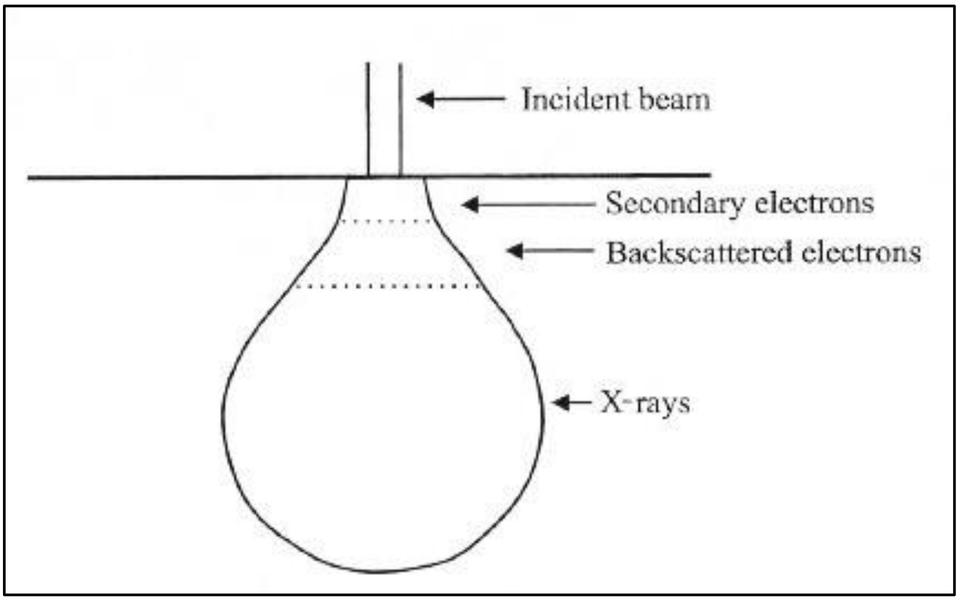



**Figure 3.6** Image showing the volume of electromagnetic interaction within a sample, and the regions from which backscattered electrons, secondary electrons, and X-rays are emitted (Goodhew *et al.* 2000: 126).

Compositional information on the samples is collected via Energy Dispersive X-ray micro-analyses (EDX), consisting in measuring the energy of the X-rays emitted by the specimen after being impinged with a primary beam (Pollard *et al.* 2007). The secondary X-ray released by an excited atom in this manner is considered to be a particle (an X-ray photon) whose energy is characteristic of the atom that emitted it. All these X-ray lines are collected simultaneously, amplified, and sent to a multichannel pulse-height analyser that will then allocate each pulse to the relevant channel that represents that particular X-ray energy (Ponting 2004). In this way, a histogram containing the data of all the different energies of the X-rays detected is created, normally displayed as a graph in which the abscissa is calibrated in energy (keV), and the Y-axis represents intensity, that is, the number of counts accumulated in one of the several hundred channels of the analyser (Goodhew *et al.* 2000).

It is important to realise that the X-rays produced during the analysis are generated not only from atoms at the sample surface but also from atoms well below it (Skoog *et al.* 2007). Thus, a part of both the incident radiation and the resulting florescence traverse a significant thickness of sample within which absorption and scattering can occur. The extent to which either beam is attenuated depends on the mass absorption coefficient of the medium, which in turn is determined by the absorption coefficients of all the elements in the sample (Pollard *et al.* 2007). Therefore, although the intensity of an X-ray line reaching the detector in a fluorescence measurement depends on the concentration of the particular element producing the line, the mass absorption coefficient of the matrix elements and their individual concentrations affect it as well. In the case of the uncoverslipped micromorphological thin-sections analysed in this study, this means that the data collected via EDX analyses will be a combination of the targeted sample area (of approximately 30 μm thickness), but also of the epoxy and araldite resins in which the sediment is embedded, and possibly of the underlying glass mounting media in some instances. Standard calibration has been applied to compensate for matrix absorption and enhancement effects, although a certain tendency to mismatch in the elemental results (which can either be too high or too low) is to be expected.

In spite of the limitations, to bear in mind when interpreting the compositional results, the application of EDX techniques to geoarchaeological materials has many advantages, such as the possibility of measuring a number of very small sample areas of the same image, the speed of analysis (a point spectrum can be obtained in one or two minutes), and the closeness of the EDX components to the sample, which results in more energy reaching the detector at any given time (Goodhew *et al.* 2000). Overall, the acquisition of different types of information – morphological, topographical, compositional – makes SEM-EDX a very versatile analytical tool with the potential of contributing key information on microscopic inclusions that are difficult to identify and interpret based exclusively on micromorphological observations.

### 3.6.2 X-ray Fluorescence Spectrometry

This technique was used on bulk sediment sub-samples extracted either from the field sections or the micromorphological blocks prior to their impregnation to both identify and quantify the elemental composition of the archaeological deposits. The data obtained have aided in the chemical characterisation of building and open-air contexts at the study sites, as well as in the identification of patterns in the materials selected for floor plaster manufacture.

In X-ray Fluorescence the sample is excited by an X-ray beam. When a primary X-ray strikes an atom it causes the ejection of an electron out of the inner shells, thus ionising the atom (Skoog *et al.* 2007). The resulting vacant position in the lower energy atomic shell is consecutively filled by an electron from a higher energy outer shell. This electron transition causes the emission of X-radiation (fluorescence) with a total energy equivalent to the energy difference between the two atomic shell levels (Pavlinsky 2008). This radiation has a characteristic wavelength for each element, irrespectively of its chemical properties.

Wavelength Dispersive X-ray Fluorescence (WDXRF) differs from EDX in the way the emitted X-rays are measured. As opposed to the collection of all energies emitted by the sample, XRF instruments commonly use analysing crystals to diffract the different X-ray wavelengths, and detectors are placed in different positions to measure the number of X-rays diffracted at each angle (Fitton 1997). As a result, WDXRF instruments have better resolution and sensitivity than their EDX counterparts, which are not able to detect below 0.1% of any particular element (Pollard *et al.* 2007).

The XRF instrument used in this research is a Bruker S8 Tiger Wavelength Dispersive X-ray Fluorescence Spectrometer. This instrument is formed by a 4 kW Rh X-ray tube operated at 60 kV and 170 mA for the identification of every element. During the analysis, the secondary X-rays emitted by the sample pass through the collimator, comprised of a series of closely spaced parallel metal plates, to form a narrow beam of X-rays (Luger 2014). Subsequently and in order to monochromatise the radiation before it reaches the detectors, the secondary X-rays are separated by wavelength via the rotation of eight analysing crystals, each of them optimised for a specific element range (Bruker-AXS n.d.). This causes the X-rays from the sample to hit the detectors at different angles. After the diffraction, the X-ray signals are collected and quantified by the detectors. The instrument used in this study is equipped with three counter detectors: a proportional counter with high-transmission window for the identification of light elements, a flow meter for light element detection, and a scintillation counter for the analysis of heavy elements (Bruker-AXS n.d.). The basic principle underlying this technique is Bragg's law of diffraction: $n\lambda = 2d \sin \theta$. For each wavelength that satisfies the equation an X-ray is diffracted from the crystals at an angle of $2\theta$ into the detectors, hence allowing the measurement of just one X-ray line, or element, at a time (Kaur 2010). WDXRF thus allows for the precise and high-resolution compositional analysis of materials.

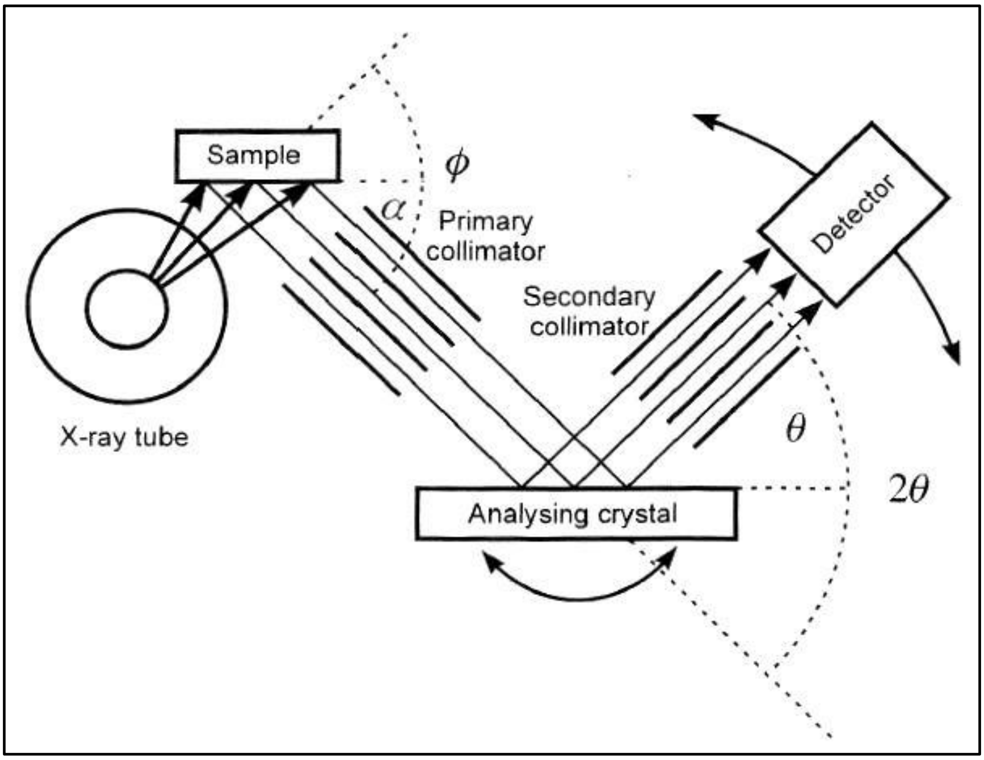



**Figure 3.7** Basic functioning of an XRF instrument. The lines with arrows represent the paths of X-rays within the spectrometer. Whereas the scattering angle $\alpha$ and the take-off angle θ are in fixed positions, the rotation of the analysing crystals and the detector causes variations in the diffraction angle θ and consequently the dispersion of X-rays into a wider spectrum (Fitton 1997: 89).

Each sediment block sub-sample was ground until homogeneous using an agate pestle and mortar, and carefully transferred to an aluminium cup with the aid of a spatula. The filled cup was then placed in a press and transformed into a disc after the application of a force of 350 kN (see Figure 3.8). This preparation technique, which results in stable, high-density pressed powder pellet samples, worked well with the sediments from the site of Çatalhöyük, predominantly silty clay, whereas those from Boncuklu and Pınarbaşı, which contain a high proportion of silt and ashes, could not be adequately pressed into pellets. These samples were alternatively run as loose powder and put into individual *Chemplex* polymer cups, each covered by a 4 µm prolene film (typical impurities contained include Ca, P, Fe, Zn, Cu, Zr, Ti, Al). This method of sample preparation for XRF analysis is the easiest and the most rapid one, and it has the additional advantage of allowing the quick recovery of the sample (Shibata *et al.* 2009). However, it can difficult to obtain accurate, reproducible XRF results with a loose powder specimen due to micro-absorption, coarse measurement surface, and mineral effects (Mzyk *et al.* 2002), the latter especially evident when the sample is formed by a non-homogeneous mixture of components, as in the case of archaeological sediments.

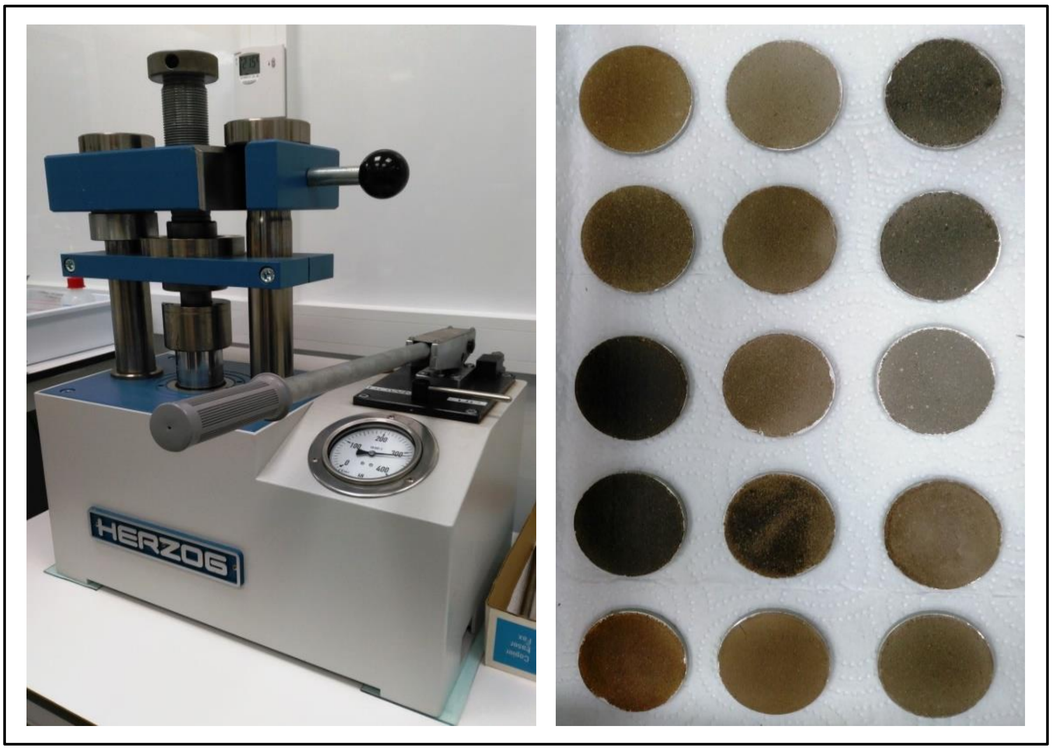



**Figure 3.8** Press used for preparation of sediment sub-samples for XRF analyses (left), and resulting pellets (right).

Due to these disadvantages and in order to obtain more precise and accurate XRF results, the Boncuklu and Pınarbaşı sediment block sub-samples were selected for an additional preparation method consisting on the melting of the specimens for the production of glass beads. This technique involves the heating at 900ºC of 1 gr of sediment per sample until its mass ceases to change. This results in the evaporation of volatile substances such as organic components, hydrates and labile hydroxy-compounds, and carbon dioxides (Nakayama *et al.* 2012). The calcined powder obtained, approximately 0.9–0.6 g for each of the samples processed, is then mixed with 8 g of anhydrous lithium tetraborate, which acts as an alkali flux, and consecutively placed in a Pt-Au (5% Au) crucible. An aqueous solution of lithium chloride (100 mL) acting as a releasing agent is pipetted into the crucible and the powdery mixture is electromagnetically fused by heating at 1100ºC during twenty minutes. The resulting molten sample is ultimately vitrified by air cooling for 2–3 minutes, causing the release of a circular glass disk from the crucible.

The homogeneity of the resulting glass beads leads to reliable and accurate XRF results, although an assessment of the uncertainty of the data obtained should reflect on the sample-to-flux ratio (dilution factor). For the present study, low diluted 1:10 glass beads have been produced. These are the most suitable for a comprehensive multi-elemental analysis involving also trace elements, although in these cases X-ray intensities might be slightly influenced by matrix effects (Nakayama *et al.* 2007).

The XRF analysis of the pressed pellet and glass bead samples was conducted under vacuum (best detection) and in oxides (compounds) setting, which is the most accurate for the elemental detection of sediments. The loose powder samples were measured following the same setting but under helium gas flow (best detection) to avoid bursting of the sample case. Total measuring time of major elements was approximately seventeen minutes per sample. The instrument software *QUANT-EXPRESS* was used to normalise and further process the results. These are displayed in weight percentages and parts per million (ppm), the latter employed for trace elements present in considerably small quantities.

#### 3.6.2.1 Portable XRF Tracer

Non-destructive portable XRF (pXRF) analyses of stratigraphic sections were carried out at Çatalhöyük during summer 2013 to determine rapidly the elemental composition of excavated deposits in Building 114 in order to assess their potential for further optical and analytical investigations of past occupation patterns.

All measurements were taken with a Bruker Tracer III-SD device equipped with a Rh X-ray tube, a silicon drift detector, and a palladium collimator. This device has the particularity of allowing variable X-ray tube parameters and beam filtering options for enhanced signal-to-noise element ratios (Bruker-AXS 2008). For this study, the instrument was operated at 15 kV excitation, a current of 25 μA, and no filter was used, being this the most suitable setting for the identification of major elemental composition in materials (Donais and George 2013). Sixty second live-time count under vacuum was used for all data collection, the results of which are reported in ppm levels.

In order to ensure an accurate data acquisition each sampling location was recorded and marked with numbered labels on the excavation sections, subsequently scraped with a scalpel to expose a flat surface for sampling, and then gently cleaned with a photographic puffer to remove loose debris. The instrument window was positioned directly on the stratigraphic sections, holding the pXRF tracer with both hands to ensure its steadiness throughout the process.

### 3.6.3 X-RAY DIFFRACTION

X-Ray Diffraction (XRD) was carried out on selected bulk sub-samples extracted from individual deposits visible in excavation sections and unimpregnated micromorphological blocks in order to obtain qualitative identifications of the crystallitic compounds present in the sediments, thus complementing the results obtained via WDXRF methods, which can also detect which chemical elements constitute the samples but not the structures or molecules they are a part of (Skoog *et al.* 2007).

The principle of this technique lies on the microstructure of crystals, which consists on a pattern of atomic layers arranged in different planes as part of a regular 3-dimensional lattice structure. The distance between planes is characteristic for each crystallitic element, and it has the same order of magnitude as the wavelength of the radiation (Luger 2014). When a monochromatic X-ray beam of known wavelength strikes the ordered atomic environment in a crystal surface, part of the radiation is reflected, while the unscattered part of the beam strikes the second layer of atoms. Here, a portion of the X-rays is scattered again, while the rest passes on to the third atomic plane, and so on. The cumulative result of this scattering is X-ray diffraction, and the angles at which the scattered X-rays are reflected are dependent on the spacings between the crystal planes of its constituent minerals (Skoog *et al.* 2004).

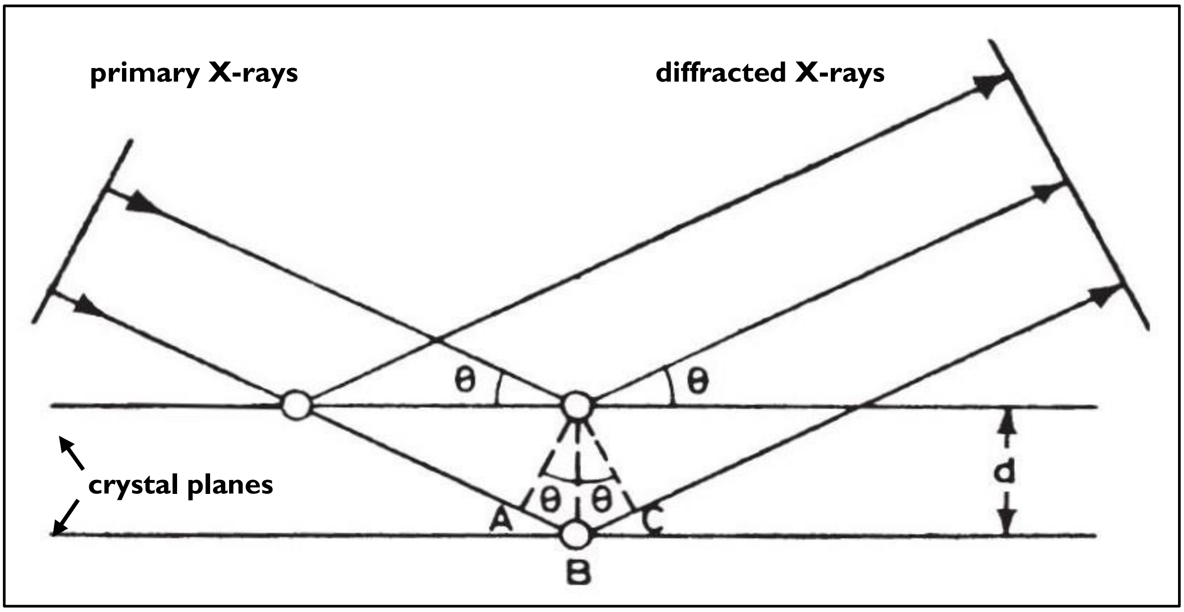



**Figure 3.9** Diagram showing the diffraction of X-rays by the planes in a crystal according to Braggs' law. Parallel X-rays strike the sample surface at an angle θ, and are then diffracted off atoms from successive planes of crystals with specific interplanar spacings, d. The difference between reflected X-rays from successive planes is given by AB + BC which, geometrically, is equal to 2dsinθ. For the diffracted X-rays to remains parallel and in-phase, which results in constructive interference, the extra distance that the second X-ray travels (AB + BC) must be equal to the whole number of wavelengths of the incoming radiation. Thus, Bragg's equation must be fulfilled for X-rays to be diffracted from the crystal. (after Pollard *et al.* 2007: 114).

Bragg's Law, $n\lambda = 2d \sin \theta$, relates the unknown distance between the planes, d, to the known wavelength of the incoming radiation, $\lambda$, at a measured angle, $\theta$. When this equation is fulfilled, a maximum in the intensity of the reflected X-rays occurs, producing a diffraction pattern that is characteristic of the molecular structure of the minerals present, and can be used to identify them (Luger 2014). Therefore, the detection procedures in XRD are identical to those in WDXRF. In XRD, however, the wavelength of the primary X-rays is known, and what is determined is the spacings between the planes conforming the crystallitic structure of minerals (Pollard *et al.* 2007). In contrast, in WDXRF the lattice spacing is known, and what is determined is the wavelengths of the secondary X-rays, eventually resulting in the identification of the chemical elements present.

Specimen preparation in XRD is also similar to that of WDXRF, with each sediment sample being ground to a fine homogeneous powder using an agate pestle and mortar, which ensures that the crystallites are randomly oriented in every possible direction. In this manner, when a primary X-ray beam passes through the sample, a significant number of particles are oriented in such ways as to fulfil Bragg's equation for reflection from every possible interplanar spacing. The ground powder is then compressed into the window of a 35 mm sample holder, and placed in the XRD instrument.

The sediments were analysed using a Bruker D8 Advance X-ray Diffractometer. The layout of the instrument is similar to that of a WDXRF, but the specimen replaces the analysing crystal. During the analysis, the sample is mechanically rotated to ensure all possible crystal reflections are recorded. Monochromatic, collimated, and filtered X-rays are then directed onto the sample, and the beams reflected at each angle are registered and plotted as peaks in a diffraction pattern of intensity versus $2\theta$ (Skoog *et al.* 2007). Each mineral has a whole set of d values that corresponds to all the possible planes in its crystal structure, partly due to the fact that the intensity of the diffracted X-rays varies from one lattice to another due to differential packing densities (Pollard *et al.* 2007). With samples constituted by more than one mineral type, as it is the case with archaeological sediments, this means that a complex pattern of overlapping peaks will eventually emerge from the XRD analyses, making the results very difficult to interpret. The diffraction patterns obtained from this study were compared to reference spectra from pure samples in the International Centre for Diffraction Data (ICDD PDF-2 database), using the search/match function on the EVA software, to aid in the identification of the minerals present in the samples. Micromorphological observations related to the abundance of specific mineral components in the targeted archaeological deposits as identified in thin-section were also used to conduct a more informed selection of probable crystallitic components during the empirical peak-matching process.

## 3.7 Integration of analytical techniques

This research aims to address the challenges involved in the identification, recording, and analysis of finely stratified occupation sequences through field experimentation with excavation approaches and methods, and the application of high-resolution contextual techniques comprising thin-section micromorphology in conjunction with geochemical microanalyses, namely XRF, XRD, FTIR, SEM-EDX and IR microscopy. The methodological strength of this investigation lies in its integrative approach, which allows direct comparisons of elemental characterisations of occupation layers and embedded components gathered from spectroscopic and X-ray analyses, to the precise depositional context of the materials via thin-section micromorphology of undisturbed section samples. Although similar multidisciplinary and multiscalar approaches have been applied to other, mainly Palaeolithic sites (Albert *et al.* 2012; Courty *et al.* 2012; Schiegl *et al.* 1996), this study represents the first attempt at integrating field approaches – encompassing excavation, recording and sampling – with microanalytical techniques.

Due to the complexity of Neolithic occupation sequences from mound (*höyük*) sites, it is important that stratigraphic studies are based on different lines of evidence. It is therefore of great interest to extract as much reliable information as possible from the archaeological record, a process that start in the field, where contexts are defined, documented, and sampled, thus creating the initial boundaries within which data are collected and interpreted. When a micro-contextual investigation of the archaeological stratigraphy is delineated from the outset, its influence on the fieldwork agenda of a site becomes desirable to ensure the development of adequate sampling strategies and the integration of microanalytical results into project discussions and wider interpretations. This entails that excavation strategies can then be adapted to the microscopic finds as they are discovered. It is important to bear in mind that there are no laboratory techniques that can resuscitate incomplete, poorly documented, or de-contextualised field observations, data, or samples.

Analyses for this research began at the macroscale through the identification, excavation, recording, and sampling of building and open-air contexts in the field, aiming at establishing an informed assessment of the spatial extent of deposits, their stratigraphic relations, embedded macroscopic finds, and patterns in large scale depositional events. The objectives of microscopic observations through thin-section micromorphology, the core technique in this study, include a refined assessment of the microstructure, components, and depositional characteristics of individual layers. The application of microanalytical techniques comprising IR microscopy and SEM-EDX, highly targeted to specific inclusions and microlayers difficult to identify on the sole basis of optical properties, provides chemical data that can aid in the interpretation of particular contexts previously observed in thin-section. The use of other methods of elemental characterisation based on the analysis of bulk sediment samples, including XRF, XRD, and FTIR, is centred on the study of floor construction materials at the three study sites. It is expected that results from these techniques will aid in defining the

| Technique | Sample type | Reasons for analysis | Expected results |
|---|---|---|---|
| Fine excavation of archaeological deposits | — | Observation and assessment of spatial distributions and relations of finds, deposits, features, spaces, and buildings. | Excavation and recording of individual microlayers in order to understand their nature, deposition, and pattern of use. |
| Thin-section micromorphology | Sediment blocks of stratigraphic sections. | Examination of undisturbed finely stratified sequences at high-resolution. Observation of components and their associations. | Data on formation processes of archaeological layers, pre-depositional histories, taphonomic alterations, human activities, and natural processes. |
| X-Ray Fluorescence (XRF) | Subsamples of loose sediment collected from field sections or micromorphological blocks. | Identification and quantification of inorganic elements and compounds in layers. | Minerological composition of building floors, open-air contexts, and other deposits. |
| Portable X-Ray Fluorescence (pXRF) | Stratigraphic sections in the field. | Field identification and quantification of inorganic elements and compounds in layers. | Identification of potentially informative deposits for further sampling and analyses. |
| Powder X-Ray Diffraction (XRD) | Subsamples of loose sediment. | Identification and quantification of crystallitic components in layers. | Minerological composition of floors and other deposits. |
| IR Spectroscopy (FTIR) | Subsamples of loose sediment. | Identification of inorganic compounds in layers. | Minerological composition of floors and other deposits. |
| IR Microscopy (μ-FTIR) | Organic and inorganic aggregates in thin-section. | Determination of the nature and causes of alteration of microscopic components that are difficult to assess in thin-section. | Assessment of non visible properties of components, such as elemental composition, taphonomic alterations, degree of heating, etc. |
| Scanning Electron Microscopy - Energy Dispersive X-Ray (SEM-EDX) | Organic and inorganic aggregates in thin-section. | Identification of archaeological inclusions and natural components that are difficult to assess solely on the basis of micromorphology. | Information on the nature and possible causes of alteration of inclusions and aggregates. |

**Table 3.6** Summary of the techniques used in this research, their rationale, and a consideration of their analytical contribution to the integrative methodological approach pursued in this investigation.

nature, distribution and variability of floor plasters present in buildings at Boncuklu, Çatalhöyük, and Pınarbaşı. It is important to acknowledge here, however, that this mineralogical investigation of occupation surfaces represents a pilot study of technological materials focused on the clean floor sequence and/or collapsed roofing of two built environments at Boncuklu (Buildings 12 and 16), three at Çatalhöyük (Buildings 114 and 89, and Space 511), and suspected constructed surfaces in a built structure at Pınarbaşı. The elemental characterisation of this limited sample set through XRF, XRD, and FTIR will help to evaluate the potential of these methods, based on loose samples, when combined with the micro-contextual analysis of undisturbed samples, i.e. thin-section micromorphology, IR microscopy, and SEM-EDX, in terms of their contribution to narrowing possible interpretations of components and deposits. Thus, the significance of this multidisciplinary study is that it has the potential of providing a more complete characterisation of both the macroscopic and microscopic records by discriminating between the range of possible interpretations emerging from the analysis of the materials. By bringing together multiple lines of evidence and connecting observations made at both the macro- and microscale, we can better define the specific past human activities that have produced the archaeology. For this approach to work properly, however, samples should be collected together, and analysed via different albeit comparable techniques – ideally with the same research aims –, as part of a wider hypothesis-led investigation.

In the end, the main goals are to reduce the degree of uncertainty of geoarchaeological interpretations by combining the qualitative nature of field and micromorphological observations with the quantitative results from microanalytical elemental characterisations, and to study the composition of a number of materials that can only be identified or verified by a multi-proxy approach. It is acknowledged that this poses a great challenge, which is the reason why a scalar, question-driven approach has been adopted in this study as the best option to resolving integrative problems related to finding balance between the high level of detail of microanalytical results, and the big picture.

# 4

# RESULTS I: BONCUKLU HÜYÜK

*Micromorphological and geochemical results from occupation layers at the site of Boncuklu Hüyük are reported in this chapter. Archaeological deposits in buildings and open areas have been optically and chemically categorised and described, in addition to the embedded bioarchaeological remains. Microstratigraphic sequences of individual buildings and open areas are discussed in more detail in Chapter 7.*

## 4.1 Introduction

The early Neolithic village of Boncuklu Hüyük, situated 9.5 km north of the large settlement at Çatalhöyük, predates this site and constitutes a unique case study for investigating the spread of farming in Central Anatolia. The ritual and domestic practices observed within buildings at Boncuklu, in particular, seem to be direct predecessors of the distinctive symbolic and architectural elaboration of Çatalhöyük (Baird *et al.* 2012b). The Neolithic occupation sequence at Boncuklu is representative of a classic *höyük* site, with mudbrick contexts that span the 9$^{th}$ and 8$^{th}$ millennia cal BC, a key period for the investigation of sedentarising communities in Central Anatolia. The importance of Boncuklu for understanding the spread of Neolithic lifeways throughout south-west Asia is evident in the fact that current models addressing the development of the first sedentary agricultural societies are largely derived from Levantine datasets, whereas the presence of these communities in the Anatolian plateau is still poorly documented (Baird 2002; Zeder 2011; Zeder and Smith 2009). The site of Pınarbaşı, excavated in the 2000s and also examined in this study, constitutes an exception to this situation. Archaeological evidence from this site revealed the 9$^{th}$ millennium short-term camp occupation of the rockshelter by highly mobile groups with 'broad-spectrum' (Binford 1968) economic strategies focused on a combination of hunting and fishing practices, and nut gathering (Baird 2012b). Whilst the picture emerging from the early occupation of Pınarbaşı challenges classic explanations for the development of sedentism elsewhere in the Near East, the socio-economic basis of this community cannot be completely understood in isolation. The early agricultural village of Boncuklu, roughly contemporary with the 9$^{th}$ millennium occupation of the Pınarbaşı rockshelter and preceding Çatalhöyük is, therefore, the missing piece in the puzzle of the Central Anatolian Neolithic. As such, the potential of this mound site to shed light into issues concerning the adoption and development of cultivation, herding, and ritual practices in this part of the Near East should not be understated.

The early sedentary settlement at Boncuklu Hüyük consists of finely stratified occupational sequences that are extremely difficult to distinguish and excavate individually. The importance of a microstratigraphic approach to understanding these archaeological deposits is heightened by the fact that, at Boncuklu, where occupation levels lie at approximately 30 cm below topsoil, post-depositional disturbances involving bioturbation and modern-day agricultural practices result in the low visibility and apparent homogeneity of individual deposits in the field. Other factors, such as the consistent high content of silt-sized particles and extremely fragmented charred organic remains of the occupation layers, especially in middens and open spaces, contribute further to this phenomenon.

Interestingly, the nature of occupation surfaces in different buildings of the settlement has been observed to vary significantly during the excavation of the mound. While some structures display continuous sequences of well-plastered calcareous floors (e.g. Buildings 2 and 6), classified as standard domestic buildings, others consist of thin ashy surfaces with abundant inclusions of charred plant matter reminiscent of rake-out deposits associated with hearths (Buildings 16 and 23), described as non-standard structures. The most critical aim of this study is thus to investigate whether these two different types of built environment were used for different purposes and display significant variations in occupation intensity. Consequently, the contextual investigation of daily activities and socio-economic practices in this early sedentary community at high-resolution through the detailed examination of archaeological deposits at the microscopic scale constitutes the main objective of this study. It is worth stressing that the research reported here, with the exception of two unpublished works on building (Goodyear 2012) and midden (Rowe 2011) sequences respectively, represents the first and most comprehensive effort at investigating the micro-stratigraphy of this key Neolithic site.

Section 4.2 below comprises the micromorphological classification of deposit types by context, including minerogenic and organic components and an evaluation of post-depositional alterations. The results obtained from the bulk chemical analysis of occupation layers and collapsed materials (infra-red and X-ray spectroscopy), and *in situ* microanalysis (SEM-EDX and IR microscopy) of aggregates and bioarchaeological inclusions present in the thin-sections are reported in sections 4.3 and 4.4. A discussion on the socio-economic significance of these integrated results is included in Chapter 7.

## 4.2 Thin-section micromorphology

The results reported below are based on the micromorphological analysis of fifteen thin-sections produced from sediment blocks collected at the site in 2013 and 2014 from contexts spanning 8300 - 7800 cal BC, as shown by the radiocarbon dates from the sampled occupation phases (D. Baird, pers. comm.). The main objectives of this study are to investigate the archaeological significance of variations in the composition of occupational sequences at Boncuklu, and to assess the range of activities present in an early agricultural settlement. Thin-section micromorphology is well-suited for this, as it enables the observation of micro-residues in their precise depositional contexts, as well as the identification of single depositional events (Matthews 2005b). In particular, micromorphological evidence is examined here to investigate: 1) choices of architectural materials and technology of floors and surfaces, and their variations through time and space; 2) the nature and extent of household activities and maintenance practices; 3) the occurrence of specialised activities and household differentiation; 4) discard practices and outdoor activities; 5) ecology and landscape use, including diet and fuel choices; and 6) the impact of post-depositional alterations on the preservation of the site. Samples were collected from various buildings and open spaces in different occupation levels and excavation areas of the settlement in order to understand temporal patterns (i.e. cyclicity, seasonality), and spatial trends in activities and daily practices.

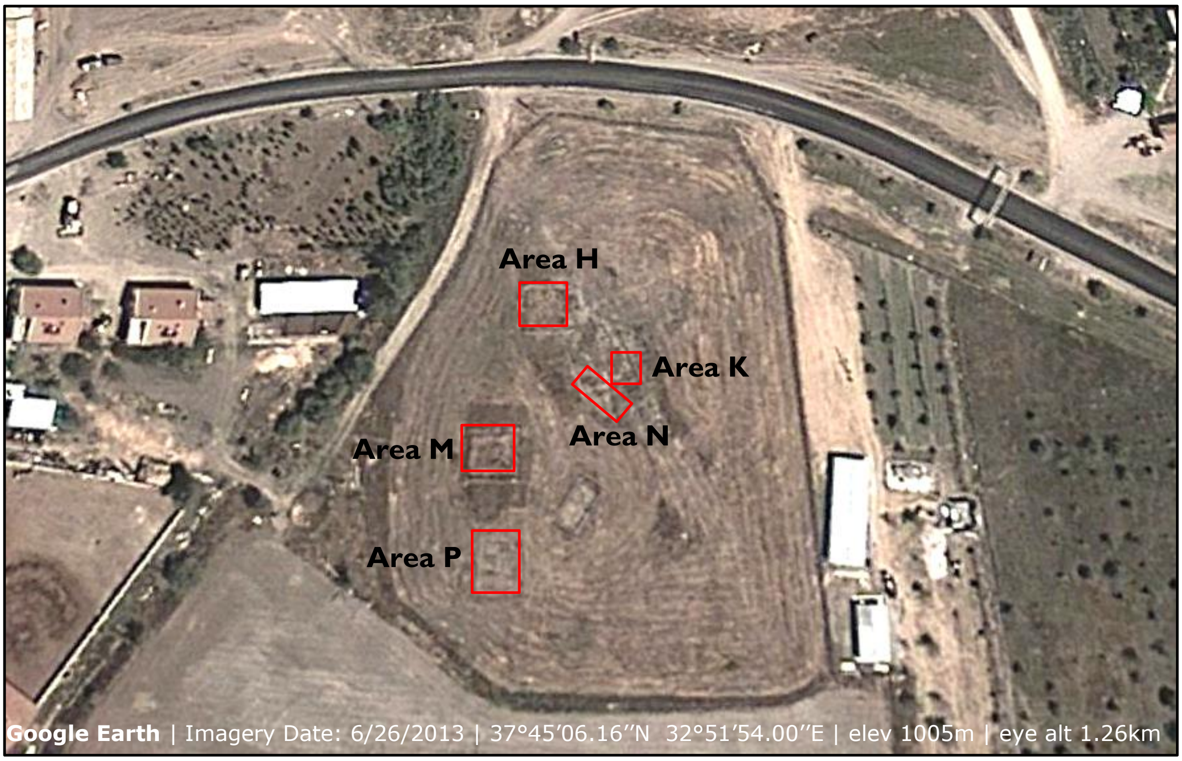



**Figure 4.1** Satellite image of Boncuklu Hüyük showing the excavation areas that are mentioned in this chapter.

### 4.2.1 Classification of deposit types in buildings

Deposits from building sequences have been classified according to diagnostic microscopic attributes and inclusions, including microstructure, particle size, coarse-fine fraction, sorting, and nature and frequency of minerogenic and anthropogenic components. Post-depositional features such as faunal activity, gypsum formation, and compression and alteration of the microstructure due to trampling, have also been taken into account. The categorisation of micro-layers into deposit types has been pursued in order to enable the comparison of similar contexts within and between different buildings, thus aiding in the identification of recurrent activities and construction materials, as discussed in Chapter 7.

| Deposit type | Deposit sub-type | Description | Interpretation |
|---|---|---|---|
| **BK1** Packing & infills | **BK1a** | Infills | Thick layers of re-deposited midden-like materials deliberately placed within building plaster sequences. |
| | **BK1b** | Floor packings/make-ups | Calcareous deposits, very homogeneous and with low quantities of organic inclusions, occurring towards the base or in between building floors, possibly representing packing materials or infilling episodes. |
| | **BK1c** | Hearth packings/foundations | Thick deposits consisting of fine alluvial sediments and embedded fuel/food remains, very crumby and often displaying evidence of thermal impact, disturbance, and erosion caused by use. |
| **BK2** Plaster floors | **BK2a** | Fine marl plasters (grey) | Well-preserved marl surfaces of <1cm thickness found in clean areas of buildings. These floors appear to have been lightly tempered with occupation residues, often charred plants. |
| | **BK2b** | Coarse marl plasters (brownish grey) | Manufactured calcareous floors rich in accumulated occupation remains. These surfaces appear eroded due to intensive trampling and compaction. |
| **BK3** Hearth plasters | **BK3a** | Coarse hearth floors | Thick surfaces of alluvial clay loam, often significantly schorched and crumby due to high firing temperatures and absence of added stabilisers. |
| **BK4** Rake-outs & accumulated materials | **BK4a** | Accumulations rich in silicified plant materials | Formed by >50% herbaceous phytoliths, frequently showing a marked parallel orientation indicating *in situ* decay of plant remains. When unoriented, these deposits represent re-deposited plant materials, likely derived from discarded fuel/food/craft sources. |
| | **BK4b** | Accumulations rich in charred and silicified plant materials | Parallel to unoriented laminations of highly fragmented charred plants and grass phytoliths, possibly re-deposited mixed fuel. |
| | **BK4c** | Accumulations rich in sediment aggregates | Heterogeneous deposits containing abundant parallel-oriented calcareous aggregates (*ca*. 25-35%), including a high proportion of mixed charred and siliceous plant remains (*ca*. 30-40%). Although these layers appear to represent accumulated and heavily trampled occupation residues, they could also be interpreted as extremely eroded plaster floors. |
| | **BK4d** | Mixed accumulations (no dominant inclusions) | Heterogeneous layers of re-deposited occupation remains, often charred, comprising very fragmented plant remains, bones and shell fragments. |
| **BK5** Collapsed construction materials | **BK5a** | Roofing building materials | Structural debris with evidence of high burning temperatures. The higher frequency of bio-archaeological inclusions in this deposit sub-type might be indicative of post-depositional mixing processes. |
| | **BK5b** | Roofing building materials | Rubefied marly structural debris rich in calcitic ashes. |
| | **BK5c** | Roofing plant structural components | Superimposed laminations of charcoal and phytoliths, probably corresponding to the wooden structure and herbaceous cover of the building roof. |

**Table 4.1** List of identified building deposit types at Boncuklu Hüyük.

#### 4.2.1.1 Deposit type 1: Packing and infills

Architectural materials other than mudbricks and floor plasters, such as packing, infill, or make-up deposits, provide important information on sources and ecological choices. These units, normally 2-5cm in thickness, were identified during the excavations as clayey deposits rich in unoriented inclusions, and midden-like materials occurring between plaster floors and occupation residues (Baird *et al.* 2014). These layers were interpreted as infilling episodes of buildings prior to their reconstruction, although similar units have been detected via micromorphology (Goodyear 2012) during the lifetime of a single building.

This study has identified three sub-types of packing/infill deposits, all occurring within the stratigraphic sequence of Building 12, in Trench H. BK1a, at the base of a sequence of dirty floors towards the east of the small hearth Feature 177, is characterised by a homogeneously heterogeneous matrix, with amorphous organic matter and calcitic silt forming the fine materials, and numerous charred plants (*ca*. 25% abundance), bone fragments displaying variable degrees of charring (*ca*. 25%), and marl and clay loam sediment aggregates (*ca*. 10%) constituting most of the coarse fraction of this deposit. The high incidence of mixing, in addition to the random orientation and distribution of these components, suggests that we are dealing with a combination of re-deposited architectural material discards and occupation remains, possibly extracted from midden areas within the settlement. The absence of distinguishable stratification within this unit indicates that it was deposited in a single event, likely as levelling/fill material for the occupation surfaces above.

Deposit sub-type BK1b, moderately compacted and very minerogenic, was identified towards the base of a late sequence of clean floors on the eastern half of Building 12. This unit, formed by *ca*. 50% calcareous aggregates and 25% alluvial silty clay, seems to have been deliberately manufactured and used as packing/infill, giving its thickness and the average coarseness of its particle size. Very homogeneous layer with a well-sorted mineral fraction, the calcareous aggregates forming most of this deposit display clear to faint edges and appear to be very amalgamated with the alluvial clayish deposits surrounding them, implying that there was probably a mixing process involving two different local alluvial sources, likely marl and fine clay loam/silty clay, before the deposition of this unit. Although plant pseudomorphic voids have not been encountered anywhere in this deposit, the evenly-distributed microcharcoal inclusions (5% abundance) were probably added as stabilisers. Moderately bioturbated by soil fauna, the presence of plane voids in this deposit might point to the occurrence of shrinking and swelling processes, suggesting that the low quantities of temper used may have caused this unit to break up more easily.

| | | | | | | | | | | Minerals | | | | | Sediment aggregates | | | | Anthropogenic inclusions | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Deposit type** | **Deposit sub-type** | **Microstructure** | **Voids** | **Particle size** | **Sorting** | **Orientation** | **$c/f_{20\mu}$ ratio** | **c/f rel. distrib.** | **B-fabric** | Quartz | Amphibole | Plagiocase | Chert | Muscovite | Calcite | Marl | Clay loam | Silty clay | Ashes | Phosphatic aggregates | Burnt bone | Burnt shell | Charcoal | Phytoliths | Melted silica | Hackberry endocarp |
| BK1 | BK1a | V | v, c ●●● | SL | U | U | 2:5 | d-p | b1 b2 | ●● | - | ○ | - | ○ | ●●● | ● | ● | ○ | - | - | ●●● | - | ●●● | ● | ○ | - |
| | BK1b | V, C | v, c, p ●● | CL | WS | U | 3:5 | s-p | b2 b3 | ●● | - | - | ○ | - | ●●● | ●●●●● | - | - | - | - | ● | ○ | ● | - | - | - |
| | BK1c | Cr | v, c, c-p ●●● | SC CL | MS | U | 5:1 | d-p | b2 b3 | ● | ○ | ○ | - | - | ●● | ●●●●● | - | - | ●● | ● | ●● | ● | ●● | ● | ○ | ● |

**Legend:** Microstructure: V=vughy, C=channel, Cr=crumby | Voids: v=vughs, c=channels, p= planes, c-p=complex packing voids | Particle size: SL=silt loam, SC=silty clay, CL=clay loam | Sorting: U=unsorted, MS=moderately sorted, WS= well sorted | Orientation: U=unoriented | c/f related distribution: s-p=single-spaced porphyric, d-p=double-spaced porphyric | B-fabric: b1=undifferentiated, b2=calcite crystallitic, b3=stipple-speckled | Abundance of Voids, Inclusions & Aggregates: ○≤1%, ●2-5%, ●●6-15%, ●●●16-30%, ●●●●31-50%, ●●●●●>50%

**Table 4.2** Micromorphological characteristics and components of the various forms of deposit type BK1: packing and infills.

Deposit sub-type BK1c, very similar in nature to BK1b, was identified towards the northern edge of fire installation Feature 171, in Building 12. This hearth was subject to several stages of construction and modification through its lifetime, with the packing unit BK1c appearing to mark the closure of the earlier phase of this feature and the foundation of the latest phases of the hearth, smaller in diameter. This deposit, slightly compacted and formed by calcareous clay loam crumbs between 0.1mm and 1cm in size and rich in embedded microcharcoal remains (*ca*. 15% abundance) and charred bones (*ca*. 10%), appears to constitute a coarse preparation unit for the edge of the later, and smaller hearth. Inclusions of organic origin such as very fragmented charred plants, phytoliths, and dung aggregates attest the presence of fuel residues highly embedded in a coarse calcareous matrix of alluvial origin.

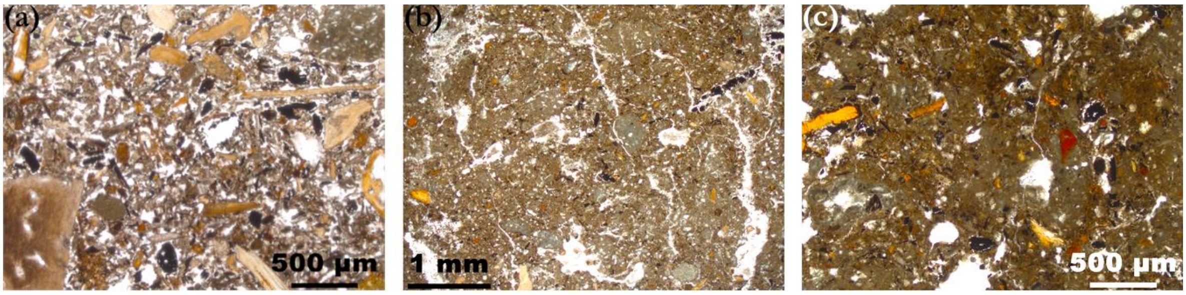



**Figure 4.2** Photomicrographs of infill/packing subtypes: a) BK1a, midden-like infill in the western part of Building 12, PPL; b) BK1b, compacted fabric of floor packing/make-up deposit in Building 12, PPL; c) BK1c, basal unit, possibly packing/foundation deposit, within Feature 171, a large hearth on the north-western area of Building 12, PPL.

#### 4.2.1.2 Deposit type 2: Plaster floors

Domestic built environments at Boncuklu display a remarkably structured use of space, divided into 'dirty' and 'clean' areas, with the former located around the fireplace in the western part of the building, and the latter occupying the higher, eastern half.

The composition of plaster floors found in the clean areas of standard buildings at Boncuklu shows a certain range of variation, from fine grey marl-based plasters to silt loam calcareous floors. The coarse mineral component is comprised predominantly of calcitic silts (<50µm size), with values not exceeding 40% of overall compositions. Quartz sands are also present, constituting between 2-10% of these deposits. Amphibole, plagioclase, and muscovite are found in low concentrations (<3%).

Fine plasters, deposit sub-type BK2a, have massive microstructures moderately disrupted by post-depositional biological agents that have resulted in vugh void formations. The sharp upper boundaries of these units frequently display a regular waviness that appears to correspond broadly to matting impressions.

| | | | | | | | | | | | Minerals | | | | | Sediment aggregates | | Anthropogenic inclusions | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Deposit type** | **Deposit sub-type** | **Microstructure** | **Voids** | **Particle size** | **Organic/mineral ratio** | **Sorting** | **Orientation** | **c/f$_{20\mu}$ ratio** | **c/f rel. distrib.** | **B-fabric** | Quartz | Amphibole | Plagiocase | Muscovite | Calcite | Marl | Clay loam | Silty clay | Burnt bone | Burnt shell | Charred plants | Phytoliths | Hackberry endocarp |
| BK2 | BK2a | V | ●●● | SC | 1:5 | MS | P | 1:10 | d-p | b2 | ● | - | ○ | ○ | ●● | ●●●●● | - | - | ● | ● | ● | ○ | - |
| | BK2b | V/Cr | v, c ●●● | CL SL | 3:5 | U | P | 2:5 | s-e d-p | b2 | ● | ○ | ○ | - | ●●● | ●●●●● | ○ | ○ | ● | ● | ●● | ●● | ○ |

**Legend:** Microstructure: V=vughy, Cr=crumby | Voids: v=vughs, c=channels | Particle size: SC=silty clay, CL=clay loam, SL=silt loam, | Sorting: MS=moderately sorted, U=unsorted | Orientation: P=parallel | c/f related distribution: s-e=single-spaced enaulic, d-p=double-spaced porphyric | B-fabric: b2=calcite crystallitic | Abundance of Voids, Inclusions & Aggregates: ○≤1%, ●2-5%, ●●6-15%, ●●●16-30%, ●●●●31-50%, ●●●●●>50%

**Table 4.3** Micromorphological characteristics and components of the various forms of deposit type BK2: building plaster floors.

These surfaces contain very few bioarchaeological inclusions (<10% abundance), comprising highly fragmented charred plant remains that were possibly incorporated at the place of manufacture, either accidentally or as intentionally added stabilisers. Burnt bone and shell remains are also present, albeit in lower quantities (*ca.* 5% abundance), which makes it probable that plaster temper originated from refuse contexts, likely hearth rake-outs.

The coarse plasters, deposit sub-type BK2b, are characterised by their higher sand-size mineral content (100-500 μm), constituting up to 30% of these deposits, and irregular boundaries. These floors appear substantially trampled and eroded in some buildings, such as Building 12 in Area H, where they consist of parallel discontinuous lenses of coarse calcareous material intermixed with occupation remains, such as fragments of bone, eggshells and charred plants. Plant pseudomorphic voids have not been encountered in these deposits, although it is likely that, similarly to deposit sub-type BK1a, the charred micro-remains found embedded in these plasters were added as temper.

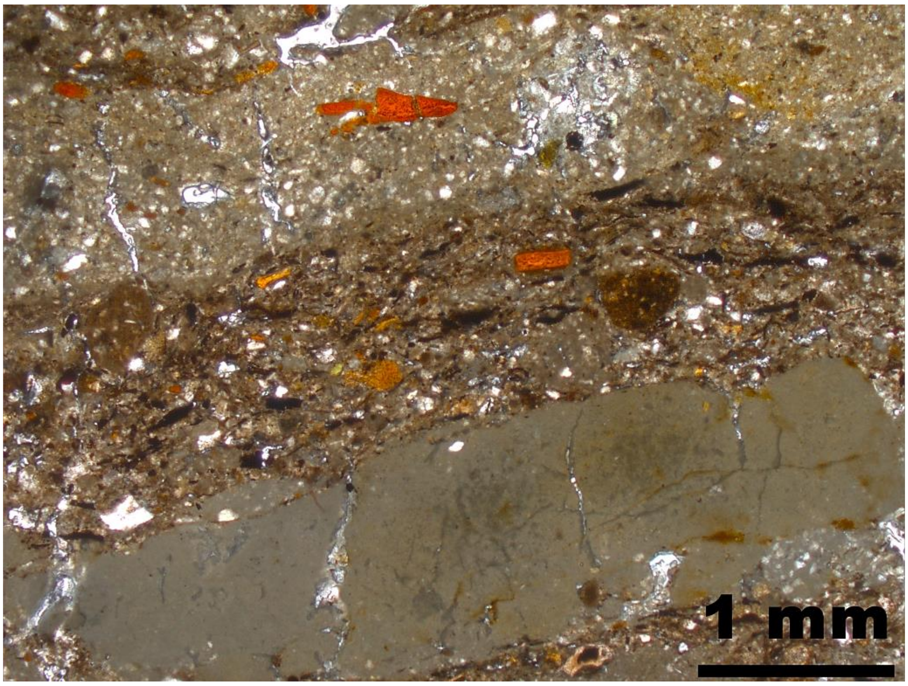



**Figure 4.3** Photomicrograph of deposit subtypes of occupation floors and surfaces: coarse (top, BK2b) and fine (bottom, BK2a) plasters separated by an accumulation of occupation debris in Building 6, PPL.

Fine and coarse plasters normally occur in conjunction within the same building sequence, sometimes in an alternating arrangement, as seen also in the samples from Buildings 6 in Area N and Structure K described by Goodyear (2012). The sediment sources for the manufacture of floor architectural materials at Boncuklu seem to derive from locally exposed and partially eroded Pleistocene lake marl deposits, as attested by soil maps (Driessen and de Meester 1969) and palaeoecological surveys (Roberts *et al.* 1999; Boyer *et al.* 2006). These materials were not randomly selected, given the consistent presence of grey silty clay and silt loam plasters in the clean areas of buildings, but rather chosen for their perceived specific attributes. These might have included light-reflective properties, as noted by the field team after the construction and plastering of the experimental house, which remained well-lit during the day due to the amount of light reflected from the smokehole and doorway (Baird *et al.* 2014), and antiseptic properties, derived from the high calcium carbonate content of these plasters.

The dirty floor areas around hearths appear commonly devoid of formally laid plasters and consist of finely laminated sequences of silty materials with a high organic content. These surfaces, frequently displaying irregular to wavy boundaries and varying thicknesses of 0.2 to 1 cm, are very similar in composition to each other, consisting of parallel-oriented phytoliths, charred plants, burned bones, calcitic ashes, and subrounded sediment aggregates in various proportions. Due to the nature of these surfaces, consisting of accumulated hearth materials as opposed to the deliberately manufactured floors described above, they have been classified as deposit type BK4, referring to rake-outs and accumulated occupation residues. This decision has been made on the basis that these dirty surfaces do not seem to have been part of a *chaîne opératoire* entailing the selection and extraction of sediment sources, mixing, manufacture, and deposition, a step-by-step production that required both technical knowledge and substantial labour. By contrast, the materials forming the sunken surfaces around hearths appear to have been deliberately spread in a more or less regular manner as part of house maintenance practices likely aimed at keeping these areas relatively dry, as charred plants and ashes, both major components of these layers, have water-repellent properties (Dlapa *et al.* 2013).

Reducing dampness in this part of the house was probably a priority, as the location of the roof smoke-hole, immediately above the hearth, would have allowed water to drip into building interiors even if temporarily covered with leaves and branches. In fact, the rosette-shaped features found in floor areas around the hearths of some buildings have been interpreted by the field team as created by the continuous action of rainwater percolating from the smoke-hole, sweeping along a fraction of the daub material used to build the roof and re-depositing it at ground level, a phenomenon that has also been observed to occur in the floors of the experimental houses (Baird *et al.* 2015). Some of these rosettes, however, seem to have been perforated, raising the possibility that at least some of them were, in fact, deliberately placed around hearths as small accumulations of marly material to act as stakeholes for wicker panels or similar types of installations (W. Matthews, pers. comm.).


**Figure 4.4** Rosette-shaped features formed around the hearth of Building 6, possibly created by the action of water percolating from the roof.

It is worth noting here that some building sequences do not appear to conform to the division of space into clean and dirty areas described above, consisting mainly of silty surfaces rich in ashes, charred bones, and highly fragmented plant remains, and where surfaces of marl-based plaster are rare (Baird *et al.* 2015). Clean areas for eating and resting are not immediately obvious in these non-standard constructions, which contain dense accumulations of reed phytoliths, hearth features, and storage pits, raising the question of whether they were in fact domestic built environments accommodating a single household, or rather task-specific constructions used for group activities. Results from the microstratigraphic analysis of the complete sequences of two of these structures, Buildings 16 and 23, are compared in the discussion chapter, section 7.2.2.

#### 4.2.1.3 Deposit type 3: Fire installation floors

The internal fire installations studied for this research, both located within Building 12, were constituted by formally laid surfaces, ranging in texture from calcareous clay loam to silty clay loam, very similar in nature to the coarse plasters found in the clean areas of houses (deposit sub-type BK2b). These hearth floors appear to have been severely affected by high burning temperatures, as seen in the rubefaction of the sediments and the crumbiness of the groundmass, likely caused by heat impact and the low presence of stabilisers (<5% abundance), mostly formed by highly fragmented charred plants, similarly to clean floor plasters.

| Deposit type | Deposit sub-type | Microstructure | Voids | Particle size | Sorting | Orientation | $c/f_{20\mu}$ ratio | c/f rel. distrib. | B-fabric | Minerals and sediment aggregates | | | | | | Anthropogenic inclusions | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | Quartz | Amphibole | Plagiocase | Chert | Calcite | Silty clay | Ashes | Burnt bone | Burnt shell | Charred plants | Phytoliths |
| BK3 | BK3a | Cr | v, c, c-p ●● | CL | U | U P | 5:2 | o-e d-p | b2 b3 | ●● | ○ | ○ | ○ | ● | ● | ● | ● | ● | ● | ●● |

**Legend:** Microstructure: Cr=crumby | Voids: v=vughs, c=channels, c-p=complex packing voids | Particle size: CL=clay loam | Sorting: U=unsorted | Orientation: U=unoriented, P=parallel | c/f related distribution: o-e=open enaulic, d-p=double-spaced porphyric | B-fabric: b2=calcite crystallitic, b3=stipple-speckled | Abundance of Voids, Inclusions & Aggregates: ○≤1%, ●2-5%, ●●6-15%, ●●●16-30%, ●●●●31-50%, ●●●●●>50%

**Table 4.4** Micromorphological characteristics and components of deposit type BK3: building hearth floors.

The thickness of these surfaces is variable (1-3 cm), and in most cases substantial fuel accumulations of ashes and herbaceous phytoliths have been gradually deposited on top of them. These interior fire installations do not appear to have been re-plastered on a periodical basis, and it is likely that hearth maintenance practices involving frequent sweeping and the collection of combustion debris contributed to the erosion and cracking of earlier surfaces, as the frequency of scorched calcareous crumbs (*ca.* 10-15%), apparently detached from hearth floors and found randomly distributed within the ashy fills, seems to indicate.

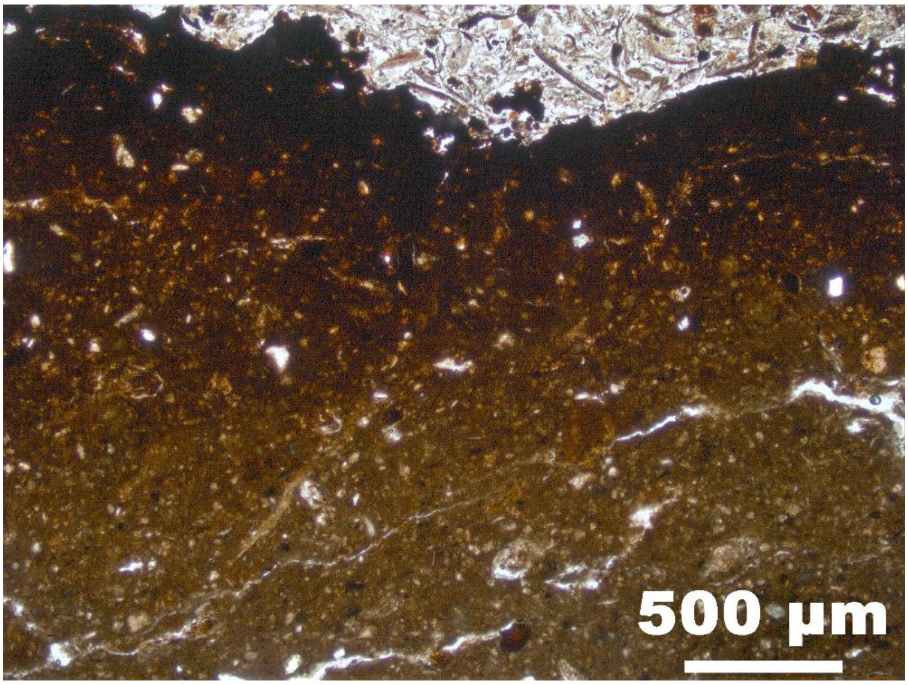



**Figure 4.5** Photomicrograph of upper floor in hearth Feature 171 (deposit sub-type BK3a) in Building 12 displaying a marked rubefaction gradient, PPL.

#### 4.2.1.4 Deposit type 4: Accumulated materials

Rake-outs and layers of accumulated materials rich in charred residues of organic origin such as bone fragments, charred plants, and phytoliths, have been identified as part of hearth contexts and in the non-plastered floor areas around them. When found as hearth fills, these deposits can be considerably thick (up to 4 cm), commonly consisting of highly articulated plant fuel residues displaying parallel orientations and distributions, suggestive of *in situ* deposition, and characterised by a low incidence of post-depositional disturbances. By contrast, the fine lenses (usually under 1 cm in thickness, some even less than 1 mm thick) of rake-outs and sweepings that form the occupation sequences found in the sunken north-western areas of standard buildings at Boncuklu are composed of unoriented aggregates and bioarchaeological remains, indicative of re-deposition. There are no signs of intentional manufacture in these accumulated units used as occupation surfaces, which formed through the gradual deposition, accumulation, and trampling of rake-outs from the hearth. The plaster and sediment lumps found embedded in these deposits were probably transported on the soles of feet from areas within and outside the building, and later incorporated into the rake-out layers through trampling. The top boundary of some of these deposits is characterised by 0.2-1 mm of extremely compressed micromass, likely caused by the compacting effect of matting or textiles on these surfaces, especially if occurring under wet conditions. It is also worth noting that these accumulated surfaces appear significantly more altered due to post-depositional biological activity than the plastered sequences found in the clean area of buildings, probably a consequence of their higher organic content and looser texture.

This type of deposits, classified as BK4, has been further sub-divided into four categories based on the relative abundance of specific constituents: BK4a, referring to layers formed by phytolith remains in a proportion higher than 50%; BK4b, consisting of charred plant materials with a substantial presence of phytoliths; BK4c, formed by up to 30% calcareous aggregates; and BK4d, mixed accumulations in which the main organic components, namely bone fragments, charred plants, and phytoliths, occur in similar concentrations.

The microscopic units classified under deposit sub-type BK4a are characterised by an extremely high abundance of siliceous plant remains, ranging between 50% and 80% of the whole layer. Stacked bulliform cells and grass husks dominate the phytolith assemblage in these deposits, with smooth long cells, jigsaw sedges, and fragments of reed/stem tissue displaying stomata occurring in much lower percentages. Calcitic ashes are also commonly present in moderate proportions, approximately 5-15%. The mineral fraction in this deposit sub-type is very limited, consisting of dispersed rounded sediment aggregates of calcareous

| | | | | | | | | | | | Rocks & Minerals | | | | | | | | Sediment aggregates | | | Anthropogenic inclusions | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Deposit type** | **Deposit sub-type** | **Microstructure** | **Voids** | **Particle size** | **Organic/mineral ratio** | **Sorting** | **Orientation** | **$c/f_{20\mu}$ ratio** | **c/f rel. distrib.** | **B-fabric** | Basalt | Limestone | Quartz | Amphibole | Plagiocase | Chert | Muscovite | Calcite | Marl | Clay loam | Silty clay | Ashes | Faecal matter | Obsidian | Burnt bone | Burnt shell | Charred plants | Phytoliths | Melted silica | Hackberry endocarp |
| BK4 | BK4a | V/S | v, c<br>●● | SL | 10:1 | U | P<br>U | 5:1 | d-e | b1 | - | - | ○ | ○ | ○ | ● | ○ | ●● | ● | ○ | ○ | ●● | - | - | ● | ○ | ●● | ●●●●● | ○ | ○ |
| | BK4b | V | v, c<br>●● | SCL | 5:2 | U | P<br>U | 2:5 | d-p | b1<br>b2 | - | - | ● | ○ | - | ○ | ○ | ● | ○ | ● | ● | ● | - | - | ●● | ● | ●●●●● | ●●● | ○ | - |
| | BK4c | V | v, c<br>●●● | SL | 5:3 | U | P | 3:5 | s-e<br>d-p | b1<br>b2 | - | - | ● | ○ | ○ | ○ | ○ | ●●● | ●●● | ● | ● | - | - | - | ●● | ● | ●●● | ●●● | - | ○ |
| | BK4d | V | v, c<br>●●● | SL | 2:1 | U | U | 5:2 | d-p<br>d-e | b1<br>b2 | ○ | ○ | ● | ○ | ● | ○ | ○ | ●● | ● | ● | ●● | ● | ○ | ○ | ●●● | ● | ●● | ●● | ○ | ○ |

**Legend:** <u>Microstructure:</u> V=vughy, S=spongy | <u>Voids:</u> v=vughs, c=channels | <u>Particle size:</u> SL=silt loam, SCL=silty clay loam | <u>Sorting:</u> U=unsorted | <u>Orientation:</u> U=unoriented, P=parallel | <u>c/f related distribution:</u> s-e=single-spaced enaulic, d-e=double-spaced enaulic, d-p=double-spaced porphyric | <u>B-fabric</u>: b1=undifferentiated, b2=calcite crystallitic | <u>Abundance of Voids, Inclusions & Aggregates</u>: ○≤1%, ●2-5%, ●●6-15%, ●●●16-30%, ●●●●31-50%, ●●●●●>50%

**Table 4.5** Micromorphological characteristics and components of the various forms of deposit type BK4: building accumulated materials.

clay loam, silty clay, and mottled fine marl, all of which do not represent more than 5% of a single deposit. Unidentifiable fragments of charred plants also constitute a significant part of these layers, with their abundance ranging between 10-20%. These units are generally 1-3 mm thick, and their excellent preservation is manifested in the high incidence of well-articulated phytolith remains and calcitic ashes commonly encountered in these contexts.

Deposit sub-type BK4b is distinguished by the high proportion (*ca.* 50-70%) of charred plant remains occurring in these layers. Due to their extreme degree of fragmentation, however, the identification of these materials to plant species has proven unfeasible. Herbaceous phytoliths are also commonly present, albeit in lower percentages (approximately 15-35%). Burnt fragments of bone and shell, the latter consisting of eggshell residues with mollusc remains being less frequent, are generally found dispersed within these units, possibly indicating the accidental incorporation of microscopic food residues into what appears to be are mainly discarded mixed fuel sources. Minerogenic aggregates are also more common in these units than in the BK4a types, although their total abundance does not normally exceed 10%.

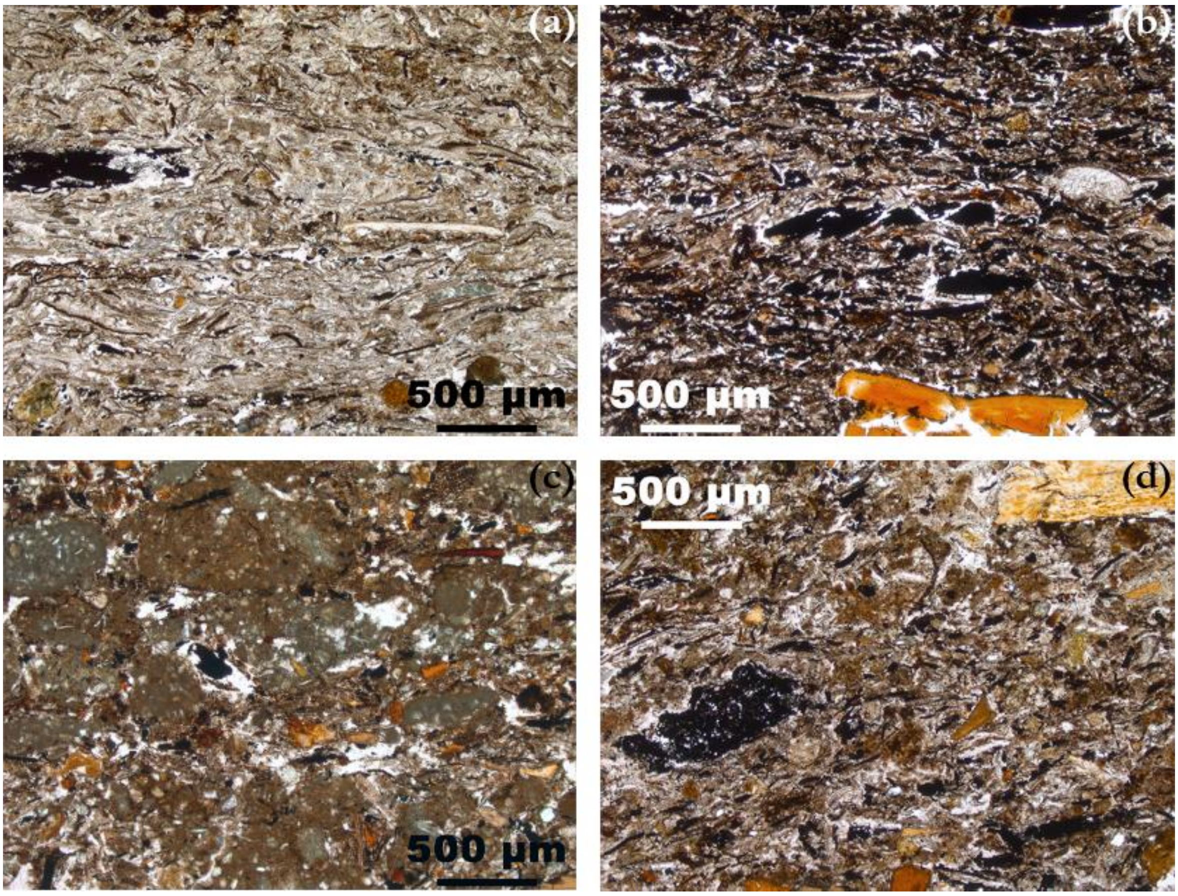



**Figure 4.6** Photomicrographs of deposit sub-types of building accumulated remains: a) BK4a, thin layer part of a sequence of sunken surfaces in Building 12 formed by silicified plant remains and calcitic ashes, PPL; b) BK4b, charcoal-rich deposit close to the central hearth of Building 12 displaying a strong parallel orientation of components, PPL; c) BK4c, subrounded aggregates of calcareous and clayish sediments in Building 12, PPL; d) BK4d, mixed accumulation of occupation residues in Building 23, PPL.

Layers of accumulated materials classified under deposit sub-type BK4c display abundant coarse calcareous silt loam aggregates intermixed with *ca*. 10% brown alluvial clay loam aggregates and silty clay sediments. These deposits, often found in the earliest phases of building occupation, consist of parallel-oriented minerogenic aggregates (single-spaced enaulic related distribution) embedded in a matrix of occupation residues formed by mixed charred plants and phytoliths with a moderate presence of bone and shell fragments (*ca*. 15%). The variable size of the sediment aggregates forming most of these units (*ca*. 200 μm – 1.2 mm) is indicative of differential trampling, sweeping, and erosion intensities.

Lastly, deposit sub-type BK4d comprises a range of heterogeneous layers with no dominant archaeological inclusions or aggregates and similar structural characteristics. These units are commonly thicker than the other two types (0.5-5cm) and contain a substantial mineral fraction with traces of basaltic rocks and limestone. Rounded aggregates of calcareous clay loam, brown silty clay sediments, and fine marl, occur in significant proportions (*ca*. 20-25%). Although charred plants and phytoliths are frequent in these layers, their abundance does not exceed *ca*. 30%, whereas hackberry endocarps, obsidian flakes, and amorphous aggregates of faecal matter have been found in very small quantities in some of these deposits. Burnt bone and shell fragments, some of which are several millimetres in size, have an important presence in this deposit sub-type, amounting to an average of 35% of these layers. Microscopic units falling under the BK4d category have been interpreted as re-deposited materials formed by mixed hearth fuel dumps and floor sweepings from food processing or storage areas. The mixture of inclusion types and random orientation and distribution of components might even indicate tertiary deposition derived from large-scale clearance activities, although the impact of post-depositional bioturbation, substantial in these layers (approximately 25-30% of the groundmass in these deposits appears to have been affected by passage features), could have contributed to these patterns.

#### 4.2.1.5 Deposit type 5: Collapsed remains

Collapsed structural materials, interpreted as the roofing of the non-standard Building 16 in Area M during the excavations, were sampled in 2013 to investigate the nature of these remains and the causes of the collapse. The very minerogenic deposit sub-types BK5a and BK5b, apparently consisting of the daub part of the roof, are characterised by their marly nature and high calcitic content, a consequence of the presence of ashes that form *ca*. 50% of these units. These ashes occur in strong association with plant inclusions, which probably derive from the combustion and post-depositional mixing of the roof plant cover.

Minerogenic aggregates include heated marl and several types of silty clay sediments showing various degrees of burning and plant pseudomorphic voids, likely part of construction materials that became mixed up after the collapse of the structure. The constituents of these units are unoriented, displaying random and highly uneven distributions that substantiate the original interpretation of these deposits as collapsed materials. The absence of crusts, water-laid deposits, and trampling indicators suggest that these units were covered up fast after deposition, preserving the fragile and easily dispersed ashes and calcined microscopic inclusions.

While these layers appear to represent a single destruction event caused by fire, the presence of large bioarchaeological inclusions within the units corresponding to the BK5a sub-type, including well-preserved millimetric fragments of spongy bone, might be indicative of various post-collapse intrusion or reworking events. In fact, the abundance of highly interconnected vughs and channels, responsible for the great porosity of these deposits and their spongy/vughy microstructure, points to the significant incidence of bioturbation.

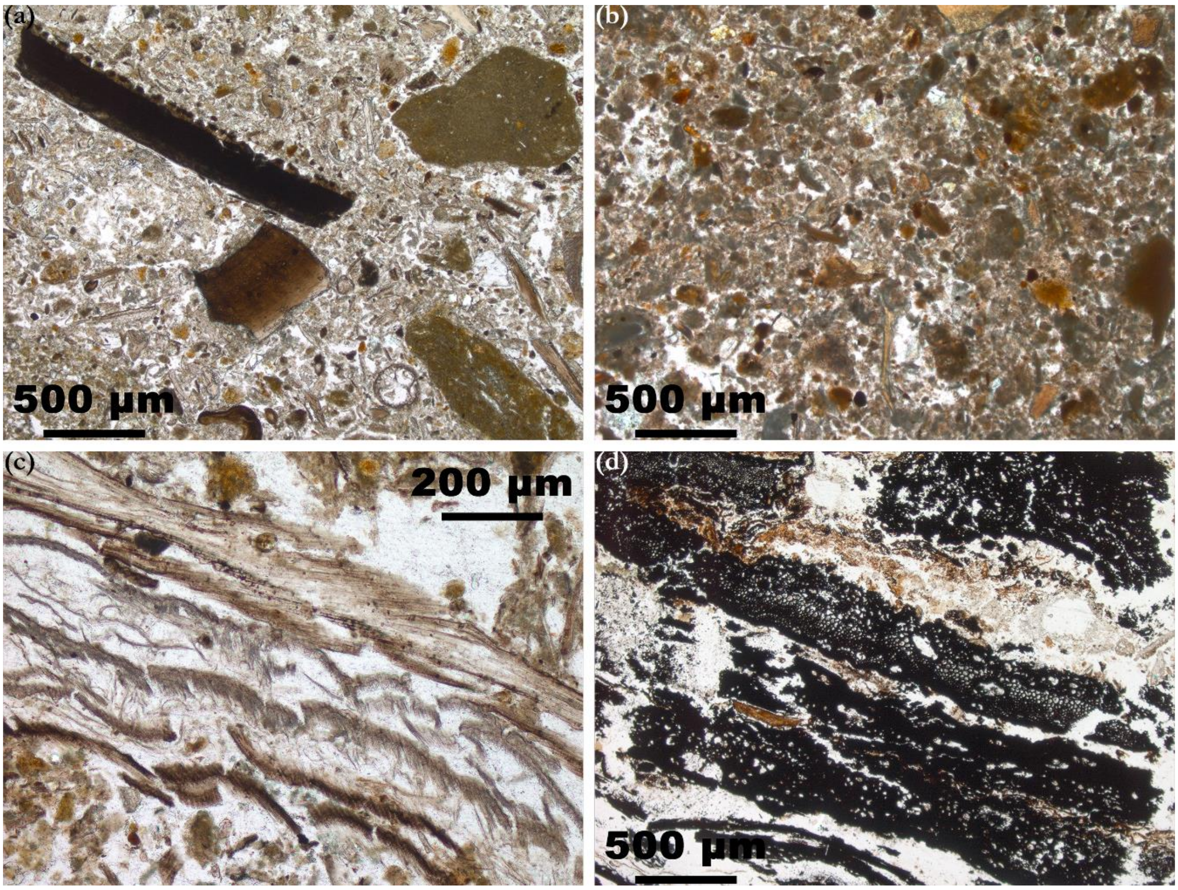



**Figure 4.7** Photomicrographs of deposit sub-types of collapsed remains: a) BK5a, ashy deposit with abundant sediment aggregates and frequent anthropogenic inclusions in the form of bone and shell fragments, PPL; b) BK5b, very minerogenic deposit formed by up to 70% calcitic ashes, PPL; c) BK5c, superimposed laminations of siliceous plants, in which leaf and grass components are strongly represented, PPL; d) BK5c, charcoal fragments found immediately under the phytolith layers, possibly the original beams of the roof, PPL.

| Deposit type | Deposit sub-type | Microstructure | Voids | Particle size | Sorting | Orientation | $c/f_{20\mu}$ ratio | c/f rel. distrib. | B-fabric | Rocks & Minerals | | | | | | Sediment aggregates | | | Anthropogenic inclusions | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | Basalt | Limestone | Quartz | Amphibole | Chert | Calcite | Marl | Clay loam | Silty clay | Ashes | Burnt bone | Burnt shell | Charcoal | Phytoliths | Melted silica | Hackberry endocarp |
| BK5 | BK5a | V/S | v, c ●●● | SL | U | U | 1:5 | d-p o-p | b2 | ○ | ○ | ● | - | - | ●●●●● | ●● | ●●● | ● | ●●●●● | ●●● | ● | - | ● | ● | ○ |
| | BK5b | V/C | v, c ●●● | SCL | U | U | 1:5 | d-p o-p | b2 | ○ | - | ● | ○ | ○ | ●●●●● | ●● | ●● | ●● | ●●●●● | ●● | ○ | - | ○ | ○ | ○ |
| | BK5c | - | c, c-p ●●●● | - | U | P | - | - | b1 | - | - | - | - | - | - | - | ●● | - | - | ●●● | ● | ●●●●● | ●●● | - | ● |

**Legend:** Microstructure: V=vughy, S=spongy, C=channel | Voids: v=vughs, c=channels, c-p=complex packing voids | Particle size: SL=silt loam, SCL=silty clay loam | Sorting: U=unsorted | Orientation: U=unoriented, P=parallel | c/f related distribution: d-p=double-spaced porphyric, o-p=open porphyric | B-fabric: b1=undifferentiated,b2=calcite crystallitic | Abundance of Voids, Inclusions & Aggregates: ○≤1%, ●2-5%, ●●6-15%, ●●●16-30%, ●●●●31-50%, ●●●●●>50%

**Table 4.6** Micromorphological characteristics and components of the various forms of deposit type BK5: collapsed construction materials.

The prominent presence of well-developed lenticular gypsum crystals, frequently occurring as loose continuous infillings of faunal channels, as well as the calcitic formations found in association with modern root tissues in passage features, are also indicators of the intensity of post-depositional alterations in these layers, situated only a few centimetres below modern topsoil.

Underlying these minerogenic units is deposit sub-type BK5c, formed by continuous laminations of very fragmented wood charcoal. These remains display a high degree of fragmentation which, together with their occurrence in tangential section in the micromorphological slides, has made any attempt at identifying the plant species of these charcoals questionable due to the impossibility of observing distinctive morphological characteristics. BK5c has been identified in slide 366, situated immediately on top of living floors and varying in thickness from 0.4 to 1 cm, and it has been interpreted as part of the collapsed roof structure, possibly the staves or woven wands that served as the base of the overlying daub materials.

The presence of phytoliths in these deposits is very low, although several superimposed laminations of siliceous plants have been identified in deposit sub-type BK5b, probably part of the roof plant cover and situated only a few millimetres over the collapsed charcoal layer BK5c. These semi-continuous laminations appear truncated at parts, although the herbaceous phytoliths constituting them are very articulated, often conjoined into complete stem sections whose plant anatomy is clearly discernible. These siliceous remains include wild grass husks (common), stacked bulliform cells (common), and smooth long cells (few), in addition to rare inclusions of melted silica that point to the localised occurrence of burning temperatures over 600ºC during the fire that resulted in the destruction and subsequent collapse of the superstructure of Building 16.

### 4.2.2 Classification of deposit types in open areas

The stratigraphic sequences found in open areas at Boncuklu are largely anthropogenic in origin. Although middens at this site have a remarkably similar composition, microstructural differences are clearly distinguishable between *in situ* activity areas and re-deposited contexts. Deposit types from open areas have been classified in accordance to key microscopic attributes, such as particle size, coarse-fine fraction, and microstructure, but also on the basis of the abundance and associations of particular aggregates and inclusions. Significant

| Deposit type | Deposit sub-type | Description | Interpretation |
| --- | --- | --- | --- |
| **BK6** Midden deposits | **BK6a** | Accumulations of silicified plant materials | These deposits are composed almost entirely by silicified plant remains, containing >50% phytoliths often mixed with calcitic ashes and charred materials occurring in lower percentages (*ca*. 10-20%). These units probably represent discard episodes of fuel excess. |
| | **BK6b** | Accumulations of charred and silicified plant materials | Charred plant remains is the major component of these layers, with overall abundances in the range of 30-50%. The occurrence of phytoliths is generally slightly lower, *ca*. 20-40%. These deposits probably formed through the discard of re-deposited mixed plant fuel derived from low temperature/short duration firing activities. |
| | **BK6c** | Coprolite accumulations | Midden contexts with abundant aggregates of faecal matter of suspected omnivore/carnivore origin. |
| | **BK6d** | Accumulations of marl aggregates | Midden deposits containing high proportions of marl and calcareous sediment aggregates, possibly derived from plaster production activities. |
| | **BK6e** | Mixed accumulations | Deposits with no dominant inclusions, generally very heterogeneous and rich in re-deposited occupation remains that appear either charred or calcined. The incidence of bone and shell fragments (*ca*. 10-40%) is especially high in these layers. |
| **BK7** Hearths | **BK7a** | Hearth linings | Marl and alluvial clay linings demarcating the edges of some external fire installations. |

**Table 4.7** List of identified deposit types in open spaces at Boncuklu Hüyük.

variations in these micromorphological characteristics have resulted in the identification of formation processes and the occurrence of specific activities in these open areas.

#### 4.2.2.1 Deposit type 6: Midden deposits

At Boncuklu, open spaces appear almost as spatially structured as internal areas, displaying abundant evidence of the occurrence of communal activities, as it has been inferred from the presence of pits, formally-arranged fire installations, and inhumations in these areas (Baird *et al.* 2012b). Middens have a strong anthropogenic component, with inclusions of organic origin, mainly charred plants, bone fragments, and shell remains, accounting for approximately 50-70% of these external deposits. Sedimentation caused by natural processes during the occupation of the settlement has not been identified in the samples analysed, although it is possible that post-depositional alterations, ubiquitous throughout the site, will have contributed to obscuring the effect of any natural agencies in these open spaces.

Substantial phytolith accumulations, classified as deposit sub-type BK6a, have been detected within the sequence of an external hearth in Trench N and in two open fire pits in Trench M. Siliceous plant remains comprising strongly to moderately articulated grass husks, smooth long cells, jigsaw-cell tissues derived from sedges, and stacked bulliform cells, comprise between 50% and 70% of these units. These materials often display an orientation parallel to the basal boundary of the layer, suggesting *in situ* plant decay, with localised areas of unoriented inclusions likely caused by post-depositional disturbances. Calcitic ashes resulting from the burning of herbaceous components represent approximately 25% of these deposits, whereas charred plants and bone fragments have been found in low percentages (*ca*. 5-10%). A similar proportion of randomly dispersed calcareous and clayish minerogenic aggregates (*ca*. 5-8%) has been encountered in these highly organic units, possibly derived from post-depositional intrusions in these layers. Overall, the nature of deposit sub-type BK6a, ranging in thickness between 0.5 and 1.5 cm, points to the frequent burning of reeds, leaves, and grasses as fuel for external fires, similarly to the much thinner (approximately 2-5 mm) rake-out deposits dominated by phytoliths found in floor areas around the fire installations of Building 12.

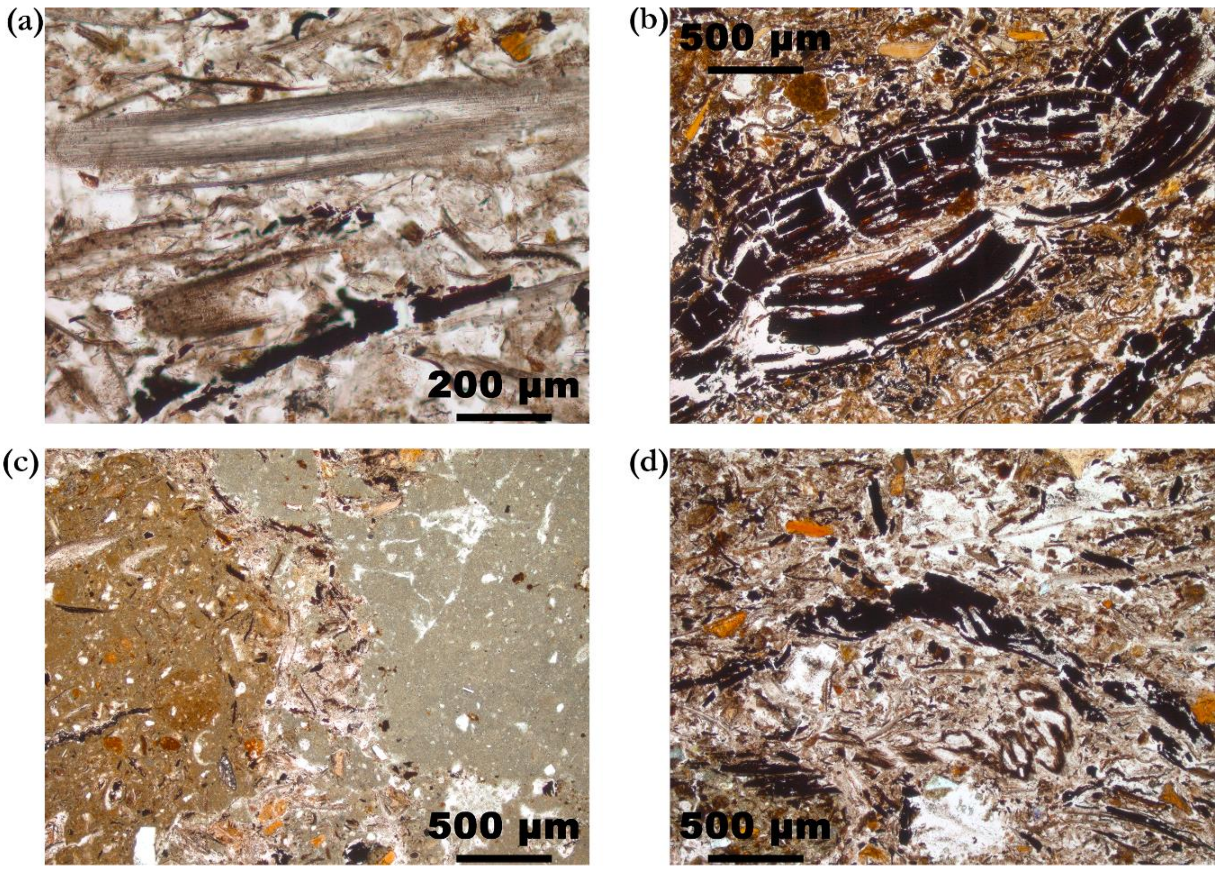



**Figure 4.8** Photomicrographs of deposit sub-types in midden contexts: a) BK6a, accumulation of herbaceous phytoliths within an open fire pit in Trench M, PPL; b) BK6b, charcoal inclusion part of a midden deposit rich in charred and silicified plant materials, PPL; c) BK6d, sediment aggregate and marl fragment embedded in a highly minerogenic midden layer in Trench M, PPL; d) BK6e, heterogeneous midden deposit displaying mixed burnt bones, charred plants, phytoliths, and sediment aggregates, PPL.

Deposit sub-type BK6b, identified as both fill units of open hearths and accumulated discard layers in middens, is characterised by an abundance of highly fragmented charred plant materials (*ca*. 30-50%), and herbaceous phytoliths (*ca*. 20-40%). Unsorted and unoriented when found in middens, these units show evidence of secondary deposition, likely as discarded fuel residues. When encountered within stratigraphic sequences corresponding to external fire pits, the layers classified under BK6b appear formed by larger fragments of charred plants (up to 4 mm) that display parallel referred orientations, suggestive of *in situ* low temperature burning.

Significant concentrations of faecal matter have only been encountered in restricted areas of the settlement, such as the south-eastern corner of Trench M. Classified as deposit sub-type BK6c, coprolites constitute approximately 40% of these otherwise very homogeneous contexts, in which no discernible microlayering has been detected, likely a consequence of slow accumulation. These coprolites contain abundant bone inclusions, and have therefore been described as suspected omnivore/carnivore faecal remains. Other anthropogenic components of this deposit sub-type include very fragmented charred plant remains (5-20% abundance), herbaceous phytoliths (5-15%), burnt bones (5-10%), shell fragments (2-5%), and approximately 5% dispersed calcitic ashes. All these inclusions have been found randomly oriented and distributed, which points to their secondary deposition in this open context as fuel/food refuse and discarded rake-outs. In addition, trampling indicators have not been encountered anywhere in this open sequence, which rules out the hypothesis of boar/pig penning as the origin of the important concentration of faeces found in this area of the settlement.

Deposit sub-type BK6d, detected as a thin (5-7 mm thickness) layer within the microstratigraphic sequence corresponding to a small fire pit visible in the south-western profile of Trench M, has a high mineral content in the form of subrounded marl aggregates (*ca*. 75% abundance) and sediment crumbs consisting of clay loam and silty clay (*ca*. 15%), some of which display mild signs of rubefaction. The presence of bioarchaeological inclusions such as bone, shell, and plant fragments is very low (*ca*. 10-15%) when compared to the vast majority of midden deposits at Boncuklu. These remains have been exclusively found filling spaces between the minerogenic crumbs that constitute most of this unit.

The last deposit sub-type identified, BK6e, is the most common in open spaces at Boncuklu. Burnt bones of sizes up to 5 mm are particularly abundant in these layers (*ca*. 15-30%), with

| Deposit type | Deposit sub-type | Microstructure | Voids | Particle size | Organic/mineral ratio | Sorting | Orientation | $c/f_{20\mu}$ ratio | c/f rel. distrib. | B-fabric | Rocks & Minerals | | | | | | | | Sediment aggregates | | | Anthropogenic inclusions | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | Basalt | Limestone | Quartz | Amphibole | Plagiocase | Chert | Muscovite | Calcite | Marl | Clay loam | Silty clay | Ashes | Faecal matter | Obsidian | Burnt bone | Burnt shell | Charred plants | Phytoliths | Melted silica | Hackberry endocarp |
| | BK6a | V/S | v, c<br>●●● | SL | 5:1 | U | U<br>P | 3:2 | o-e | b1 | - | - | ○ | ○ | ○ | ● | ○ | ●●● | ● | ● | ○ | ●●● | - | - | ● | ○ | ● | ●●●●● | ○ | ○ |
| | BK6b | V | v, c<br>●●● | SL | 5:2 | U | U<br>P | 3:2 | d-e | b1<br>b2 | - | - | ● | ○ | - | ○ | ○ | ●● | ● | ● | ● | ● | - | - | ●● | ● | ●●●● | ●●● | ○ | - |
| BK6 | BK6c | V | v, c, c-p<br>●●●● | SC | 4:1 | U | U<br>P | 1:10 | c-e | b1<br>b2 | ○ | - | ●● | ○ | - | - | - | ● | ●● | ● | ○ | ● | ●●●● | ○ | ● | ● | ●● | ●● | ○ | - |
| | BK6d | Cr | c, c-p<br>●●● | SC | 1:5 | U | U | 1:5 | c-e | b2 | - | - | ● | ○ | ○ | ○ | - | ●●● | ●●●●● | ●● | ● | - | - | - | ● | ○ | ● | ● | - | - |
| | BK6e | V | v, c<br>●●● | SCL | 2:1 | U | U | 2:5 | s-e<br>o-e | b1<br>b2 | ○ | ○ | ● | - | ● | - | ○ | ●●● | ●● | ●● | ● | - | ○ | ○ | ●●● | ● | ●● | ●●● | ○ | ○ |

**Legend:** Microstructure: V=vughy, S=spongy, Cr=crumby | Voids: v=vughs, c=channels, c-p=complex packing voids | Particle size: SL=silt loam, SC=silty clay, SCL=silty clay loam | Sorting: U=unsorted | Orientation: U=unoriented, P=parallel | c/f related distribution: c-e=close enaulic, s-e=single-spaced enaulic, d-e=double-spaced enaulic, o-e=open enaulic | B-fabric: b1=undifferentiated, b2=calcite crystallitic | Abundance of Voids, Inclusions & Aggregates: ○≤1%, ●2-5%, ●●6-15%, ●●●16-30%, ●●●●31-50%, ●●●●●>50%

**Table 4.8** Micromorphological characteristics and components of the various forms of deposit type BK6: midden contexts.

aggregates in the form of randomly distributed and unoriented marl, calcareous clay loam, and silty clay crumbs, all of which constitute approximately 40% of these units. Small amorphous aggregates of charred herbivore dung have been detected in trace concentrations (*ca.* 1-2%) in some of the layers classified under BK6e. These homogeneously heterogeneous deposits are often very thick (up to at least 8-10 cm), and they seem to have formed through the gradual dumping of debris resulting from food processing and cooking, hearth rake-outs and floor sweepings. The slow rate of deposition of anthropogenic components in open spaces seen in sub-type BK6e led to an accumulation of reworking and pedogenetic processes that appears to have altered considerably the microstructure of these units, diffusing the boundaries of any possible microlayering representing single dumping events.

#### 4.2.2.2 Deposit type 7: Constructed external fire installations

Fire spots at Boncuklu are relatively common in open spaces, frequently occurring within shallow pits that were rapidly covered after use. These features do not show any traces of prepared hearth bases or floors, in contrast with the fire installations found in building interiors. One external hearth, however, Feature 303, situated in an open area immediately to the north of Building 6, in Trench N, does display evidence of intentional construction, as opposed to the majority of fire spots found in open areas at the site, rather ephemeral in nature. In this case, the perimeter of Feature 303 was marked by a prepared and formally laid lining made predominantly of calcareous material. This deposit, classified as sub-type BK7a, is formed by 70% mottled marl and 15% silty clay and clay loam aggregates that show no evident signs of rubefaction. Plant pseudomorphic voids have not been encountered in this

| | | | | | | | | | | **Minerals** | | | | | **Sediment aggregates** | | | **Anthropogenic inclusions** | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Deposit type** | **Deposit sub-type** | **Microstructure** | **Voids** | **Particle size** | **Sorting** | **Orientation** | **c/f$_{20\mu}$ ratio** | **c/f rel. distrib.** | **B-fabric** | Quartz | Amphibole | Plagiocase | Chert | Calcite | Marl | Clay loam | Silty clay | Burnt bone | Burnt shell | Charred plants | Phytoliths | Hackberry endocarp |
| BK7 | BK7a | V/Cr | v, c ●●●● | SC CL | U | U | 1:5 | c-e | b2 | ●● | ○ | ○ | ● | ● | ●●●●● | ● | ●● | ●● | ● | ●● | ● | ○ |

**Legend:** Microstructure: Cr=crumby, V=vughy | Voids: v=vughs, c=channels | Particle size: CL=clay loam, SC=silty clay | Sorting: U=unsorted | Orientation: U=unoriented | c/f related distribution: c-e=close enaulic | B-fabric: b2=calcite crystallitic
Abundance of Voids, Inclusions & Aggregates: ○≤1%, ●2-5%, ●●6-15%, ●●●16-30%, ●●●●31-50%, ●●●●●>50%

**Table 4.9** Micromorphological characteristics and components of deposit type BK7: constructed external fire installations.

layer, although the highly fragmented burnt bones (*ca.* 10% abundance), and plant remains (*ca.* 5-10%) with sizes between 0.1 and 3 mm found completely embedded in this deposit could have acted as stabilisers. The use of these randomly oriented and distributed components, however, points to a coarsely produced construction material. This temper, that might not have been deliberately added to the sediments but rather accidentally incorporated during manufacture, did not prevent the fine-grained materials from cracking, probably an effect of fluctuating moisture levels, as deposit BK7a does not display any evidence of heat impact.

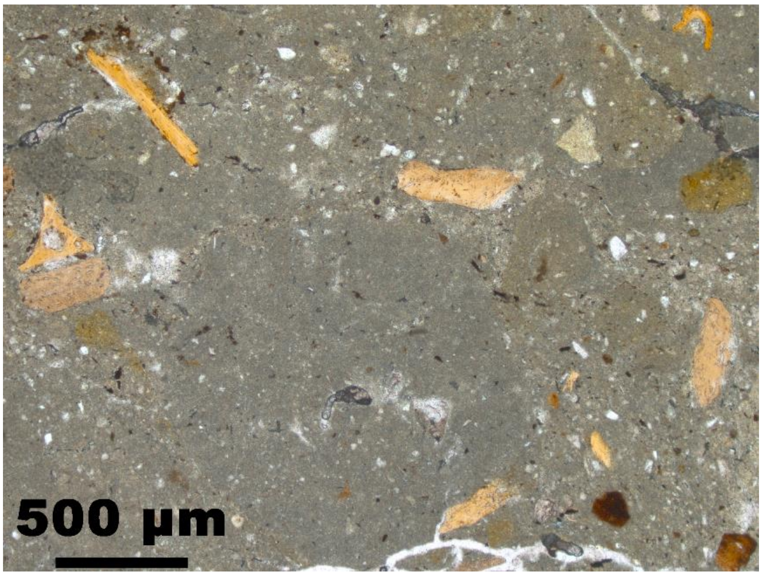



**Figure 4.9** Photomicrograph of the calcareous lining (deposit sub-type BK7a) of an external hearth in Trench N, immediately to the north of Building 6, PPL.

### 4.2.3 Classification of microscale inclusions

The range of inclusions identified at the microscopic scale in occupation layers from Boncuklu include mineral aggregates, ashes, coprolitic materials, obsidian flakes, bones, shells, and plant materials. Microartefacts, including lithic fragments and clay balls are especially rare in the samples analysed. Table 4.10 in the next page includes a summary of the major inclusion types observed in occupation deposits at Boncuklu, their pre-depositional origin, and state of preservation. The frequency of inclusions, as well as their size and microstructural characteristics such as orientation and related distribution, are important activity indicators, and for this reasons they have been taken into consideration during the classification of the layers into deposit types and sub-types.

Occupation deposits at Boncuklu are characterised by their high silt content, formed mainly by subrounded quartz and calcite minerals. Gypsum has also been observed to occur abundantly, albeit as a post-depositional phenomenon. Traces of plagioclase, amphibole, chert and muscovite minerals of sizes between 100μ and 0.5 mm have been found in most layers at Boncuklu. Rock fragments include rounded limestones and igneous (basaltic) inclusions of sand-size (*ca*. 400 μ - 1.2 mm). The closest source for the igneous material is the volcanic highlands situated over 50 km to the east and west of the site, whereas the limestone rocks could have been transported by natural agents from the range of low limestone hills, the Bozdağ, that project north-west from the volcanic mountain of the Karadağ (Kuzucuoğlu 2002; Roberts 1982).

| Inclusion type | Description | Variations | Origin & Preservation |
|---|---|---|---|
| **Rocks & Minerals** | *Quartz, calcite, gypsum, traces of mica and feldspar, basaltic rocks, limestone rocks.* | Size, shape, roundness, sphericity, smoothness, alterations. | Sediment sources and post-depositional processes. Minerals have been found embedded in aggregates and minerogenic units and randomly distributed in highly organic deposits. Gypsum precipitation occurred post-depositionally. |
| **Sediment aggregates** | *Marl/Softlime* Fine-grained, pale grey aggregates displaying iron mottling. Few mollusc shells and plant pseudomorphic voids present. | Size, shape, roundness, sphericity, boundary, voids, inclusions, coatings, alterations. | Alluvial sources. When rounded aggregates are found, these might be indicative of floor sweepings if unburnt, or hearth area rake-outs / plaster production activities if rubefied. |
| | *Clay loam* Coarse dark brown to greyish-brown aggregates frequently containing fragments of charred plants. | Size, shape, roundness, sphericity, boundary, voids, inclusions, coatings, alterations. | Aggregates display a high to moderate calcareous content with striated clays identified in some cases. Large, coarse crumbs suggest a mudbrick or coarse floor plaster origin. |
| | *Silty clay* Fine-grained, brown to reddish-brown aggregates sometimes displaying internal alluvial layering. | Size, shape, roundness, sphericity, boundary, voids, inclusions, coatings, alterations. | On-site indicators of off-site sediments, alluvial sources. Very large, charred fragments found in midden contexts might correspond to clay balls. |
| **Ashes** | *Construction materials origin* Pale to dark grey amorphous crystals. Found associated to multiple baked sediment aggregates. | Mineral composition, morphology of ash crystals, inclusions, alterations dependent on firing temperatures. | Building destruction event, high temperature burning. Excellent preservation and low rate of post-depositional scattering. |
| | *Plant origin* Light grey rhomboidal crystals, high calcitic content. | Mineral composition, morphology of ash crystals, inclusions, alterations. | Short-length burning of plant materials, frequently containing inclusions of charred plants and grass phytoliths. |
| | *Dung origin* White to light grey crystals frequently found in association with spherulites and phytoliths. | Mineral composition, morphology of ash crystals, inclusions, alterations dependent on firing temperatures. | Herbivore dung used as fuel, high temperature burning. These inclusions are more frequently encountered in open hearth fill deposits. |

**Table 4.10** Summary of inclusion types found in Neolithic occupation contexts at Boncuklu. (*Table continues in the next page*).

| Inclusion type | Description | Variations | Origin & Preservation |
|---|---|---|---|
| **Faecal matter** | *Herbivore dung* Yellowish (unburnt) to dark brown (charred) amorphous pellets. | Size, shape, inclusions, spherulite count, alterations. | Deposition of ruminant dung - cleaning activities and/or fuel use. Frequently found containing inclusions of charred plants, indicating firing at low temperatures for short periods of time. |
| | *Carnivore coprolites* Yellowish pellets rich in digested bones and devoid of spherulites. | Size, shape, inclusions, spherulite count, alterations. | Faecal waste deposition - cleaning, health. Excellent preservation in middens, diet indicators. |
| | *Omnivore coprolites* Orange, smooth and amorphous pellets containing both plant and bone inclusions. | Size, shape, inclusions, spherulite count, alterations. | Faecal waste deposition - cleaning, health. Good preservation in middens, few spherulites present and highly phosphatic mass. |
| **Micro-artefacts** | *Obsidian flakes* Very sharp inclusions often a few millimetres in size. | Size, shape, sharpness, alterations. | Débitage from tool-making activities or flakes detached during tool use. Building/open space cleaning and maintenance activities. |
| **Bones** | *Bones* Yellowish (unburnt), dark brown (charred), and greyish (calcined) fragments. | Size, shape, alterations (burning, calcination, weathering, digestion). | These remains derive from food preparation/cooking activities, often found re-deposited as waste in middens and around hearths. |
| **Shells** | *Eggshells* Dark greyish brown fragments >0.5 mm in size. | Size, shape, alterations. | Commonly found charred and very fragmented, they represent discarded food remains. |
| | *Water mollusc shells* Small greyish linear and curved fragments, often striated. | Size, shape, alterations. | Commonly found in building floors and calcareous sediment aggregates, indicating the alluvial origin of the source materials. |
| | *Land mollusc shells* Large, almost complete spiral fragments. | Size, shape, alterations. | Post-depositional intrusions. Bioturbation. |
| **Plant remains** | *Wood charcoal* Millimetric fragments of black charcoal. | Size, shape, species, alterations. | Found as part of collapsed structural remains destroyed by fire. The cellular morphology of the remains is hindered by their poor preservation. |
| | *Charred plants* Smaller fragments of black plant-derived (non-arboreal) materials. | Size, shape, species, alterations. | Plant burning activities - fuel for low temperature/short duration fires, or cooking remains. Extremely fragmented and moderately preserved. |
| | *Siliceous plants (phytoliths)* Semi-transparent impressions of plant cells. | Size, shape, species, plant part, degree of articulation, alterations. | Derived from plant burning activities or *in situ* plant decay. When exposed to temperatures >600°C inclusions of melted silica might form. |
| | *Plant pseudomorphic voids* Voids caused by *in situ* plant decay. | Size, shape. | Commonly found as plant impressions in construction materials tempered with chaff. |

**Table 4.10** (*Table continues from previous page*). Summary of inclusion types found in Neolithic occupation contexts at Boncuklu.

The aggregate materials observed in thin-section include architectural components such as plaster fragments, as well as natural sediments of diverse origins. These mineral constituents are quite variable, having been found calcined, charred, and unburnt, and usually displaying rounded to subrounded shapes. Sediment aggregates containing plant pseudomorphic voids and/or charred flecks have been identified as construction materials. Aggregates that appear to be the result of a mix of natural and anthropogenic origins, however, displaying no clear evidence of manufacture, are more abundant, occurring in widely variable percentages (*ca.* 2-50%) in each deposit. They might derive from the production of architectural materials when found embedded in plaster floors, waste debris from building construction, modification, or destruction processes when occurring in midden contexts, sweepings derived from the cleaning of living areas when found as small rounded particles in accumulations of occupation residues, or from natural (e.g. wind-rolled) agents and accidental transportation and deposition through the soles of shoes and animal hooves.

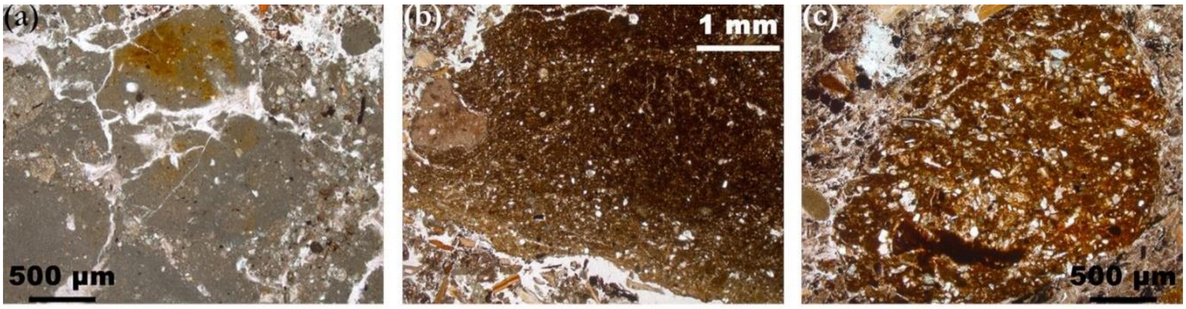



**Figure 4.10** Photomicrographs of sediment aggregates found in archaeological deposits at Boncuklu: a) marl/softlime fragments displaying iron mottling, PPL; b) burnt silty clay aggregate, possibly a discarded clay ball, PPL; c) slightly oxidised clay loam crumb, PPL.

Charred aggregates embedded in an unburnt matrix indicate a pre-depositional process of burning before being incorporated to the final material. Aggregates that have been burnt *in situ* are encountered in layers that display the effects of heating, such as the collapsed materials of Building 16 and hearth floors, often associated with the rubification of the layers and differential gradients of reduced and oxidised burning (Canti and Linford 2001). Of particular interest is a large aggregate found embedded in the ashy layers of an external hearth in Trench N, identified as a possible clay ball used in cooking practices (see Figure 4.10).

Ashes have been detected as part of collapsed materials after a building destruction event, and in hearth fills and surrounding areas, strongly associated with siliceous plant material. The chemical nature of ash has been shown to be susceptible of alteration under certain post-depositional conditions (Schiegl *et al.* 1996), which can make this component difficult to identify in mixed layers. Also, the composition of ash varies depending on the nature of the burnt materials, and the fact that these can be completely or partially combusted, with observable micromorphological features depending on the temperature and length of burning (Canti 2003). At Boncuklu, ashes are present in the form of amorphous crystals derived from the combustion of construction materials, and rhombohedral calcitic crystals of plant and, to a lesser degree, dung origin, the latter identified through the presence of calcareous spherulites.

A range of faecal aggregates has been identified in a variety of contexts, including open areas, building interiors, and fire installations. These remains have been classified after a detailed observation of their micromass, and the nature and size of particular components. Three main types of faecal aggregates have been distinguished, according to suspected dietary categories: herbivore, carnivore and omnivore. It is important, however, to bear in mind that the nature of faecal remains may vary not only according to diet, but to a number of other factors including seasonality, age, depositional context, and preservation state (Brochier *et al.* 1992).

Herbivore coprolites are commonly found as randomly dispersed amorphous aggregates in dirty floors and middens, and as calcitic dung ash in both building and open hearth deposits. The abundance of spherulites and digested grass phytoliths (*ca.* 30% abundance, often consisting of Graminae) within the faecal pellets suggest a herbivore origin for these aggregates (Canti 1997; Charles 1998), although substantial post-depositional alterations of the coprolites have precluded species identification. Extant pellets encountered in the micromorphological slides range from 0.5 to 3 mm in size, with the smallest, most reworked aggregates found in dirty building floors as part of trampled hearth rake-outs. The vast majority of the herbivore dung detected at Boncuklu is either dark brown or greyish brown in colour, bearing the effects of either low temperature or high temperature burning, in the last case often associated with ashes. Charred and calcined herbivore coprolites have been identified in moderate to high quantities in open hearth fills (*ca.* 10-20% occurrence), pointing at the frequent use of dung as fuel for these external fire spots (Sillar 2000).

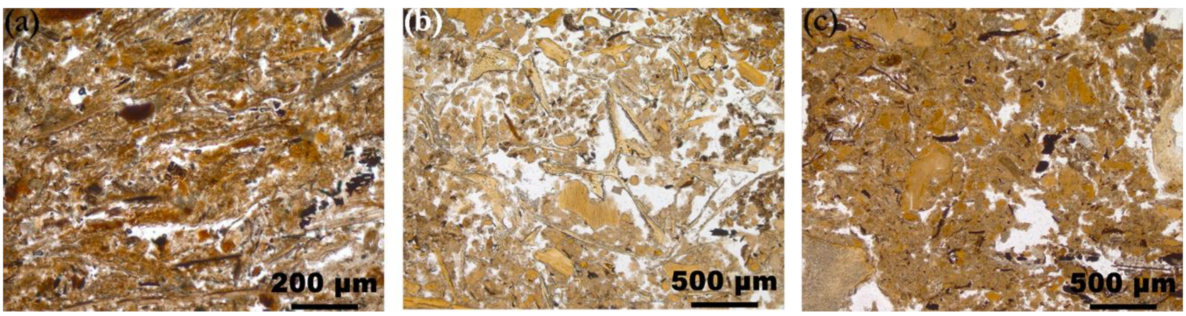



**Figure 4.11** Photomicrographs of faecal aggregates found in archaeological deposits at Boncuklu: a) burnt herbivore dung with charred flecks and articulated siliceous plant remains (stacked bulliforms and articulated stems) identified within an external hearth fill in Trench N, PPL; b) carnivore coprolite displaying abundant digested bone fragments, PPL; c) omnivore coprolite with embedded bone, phytolith, and charred plant inclusions, PPL.

Carnivore coprolites have only been detected in a midden located at the south-eastern corner of Trench M, consisting of 80% crushed and digested bones, at least some of which seem to belong to micromammals or amphibian species. The remaining 10-15% of these coprolites is formed by phytoliths and other plant remains, with phosphatic aggregates representing 5-10% of the total. This dung type does not contain spherulites. Very porous, void space within these faecal pellets, which reach up to 8cm in size, represents approximately 40% of their mass. Macroscopically, this type of faecal remains has a pale yellow colour, probably an effect of the high presence of embedded bone fragments. By contrast, omnivore coprolites appear as dense, bright orange masses of phosphatic material embedding up to 20% of extremely weathered bones, 2% herbaceous phytoliths, and up to 15% charred plant flecks. Void space is reduced to 10-15% of the faecal pellets, which are generally smaller and more disaggregated than their carnivore counterparts, ranging between 0.8 and 4 cm in size.

Determining the sources and digestive processes for each coprolite type would require the application of further analytical techniques, such as lipid biomarker detection (Bull *et al.* 2002). Preliminary Gas Chromatography Mass Spectroscopy (GC-MS) analyses focused on the sterol extraction and examination of one faecal sample from a midden in Trench M indicate an omnivore origin (Bull, pers. comm.), although specific species determination could not be reached. With respect to carnivore coprolites, the possibility that these were deposited by domestic dogs remains intriguing. Zooarchaeological analyses of the animal bone assemblage at Boncuklu remain inconclusive on whether the large *Canis* remains identified corresponded to wolves rather than domesticated dogs. Also, gnawing or carnivore digestion signatures appear absent from the Boncuklu faunal assemblage, raising the question as to whether dogs were present at the site (Baird *et al.* 2012b). With concern to the composition of the suspected carnivore coprolites found, the low fragmentation of some of the embedded bone fragments has allowed for their morphology to be distinguishable to the point of allowing diagnosis. Microfaunal vertebrae and long limb bones, possibly derived from bird or amphibian species, have been identified within these coprolites, although further analyses would be required to confirm this observation. A number of additional coprolite samples have been collected from this open space and further GC-MS analyses aimed at diet research and, when possible, species determination, will be conducted at the Life Science Mass Spectrometry Facility of the University of Bristol in the future.

Obsidian inclusions are extremely rare in the micromorphological samples from Boncuklu. This type of material has only been identified in midden contexts, comprising very small (*ca.* 0.3 mm) angular fragments, some of which appear to have been heated. From the virtual absence of lithic materials in both building and exterior deposits, it can be inferred that flaking and tool production activities were not usually performed inside the settlement.

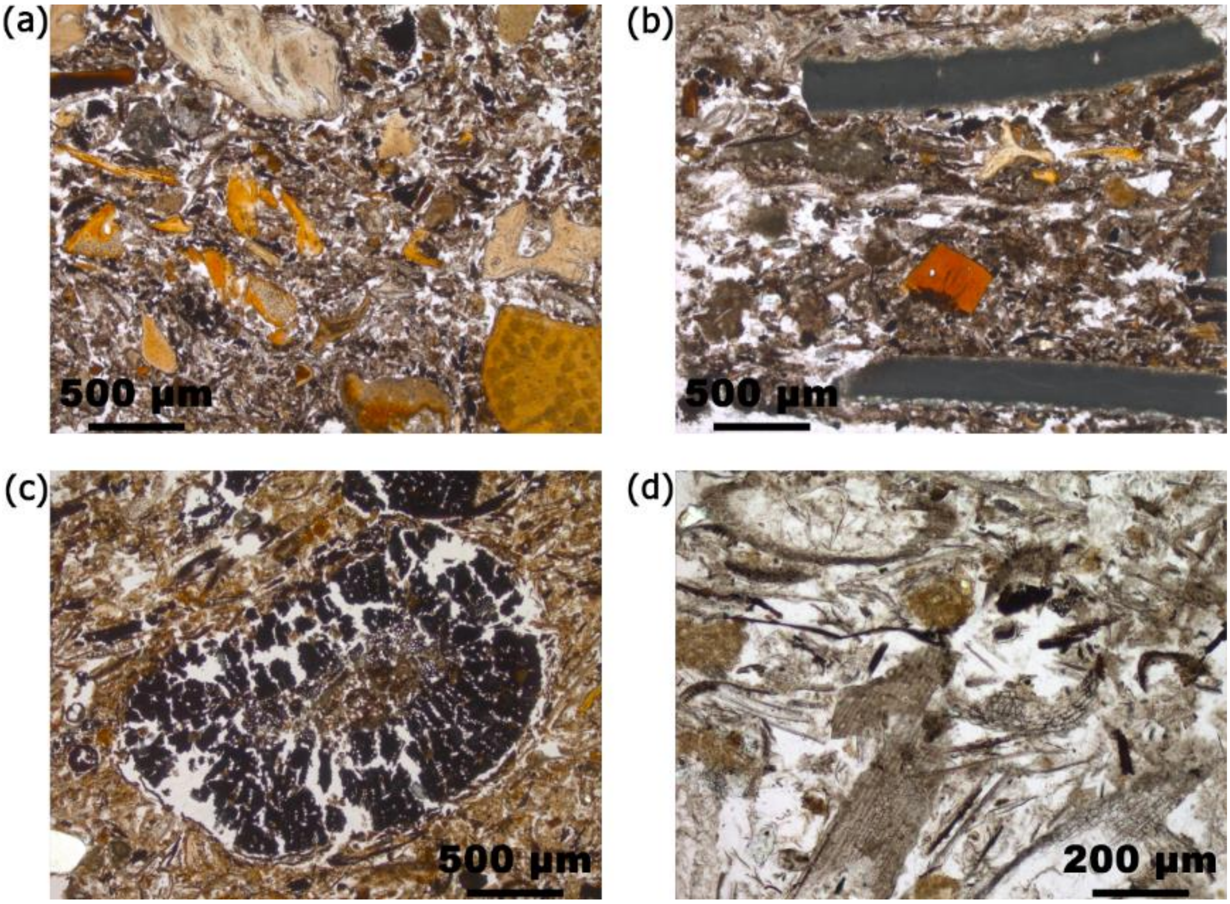



**Figure 4.12** Photomicrographs of anthropogenic inclusions found in archaeological deposits at Boncuklu; a) charred bones in an ashy midden layer of Trench M, PPL; b) burnt eggshell fragments found within the dirty floors of Building 12, PPL; c) transverse section of unidentified charcoal fragment, PPL; d) fuel remains consisting of herbaceous phytolith remains and calcitic ashes, part of the sequence of an external hearth in Trench M, PPL.

Secondarily deposited bone fragments are present in almost every context throughout the settlement. The size of these remains ranges from 0.3 mm to 6 mm in middens, and from 0.2 mm to 2.5 mm in accumulated occupation units within buildings. The occurrence of bone remains in open contexts is high (20-30% abundance), the majority of which display signs of low temperature burning or, less commonly, calcination. Bone is also found in middens as embedded inclusions in coprolites, as seen in Figure 4.11. The proportion of bone fragments in house floors and occupation surfaces is considerably lower than in open areas, varying from 2% to 15% abundance. Again, most of the bone micro-assemblage is formed by charred fragments, with few instances of intact and calcined remains. Burnt and unburnt bones are adjacent to each other, frequently randomly distributed and oriented, which indicates secondary deposition, likely as part of trampled hearth sweeps. The widespread occurrence of heated bone micro-remains, especially in and around fire installations, might be consistent with the hypothesis of marrow consumption by the Boncuklu population, a possibility that has already been suggested by the faunal team (Baird *et al.* 2014).

Shell fragments have been identified in a number of building and open contexts, although almost consistently in low proportions. Midden deposits are characterised by approximately 3% of relatively large remains (0.5-4mm in size) of charred and calcined eggshells, with freshwater molluscs representing only 1% of these contexts. In the occupation remains of Building 12, the shell micro-assemblage is again dominated by very small (below 1.2mm in size) egg remains, at least 80% of which have been heated. Shell occurrence ranges from 2% to 5% in the accumulated residues found in the north-western floors of this buildings, consisting mainly of trampled hearth rake-outs. The sequence of floors of Sample 380, collected from the south-east of Building 12, by contrast, is completely devoid of shell micro-fragments, a pattern also observed in the clean areas of Building 6 and Structure K (Goodyear 2012). Interestingly, the very few shell remains (1% abundance) found in non-standard structures (Building 16/23) appear to consist almost exclusively of freshwater mollusc species, in marked contrast with the ubiquity of eggshell fragments in most contexts. The majority of mollusc and eggshell remains studied in thin-section consistently display signs of burning, suggesting their introduction into the site as food sources that were later cooked and discarded. The total abundance of shell remains in fire installations ranges between 2% and 5%, with egg and mollusc fragments occurring in similar proportions in these features.

The microscopic examination of archaeological deposits at Boncuklu has established plant remains as the most common type of anthropogenic residue, comprising 10-30% of occupation layers in the eastern half of buildings, and 25-80% of deposits in open areas. In terms of anatomy, a range of husk, stem, leaf, and to a lesser extent seed elements have been identified. These have been largely preserved in the form of charred and siliceous remains, with calcareous ashes and pseudomorphic voids attesting the presence of plant materials in hearth infills and plaster floors, respectively.

Wood charcoal has only been safely detected as part of the collapsed roofing materials of Building 16 forming a finely laminated layer immediately on top of the last occupation surfaces, although the poor preservation of the microstructure of these remains has prevented species identification. Fibrous charred plants are extremely fragmented throughout all contexts, ranging in size from 50μm to 2.5mm but usually consisting of flecks under 0.5mm, which render their identification to species almost impossible. Their ubiquity in both building interiors (dirty floors around hearths) and middens at this site is the main responsible for the striking similarity of these deposits. While the origin of the vast majority of charred plants at

Boncuklu can be traced back to fuel sources – trampled rake-outs in dirty floors and sweeping discards in middens – other origins such as discarded food sources, or re-used matting and structural elements, cannot be completely ruled out.

Siliceous plant remains are generally well-preserved and often highly articulated, forming leaf and stem epidermises with stomata, stacked bulliform cells, husks, and both long and short cells, the vast majority of which are derived from monocotyledon reeds and grasses. Phytolith remains of cereal-like epidermises have been identified in Building 16, although it has not yet been possible to indisputably distinguish them morphologically as cultivated grasses, partly because, in spite of their good preservation and articulation, phytoliths are often difficult to assess in thin-section. The visibility of siliceous plant remains, especially the smaller types, is hindered in micromorphological slides due to the superposition of other materials, such as fine organic matter or occluded black carbon (Shillito 2013), and the orientation they display in thin-section, which might not show diagnostic anatomical features. Although the degree of articulation of these remains is a good indicator of *in situ* activities, such as crop dehusking, phytolith extraction is required to accurately quantify the full range of plant species and anatomic parts present in a specific deposit.

Vesicular aggregates of melted silica, approximately 0.5 mm in size, have been found in low numbers (*ca*. 1% occurrence) in ashy midden and hearth contexts. These inclusions commonly form after the melting of siliceous plant remains at very high temperatures. Although the melting point of pure silica is 1713ºC and it is unlikely that fires at Boncuklu consistently reached these extreme temperatures, the presence of alkaline salts would have contributed to decreasing the melting point of siliceous plant remains (*ca*. 800ºC; Canti, 2003).

Fragmented endocarps derived from hackberry fruit stones have been encountered in low proportions in both building and midden contexts, commonly charred. These plant inclusions, usually well-preserved due to their calcareous nature, are very abundant in Neolithic settlements from Central Anatolia (Asouti and Fairbairn 2002). At Boncuklu, they are present (*ca*. 2% abundance) in rake-outs and accumulated deposits, likely derived from cooking activities.

### 4.2.4 Post-depositional alterations

Post-occupational disturbances of archaeological deposits at Boncuklu had already been noted during excavation (Baird *et al.* 2012b). These include bioturbation caused by root action and animal burrowing, re-precipitation of gypsum salts, deposition of calcite in pores, and truncation and reworking of the uppermost occupation levels by trampling, largely caused by modern agricultural practices.

The effects of sediment mixing by ground mammals have been readily observed in the field as networks of burrows infilled with materials from other levels. Soil mesofauna, such as insects, produce additional burrows that, despite often being more destructive for the archaeology, are commonly undetected at the macroscale (Stein 1983). These are manifested in the micromorphological samples from Boncuklu as crescentic passage features, channels, and chambers. The boundaries of these features are easily detected in thin-section, sometimes occurring as areas of highly porous or crumby groundmass, and their presence, although high in some contexts (ranging between 10-35% abundance), especially in those with a considerable proportion of organic components such as middens, has not precluded the substantial preservation of the finely stratified prehistoric depositional sequences.

These faunal bioturbation features occur frequently at Boncuklu in association with other post-depositional alterations, such as gypsum re-precipitation. Gypsum infillings are a frequent pedofeature in arid and semi-arid regions, as its crystallisation from gypsum-saturated groundwater requires an evaporative regime (Herrero and Porta 2000). These salts are present in moderate proportions (2-10% abundance) in channels and chambers as infillings of loose lenticular crystals, coarse to fine sand in size, or as xenotopic aggregations. This type of slow-growing crystals is commonly found when the presence of organic components in the deposits is high (Cody 1979), such as in the case of Boncuklu, where both interior and exterior areas contain abundant charred organic materials of plant origin.

By contrast, calcitic pedofeatures such as hypocoatings in voids are formed by the rapid precipitation of calcium carbonates from percolating water due to root metabolism (Durand *et al.* 2010). At Boncuklu, these post-depositional alterations are rare and weakly developed, which entails that the fabric of the groundmass has remained largely undisturbed.

Trampling has played a prominent role both in forming archaeological deposits through the compaction of accumulated residues on occupation surfaces (Gé *et al.* 1993), and in the post-depositional modification of floor plasters and other deposits at Boncuklu. The impact of trampling on archaeological deposits depends on its intensity and on particular attributes determining the nature of the impact surface, such as particle size, chemical constituents, and moisture content (Schiffer 1987). At Boncuklu, the most significant effects of trampling are evident in the embedding of mineral and organic residues into occupation surfaces through compaction, and in the fragmentation and transfer of floor plaster materials. Mechanical pressure, as well as the shrinking and swelling of the clay minerals present in the marl plasters, contributed to the occurrence of sub-horizontal fissures in these layers, ultimately resulting in the detachment and re-deposition of plaster crumbs (Gifford-Gonzalez *et al.* 1985).

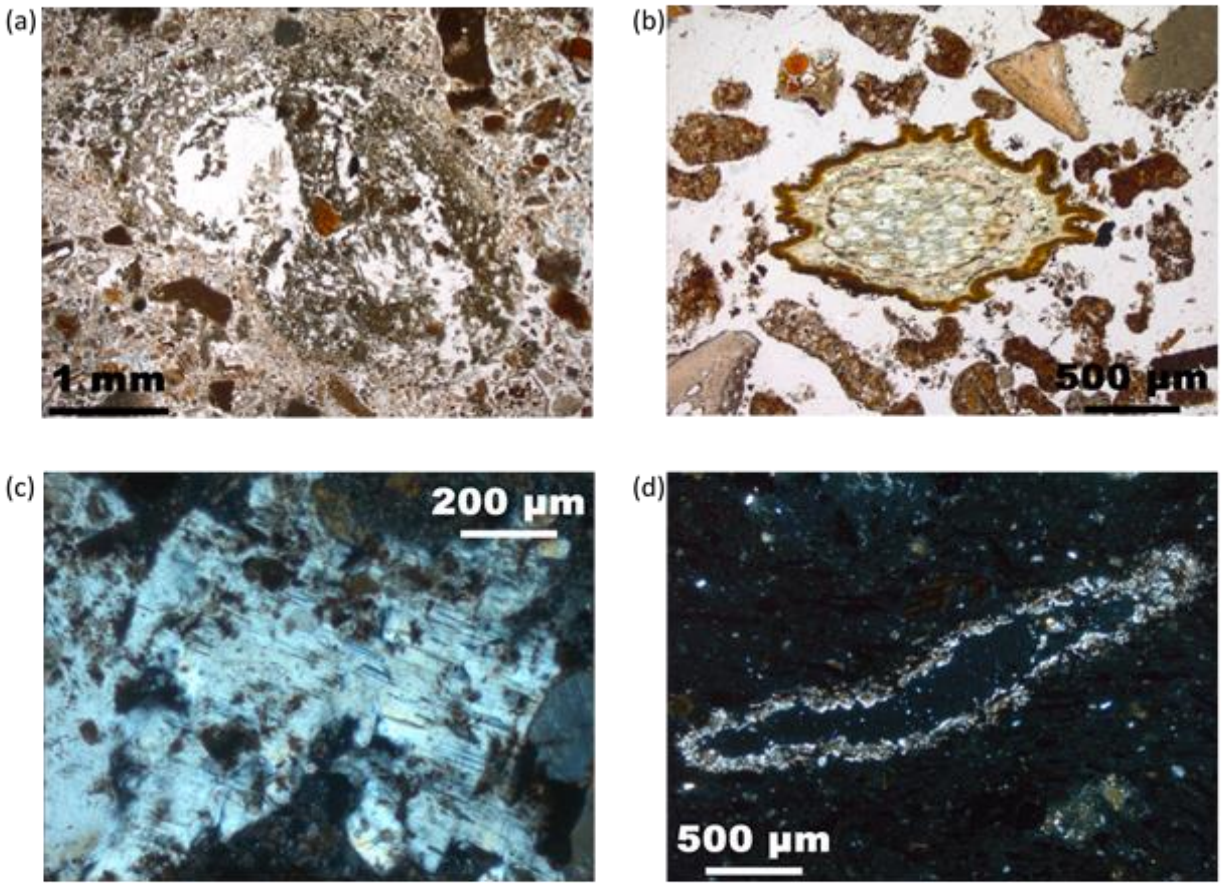



**Figure 4.13** Photomicrographs of post-depositional alterations: a) crescentic passage feature produced by soil fauna, PPL; b) section of modern root within bioturbated groundmass, PPL; c) xenotopic gypsum crystals, XPL; d) coating of sparitic calcite in channel, XPL.

All in all, the most severe post-occupational disturbance affecting the site has been, by far, the bulldozing of the mound, which was responsible for the removal of the Bronze Age and uppermost Neolithic deposits (Baird *et al.* 2012b). The beginning of the archaeological field project in 2006 put an end to these practices, preserving the 9th-8th millennium occupation layers that, despite having been subject to pedogenetic processes, prominently bioturbation, remain substantially undisturbed, as the micromorphological analysis of these finely stratified deposits has confirmed.

## 4.3 Infra-Red and X-Ray Spectroscopy

The chemical composition of architectural materials at Boncuklu has been further investigated through the analysis of the collapsed roofing remains of Building 16, and a sequence of well-preserved plastered floors and dirty occupation surfaces in Building 12 with XRF, XRD, and bulk FTIR techniques. Due to the very limited sample pool, comprising eight sub-samples extracted from key contexts identified during the micromorphological analysis of blocks 365 and 373, this is a pilot geochemical study, principally aimed at: 1) exploring choices of construction materials, 2) investigating the preservation conditions of these remains, and 3) establishing the potential of these high-resolution compositional studies for understanding early Neolithic architectural technologies and concepts of space at Boncuklu.

Two different sample preparation procedures were followed for XRF, as described in Chapter 3: glass beads and loose pellets. Both methods supplied strikingly similar results, so a decision was made to process only the analytical data obtained from the analysis of the loose pellets on two grounds: 1) that this preparation did not involve the substantial modification of the sample through calcination, melting, and the addition of flux; and 2) to demonstrate that the level of accuracy necessary for the analysis of archaeological sediments can be achieved with simpler sample preparation methods. The complete XRF dataset can be found in the Appendices included in the DVD-ROM.

The processing of XRF results involved the normalisation of the data following standard calculations, with main components expressed in weight percentages (wt%), and trace elements reported in parts per million (ppm).

XRD and FTIR results from the same samples have been interpreted in a qualitative rather than a quantitative way, complementing the detailed compositional data obtained through XRF by determining the presence or absence of specific compounds and molecules.

### 4.3.1 Occupation surfaces

The deposits analysed in Building 12 comprise calcareous floors, classified as deposit sub-type BK2b following micromorphological description and characterisation, and living surfaces constituted by accumulated organic remains of plant origin (deposit sub-types BK4a and BK4b), and sediment aggregates (BK4c). These deposits have been critically selected for chemical characterisation in order to investigate differences in elemental composition.

The XRF results, summarised in Table 4.11, highlight the remarkable similarity of building deposits at Boncuklu. The analysis has not succeeded in detecting significant variations in elemental composition between the samples classified as accumulated deposits of phytolith remains (BK4a), charred and siliceous plant residues (BK4b), and minerogenic aggregates (BK4c), indicating the high degree of mixture of these layers or, alternatively, cross-contamination during section sub-sampling. The two samples of floor plaster analysed (BK2b), also display consistent results regarding chemical compositions, although more variation is evident in the proportion of specific elements, such as silicon, calcium, aluminium, or strontium.

| Sample | Deposit type | wt% SiO2 | wt% CaO | wt% Al2O3 | wt% P2O5 | wt% Fe2O3 | wt% K2O | wt% MgO | wt% Na2O | wt% TiO2 | wt% MnO | wt% SO3 | wt% Cl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **BK373_1** | BK4c | 77,33 | 11,88 | 1,71 | 2,83 | 1,65 | 1,75 | 1,33 | 0,32 | 0,12 | 0,09 | 0,63 | 0,34 |
| **BK373_2** | BK4a | 77,61 | 12,36 | 1,40 | 2,83 | 1,48 | 1,71 | 1,14 | 0,30 | 0,11 | 0,08 | 0,63 | 0,34 |
| **BK373_3** | BK4b | 79,44 | 11,80 | 1,11 | 2,53 | 1,12 | 1,49 | 1,22 | 0,26 | 0,08 | 0,11 | 0,54 | 0,30 |
| **BK373_4** | BK2b | 69,26 | 18,63 | 1,77 | 3,76 | 1,73 | 1,65 | 1,64 | 0,31 | 0,13 | 0,11 | 0,67 | 0,35 |
| **BK373_6** | BK2b | 60,92 | 26,11 | 2,36 | 3,05 | 2,22 | 1,76 | 1,99 | 0,33 | 0,20 | 0,09 | 0,70 | 0,27 |

| Sample | Deposit type | ppm Sr | ppm Zn | ppm Ni | ppm Zr | ppm Rb | ppm Cu | ppm Br |
|---|---|---|---|---|---|---|---|---|
| **BK373_1** | BK4c | 570 | 325 | 53 | 52 | 14 | 38 | 76 |
| **BK373_2** | BK4a | 575 | 328 | 51 | 16 | 15 | 0 | 75 |
| **BK373_3** | BK4b | 573 | 218 | 38 | 8 | 11 | 61 | 81 |
| **BK373_4** | BK2b | 789 | 321 | 44 | 20 | 15 | 68 | 59 |
| **BK373_6** | BK2b | 1010 | 213 | 70 | 43 | 10 | 54 | 64 |

**Table 4.11** Normalised X-ray Fluorescence results from the analysis of plastered floors and occupation surfaces in Building 12, Sample 373.

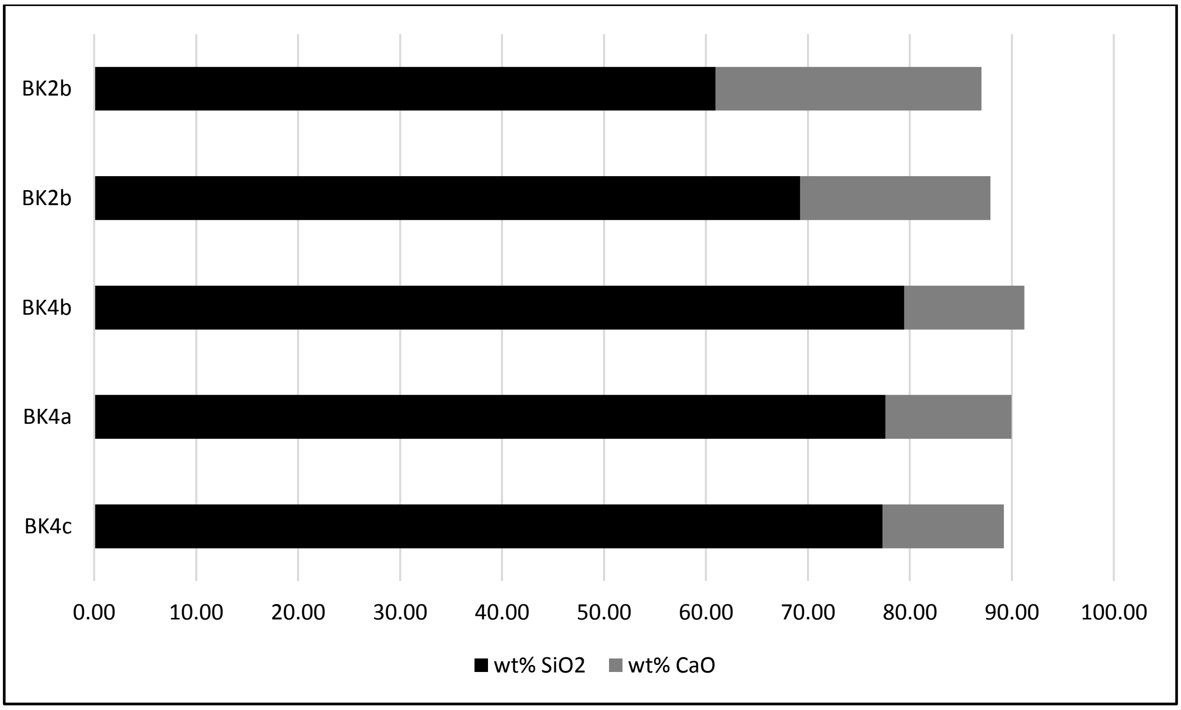



**Figure 4.14** Graph displaying the weight percentage (wt%) of $SiO_2$ and CaO in each of the building samples analysed. Notice the higher content of calcium in the floor plasters, BK2b.

Overall, the calcareous floor plasters analysed have a higher content of calcium than the accumulated residues (see Fig. 4.14). Magnesium values, however, are consistently low, which excludes the presence of dolomite and the addition of softlime to these plasters (Matthews *et al.* 2013). The moderate levels of phosphorus, strontium, and zinc seen in these deposits at Boncuklu can either relate to the geological background of the site, or be the result of the intensity of human activities in these contexts (Middleton and Price 1996). A definitive interpretation of chemical differences is complicated as the patterns seen above could relate to the behaviour of elements in soils. For example, the abundance of charred plants and bone in archaeological deposits, such as in the case of occupation layers at Boncuklu, has been observed to be positively correlated to the retention of calcium, phosphorus, strontium, and zinc in those layers (Wilson *et al.* 2008).

XRD analyses identified the presence of muscovite, hornblende, quartz, plagioclase feldspar, aragonite, and small quantities of chlorite in both deposit types analysed, accumulated units (BK4, see Figure 4.15 below), and plaster floors (BK2, see Figure 4.16 in the next page). Post-depositionally formed salts comprising gypsum are more abundant in the BK4 deposits, whereas the carbonate mineral calcite dominates the XRD spectrum of the plaster unit, as it would have been expected from a floor layer manufactured with marl sediments (Anderson *et al.* 2014a).

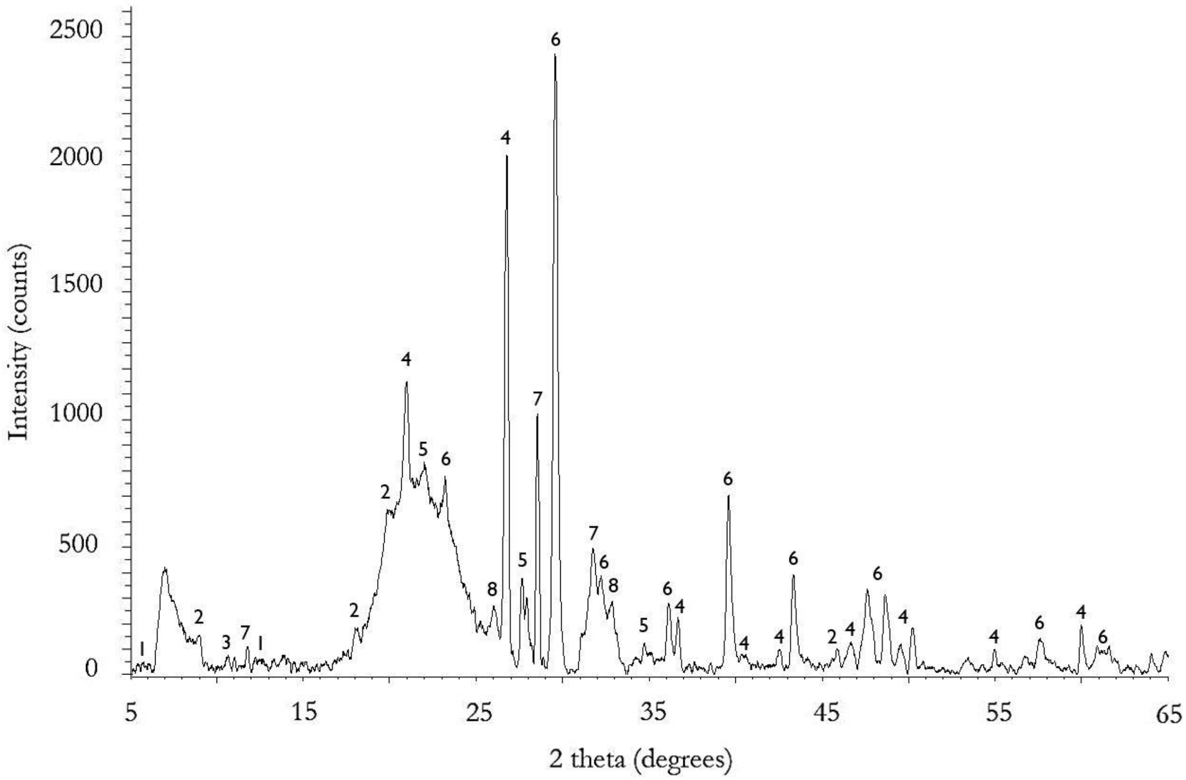



**Figure 4.15** XRD pattern of deposit sub-type BK4c, accumulations of sediment aggregates, from Building 12 at Boncuklu: 1-chlorite, 2-muscovite, 3-hornblende, 4-quartz, 5-plagioclase feldspar, 6-calcite, 7-gypsum, 8-aragonite.

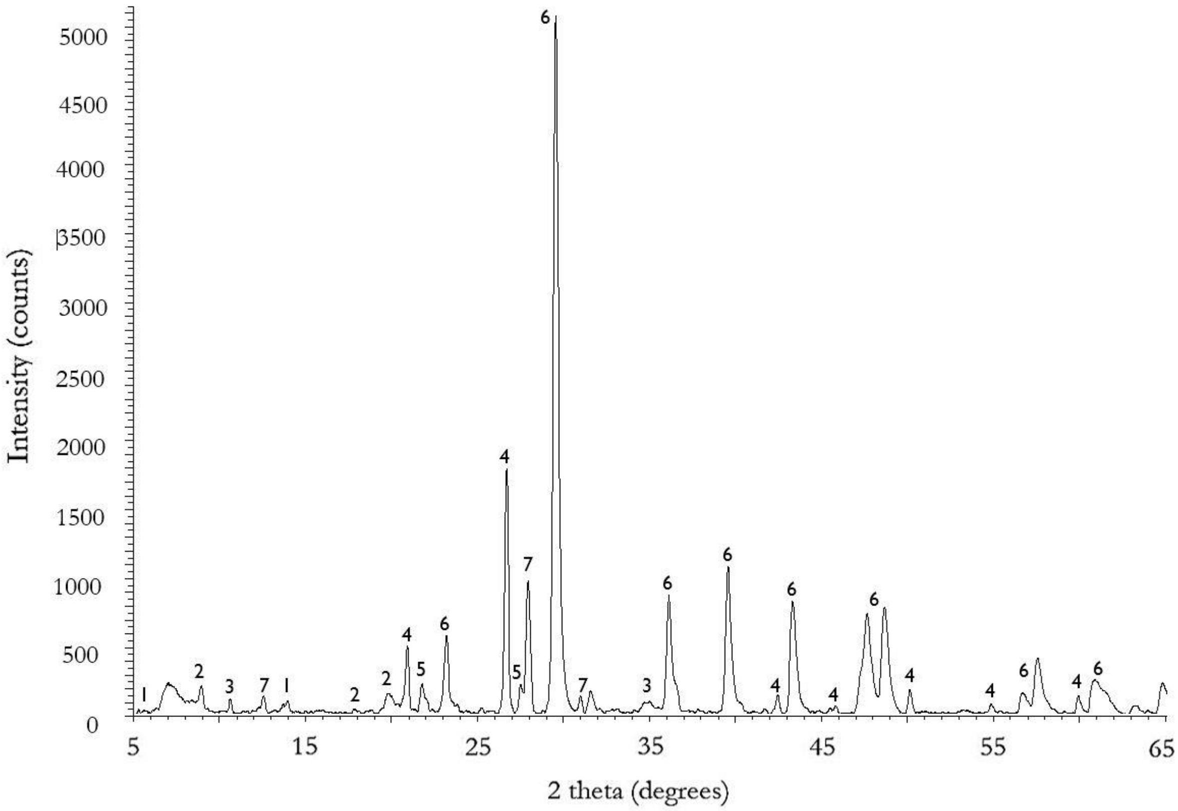



**Figure 4.16** XRD pattern of deposit sub-type BK2b, marl plaster floors from Building 12 at Boncuklu: 1-chlorite, 2-muscovite, 3-hornblende, 4-quartz, 5-plagioclase feldspar, 6-calcite, 7-gypsum.

Overall, deposit type BK4c, in spite of being substantially minerogenic, displays a greater compositional heterogeneity than the floor plasters, a result of the number of anthropogenic inclusions embedded in these deposits. Accumulated layers also appear more affected by post-depositional salt re-precipitation (gypsum and halite) than the constructed deposits.

The IR spectra of the spot samples comprising loose sediment from both accumulated residues and floor plasters (see Figure 4.17 in the next page) have produced similar data to that obtained through XRF and XRD methods. The analysis has allowed the detection of calcite as a major component of occupation surfaces at Boncuklu, being especially abundant in floor plasters, which were likely manufactured from marl outcrops near the site. Significantly, the IR spectra do not show evidence for a substantial presence of clay in these samples, in spite of the fact that the settlement at Boncuklu lies within an alluvial sequence rich in mud sediments. Other peaks correspond to the quartz grains found embedded in most units at this site, and to gypsum salts that are post-depositional in origin, as concluded after the micromorphological observation of these layers (see section 4.2.4),. The occurrence of this mineral in archaeological layers at Boncuklu is therefore dependent upon the environment each deposit was exposed to during and after the Neolithic occupation.


**Figure 4.17** IR spectra of deposit sub-types BK4c, accumulations of sediment aggregates, and BK2b, floor plasters. Both samples were collected from Building 12, in Trench H, at Boncuklu.

<table>
<tr><th colspan="2">Wavenumber ($cm^{-1}$)</th><th rowspan="2">Mineral</th></tr>
<tr><th>BK4c</th><th>BK2b</th></tr>
<tr><td>3405</td><td>3403</td><td>Water</td></tr>
<tr><td>-</td><td>1798</td><td>Calcite</td></tr>
<tr><td>1630</td><td>1622</td><td>Water</td></tr>
<tr><td>1419</td><td>1412</td><td>Calcite</td></tr>
<tr><td>1033</td><td>1026</td><td>Clay</td></tr>
<tr><td>871</td><td>872</td><td>Calcite</td></tr>
<tr><td>795</td><td>797</td><td>Quartz</td></tr>
<tr><td>779</td><td>777</td><td>Quartz</td></tr>
<tr><td>-</td><td>713</td><td>Calcite</td></tr>
<tr><td>601</td><td>602</td><td>Gypsum</td></tr>
</table>

**Table 4.12** Wavenumber values and mineral assignments for the main peaks in the IR spectra of occupation surfaces (trampled residues and plaster floors) from Boncuklu.

### 4.3.2 Collapsed materials

The collapsed materials analysed correspond to the structural remains of Building 16, a non-standard built environment surrounded by open areas uncovered in Trench M. The micromorphological analysis of these materials revealed that these deposits, originally the mud roof of Building 16, had sustained high temperature burning and substantial post-collapse reworking.

The XRF results of these materials, reported in Table 4.13, indicate a very high content of calcium oxide, likely due to the abundance of calcitic ashes embedded in these deposits, as determined through micromorphology. Collapsed materials also have noticeable higher values of aluminium, phosphorus, iron, potassium, and strontium than the occupation surfaces of standard buildings. Although high levels of phosphorus in archaeological deposits are often associated with anthropogenic activity areas (Terry *et al.* 2004), the presence of this element in collapsed roofing materials is probably the result of post-depositional ion fixation due to the slightly higher content of iron and aluminium compounds in these deposits (Parnell *et al.* 2002). In addition, the higher concentration of sulphate minerals in these materials is likely to be the result of secondary gypsum accumulations.

| Sample | Deposit type | wt% SiO2 | wt% CaO | wt% Al2O3 | wt% P2O5 | wt% Fe2O3 | wt% K2O | wt% MgO | wt% Na2O | wt% TiO2 | wt% MnO | wt% SO3 | wt% Cl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **BK365_1** | BK5a | 45,43 | 31,34 | 3,64 | 6,20 | 2,57 | 2,76 | 2,01 | 0,45 | 0,27 | 0,08 | 4,49 | 0,77 |
| **BK365_2** | BK5b | 42,14 | 34,63 | 5,35 | 4,73 | 3,56 | 3,46 | 1,91 | 0,58 | 0,40 | 0,08 | 2,69 | 0,48 |
| **BK365_3** | BK5b | 46,63 | 31,03 | 5,00 | 3,92 | 3,40 | 3,31 | 2,26 | 0,46 | 0,38 | 0,08 | 3,14 | 0,39 |

| Sample | Deposit type | ppm Sr | ppm Ba | ppm Zn | ppm Cr | ppm Ni | ppm Zr | ppm Rb | ppm Cu | ppm Br | ppm As |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **BK365_1** | BK5a | 1191 | 0 | 206 | 0 | 74 | 52 | 18 | 37 | 38 | 13 |
| **BK365_2** | BK5b | 1228 | 473 | 212 | 45 | 77 | 64 | 30 | 49 | 0 | 0 |
| **BK365_3** | BK5b | 999 | 823 | 211 | 45 | 78 | 57 | 31 | 46 | 41 | 0 |

**Table 4.13** Normalised X-ray Fluorescence results from the analysis of the collapsed materials of Building 16 in Trench M, Sample 365.

XRD results for deposit sub-type BK5b, consisting of rubefied structural debris of calcareous origin, indicate very high levels of calcite, which could be due to both the nature of the material, and the abundance of calcitic ashes in these layers. Aragonite, a polymorph of calcite often occurring as re-precipitated formations in sediments and found in certain types of shell, has also been identified in these deposits. Other minerals include quartz, muscovite, hornblende, and plagioclase feldspar. The moderate abundance of gypsum salts has also been detected through XRD. Surprisingly, traces of dolomite are also present in these collapsed remains, which suggests the occurrence of small amounts of softlime, possibly added to the marl sources that appear to have been preferentially selected for the production of these construction materials during the manufacture process.

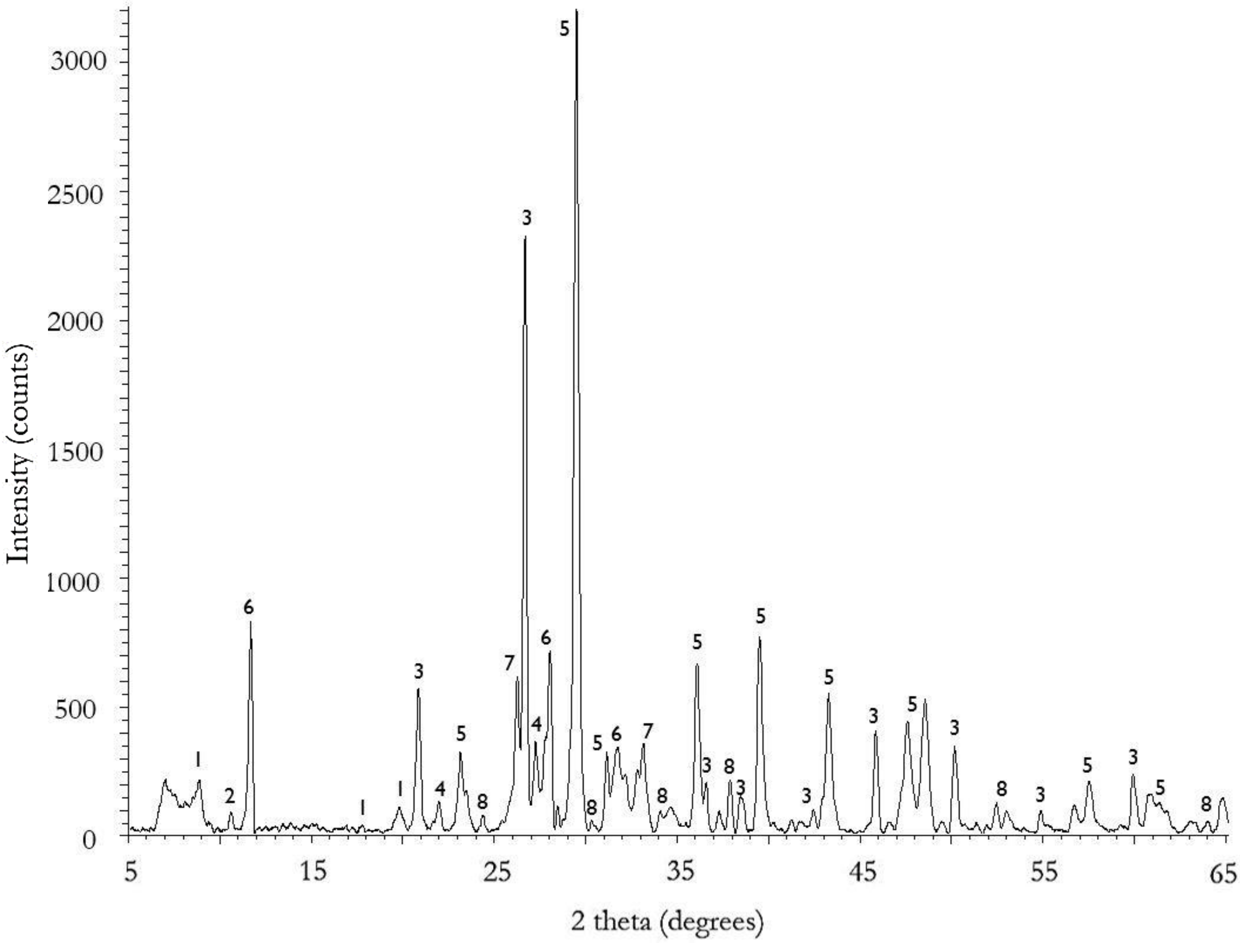



**Figure 4.18** XRD pattern of deposit sub-type BK5b, collapsed roofing materials from Building 16 at Boncuklu: 1-muscovite, 2-hornblende, 3-quartz, 4-plagioclase feldspar, 5-calcite, 6-gypsum, 7-aragonite, 8-dolomite.

The IR spectrum of deposit sub-type BK5b (Figure 4.19 in the next page), displays intense peaks for calcite/dolomite, indicating a high concentration of these minerals. Further, in contrast with the floor plasters and occupation surfaces of buildings, collapsed materials contain a substantial proportion of clays. Although different classes of clay minerals can be readily identified in IR spectra if there is just one type present in the sample, this is often not the case with archaeological deposits, which comprise a mixture of sediments and components of various origins. This means that it is frequently difficult to assign IR bands to specific clay minerals with accuracy when analysing archaeological materials (Farmer 1974; Weiner 2010). Nevertheless, the peaks identified in the sample studied suggest the possible presence of illite (peak value 1020 $cm^{-1}$), and montmorillonite (peak value 854 $cm^{-1}$), both of which are two of the most common clay minerals in sediments (Van der Marel and Beutelspacher 1976). It remains unclear, however, whether the presence of clays in these collapsed materials is due to the nature of the original sediment sources used in the manufacture of the roof structure of Building 16, or rather the result of post-depositional soil intrusions. The IR spectrum has also revealed the presence of quartz and gypsum minerals in the sample, in addition to a less intense peak corresponding to phosphate, probably caused by the presence of bone fragments and phosphatic aggregates in this deposit.

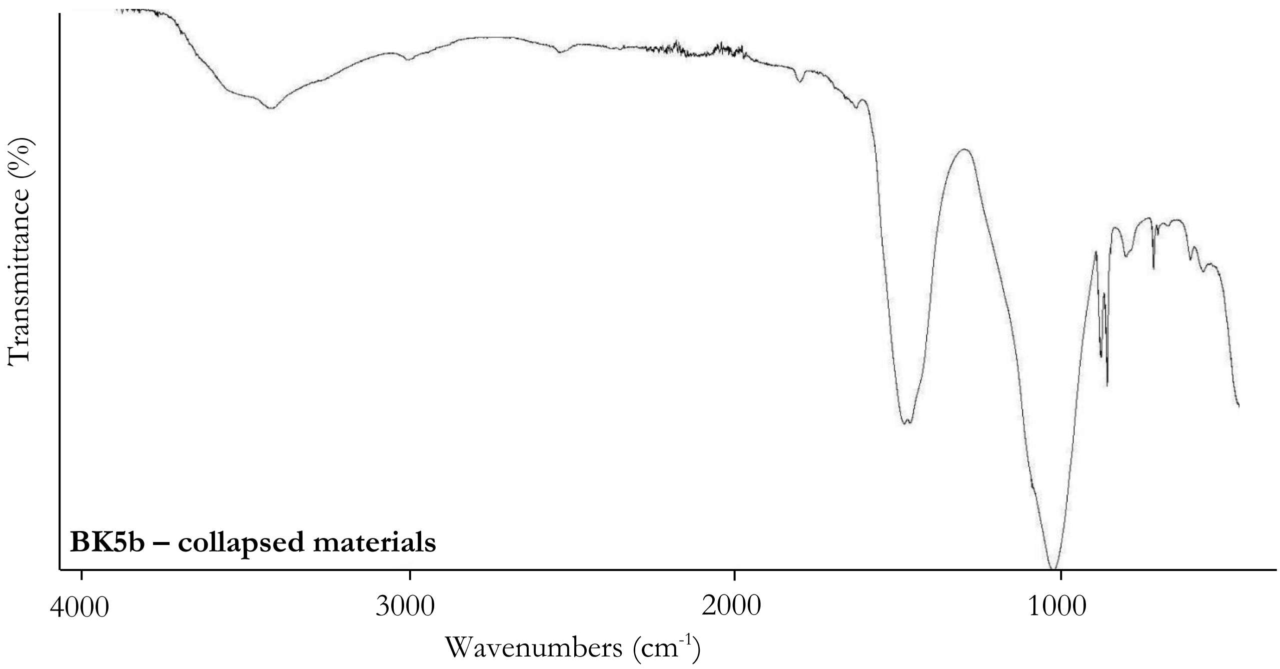



**Figure 4.19** IR spectra of deposit sub-type BK5b, collapsed structural materials from Building 16, in Trench M, at Boncuklu.

| Wavenumber ($cm^{-1}$) | Mineral |
|---|---|
| 3402 | Water |
| 2524 | Calcite/Dolomite |
| 1792 | Calcite/Dolomite |
| 1622 | Water |
| 1448 | Calcite/Dolomite |
| 1020 | Clay |
| 873 | Calcite/Dolomite |
| 854 | Clay |
| 798 | Quartz |
| 714 | Calcite |
| 699 | Quartz |
| 668 | Gypsum |
| 601 | Gypsum |
| 561 | Phosphate |

**Table 4.14** Wavenumber values and mineral assignments for the main peaks in the IR spectrum of collapsed structural materials (likely roofing remains) from Boncuklu.

## 4.4 SEM-EDX AND IR MICROSCOPY

Targeted SEM-EDX and FTIR analyses were carried out on micromorphological thin-sections to characterise particular components and investigate the mineralogy of individual microunits, thus aiding in the interpretation of formation processes and post-depositional alterations at Boncuklu.

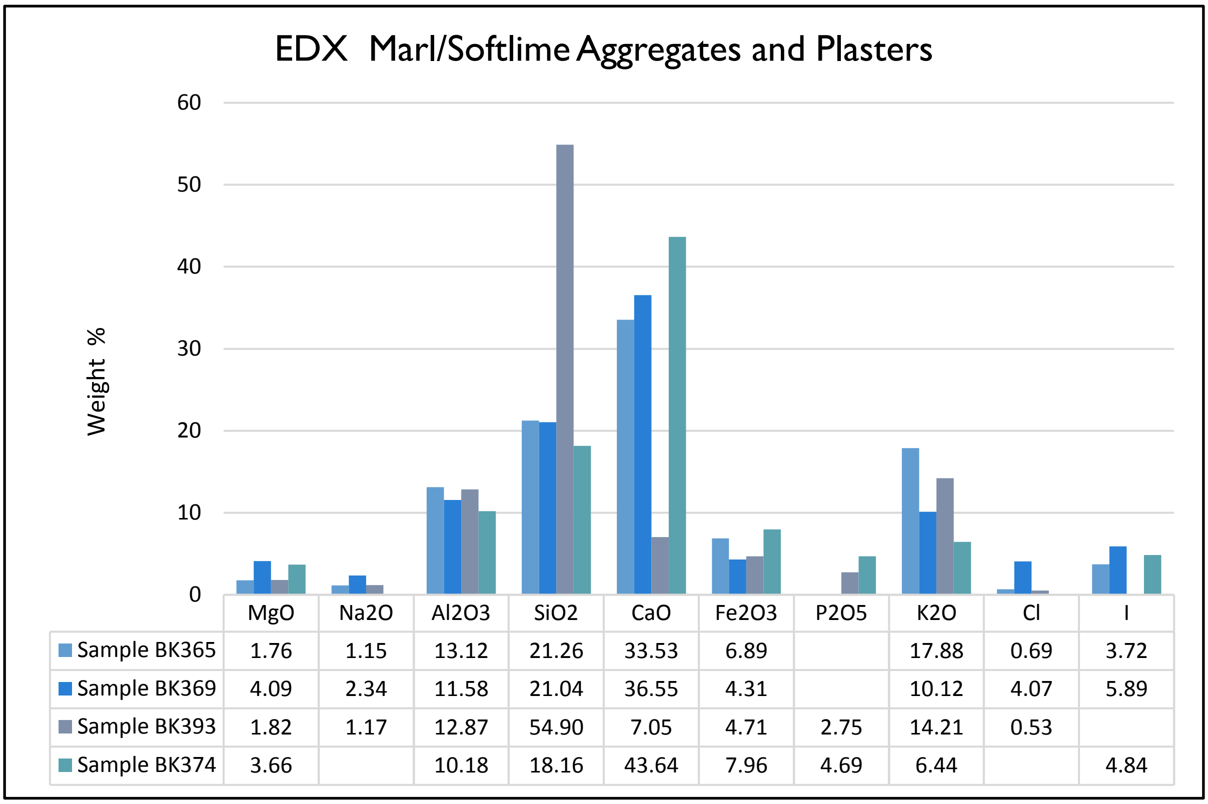
EDX elemental data has been converted to oxides, a standard practice for soil and sediment samples, and normalised. Approximately three points were obtained for every component/ layer analysed, and the mean was subsequently calculated for every sample. The original and transformed EDX data can be found in the Appendix included in the DVD-ROM.

Two types of materials have been studied: inorganic aggregates, mainly comprising sediment aggregates and building plasters, and organic inclusions that can be difficult to characterise on the sole basis of micromorphological observations, such as faecal matter and altered bone. IR microscopy, in particular, has proven a very useful technique in the past for determining the causes of minerological changes frequently observed in bone and shell microremains, including diagenesis and burning (Weiner 2010; Weiner *et al.* 1993).

### 4.4.1 INORGANIC AGGREGATES AND DEPOSITS

Figure 4.20 in the next page summarises the chemical composition of the inorganic components and layers analysed. It is important to note that carbon has been deliberately excluded in this table as it was found to be overrepresented in the EDX results due to the effect of the epoxy resin used in the production of the thin-sections. Two control points of the resin in which the samples are embedded were obtained during analysis, showing that this material is mainly constituted by carbon and trace amounts of chlorite, as seen in Figure 4.21. Unfortunately, this means that all the EDX data obtained from the analysis of the thin-sections have a marked skewness towards carbon. As this element was not expected to be detected in inorganic materials, it has been excluded in the results from these samples, which has involved a re-normalisation of the data. This procedure entails that the elemental proportions presented in the graphs are more representative of the actual composition of the materials targeted.

What stands out from the microanalytical EDX results is the high content of silicon dioxide present in the plasters of Building 23 (Sample BK393). These fine floors were described as




| | MgO | Na2O | Al2O3 | SiO2 | CaO | Fe2O3 | P2O5 | K2O | Cl | I |
|---|---|---|---|---|---|---|---|---|---|---|
| Sample BK365 | 1.76 | 1.15 | 13.12 | 21.26 | 33.53 | 6.89 | | 17.88 | 0.69 | 3.72 |
| Sample BK369 | 4.09 | 2.34 | 11.58 | 21.04 | 36.55 | 4.31 | | 10.12 | 4.07 | 5.89 |
| Sample BK393 | 1.82 | 1.17 | 12.87 | 54.90 | 7.05 | 4.71 | 2.75 | 14.21 | 0.53 | |
| Sample BK374 | 3.66 | | 10.18 | 18.16 | 43.64 | 7.96 | 4.69 | 6.44 | | 4.84 |

**Figure 4.20** Elemental composition of heated marl (Sample BK365), unburnt marl lining of external hearth in Trench N (Sample BK369), plaster floor in Building 23 manufactured from calcareous sediments (Sample BK393), and scorched floor in main hearth of Building 12, Feature 171 (Sample BK374).

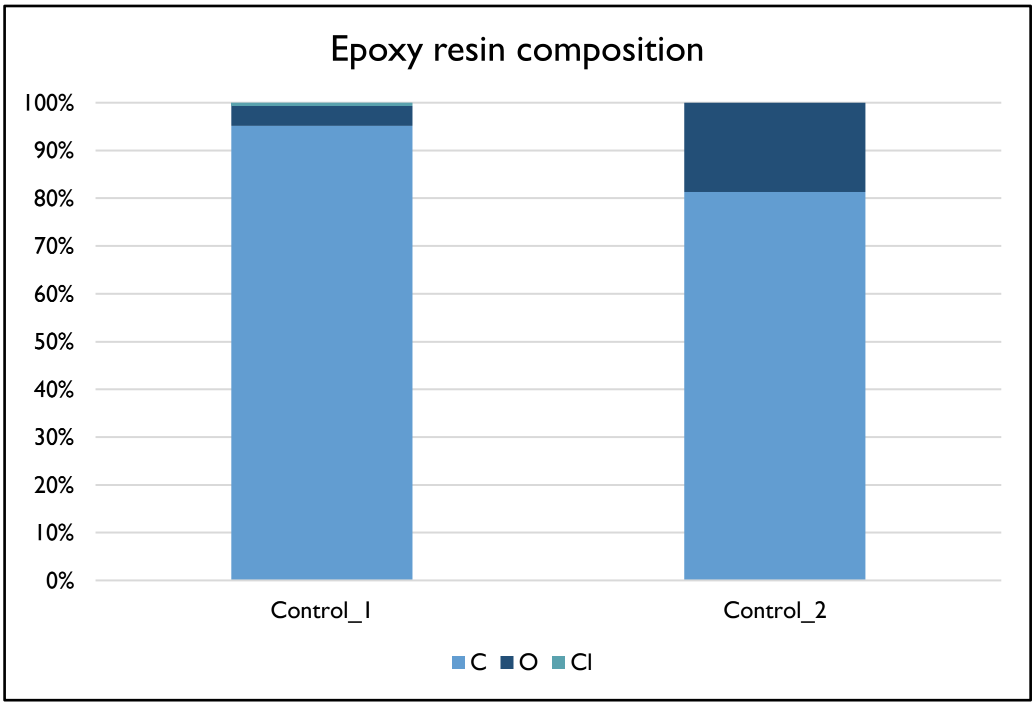



**Figure 4.21** Chemical composition of the epoxy resin used for the impregnation of micromorphological sediment blocks as sampled from the finished slides. These resins are often highly cross-linked polymeric materials derived from petroleum sources and containing many OH groups, which confer adhesive properties.

marl-based, during micromorphological observations (see section 4.2.1.2), although the elemental data reveal a low content of calcite, especially when compared to Samples BK365 and BK369, both very fine marl. These results are similar to those obtained from the XRF analysis of the clean plasters of Building 12, reported in section 4.3.1 above. Although the abundance of quartz silt- and sand-size particles and the occurrence of plant phytoliths in these deposits could partly explain these peaks in silicon, it is likely that that these plasters are actually the result of a mixture of marl and silty clay sediments.

The high calcitic content of Sample BK374, a scorched floor within hearth Feature 171, is probably representative of both the calcareous nature of the source materials used for the manufacture of this surface, but also of the presence of accumulated ashes, especially when considering the high degree of reworking observed in these deposits.

IR point spectra of the aggregate in Sample BK365 and the calcareous floor plaster of Sample BK393, presented in Figure 4.22, also indicate a different mineralogical composition. The intense peaks for calcite in the sediment aggregate, in addition to the absence of dolomite, are suggestive of a marl origin. By contrast, the most intense peak in the floor deposit corresponds to clay, although a significant presence of calcite (1414 $cm^{-1}$ and 871 $cm^{-1}$) has also been recorded. Secondary peaks for quartz indicate the presence of this mineral, also identified as embedded grains during the micromorphological analysis of the samples.

Overall, the microanalytical results of inorganic aggregates and fine plasters at Boncuklu have revealed the mixed origin of the latter, which were probably produced through the combination of marl and fine alluvial sediments extracted from the vicinity of the site.

| Wavenumber ($cm^{-1}$) | | Mineral |
|---|---|---|
| Marl | Floor | |
| 3628 | 3625 | Clay |
| 1410 | 1414 | Calcite |
| 1161 | 1165 | Clay/Quartz |
| 1000 | 1007 | Clay |
| - | 911 | Clay |
| 872 | 871 | Calcite |
| 793 | 796 | Quartz |
| 774 | 776 | Quartz |
| 711 | 710 | Calcite |
| - | 690 | Quartz |
| - | 534 | Clay |

**Table 4.15** Wavenumber values and mineral assignments for the main peaks in the IR spectra of marl aggregates and calcareous floor plasters from Boncuklu.

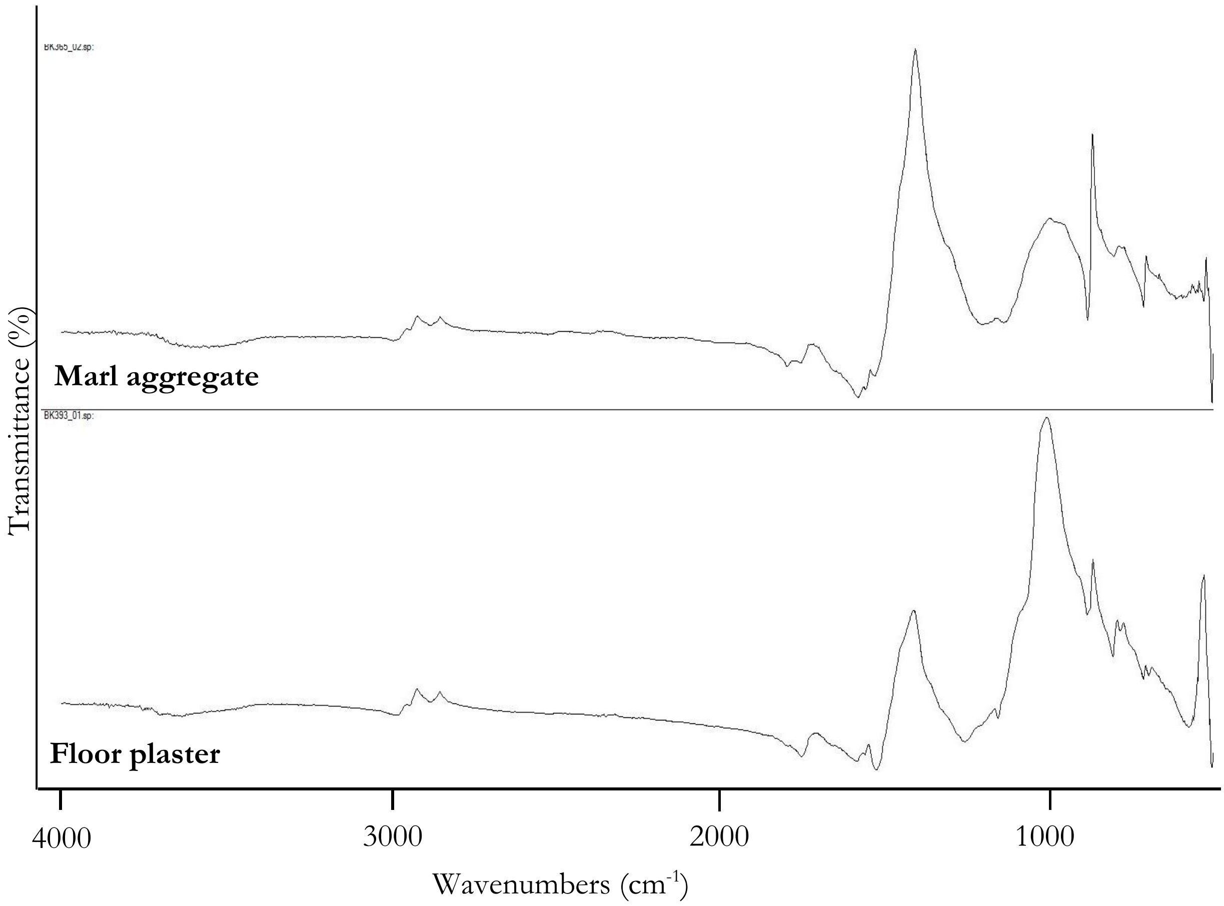



**Figure 4.22** IR spectra of marl aggregate embedded in the collapsed structural materials of Building 16, and calcareous floor plaster in Building 23, at Boncuklu.

### 4.4.2 Organic inclusions

The microanalysis of organic residues at Boncuklu has focused on faecal materials found in abundance in the south-western area of Trench M. Accumulated midden deposits in this open space contain numerous yellowish-brown to orangish-brown inclusions suspected of being coprolites. Although GC-MS is the most unambiguous method to characterise faecal residues, it has been demonstrated that other techniques, such as SEM-EDX and IR spectroscopy, serve to determine the presence of key minerals in the samples and can therefore be used as screening methods of archaeological materials prior to conducting more expensive and time-consuming analyses, such as GC-MS or GC-FID (Shillito 2009b).

Micromorphological observations have determined the occurrence of two different types of faecal aggregates in Trench M: suspected omnivore coprolites, formed by a dense phosphatic mass containing bone and phytolith inclusions, and suspected carnivore coprolites, consisting of a more or less amorphous mass of bones with few phosphatic inclusions (see Figure 4.23).

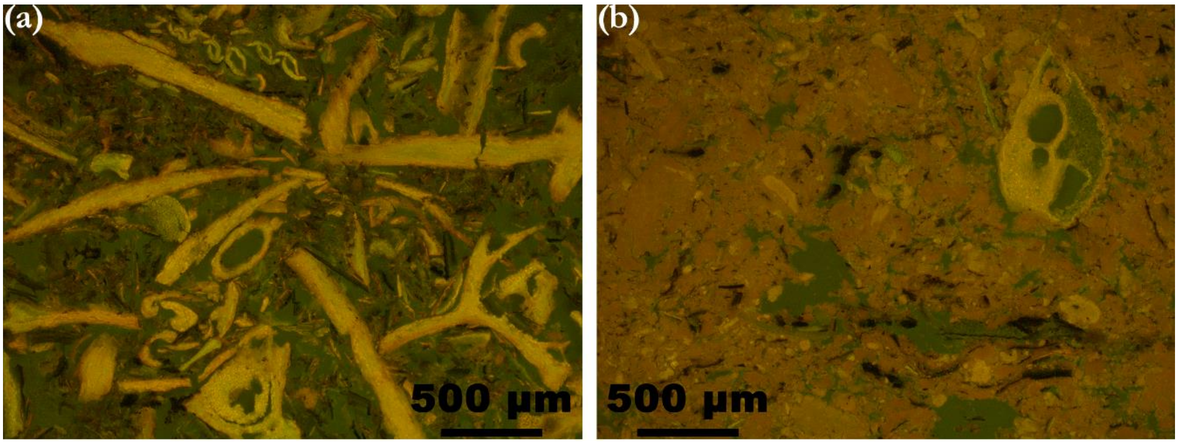



**Figure 4.23** Photomicrographs of faecal inclusions found in midden area in Trench M: a) carnivore coprolite showing multiple digested bones; b) omnivore coprolite displaying a dense phosphatic mass with inclusions of bones and charred plants (Fluorescent Light).

These inclusions displayed none to very few calcareous spherulites when observed under cross-polarised light, although these components, whose presence in archaeological contexts is frequently cited in the literature as incontestable evidence of the deposition of faecal matter (Lancelotti and Madella 2012), are only abundant in herbivore dung (Canti 1999; Shahack-Gross 2011). As such, and due to the importance of accurately identifying and understanding faecal matter in occupation contexts as indicators of concepts of space, fuel choices, diet, and health, the chemical content of the suspected coprolites found in open areas at Boncuklu has been investigated through SEM-EDX and IR spectroscopy. These analyses were carried out directly on the uncoverslipped slides, so carbon is overrepresented in the results due to the presence of epoxy resin.

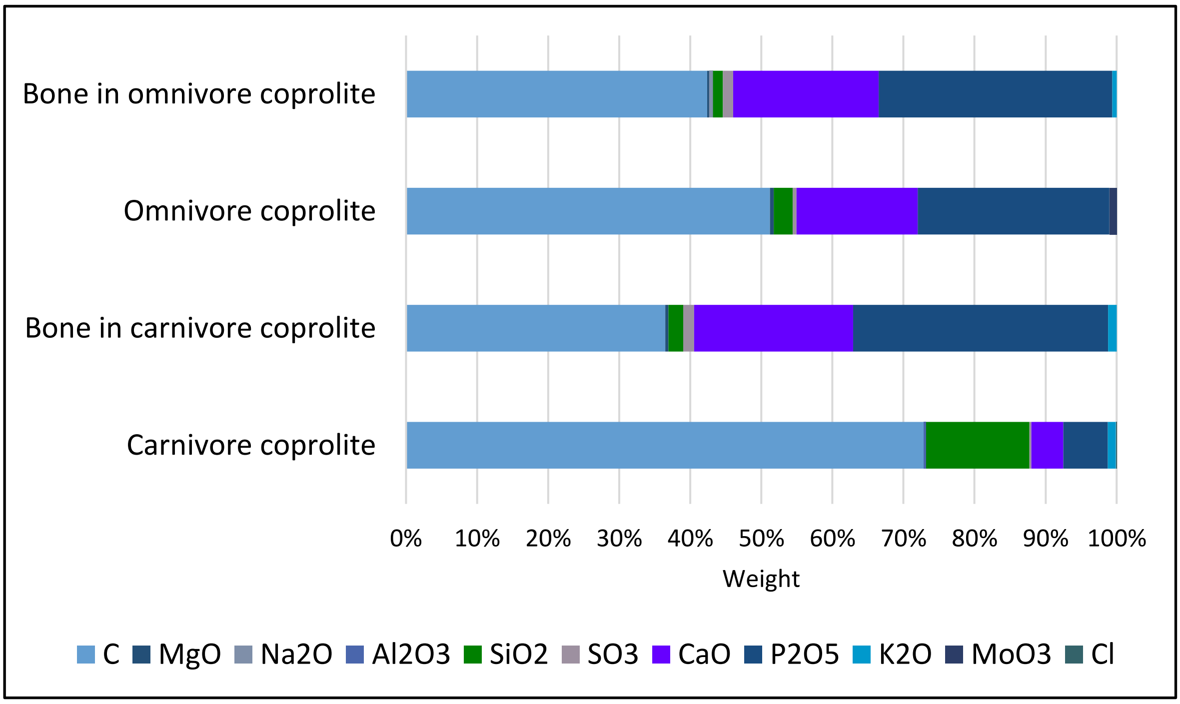



**Figure 4.24** Elemental composition of organic inclusions found in midden context in Area M.

Figure 4.24 illustrates the EDX results obtained from the analysis of the bone inclusions embedded in the faecal aggregates, as well as their phosphatic groundmass. From this data, what stands out is the low content in calcite and phosphate displayed by the fine fraction of the suspected carnivore coprolite, especially when compared to the omnivore coprolite and the bone inclusions analysed. This is accompanied by an increase in the amount of silicon, which is possibly indicating the presence of quartz grains in this faecal aggregate.

Microscopic IR data for these materials, reported in Figure 4.25 below and Table 4.16, reveal similar chemical results to those of EDX. Both samples of digested bone and the suspected omnivore coprolite show the typical bands that arise from the stretching and bending modes of the phosphate ion at approximately 1030 and 600/560 $cm^{-1}$ (Nakamoto 1986). These peaks are much less intense in the suspected carnivore coprolite, which displays further peaks for quartz minerals, and an absence of strong signals for the presence of calcite.

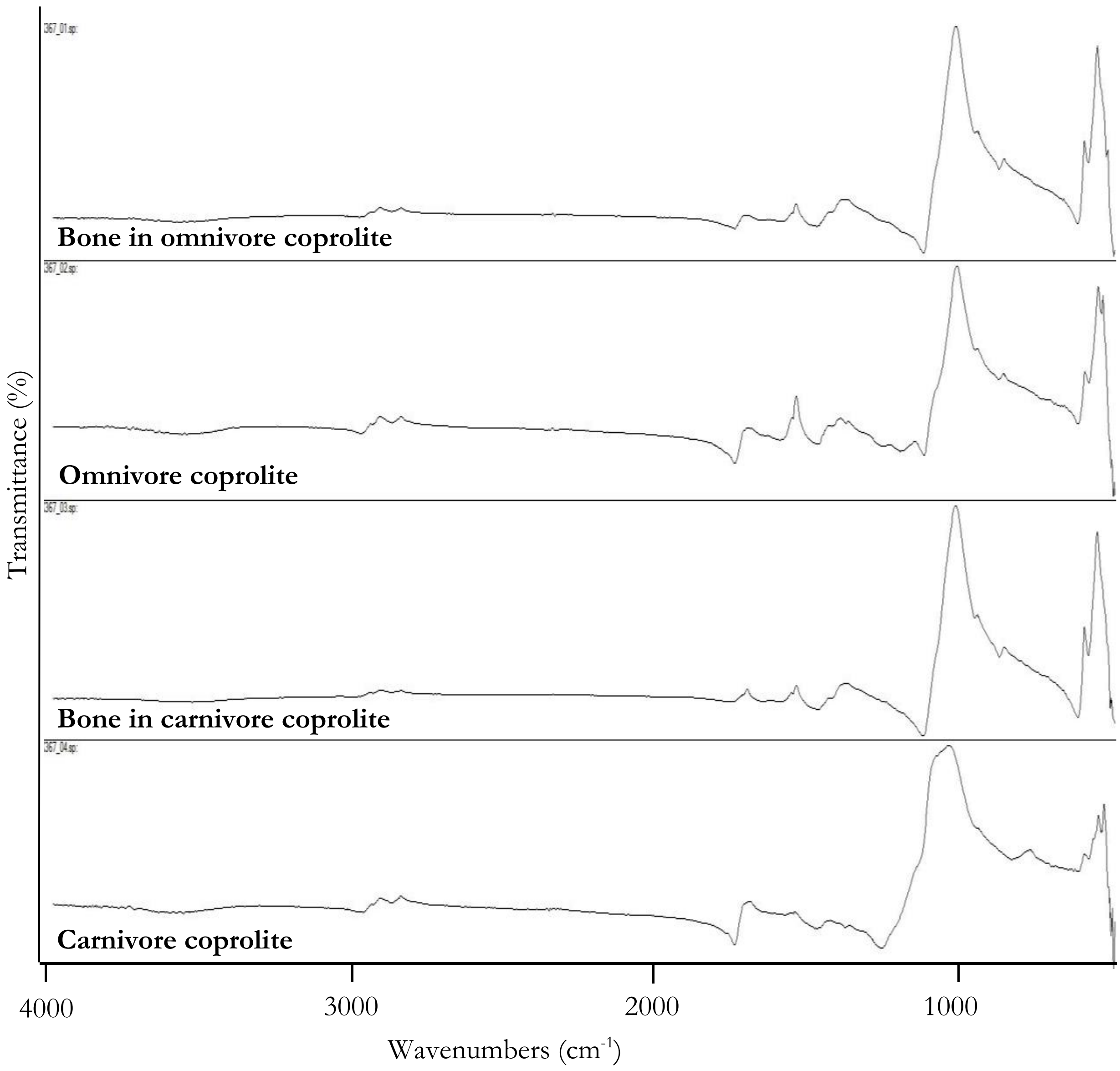



**Figure 4.25** IR spectra of organic inclusions of faecal origin from midden context in Area M at Boncuklu.

| Wavenumber ($cm^{-1}$) | | | | Mineral |
|---|---|---|---|---|
| Bone in omnivore coprolite | Omnivore coprolite | Bone in carnivore coprolite | Carnivore coprolite | |
| 1404 | 1408 | 1402 | - | Calcite |
| 1029 | 1026 | 1028 | 1039 | Phosphate |
| 955 | 953 | 954 | 953 | Clay |
| 870 | 867 | 864 | - | Calcite |
| - | - | - | 781 | Quartz |
| 601 | 599 | 601 | 600 | Phosphate |
| 570 | 557 | 560 | 555 | Phosphate |
| - | 540 | - | 538 | Phosphate |
| 526 | - | 524 | - | Phosphate |

**Table 4.16** Wavenumber values and mineral assignments for the main peaks in the IR spectra of organic components in middens from Boncuklu.

Phosphate peaks are present in all the samples, which makes IR microscopy a useful technique for distinguishing between organic and inorganic aggregates in thin-section. However, the intensities of the peaks detected, in addition to their widths, are variable. Differences in peak widths for the same element are especially marked in phosphatic components, as this mineral is often disordered at the atomic level and composed of small crystals, notably when found in archaeological contexts (Weiner 2010). The case of the bone fragments embedded in the faecal aggregates is of particular interest as their IR peak pattern, specifically the doublet at 600 $cm^{-1}$ and 560 $cm^{-1}$, where the latter is more intense than the former, suggests the presence of slightly re-crystallised dahllite (carbonate hydroxylapatite). This indicates that these bones were heated at a temperature below 500ºC, most likely before consumption (Goldberg *et al.* 2012). Other peaks, such as those at approximately 540 $cm^{-1}$ and 525 $cm^{-1}$, indicate further alterations in the crystallinity of the phosphatic minerals present in these samples, although the nature of these processes, possibly related to digestion rather than preservation factors, has been impossible to determine. Similarly, the low phosphatic content present in the groundmass of the suspected carnivore coprolite could be related to agents affecting bone dissolution in the digestive system. These hypotheses, however, need to be experimentally tested, as the chemical characteristics, compositional variability, and preservation of archaeological faecal matter are still not completely understood.

# 5

# RESULTS II: ÇATALHÖYÜK

*Excavation, micromorphological, and geochemical results from Neolithic occupation levels at the site of Çatalhöyük East are reviewed in this chapter. The importance of understanding the socioeconomic role of small-sized buildings at this settlement is highlighted, and the field investigation of one of these constructions is reported in detail. The micromorphological and microanalytical results comprise the description and categorisation of all the contexts studied at this site, including remains of activities.*

## 5.1 Introduction

Domestic built environments at the large Neolithic settlement of Çatalhöyük have been the focus of archaeological research for several decades due to the outstanding preservation of their architecture and elaborate wall art, the valuable information they provide on household activities and social structure, and the distinctive highly agglomerated pattern of the site. As it has already been highlighted in Chapter 2, building interiors at Çatalhöyük are characterised by a strict division of space that shows remarkable continuity within the life-history of buildings across the settlement and through time, a uniformity that has been interpreted as dictated by social regulations (Asouti 2005a; Bogaard *et al.* 2009; Düring 2001; 2007; 2013a; Hodder 2005b; 2013b; Hodder and Cessford 2004; Matthews 2005a; Wright 2014; Yalman 2005). The microstratigraphic research conducted at this settlement intends to draw attention to the multiple forms in which built environments were constructed and used at Çatalhöyük by investigating formation processes and activities in the insufficiently studied small-sized buildings, usually under *ca.* 9 $m^2$ in extension, an approach that has been deemed vital for the development of a more holistic understanding of household dynamics and socio-economic systems at this settlement.

In this light, the aims of this study include: 1) to develop a range of high-resolution analytical approaches and methods for the excavation, documentation, and microanalysis of finely stratified occupation sequences in the small-sized Building 114; 2) to determine the type and range of architectural floor materials and environmental resources selected for domestic built environments from the macro- to the micro-scale; 3) to investigate the intensity of occupation and maintenance of small buildings; 4) to explore the degree of socio-economic independence displayed by small-sized buildings; 5) to assess the occurrence of specialised activities in these structures; and 6) to determine the nature and impact of post-depositional processes on the preservation of building stratigraphy. In addition to the excavation, sampling, and microanalysis of Building 114 and in order to place the results of this research into a wider context, floor construction materials and activity residues from three roughly contemporary domestic built environments, Space 470, Building 89, and Building 77, have also been targeted in this study. The occupation sequence of Space 470, a small building approximately 7.5 $m^2$ in size situated in the South Area, constitutes a comparable case study to Building 114, located in the North Area. Further, as it would be unproductive to define the socio-economic status of small buildings at Çatalhöyük without consideration of other contexts, microstratigraphic samples from the larger Building 89, in the South Area, and the very elaborate Building 77, situated immediately to the west of Building 114, have been included in this research to identify differences and similarities in construction materials, ecological residues, range of activities performed in the house, spatial boundaries, and intensity of occupation and renewal. Finally, midden sequences from open spaces in the TPC and GDN Areas have been examined to explore aspects of domestic practices and communal activities that are potentially absent from interior spaces. The range of structured activities identified in previous research (Shillito *et al.* 2011b; 2013a; Shillito and Matthews 2013) in midden spaces from the North and South Areas at Çatalhöyük highlights the importance of a multi-sited approach that draws upon two strands of microstratigraphic evidence, namely buildings and exterior areas, in order to explore the full array of community interrelationships in this settlement more generally.

This chapter is structured in five parts. The first section reviews the socio-economic role of small buildings as discussed in previous studies and outlines the excavation approach and recording methods used during fieldwork in Building 114. The macroscopic field results of this investigation are reported in section 5.2.3. Section 5.3 introduces the descriptions of the deposit and inclusion types identified in the Çatalhöyük sequences after the microscopic analysis of the samples through thin-section micromorphology. Parts 5.4 and 5.5 examine the elemental characterisation of key deposits and inclusions using Infra-Red, X-Ray Spectroscopy, SEM-EDX and IR microscopy techniques. Complete building and midden sequences are discussed in detail in Chapter 7, followed by a comparative discussion of household differentiation and society and the role of open spaces. A brief overview of the advantages and disadvantages of the field strategy adopted in this research is included in Chapter 8.

## 5.2 The socioeconomic role of Neolithic small buildings

Buildings at Çatalhöyülk are renowned for the striking degree of conformity they display in internal spatial boundaries, including the division of the house into clean and dirty areas, and the location of the roof entrance, interior platforms, fire installations, burials, and decorative elements such as paintings, bucrania, and reliefs. The occurrence of at least one side room accessed off the main room of the building and apparently destined to store harvested crops, is also considered a common feature of buildings at Çatalhöyük. This strict architectural uniformity points to social conventions and strategies as the main factors determining the choices made by those who constructed buildings at this settlement. Therefore, the built environment should not be viewed simply as an architectural structure at this site, but as an important element in the constitution of the social fabric. However, in spite of the high level of standardisation displayed in architectural constructions and features, almost all of which can be found in every building, there are also many differences. These pertain to such matters as the amount of symbolic elaboration, the number of individuals buried beneath house floors, the number of rooms, and the size of a building. In this respect, interdisciplinary works by Hodder and his team have resulted in the identification of various house types based on size, specific building features, and both architectural and symbolic elaboration (Hodder 2013b). This classification has been used in recent years as the basis for the exploration of social differentiation and inequality, and the occurrence of corporate groups at Çatalhöyük (Hodder and Pels 2010).

Elaborate houses are the first house type identified as 'special buildings', meaning that, despite containing indications of domestic use, such as ovens and storage bins, they appear to hold a differential household status or special function. These houses are characterised by an unusual large size, frequently well over 40 $m^2$, and the presence of decorative features such as wall paintings, reliefs, or bucrania. In addition, elaborate houses often display greater architectural complexity and more storage space relative to their size than other buildings.

Multiple burial buildings are the ones that have numerous individuals buried beneath the floors. In some cases, such as Building 1, with sixty-two individuals, there are too many burials to have been produced by the occupants of the house during its period of habitation. In fact, some of the buried individuals found in Building 1 were in secondary deposition, suggesting that human bodies could have been transferred from other burials and houses. This could be indicative of the existence of supra-household connections operating on the base of the use of particular buildings for burial (Cessford 2007).

The concept of 'history house' is perhaps the most notable in this classification, referring to high-rank, prestige buildings showing a specific set of parameters that mark their importance, including large size, a high number of formal burials, the degree of symbolic and architectural elaboration, and the occurrence of so-called history-making activities, such as the retrieval of murals or reliefs after the abandonment of the building. Further, these elaborate domestic built environments endured for generations, displaying a marked continuity over time in wall foundations and the locations of mouldings, paintings, and platforms through numerous rebuilding phases. The socio-economic significance of these houses, which could have entailed the control of agricultural production and storage, or the performance of community rituals, is still debatable (Hodder and Pels 2010).

The last house type in this classification refers to non-elaborate buildings, the most common category at Çatalhöyük to which small built environments belong. These buildings are very variable in size, and do not display any of the special characteristics described above for the other three types, and as such they are generally considered undistinguished.

These four house types at Çatalhöyük have the advantage of allowing the exploration of social differentiation in relation to the architectural and symbolic features of buildings and the artefacts found in them. However, the correlations established between house size, rebuilding events, number of burials, and ritual elaboration in buildings have been found to be not as simple as previously thought (see Figure 5.1 below), which casts some doubts on the degree to which the classification of built environments at Çatalhöyük into mutually exclusive categories is representative of the social geography of the site.

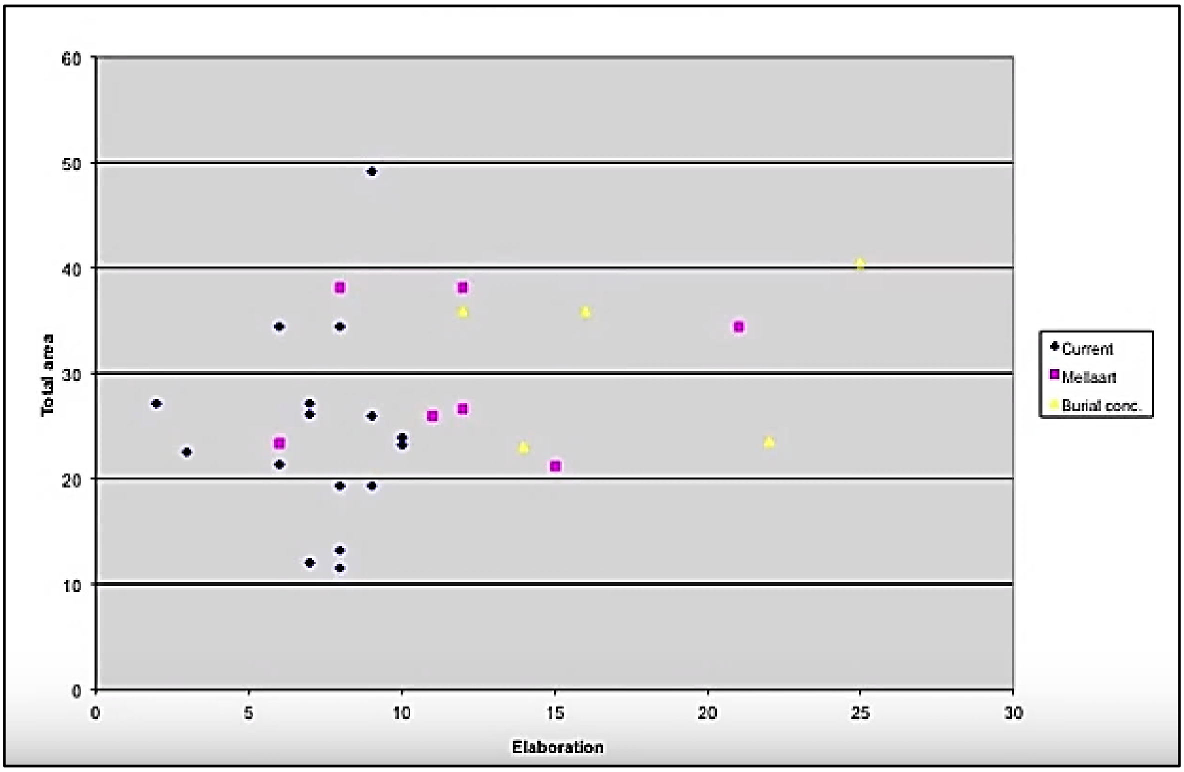



**Figure 5.1** Graph plotting building total size in relation to architectural and symbolic elaboration at Çatalhöyük. Notice that linear relations are not immediately obvious (Source: I. Hodder, pers. comm.).

Most buildings vary in dimensions between 30 and 52 m$^2$ (Düring 2001), although in some cases very small built structures are present, such as Z1 and 33 in Mellaart Level VIa or Z9 and Z10 in Level V (see Figure 5.2). These buildings were originally interpreted as annexes to larger buildings nearby, and considered too small to have functioned as independent units, an interpretation that has not been challenged so far, in spite of the fact that they have their own walls, and the absence of evident links with adjacent buildings. Despite this neglect, small buildings constitute a very interesting and important source of information for several reasons.


**Figure 5.2** Plans of Mellaart excavations for levels V and VIA with small built environments displaying independent walls circled in red (after Düring 2001: 7-8).

Firstly, differences in building size do not automatically signify inequality, but raise questions about corporate groups. Individual houses seem to have been relatively self-sufficient, but they appear to share ties with other houses centred on a history house in which members of these tightly-knit networks were preferentially buried (Hodder 2013b; Hodder and Pels 2010). However, many questions about the Neolithic social organisation of Çatalhöyük remain unanswered, in particular 1) how domestic units articulated with corporate groups, possibly including lineages, neighbourhoods, and other types of networks; 2) how much power resided in corporate groups; 3) whether residential groups had similar access to ecological resources and materials, possibly involving sharing; and 4) whether certain elaborate buildings were corporate.

Secondly, although the placement of multiple burials within special buildings indicates a certain association of individuals and social groups with particularly elaborate houses, those interred may only represent a portion of the population associated with that specific built environment, possibly also involving non-residents (Kuijt 2000). Therefore, as individuals and households are often associated with more than one building, the traditional equalisation house=household might not be representative of the actual articulation of this community. In this scenario, the systematic investigation of all built environments, regardless of their size and the degree of symbolic elaboration they display, usually taken as evidence of the status of a particular building, becomes highly significant for the exploration of neighbourhood-based corporate groups.

Thirdly, it is important to bear in mind the historical trajectory of Çatalhöyük and the socio-economic changes that affected the social geography of the site in the upper levels. In this respect, both Mellaart (1967) and Düring (2001; 2006) showed that a major shift occurred between levels VI and V in the Mellaart scheme, involving a change from neighbourhood clusters and collective labour to more autonomous house units that appeared to expand gradually through time (Düring and Marciniak 2006; Marciniak and Czerniak 2007b).

The large size of the community at Çatalhöyük has unavoidably raised many questions regarding the integration of large populations. In order to fully understand how individuals and social groups were organised, and how they engaged with the built environment, our examination of architectural remains must include the widely disregarded small buildings as the potential scenario of neighbourhood-based communal practices, sharing of resources, or specialised activities. Although relatively uncommon and largely unexplored due to their unimpressive spatial extension, a fact that has caused a number of assumptions to be made on their socio-economic role at Çatalhöyük, including their function as secondary annexes and simple storage areas, a careful examination of these small built environments might shed light into the constitution and development of corporate groups at this site, improving our understanding of the material engagement of individuals with the settlement architecture.

The following sections describe the microstratigraphic excavation and recording methodology of Space 87/Building 114, assigned to Mellaart Level VI and therefore immediately preceding the great socio-cultural change at *ca.* 6,400 cal BC. The detailed field and laboratory investigation of this small built environment, which displays a usable area of approximately $6m^2$, has the potential to add new details to our current knowledge of the socio-economic constitution of the settlement during this time.

### 5.2.1 Previous works in Building 114

From 1997 to 2003, the BACH team (Berkeley Archaeologists at Çatalhöyük), directed by Ruth Tringham and Mirjana Stevanović, conducted the excavation of an 11 x 7 m trench in the North Area of the site comprising Building 3 and what was originally described as three 'small cells' to its south: Spaces 87, 88, and 89 (Tringham and Stevanović 2012). After the excavations the team concluded, based on wall construction, that these three small rooms were built at the same time, being at least partially contemporary with each other and with the larger Building 3 to the north (Stevanović 2012b). However, it was not possible to demonstrate any direct communication between these three spaces, separated from Building 3 by double walls, although an opening could have existed in the single wall between Space 87 and Space 88 (Stevanović 2012a). Unfortunately, this part of the wall was damaged by a late Roman burial, so the existence of a crawl hole feature between these two built environments cannot be completely substantiated.

While the occupation sequences of the last two spaces were excavated to completion, only one third of Space 87, with a total size of approximately 4.0 x 1.7 m, was unveiled (Stevanović 2012b). In the area excavated, corresponding to the eastern end of the structure and measuring 1.68 x 1.40 m, archaeologists found a very heterogeneous and compacted abandonment fill formed by building materials and inclusions of burnt clay, charcoal, and plaster fragments. The team also documented a cut in the south-western corner of the building, where a redeposited fire installation was found in association with two severely burned human bones and a lump of red ochre (Stevanović 2012a). Underlying this thick fill deposit, a platform (Feature 638) containing multiple burials was discovered. The BACH team removed five floor levels from this area, each comprising a coat of light grey plaster overlying a layer of brown clay packing. AMS dating of charred seeds found on the late floors of Space 87 was carried out at the Poznań Radiocarbon Laboratory in 2004, yielding dates between 6650 and 6460 cal BC (Stevanović 2012b).

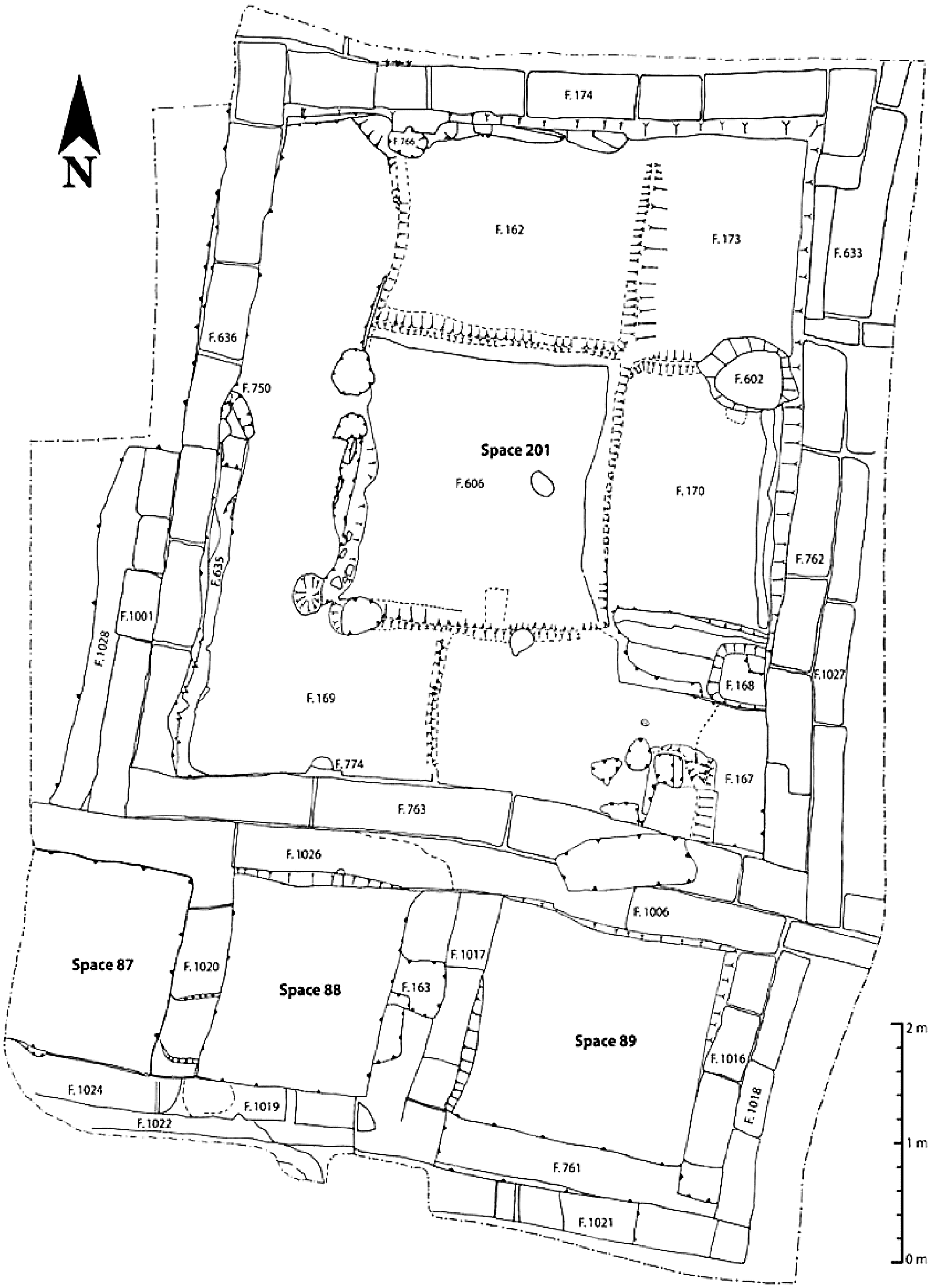



**Figure 5.3** General plan of the BACH Area excavations: Building 3 and Spaces 87, 88, and 89 (Source: Stevanović 2012: 51).

Cutting through the eastern platform of Space 87 archaeologists found nine complete skeletons interred in at least five primary burial events. Seven individuals were excavated and two partly exposed skeletons, a neonate in a lidded basket and an adult, were left *in situ* due to time constraints (Stevanović 2012a). Hager and Boz (2012) reported that the bodies buried in Space 87 corresponded to individuals distributed in nearly all age groups. These comprised an old female (44-50 years old) displaying signs of degenerative joint disease in the spinal column and a neonate apparently buried in the same interment event, an infant (4-6 months), an adolescent (13-15 years) showing abundant black carbon residues in the thoracic area, a juvenile (8-9 years), another adolescent skeleton, and an old male (44-50 years old), who was the last individual to be buried under this platform. No grave goods were found directly associated with any of these individuals. All in all, the tight constraint of the skeletons in this small area and the pattern of disturbance of earlier burials by later ones, suggestive of a rapid succession of interments, appear to reflect the intensive use of this platform for burial purposes (Hager and Boz 2012). Stevanović (2012b) hypothesised that the reason for this concentration of interments in the southern platform of Space 87 might have lain in the fact that the northern half of the construction could have been considered inappropriate as a burial ground.

The BACH team considered Spaces 87, 88, and 89 as 'specialised use' rooms based on the limited evidence for activities of residential character encountered during the excavation of these constructions (Stevanović 2012a). Space 89 was described as a room with few traces of *in situ* activity, but with a very rich closure deposit. Space 88 contained abundant evidence of production activities, such as the grinding of various non-food materials, suggesting that this space could have acted as a workshop. Finally, and in spite of the fact that only a very limited area of Space 87 was excavated by the BACH team, Stevanović (2012b) argued that the activities carried out in this particular built environment were mostly, if not completely, linked to human burial, as inferred from the range of artefacts and human remains recovered during the early excavation of this space. Further, the fact that the partially exposed east and south walls of Space 87 had traces of red paint in the form of a continuous panel covering the lower part of these walls was taken as indicative of the performance of ceremonies associated with the human burials found under the plastered platform (Stevanović 2012a).

Works in this area resumed in 2012, when the re-examination of the make-up units of Spaces 87 and 88 resulted in the observation of strong connections between both rooms, which led to the re-definition of these two spaces as Building 114 (Tung 2012). The new team excavated the burials left *in situ* by the BACH project, a young adult female skeleton (20-30 years of age) with traces of red ochre on its skull, and a neonate placed in a basket.


**Figure 5.4** Human and faunal skeletal remains found within the building abandonment fill of Space 87: a) relatively complete and well-articulated remains of sub-adult individual, Skeleton 19593; b) adult human skull found lying immediately on top of the last floors of Space 87; c) auroch horns. (Source: photographs a and c by J. Quinlan).

The 2012 field season in Space 87 also involved the excavation of the remaining building fill in the central and western areas of this built environment. This deposit was defined as consisting of a highly compacted matrix of clay loam rich in heterogeneous aggregates, including fragments of mudbricks and wall plasters, re-deposited burnt surfaces, and large numbers of articulated animal and human bones, as well as an impressive total of seventeen auroch horn cores (Tung 2012).

A number of important human skeletal remains were also found in the abandonment fill of Space 87. The most conspicuous of these finds was skeleton 19593, corresponding to a well-preserved sub-adult individual (approximately 15 years of age) in primary disturbed deposition (Knüsel *et al.* 2012). No cut was found associated with this skeleton, which does not appear to have been properly buried but rather carelessly deposited with the building infill. The cranium was absent, but the mandible was found in place, which suggests a possible case of cranial removal. Additionally, two adult male crania and a pair of highly articulated feet were also found in this context, again displaying no evidence of formal burial.

The excavation of Space 87 in 2012 ended before floor levels were reached in the central and western areas of this structure, leaving approximately 15-20 cm of building fill still to be removed and documented.

### 5.2.2 The excavation approach

The excavation approach of any given archaeological site has an important effect on sampling strategies for micromorphology. One of the main purposes of this study was to invert this relationship by designing an excavation strategy that would allow the systematic collection of highly representative micromorphological block samples from a wide range of contexts. At Çatalhöyülk, excavation and recording methodologies are based on the single-context system developed in British urban archaeology during the 1970s and currently established as standard practice in contract archaeology across the United Kingdom (Harris 1979; Roskams 2001). The basic recording element in this system is the Unit, also referred to as 'context', which does not always represent a single depositional event. In practice, the millimetric thickness of some layers makes it almost impossible to distinguish them individually, and they are frequently excavated and recorded as groupings of three to six microlayers identified under a single unit number. In addition, massive layers representing a single depositional event such as many building fills, are usually excavated in arbitrary units whose boundaries do not relate to a specific depositional event (Farid *et al.* 2000). Thus, at Çatalhöyük, an individual layer or deposit does not always translate as a single unit. However, from a strictly methodological point of view, the well-defined architectural elements at this settlement provide rigorous contextual data for the testing of new techniques and geoarchaeological strategies aimed at investigating formation processes and activities at high spatial and temporal resolutions, critical to studying the nature and scale of the ecological and social strategies that sustained Neolithic communities.

The micro-stratigraphic excavation of Space 87, which could be interpreted as the main room of Building 114, started in 2013. The purpose of this approach was the identification, recording, and excavation of individual microlayers at the macroscale through the fine excavation of deposits, their documentation (using photography, 3D modelling, section drawing, and excavation records), and geoarchaeological sampling. This process was followed by the micro-scale analysis of micromorphological thin-sections to study the fine layers that were difficult to observe at the macroscale, and targeted spectroscopy and organic chemistry analyses of specific components and layers to extract critical archaeological data embedded in these contexts. It was also expected that having a micromorphologist excavating as well as studying the deposits under the microscope would strengthen the interpretation of these contexts through a tight integration of macroscale observations and microanalytical results.

At the start of the 2013 field season, the section left by the BACH team separating the eastern end of Space 87 from the rest of the structure was established as the primary reference for the novel micro-stratigraphic excavation approach, improved after discussion with site director Ian Hodder and Head of the micromorphology team Wendy Matthews. From the beginning of the season, the decision was made to excavate the occupation sequence of Space 87 with fine tools (i.e. trowels and scalpels) in a pattern of vertical 'slices', each measuring *ca.* 1 x 1.7 m and starting in an area defined by the BACH trench to the east and the walls of Space 87 to the north and south, leaving a section exposed to the west during the process. The sections provided great insight into the depositional histories of the building, enhancing the visibility and excavation of microlayers, as once these were identified in the field profile it was found to be much easier to expose them on a horizontal plane, using the western section as a guide. This method further enabled the application of pXRF characterisations of a number of key contexts visible in the arbitrary section.

Excavation proceeded by the definition and excavation of single contexts, each one identified and recorded as a unique depositional event. The single contexts were revealed and excavated wherever possible in their sequence of deposition and then constructed into a microstratigraphic sequence using a Harris matrix (Harris 1979). However, as the floors and accumulated layers were being revealed into units measuring a maximum of approximately 1 x 1.7 m – that is, the size of the building area under excavation at any given time –, a number of problems with this approach became obvious. First of all, whole units were rarely seen in plan; secondly, stratigraphic discordances were encountered when attempting to link and correlate layers from different excavated areas together; thirdly, significant problems were encountered if certain features (e.g. burials) were found lying between two excavated areas/stripes; and

**Figure 5.5** Field section through Space 87 during excavation, looking west.

finally, as more excavation sheets were produced, this excavation approach turned out to be more time-consuming.

These difficulties inspired the adoption of a more flexible micro-stratigraphic excavation strategy based on removing the permanent sections and employing instead temporary plinths and baulks left in strategic locations within the space to record the vertical dimension of its stratigraphic sequence and elucidate important depositional relationships. This strategy, which was adopted during the 2014-2015 excavations of Space 87, also made possible enhanced micromorphological sampling, for which the presence of vertical sections or baulks in the field is essential.

#### 5.2.2.1 Recording methods

The standard procedures of documentation at Çatalhöyük have been described in a number of places (Farid *et al.* 2000; Hodder *et al.* 2007; Farid and Hodder 2013). However, in recent years few refinements have been made to the basic system, involving mainly the progressive digitalisation of the recording process (Forte *et al.* 2012; Taylor and Issavi 2013).

Observations and measurements of the excavation were recorded by hand in the field on the standard Çatalhöyük Research Project forms for units, features, and skeletons until 2014, with the latter filled out almost exclusively by members of the human remains team (Hodder *et al.* 2007). The data recorded in the field sheets was then entered into a central database (Microsoft Access) during the excavation season. Field diary entries also had to be typed into a database. Every participant of the project has access to the excavation databases while in the field, with the data becoming available on-line to the general public after the excavation season through the project webpage. Field plans and drawings of individual units and multiple contexts were made by hand once the relevant areas had been cleaned, photographed, and measured with a total station or theodolite.

Since 2014, the digital recording of the excavation process, entailing completely paperless documentation, was implemented at Çatalhöyük. Each building/space supervisor was assigned a Microsoft Surface Pro tablet connected to the Project intranet in order to input all the information directly into the central excavation databases, including the digital photography log and the diary database, making the data immediately available to all project members. Field plans and sections were no longer drawn by hand on paper sheets, but rather entered directly into the Çatalhöyük survey system through a digital workflow operating in ESRI's ArcGIS 10.2. This method had the advantage of enabling quick and accurate three-dimensional representations and measurements of details of units, samples, and special finds at any stage during the excavation.

To implement this novel approach to field planning in this research, I started by setting up a mini grid in Space 87 with numbered, semi-permanent targets placed in the excavation area in a 1 x 1m pattern. The three-dimensional locations of these targets were measured by the total station and saved into a shapefile (Taylor and Issavi 2013). During excavation, photographs were taken using the site camera with the aid of a monopod to keep distortion to a minimum. However, this proved to be very difficult, especially when large areas had to be recorded, as in the frequent cases when the camera lens was not completely parallel to the surfaces being photographed, the orthophotos obtained after transferring and georeferencing the field images in ArcMap would result in rectified version that displayed a high degree of skewness, making them very inadequate for planning. This problem was resolved with photogrammetry, a technique based on the creation of 3-D models from a series of digital images of an area, feature, or artefact (Barazzetti *et al.* 2011; Dell'Unto *et al.* 2015; Pollefeys *et al.* 2003). The software used included Agisoft Photoscan and Meshlab, which resulted in the production of high-resolution 3-D models created through dense stereo matching techniques that were then used for the production of orthophotos (Issavi and Taylor 2014). However, this process could not be carried out in the trench due to the frequent malfunctioning of the digital tablets caused by overheating. Thus, the graphical documentation of the excavation of Space 87 was only possible thanks to the contribution of digital specialist Marta Perlińska, who was responsible for the creation of all the 3-D models and associated orthophotos of this space.

Once the ortho-rectified image of the excavated area was obtained, field sections and single context, as well as multi-context plans, were produced in ArcMap through the creation and editing of a series of shapefiles, including base unit polygon, X-finds, elevations, samples, and annotations (Taylor and Issavi 2013). Each of these shapefiles had a number of pre-set attribute fields, such as unit/find/sample number, type, and elevation, comprising the standard information traditionally added to field plans and sections. As a result of the implementation of these new methodological developments in the recording of the excavation process at Çatalhöyük, the site is now completely paperless, with both database and graphic recording performed digitally on-site by the excavators.

### 5.2.3 The archaeostratigraphic sequence

As Space 87 could not be excavated in its entirety due to time restraints, the phasing of this built environment is preliminary and it is based on the stratigraphy of the deposits as well as the spatial and temporal interconnections of the exposed features (Farid 2013). Phase 1 relates to the construction of this structure; Phase 2 makes reference to the initial occupation of the space, formed by a sequence of thick, coarse plasters extending across the whole constructed area that remain unexcavated; Phase 3 refers to the later occupation of Space 87, consisting in multiple construction and modification events of internal features, as well as the placing of burials; and Phase 4 represents the abandonment of this built structure and its subsequent infilling. This phasing differs considerably from the one proposed by Stevanović (2012b), based on the introduction of new floors in the eastern end of Space 87 as the main indicators of change.

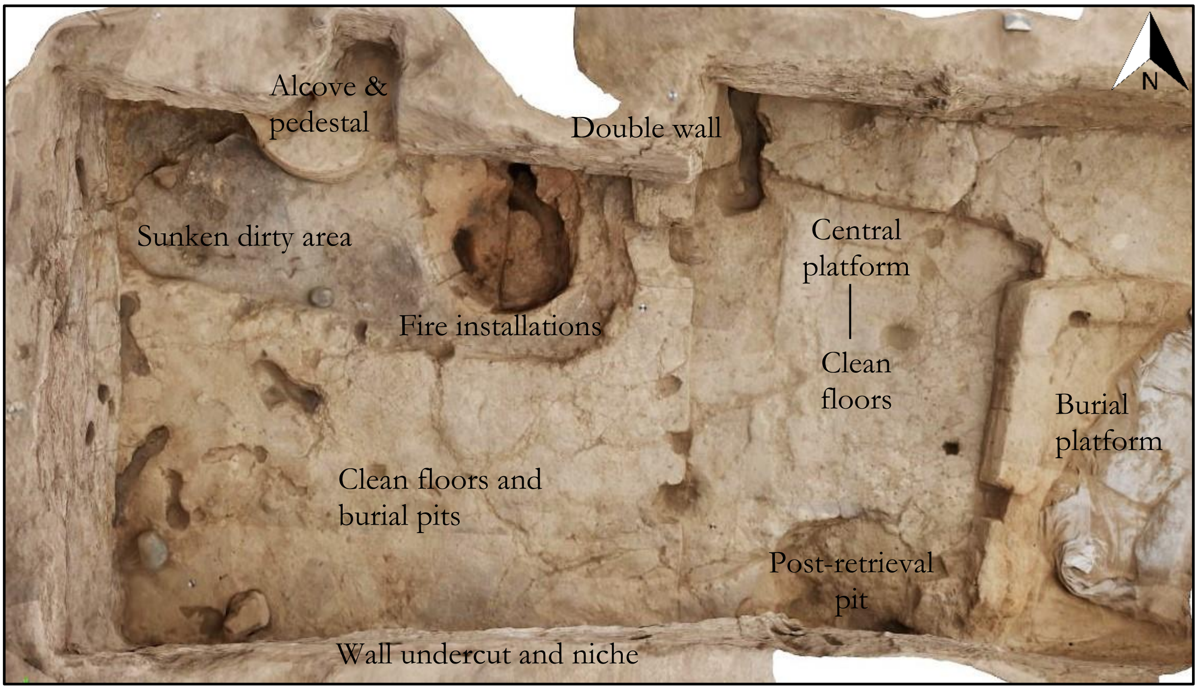



**Figure 5.6** Space 87 during excavation, displaying the interior features present during its main occupation phase. Orthophoto by M. Perlińska.

A report of the excavation results of Space 87 is included in the following sections. The sequence of this built environment is presented in reverse stratigraphic order, first describing the partly excavated walls and foundations, followed by a detailed report of its occupation sequence by area, as Space 87 displayed a clearly defined, although very distinct, division of its internal space (see Figure 5.6). Finally, the closure of the space and the associated abandonment infill are briefly examined.

### 5.2.3.1 Architecture: walls and decorations

The walls of Space 87, formed by brown sandy mudbricks and dark grey mortar likely derived from midden materials, have a thickness of *ca.* 35-40 cm. These walls are heavily plastered on the inside, a characteristic of this space that was also noticed by Stevanović (2012a), who described multiple coatings of white plaster applied to the walls of Space 87, the most prominent from all the buildings in the BACH Area. The thickness of the combined layers of wall plaster appears to be greater in the southern wall of the structure, measuring up to *ca.* 7.5 cm. The east and south walls around the burial platform contain more than one red painted plaster sequence in the form of monochrome panels located very low on the walls, just above the level of the latest floor. Due to the heavily dehydrated nature of these plasters at the start of the microstratigraphic research reported here, however, it has been impossible to quantify the layers of red paint applied to the walls, as these have flaked and degraded considerably over the years after first being exposed in 2002. However, it is worth noting that the occurrence of painting on the south walls of buildings is atypical at Çatalhöyük.

The northern wall of Space 87 is flanked by a support wall that abuts the western wall of this building and extends approximately 2.8 m to the east. The construction of this support wall entailed a major change in the life-history of Space 87, further restraining the available interior living space, and appears to be associated with the final use phase of the structure. The reasons for this addition to the building was probably the progressive structural weakening of the main north wall, caused by the large cut made to fit the oven, and problems associated with the proximity to Space 85, a midden area immediately to the north of Space 87. However, this support wall displays a sequence of plasterings of *ca.* 1 cm in thickness, and it shows substantial soot accumulations in some areas, which hints to a lengthy use. A pedestal feature was found abutting the support wall on its western end, made of very compacted silty clay and coated with multiple layers of white plaster. Three longitudinal shallow grooves painted with red pigment decorated this feature.

**Figure 5.7** View of the partly excavated double North wall of Space 87. Orthophoto by M. Perlińska.

The southern wall contains two grooves painted in red and separated by a small circular depression running across its western half. Similar motifs have been found in Building 80 (South Area), and in a number of 'shrines' excavated by Mellaart (Mellaart 1963), although these are represented by a single band. Further, the southern wall in Space 87 was substantially undercut by 15-20 cm during the occupation of the building, as seen in the multiple re-plasterings of this area. Within this undercut lies a very deep, distinct niche displaying several plaster layers painted in red. This feature has been later found to be a blocked crawl hole, connecting the earliest phase of occupation of Space 8, which comprises a sequence of thick floor plasters unexcavated at the time of writing, with an adjacent building immediately to the south. Next to this niche feature a post-retrieval scar can be observed on the wall, showing a scorched area towards the base that is possibly associated with *in situ* burning activities performed at various times during the infilling of the building, as attested by the patches of charred plant materials encountered during the excavation.

**Figure 5.8** View of South wall of Space 87. Orthophoto by M. Perlińska.

A geometric painting made with an unusual orange pigment, possibly cinnabar, was found underneath multiple layers of white plaster and red paint on the southern wall by the east platform Feature 638 (see Figure 5.9 in the next page), apparently associated with the earliest phases of this platform.

Soot on walls caused by smoke was not pervasive or extensive in Space 87, and it has been found to be restricted to the north wall of this built environment, where the fire installations were located, and the area of the south wall where the post used to be.

The outside entrance into Space 87 could not be defined by the present work, although Stevanović (2012a) stated that there was some indication that the northeast corner of the burial platform served as a point of entry into the room after descending through the roof opening. Finally, Stevanović (2012a) further described the walls of an earlier building constructed with black bricks below Space 88, extending in a northwest direction under Building 3. It is possible that similar walls also exist under Space 87, but the excavations have not reached the necessary depth to establish this.

**Figure 5.9** Geometric painting on southern wall of Space 87, situated by the burial platform.

### 5.2.3.2 Occupation sequence: the eastern quadrant

The absence of artefacts and finely laminated nature of the stratigraphic sequence in this part of Space 87 hints at an intensive use that involved thorough cleaning before re-furnishing. The earliest deposits exposed comprise a series of four grey and white plaster floors and associated make-ups underlying the burial platform and extending from the east wall to a central plaster ridge that divided Space 87 into two areas. These floors were cut by a small pit located immediately to the east of an extracted post, which did not contain any significant finds.

The burial platform (Feature 638), which appeared to be earlier than the central platform Feature 7114 and measured *ca.* 1.4 m east-west and 1.2 m north-south, was situated in the south-eastern corner of Space 87, abutting the southern and eastern walls of the construction. This feature was formed by a very compacted orangish brown clay core placed upon a heterogeneous levelling deposit. On top of the core, a series of very eroded white plaster floors with associated brown silty clay make-ups were laid down. The platform corresponded to the area excavated by the BACH team, who described the excavation of four plaster floors in this part of Space 87 (Stevanović 2012a). Small fragments of red paint were found in the eastern and western edges of the feature, which indicate the existence of at least one platform plastering event involving paint.

Sometime after its construction, the northern side of the burial platform was cut back approximately 10-15 cm for the addition of a raised light grey clay ridge, heavily plastered with multiple fine layers of white clay. On the western side of the platform and running north-south sat another compacted clay ridge/lip, apparently connecting the burial platform with the central platform Feature 7114. This elevated ridge which took over the western 10 cm of platform Feature 638 could have constituted a spatial division between the burial space and the living area of the building. The burial platform was then re-furbished with a coarse layer of dark brown sandy clay that possibly constituted a levelling episode aimed at raising the height of the platform, which appeared to have sunk after the continuous re-opening of its central area for burial practices. After these modifications, platform Feature 638 continued to be re-plastered with white clay on a regular basis, possibly annually or seasonally, as previously observed in other buildings at Çatalhöyük (Matthews 2005a).

**Figure 5.10** Burial platform Feature 638 in the southeastern corner of Space 87, looking north.

In addition to the skeletons excavated during the 2002-2003 seasons by the BACH team, and those extracted during the 2012 season, two more interments were documented in 2015 after the re-opening of the burial pit in platform Feature 638. These consisted of an adult male skeleton and an infant placed on the adult's left shoulder (see Figure 5.11 below). On the right shoulder of the adult individual a complete marble mace-head was found. Pigment staining, possibly cinnabar, was found on the infant's skull as well as on the cervical vertebrae and cranium of the adult skeleton. These burials, the earliest performed in Space 87, added to those documented in previous field seasons, make a total of eleven individuals formally interred under the eastern platform of this built environment.

**Figure 5.11** Burial of adult Skeleton 30007 and infant Skeleton 30010 within burial platform Feature 638, looking east.

Before the construction of the central platform, a shallow oval pit was cut immediately above a floor sequence of approximately eight grey plaster floors and associated brown silty clay make-ups, measuring *ca*. 80 x 50 cm and 9 cm in depth. This pit, Feature 7129, was used as a fire spot, as attested by the large number of charred plant remains recovered from it. No formal fire installation was found associated with this feature. The walls of the small cut were lined with clay sediment, which showed mild signs of rubefaction, as it would be expected from a low-temperature fire. The nature of the fill, consisting in charred fragments of wood and seeds, together with the absence of discernible layering, point to the possibility that this was a single burning event. Towards the base of the pit, a concentration of grass-like phytoliths was found. The southern half of this feature consisted of dispersed ashes and burnt plant materials, completely devoid of artefacts or animal remains. Overall, this feature seems to represent an opportunistic activity area, and there is no clear explanation for the presence of such a shallow fire pit in the middle of a building during its main phase of occupation. The fact that the ashes were not swept and that this feature was sealed by a single grey plaster floor, similar in nature to the sequence of floors underlying it, point towards the possibility that this fire pit was related to ritual activities of some sort. Interestingly, shallow scoops, often filled with artefacts such as clay balls, obsidian tools, or pebbles, are sometimes found

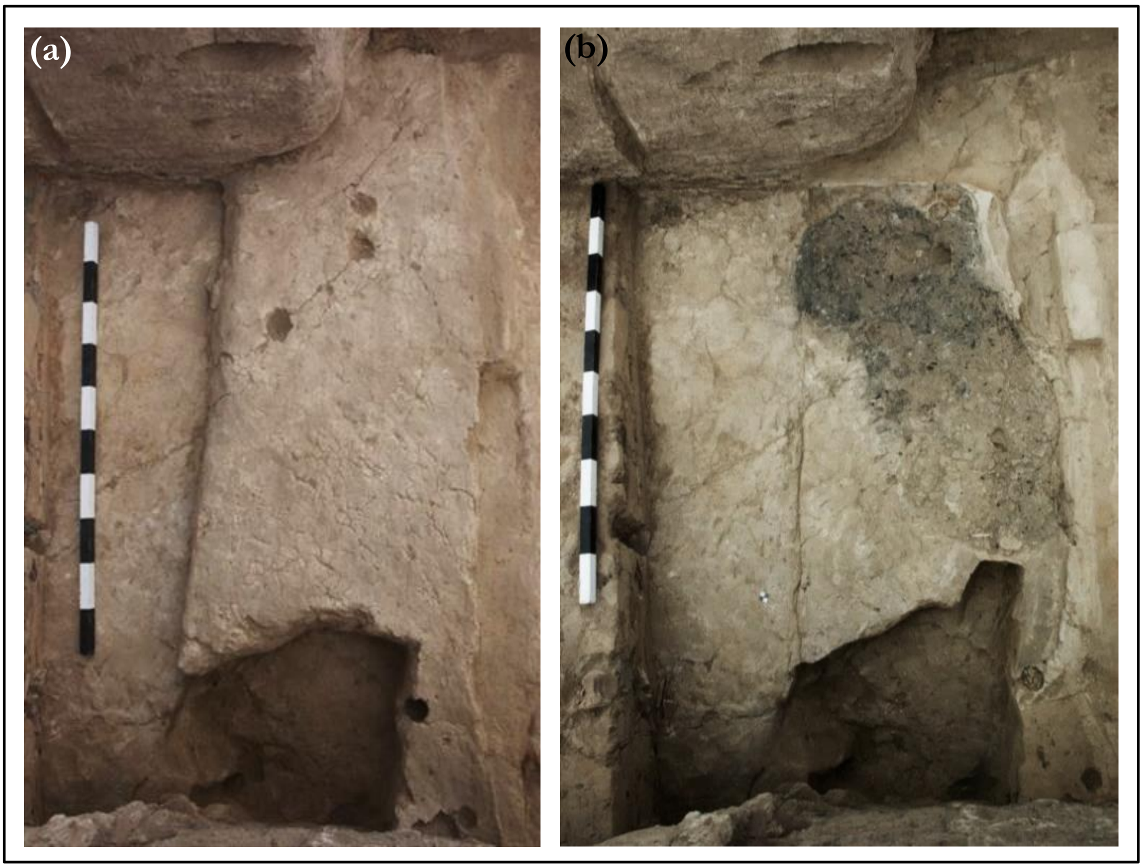



**Figure 5.12** East-central platform Feature 7114 and post-retrieval pit in Space 87, looking north: a) multiple layers of white plaster on platform; b) charred plant materials found in small fire pit, Feature 7129, underlying the platform core.

near the oven and hearth of houses at Çatalhöyük, as encountered in Building 59 and Building 60 (House 2013b). However, these small pits, which occur mainly in the south area of the main room, are often found empty.

The final phase of occupation in this area was represented by a plastered platform, Feature 7114, damaged in its southern edge by post-retrieval activities. The platform was 0.7 m wide and 1.70 m in length, stretching across the whole width of Space 87, from its north to its south wall. However, with an elevation of approximately 10 cm, this platform was much lower than the majority of benches and platforms found inside buildings at Çatalhöyük.

The construction elements of Feature 7114 were also atypical of platform cores at this site, which possibly reflects an opportunistic use and re-utilisation of various construction materials or, alternatively, the extensive transformation of an older feature which was no longer recognisable in its original form at the time of excavation. This platform displayed approximately 2 cm of white plaster formed by multiple microlayers, underlying which was a core deposit formed by different materials, including red clay, mortar-like sediment, burnt building materials, and re-used plasters that appear to have been used as repairing materials, as they were found patching the edges of the platform. Further, the north-eastern corner of the platform contained what appeared to be a mudbrick dump.

### 5.2.3.3 Occupation sequence: the north-western quadrant

The western half of Space 87 appears to have been divided into two distinct areas by means of a large depression running on an east-west axis, although the boundaries of these areas changed under specific spatial configurations defined through time. The north-western quadrant contained dirty area features associated with cooking practices, including a number of formal fire installations that were used in different building sub-phases, a type of feature that is almost never found in the north section of houses at Çatalhöyük. When the fire installations went out of use, this part of the building was filled with a light brown silty clay deposit, which was subsequently sealed by the heterogeneous building abandonment fill.

The earliest evidence of cooking activities in this part of the building derived from a scorched area situated by the north wall underlying a later fire installations. This unit contained abundant grassy phytoliths that were randomly distributed through the layer, possibly herbaceous fuel remains. The sediment underneath this deposit displayed a marked rubefaction gradient, evidence of *in situ* burning.

An early formal fire installation, oven Feature 8101, was cut into the north wall of Space 87 but has been severely damaged by post-depositional bioturbation, which has contributed to occluding important stratigraphical links. Nevertheless, the sandy clay base and the three scorched oven floors identified were heavily truncated in the Neolithic, an action that was probably related to the construction of the support wall abutting the earlier north wall of Space 87. The oven superstructure, plastered with white clay possibly as part of the ritualistic closure of this feature, displayed no signs of rubification. Before its abandonment, the oven was sealed with an orangish brown clay packing, very similar in nature to the closure deposits found blocking other features of this building, such as the south wall undercut.


**Figure 5.13** View of north-western quadrant of Space 87, comprising the dirty area of the building. Partly excavated fire installation Feature 7345 can be seen to the east of the decorated pedestal.

The latest fire installation, Feature 7345, was built within a shallow oval pit cutting into a coarse sandy clay deposit, likely one of the earliest thick floors of Space 87 that extended across its whole area, as seen in the sections of the burial and post-retrieval pits. Four plastered surfaces formed the sequence of this feature, which was carefully lined with a thick lip made of light brown silty clay materials. The use of this hearth coincided with a sequence of grey plaster floors that covered the entire north-western quadrant and displayed substantial accumulations of rake-outs consisting of charred plants and calcitic ashes. This fire installation truncated an earlier hearth, Feature 7607, formed by three poorly preserved scorched floors that have been significantly disturbed by animal burrowing. This early hearth was sealed immediately before the construction of Feature 7345 with a heterogeneous packing deposit made of mudbrick and plaster fragments.

### 5.2.3.4 Occupation sequence: the south-western quadrant

The south-eastern quadrant of Space 87 was defined by a clean platform containing multiple grey plaster floors and associated make-up units. The carefully swept surfaces encountered in this area of the building, almost completely devoid of artefacts, show a steep slope of 10 to 25 degrees towards the southern wall, especially marked in the earliest floors. The elevations and stratigraphic relationships of this platform suggest that it might predate both the east platform Feature 638, and the central platform Feature 7114.

Two burial pits were found in this area, situated along the south wall of the space and sealed by a series of grey plaster floors and make-ups. These floors might have been contemporary with the use of the latest fire installation Feature 7345 within the north-western quadrant of Space 87. The last of these floors was overlaid by the heterogeneous building abandonment fill. On the other hand, the earliest of these floor plasters was truncated by the two burial features. The westernmost burial pit contained a female young adult skeleton with no grave goods. The easternmost burial consisted of a middle adult female (35-50 years of age) facing an infant individual placed on her chest (see Figure 5.14). Again, no associated grave goods were found.

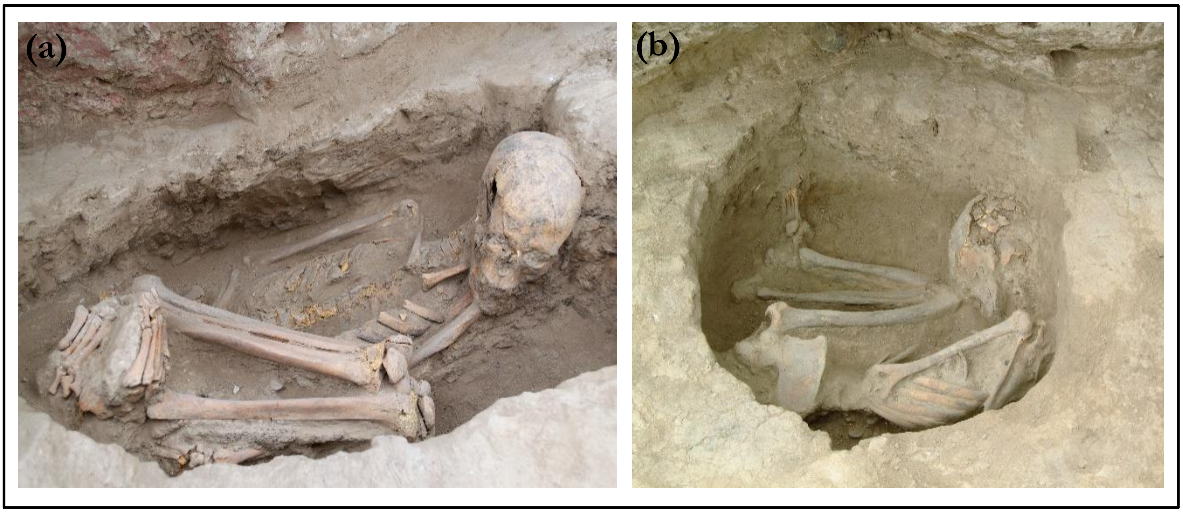



**Figure 5.14** Human interments in south-western quadrant of Space 87, looking south: a) adult Skeleton 21571; b) young female Skeleton 21550.

#### 5.2.3.5 Closure of Space 87

The last 15-20 cm of building fill that remained to be excavated after the 2012 season was removed at the beginning of the 2013 and 2014 field seasons. Space 87 was infilled with a heterogeneous mix of materials, including mudbricks (*ca*. 25% abundance), fragments of baked floors (*ca*. 5%), broken wall and floor plasters (*ca*. 5%), mortar (*ca*. 2%), rocks (*ca*. 2%), scattered fragments of charcoal and, particularly, a large number of unburnt animal and human bones (*ca*. 10%), all of which were embedded in a light brown matrix of clay loam sediment. Further, large patches of re-deposited ashes and charcoal fragments were found throughout the unit.

The excavations suggest that the infilling of Space 87 took place within a short span, as no surfaces were identified during fieldwork. However, there may have been a break in the ritualistic infilling of this built environment, represented by the retrieving of what seems was the only wooden post in this space, situated against the south wall. The post-retrieval pit left was subsequently filled with a mix of burnt materials displaying high concentrations of ash, charcoal, and burnt mudbrick.

As in many other buildings at Çatalhöyük, the abandonment of Space 87 started with cleaning the floors of artefacts and substantial occupation deposits and with the 'closure' of domestic features such as fire installations and, in this particular case, the undercut of the south wall. Here, the space at the base of the wall was filled with orange clay sediment, very hard and compacted. Packed clusters of mixed animal (cattle, pig, and sheep/goat) and human bones from different individuals, some of which displayed a considerable degree of articulation, were encountered lying directly on top of the latest building floors, especially against the southern wall of Space 87 and within its undercut, remains that were possibly deliberately placed in this particular area of the space as part of the abandonment process. In addition, and more exceptionally, an adult human skull was found carefully deposited on the central platform of the space, Feature 7114. This practice of final stage activities has been previously observed in other domestic built environments, such as Buildings 1 and 5, for which Cessford (2007) discussed the evidence for the deliberate deposition of a wide range of artefacts.

This evidence adds to the 2012 excavation of seventeen auroch horn cores from the abandonment fill, which is suggestive of the ritualistic abandonment of Space 87, possibly linked to feasting practices, as the nature of the finds seems to suggest. Interestingly, the sequence of house-abandonment of this space does not fit into typical Çatalhöyük practices.

### 5.2.4 PORTABLE XRF ANALYSES

During the 2013 excavations, pXRF analysis of the central field section in Space 87 were undertaken in order to characterise specific deposits in a rapid manner for further micromorphological and geochemical sampling. The specific aims of this study were: 1) to distinguish between floor plasters and fill materials based on elemental composition; 2) to identify residues related to past human activity, such as ashes; and 3) to detect post-depositional processes affecting the integrity of occupation deposits, including gypsum re-precipitation. The chemical data was quantified in raw photon counts, with focus on trace elemental composition (Drake 2013).

However, the results obtained, converted to element proportions and displayed as percentages of the total in Table 5.1 below, have been found unsatisfactory, with chemical patterns being strikingly similar between deposits. Further, the amount of iron in each sample is greatly overrepresented, especially when compared to the elemental data obtained from similar contexts through WD-XRF methods, reported in section 5.4.1. It is important to bear in mind, however, that the sediment samples analysed with WD-XRF underwent a preparation process that entailed grinding each specimen into a homogenised powder that was

| | element proportions (%) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Contexts** | **Fe** | **Ca** | **Co** | **Sr** | **Ti** | **Rh** | **Zr** | **Ba** | **Ni** | **Mn** | **Rb** | **Cu** |
| Top of building infill | 49,51 | 21,22 | 4,10 | 2,27 | 2,30 | 2,04 | 1,84 | 2,01 | 1,55 | 1,29 | 1,28 | 1,19 |
| Mid building infill | 48,83 | 21,03 | 4,08 | 2,41 | 2,27 | 2,07 | 1,84 | 1,99 | 1,64 | 1,51 | 1,35 | 1,23 |
| Lower building infill | 48,81 | 20,31 | 4,10 | 2,45 | 2,29 | 2,19 | 1,93 | 2,00 | 1,64 | 1,36 | 1,40 | 1,26 |
| Grey plaster floor | 41,47 | 30,88 | 3,50 | 2,81 | 1,96 | 1,95 | 1,62 | 1,72 | 1,58 | 1,25 | 1,18 | 1,15 |
| Grey plaster floor | 43,33 | 20,52 | 4,07 | 3,09 | 2,13 | 2,45 | 2,09 | 1,89 | 2,18 | 2,15 | 1,66 | 1,71 |
| Ashy layers | 42,79 | 24,76 | 3,86 | 3,00 | 2,10 | 2,12 | 1,91 | 1,84 | 1,85 | 1,91 | 1,47 | 1,44 |
| Clay packing | 48,15 | 22,20 | 4,02 | 1,95 | 2,32 | 2,14 | 1,95 | 2,02 | 1,64 | 1,42 | 1,29 | 1,22 |
| Gypsum nodules | 49,04 | 19,61 | 4,14 | 2,77 | 2,19 | 2,17 | 1,95 | 1,90 | 1,67 | 1,47 | 1,43 | 1,30 |

| | element proportions (%) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Contexts** | **As** | **Zn** | **Pb** | **Th** | **U** | **Y** | **Mo** | **Nb** | **Cr** | **Sn** | **Sb** | **Totals** |
| Top of building infill | 0,98 | 0,99 | 0,98 | 1,01 | 0,99 | 1,02 | 0,88 | 0,88 | 0,78 | 0,48 | 0,40 | 100 |
| Mid building infill | 1,02 | 1,05 | 1,03 | 1,05 | 1,06 | 1,06 | 0,92 | 0,90 | 0,78 | 0,48 | 0,39 | 100 |
| Lower building infill | 1,07 | 1,05 | 1,07 | 1,09 | 1,11 | 1,11 | 1,00 | 0,95 | 0,83 | 0,54 | 0,44 | 100 |
| Grey plaster floor | 0,96 | 0,95 | 0,96 | 0,96 | 0,97 | 0,95 | 0,83 | 0,82 | 0,72 | 0,46 | 0,36 | 100 |
| Grey plaster floor | 1,38 | 1,42 | 1,38 | 1,32 | 1,36 | 1,34 | 1,25 | 1,16 | 1,05 | 0,58 | 0,49 | 100 |
| Ashy layers | 1,19 | 1,22 | 1,19 | 1,19 | 1,19 | 1,19 | 1,04 | 1,02 | 0,85 | 0,50 | 0,41 | 100 |
| Clay packing | 1,02 | 0,99 | 1,02 | 1,03 | 1,02 | 1,04 | 0,92 | 0,90 | 0,81 | 0,51 | 0,42 | 100 |
| Gypsum nodules | 1,08 | 1,12 | 1,08 | 1,11 | 1,12 | 1,13 | 1,00 | 0,97 | 0,82 | 0,52 | 0,43 | 100 |

**Table 5.1** Split table displaying the pXRF results obtained from the analyses of the central field section, facing west (see Figure 5.5). Due to the overrepresentation of iron, the results are presented in proportions instead of counts per second, although the raw data can be found in the Appendices included in the DVD-ROM.

subsequently pressed into a pellet, thus producing a uniform material for analysis (see section in 3.6.2 Chapter 3). The present experimental integration of pXRF analysis in the excavation and documentation approach to Space 87 at Çatalhöyük lacked the means to prepare the samples in such a manner.

The application of pXRF in the field, however, served to identify the calcareous nature of a fine grey plaster floor of approximately 1mm in thickness that was visible in the exposed stratigraphic section, as seen in the amount of calcium detected. The ashy layers targeted also display a higher proportion of calcium than average for these samples, possibly due to the presence of calcitic ashes in these deposits. However, the analysis failed to detect differences between clayish units (building infill and clay packing), and the white nodules found embedded in some layers and identified later as post-depositional gypsum infillings through thin-section micromorphology.

Overall, the great homogeneity of these results can be partly due to the conglomerate nature of the materials analysed. Sediments are particularly problematic as the potential variability of constituents within the narrow X-ray field of the pXRF device means that individual readings can be skewed, therefore not representing the composition of the material as a whole. In addition, measurement depth varies for each chemical element, as it is dependent on the energy that is reflected back into the analyser. As each element has a different energy, the depth of analysis can vary as much as 0.01 mm to 5 cm (L. Drake, pers. comm.), an aspect of pXRF studies that the user can hardly control. Therefore, the elemental concentrations obtained for each sample are relative measurements, and these are further affected by the way in which the atomic structure of specific elements influences their fluorescence efficiency. This particular aspect, however, can be managed by the archaeologist through the use of different standardised filters to enhance the signal collected from specific chemical elements.

The challenges involved in the application of pXRF detection methods to archaeological sediments have been noted by several authors (Killick 2015; Shackley 2010), who have pointed out that the accuracy and precision of these analytical devices is not only dependent on the type of material being analysed, but also on the manufacturer and model. As a result, pXRF data cannot be directly compared with data obtained from laboratory chemical analyses or even from other pXRF units. Nevertheless, this method remains a valuable tool for exploratory field analysis, although the information gathered from the application of pXRF to occupation layers at Çatalhöyük, mainly aimed at distinguishing between deposits and components based on chemical composition, has proven very limited.

## 5.3 Thin-section micromorphology

Micromorphological analyses were conducted not only to investigate the mineral and organic components in the deposits as indicators of access to resources but, as importantly, the fabric of these inclusions both with regard to themselves and to other components, and the microstructural characteristics of the sediments. The study of layer composition, texture, and fabric at the microscale was undertaken in order to develop more robust interpretations about the origin of the materials, their depositional pathways, and any modifications they underwent post-depositionally. In the following sections, the results emerging from the micromorphological observations of selected sequences at Çatalhöyük are reported in three sections. The first two parts consider the arrangements of components in buildings contexts on one hand, and in open areas on the other, as represented by distinct and recurrent groups of similar composition and organisation, designated as deposit types. The third part provides an evaluation of the basic mineral and organic components found in the slides examined.

### 5.3.1 Classification of deposit types in buildings

Deposits from building sequences have been classified according to diagnostic microscopic attributes, mainly microstructure, particle size, sorting, c/f ratio, c/f related distribution, and colour, as stated in Chapter 3. The sparsity of finds in building floor materials and the absence of significant post-depositional alterations apart from bioturbation have made these two attributes non-reliable for the categorisation of constructed building surfaces at Çatalhöyük. However, the classification of accumulated residues has been made according to the abundance of specific inclusions and aggregates in the deposits studies, such as charred plants or faecal nodules. This strategy has allowed the identification of similar deposits occurring in different buildings across the site.

| Deposit type | Deposit sub-type | Description | Interpretation |
|---|---|---|---|
| **CH1** Infills | **CH1a** | Building abandonment infills | Heterogeneous unit rich in re-deposited construction materials such as mudbrick, mortar, and wall plasters, and microcharcoal. |
| | **CH1b** | Feature closure infills | Coarse deposit formed by multiple sediment aggregates of various sources, including marl, oxidised silty clay sediment, clay loam nodules, and baked aggregates, the latter possibly consisting of re-deposited fragments of oven/hearth floors. |

**Table 5.2** List of identified building deposit types at Çatalhöyük East. *(Continues in the next two pages).*

| Deposit type | Deposit sub-type | Description | Interpretation |
|---|---|---|---|
| **CH2** Plaster floors | **CH2a** | Softlime plasters (pale grey) | Extremely thin and fine-grained layers of suspected softlime sediments tempered with *ca.* 10-15% chaff, and almost completely devoid of finds. |
| | **CH2b** | Marl plasters (grey) | Poorly-sorted silty clay floors of slightly oxidised marl sediment displaying *ca.* 5-15% plant stabilisers. |
| | **CH2c** | Silty clay plasters (orangish brown) | Moderately-sorted deposits of lightly to strongly oxidised sediment showing abundant calcareous and non-calcareous minerogenic aggregates (*ca*. 15-30%). |
| | **CH2d** | Silty clay loam plasters (light brown) | Moderately-sorted plasters often displaying a strong parallel orientation, and a highly variable temper content (2-20%). |
| | **CH2e** | Clay loam plasters (dark brown) | Poorly-sorted coarse plasters, usually lightly tempered (*ca*. 5% plant pseudomorphs), and containing abundant charred flecks (*ca*. 10-15%). |
| | **CH2f** | Loamy sand (brownish grey) | Moderately-sorted sandy deposits, mainly formed by quartz minerals, and displaying an intergrain microaggregate structure. Likely used as levelling units. |
| | **CH2g** | Sandy loam (light greyish brown) | Moderately-sorted and unoriented coarse plasters containing abundant sand-size particles. |
| | **CH2h** | Mixed clay loam plasters (dark greyish brown) | Poorly-sorted coarse deposits, frequently over 1 cm in thickness and apparenly used as floor base/packing material. High occurrence of sediment aggregates and re-utilised architectural materials. |
| **CH3** Oven & hearth plasters | **CH3a** | Silty clay loam plasters | Poorly-sorted deposits, often displaying well-developed crumby microstructures towards the upper boundary, and containing abundant calcareous and clayish sediment aggregates (*ca*. 40-50% abundance). |
| | **CH3b** | Sandy clay loam plasters | Moderately-sorted coarse plasters formed by >50% sand-sized quartz minerals. |
| | **CH3c** | Silty clay plasters | Well-sorted units displaying *ca*. 5-15% plant pseudo-morphic voids and few (*ca*. 15%) non-calcareous sediment aggregates. |
| | **CH3d** | Sandy clay plasters | Poorly-sorted coarse plasters frequently displaying a crumby microstructure caused by heat impact and sweeping practices. High occurrence of re-used architectural materials such as mudbrick (*ca*. 20-30% abundance) and wall plasters (1%). |
| | **CH3e** | Hearth lip (sandy clay loam) | Completely unsorted and unoriented deposit rich in clayish sediment aggregates (*ca*. 50-60%), and forming the edge of hearth Feature 7354 in Building 114. |

**Table 5.2** List of identified building deposit types at Çatalhöyük East. (*Continues in the next page*).

| Deposit type | Deposit sub-type | Description | Interpretation |
|---|---|---|---|
| **CH4** Accumulated materials | **CH4a** | Accumulations rich in silicified plant materials | Accumulated residues on occupation floors and fire installations consisting of >50% phytoliths, *ca.* 5-15% charred plants, and *ca.* 15-25% calcitic ashes. These layers frequently display a parallel orientation relative to the base of the unit, and appear to represent *in situ* decay of plant remains, possibly related to fuel, craft, or cooking activities. |
| | **CH4b** | Accumulations rich in charred plant materials | Highly organic deposits formed by charred plant materials (>50% abundance) mixed with dispersed dung inclusions (*ca*. 10%), and sediment aggregates (*ca*. 10-20%), likely representing plant fuel. |
| | **CH4c** | Accumulations rich in faecal matter | Millimetric layers containing abundant inclusions of reworked herbivore dung (*ca*. 20-35%) found accumulated on building floors and fire installations. |
| | **CH4d** | Mixed accumulations (no dominant inclusions) | Heterogeneous deposits containing mainly unoriented minerogenic aggregates (*ca*. 10% abundance), calcitic ashes (*ca*. 5%), dung inclusions (*ca*. 5%), and plant materials (*ca*. 30%). |

**Table 5.2** List of identified building deposit types at Çatalhöyük East. (*Continued from the previous two pages*).

### 5.3.1.1 Deposit type 1: Infills

Infills have a special significance at Çatalhöyük, as these deposits frequently form part of an elaborate process of building abandonment and closure of particular features such as ovens. Unburnt buildings are usually filled with clean and heavily compacted materials, commonly derived from the dismantling of the upper walls and roof and virtually devoid of artefacts and bioarchaeological inclusions (Hodder and Farid 2013). This process has the advantage of providing a stable foundation for the surfaces of the new building.

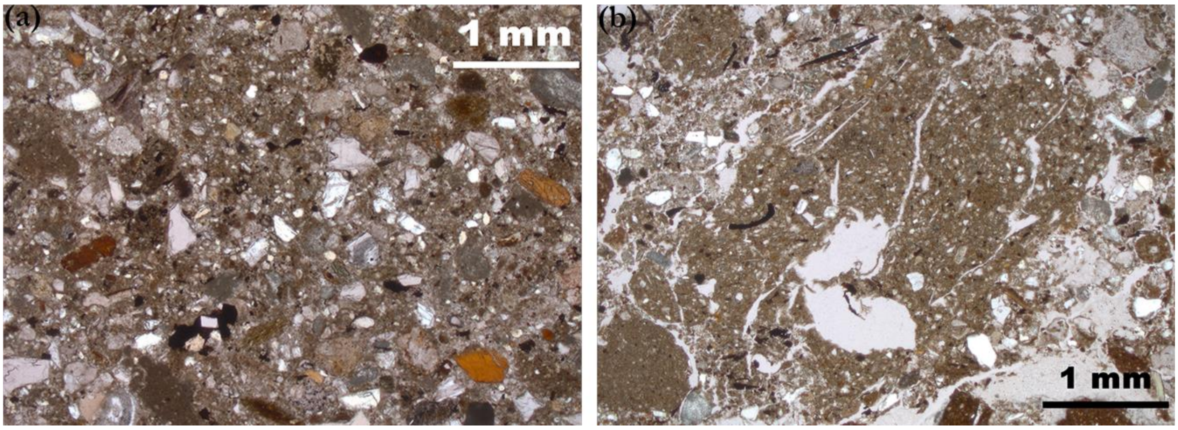



**Figure 5.15** Photomicrographs of infill sub-types: a) CH1a, heterogeneous, highly compacted building abandonment fill in Space 87, PPL; b) CH1b, closure fill of north-western quadrant of Space 87, PPL.

| | | | | | | | | | | Rocks & Minerals | | | | | | Sediment aggregates | | | Anthropogenic inclusions | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Deposit type** | **Deposit sub-type** | **Microstructure** | **Voids** | **Particle size** | **Sorting** | **Orientation** | **c/f$_{20\mu}$ ratio** | **c/f rel. distrib.** | **B-fabric** | Basalt | Quartz | Amphibole | Plagiocase | Chert | Calcite | Marl/softlime | Clay loam | Silty clay | Wall plaster | Baked plaster | Mudbrick | Phosphatic aggregates | Bone | Shell | Charred plants |
| CH1 | CH1a | V/M | v, c ● | SCL | U | U | 2:5 | s-p | b3 | ○ | ●●● | ● | ○ | ● | ● | ●● | ● | ●● | ●● | ● | ●● | ● | ○ | ○ | ● |
| | CH1b | V | v, c, p ●● | CL | PS | U | 4:5 | c-p | b3 | - | ●●● | ● | ○ | ○ | ●● | ● | ●●●● | ●●●● | - | ● | - | - | ○ | ○ | ● |

**Legend:** Microstructure: V=vughy, M=massive | Voids: v=vughs, c=channels, p= planes | Particle size: SCL=silty clay loam, CL=clay loam | Sorting: U=unsorted PS=poorly sorted | Orientation: U=unoriented | c/f related distribution: s-p=single-spaced porphyric, c-p=close porphyric | B-fabric: b3=stipple-speckled | Abundance of Voids, Inclusions & Aggregates: ○≤1%, ●2-5%, ●●6-15%, ●●●16-30%, ●●●●31-50%, ●●●●●>50%

**Table 5.3** Micromorphological characteristics and components of the various forms of deposit type CH1: infills.

The building abandonment fill of Space 87 was particularly rich in large and partly articulated faunal and human bones, which raises the question of whether feasting was performed as part of the closure process. Microscopically, this deposit, classified as CH1a, is characterised by a poorly-sorted silty clay loam matrix containing abundant sediment aggregates of various nature. Some of these components are alluvial aggregates, such as marl/softlime inclusions, brown clay loam, and oxidised fragments of silty clay, few of which retain their natural layering. Discarded or re-used architectural materials, including wall plasters, broken mudbricks, and fragments of baked floors, possibly derived from oven plasters, form between 20-35% of this unit. Bone and shell fragments are present in trace concentrations, whereas flecks of charred plants (*ca.* 5% abundance), ranging in size from 50 to 500 μm, were found randomly scattered throughout this deposit. Highly reworked phosphatic aggregates of suspected faecal origin, few of which show signs of burning, have also been found in low concentrations (*ca.* 5% abundance). Extremely compacted, displaying a massive microstructure with a very low occurrence (*ca.* 5%) of vughs and channels associated to bioturbation by soil fauna, deposit sub-type CH1a is further characterised by the occurrence (1% abundance) of rounded basaltic rocks, 250 μm to 1.5 mm in size, that were probably subjected to long-distance transportation from the volcanic massifs of the Konya Plain.

Deposit sub-type CH1b has been identified as a dark heterogeneous fill restricted to the north-western quadrant of Space 87. This deposit, consisting of poorly-sorted clay loam sediment, is more porous (*ca.* 15% vugh, channel and plane voids) than the building abandonment fill. As deposit sub-type CH1a, anthropogenic inclusions such as bone, shell, and charred plants are rare in this layer. However, in contrast with the abandonment fill, deposit sub-type CH1b is practically devoid of fragmented architectural materials, displaying a greater concentration of randomly distributed natural components such as calcareous nodules, clay loam, and oxidised silty clay aggregates, which constitute approximately 50-60% of this unit.

#### 5.3.1.2 Deposit type 2: Plaster floors

A range of samples of floor plasters from the main room of Buildings 77, 89, 114, and Space 470, in addition to collapsed roof sequences found in Space 511, have been analysed in order to study variations in the selection of floor materials at Çatalhöyük, their use in specific contexts, and periodicity. Both 'dirty' areas surrounding fire installations, and 'clean' contexts from the central and northern areas of buildings, including raised platforms used for sitting and sleeping, have been selected to delineate variations in spatial boundaries and activity areas.

| Deposit type | Deposit sub-type | Microstructure | Voids | Particle size | Sorting | Orientation | $c/f_{20\mu}$ ratio | c/f rel. distrib. | B-fabric | Rocks & Minerals | | | | | | | | | Sediment aggregates | | | Anthropogenic inclusions | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | Basalt | Limestone | Quartz | Amphibole | Plagioclase | Chert | Biotite | Muscovite | Calcite | Marl/Softlime | Silty clay loam | Silty clay | Wall plaster | Baked plaster | Phosphatic aggregates | Obsidian | Bone | Shell | Charred plants | Phytoliths |
| CH2 | CH2a | V | p-p, v, c ●● | C | WS | P | 1:10 | o-p | b1 | - | - | ● | ○ | - | ○ | ○ | - | - | - | ○ | ○ | ○ | - | - | - | - | ○ | ○ | - |
| | CH2b | V | p-p, v, c ●● | SC | PS | U | 1:5 | o-p | b2 | ○ | - | ●● | ○ | ○ | ● | - | - | - | ● | - | ● | ● | - | - | ○ | - | ○ | ● | - |
| | CH2c | V/C | p-p, v, c, p ●●● | SC | MS | U | 2:5 | d-p | b3 | ○ | ○ | ●●● | ● | ○ | ● | ○ | - | ● | ●● | ○ | ●● | ● | - | ○ | ○ | ○ | ○ | ● | ○ |
| | CH2d | V | p-p, v, c ●● | SCL | MS | P U | 3:5 | s-p | b3 | ○ | - | ●●● | ● | ○ | ● | ○ | ○ | ● | ○ | ● | ●● | - | - | ○ | ○ | ○ | ○ | ● | ○ |
| | CH2e | V/C | p-p, v, c ●●● | CL | PS | P U | 3:5 | d-p | b3 | ○ | - | ●●● | ● | ○ | ○ | ○ | ○ | ○ | ○ | ● | ● | ○ | - | - | - | ○ | - | ●● | - |
| | CH2f | IM | s-p ●●● | LSa | MS | U | 10:1 | d-e | b3 | ○ | ● | ●●●●● | ● | ○ | ●● | - | - | ● | ● | - | ● | - | - | ●● | ○ | ○ | - | ● | - |
| | CH2g | V | v, c ●● | SaL | MS | U | 5:1 | c-p | b3 | ○ | - | ●●●●● | ● | - | ○ | - | - | ● | ● | - | ● | - | - | - | - | ○ | ○ | ○ | - |
| | CH2h | V | p-p, v, c ●●● | CL | PS | P U | 3:5 | s-p | b3 | ○ | ○ | ●●● | ● | ○ | ● | ○ | ○ | - | ●●● | ●● | ●● | ● | ● | ○ | ○ | ○ | ○ | ●● | - |

**Legend:** Microstructure: V=vughy, C=channel, IM=intergrain microaggregate | Voids: p-p=plant pseudomorphs, v=vughs, c=channels, p= planes, s-p=simple packing voids | Particle size: C=clay, SC=silty clay, SCL=silty clay loam, CL=clay loam, LSa=loamy sand, SaL=sandy loam | Sorting: PS=poorly sorted, MS=moderately sorted, WS= well sorted | Orientation: U=unoriented, P=parallel | c/f related distribution: o-p=open porphyric, d-p=double-spaced porphyric, s-p=single-spaced porphyric, c-p=close porphyric, d-e=double-spaced enaulic | B-fabric: b1=undifferentiated, b2=calcite crystallitic, b3=stipple-speckled | Abundance of Voids, Inclusions & Aggregates: ○≤1%, ●2-5%, ●●6-15%, ●●●16-30%, ●●●●31-50%, ●●●●●>50%

**Table 5.4** Micromorphological characteristics and components of the various forms of deposit type CH2: plaster floors.

The first deposit sub-type identified, CH2a, corresponding to pale grey plasters of suspected softlime origin, is characterised by an extremely fine particle size (clay grade), and the low occurrence of inclusions and sediment aggregates. Heavily tempered with plant stabilisers (*ca.* 10-15% abundance), only two occurrences of these plasters, ranging in thickness from 0.1 to 2 cm, have only been found in the clean areas of Buildings 89 and 114.

Deposit sub-type CH2b, formed by slightly oxidised grey marl sediments constituted by fine silty clay and *ca.* 10% of quartz, amphibole, plagioclase, and chert mineral grains, has been detected in multiple floor sequences across Buildings 77, 89, and 114, in addition to suspected roof/upper storey plasters found in secondary deposition within Space 511. These layers, which frequently contain embedded calcareous and clayish sediment aggregates (*ca.* 5% abundance), in addition to charred plant flecks and mollusc shells (*ca.* 2-5%), display a variable content of plant temper, as inferred from the occurrence of plant pseudomorphic voids, which ranges between 5% and 15%.

It is important to bear in mind, however, that the optical distinction between softlime and marl plasters, whether performed at the macro- or the microscale, is far from straightforward due to the similar texture and colour of these materials. Compositionally, softlime plasters are defined by the presence of dolomite with small amounts of clays, in contrast with the chemistry of marl plasters, which contain high quantities of calcite and clays (Anderson *et al.* 2014a; Matthews *et al.* 2013). During the micromorphological analysis, the Çatalhöyük samples selected for this study were compared to slides from the reference collection available at the University of Reading and comprising thin-sections from the KOPAL trenches and other buildings at Çatalhöyük, and thus an attempt was made to optically distinguish between softlime and marl plasters, although it is acknowledged here that only elemental analyses can provide a conclusive determination of the nature of these plasters.

Orangish brown silty clay plasters have been classified under deposit sub-type CH2c. These apparently oxidised deposits vary in colour from reddish brown to light orangish brown, and are frequently identified as thick (>1cm) layers within clean floor sequences from the central and eastern areas of houses. Interestingly, in Building 114 these fine-grained sediments were used for blocking the oven and the south wall undercut, which suggests that they could have been perceived as packing in addition to floor materials. The plasters falling under the CH2c category usually contain abundant calcareous and clayish sediment aggregates (*ca.* 15-30%), and occasional fragments of recycled wall plasters (*ca.* 2-5%). These deposits appear to have been lightly tempered, with plant pseudomorphic voids displaying a low abundance (*ca.* 5%), and charred plant flecks representing 5% of these units.

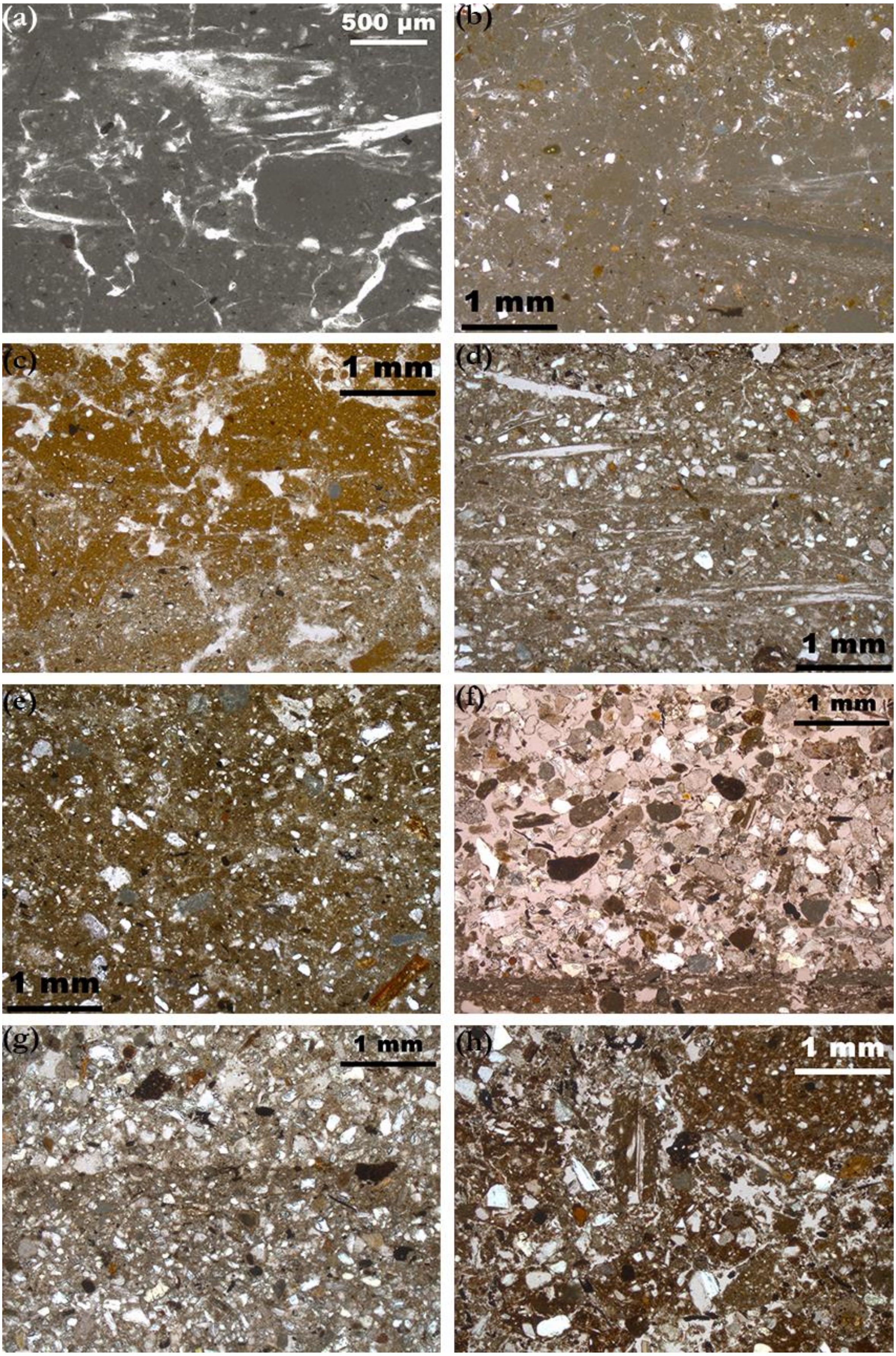



**Figure 5.16** Photomicrographs of plaster floor sub-types: a) CH2a, possible softlime-based plaster in Building 89, PPL; b) CH2b, marl-based plaster in Building 89, PPL; c) CH2c, orangish-brown silty clay deposit in Building 114, PPL; d) CH2d, silty clay loam floor in Building 89, PPL; e) CH2e, clay loam plaster in Building 114, PPL; f) CH2f, loamy sand layer part of central platform sequence (Feature 7114) in Building 114, likely used as a levelling unit, PPL; g) CH2g, sandy loam floor in Building 114, PPL; h) CH2h, mixed plaster in Building 77, PPL.

The light brown floor plasters classified as deposit sub-type CH2d are the most common in the Çatalhöyük sequences analysed for this study. These units have been identified in Buildings 77, 89, 114, and the suspected roof/upper storey plaster sequence found in secondary deposition in Space 511. These layers, consisting of moderately-sorted silty clay loam sediments frequently displaying a strong parallel orientation and a highly variable temper content (2-20% of plant chaff), include a number of oxidised clayish sediment nodules (*ca.* 5-15%), some of which display parallel graded bedding, suggesting that these aggregates originated from an alluvial source.

Deposit sub-type CH2e, consisting of dark brown clay loam plasters identified in the clean floor sequences of Buildings 77 and 114, is characterised by the presence of poorly-sorted sub-rounded minerals, including quartz, amphibole, plagioclase, chert, biotite, muscovite, and calcite. The incidence of plant-pseudomorphic voids derived from added stabilisers is generally very low in these deposits (5% or less), although fragments of charred plants are more abundant than in the other plaster types, ranging between 10% and 15%. The occurrence of sediment aggregates is also lower than in other types of mud plasters, forming 5-10% of these layers.

Loamy sand deposits, classified as sub-type CH2f, have only been documented in Building 114 as part of the sequence forming the central platform Feature 7114. These unusual plasters are constituted by moderately sorted rounded and sub-rounded mineral grains of quartz, but also chert, amphibole, calcite, and plagioclase (*ca.* 80% abundance), and a small number of calcareous and silty clay aggregates (*ca.* 5%). Due to their high content of sands, it is unlikely that these units were used as occupation surfaces. Instead, the CH2f layer detected in Building 114 could represent a base or levelling unit for the platform. Strikingly, discontinuous accumulations of phosphatic aggregates (*ca.* 5-10%) have been found along the upper boundary of this deposit and embedded in the groundmass, although the suspected faecal nature of these could not be determined by micromorphology.

Deposit sub-type CH2g, referring to light greyish brown sandy loam plasters, has also been uniquely identified in Building 114. This unit, although constituted by a high proportion of sand-size particles (>50%), displays a more compacted microfabric than the layers classified as CH2f due to the higher clay content. Anthropogenic inclusions are extremely rare with the exception of fragments of wall plasters (2% abundance). Other components include natural aggregates of calcareous and silty clay sediments (*ca.* 5% abundance).

The last plaster category identified, deposit sub-type CH2h, consists of coarse mixed units of poorly-sorted clay loam sediment, usually between 1 and 3 cm in thickness, frequently found towards the base of the stratigraphic sequences studied. These layers have been detected in all the domestic built environments examined for this research, including Space 470, Buildings 77, 89, and 114, and the collapsed roof/upper storey sequence unearthed in Space 511. Interestingly, although these units usually display continuous accumulations of occupation residues along their upper boundaries, they are frequently classified as packing/make-ups in the field due to their thickness and overall heterogeneity. In fact, CH2h plasters are constituted by a high proportion of various types of calcareous and clayish sediment aggregates (*ca.* 30-40% abundance), and re-utilised construction materials, predominantly wall plasters and fragments of baked oven floors (*ca.* 5-10%). The occurrence of charred plant flecks, *ca.* 10-15%, is significant when compared to the percentage of anthropogenic inclusions of organic origin found in other plaster types, but their incorporation to these deposits, although possibly intentional to act as stabilisers, was more probably caused accidentally at the place of manufacture, especially if taking place in open spaces within the settlement or its immediate surroundings.

#### 5.3.1.3 Deposit type 3: Fire installation plasters

The fire installations considered in this study correspond to the oven of Building 77, Feature 7108, and the two hearths of Building 114, Features 7607 and 7645. Five types of plaster have been identified based on key micromorphological attributes, including particle size, microstructure, and sorting. Colour has not been taken into account in this categorisation as it has been found to be too dependent on post-depositional alterations related to firing temperatures. These were considerably higher in the oven, whose plasters were completely baked and hardened, than in the hearths, which display substantial rubefaction and scorching of their upper surfaces but were not hardened by heat.

The first deposit sub-type identified, CH3a, corresponding to poorly-sorted silty clay loam plasters, often displays a well-developed crumby microstructure towards its upper boundary, likely an effect of high burning temperatures and erosion caused by maintenance practices, such as the regular sweeping of these surfaces. This type of plaster, tempered with *ca.* 5% plant chaff, has been identified in all the examined fire installations, being the most common oven/hearth floor in the samples studied. The deposits classified as CH3a often contain abundant calcareous and clayish sediment aggregates, ranging in abundance between 40% and 60% and making these plasters the most heterogeneous ones in this classification.

| | | | | | | | | | | Rocks & Minerals | | | | | | | Sediment aggregates | | | Anthropogenic inclusions | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Deposit type** | **Deposit sub-type** | **Microstructure** | **Voids** | **Particle size** | **Sorting** | **Orientation** | **c/f$_{20\mu}$ ratio** | **c/f rel. distrib.** | **B-fabric** | Basalt | Limestone | Quartz | Amphibole | Plagioclase | Chert | Calcite | Marl/Softlime | Silty clay loam | Silty clay | Wall plaster | Baked plaster | Mudbrick | Ashes | Phosphatic aggregates | Obsidian | Bone | Shell | Charred plants | Phytoliths |
| CH3 | CH3a | V/Cr | p-p, c-p, v, c ●● | SCL | PS | U | 4:5 | s-p | b3 | ○ | ○ | ●●● | ● | ○ | ○ | ● | ●● | ●●● | ●●● | ○ | - | - | - | - | ○ | ○ | ○ | ● | ○ |
| | CH3b | V | p-p, v, c ●●● | SaCL | MS | U | 5:2 | c-p | b3 | ○ | - | ●●●●● | ● | ○ | ○ | - | - | ● | ● | - | - | - | - | - | ○ | - | ○ | ● | - |
| | CH3c | V/Cr | p-p, v, c, p ●●● | SC | WS | U | 2:5 | d-p | b3 | ○ | ○ | ●●● | ● | ○ | ○ | - | - | ● | ●● | - | - | - | ● | - | - | ○ | ○ | ● | - |
| | CH3d | Cr/V | c-p, v, c ●●● | SaC | PS | U | 5:3 | c-p | b3 | ○ | - | ●●●● | ● | ○ | ○ | - | ● | ● | ●● | ○ | ● | ●●● | ●● | - | ○ | ○ | ○ | ● | - |
| | CH3e | V | v, c ●● | SaCL | U | U | 1:1 | c-p | b3 | ○ | - | ●●●● | ● | ○ | ○ | - | ○ | ●●●● | ●● | - | - | ●● | - | ● | ○ | ○ | ○ | ● | - |

**Legend:** Microstructure: V=vughy, Cr=crumby | Voids: v=vughs, c=channels, p= planes, c-p=complex packing voids, p-p=plant pseudomorphs | Particle size: SC=silty clay, SCL=silty clay loam, SaC=sandy clay, SaCL=sandy clay loam | Sorting: U=unsorted, PS=poorly sorted, MS=moderately sorted, WS= well sorted | Orientation: U=unoriented | c/f related distribution: c-p=close porphyric, s-p=single-spaced porphyric, d-p=double-spaced porphyric | B-fabric: b3=stipple-speckled | Abundance of Voids, Inclusions & Aggregates: ○≤1%, ●2-5%, ●●6-15%, ●●●16-30%, ●●●●31-50%, ●●●●●>50%

**Table 5.5** Micromorphological characteristics and components of the various forms of deposit type CH3: oven and hearth plasters.

Deposit sub-type CH3b, corresponding to sandy clay loam plasters formed by over 50% quartz grains, has only been identified in the oven sequence of Building 77. Sediment aggregates (*ca.* 5-10% abundance) and anthropogenic inclusions (2-5%) are rare in these deposits, which appear to have been substantially tempered with plant materials (*ca.* 15-20% plant pseudormorphic voids). These layers are frequently black to very dark brown in colour due to the intensity of firing temperatures and the repeated use of the oven. In spite of their

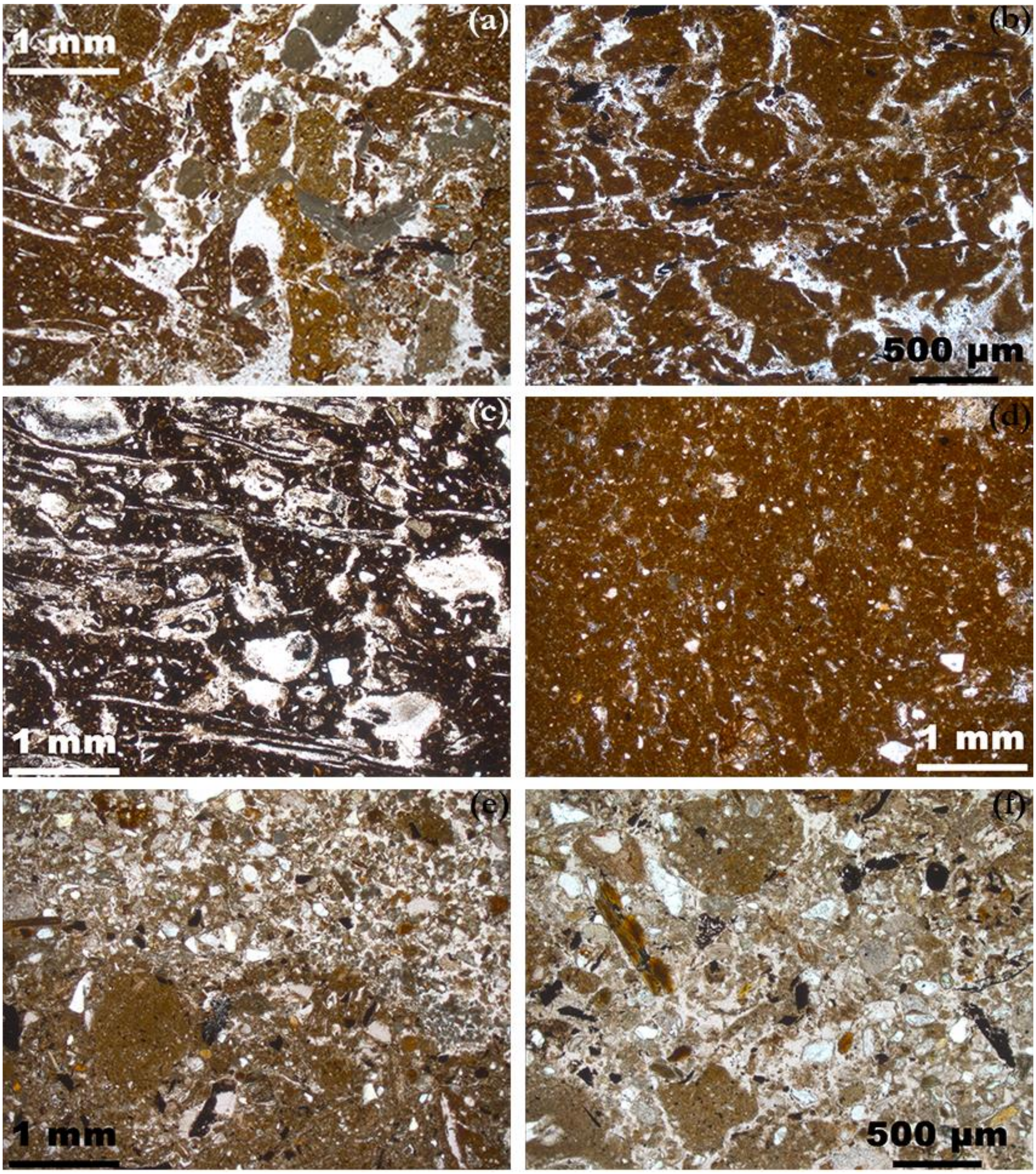



**Figure 5.17** Photomicrographs of plastered surfaces found within fire installations in buildings: a) CH3a, heterogeneous layer formed by different sediments in oven Feature 7108, Building 77, possibly acting as a levelling unit, PPL; b) CH3a, silty clay loam plaster within hearth Feature 7607, Building 114, PPL; c) CH3b, baked oven floor displaying abundant plant pseudomorphic voids and vesicles, the latter caused by extremely high firing temperatures, PPL; d) CH3c, silty clay deposit part of hearth sequence Feature 7345, PPL; e) CH3d, sandy clay plaster within hearth Feature 7607, Building 114, PPL; f) CH3e, fabric of hearth lip deposit surrounding fire installation 7345 in Space 87, PPL.

high porosity (approximately 25-30% voids), these units were found to be extremely hardened in the field, and described as 'baked oven floors' during the excavation. The upper boundary of the deposits categorised as CH3b is often sharp and prominent, showing no traces of residue accumulation, indicative of the careful maintenance of this fire installation. Occasionally, vesicle voids have been detected in these plasters, likely produced by the effect of high temperatures on the plant materials used as stabilisers, which caused them to burst.

Orangish brown silty plasters have been classified as deposit sub-type CH3c. These fine-grained floors, which display a marked rubefaction gradient with scorched upper boundaries, have been found as part of the hearth sequence Feature 7345 in Building 114. Well-sorted and moderately tempered with approximately 10% plant stabilisers, these units often contain embedded alluvial aggregates of oxidised silty clay and silty clay loam (*ca.* 10-15% abundance). Very thin layers (200-500 μm thick) of accumulated residues have been detected on top of these plasters, consisting of extremely fragmented charred plant remains mixed with calcitic ashes, and small allochthonous sediment particles.

Coarse, sandy clay hearth plasters have been identified within the sequence of fire installation Feature 7607, in Building 114. These deposits, classified as sub-type CH3d, were poorly tempered (*ca.* 5% plant stabilisers), which appears to have been the cause for the crumbiness and fragmentation observed in their upper boundaries, damaged by heat impact and sweeping practices. In addition, the top of these plasters seems to contain re-precipitated ashes, deposited in the cracks and complex packing voids that characterise the upper part of these layers. Deposit sub-type CH3d displays a high degree of compositional heterogeneity overall, comprising recycled architectural materials such as mudbricks (*ca.* 25% abundance), baked floors (*ca.* 5%) and wall plasters (*ca.* 1%).

The sandy clay loam lining of hearth Feature 7345 in Space 87, classified as deposit sub-type CH3e, was sampled to investigate the composition and manufacture of this architectonical element. This deposit appears constituted by a range of unsorted and unoriented components, which include coarse silty clay loam and silty clay sediment aggregates (approximately 50-60% abundance), apparently derived from at least two different alluvial sources and mixed together during plaster manufacture, and re-cycled fragments of mudbrick. Although no plant pseudomorphic voids were identified, the small amount of fragmented charred plant remains found embedded in this unit could have acted as stabilisers. The occurrence of *ca.* 5% amorphous phosphatic aggregates in this deposit is especially interesting. Even though no spherulites have been detected, these seem to represent charred dung remains, likely incorporated to this unit at the place of manufacture.

#### 5.3.1.4 Deposit type 4: Accumulated materials

Units of accumulated occupation residues in buildings have been encountered in floor areas around fire installations as re-deposited rake-outs, and as thin 'dust' layers of trampled materials on the surfaces of fire installations and building floors. These accumulations are often rich in charred residues of plant origin and ashes, and they can vary in thickness from 200 μm to several millimetres. In the case of rake-outs, these units are usually formed by superimposed microlaminations of charred materials, each of which seems to constitute a single depositional event of oven/hearth discards. In the clean areas of buildings at Çatalhöyük, mainly used for sitting and sleeping (Matthews 2005b), accumulated deposits are often thin and sparse, comprising microlenses of silt-sized organic and inorganic materials that were gradually deposited under mats and soft furnishings.

The first deposit sub-type in this category, CH4a, consists of highly organic accumulations rich in silicified plant materials, which represent up to 70% of these units, and other inclusions such as charred plant fragments (*ca.* 5-15% abundance), calcitic ashes (*ca.* 15-25%) and, less frequently, phosphatic aggregates of suspected faecal origin (*ca.* 1%). Small particles or inorganic materials in the form of rounded aggregates of clayish sediment (*ca.* 5-15%) have also been found in these layers. Deposits classified as CH4a have only been detected in hearth sequences, displaying strong parallel orientations that are indicative of *in situ* deposition. Thus, these were probably fuel remains of herbaceous/mixed origin, although phytolith identification has been hindered by the obscuring effect of superimposed organic remains.

Deposit sub-type CH4b comprises layers rich in charred plants (>50% abundance), often poorly-sorted and highly fragmented, and other components of both organic and inorganic origin that are present in lower quantities, such as phytoliths (*ca.* 5%), herbivore dung (*ca.* 5-10%), bone fragments (*ca.* 2-5%), and calcitic ashes (*ca.* 5%). Burnt sediment aggregates are especially abundant in these units, including swept floor particles and rounded inclusions of calcareous and clayish materials, some of which appear to be fragments of oven plaster. This type of deposit, often consisting of multiple microlayers that display a moderate parallel orientation, are especially frequent in the dirty area of buildings, adjacent to fire installations and locations for food preparation.

Deposit sub-type CH4c is distinguished by the relatively high proportion (*ca.* 20-30%) of faecal lenses of suspected herbivore origin occurring in these layers. These units are only a few millimetres thick and appear substantially reworked by trampling. Interestingly, deposit sub-type CH4c has been identified in two very different contexts: as re-deposited rake-outs from

| Deposit type | Deposit sub-type | Microstructure | Voids | Particle size | Organic/mineral ratio | Sorting | Orientation | c/f$_{20\mu}$ ratio | c/f rel. distrib. | B-fabric | Rocks & Minerals | | | | | | | | | Sediment aggregates | | | Anthropogenic inclusions | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | Basalt | Limestone | Quartz | Amphibole | Plagioclase | Chert | Biotite | Muscovite | Calcite | Marl/Softlime | Clay loam | Silty clay | Wall plaster | Ashes | Phosphatic aggregates | Faecal matter | Obsidian | Bone | Shell | Charred plants | Phytoliths | Hackberry endocarp |
| CH4 | CH4a | S | c-p, v, c ●●●● | - | 10:1 | U | P | - | - | b1 | - | - | ● | ○ | - | - | - | - | - | - | ●● | ● | - | ●●● | ○ | - | - | - | - | ●● | ●●●●● | - |
| | CH4b | V | v, c ●● | CL | 3:1 | PS | P | 1:2 | s-p | b3 b1 | ○ | - | ●●● | ○ | ○ | ○ | ○ | - | ● | ●● | ● | ● | ● | ● | ○ | ●● | ○ | ● | ○ | ●●●●● | ● | - |
| | CH4c | V/L | v, c, p ●● | SCL | 2:1 | MS | P | 1:5 | o-p | b4 | ○ | - | ●● | ○ | ○ | ○ | - | - | - | - | ● | ● | - | ○ | - | ●●● | ○ | ○ | ○ | ● | ○ | - |
| | CH4d | V | v, c ●●● | CL | 1:1 | U | U | 2:3 | s-p | b3 b2 | ○ | ○ | ●●● | ○ | ○ | ● | - | ○ | ●● | ● | - | ● | - | ● | - | ● | ○ | ● | ○ | ●●● | ○ | ○ |

**Legend:** Microstructure: S=spongy, V=vughy, L=laminated | Voids: v=vughs, c=channels, p= planes, c-p=complex packing voids | Particle size: CL=clay loam, SCL=silty clay loam | Sorting: U=unsorted, PS=poorly sorted, MS=moderately sorted | Orientation: U=unoriented, P=parallel | c/f related distribution: s-p=single-spaced porphyric, o-p=open porphyric | B-fabric: b1=undifferentiated, b2=calcite crystallitic, b3=stipple-speckled, b4=parallel striated | Abundance of Voids, Inclusions & Aggregates: ○≤1%, ●2-5%, ●●6-15%, ●●●16-30%, ●●●●31-50%, ●●●●●>50%

**Table 5.6** Micromorphological characteristics and components of the various forms of deposit type CH4: accumulated materials.

the fire installations in Building 114, and as gradually accumulated and severely trampled layers in Space 470. In the former case, CH4c deposits are formed by burnt herbivore dung and other charred components, including rounded sediment aggregates (*ca.* 5% abundance) and anthropogenic inclusions such as charred plants (*ca.* 5% abundance), and dispersed fragments of bone, shell, and obsidian flakes. Here, the abundance of faecal aggregates and their contextual associations suggest the use of dung as fuel, although given the scarcity of these layers, this was probably an unusual practice in buildings. By contrast, in Space 470, *in situ* herbivore dung lenses and fine sediment particles constitute deposit sub-type CH4c, which was considerable altered by trampling, a depositional pattern reminiscent of penning deposits identified elsewhere on site (Matthews *et al.* 1996).

The last deposit sub-type, CH4d, has been described as mixed accumulations due to the absence of clearly dominant inclusions. These heterogeneous units, the most common in buildings at Çatalhöyük, contain a wide range of unoriented and randomly distributed components, including burnt plant materials (*ca.* 20-30% abundance), heated bone and shell

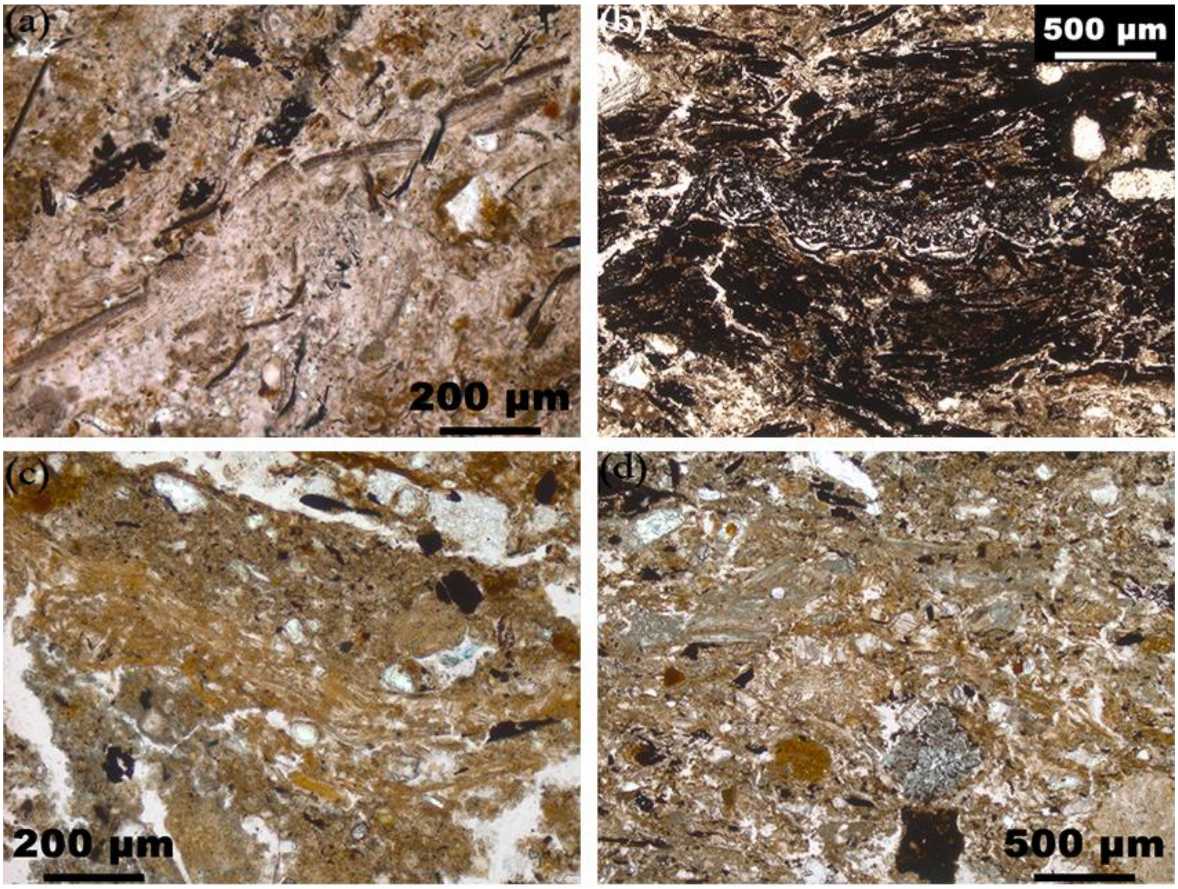



**Figure 5.18** Photomicrographs of deposit sub-types of accumulated materials found on building surfaces: a) CH4a, hearth fill dominated by silificied plant materials in Building 114, PPL; b) CH4b, rake-out layer rich in charred plant materials identified within the north-western quadrant of Building 114, PPL; c) CH4c, discontinuous accumulations of herbivore dung on the floors of Building 114, PPL; d) CH4d, mixed accumulations of charred and silicified plants, calcitic ashes, dung, and sediment aggregates in Building 89, PPL.

fragments displaying varying degrees of charring (ca. 5%), burnt faecal matter (ca. 5%), calcitic ashes (ca. 5%), and approximately 10% rounded and subrounded minerogenic aggregates. These re-deposited units seem to represent mixed hearth/floor sweepings that were gradually accumulated in the dirty area of buildings through daily maintenance practices.

## 5.3.2 Classification of deposit types in open areas

The midden contexts analysed in this thesis, collected from the TPC and GDN excavation areas, span Mellaart Levels III-I. Similarly to Boncuklu, open areas at Çatalhöyük are mainly

| Deposit type | Deposit sub-type | Description | Interpretation |
|---|---|---|---|
| **CH5** Midden deposits | **CH5a** | Accumulations rich in silicified plant materials | These units are formed by >50% articulated phytolith materials frequently oriented to the unit base. Inclusions of fragmented charred plants are also common (up to 25% abundance). These layers appear to have formed through the accumulation of plant fuel derived from *in situ* burning activities. |
| | **CH5b** | Accumulations rich in charred plant materials | These deposits, dominated by charred plant inclusions (>50% abundance), and containing also phytoliths (*ca*. 5-15%), and sediment aggregates (*ca*. 10-20%) have been found displaying strong parallel orientations, indicating *in situ* plant decay of fuel materials. The presence of wood charcoal and smaller fragments of unidentifiable charred plants points to diverse sources. |
| | **CH5c** | Accumulations rich in calcitic ashes | These deposits are commonly formed by *ca.* 20-40% calcitic ashes derived from the burning of plant materials. Charred plants and phytoliths occur as embedded inclusions up to 35% abundance. These layers probably represent discarded mixed fuel sources. |
| | **CH5d** | Accumulations rich in faecal matter | Organic layers composed by up to 30% faecal pellets of suspected herbivore origin, and *ca*. 25% reworked phosphatic aggregates. These units seem to have formed through the re-deposition of animal waste from stabling rake-outs, as the coprolitic remains appear unburnt and are therefore unlikely to have been used as fuel. |
| | **CH5e** | Accumulations rich in sediment aggregates | Charred and unburnt sediment crumbs of various origins form >50% of these units, possibly the remains of plaster, brick, or pottery production activities, or the debris from floor sweeping and/or partial burning of aggregate materials. |
| | **CH5f** | Mixed accumulations (no dominant inclusions) | There is more than one dominant inclusion type in these layers, commonly plant materials, rounded minerogenic aggregates, and bone fragments. These units possibly represent re-deposited hearth/floor sweepings and mixed dumping events. |

**Table 5.7** List of identified midden deposit types at Çatalhöyük.

anthropogenic in origin, displaying a high proportion of re-deposited organic components (Shillito and Matthews 2013). As specific micromorphological attributes, such as particle size, sorting, orientation, c/f ratio, and c/f related distribution tend to be fairly similar in most midden contexts, these have been evaluated according to dominant inclusion types. Midden deposit classification is reported in Table 5.7 in the previous page, and it has been developed through the analysis of variability in the components constituting these deposits, including abundance, alterations, and contextual associations. The identification of these categories has allowed to distinguish patterns in deposition and activities in open areas at Çatalhöyük.

#### 5.3.2.1 Deposit type 5: Midden deposits

Previous microstratigraphic works on midden contexts from the TP Area, immediately to the north of the current TPC Area and close to the top of the East Mound, highlighted the occurrence of less finer laminated sequences in these areas when compared to middens from earlier occupation levels, in addition to a higher incidence of post-depositional alterations in the form of gypsum crystallisation and bioturbation (Shillito 2011b; Shillito *et al.* 2008). The research conducted here, however, has detected finely laminated midden stratigraphy in a number of field sections at these excavation areas, especially in Mellaart Levels II-I, apparently representing a rapid built up of materials in this later period.

The first deposit sub-type identified in these open sequences is CH5a, which comprises accumulations rich in silicified plant materials. These layers, ranging in thickness between 1 and 9 mm, are constituted by over 50% semi-articulated phytoliths derived from grasses and reeds that display a strong parallel orientation relative to the basal boundary. Other components of these units include fragments of charred plants (*ca.* 20-30% abundance), and calcitic ashes (*ca.* 5%). These units are likely to represent *in situ* plant decay related to distinct discard events of plant remains used as fuel or craft sources.

Midden layers predominantly formed by charred plant materials (>50% abundance) have been classified as deposit sub-type CH5b. These units also comprise phytolith remains (*ca.* 5-15%), burnt and unburnt sediment aggregates (*ca.* 10-20%), and low quantities of other anthropogenic inclusions such as obsidian flakes, shell fragments, and heated bones, occurring in slightly variable proportions in each CH5b deposit. The unsorted components of these layers commonly display a strong to moderate parallel orientation, indicative of *in situ* decay. The slightly mixed nature of these deposits, with wood charcoal, small charred plant materials, and phytoliths as the major components, points towards their origin as fuel residues from cooking or heating.

| Deposit type | Deposit sub-type | Microstructure | Voids | Particle size | Organic/mineral ratio | Sorting | Orientation | $c/f_{20\mu}$ ratio | c/f rel. distrib. | B-fabric | Rocks & Minerals | | | | | | | | Sediment aggregates | | | Anthropogenic inclusions | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | Basalt | Limestone | Quartz | Amphibole | Plagioclase | Chert | Biotite | Calcite | Marl/Softlime | Clay loam | Silty clay | Ashes | Phosphatic aggregates | Faecal matter | Obsidian | Bone | Shell | Charred plants | Phytoliths | Hackberry endocarp |
| CH5 | CH5a | S/V | s-p, c<br>●●● | - | 10:1 | PS | P | - | - | b1<br>b2 | - | - | - | - | - | - | - | - | ○ | - | - | ● | - | - | - | - | - | ●●● | ●●●●● | - |
| | CH5b | L/V | c-p, c<br>●●● | - | 10:1 | U | P | - | - | b1 | ○ | ○ | ● | ○ | - | ○ | - | - | ○ | ● | ●● | ○ | ○ | - | ○ | ● | ○ | ●●●●● | ●● | ○ |
| | CH5c | S/V | c-p, v, c<br>●●● | - | 2:1 | U | U | - | - | b1<br>b2 | ● | - | ● | ○ | ○ | ○ | - | - | ● | ●● | ● | ●●●● | ○ | ● | - | ● | - | ●● | ●●● | - |
| | CH5d | Cr | c-p, c<br>●●● | SCL | 3:1 | U | U | 5:3 | c-e<br>s-p | b2<br>b3 | - | - | ●●● | ● | ● | ● | ○ | ● | ●●● | - | - | - | ●●● | ●●● | - | ● | ○ | ● | ○ | - |
| | CH5e | Cr | c-p, c<br>●●● | SCL | 4:5 | U | U | 5:4 | s-e<br>s-p | b2<br>b3 | ○ | ○ | ●● | ○ | ○ | ● | - | ● | - | ●●●● | ●●● | ● | ● | - | ○ | ● | - | ●● | ● | - |
| | CH5f | Cr | c-p, v, c<br>●●● | CL | 2:3 | U | U | 5:2 | s-e<br>s-p | b2<br>b3 | ○ | ○ | ●● | ○ | ○ | ● | ○ | ● | ● | ● | ●● | ● | ○ | ● | - | ●● | ○ | ●●● | ●● | ○ |

**Legend:** Microstructure: S=spongy, L=microlaminated, V=vughy, Cr=crumby | Voids: v=vughs, c=channels, s-p=simple packing voids, c-p=complex packing voids | Particle size: SCL=silty clay loam, CL=clay loam | Sorting: U=unsorted, PS=poorly sorted | Orientation: U=unoriented, P=parallel | c/f related distribution: s-p=single-spaced porphyric, c-e=close enaulic, s-e=single-spaced enaulic | B-fabric: b1=undifferentiated, b2=calcite crystallitic, b3=stipple-speckled | Abundance of Voids, Inclusions & Aggregates: ○≤1%, ●2-5%, ●●6-15%, ●●●16-30%, ●●●●31-50%, ●●●●●>50%

**Table 5.8** Micromorphological characteristics and components of the various forms of deposit type CH5: middens.

Deposit sub-type CH5c can be distinguished by the moderate to high proportion (approximately 20-40%) of calcitic ashes forming the fine fraction of these units. These ashes appear to be derived from the combustion of plant materials, also present in these layers as conjoined phytolith remains (*ca.* 15-20%), and charred plants (*ca.* 10-15%). Other components include subrounded sediment aggregates of calcareous and clayish origin (*ca.* 10-20%), rounded basaltic rocks (*ca.* 2-5%), and dispersed inclusions of burnt and unburnt bone and

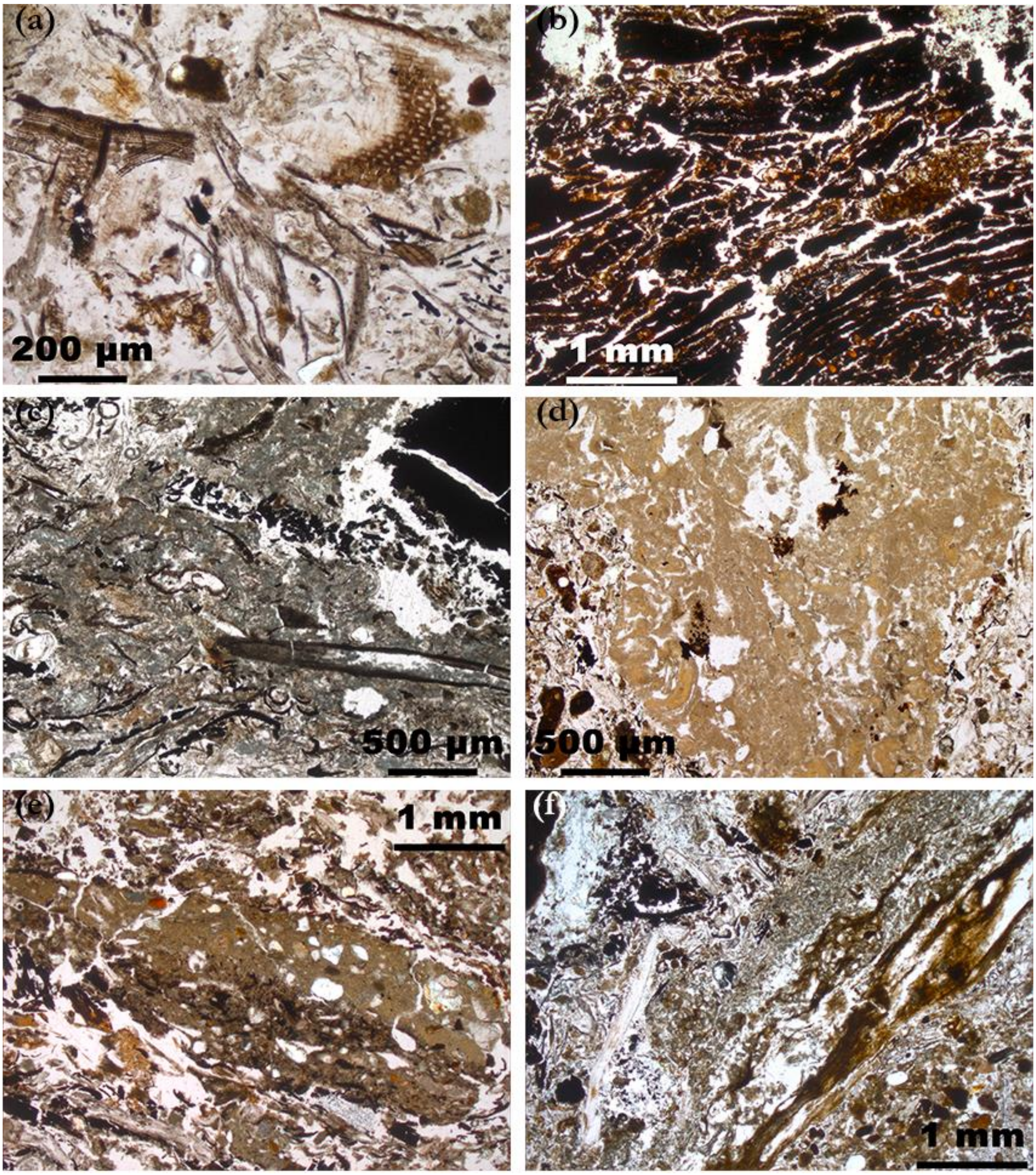



**Figure 5.19** Photomicrographs of deposit sub-types in middens: a) CH5a, accumulation of silicified plant materials displaying carbon occlusion caused by charring, PPL; b) CH5b, accumulation of charred plant materials and wood phytoliths, PPL; c) CH5c, midden deposit mainly formed by calcitic ashes and dispersed silicified and charred plant fragments, PPL; d) CH5d, accumulations of faecal matter, usually herbivore dung, PPL; e) CH5e, highly minerogenic midden deposit rich in sediment aggregates, PPL; f) CH5f, accumulation of mixed materials comprising calcitic ashes, bone and plant inclusions, and sediment aggregates, PPL.

herbivore dung (*ca.* 5-10%). Deposits classified as CH5c are rare in open areas at Çatalhöyük, as for ash layers to be preserved they must be covered rapidly after deposition, due to the dispersive effect of wind and other agents on this type of material (Mallol *et al.* 2007). As deposit sub-types CH5a and CH5b, these unsorted and unoriented ash units seem to represent discarded fuel materials, possibly derived from shorter-term burning events.

The microscopic units classified under deposit sub-type CH5d are characterised by a high frequency of faecal pellets of suspected herbivore origin, based on the abundance of spherulites (*ca.* 30% abundance), and phosphatic aggregates (*ca.* 25%), some of which might be post-depositional intrusions. These layers also display an abundance of minerogenic materials, in particular calcareous aggregates (*ca.* 15-20%), and small numbers of anthropogenic inclusions such as bone and shell fragments, and plant materials (<10% abundance). Although these units are less than a centimetre in thickness, no trampling or compaction indicators have been detected. The absence of significant alterations in the faecal aggregates, such as charring, suggests that these layers could have formed through the re-deposition of animal waste in open spaces from stabling contexts.

Substantial accumulations of sediment aggregates, classified as deposit sub-type CH5e, have been detected in every midden context examined in this research, varying in thickness from a few millimetres to 6 cm. These units are mainly constituted by clay loam and silty clay sediments (>60% abundance), and a range of embedded anthropogenic inclusions such as plant materials, bone fragments, and phosphatic aggregates, all of which rarely exceed 15-20% of these deposits. Lenses of water-laid or other naturally deposited materials have not been detected, although this does not preclude the hypothesis that some of these units might correspond to periods in which the middens were in disuse, thus the hiatus in the accumulation of anthropogenic materials in these contexts. An alternative, but non-excluding hypothesis, is that these sediments were intentionally deposited in middens to seal these spaces in order to counteract the strong odours that the decomposition and occasional burning of organic materials would have caused. If this hypothesis were accepted, this would indicate the performance of maintenance practices and waste management in open spaces comparable to that observed in building contexts at this settlement. However, some of the minerogenic layers classified as CH5e display *in situ* charring and rubefaction of the sediments, indicative of the occurrence of burning activities in middens.

Lastly, deposit sub-type CH5f encompasses midden layers consisting of unsorted and unoriented accumulations of mixed materials where no dominant inclusion type can be distinguished. Plant materials, represented by highly fragmented charred plants (*ca.* 20%

abundance) and phytoliths (*ca.* 10-15%) are the most common constituents of these units, followed by burnt and unburnt sediment aggregates of various origins (*ca.* 10-15%), faecal pellets (*ca.* 5%), calcitic ashes (2-5%), and partially charred and calcined bone fragments up to 1.5 cm in size (*ca.* 10-15%). The organic and inorganic components that form these re-deposited units are often rounded or subrounded and small-sized (<1mm), indicative of their possible origin as mixed hearth and floor sweepings from food preparation areas.

### 5.3.3 Classification of microscale inclusions

A summary of the range of micromorphological components found in the slides examined is presented in Table 5.9 below. Most of these constituents have been found in all the samples, although considerable variations occur in their proportions and organisation depending on the context (*i.e.* building floors, hearth fills, or middens), and the nature of the deposit. Charred plant flecks, however, are ubiquitous across the site, occurring as 'background noise' in every layer up to 10% abundance.

| Inclusion type | Description | Variations | Origin & Preservation |
|---|---|---|---|
| **Rocks & Minerals** | *Quartz, hornblende (amphibole), chert, calcite, gypsum, traces of mica and feldspar, basaltic rocks, limestone rocks.* | Size, shape, roundness, sphericity, smoothness, alterations. | Pre- and post-depositional origin of deposits. Minerals have been found embedded in aggregates, plasters, and accumulated materials. |
| **Sediment aggregates** | *Marl/Softlime* Fine-grained, pale grey aggregates often containing mollusc shells and occurring burnt and unburnt. | Size, shape, roundness, sphericity, boundary, voids, inclusions, coatings, alterations. | Alluvial sources. When rounded aggregates are found in accumulated layers, these might be indicative of floor sweepings if unburnt, or plaster production activities if rubefied. |
| | *Clay loam* Dark brown to greyish-brown aggregates with coarse mineral inclusions and fragments of charred plants. | Size, shape, roundness, sphericity, boundary, voids, inclusions, coatings, alterations. | Anthropogenic origin when displaying plant voids. Indicate source materials used when found embedded in plasters, and activities involving sediments when found in middens and accumulated units. |
| | *Silty clay* Fine-grained, brown to reddish-brown aggregates sometimes displaying internal alluvial layering. | Size, shape, roundness, sphericity, boundary, voids, inclusions, coatings, alterations. | On-site indicators of off-site sediments sources. If plant stabilisers are present, these aggregates are suggestive of fine plaster. |
| **Building materials** | *Fragments of wall plaster, baked hearth/oven floors tempered with plants, and mudbrick remains.* | Size, shape, roundness, sphericity, boundary, voids, inclusions, alterations. | Re-deposited fragments of architectural materials: as swept particles if small and rounded, or as recycled materials if found embedded in floor and hearth/oven plasters. |

**Table 5.9** Summary of inclusion types found in Neolithic occupation contexts at Çatalhöyük. (*Table continues in the next page*).

| Inclusion type | Description | Variations | Origin & Preservation |
| --- | --- | --- | --- |
| **Ashes** | *Plant origin*<br>Light grey rhomboidal crystals, high calcitic content. | Mineral composition, morphology of ash crystals, inclusions, alterations. | Burning activities and rapid burial, frequently containing inclusions of charred plants and grass phytoliths. |
| **Faecal matter & phosphates** | *Herbivore dung*<br>Yellowish (unburnt) to dark brown (charred) or pale greyish brown (calcined) amorphous pellets. | Size, shape, inclusions, spherulite count, alterations. | Deposition of ruminant dung - penning and cleaning activities when found unburnt, and evidence of use as fuel when charred (*ca*. 650-750 ºC) and calcined. |
| | *Phosphatic aggregates*<br>Bright orange to yellowish brown, smooth and amorphous pellets rarely containing inclusions. | Size, shape, inclusions, spherulite count, alterations. | Very few to no spherulites present and massive phosphatic groundmass. Found in building and open contexts but especially frequent in late middens. Possible post-depositional origin. |
| **Micro-artefacts** | *Obsidian flakes*<br>Very sharp inclusions often a few millimetres in size. | Size, shape, sharpness, alterations. | Débitage from tool-making activities or flakes detached during tool use. Highly burnt flakes have been found in hearth rake-outs and midden contexts. |
| **Bones** | *Bones*<br>Yellowish (unburnt), dark brown (charred), and greyish (calcined) fragments. | Size, shape, alterations (burning, calcination, weathering, digestion). | These remains derive from activities involving animal resources, often found re-deposited as waste in middens and around fire installations. |
| **Shells** | *Water mollusc shells*<br>Small greyish linear and curved fragments, often striated. | Size, shape, alterations. | Indicative of origin of sediment aggregates and plaster materials, and possible food resources when found charred in hearth rake-outs and middens. |
| | *Land mollusc shells*<br>Large, almost complete spiral fragments. | Size, shape, alterations. | Post-depositional intrusions. Bioturbation. |
| **Plant remains** | *Wood charcoal*<br>Millimetric fragments of black charcoal. | Size, shape, species, alterations. | Well-preserved, large fragments found in midden contexts, indicative of the use of wood as fuel. |
| | *Charred plants*<br>Smaller fragments of black plant-derived (non-arboreal) materials. | Size, shape, species, alterations. | Plant burning activities - discarded oven/hearth fuel sources in rake-outs and possible *in situ* burning in middens. Extremely fragmented and moderately preserved. |
| | *Siliceous plants (phytoliths)*<br>Semi-transparent impressions of plant cells. | Size, shape, species, plant part, degree of articulation, alterations. | Derived from plant burning activities or *in situ* plant decay. When exposed to temperatures >600ºC inclusions of melted silica might form. |
| | *Hackberry endocarps*<br>Pale grey to dark brown fruit shells. | Size, shape, starch content, alterations. | Fragmented remains of hackberry (*Celtis*) stones, often found charred in hearth rake-outs and middens. Potential as seasonal marker for summer/autumn. |
| | *Plant pseudomorphic voids*<br>Voids caused by *in situ* plant decay. | Size, shape. | Commonly found as plant impressions in plasters and inclusions of architectural materials tempered with chaff. |

**Table 5.9** Summary of inclusion types found in Neolithic occupation contexts at Çatalhöyük.

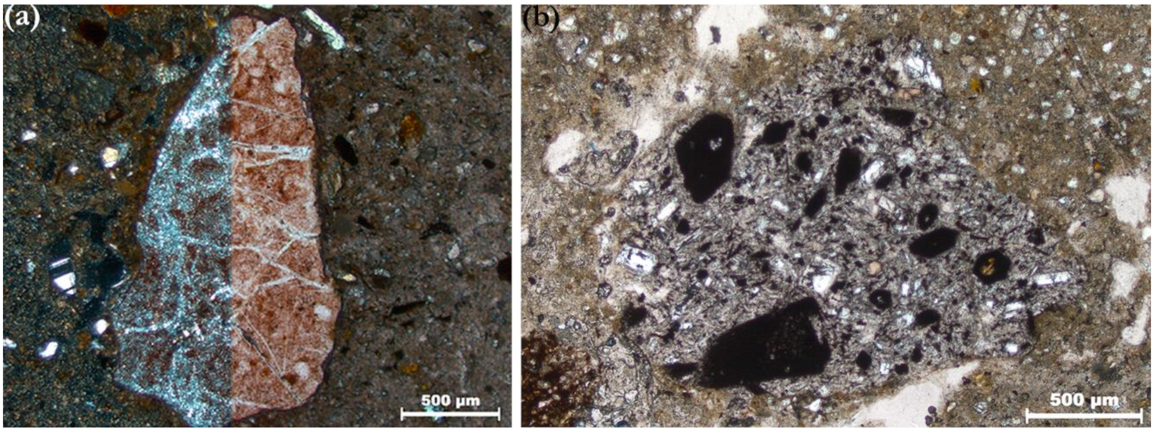



**Figure 5.20** Photomicrographs of minerals and rocks found in samples from Çatalhöyük: a) chert displaying an altered pattern caused by impregnating iron oxides, XPL (left) and PPL (right); b) rounded basaltic rock fragment, PPL.

The coarse minerogenic fraction of deposits at Çatalhöyük is formed by subrounded to subangular quartz grains, varying in size from *ca.* 20 µm to approximately 1.3 mm, and traces of amphibole, plagioclase, chert, biotite, muscovite, and calcite minerals. Gypsum crystals are present in most units, especially in those from midden contexts, although their occurrence as void infillings points to their post-depositional nature. Rounded rock fragments of limestone and igneous (basaltic) materials measuring up to 3 mm in diameter have been observed in almost every deposit type at Çatalhöyük. The shape of the igneous inclusions indicates natural transportation and deposition, possibly from the volcanic highlands situated *ca.* 50 km to the east and south-west of the settlement (Kuzucuoğlu 2002). Limestone fragments, however, are likely derived from any of the Upper Cretaceous and Paleozoic limestone formations located towards the north, south, and west of the site (Driessen and de Meester 1969).

A wide range of natural sediment aggregates has been observed in deposits at Çatalhöyük, some of which are presented in Figure 5.21. These components occur as both burnt and unburnt elements, and display variable compositions. The size of these minerogenic constituents varies between 200 µm and several centimetres. They often display sharp and prominent/distinct boundaries, and rounded to subrounded shapes. In some cases, these aggregates contain plant pseudomorphic voids, attesting their origin as building materials like floor or oven plasters. When these are found embedded in accumulated layers such as rake-outs or midden deposits, they often display rounded shapes, suggestive of sweepings. However, these aggregates have also been identified in floor and hearth/oven plasters, in which case they indicate re-utilisation of construction materials, a practice that appears to have been relatively common at Çatalhöyük, based on the frequency of these constituents. In the cases in which plant pseudomorphic voids are absent, subangular aggregate shapes and larger sizes are more common. These components are frequently encountered in building materials

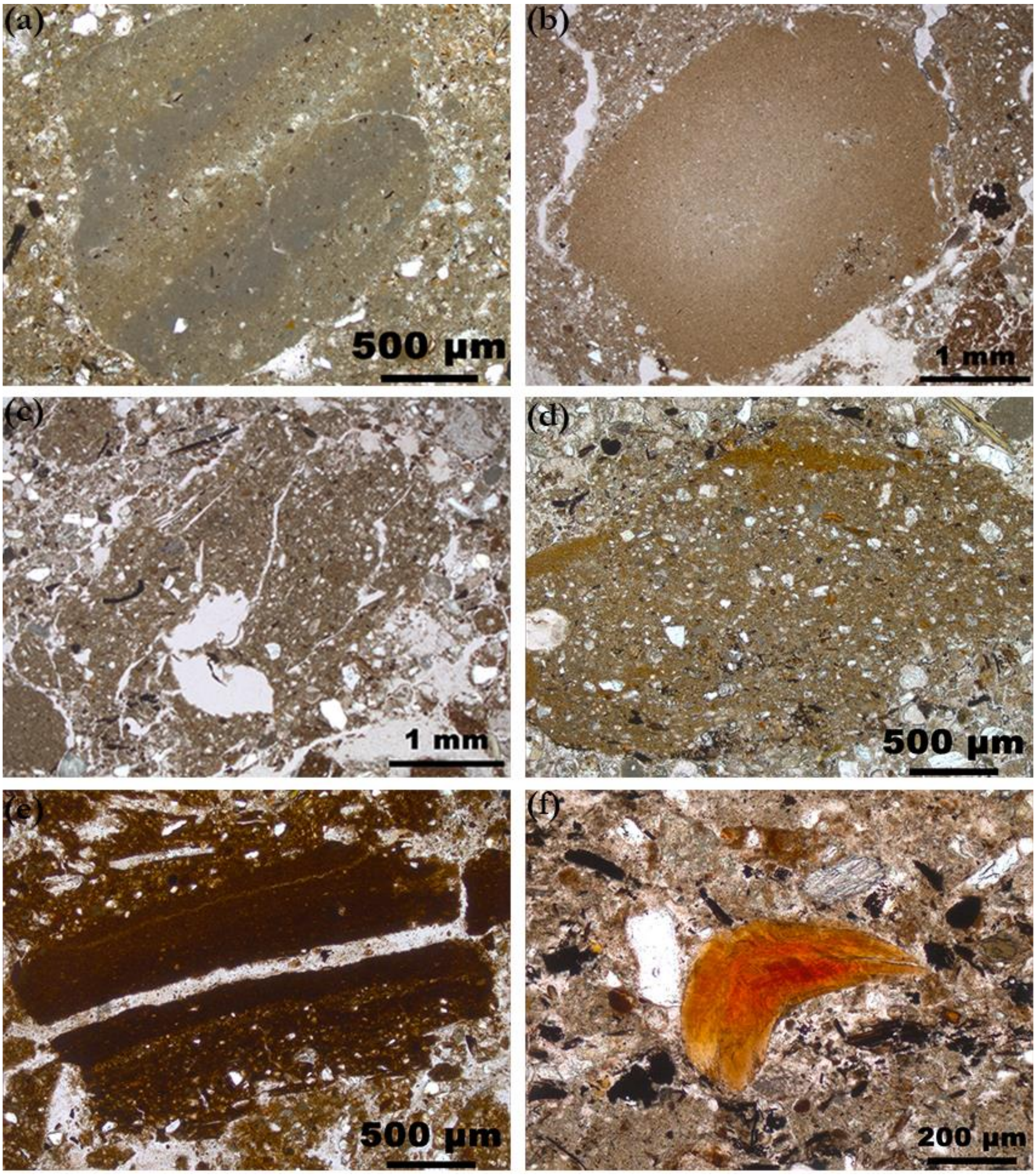



**Figure 5.21** Photomicrographs of sediment aggregates found in archaeological deposits at Çatalhöyük: a) calcareous aggregate displaying laminations of marl/softlime sediments, PPL; b) fine silty clay aggregate, PPL; c) disturbed silty clay loam sediment nodule, PPL; d) clay loam crumb, PPL; e) oxidised alluvial aggregate displaying parallel graded bedding, PPL; f) re-deposited limpid clay coating showing intense oxidation, PPL.

such as floor plasters, either as part of the original sediment sources, or as a result of the mixing of different sediments during plaster manufacture. Charred sediment aggregates found embedded in an unburnt matrix indicate pre-depositional burning, although *in situ* burnt minerogenic inclusions have been identified in fire installations and midden contexts. These have been found in layers that display rubefraction indicators, such as a gradient between reduced and oxidised burning zones (Canti and Linford 2001). Other sediment inclusions appear to be intrusive pedofeatures, such as the re-deposited limpid and dusty fragments of

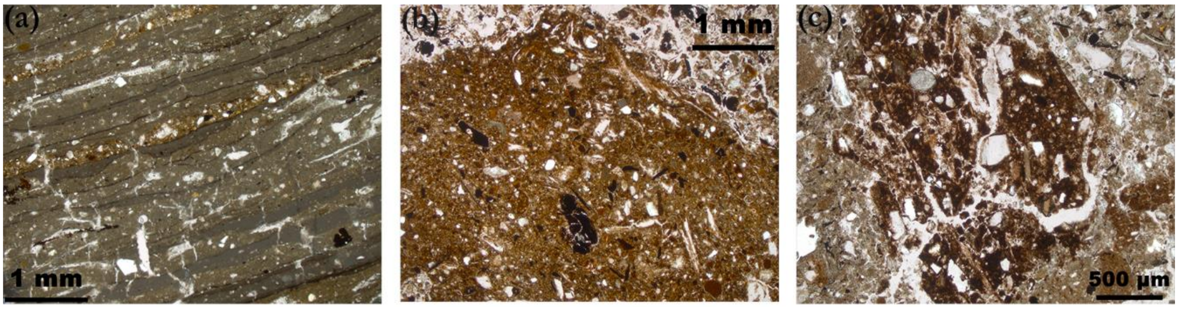



**Figure 5.22** Photomicrographs of fragments of architectural materials found in deposits at Çatalhöyük: a) re-deposited fragment of wall plaster displaying multiple coatings of calcareous materials and soot accumulations, PPL; b) fragment of coarse plaster showing plant impressions, PPL; c) charred aggregate of clay loam sediment, possibly a re-deposited fragment of oven plaster, PPL.

clay coatings detected in the upper layers of open spaces in the TPC and GDN excavation areas, affected by modern soil formation processes. These inclusions are usually very small (*ca.* 200-500 µm) and oxidised, and have been found in association with passage features.

Microscopic components consisting of building materials, such as fragments of wall plasters, baked floors from ovens, and mudbricks, have been documented in fill deposits and, more rarely, in floor plasters. These materials relate to waste debris from building construction, modification, or destruction processes. When intentionally added to coarse plasters, these constituents indicate re-utilisation of manufactured materials.

Accumulations of calcitic ashes derived from the combustion of plant and mixed sources have been detected in midden layers and, occasionally, in rake-outs and accumulated deposits within buildings. In this latter case, however, they appear substantially mixed with other burnt materials. Microscopic investigations of ash contexts at other sites have demonstrated the high susceptibility to post-depositional alterations of this component. Changes in burial conditions can significantly alter the chemical nature of ashes, thus complicating their identification (Canti 2003; Schiegl *et al.* 1996). At Çatalhöyük, ash materials are moderately to well preserved, often displaying a combination of rhombohedral calcitic crystals, burnt amorphous organic matter, and phytolith remains of reeds and grasses. Dung ash has not been identified in the samples analysed for this research, although Shillito *et al.* (2011b) describe the occurrence of this component in midden deposits at Çatalhöyük based on the presence of spherulites.

Coprolites and masses of phosphatic materials have been detected in a range of building and open contexts at Çatalhöyük. Small (<1 mm) aggregates of herbivore dung have been identified embedded in floor plasters, although their low frequency (usually 1-2%) makes it unlikely that they were intentionally added as stabilisers. Herbivore dung, characterised by its

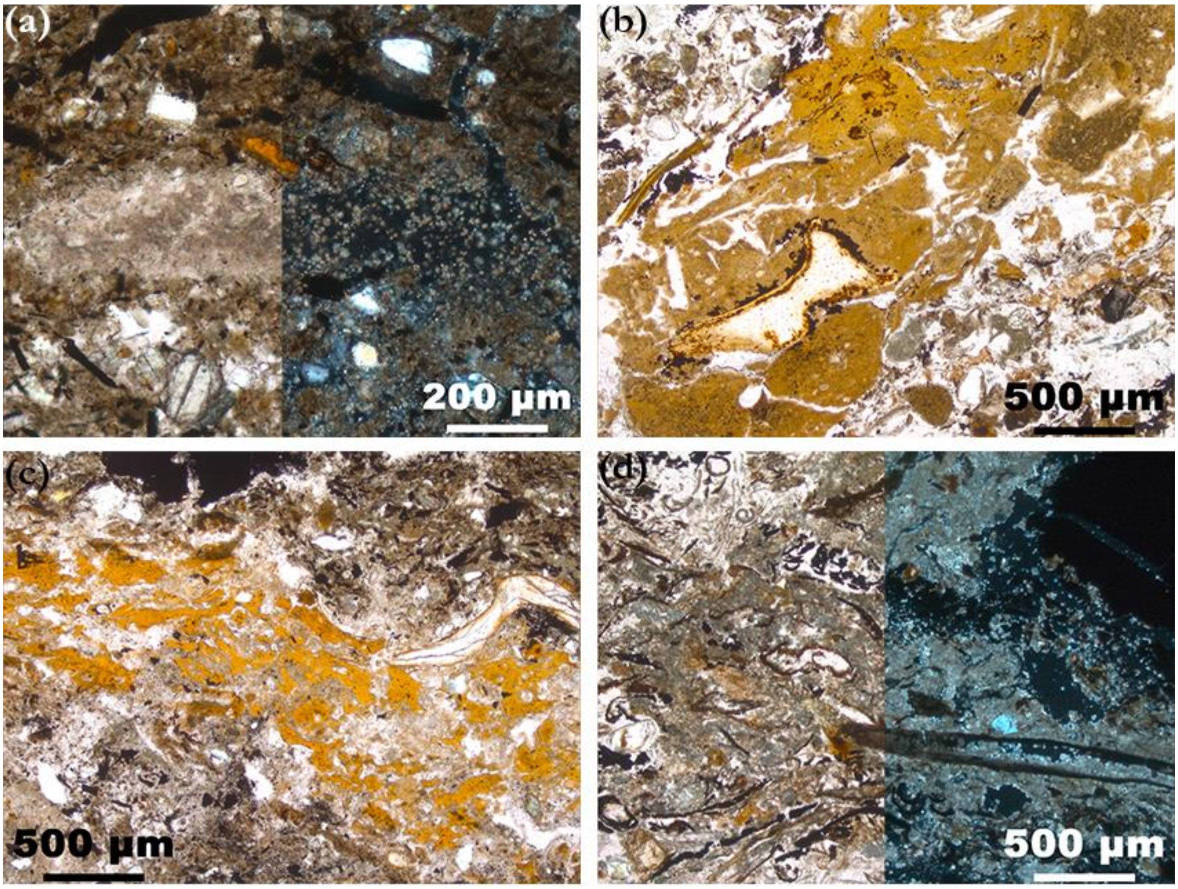



**Figure 5.23** Photomicrographs of faecal aggregates and calcitic ashes found in archaeological deposits at Çatalhöyük: a) unburnt herbivore dung pellet containing multiple spherulites, PPL (left) and XPL (right); b) possible omnivore faecal aggregate with embedded bone fragments, PPL; c) disaggregated phosphatic aggregates, PPL; d) calcitic ashes and plant materials in midden context, PPL (left) and XPL (right).

abundance of calcareous spherulites (Shahack-Gross 2011), has been detected as severely trampled lenses in Space 470, suggesting penning activities, and as re-deposited materials in middens, likely derived from the cleaning of stabling areas. Faecal matter of suspected herbivore origin has also been identified as charred and partially calcined aggregates in accumulated deposits within buildings, indicative of the use of dung as fuel. In this case, however, coprolites are associated with numerous burnt plant materials, which points towards the use of mixed fuel sources, not exclusively dung. These suspected herbivore pellets vary in colour from yellowish (intact) to dark brown or pale greyish brown, depending on burning temperatures. Occasionally, plant inclusions have been found embedded in these faecal aggregates, consisting of charred flecks and siliceous remains such as single long cells and bulliforms. Unfortunately, multi-cells or other diagnostic phytoliths types that could indicate diet have not been observed in these materials.

Phosphatic aggregates of unclear origin have been identified in several contexts, including fine layers of accumulated materials on top of building floors, and midden deposits. These aggregates are frequently bright orangish/yellowish brown and do not display signs of burning. No spherulites have been observed in these inclusions, although in some cases eroded bone fragments have been found embedded in their groundmass, suggesting their origin as omnivore coprolites. However, this identification, based on optical microscopic characteristics, remains ambiguous. While these aggregates show a dense phosphatic mass, they occur in many shapes, such as distinct pellets, disaggregated material, and vesicles. These components frequently display organic staining, and when found in the uppermost layers of TPC Area middens, they appear associated to modern root decay.

Microartefact inclusions, comprising mainly intact and severely heated obsidian flakes, have been rarely encountered in the micromorphological slides from occupation layers at Çatalhöyük. These components, ranging in size from approximately 500 μm to 1 cm, have been detected in almost every deposit type, although always in very low proportions (*ca.* 1%). This sparsity of microscopic lithic debris seems to suggest that these flakes were probably detached during tool use, and that tool production activities were not usually performed inside the settlement. Another category of microartefact comprises pottery and clay objects, although only two possible inclusions have been detected in the examined samples from Building 114 that could fall in this classification (see Figure 5.24 below). These components, likely detached pottery sherd, display prominent, sharp, and straight edges, and an internal fabric suggestive of ceramic objects.

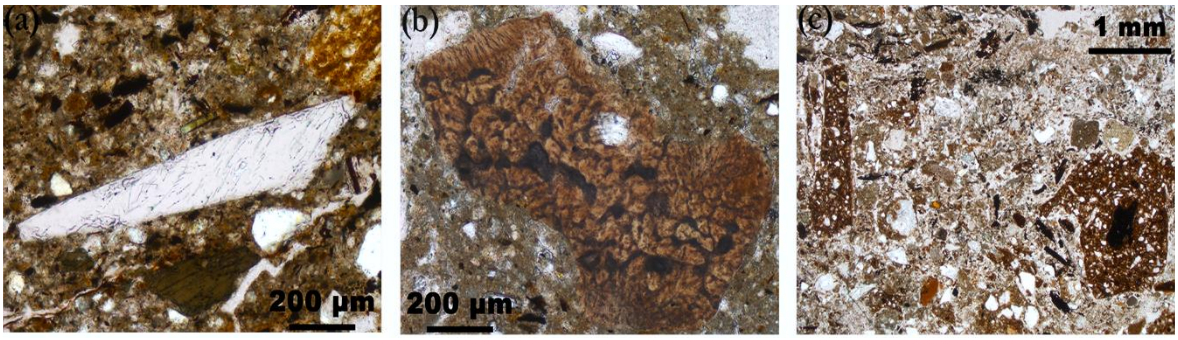



**Figure 5.24** Photomicrographs of microartefacts found in archaeological deposits at Çatalhöyük: a) microcrystalline obsidian flake, PPL; b) burnt obsidian flake likely fired at high temperatures, PPL; c) microscopic pottery sherds, PPL.

Bone fragments, the large majority of which are charred, with calcined and unburnt occurrences not exceeding 15% of the total, have been found in moderate numbers in midden contexts, hearth rake-outs, and other accumulated deposits comprising a large proportion of occupation residues. Bone remains usually consist of sand-sized fragments (*ca.* 200 μ - 5 mm), often rounded or sub-rounded in shape, although sub-angular splinters have been identified

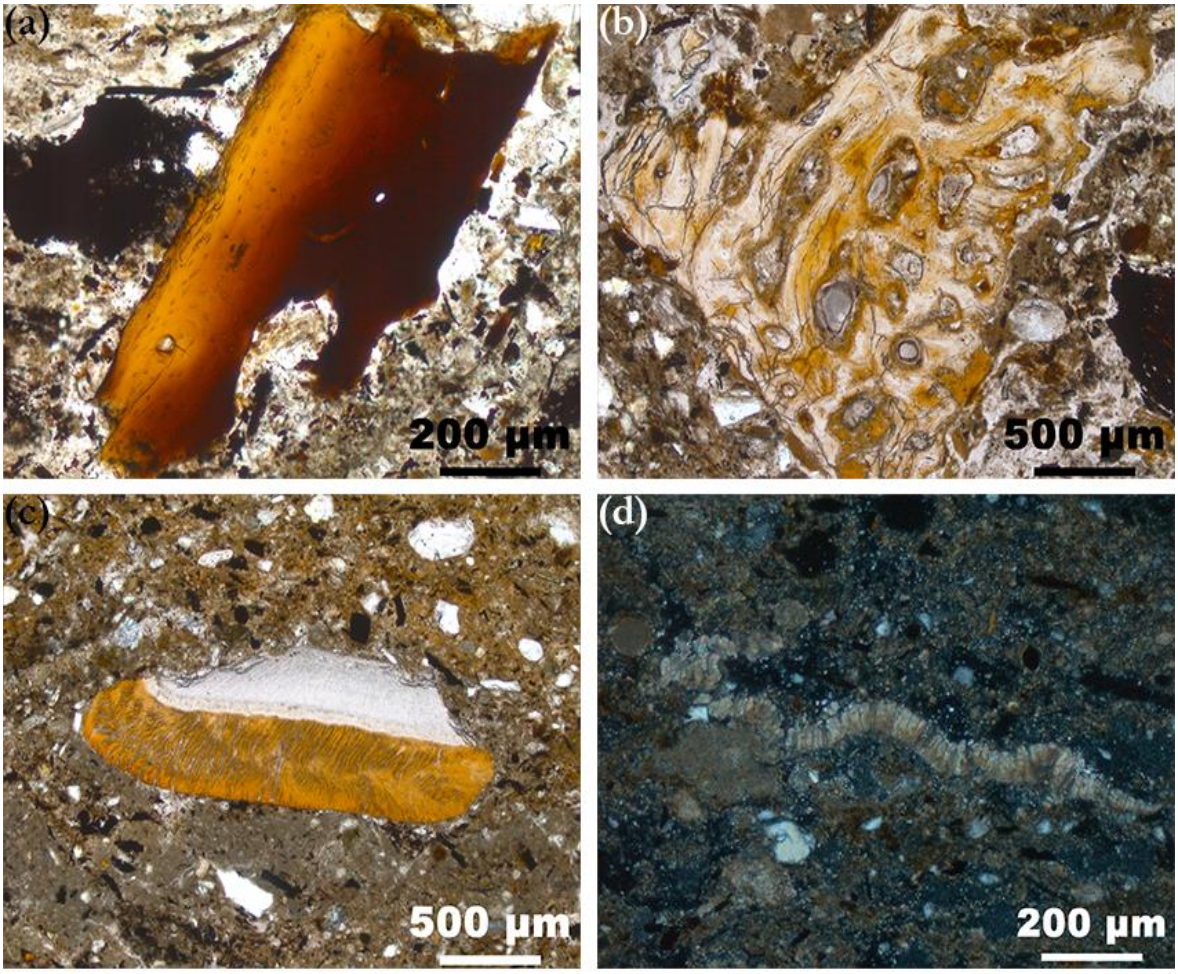



**Figure 5.25** Photomicrographs of anthropogenic inclusions found in archaeological deposits at Çatalhöyük: a) charred bone embedded in midden materials, PPL; b) weathered bone fragment, PPL; c) charred tooth, PPL; d) mollusc shell, XPL.

embedded in hearth fills. These components display random distributions throughout the observed deposits, frequently unoriented and mixed with other materials. Occasionally, fragments of tooth enamel, sometimes displaying charring, have been encountered in accumulated deposits.

In marked contrast with Boncuklu, eggshells are almost completely absent from occupation deposits at Çatalhöyük. Ostracod shells have been found as natural inclusions in marl plasters and calcareous aggregates, and as secondarily deposited unburnt and charred fragments in accumulated deposits in buildings and open areas, suggestive of food discard. Although ubiquitous across the site, shell remains occur in very low numbers (*ca*. 1% abundance), and display small sizes ranging from *ca*. 200 µm to 1.8 mm. Land mollusc shells, mainly present in the late open spaces of the TPC and GDN excavation areas, are often associated with passage features, indicative of their nature as post-depositional intrusions related to bioturbation and soil formation processes.

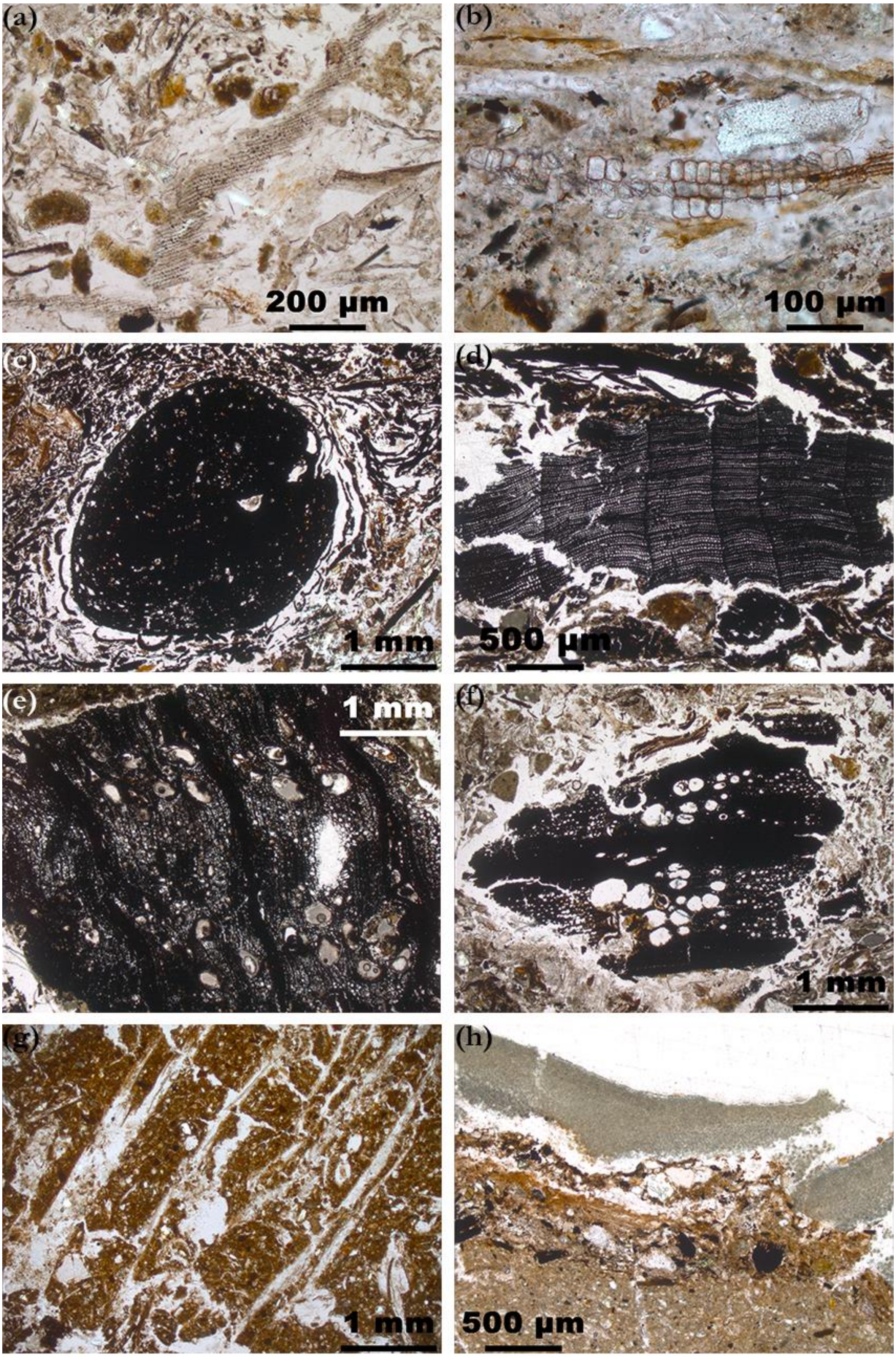



**Figure 5.26** Photomicrographs of plant inclusions found in archaeological deposits at Çatalhöyük: a) dendritic siliceous cells (cereal husk), PPL; b) highly articulated bulliform cells, PPL; c) charred seed, PPL; d) *Juniperus* charcoal, PPL; e) *Ulmus* charcoal, PPL; f) *Quercus* charcoal, PPL; g) plant impressions in the form of pseudomorphic voids found as plaster stabilisers, PPL; h) Chenopod endocarp and associated mineralised organic materials, PPL.

This micromorphological study has established plant remains as the most common type of anthropogenic inclusions at Çatalhöyük. Charred plant flecks, in particular, are in almost every deposit at this site in frequencies of at least 5%. These plant remains are, in most cases, too fragmented to allow species identification. Although it is possible that charred plants were deliberately used as stabilisers in certain floor and oven plasters, in most cases their uneven distribution and low abundance suggest that they were accidentally incorporated at the place of manufacture, possible in locations around the site or in open spaces within the settlement. In addition to charred plant flecks, large fragments of wood charcoal have been detected on site, being especially abundant in the TPC and GDN middens. *Juniperus*, *Ulmus*, and *Quercus* charcoal has been observed in these contexts, species growing on the foothills of the Konya Plain that had been previously documented on site by the anthracology specialist (Asouti 2005b; 2013b). Other charcoal types have been observed, although species determination has failed due to the intrinsic difficulty involved in identifying these materials based only on the morphology of a single visible section.

Siliceous plant remains occur in a disaggregated form, usually mixed with other types of plant-derived components in re-deposited or accumulated layers. Less frequently, however, phytoliths form distinct but thin (*ca.* 1-5 mm) deposits of moderately articulated remains, usually displaying strong parallel orientations and thus representing residues from *in situ* activities. Siliceous plants have also been detected in herbivore dung pellets and, more rarely, in the plant pseudomorphic voids observed in some floor plasters. Suspected cereal husks and *Phragmites* stem cells have been frequently identified in both building and midden contexts, including stacked bulliforms, long cells, and stomata. It is important to mention here that only the largest phytolith types are usually visible in micromorphological thin-sections of archaeological deposits. Small and disaggregated types, such as rondels or trapeziforms, measuring 10-20 μm, are usually masked by other deposit components. Therefore, although micromorphology provides important information on the contextual associations and deposition of phytolith materials, there is usually a bias towards the identification and quantification of particularly large or conjoined cell types (Shillito 2013).

Other plant inclusions found in Neolithic occupation deposits at Çatalhöyük include melted silica, only occasionally observed in rake-out contexts and indicative of high (over 600ºC) firing temperatures. In addition, well-preserved hackberry endocarps have been found in low concentrations (*ca.* 1%) in building contexts, usually as part of accumulated layers of domestic residues. Finally, the plant pseudomorphic voids documented in almost every plaster type attest the recurrent use of grasses and reeds as temper, the proportion of which has been observed to vary depending on the particle size and clay content of the sediments used.

### 5.3.4 Post-depositional alterations

The most common post-depositional features of natural origin observed in thin-section include bioturbation, re-crystallised salts, and organic staining. Post-depositional processes of anthropogenic origin comprise trampling, abrasion, sweeping, burning, compaction below mats, and truncation of surfaces and deposits.

Post-depositional alterations are particularly marked in the open sequences of the TPC and GDN areas, lying immediately below topsoil, and in Building 114. The most conspicuous of these processes is bioturbation caused by insect and small mammal burrowing, also comprising the deposition of excremental pellets, and root action. The latter is distinguished by traces of modern roots, often displaying ferruginous coatings, partially degraded cellulose tissue, and associated calcitic hypocoatings.

Precipitation of gypsum salts is common in building contexts, occurring as poorly-developed lenticular, xenotopic or, more rarely, needle crystalline formations infilling channels, sometimes visible macroscopically in the field as white nodules up to several millimetres in size. The formation of these crystals often causes the surrounding groundmass to become disaggregated. In open areas, gypsum has been observed to occur as well-developed lenticular and hypidiotopic pedofeatures in voids produced by biological agents, and also as dispersed crystals within the deposits. Gypsum precipitation occurs when the concentrations of calcium and sulphate ions in the soil are high. These ions can derive from the dissolution of calcium sulphates from rocks, or from the alteration of limestone and sulphate-bearing formations (Poch *et al.* 2010). Gypsum formations are more abundant in arid and semi-arid regions, where soil moisture easily evaporates, and salts from solution are deposited (Herrero and Porta 2000). This phenomenon occurs both within the groundmass and in voids created by plant roots and faunal activity, which provide a pathway for the flow of gypsum-saturated solutions, ultimately leading to the precipitation of these salts in voids.

Ferruginous features occur mainly in the form of typic and dendritic nodules within the matrix of building plasters, likely representing inherited features that formed in the natural sediments from which the architectural materials were manufactured. Localised iron staining of bone, plant, and faecal inclusions has been observed in some deposits, especially in middens, an alteration associated with microbial action and the breakdown of organic matter.

Other post-depositional alterations observed in occupation deposits at Çatalhöyük include frost features, detected in a suspected collapsed roof sequence in Space 489/511 and consisting of poorly to moderately developed platy microstructures. These features are produced by temperature-driven desiccation caused by frost, which can open shrinking fissures in deposits below the surface (Van Vliet-Lanoë 2010).

Human and animal trampling is a conspicuous anthropogenic phenomenon in floor and accumulated deposits at Çatalhöyük, which results in the compaction of the groundmass close to the upper boundary of these layers and the *in situ* fragmentation of inclusions, in particular of fragile plant remains (Matthews 2010).

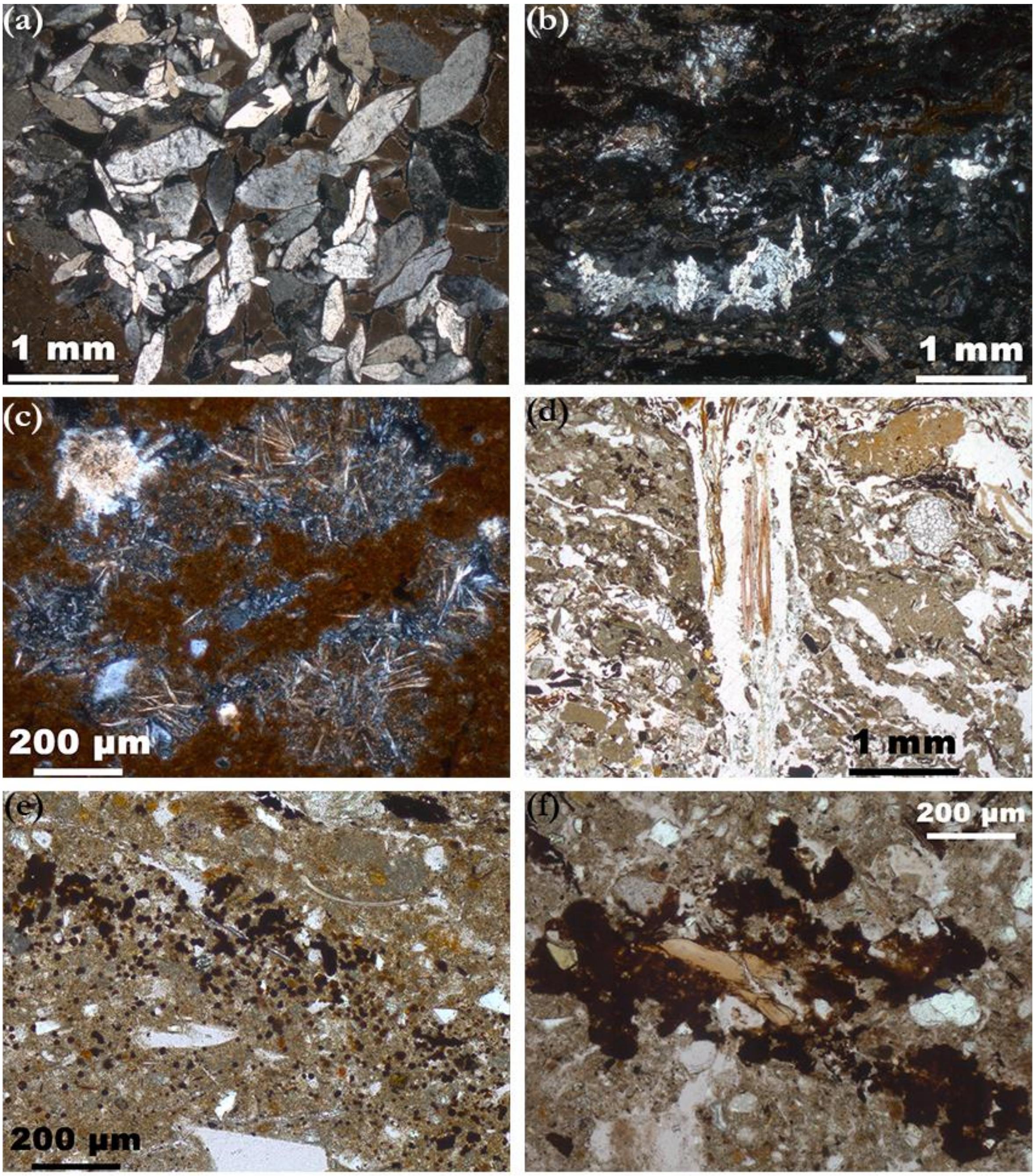



**Figure 5.27** Photomicrographs of post-depositional alterations found in archaeological layers at Çatalhöyük: a) well-developed lenticular gypsum formations, XPL; b) hypidiotopic gypsum crystals within charred layer, XPL; c) gypsum needles infilling channel voids, XPL; d) root feature displaying modern plant tissue and calcite re-deposition, PPL; e) iron aggregate nodules, PPL; f) organic staining (ferruginous formations) on bone fragment, PPL.

## 5.4 Infra-Red and X-Ray Spectroscopy

Microchemical XRF, XRD, and FTIR analyses were carried out on spot samples extracted from the micromorphological blocks prior to impregnation in order to determine their composition and possible natural sediment sources used in the preparation of floor plasters from the studied buildings through the comparison of these results with the published data of previous provenance investigations focused on architectural samples from Çatalhöyük, as well as on samples from the natural alluvial sediments surrounding the site (Anderson *et al.* 2014a; 2014b; Matthews *et al.* 2013; Wiles 2008). This study aims to build upon this research by analysing materials from recently excavated built environments, including the exceptionally small and complex Building 114.

Key samples from clean floor contexts in the main rooms of Buildings 89 and 114, in addition to suspected roof/upper storey materials found in Space 511, were selected for this investigation. At least one representative example of each plaster floor deposit sub-type was analysed, with the exception of CH2f and CH2g, both of which consisting of single occurrences documented in Building 114 that were only identified through micromorphology, and therefore not sub-sampled in the laboratory. Deposits from Building 77 were not included in the study as this structure was set on fire upon abandonment, a fact that hinders the comparison of the IR data that would have been obtained from this built environment with that from Buildings 89 and 114. The complete processed dataset can be found in the Appendices included in the attached DVD-ROM.

### 5.4.1 Floor plasters and architectural surfaces

The goal of these infra-red and X-ray analyses of floor plasters is to further characterise the deposit sub-types identified through thin-section micromorphology by determining their overall elemental composition, establishing differences and similarities in mineral content that could shed light into the types of natural sediments used in their manufacture. This information will eventually be compared with the results obtained from floors and architectural surfaces at Boncuklu in Chapter 7 in order to explore continuity and change in the selection and provenance of architectural sources in the Konya Plain during the Neolithic period.

Only clean plasters, practically devoid of occupation residues, have been selected for analysis to avoid the background 'noise' caused by the presence of anthropogenic remains, often

| Deposit type | Blg/Sp | Context | wt% SiO2 | wt% CaO | wt% Al2O3 | wt% Fe2O3 | wt% P2O5 | wt% K2O | wt% MgO | wt% Cl | wt% SO3 | wt% Na2O | wt% TiO2 | wt% MnO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CH2a** | 89 | Central platform | 42,9 | 27,65 | 12,97 | 5,96 | 0,3 | 3,14 | 3,13 | 0,81 | 1,11 | 0,94 | 0,74 | 0,08 |
| **CH2b** | 511 | Upper storey | 43,35 | 19,74 | 13,45 | 6,44 | 0,43 | 3,4 | 2,72 | 0,6 | 7,83 | 0,91 | 0,8 | 0,1 |
| **CH2c** | 114 | Eastern platform | 48,61 | 13,61 | 14,55 | 6,51 | 0,32 | 4,09 | 2,89 | 2,26 | 4,25 | 1,78 | 0,81 | 0,09 |
| **CH2d** | 89 | Central platform | 49,31 | 14,17 | 14,01 | 6,2 | 0,49 | 3,9 | 3,33 | 3,92 | 1,03 | 2,46 | 0,82 | 0,1 |
| **CH2e** | 114 | Central platform | 47,99 | 16,85 | 13,55 | 5,7 | 1,31 | 3,23 | 2,82 | 0,58 | 5,91 | 0,99 | 0,77 | 0,08 |
| **CH2h** | 89 | Central platform | 51,25 | 16,87 | 14,31 | 5,91 | 0,42 | 3,44 | 2,91 | 1,49 | 0,87 | 1,47 | 0,78 | 0,08 |
| **CH2h** | 511 | Upper storey | 49,04 | 18,44 | 13,48 | 5,73 | 1,73 | 3,64 | 3,09 | 0,72 | 2,1 | 0,95 | 0,75 | 0,08 |
| **CH2h** | 114 | Central platform | 46,87 | 19,95 | 13,46 | 6,03 | 1,22 | 3,36 | 2,98 | 0,55 | 3,5 | 0,92 | 0,79 | 0,1 |

**Table 5.11** Normalised X-ray Fluorescence results from the analysis of plaster floors at Çatalhöyük displaying the major compounds present.

| Deposit type | Blg/Sp | Context | wt% V2O5 | wt% BaO | wt% SrO | wt% ZnO | wt% Cr2O3 | wt% NiO | wt% ZrO2 | wt% Rb2O | ppm Cu | ppm Br | ppm As | ppm Nb | ppm Ga | ppm Pb | ppm Y | ppm Co |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CH2a** | 89 | Central platform | 0,02 | 0,04 | 0,08 | 0,01 | 0,02 | 0,01 | 0,04 | 0,01 | 61 | 32 | 11 | 6 | 0 | 0 | 11 | 0 |
| **CH2b** | 511 | Upper storey | | 0,05 | 0,07 | 0,01 | 0,02 | 0,01 | 0,02 | 0,01 | 55 | 17 | 0 | 8 | 8 | 47 | 14 | 0 |
| **CH2c** | 114 | Eastern platform | 0,03 | 0,04 | 0,03 | 0,02 | 0,02 | 0,01 | 0,02 | 0,01 | 50 | 39 | 19 | 8 | 8 | 0 | 13 | 9 |
| **CH2d** | 89 | Central platform | 0,02 | 0,06 | 0,06 | 0,01 | 0,02 | 0,01 | 0,03 | 0,01 | 46 | 61 | 0 | 7 | 9 | 61 | 13 | 0 |
| **CH2e** | 114 | Central platform | | 0,05 | 0,06 | 0,01 | 0,02 | 0,01 | 0,02 | 0,01 | 58 | 15 | 0 | 7 | 8 | 38 | 11 | 0 |
| **CH2h** | 89 | Central platform | | 0,05 | 0,06 | 0,01 | 0,02 | 0,01 | 0,03 | 0,01 | 50 | 38 | 8 | 5 | 6 | 0 | 13 | 0 |
| **CH2h** | 511 | Upper storey | | 0,04 | 0,08 | 0,02 | 0,02 | 0,01 | 0,04 | 0,01 | 58 | 35 | 6 | 7 | 7 | 33 | 11 | 0 |
| **CH2h** | 114 | Central platform | 0,03 | 0,05 | 0,07 | 0,02 | 0,02 | 0,02 | 0,03 | 0,01 | 55 | 27 | 16 | 13 | 0 | 0 | 13 | 1 |

**Table 5.10** Normalised X-ray Fluorescence results from the analysis of plastered floors at Çatalhöyük displaying the minor compounds and elements present.

organic in origin, in the chemical results. However, the small dataset considered here due to practical reasons means that this is only a pilot study, mainly aimed at evaluating both the contribution of these methods to micromorphological observations, and the potential of micro-analytical techniques for identifying the range of natural sediments used in the preparation of building plasters, their technical modifications by Neolithic builders, and possible taphonomic alterations.

The chemical composition of the plasters as determined by XRF analyses is summarised in the previous page. Three samples corresponding to deposit sub-type CH2h, defined as mixed plasters, have been analysed because the heterogeneity of these deposits entails that a single representative example could not be selected. Based on the quantitative chemical information provided by the XRF results, suspected softlime plasters, classified as deposit sub-type CH2a based on micromorphological observations, are characterised by containing the lowest amounts of silicon dioxide and sulphur trioxide, the latter possible related to the absence of post-depositional gypsum in the sample selected. Further, these plasters display the highest amounts of calcium oxide, indicating the presence of carbonate minerals. However, a higher proportion of magnesium oxide indicating the presence of dolomite was expected to occur in this sample, suspected to be softlime-based. Deposit sub-type CH2b, referring to marl plasters, shows similar amounts of silicon dioxide but a much lower proportion of calcium oxide than CH2a. The sample comprising orangish brown silty clay sediments, CH2c, contains the lowest amount of calcium oxide and an important weight percentage of silicon dioxide, indicating an important content of clays. Significantly, although the reddish tone of this deposit suggests oxidation, results show no peak in ferric oxide.

XRF data have yielded strikingly similar results regarding the elemental composition of deposit sub-types CH2d, light brown silty clay loam plasters, and CH2e, dark brown clay loam plasters. The only marked differences between these two deposits correspond to the slightly higher amount of chlorine and sodium oxide contained by CH2d, and the substantial proportion of sulphur trioxide observed in CH2e. However, the presence of chlorine in deposits classified as CH2d is likely due to post-depositional processes, as chlorides of sodium and potassium are commonly deposited from soil water solutions in arid regions (Freestone 2001). Mixed plasters, classified as CH2h, also display strong compositional similarities with sub-types CH2d and CH2e, although they contain the highest proportion of silicon dioxide and phosphorus pentoxide from all the samples analysed.

The important amounts of silicon dioxide and aluminium oxide found in all the samples are likely derived from clay minerals. However, the proportion of quartz, muscovite, plagioclase feldspar, and hornblende (amphibolite) minerals within the sediments should also be accounted for with regard to the percentage of silicon. The abundance of these minerals in the deposits also contribute to the concentration of other elements, including sodium, calcium, magnesium, potassium, and iron.

Finally, the minor compounds and trace elements detected by XRF and reported in parts per million (ppm), do not appear to display a significant variability between deposits.

XRD analyses identified the presence of quartz in all the samples, in addition to muscovite, plagioclase feldspar, and calcite. The occurrence of both dolomite and calcite in deposit sub-type CH2a suggests that marl and trace amounts of softlime were used in their production, although it does not exclude the possible addition of small proportions of lower alluvium sources (Anderson *et al.* 2014a). Interestingly, in the XRD pattern of the marl plaster, deposit sub-type CH2b, dolomite appears absent, although strong peaks indicating the occurrence of calcite have been observed (see Figure 5.29 in the next page). Diffraction results from the analysis of plaster type CH2c display a similar compositional profile to that of CH2b, although the peaks for quartz and muscovite are more intense in the former, suggesting the presence of more sand- and silt-size grains of these two minerals. The XRD pattern of deposit sub-type CH2e also indicates an abundance of quartz and calcite minerals. However, this sample displays additional peaks for aragonite, likely derived from the presence of shell fragments.

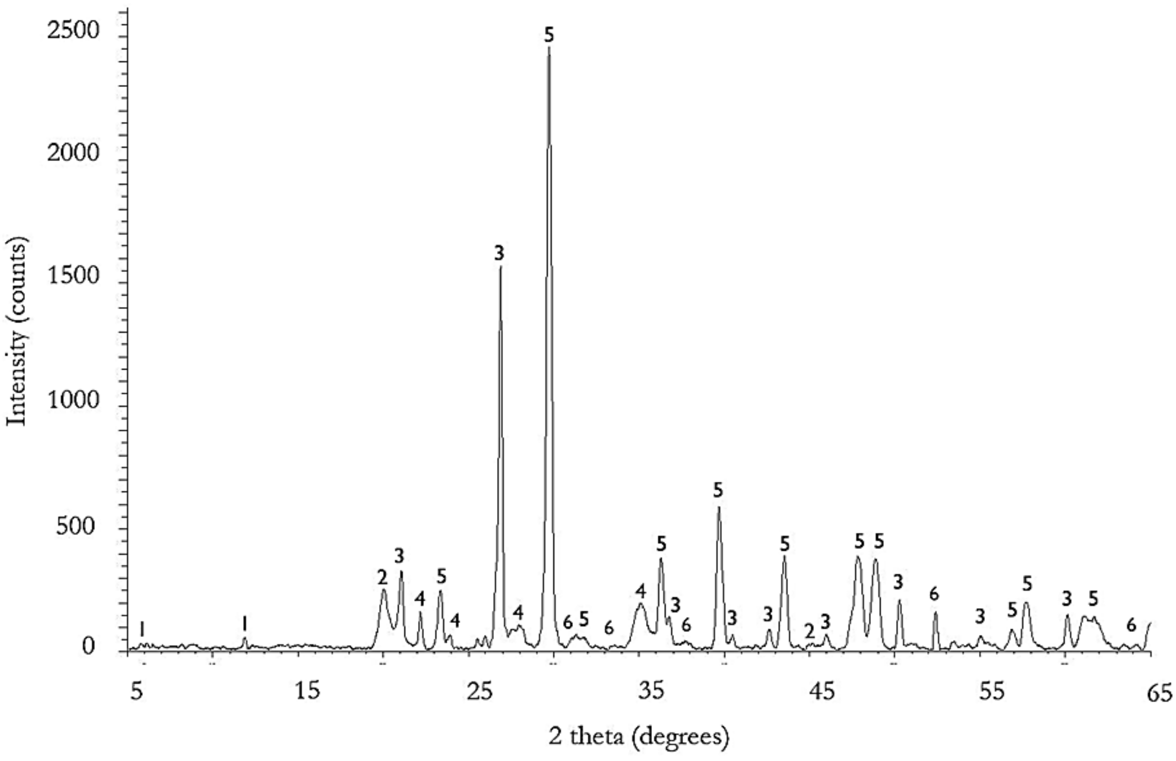



**Figure 5.28** XRD pattern of deposit sub-type CH2a from the central platform of Building 89 at Çatalhöyük: 1-chlorite, 2-muscovite, 3-quartz, 4-plagioclase feldspar, 5-calcite, 6-dolomite.

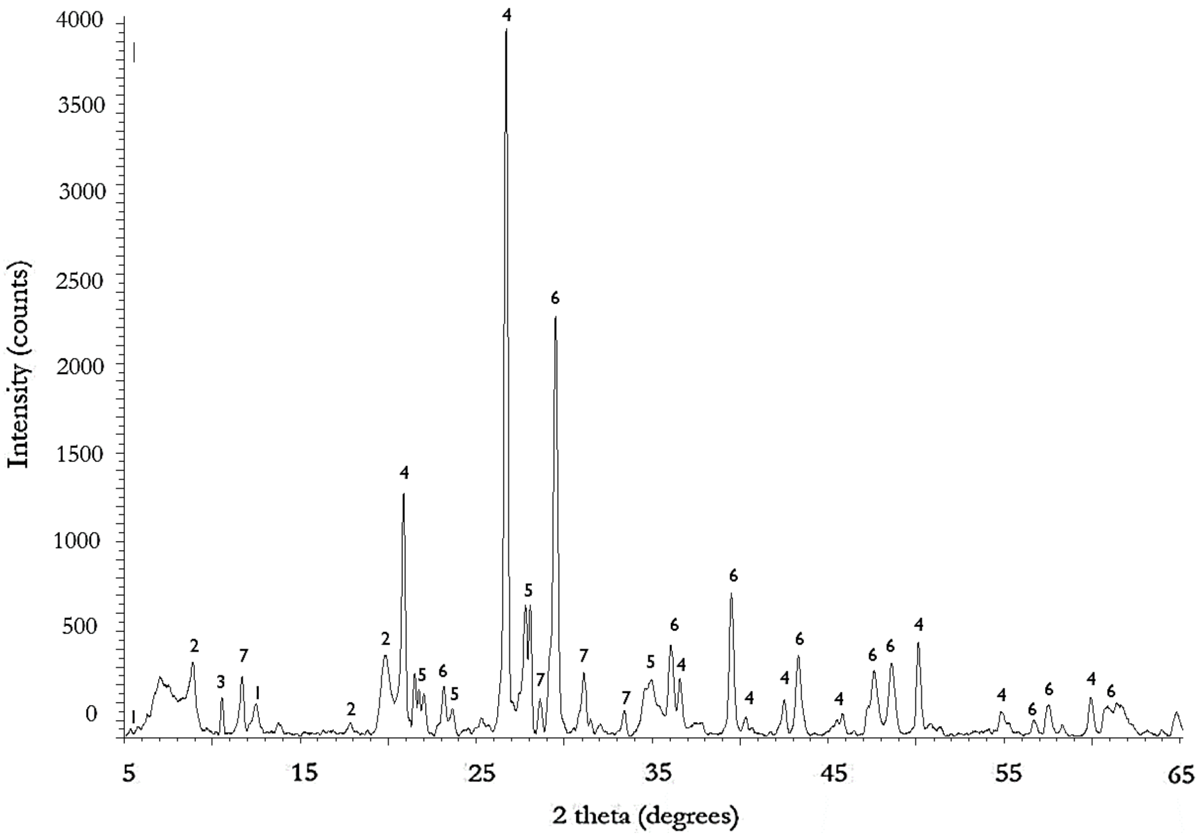



**Figure 5.29** XRD pattern of deposit sub-type CH2b from upper-storey plasters found in Space 511 at Çatalhöyük: 1-chlorite, 2-muscovite, 3-hornblende, 4-quartz, 5-plagioclase feldspar, 6-calcite, 7-gypsum.

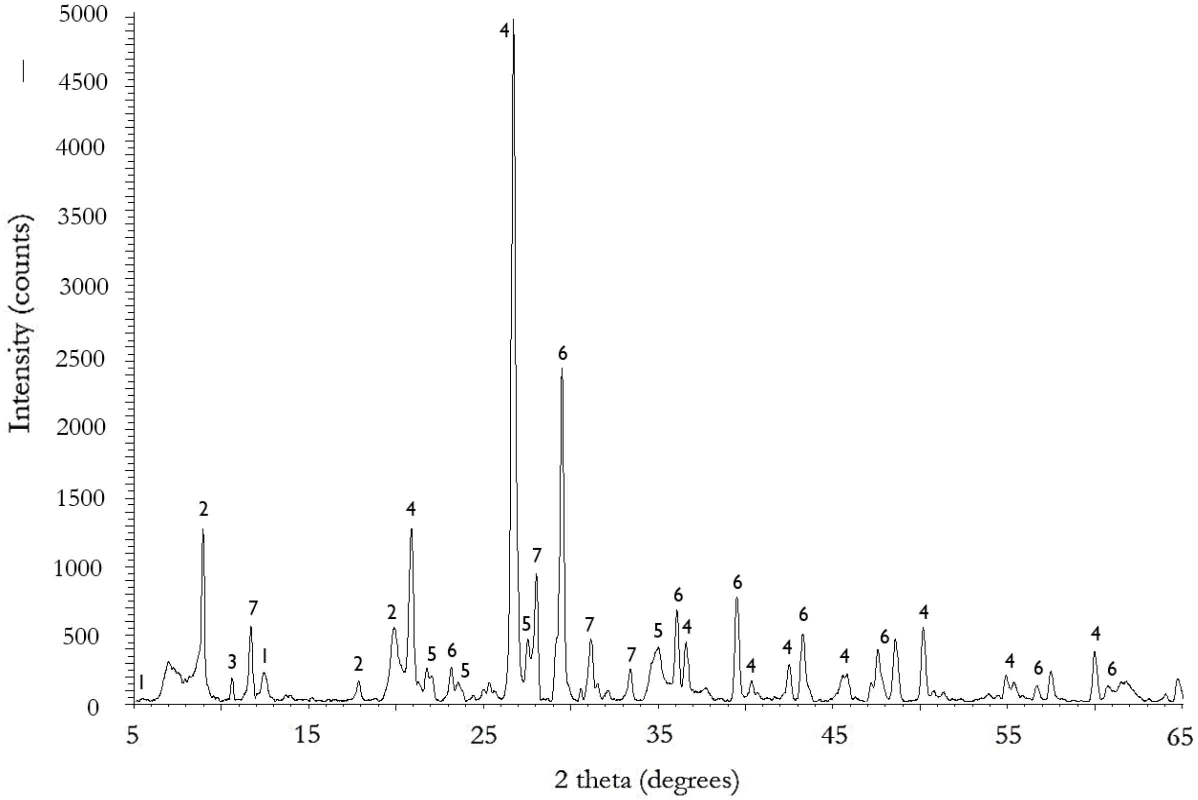



**Figure 5.30** XRD pattern of deposit sub-type CH2c from clean area of Building 114 at Çatalhöyük: 1-chlorite, 2-muscovite, 3-hornblende, 4-quartz, 5-plagioclase feldspar, 6-calcite, 7-gypsum.

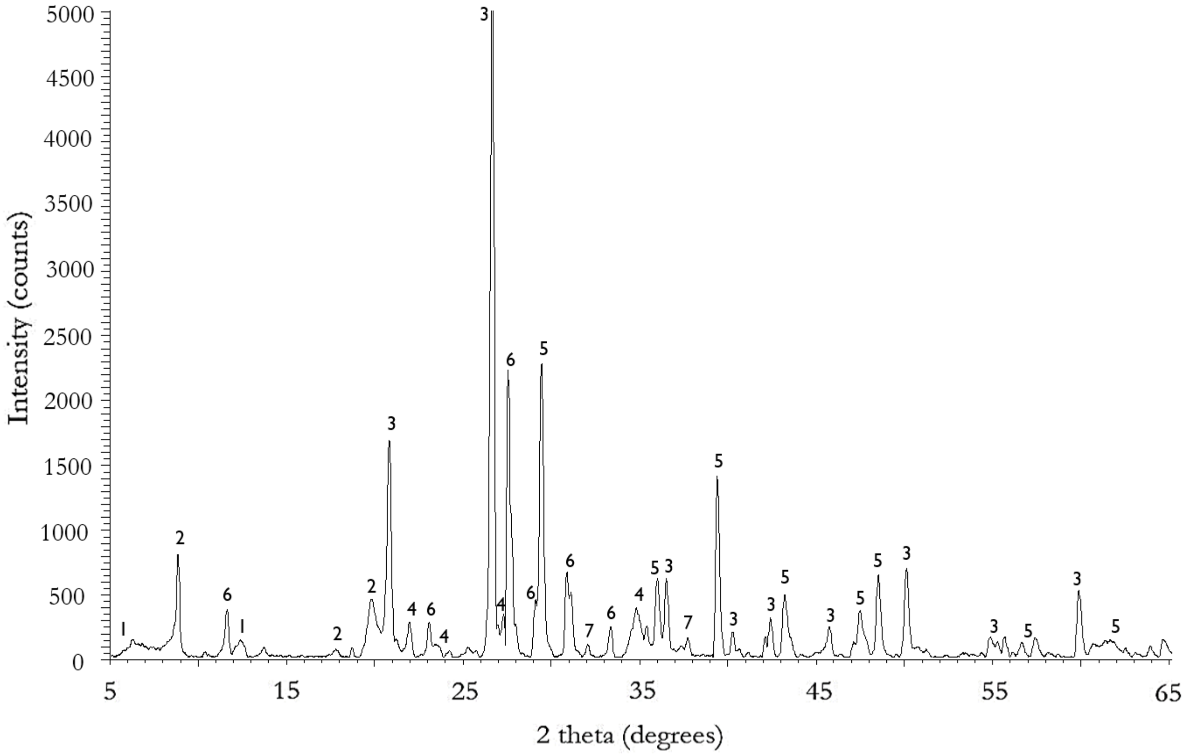



**Figure 5.31** XRD pattern of deposit sub-type CH2e from the central platform of Building 114 at Çatalhöyük: 1-chlorite, 2-muscovite, 3-quartz, 4-plagioclase feldspar, 5-calcite, 6-gypsum, 7-aragonite.

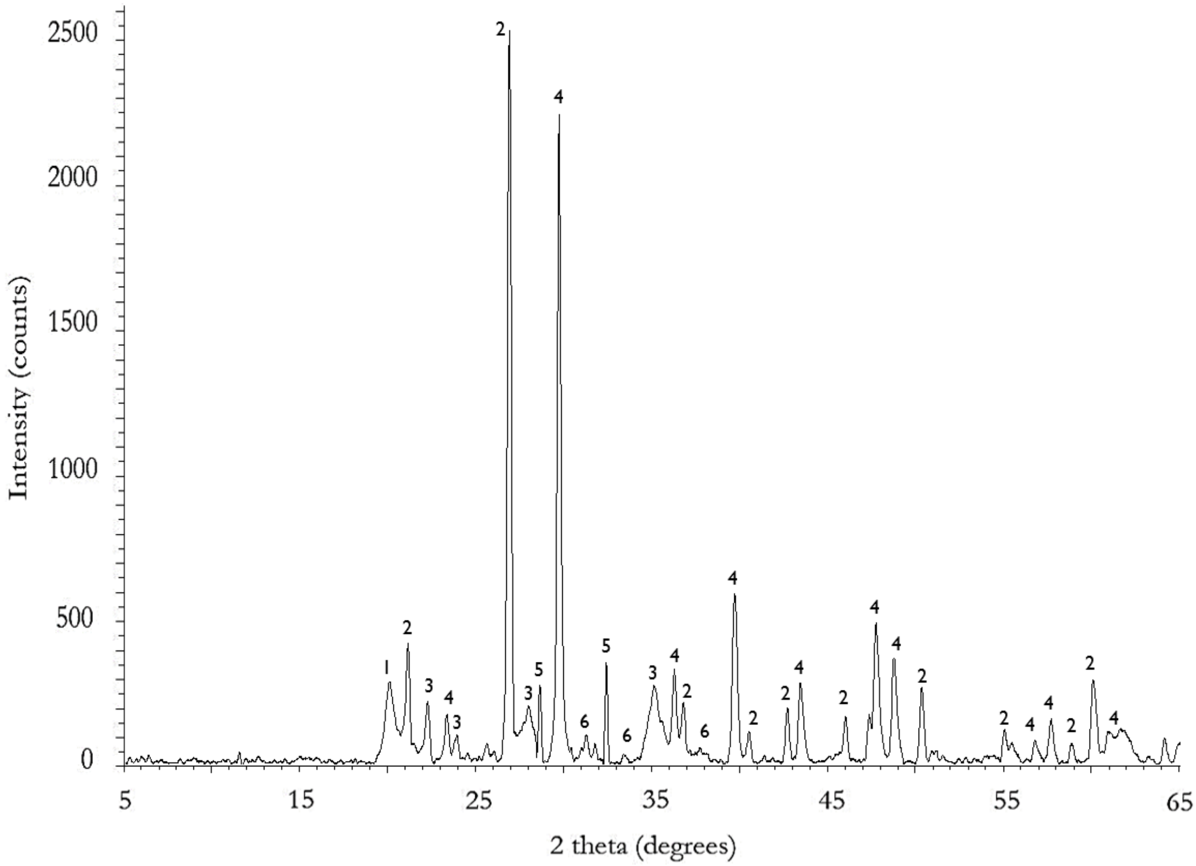



**Figure 5.32** XRD pattern of deposit sub-type CH2h from the central platform of Building 89 at Çatalhöyük: 1-muscovite, 2-quartz, 3-plagioclase feldspar, 4-calcite, 5-gypsum, 6-dolomite.

The intense peaks indicating the occurrence of gypsum in deposit sub-type CH2e suggest that this particular unit was substantially altered by salt crystallisation. Finally, mixed clay loam plasters, classified as CH2h and characterised by their heterogeneity, appear strongly dominated by quartz and calcite minerals. Surprisingly, trace amounts of dolomite were detected in this unit, suggesting the presence of softlime, possibly in the form of aggregates.

The IR spectra presented in the next page show that all the plaster types analysed contain abundant clay as well as quartz. This is consistent with the mineralogy determined by XRF and XRD methods. Unfortunately, the mixture of clay minerals in the sediments analysed means that it is not possible to identify the specific types from the IR spectra. The content of calcite is also important in all deposits, although the peaks are more intense in deposit sub-types CH2a and CH2b, indicating that they contain a higher concentration of this mineral than the other types. Interestingly, deposit CH2a shows no significant peaks for dolomite at 730 $cm^{-1}$, which indicates that softlime is not the main natural sediment source of these plasters, but rather a different marl source than the one used in the production of the CH2b types.

All in all, the mineral spectra of the floor plasters are all very similar, displaying peaks for quartz, calcite, dolomite, clay, and gypsum, the latter formed post-depositionally as micromorphological observations have determined. Minor differences in the IR peaks are likely due to slightly different concentrations of mineral in each plaster type.

| Wavenumber ($cm^{-1}$) | | | | | | Mineral |
|---|---|---|---|---|---|---|
| CH2a | CH2b | CH2c | CH2d | CH2e | CH2h | |
| 3697 | 3695 | 3695 | 3695 | 3695 | 3695 | Clay |
| 3620 | 3620 | 3620 | 3620 | 3618 | 3620 | Clay |
| 3406 | 3402 | 3401 | 3401 | 3398 | 3405 | Water |
| 2519 | 2520 | 2517 | 2517 | 2518 | 2520 | Calcite/Dolomite |
| 1798 | 1798 | 1797 | 1800 | 1798 | 1795 | Calcite/Dolomite |
| 1632 | 1623 | 1622 | 1627 | 1620 | 1629 | Water |
| 1409 | 1423 | 1414 | 1419 | 1419 | 1417 | Calcite/Dolomite |
| 1163 | 1162 | 1162 | 1160 | - | 1162 | Clay/Quartz |
| 1002 | 1001 | 993 | 995 | 999 | 996 | Clay |
| 915 | 912 | 912 | 910 | 912 | 910 | Clay |
| 871 | 871 | 872 | 870 | 872 | 872 | Calcite/Dolomite |
| 831 | 827 | 828 | 828 | 827 | 828 | Clay |
| 798 | 797 | 797 | 797 | 797 | 797 | Quartz |
| 779 | 777 | 776 | 776 | 777 | 777 | Quartz |
| 713 | 712 | 713 | 713 | 712 | 713 | Calcite |
| 695 | 694 | 694 | 692 | 693 | 695 | Quartz |
| - | 672 | 671 | - | 672 | - | Gypsum |
| - | 599 | 601 | - | 600 | - | Gypsum |

**Table 5.12** Wavenumber values and mineral assignments for the peaks in the IR spectra of the selected plaster floor types from Çatalhöyük.

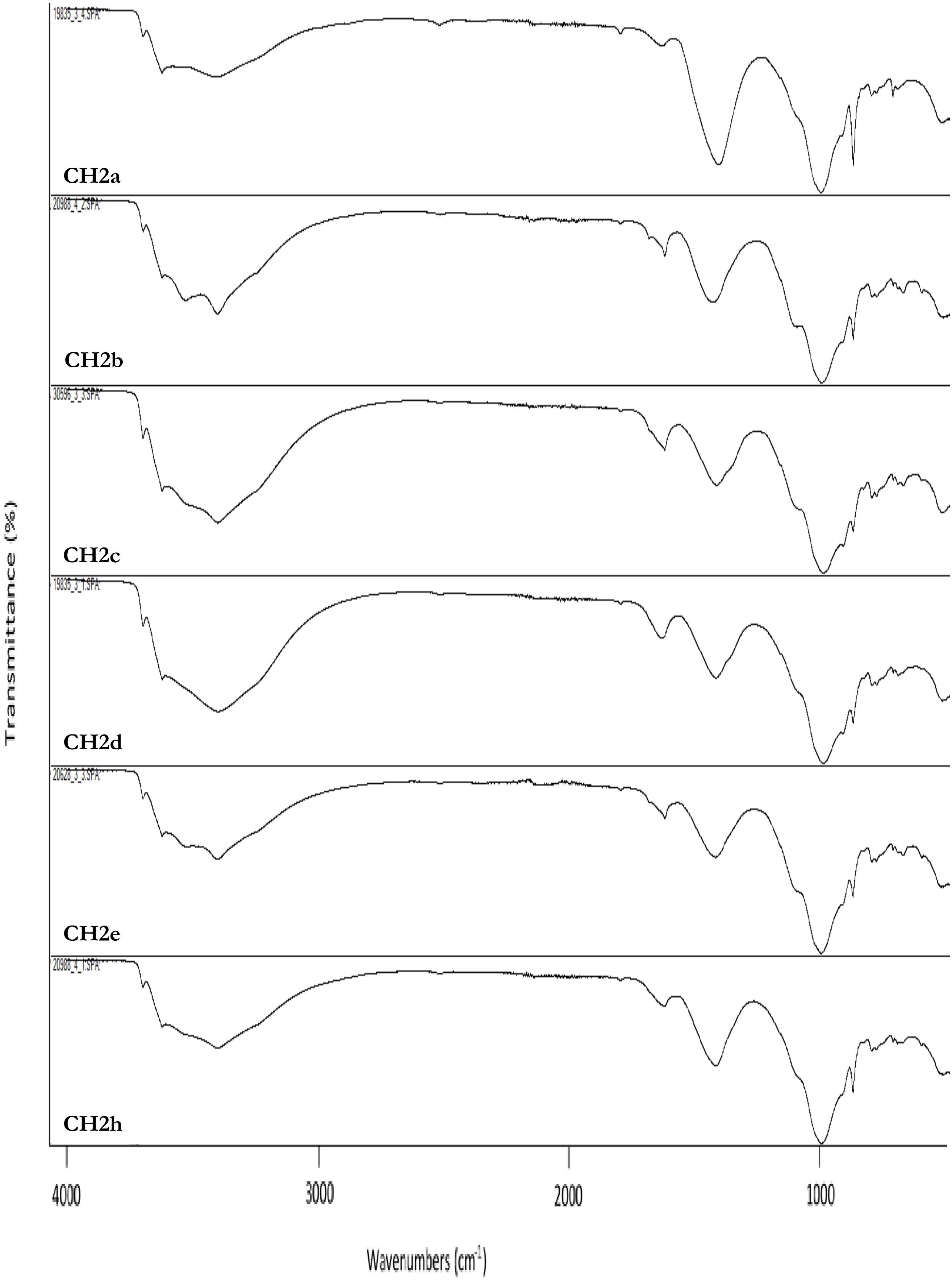



**Figure 5.33** IR spectra of key floor plaster types at Çatalhöyük. Wavenumber values for the visible peaks are reported in Table 5.12 in the previous page.

## 5.5 SEM-EDX AND IR MICROSCOPY

Microanalytical techniques aimed at gathering compositional information on key aggregates and inclusions were carried out directly on the uncoverslipped micromorphological slides. This study has targeted inorganic aggregates, specifically, floor finishing coats (suspected softlime plasters, deposit sub-type CH2a), and a marl nodule, to investigate and compare their mineralogy and calcitic content. This type of plaster deposits, in particular, are usually analysed with SEM-EDX and, especially, IR microscopy due to the difficulties entailed in collecting uncontaminated spot samples of loose sediments from these microlayers, often only 1-2 mm thick (Matthews *et al.* 2013). Unfortunately, extensive micro-FTIR analyses could not be conducted as the thin-sections had to be coverslipped rapidly after the micromorphological and SEM-EDX analyses due to the incipient signs of resin decay detected in the slides.

The microanalysis of organic inclusions focused on two types of materials whose nature was not completely clarified by micromorphology. These comprise calcitic, possibly ashy inclusions displaying a morphology that is reminiscent of plant remains (see Figure 5.36), and vesicle voids apparently filled with phosphatic materials found between the boundary of two plaster floors in the clean area of Building 114.

As standard, EDX raw data has been converted to oxides and normalised. Between three and four data points were obtained from each component/unit analysed for quality control. The mean was subsequently calculated for every element and sample. The original and transformed EDX data can be found in the Appendix included in the DVD-ROM.

### 5.5.1 INORGANIC AGGREGATES

Figure 5.34 in the next page summarises the chemical composition of the microunits and inorganic component analysed as determined by EDX. Carbon has been excluded from these results due to the high content of this mineral present in the resin used for the impregnation and consolidation of the samples, which causes carbon to be markedly overrepresented in all the microanalytical results. As this element was not expected to be naturally present in inorganic materials, it has been excluded in the results from these samples, a process that has entailed a re-normalisation of the data.

From the chart in the next page, it can be seen that the levels of silicon and aluminium in the plaster samples, higher than in the marl, indicate that clay is present in substantial quantities.

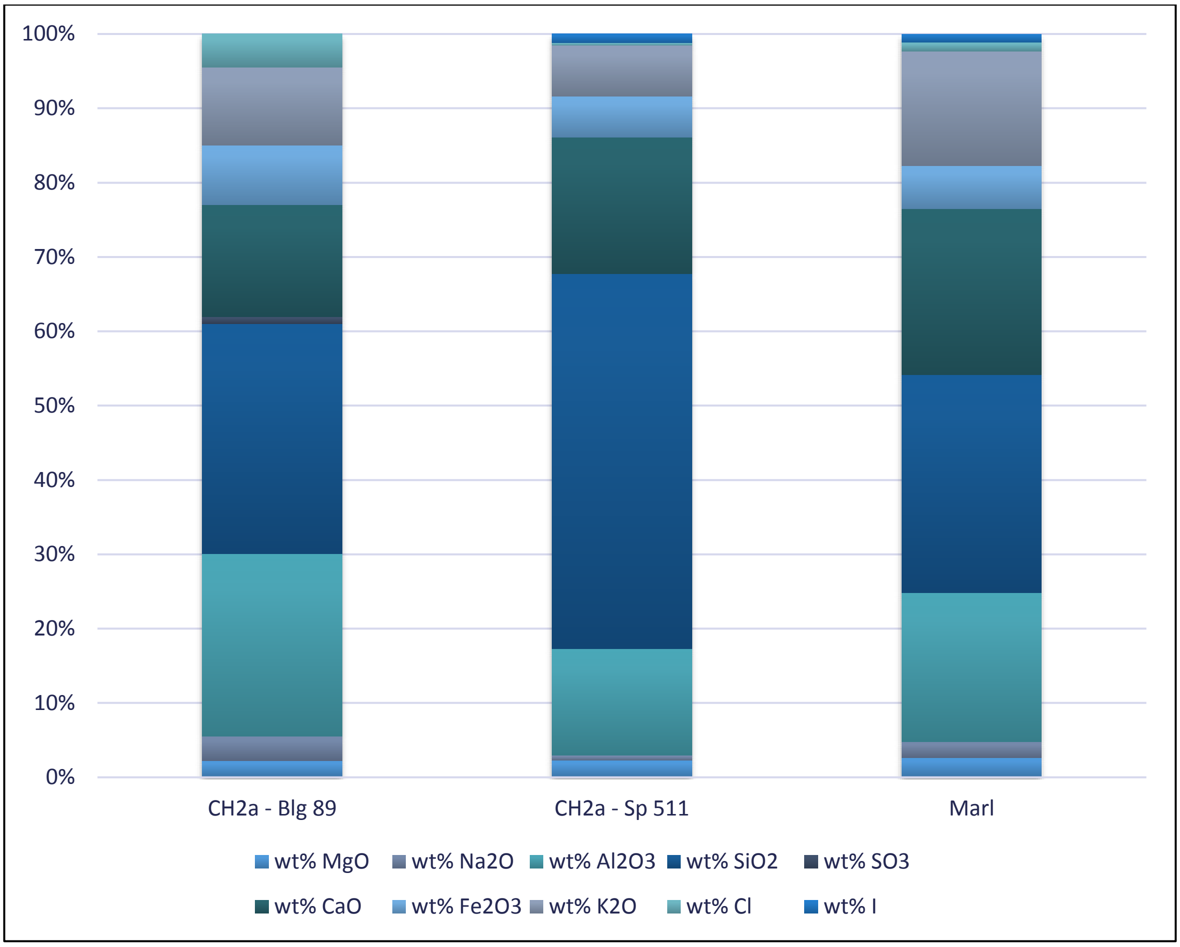



**Figure 5.34** Elemental composition of calcareous floors classified as deposit sub-type CH2a, suspected softlime floors, from Building 89 and collapsed roofing found in Space 511. The last sample presented here represents the chemical composition of a marl aggregate found embedded in a mud plaster deposit in Building 114.

The occurrence of calcite and magnesium in all the samples suggests the possible presence of dolomite, although in extremely low quantities (*ca.* 1%). The proportion of calcite found in the samples from deposit sub-type CH2a is significant, and is probably representative of the calcareous nature of the sediments used for the manufacture of these plasters. Overall, the most abundant element in these materials is silicon, likely due to the presence of clays and numerous quartz grains in these deposits and aggregate.

These results are consistent with those obtained from XRF, XRD and FTIR analyses of spot samples, indicating that the source of deposits CH2a, originally classified as suspected softlime plaster on the basis of optical properties assessed through micromorphology, is indeed marl. This study demonstrates the importance of an integrated, multi-disciplinary methodology for the investigation of sediments and architectural floor materials, as their often complex histories (origin, manufacture, deposition, post-depositional alteration), require the application of more than one geoarchaeological technique to extract all the information contained in these materials.

## 5.5.2 Organic inclusions

Results from the EDX analysis of organic inclusions found in accumulated occupation deposits at Çatalhöyük are displayed in Figure 5.35 below. As previously mentioned, the high percentages of carbon in each sample are mainly due to the composition of the resin in which these materials are embedded.

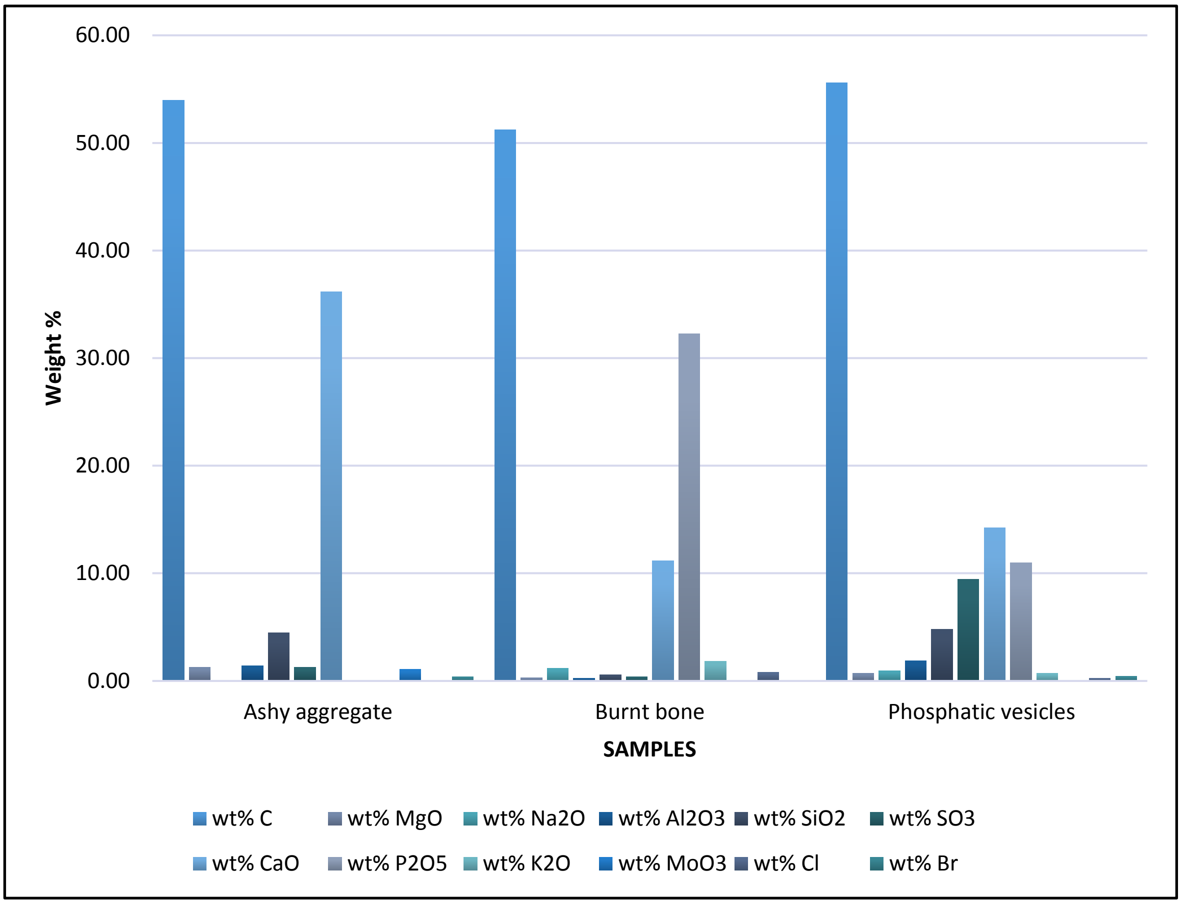



**Figure 5.35** Elemental composition of anthropogenic inclusions found in accumulated residues at Çatalhöyük.

Interestingly, the suspected ashy aggregate found as part of rake-out residues in the dirty area of Building 89 shows a very high proportion of calcium. Much lower amounts of silicon, magnesium, aluminium, and sulphur are also present. These data confirms the hypothesis that this inclusion is mainly composed of calcitic ash. The outstanding preservation of its fragile porous morphology is indicative of the absence of trampling in this area of the house. Although it is proposed here that this inclusion is in fact a calcined plant fragment, possibly wood-derived, this identification cannot be confirmed based on EDX data as it is impossible to isolate the carbon contribution of resin versus that of the calcined inclusion. This component, however, is another example of the exceptional preservation of bioarchaeological remains at Çatalhöyük.

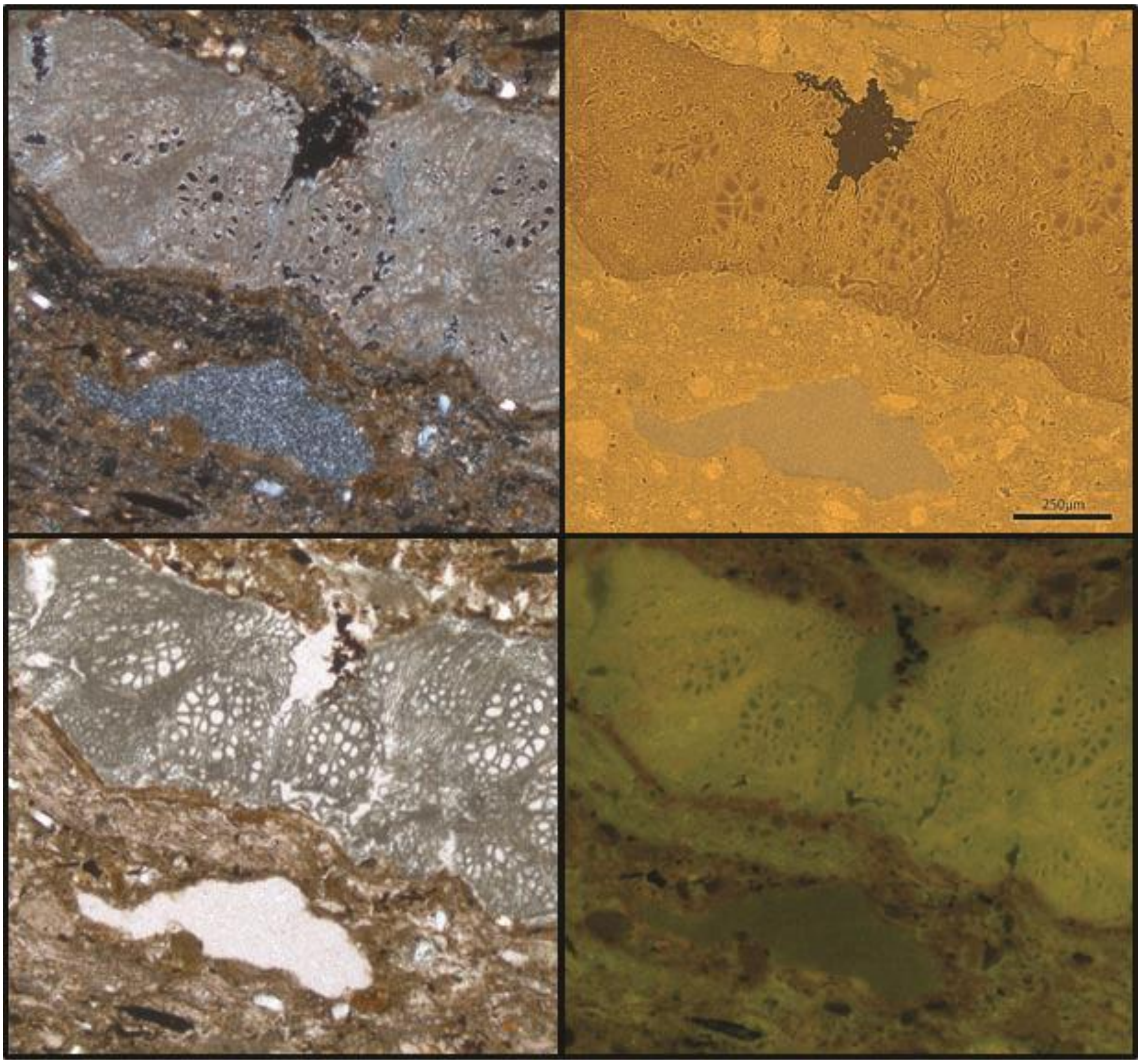



**Figure 5.36** Photomicrographs of ashy plant pseudomorph found in accumulated deposits within Building 89: (from the top left, clockwise) XPL light, SEM image, fluorescent light, and PPL light. Images assembled by Amanpreet Kaur.

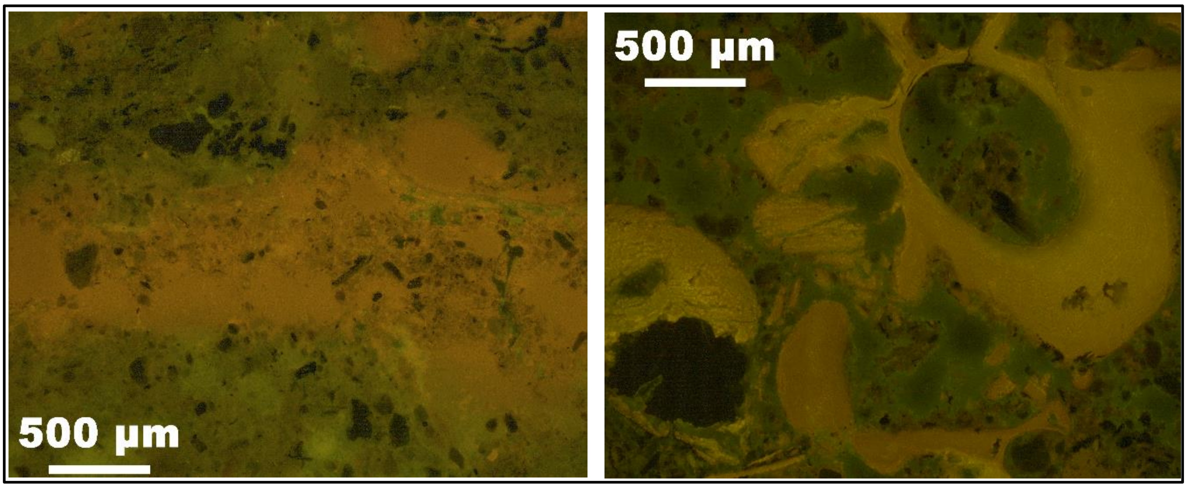



**Figure 5.37** Photomicrographs of phosphatic inclusions found in accumulated deposits at Çatalhöyük: left, phosphatic vesicles found on top of plaster floor in Building 114; right, bone fragments within midden unit. Images taken under fluorescent light.

Phosphatic vesicles, referring to small (*ca.* 200-300 μm in diameter), oval voids apparently filled with phosphatic materials, have been found as a discontinuous layer on top of a floor plaster unit in Building 114. The level of fluorescence observed in these components is similar to that of bone remains, indicative of the presence of phosphates (see Figure 5.37 in the previous page). Surprisingly, the elemental composition of these vesicles, as determined through EDX, consists mainly of calcium, phosphorus, and sulphur. Therefore, although phosphates are present, possibly derived from organic components, their proportion in these vesicles is considerably lower than in the bone sample. Gypsum ($CaSO_4 \cdot 2H_2O$) is undoubtedly contained in these vesicles, likely in a highly micritic form, as micromorphological observations of these features failed to detect crystallitic formations. The mechanisms that led to the creation of these vesicles have still not been deciphered at the moment of writing, although they are probably related to the post-depositional genesis of gypsum. It is known that the soluble form of this mineral can percolate through several layers until it encounters a deposit that it cannot penetrate. It is on the surface of these units, usually very compacted and clay-enriched, that gypsum precipitates. This phenomenon has been widely observed during excavations at Çatalhöyük where, occasionally, a single archaeological deposit containing multiple white nodules on its surface is exposed. In the particular case of the vesicles examined here, the organic decay of faecal aggregates, found associated with these features, might be related to the considerable amount of gypsum re-precipitation in this deposit.

IR microscopy analyses of plant ashes and charred bone have contributed further to the chemical characterisation of these two components of organic origin that are commonly encountered in midden and domestic contexts. The spectra included in Figure 5.39 in the next page display the main peaks produced by these different materials. In the case of the plant ashes, the strongest transmittance peaks can be observed at 1409cm$^{-1}$, corresponding with the $CO_3{}^{2-}$ stretch, and at 872cm$^{-1}$, marking the $CO_3{}^{2-}$ bend (M.Almond, pers.comm.).

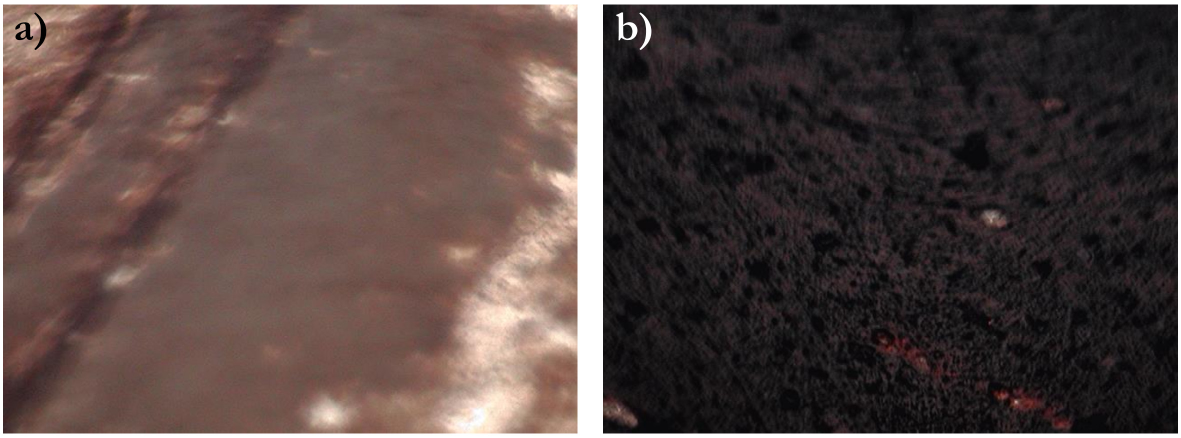



**Figure 5.38** Photomicrographs displaying the visible images of a) plant ashes, and b) charred bone under the IR microscope (frame width of each image = 2.6 mm).

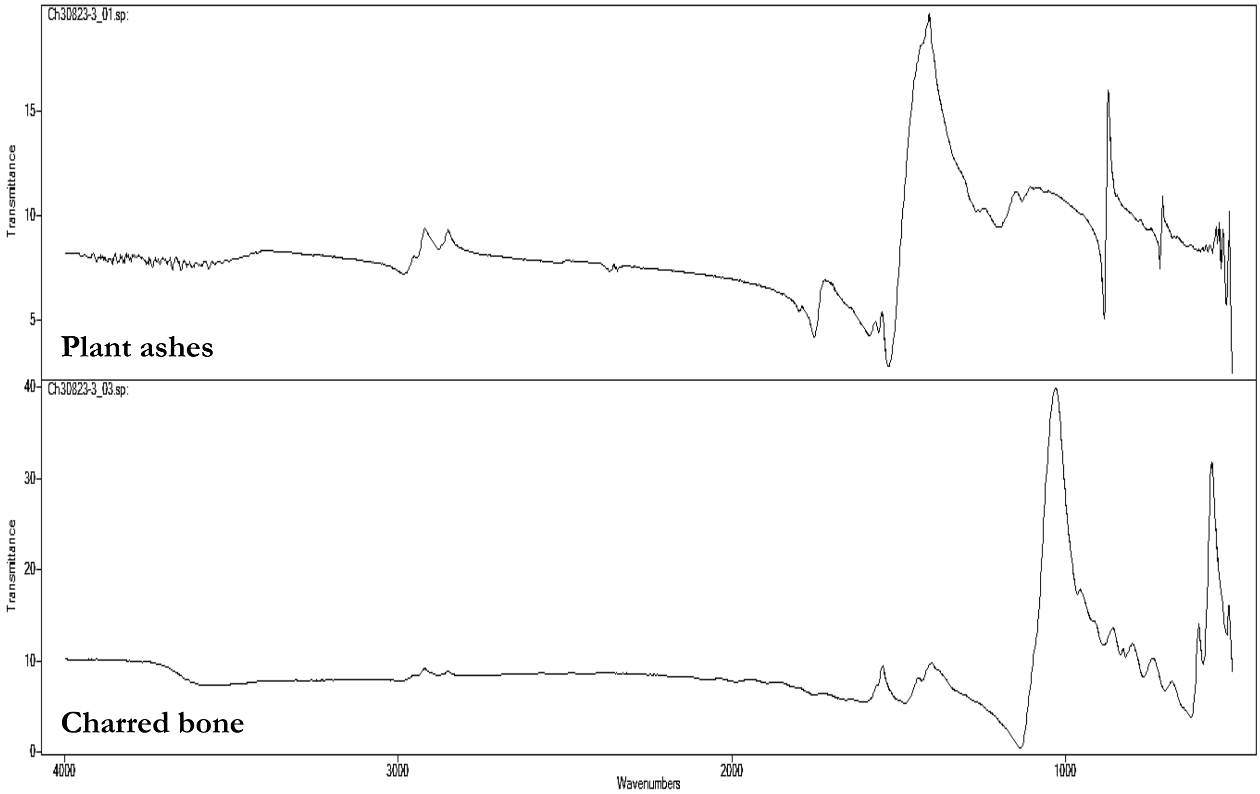



**Figure 5.39** IR spectra of plant ashes (top) and bone fragment (bottom) found in a midden deposit.

| Wavenumber ($cm^{-1}$) | | Mineral |
|---|---|---|
| Ash | Bone | |
| 1409 | 1403 | Calcite |
| - | 1029 | Phosphate |
| 872 | - | Calcite |
| 710 | - | Calcite |
| - | 602 | Phosphate |
| - | 563 | Phosphate |
| 510 | 511 | Phosphate |

**Table 5.13** Wavenumber values and mineral assignments for the main peaks in the IR spectra of organic components found in middens at Çatalhöyük.

The spectrum of the moderately burnt bone fragment shows that this component is formed by slightly recrystallised dahllite, indicating that it was heated at a temperature below 500ºC. Note that in the doublet peaks at 602 $cm^{-1}$ and 563 $cm^{-1}$, the latter is substantially more intense than the former, probably due to the presence of crystallised carbonate hydroylapatite (Weiner 2010).

# 6

# RESULTS III: PINARBAŞI

*Micromorphological and geochemical results from occupation layers at the Pınarbaşı rockshelter are reported in this chapter. Archaeological deposits from excavation Areas A and B, comprising respectively the 9th millennium and the 7th millennium occupation of the site have been analysed. Microstratigraphic sequences from buildings and open areas have been optically and chemically categorised and described. Integrated results from individual contexts are discussed in detail in Chapter 7.*

## 6.1 Introduction

The site of Pınarbaşı is situated within a ridge of limestone hills, at the ecotone zone between the alluvial plain and the volcanic massif of Karadağ. In spite of its modest size, the archaeological evidence from Pınarbaşı is of utmost importance for understanding the development of Neolithic lifeways in the Konya Plain, and continuity and change in ecological strategies and social networks during this period. While the occupation of Area A is roughly contemporaneous with that of the early agricultural village of Boncuklu, Area B has been radiocarbon dated to the late 7$^{th}$ millennium (Watkins 1996), contemporary with the latest levels of Neolithic occupation at Çatalhöyük East (Cessford *et al.* 2005). Therefore, the microcontextual examination and comparison of archaeological deposits and components at this site can shed light into important aspects of the social geography of the Konya Plain during the Neolithic period.

The late occupation of the rockshelter, which is the main focus of analysis of this research, is of particular interest due to its non-permanent, seasonal occupation pattern, inferred mainly from both excavation and faunal evidence (Baird *et al.* 2011b). Based on geoarchaeological studies that determined that the main Neolithic occupation of Çatalhöyük coincided with a period of active river alluviation, Roberts and Rosen (2009) proposed a model of seasonal fission and fusion of population that entailed the systematic exploitation of a range of different ecological zones in the Konya Basin coincident with the drier months of the year. Although this hypothesis cannot be tested based on microstratigraphical evidence, it is possible that Pınarbaşı was part of this landscape strategy, due to the marked seasonal indicators (spring/summer) detected in its animal bone assemblage (Baird *et al.* 2011b).

The micro-contextual study presented here aims at shedding light into the nature of the occupation of this rockshelter through the high-resolution analysis of archaeological deposits and activity residues. The nature, range, and use of environmental resources, in particular, are examined to investigate landscape exploitation strategies and seasonal indicators that could suggest temporality in the occupation of Pınarbaşı. Natural agencies, processes, and events are evaluated to detect periods of abandonment in the stratigraphic sequence. Finally, concepts of space and maintenance practices are investigated through the analysis of occupation surfaces and accumulated remains in both building and open sequences in order to detect the possible existence of strong social conventions regulating spatial boundaries and activities, such as those in place at the sites of Boncuklu and Çatalhöyük.

This chapter is structured in three parts. Micromorphological results, comprising the classification of the archaeological deposits and components identified at Pınarbaşı into key types, are reported in section 6.2 below. Part 6.3 evaluates the elemental characterisation of deposits using Infra-Red and X-ray Spectroscopy. Complete stratigraphic sequences are reported and discussed in section 7.4 in Chapter 7.

## 6.2 Thin-section micromorphology

Thin-section micromorphology allows the *in situ* examination of single depositional units, even those that are difficult or impossible to distinguish at the macroscale, as well as the components that form each stratigraphic unit. The study of undisturbed sediments, and both anthropogenic and natural inclusions, through the evaluation of their microscopic properties, such as fabric, sorting, shape, abundance, and alterations, contributes to shed light on the origin of materials, site formation processes, past human activities, and post-depositional processes at high spatial and temporal resolutions (Courty *et al.* 1989; French 2003).

In the next pages, the results emerging from the micromorphological observations of 9th and 7th millennium occupation contexts at the site of Pınarbaşı are reported in three parts. Section 6.2.1 below considers the range of deposit types present in buildings, whereas section 6.2.2 includes a classification of layers of similar composition and organisation present in open areas. Section 6.2.3 provides an evaluation of the range of mineral and organic components found in the samples examined.

### 6.2.1 Classification of deposit types in buildings

The building sequence analysed in this research corresponds to a 7th millennium habitation with a central hearth contained by a curved wall with an oven built into it (Baird *et al.* 2011b). Accumulated occupation discards and living surfaces have been analysed and classified according to diagnostic microscopic attributes, mainly microstructure, particle size, sorting, c/f ratio, c/f related distribution, and the nature and abundance of key inclusions. This strategy has allowed the identification of similar deposits occurring at various depths within this living structure, presented in Table 6.1 in the next page, suggesting repeated activities and occupation strategies.

| Deposit type | Deposit sub-type | Description | Interpretation |
|---|---|---|---|
| **PB1** Living floors | **PB1a** | Occupation surfaces | Compacted, ocassionally crumby minerogenic units of alluvial silty clay sediments containing little to no inclusions. Although temper materials have not been found, these layers are suspected to represent deliberately laid fine-grained sediments to act as living surfaces. |
| **PB2** Accumulated materials | **PB2a** | Accumulations rich in charred and silicified plant materials | These units are formed by approximately 25-35% plant matter comprising charcoal fragments and unidentifiable charred plants, in addition to lower proportions of herbaceous phytoliths. These components are usually unsorted and unoriented, representing re-deposited materials, likely derived from discarded fuel/craft sources. |
| | **PB2b** | Accumulations rich in calcitic ashes | Deposits comprising >50% disaggregated calcitic ashes derived from the combustion of different fuel materials, usually herbivore dung and reeds/grasses. These units appear disturbed and highly reworked. |
| | **PB2c** | Accumulations rich in rock fragments and sediment aggregates | Layers formed by *ca.* 35-50% limestone clasts and lower proportions of clayish sediment aggregates. The very low frequencies of anthropogenic inclusions embedded in these units suggests that they represent periods of abandonment of this structure. |
| | **PB2d** | Mixed accumulations (no dominant inclusions) | Heterogeneous layers of re-deposited occupation remains, often charred, comprising rocks, sediment aggregates, and very fragmented plant remains, bones and shell fragments. |

**Table 6.1** List of identified building deposit types at Pınarbaşı.

### 6.2.1.1 Deposit type 1: Occupation surfaces

Only four possible prepared and deliberately laid occupation surfaces, classified as deposit sub-type PB1a, have been detected in the building samples analysed. These units are remarkably different from the manufactured plasters identified at Boncuklu and Çatalhöyük, which show evidence of a careful manufacturing process. Instead, the suspected living floors of late Neolithic Pınarbaşı consist of fine-grained, slightly oxidised silty clay sediments that do not occur in the vicinity of the rockshelter. Highly eroded and fragmented, likely due to the absence of stabilising agents, these units contain very sparse embedded anthropogenic finds. Thick accumulations of discarded materials, however, overlie each of these suspected floor deposits.

The composition and micromorphological attributes of these deposits do not suggest that these are naturally deposited sediments, as for example colluvium (Mücher *et al.* 2010), and

| | | | | | | | | | | Minerals | | | Sediment aggregates | | Anthropogenic inclusions | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Deposit type** | **Deposit sub-type** | **Microstructure** | **Voids** | **Particle size** | **Sorting** | **Orientation** | **c/f$_{20\mu}$ ratio** | **c/f rel. distrib.** | **B-fabric** | Quartz | Amphibole | Plagiocase | Clay loam | Silty clay | Burnt bone | Burnt shell | Charred plants | Phytoliths |
| PB1 | PB1a | V/Cr | v, c, c-p ●●● | SC | MS PS | U | 2:5 | d-p s-e | b3 | ● | ○ | ○ | ●● | ● | ○ | ○ | ●● | ○ |

**Legend:** Microstructure: V=vughy, Cr=crumby | Voids: v=vughs, c=channels, c-p=complex packing voids | Particle size: SC=silty clay | Sorting: MS=moderately sorted, PS=poorly sorted | Orientation: U=unoriented | c/f related distribution: s-e=single-spaced enaulic, d-p=double-spaced porphyric | B-fabric: b3=stipple speckled | Abundance of Voids, Inclusions & Aggregates: ○≤1%, ●2-5%, ●●6-15%, ●●●16-30%, ●●●●31-50%, ●●●●●>50%

**Table 6.2** Micromorphological characteristics and components of deposit type PB1: occupation surfaces.

there is no particle-size gradient indicative of water-laid materials. Therefore, the most likely explanation for the occurrence of these deposits within this building sequence is that the occupants of this structure intentionally deposited them as floors, albeit in a crude manner. The modest thickness of these units, *ca.* 1 cm, in addition to their poor preservation due to cracking and post-depositional processes involving re-precipitation of gypsum salts, indicates poor maintenance practices.

It is here hypothesised that this behaviour was due to the fact that this structure was only temporarily or seasonally inhabited, and therefore its residents did not invest substantial amounts of time and energy into preparing and arranging the floor area of this building.

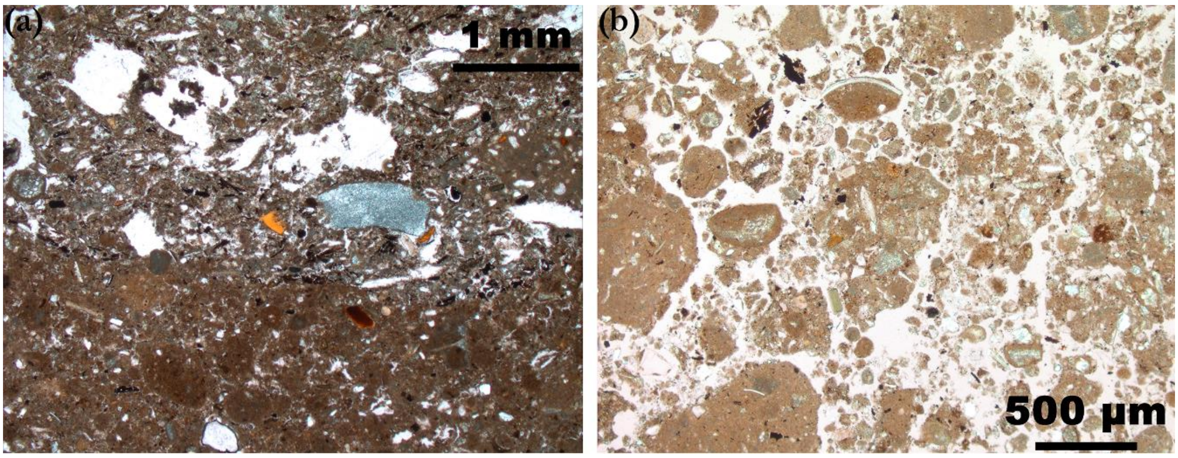



**Figure 6.1** Photomicrographs of deposit sub-types of suspected occupation surfaces: a) PB1a, sharp boundary between accumulated deposit (top) and suspected occupation floor (bottom), PPL; b) PB1a, silty clay sediment crumbs possibly derived from an eroded floor, PPL.

### 6.2.1.2 Deposit type 2: Accumulated materials

Accumulated materials are the most common deposit type at the Pınarbaşı rockshelter. Surprisingly, this is also the case in the late Neolithic building sequence examined in this study. These accumulated units are rich in anthropogenic inclusions and subangular limestone clasts that detached from the rockshelter face, and they are characterised by extremely thick (up to 10 cm and occasionally more) and homogeneous materials, suggesting very slow depositional rates. However, it is important to highlight here that this part of the site has been severely affected by post-depositional processes related to gypsum formation, as discussed in section 6.2.4, a factor that has undoubtedly contributed to the alteration of the groundmass and the apparent homogeneity of these deposits.

The first deposit sub-type identified in this category is PB2a, accumulated layers rich in charred plant materials, especially wood charcoal, and phytoliths. The charred plant remains are very variable in size, ranging between 200 μm and 1.2 cm, and occur in random orientation and distribution. Only a fraction of the charcoal fragments observed in thin-section have been

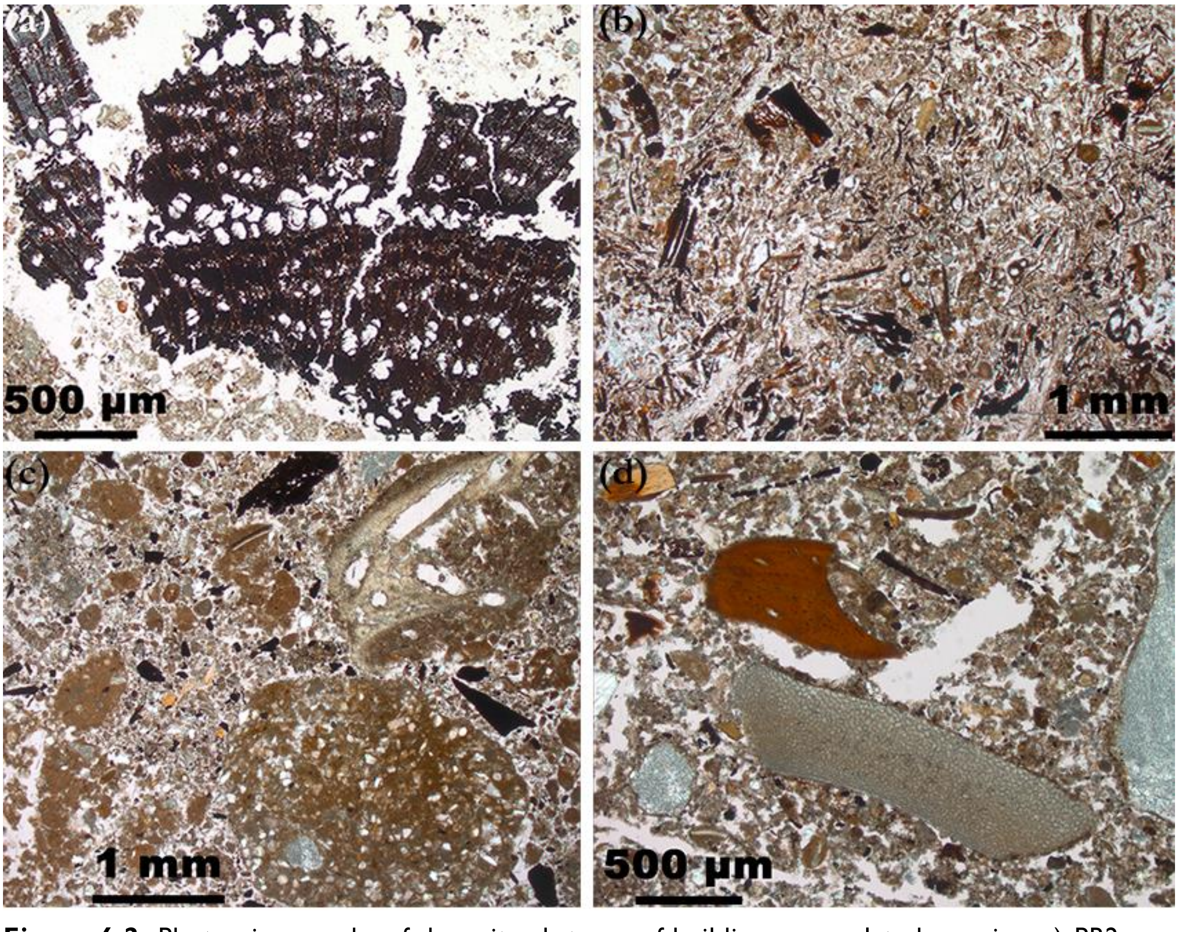



**Figure 6.2** Photomicrographs of deposit sub-types of building accumulated remains: a) PB2a, wood charcoal embedded in highly organic layer containing abundant charred plant materials, PPL; b) PB2b, ash accumulations rich in embedded burnt plant remains and amorphous organic matter, PPL; c) PB2c, subrounded aggregates of clay loam sediment in minerogenic layer, PPL; d) PB2d, mixed accumulation of occupation residues, PPL.

| | | | | | | | | | | Rocks & Minerals | | | | | | | Sediment aggregates | | | Anthropogenic inclusions | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Deposit type** | **Deposit sub-type** | **Microstructure** | **Voids** | **Particle size** | **Sorting** | **Orientation** | **c/f$_{20\mu}$ ratio** | **c/f rel. distrib.** | **B-fabric** | Basalt | Limestone | Quartz | Amphibole | Plagiocase | Muscovite | Calcite | Marl | Clay loam | Silty clay | Ashes | Faecal matter | Obsidian | Burnt bone | Burnt shell | Charred plants | Phytoliths | Melted silica | Hackberry endocarp |
| PB2 | PB2a | V/Cr | v, c, c-p ●●● | SCL | PS | U | 3:2 | s-p c-e | b2 | ○ | ●● | ●● | ○ | ○ | ○ | ●●●● | - | - | - | ● | ○ | - | ○ | ● | ●●● | ● | - | ○ |
| | PB2b | V/Cr | v, c, c-p ●●● | SL | PS | U | 5:2 | o-p s-e | b2 | - | ●●● | ● | ○ | - | ○ | ●●●●● | ○ | ● | ● | ●●●●● | ● | ○ | ● | ● | ●● | ●● | ○ | ○ |
| | PB2c | V | v, c ●●● | SL | U | U | 3:5 | d-p | b2 | - | ●●●● | ●● | ○ | ○ | - | ●● | - | ●● | ● | - | ● | - | ● | ● | ● | ○ | - | - |
| | PB2d | V | v, c ●●● | SCL | U | U | 5:2 | s-p | b2 | - | ●●● | ●● | ○ | - | - | ●● | ● | ●● | ●● | ● | ● | - | ● | ● | ●● | ● | ○ | ○ |

**Legend:** Microstructure: V=vughy, Cr=crumby | Voids: v=vughs, c=channels, c-p=complex packing voids | Particle size: SL=silt loam, SCL=silty clay loam | Sorting: PS=poorly-sorted, U=unsorted | Orientation: U=unoriented | c/f related distribution: c-e=close enaulic, s-e=single-spaced enaulic, s-p=single-spaced porphyric, d-p=double-spaced porphyric, o-p=open porphyric | B-fabric: b2=calcite crystallitic | Abundance of Voids, Inclusions & Aggregates: ○≤1%, ●2-5%, ●●6-15%, ●●●16-30%, ●●●●31-50%, ●●●●●>50%

**Table 6.3** Micromorphological characteristics and components of the various forms of deposit type PB2: accumulated materials.

identified to species, and from these, *Ulmus* appears as dominant, followed by *Juniperus*, a pattern that has also been observed in late midden deposits at Çatalhöyük, discussed in more detail in Chapter 7. Other inclusions, such as dispersed calcitic ashes and fragments of burnt bones and shells, are present in low frequencies (*ca.* 5%). Overall, the nature and arrangement of components in these units indicate that they represent dumps of discarded wood fuel.

Occupation deposits displaying high frequencies of accumulated calcitic ashes have been classified as sub-type PB2b. Ashes form over 50% of these layers, which have only been identified in the earliest levels excavated in Area B. These units, apparently derived from the combustion of plant materials, frequently display a wide range of embedded sediment aggregates and inclusions, such as charred plant fragments, herbaceous phytoliths, charred and calcined bones, and shell remains. However, these components, which show random orientations and distributions, occur in substantial proportions, ranging between 25-40% of these units. As in the case of deposit sub-type PB2a, these layers appear to have formed through dumping events of fuel and food materials.

Deposit sub-type PB2c comprises accumulations of limestone rocks and subrounded minerogenic aggregates of clayish sediment. These units range in thickness from 1 cm to over 10 cm, and generally contain very low frequencies of anthropogenic inclusions. The angular and subangular shapes of the limestone rocks that constitute approximately 40-50% of these deposits indicate the deposition of freshly fractured limestone, likely originating from the rockshelter and detached due to erosion processes such as frost shattering. Although traces of herbivore dung, bones, shells, and plant materials have been found in these layers, they occur in very low amounts (*ca.* 5-10%) and appear to be re-deposited from other areas of the site, possibly even by natural agents. Thus, the units classified as PB2c are practically sterile in archaeological terms, and they might represent periods of abandonment of the rockshelter.

Lastly, thick, heterogeneous accumulations of mixed materials with no apparent dominant inclusions have been detected in two samples and classified as deposit sub-type PB2d. These units, formed by unoriented and randomly distributed components of various sizes, ranging between 200 μm and 1.5 cm, are constituted by a variety of minerogenic and anthropogenic remains. Subrounded aggregates of calcareous and clayish sediment have been found in moderate concentrations (*ca.* 10-25%), whereas charred bones and shells, plant materials, and small aggregates of burnt herbivore dung occur highly intermixed in a matrix that shows no signs of rubefaction. Thus, these layers, formed by re-deposited materials derived from fire activities, appear to have formed through continuous dumping and reworking events of fuel and food discards.

### 6.2.2 Classification of deposit types in open areas

The midden contexts analysed span the latest phases of Neolithic occupation of the rockshelter. Both accumulated deposits and external fire installations have been studied in order to explore patterns of discard and activity in open areas at this site. Unfortunately, these contexts have been severely disturbed by Byzantine pits (Baird *et al.* 2011b), although intact sequences were documented and subsequently sampled in the field.

As in the case of midden units at Boncuklu and Çatalhöyük, deposits found in open areas at Pınarbaşı have been classified according to dominant inclusion types, although key microscopic attributes such as sorting, orientation, c/f ratio, and c/f related distribution have also been taken into consideration. The resulting midden deposit classification is reported in Table 6.4 below.

| Deposit type | Deposit sub-type | Description | Interpretation |
|---|---|---|---|
| **PB3** Midden deposits | **PB3a** | Accumulations rich in charred plant materials | The components of these deposits, mainly large charcoal fragments and smaller charred plant inclusions (>50% abundance), display a random orientation and distribution, indicative of dumping. The presence of wood charcoal and smaller fragments of unidentifiable charred plants points to diverse sources. |
| | **PB3b** | Accumulations rich in calcitic ashes | These deposits are formed by >50% calcitic ashes displaying, in most cases, an astounding preservation. When found in hearth contexts, these appear to derive from the burning of plant materials, although dung-derived ashes have been found in dumped deposits. |
| | **PB3c** | Accumulations rich in faecal matter | Organic layers formed by >50% faecal aggregates showing rounded and amorphous shapes. These aggregates, of suspected herbivore origin, display abundant spherulites and are often found charred. These units seem to have formed through the re-deposition of animal waste, at least some of which seems to have been used as fuel. |
| | **PB3d** | Accumulations rich in bone fragments | Midden deposits containing *ca*. 30-50% bone fragments of sizes ranging between 300 µm and 1 cm. At least 80% of these remains appear highly charred, possibly representing food discards. |
| | **PB3e** | Mixed accumulations (no dominant inclusions) | Deposits with no dominant inclusions, generally very heterogeneous and rich in re-deposited burnt occupation remains and clayish sediment aggregates. |

**Table 6.4** List of identified midden deposit types at Pınarbaşı.

### 6.2.2.1 Deposit type 3: Midden deposits

Midden deposits at Pınarbaşı are substantially minerogenic, especially when compared with similar contexts from Boncuklu and Çatalhöyük. Herbivore dung is ubiquitous in open areas dated to the 7th millennium, and completely absent from the 9th millennium sequences. Overall, two types of external contexts have been examined: *in situ* fills of fire spots and thick midden layers formed by re-deposited charred anthropogenic materials embedded in unburnt sediments. These contexts are discussed in more detail in Chapter 7.

The first deposit sub-type identified in open sequences at Pınarbaşı is PB3a, which comprises accumulations rich in plant materials, predominantly wood charcoal and smaller fragments of charred plants. A wide variety of arboreal sources has been observed in these layers, particularly *Ulmus* and *Juniperus,* possibly available near the site. Interestingly, dumped deposits are dominated by large (*ca.* 1 cm) fragments of tree bark, occurring in association with charred herbivore dung, indicating mixed fuel sources. *In situ* charred plant accumulations have been found in an external fire spot, overlaid by extraordinarily well-preserved ash accumulations.

Midden deposits predominantly formed by ash (>50% abundance) have been classified as deposit sub-type PB3b. These units have been found in dumped contexts, strongly associated with re-deposited charred and calcined aggregates of herbivore dung, and in hearth contexts, where both grass- and wood-derived ashes have been identified (see Figure 6.3). Ash has been found to be much better preserved at Pınarbaşı than at the other two study sites, indicating the performance of diverse discard and space maintenance practices by the residents of the rockshelter.

Deposit sub-type PB3c is distinguished by the high proportion (approximately 50-70%) of faecal matter of herbivore origin that constitutes these units. In most cases, dung aggregates occur randomly mixed with other materials, such as charred plants and bone fragments, suggestive of dumping and re-deposition. In some instances, single discard events can be distinguished based on the alterations displayed by the faecal remains: while in most cases dung appears intact, with the edges of complete pellets clearly evident, distinct areas of charred dung have been noticed in thin-section. Interestingly, these seem to be the discarded remains of dung used as fuel, and often occur in association with dispersed ashes. In spite of the considerable accumulations of faecal matter observed in specific areas of the Pınarbaşı rockshelter, the vughy to spongy microstructure of these layers together with a general absence of compaction and trampling features, dismisses the interpretation of these sequences as penning areas.

| Deposit type | Deposit sub-type | Microstructure | Voids | Particle size | Sorting | Orientation | $c/f_{20\mu}$ ratio | c/f rel. distrib. | B-fabric | Rocks & Minerals | | | | | | | | Sediment aggregates | | | Anthropogenic inclusions | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | Basalt | Limestone | Quartz | Amphibole | Plagiocase | Chert | Muscovite | Calcite | Marl | Clay loam | Silty clay | Ashes | Faecal matter | Obsidian | Burnt bone | Burnt shell | Charred plants | Phytoliths | Melted silica | Hackberry endocarp |
| PB3 | PB3a | V/C | v, c ●●●● | SL | U | U | 3:5 | o-p | b2 | - | ●● | ● | ○ | - | - | ○ | ○ | - | - | - | ● | ● | - | ● | ○ | ●●●●● | ●● | - | - |
| | PB3b | V/S | v, c ●●● | S | U | U | 1:10 | o-p | b2 | - | ●●● | ● | ○ | - | - | - | ●●●●● | - | ● | ○ | ●●●●● | ● | ○ | ● | ○ | ● | ● | - | - |
| | PB3c | V/S | v, c, c-p ●●●● | SL | U | U | 5:2 | c-e | b1 b2 | ○ | ●●● | ● | ○ | - | ○ | ○ | ●● | - | - | ○ | ●● | ●●●●● | - | ● | ○ | ● | ● | - | ○ |
| | PB3d | V | v, c ●● | SL | U | U | 5:2 | d-p | b2 | ● | ●●● | ● | ○ | - | ○ | - | ●● | ●● | ● | ○ | - | - | - | ●●●● | ● | ● | ○ | - | - |
| | PB3e | V/Cr | v, c, c-p ●●● | SL | U | U | 5:3 | d-p c-e | b2 | ○ | ●●● | ●● | ○ | ○ | ○ | - | ●●● | ○ | ● | ●● | ●● | ●● | ○ | ●● | ○ | ● | ● | ○ | ○ |

**Legend:** Microstructure: V=vughy, C=channel, S=spongy, Cr=crumby | Voids: v=vughs, c=channels, c-p=complex packing voids | Particle size: s=silt, SL=silt loam | Sorting: U=unsorted | Orientation: U=unoriented | c/f related distribution: c-e=close enaulic, d-p=double-spaced porphyric, o-p=open porphyric | B-fabric: b1=undifferentiated, b2=calcite crystallitic | Abundance of Voids, Inclusions & Aggregates: ○≤1%, ●2-5%, ●●6-15%, ●●●16-30%, ●●●●31-50%, ●●●●●>50%

**Table 6.5** Micromorphological characteristics and components of the various forms of deposit type PB2: accumulated materials.

Deposit sub-type PB3d, consisting of accumulated materials comprising *ca*. 30-50% charred bone fragments, has only been identified in the 9th millennium sequence sampled in excavation Area A, and it is, in fact, the only deposit category detected in this sequence. Here, bone fragments range in size between 200 μm and 1 cm, and appear considerably fragmented and weathered, as the frequency of microfissures appears to indicate. Probably the remains of food

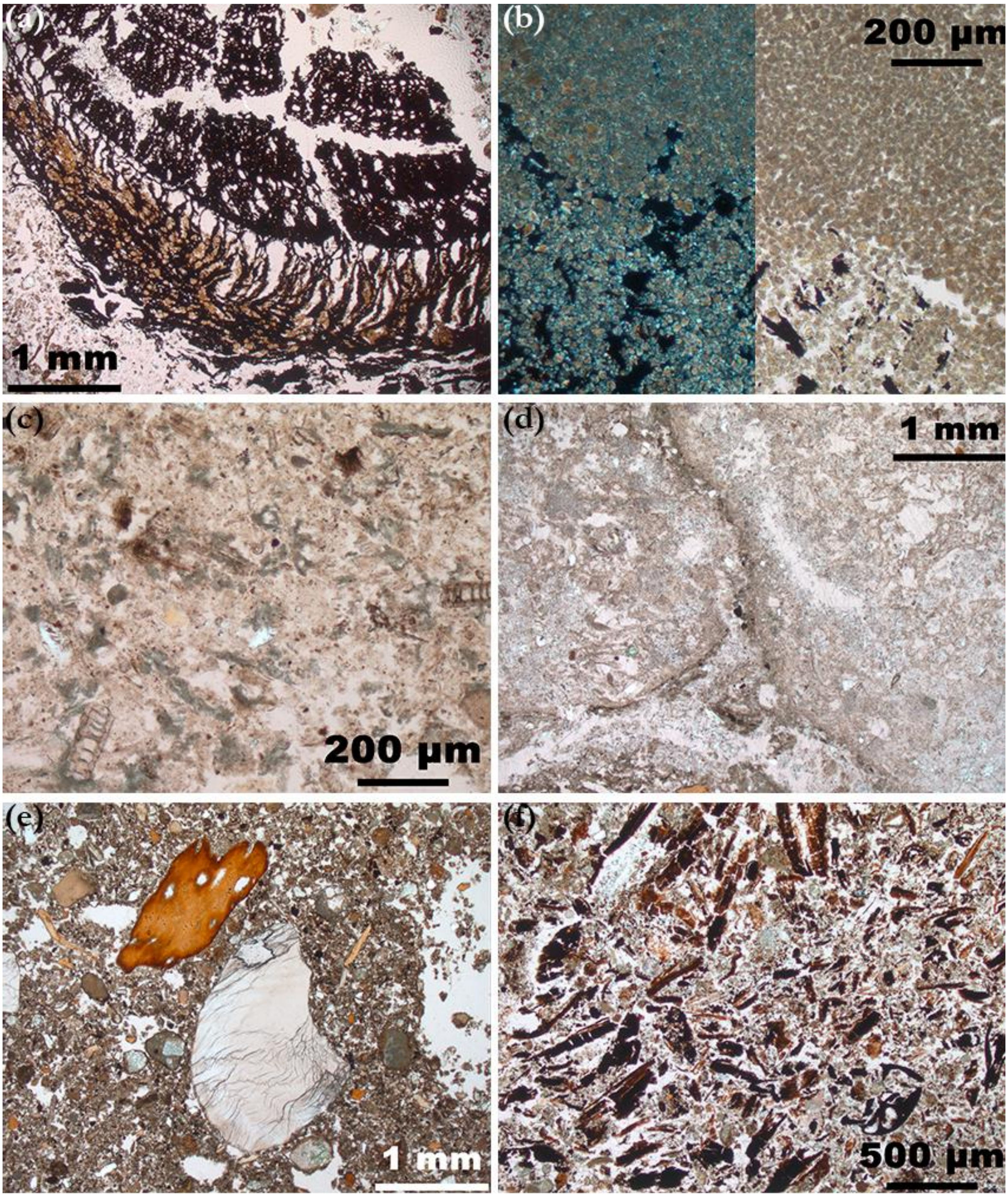



**Figure 6.3** Photomicrographs of deposit sub-types of accumulated midden materials: a) PB3a, charred bark fragment displaying abundant wood phytoliths embedded in organic layer, PPL; b) PB3b, accumulations of wood-derived ash in external fire installation, XPL (left) and PPL (right); c) PB3b, accumulations of dung-derived ash showing embedded reed phytoliths, PPL; d) PB3c, herbivore faecal pellets in coprolite-rich midden layer, PPL; e) PB3d, charred and calcined bone fragments in accumulated external deposit, PPL; f) PB3e, mixed deposits of discarded remains in open area, mainly formed by ashes, charred plants, faecal matter, and sediment aggregates, PPL.

sources, these inclusions were discarded and gradually accumulated in this external area, which displays an otherwise highly homogeneous groundmass containing abundant limestone clasts (*ca.* 20%), characteristics that point to slow rates of accumulation in this sequence.

The last deposit sub-type identified in open areas at Pınarbaşı, PB3e, comprises mixed accumulations of minerogenic and anthropogenic materials. These units are characterised by their heterogeneous nature, consisting of unoriented and randomly distributed calcareous and clayish sediment aggregates, some of which appear slightly charred, and occupation remains that include charred plants and bones, obsidian flakes, dispersed calcitic ashes, and amorphous aggregates of herbivore dung. These units, which seem to represent mixed discard deposits, have been particularly affected by post-depositional processes, including bioturbation and gypsum precipitation.

### 6.2.3 Classification of microscale inclusions

A summary of the range of micromorphological components found in the slides examined is presented in Table 6.6. While angular limestone clasts are ubiquitous across the site, deposited in occupation contexts due to erosive processes affecting the rockshelter, other components are only present in specific contexts, such as wood fragments and charred dung aggregates. Variations in the relative proportions and organisation of these components contribute important information on concepts of space, activities, and use of resources at this site.

| Inclusion type | Description | Variations | Origin & Preservation |
|---|---|---|---|
| **Rocks & Minerals** | *Quartz, calcite, gypsum, traces of mica and feldspar, basaltic rocks, limestone rocks.* | Size, shape, roundness, sphericity, smoothness, alterations. | Pre- and post-depositional origin of deposits. |
| **Sediment aggregates** | *Marl/Softlime*<br>Fine-grained, massive grey aggregates. | Size, shape, roundness, sphericity, boundary, voids, inclusions, coatings, alterations. | On-site indicators of off-site sediments, alluvial origin. |
| | *Clay loam*<br>Coarse dark brown to greyish-brown aggregates. | Size, shape, roundness, sphericity, boundary, voids, inclusions, coatings, alterations. | On-site indicators of off-site sediments. |
| | *Silty clay*<br>Fine-grained, brown aggregates. | Size, shape, roundness, sphericity, boundary, voids, inclusions, coatings, alterations. | On-site indicators of off-site sediments, possibly alluvial in origin. |

**Table 6.6** Summary of inclusion types found in occupation contexts at Pınarbaşı. (*Table continues in the next page*).

| Inclusion type | Description | Variations | Origin & Preservation |
|---|---|---|---|
| **Ashes** | *Plant origin*<br>Light grey rhomboidal crystals, high calcitic content. | Mineral composition, morphology of ash crystals, inclusions, alterations. | Short-length burning of plant materials, usually containing inclusions of charred plants and grass phytoliths. |
| | *Dung origin*<br>White to light grey crystals frequently found in association with spherulites and phytoliths. | Mineral composition, morphology of ash crystals, inclusions, alterations dependent on firing temperatures. | Herbivore dung used as fuel, high temperature burning. These materials have been abundantly found in open contexts. |
| **Faecal matter** | *Herbivore dung*<br>Yellowish (unburnt) to dark brown (charred) amorphous and rounded pellets. | Size, shape, inclusions, spherulite count, alterations. | Deposition of ruminant dung - cleaning activities and/or fuel use. Frequently containing abundant spherulites and few grass phytoliths, indicators of dietary sources. |
| **Micro-artefacts** | *Obsidian flakes*<br>Sharp inclusions of volcanic glass. | Size, shape, sharpness, alterations. | Débitage from tool-making activities or flakes accidentally detached during tool use. |
| **Bones** | *Bones*<br>Yellowish (unburnt), dark brown (charred), and greyish (calcined) fragments. | Size, shape, alterations (burning, calcination, weathering, digestion). | Derived from food preparation/cooking activities, these remains are often found charred and calcined embedded in re-deposited layers. |
| **Shells** | *Eggshells*<br>Dark greyish brown fragments >0.5 mm in size. | Size, shape, alterations. | Commonly found charred and very fragmented, they represent discarded food remains. |
| | *Water mollusc shells*<br>Small greyish linear and curved fragments, often striated. | Size, shape, alterations. | Frequently found charred, possibly indicating their use as food resources. |
| | *Land mollusc shells*<br>Large, almost complete spiral fragments. | Size, shape, alterations. | Post-depositional intrusions. Bioturbation. |
| **Plant remains** | *Wood charcoal*<br>Large fragments of charcoal up to 2 cm in size. | Size, shape, species, alterations. | Well-preserved, large fragments found in re-deposited contexts, indicative of the use of wood as fuel. |
| | *Charred plants*<br>Smaller fragments of black plant-derived (non-arboreal) materials. | Size, shape, species, alterations. | Plant burning activities - fuel for low temperature/short duration fires. Moderately fragmented and well-preserved. |
| | *Siliceous plants (phytoliths)*<br>Semi-transparent impressions of plant cells. | Size, shape, species, plant part, degree of articulation, alterations. | Derived from plant burning activities or *in situ* plant decay. When exposed to temperatures >600°C inclusions of melted silica might form. |
| | *Hackberry endocarps*<br>Pale grey to dark brown fruit shells. | Size, shape. | Fragmented remains of hackberry (*Celtis*) stones, ocassionally found charred in re-deposited contexts. Potential as seasonal marker for summer/autumn. |

**Table 6.6** Summary of inclusion types found in occupation contexts at Pınarbaşı. (*Table continues from previous page*).

In addition to the large limestone inclusions derived from the face of the rockshelter, the coarse minerogenic fraction of deposits at Pınarbaşı is formed by subrounded to subangular quartz grains, varying in size from *ca.* 10 µm to approximately 0.7 mm, and traces of amphibole, plagioclase, chert, muscovite, and calcite minerals, the latter partially derived from calcitic ashes, especially in open contexts. Rounded fragments of basaltic rocks derived from the volcanic highlands of the Konya Basin have been observed in some layers. Gypsum salts are ubiquitous in most contexts as post-depositional features, especially in midden sequences consisting of abundant accumulations of herbivore dung.

Calcareous sediment aggregates are rare at Pınarbaşı, and these are usually very small (*ca.* 300-600 µm) and rounded. Brownish clay loam and silty clay aggregates are slightly more numerous, especially in building contexts, where burnt occurrences of these materials have been observed in association with accumulations of charred plants. These components usually display a massive microfabric devoid of plant pseudormorphic voids, suggesting that they are not derived from construction materials.

Ashes at Pınarbaşı have been observed in re-deposited contexts and, interestingly, in *in situ* fire locations, where their extraordinary preservation indicate that these features were covered rapidly after use, as ash materials are very easily dispersed by natural agents. In fact, the excellent preservation of ashes has allowed the identification of a wide range of fuel materials selected by the late Neolithic occupants of the site, including herbivore dung, predominantly found in open contexts, and plant materials derived from woods and, to a lesser extent, grasses.

Herbivore dung is also very abundant in the late Neolithic deposits of the rockshelter, particularly in open areas, where charred accumulations, indicative of the use of this material as a fuel source, have been documented. Faecal aggregates are well-preserved at Pınarbaşı, and in some instances complete pellets measuring *ca.* 5-8 mm in size have been observed. Interestingly, the boundary of these pellets is characterised by the presence of a thin coat of dark brown, silty clay sediment, which appears to indicate rolling. In spite of the abundance of coprolitic material, which has been exclusively classified as herbivore in origin due to the abundance of spherulites and grass phytoliths embedded in these aggregates, penning deposits have not been detected at Pınarbaşı. All the faecal matter identified at this site has been found in dumped layers, completely devoid of trampling or compaction indicators.

Microartefact inclusions, comprising obsidian flakes, are extremely rare in the samples examined, likely due to the performance of tool production activities elsewhere on site.

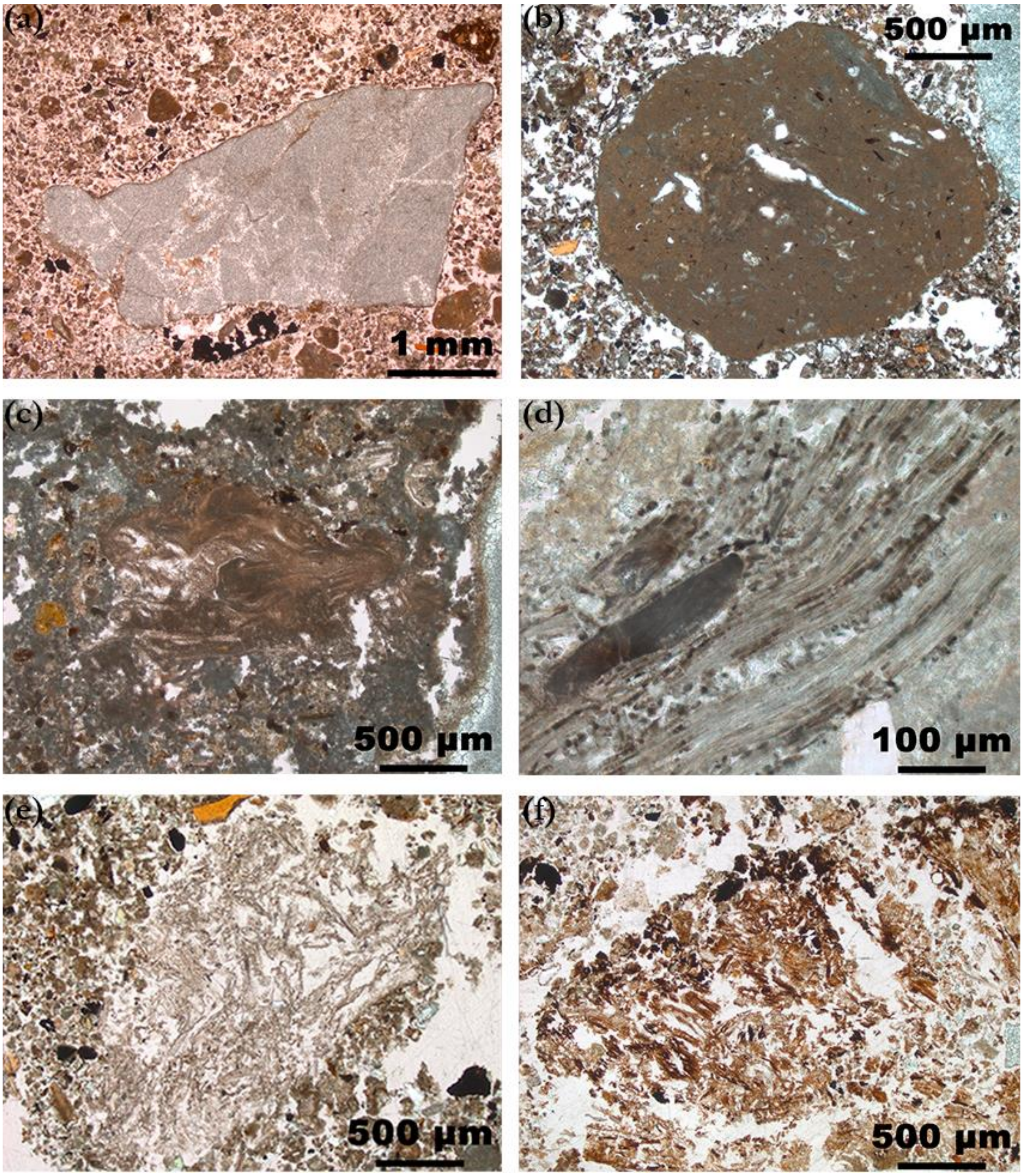



**Figure 6.4** Photomicrographs of inorganic and organic inclusions occurring in occupation deposits at Pınarbaşı: a) limestone fragment detached from the rockshelter, PPL; b) clayish sediment aggregate, PPL; c) mixed ashes and embedded calcined bone, PPL; d) partly calcined reed/grass remains in ashy matrix, PPL; e) unburnt herbivore faecal pellet, PPL; f) charred herbivore dung, PPL.

Bone fragments, the large majority of which are charred, with calcined and unburnt occurrences not exceeding 15% of the total, have been found in low to moderate numbers in all contexts, being particularly abundant in the 9$^{th}$ millennium occupation levels (*ca*. 30-50% abundance). Bone usually occurs in large fragments (*ca*. 500 µm - 1 cm), often rounded or sub-rounded in shape, and randomly oriented and distributed throughout the contexts, indicating re-deposition. They are frequently found in association with other materials, such as charred plants. Fragments of tooth enamel have been occasionally encountered in the layers examined.

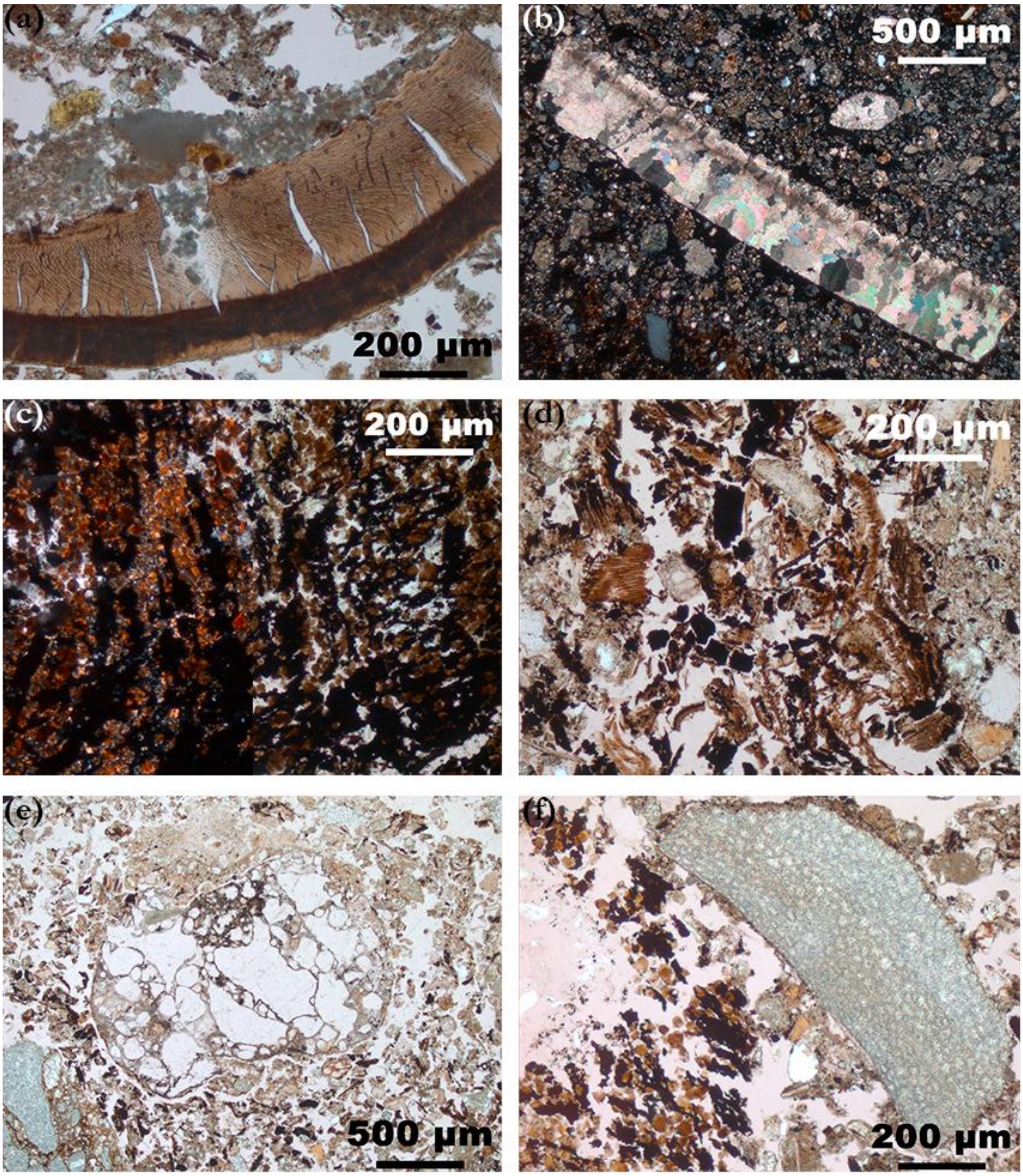



**Figure 6.5** Photomicrographs of organic components found in occupation deposits at Pınarbaşı: a) charred tooth fragment, PPL; b) eggshell, XPL; c) charcoal fragment showing abundant wood phytoliths (calcium oxalates), XPL (left) and PPL (right); d) charred plant materials including herbaceous phytolith types, PPL; e) melted silica, PPL; f) fragment of hackberry endocarp, PPL.

Although eggshells have been detected at Pınarbaşı (see Figure 6.5 above), they have been found in much lower quantities than at the early Neolithic settlement of Boncuklu (*ca*. 1%). The shell assemblage of the rockshelter, as identified in thin-section, is mainly constituted by water molluscs, few of which display signs of charring, possibly indicating their occasional consumption as food sources. Land mollusc shells have also been observed, although associated with post-depositional passage features caused by bioturbation.

Wood charcoal is the most common organic component observed in building contexts. It occurs frequently as large (>1 cm) inclusions, occasionally fragmented *in situ*, and often containing well-preserved phytoliths (calcium oxalates). *Ulmus* is significantly abundant in these deposits, although a wider range of woods appears to have been used by the occupants of the rockshelter. Species identification, however, has not been possible due to the moderate to high degree of fragmentation of these remains. Smaller charred fragments of non-arboreal materials are frequently found associated with wood charcoal, suggestive of the use of mixed fuel. The abundance of these inclusions in late Neolithic deposits at Pınarbaşı highlights the importance of fire-related activities at this site.

Other categories of plant materials, such as hackberry endocarps and siliceous plants, are far less commonly encountered in the occupation deposits of the rockshelter, generally ranging in frequency from <1% to 8%. The latter are frequently present in the form of stacked bulliform cells and grass husks, likely derived from herbaceous species. In addition, crystals of calcium oxalate have been documented in several contexts in strong association with charcoal remains.

### 6.2.4 Post-depositional alterations

Post-depositional processes have extensively affected occupation deposits at Pınarbaşı, particularly those of open areas. The most conspicuous of these is the precipitation of gypsum salts, occurring as well-developed lenticular crystals up to several millimetres in size. These formations have significantly altered the groundmass of some layers, especially of those dominated by the presence of coprolites. The porosity of these faecal components appears to have contributed to the crystallisation and development of gypsum salts in these units.

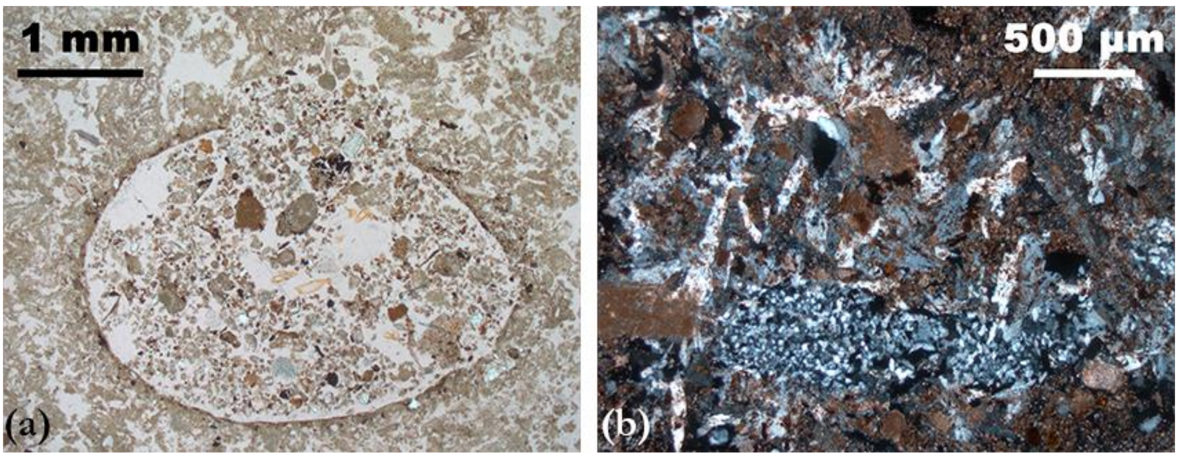



**Figure 6.6** Photomicrographs of post-depositional alterations found in Neolithic occupation deposits at Pınarbaşı: a) passage feature created by bioturbation processes, PPL; b) two generations of lenticular gypsum formations, with a number of crystals containing groundmass material, XPL.

At Pınarbaşı, the proximity of the limestone rockshelter to the late Neolithic occupation areas appears to have been determinant in the formation of gypsum salts. As it has been previously observed, gypsum precipitation occurs when the concentrations of calcium and sulphate ions in the soil are high. At this site, these ions derive from the alteration of limestone, thus contributing to the crystallisation of this mineral (Poch *et al.* 2010; Porta and Herrero 1990). High evaporation rates of soil moisture in this semi-arid region have contributed further to this phenomenon.

Bioturbation by faunal agents, probably insects, has also been frequently observed in occupation deposits, particularly those late Neolithic and Chalcolithic midden contexts that are close to the topsoil.

Surprisingly, and in marked contrast with archaeological deposits at both Boncuklu and Çatalhöyük, post-depositional processes of anthropogenic origin such as trampling, compaction, and abrasion are absent from Pınarbaşı. However, truncation of Neolithic surfaces and deposits by later features has been documented in the field (Baird *et al.* 2011b).

## 6.3 Infra-Red and X-Ray Spectroscopy

Microchemical XRF, XRD, and FTIR analyses were undertaken on spot samples extracted from the micromorphological blocks prior to impregnation in order to determine their elemental composition. Key samples from the late Neolithic building sequence in excavation Area B were selected for analysis, mainly comprising accumulated deposits deriving from both occupation and dumped materials (type PB2), and a suspected living surface detected in thin-section (type PB1). The complete processed dataset can be found in the Appendices included in the attached DVD-ROM.

### 6.3.1 Occupation surfaces and accumulated deposits

XRF results are displayed in Table 6.7 in the next page. A close inspection of these data shows striking chemical similarities across the whole range of samples analysed, with calcium being the most abundant chemical element, undoubtedly due to the presence of limestone clasts in these deposits. Typical clay elements, including silicon, aluminium, magnesium, and iron, are present in moderate quantities in all the samples analysed. Interestingly, the sediments corresponding to the sequence of micromorphological sample PB11 show higher amounts

| Sample | Deposit type | wt% SiO2 | wt% CaO | wt% Al2O3 | wt% Fe2O3 | wt% P2O5 | wt% K2O | wt% MgO | wt% Cl | wt% SO3 | wt% Na2O | wt% TiO2 | wt% MnO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **PB7_1** | PB2d | 23,90 | 62,11 | 2,11 | 1,67 | 1,90 | 2,20 | 2,04 | 0,38 | 3,11 | 0,33 | 0,18 | 0,06 |
| **PB7_3** | PB2c | 30,06 | 52,85 | 2,61 | 3,19 | 2,11 | 2,72 | 2,29 | 0,56 | 3,02 | 0,30 | 0,20 | 0,09 |
| **PB8_1** | PB2a | 23,57 | 61,36 | 2,64 | 2,03 | 1,20 | 2,27 | 3,96 | 0,29 | 2,10 | 0,26 | 0,26 | 0,06 |
| **PB8_3** | PB2a | 24,66 | 58,91 | 2,49 | 2,02 | 1,22 | 3,30 | 2,92 | 0,45 | 3,39 | 0,33 | 0,25 | 0,06 |
| **PB8_4** | PB2d | 21,94 | 62,91 | 2,93 | 2,16 | 1,29 | 3,14 | 2,87 | 0,45 | 1,62 | 0,32 | 0,32 | 0,06 |
| **PB11_1** | PB2c | 21,33 | 55,51 | 2,04 | 1,59 | 1,62 | 1,59 | 2,74 | 0,03 | 13,14 | 0,15 | 0,20 | 0,06 |
| **PB11_2** | PB2a | 15,38 | 62,88 | 1,63 | 1,34 | 1,78 | 2,68 | 2,94 | 0,08 | 10,88 | 0,20 | 0,15 | 0,05 |
| **PB11_3** | PB1a | 22,31 | 60,31 | 3,05 | 2,35 | 0,99 | 1,76 | 3,47 | 0,04 | 5,09 | 0,26 | 0,30 | 0,07 |

| Sample | Deposit type | ppm Ba | ppm Sr | ppm Zn | ppm Cr | ppm Ni | ppm Zr | ppm Rb | ppm Cu | ppm Br | ppm As |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **PB7_1** | PB2d | 0 | 1799 | 114 | 0 | 69 | 14 | 21 | 73 | 55 | 0 |
| **PB7_3** | PB2c | 0 | 1577 | 250 | 202 | 95 | 32 | 31 | 94 | 54 | 18 |
| **PB8_1** | PB2a | 0 | 1960 | 99 | 50 | 79 | 26 | 27 | 60 | 54 | 0 |
| **PB8_3** | PB2a | 0 | 1887 | 87 | 0 | 84 | 20 | 26 | 67 | 110 | 0 |
| **PB8_4** | PB2d | 0 | 2033 | 111 | 0 | 115 | 27 | 34 | 0 | 150 | 18 |
| **PB11_1** | PB2c | 0 | 1602 | 117 | 0 | 0 | 16 | 31 | 57 | 80 | 0 |
| **PB11_2** | PB2a | 0 | 2191 | 120 | 0 | 84 | 0 | 26 | 55 | 152 | 0 |
| **PB11_3** | PB1a | 516 | 1947 | 116 | 49 | 0 | 49 | 28 | 0 | 40 | 0 |

**Table 6.7** Normalised X-ray Fluorescence results from the analysis of both accumulated deposits and living surfaces at Pınarbaşı, displaying the major compounds (expressed in weight percentages) and minor elements (expressed in parts per million) present.

of sulphur than the other samples, attesting the occurrence of gypsum salts in these deposits. The striking compositional similarity of these contexts, which display only minor variations in their amounts of key elements such as calcium, highlights the marked homogenisation of these units, a characteristic possibly accentuated by reworking processes and post-depositional mixing caused by bioturbation.

These data are consistent with the XRD results obtained from the same contexts. In spite of the differences detected through thin-section micromorphology, mainly related to the nature, distribution, and abundance of specific inclusions, the fabric of the occupation deposits that form the archaeological sequence of the habitation structure in Area B is remarkably similar. The XRD spectra included in the next pages illustrate this absence of significant differences in the elemental composition of these layers. Calcite is dominant in all the samples analysed, again due to the ubiquitous occurrence of limestone clasts in the archaeological deposits at this site. Quartz is also present in all the samples although in moderate concentrations. Other minerals, such as hornblende, plagioclase feldspar, muscovite, and aragonite, occur in trace concentrations. Gypsum has been identified in all the studied contexts, although the height of its peaks varies substantially between samples, something not surprising due to the post-depositional and cumulative nature of this mineral at Pınarbaşı (see micromorphological observations in Section 6.2.4).

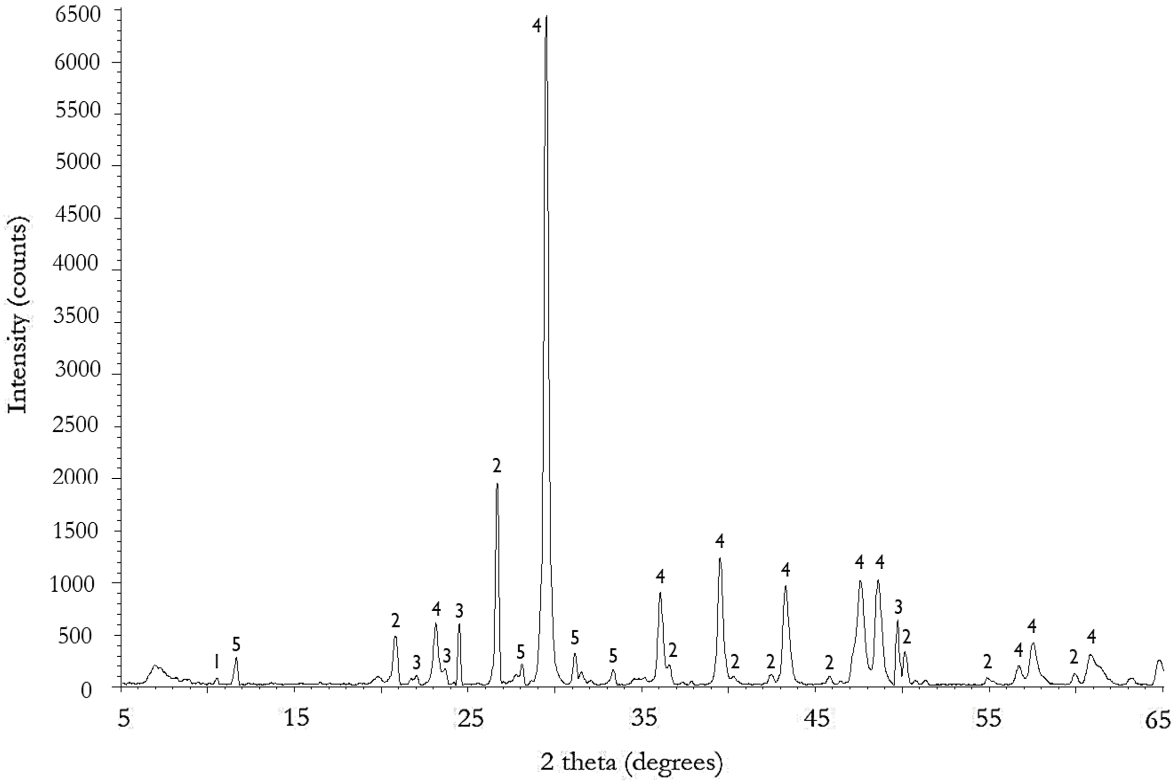



**Figure 6.7** XRD pattern of deposit sub-type PB1a, occupation surfaces, at Pınarbaşı: 1-hornblende, 2-quartz, 3-plagioclase feldspar, 4-calcite, 5-gypsum.

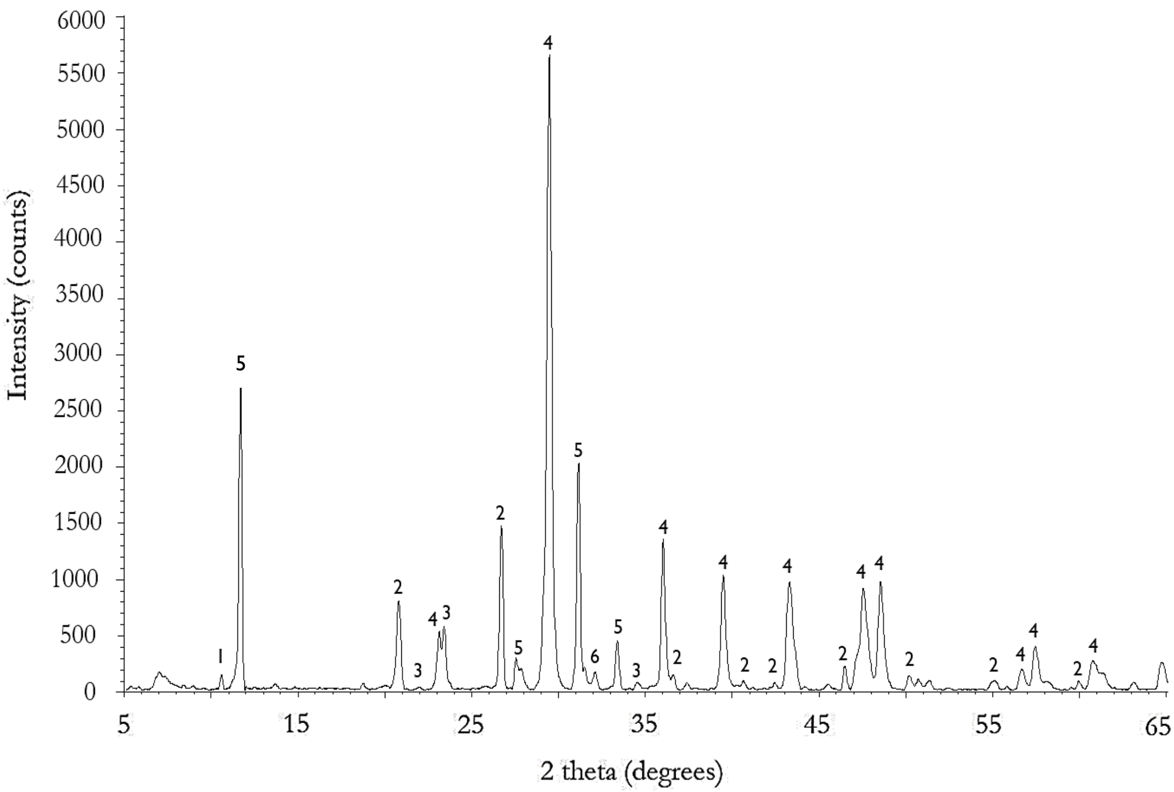



**Figure 6.8** XRD pattern of deposit sub-type PB2a, building accumulations of charred and silicified plant materials, at Pınarbaşı: 1-hornblende, 2-quartz, 3-plagioclase feldspar, 4-calcite, 5-gypsum, 6-aragonite.

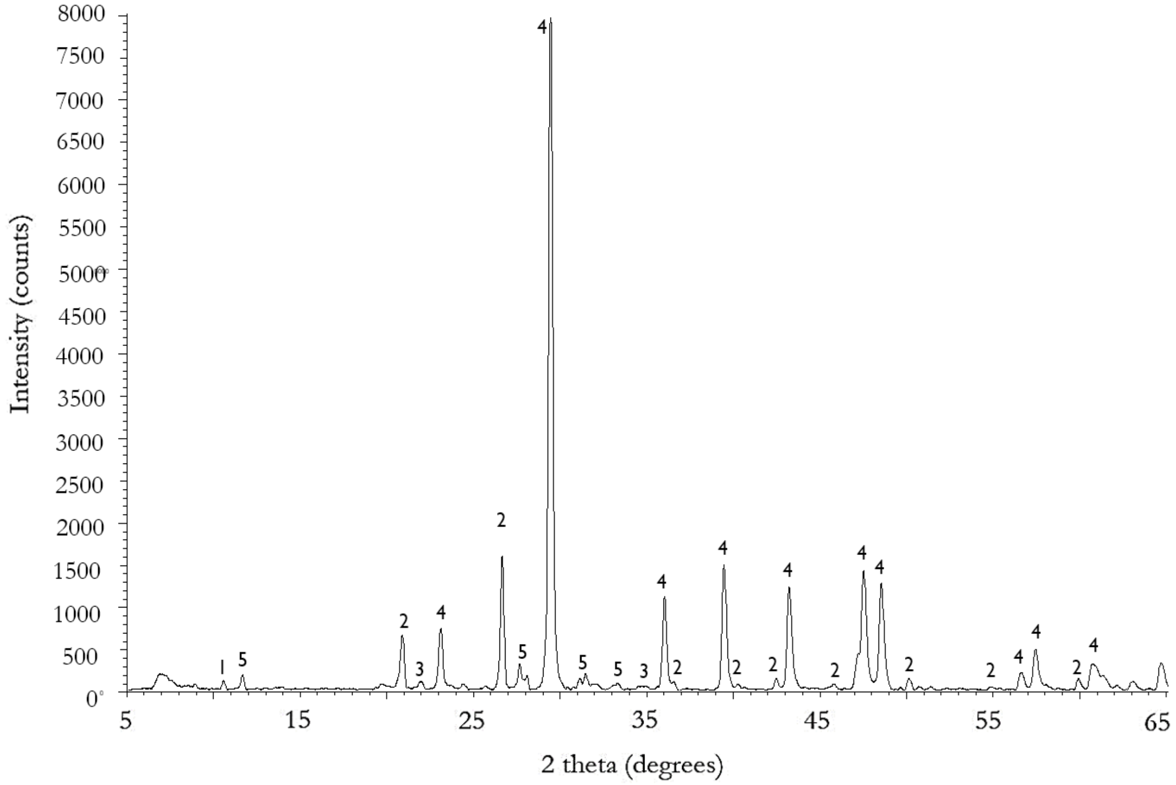



**Figure 6.9** XRD pattern of deposit sub-type PB2c, building accumulations of rock fragments and sediment aggregates, at Pınarbaşı: 1-hornblende, 2-quartz, 3-plagioclase feldspar, 4-calcite, 5-gypsum.

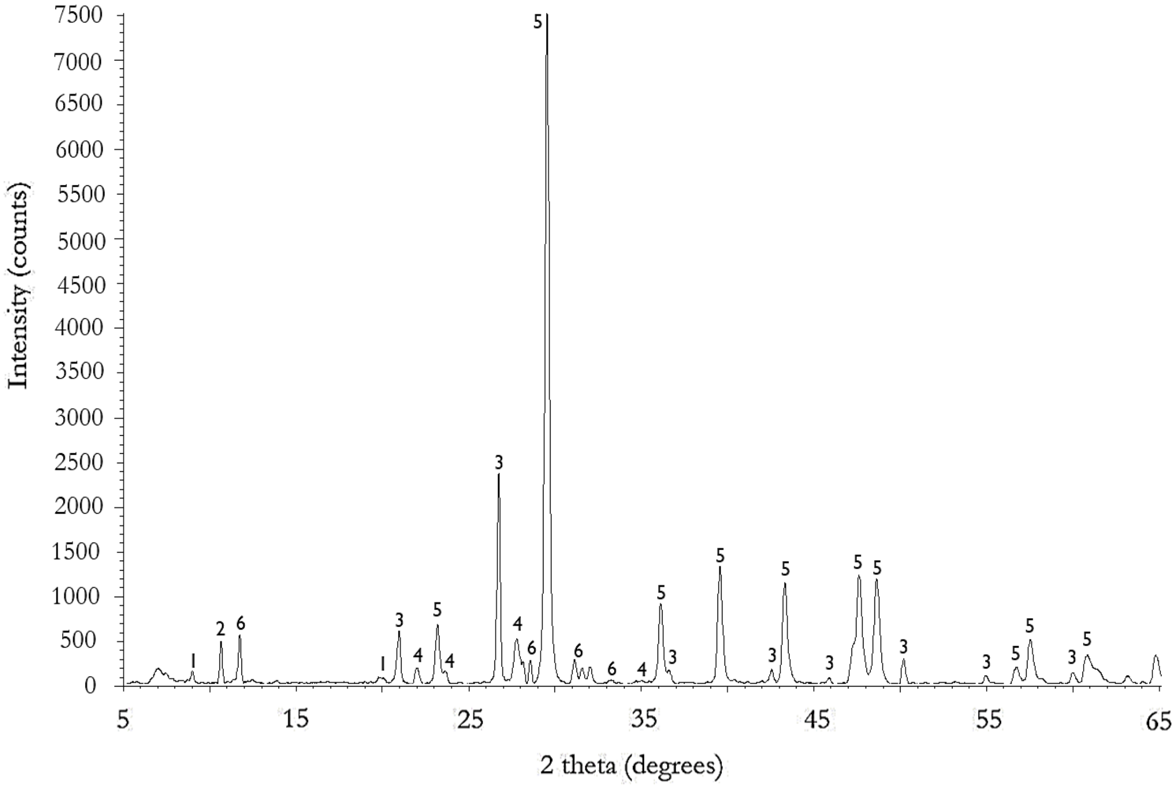



**Figure 6.10** XRD pattern of deposit sub-type PB2d, building accumulations of mixed materials, at Pınarbaşı: 1-muscovite, 2-hornblende, 3-quartz, 4-plagioclase feldspar, 5-calcite, 6-gypsum.

Finally, the FTIR spectrum of the suspected floor deposit from the Late Neolithic habitation in Area B (deposit sub-type PB1a), presented in Figure 6.11 below, highlights the main mineral components of this sample. The most intense peaks, at 1410 $cm^{-1}$ and 872 $cm^{-1}$ correspond to calcite, indicative of the high abundance of this mineral derived from the gradual but constant erosion of the limestone rockshelter. Clays have also been detected, although their peaks, at 3616 $cm^{-1}$ and 914 $cm^{-1}$, are more modest. Again, and in line with the chemical results obtained from XRF and XRD, gypsum signals appear to be considerably strong in this deposit, as the peaks at 669 $cm^{-1}$ and 601 $cm^{-1}$ attest.

In conclusion, the absence of chemical evidence to support the classification of deposit sub-type PB1a as deliberately selected and deposited floor materials, clearly distinct from the accumulations of occupation remains at this site, appears to suggest that these sediments were actually autochthonous, possibly accumulated or dumped in this habitation. In fact, this appears to have been the depositional pathway of other highly minerogenic layers in this sequence.

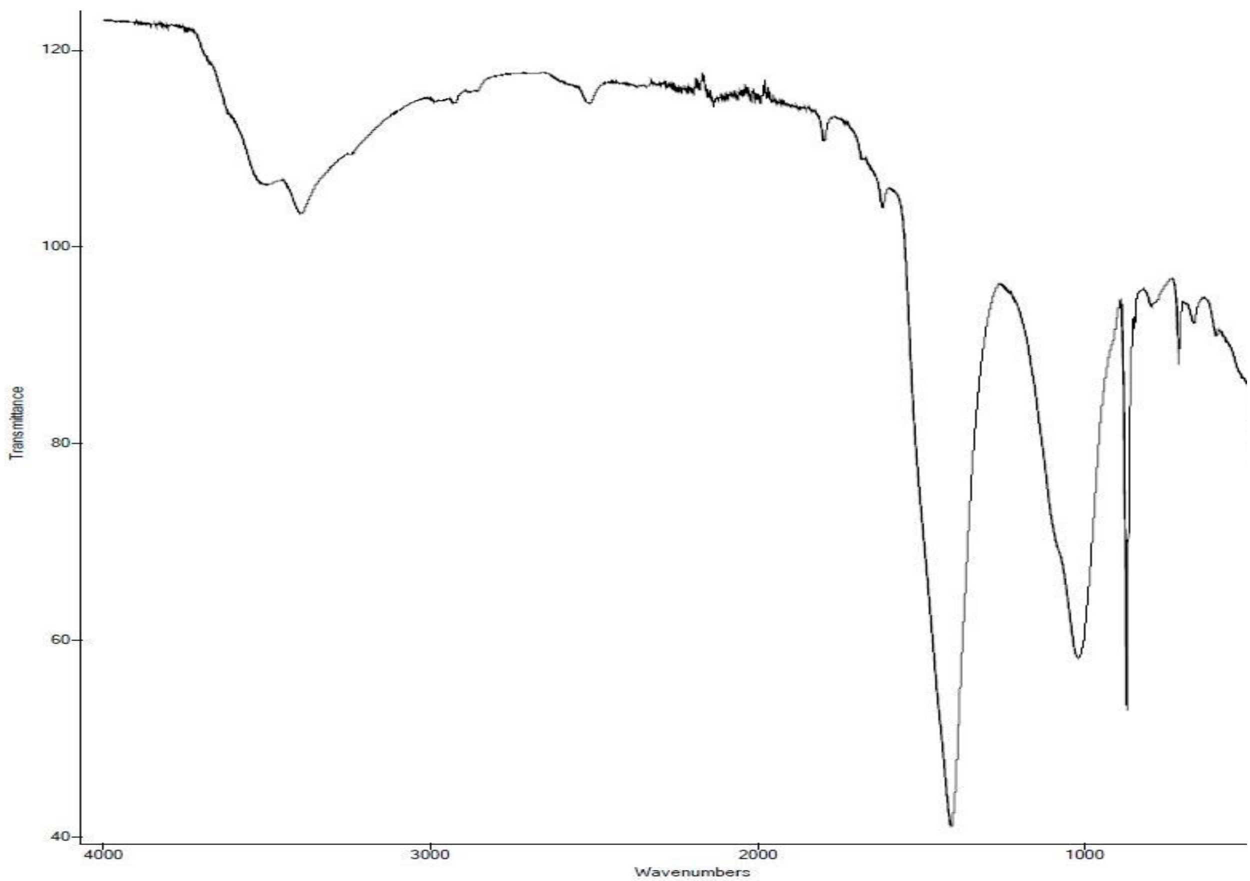



**Figure 6.11** IR spectrum of suspected mud floor at Pınarbaşı.

| Wavenumber ($cm^{-1}$) | Mineral |
|---|---|
| 3616 | Clay |
| 3403 | Water |
| 2519 | Calcite |
| 1798 | Calcite |
| 1620 | Water |
| 1410 | Calcite |
| 1026 | Clay/Quartz |
| 914 | Clay |
| 872 | Calcite |
| 797 | Quartz |
| 713 | Calcite |
| 692 | Quartz |
| 669 | Gypsum |
| 601 | Gypsum |

**Table 6.8** Wavenumber values and mineral assignments for the peaks in the IR spectrum of the suspected mud floor at Pınarbaşı.

## 6.4 SEM-EDX AND IR MICROSCOPY

*In situ* microanalyses of micromorphological components found in the Pınarbaşı samples have been limited to inclusions of organic origin, specifically combustion by-products such as charcoal and ashes. Investigating the chemical composition of latter is of particular interest to explore choices of fuel sources, as well as to understand the range of transformations acting on these materials as a result of heating and cooling. Thus, the main objective of this micro-analytical study is to characterise the mineralogical composition of these components to build on the micromorphological interpretations of site formation processes and post-depositional alterations, such as weathering and dissolution, at this rockshelter site.

Standard procedures have been followed regarding data collection and manipulation, entailing first the processing of a minimum of three EDX data points for every component analysed, with the results being subsequently combined and averaged in order to improve the reliability of the data, and the conversation and final normalisation of EDX elemental data to oxides. The original and transformed EDX data can be found in the Appendix included in the DVD-ROM. Similarly, IR micro-analyses have been conducted directly on the uncoverslipped thin-sections, involving the collection of one data point per sample in transmittance mode for the production of the spectra.

### 6.4.1 Organic inclusions

Wood charcoal, in addition to the ashes of three different types of fuel sources as identified in open spaces at Pınarbaşı through thin-section micromorphology, namely calcitic ashes suspected to have originated from grasses, wood-derived ashes, and dung ashes (see Fig. 6.12 in the next page), have been analysed with SEM-EDX. Although the distinction between these types has been made based on morphological differences as observed under the microscope, previous work has shown that ashes can also have a wide range of chemical compositions depending on various factors such as fuel choices, atmospheric conditions, and burning temperatures (Courty *et al.* 1989).

Canti (2003) described the main constituents of mixed plant ashes as consisting of micro-crystalline calcium carbonate aggregates, silica structures, vesicular glassy slags, and fine crystalline material. For the samples analysed in this study, the EDX results displayed in Fig. 6.13 confirm the presence of calcium carbonate as the main component in both suspected grass and wood ashes. Prismatic calcium oxalate crystals, usually found concentrated in the leaves of most common trees, are particularly abundant in the wood-derived ashes (see Fig. 6.12b), possibly indicating the use of leafy branches as fuel. Interestingly, although silica is particularly ubiquitous in Poaceae (Sangster and Parry 1981), this mineral does not appear to be well-represented in the suspected grass ashes. However, the high percentage of silica occurring in the dung ashes, although partly derived from the substantial occurrence of siliceous phytoliths as digested plant inclusions in herbivore faecal matter, is also likely to be due to the presence of quartz grains and other sediment particles in the sample due to re-depositional processes. In addition, the trace quantities of chloride and potassium, sulphate, and phosphate oxides observed in some of the samples are probably derived from dissolved plant nutrients.

All in all, the most significant contributors to the final compositional percentages in all the ash samples are the main plant inter- and intracellular mineral deposits, specifically carbonates, oxalates, and silica. Further, the chemical similarities between suspected grass- and wood-derived ashes could be indicative of the predominance of leaf elements in these combusted deposits. The differences observed between the ashes originated from plant fuels and those stemming from herbivore faeces, entailing higher proportions of magnesium, aluminium, silicon, and sulphur oxides in the latter, are probably the result of mixing and re-working processes affecting dung-enriched deposits, as well as of variations in burning temperatures. Finally, the occurrence of highly soluble salts, such as carbonates and hydroxides of sodium and potassium, in these ashy materials attests the excellent preservation of these deposits.

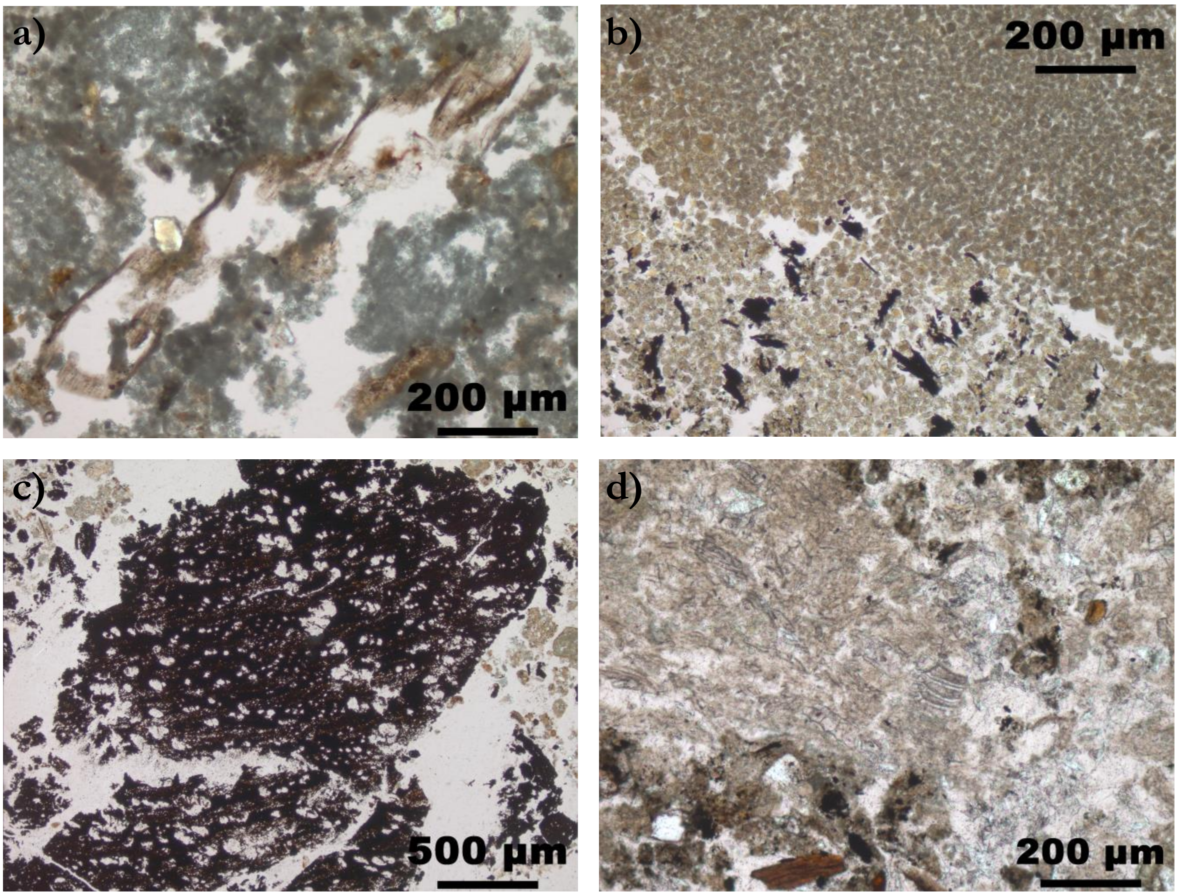



**Figure 6.12** Photomicrographs of components of organic origin targeted for SEM-EDX and IR microanalyses: a) calcitic ashes resulting from the combustion of reeds and grasses, PPL; b) wood-derived ashes, PPL; c) wood charcoal, PPL; d) herbivore dung pellet displaying inclusions of herbaceous phytoliths, PPL.

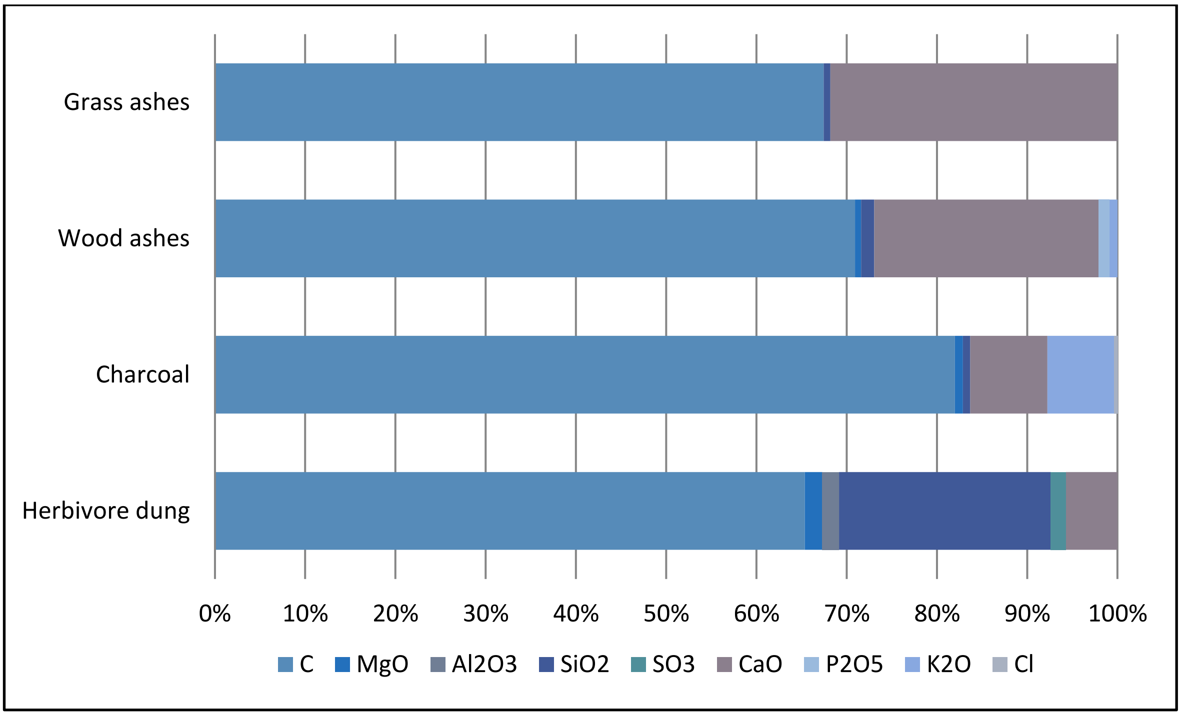



**Figure 6.13** EDX Elemental composition of micromorphological components of organic origin found in archaeological deposits at Pınarbaşı.

*In situ* IR microanalyses of accumulated open-air deposits rich in discarded herbivore dung used as fuel have failed to show any interesting differences in composition and preservation between the materials analysed. The strong peaks for quartz and clay observed in the calcined dung spectrum appear to indicate deposit mixing, which correlates with micromorphological observations of these materials (see section 6.2). Unsurprisingly, phosphatic peaks are evident in the spectrum corresponding to charred dung materials, likely due to lower burning temperatures or a shorter combustion time that led to the survival of this mineral, as opposed to the calcined dung sample.

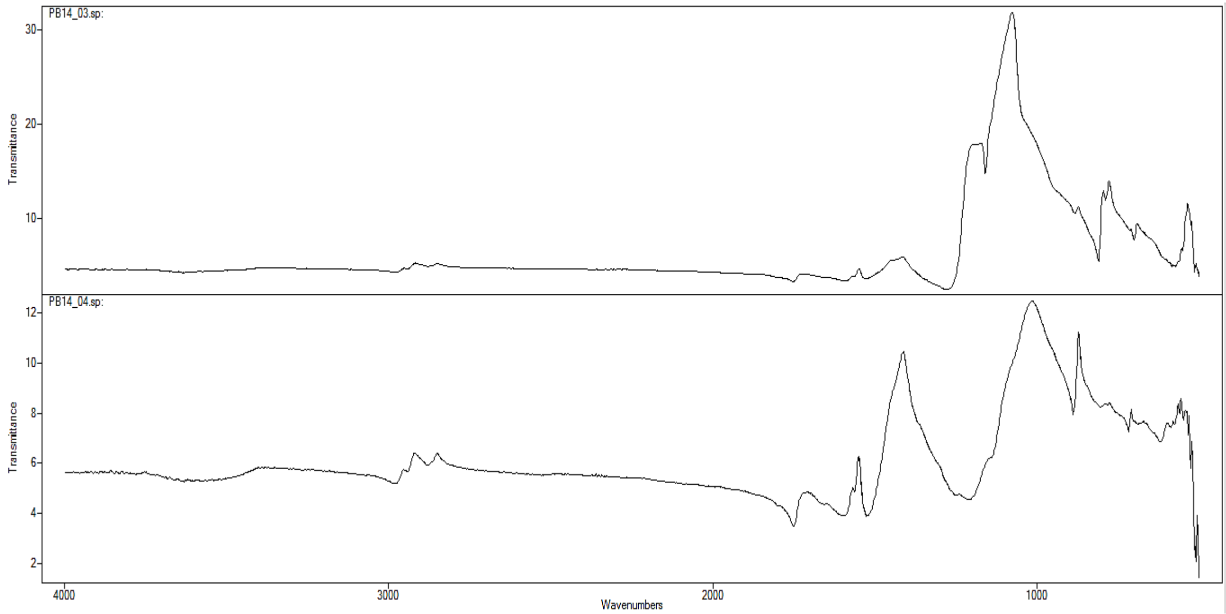



**Figure 6.14** IR spectra of calcined (top) and charred (bottom) herbivore dung at Pınarbaşı.

| Wavenumber ($cm^{-1}$) | | Mineral |
|---|---|---|
| Calcined dung | Charred dung | |
| 1730 | 1725 | Water |
| 1552 | 1550 | Water |
| 1410 | 1411 | Calcite |
| 1167 | - | Clay/Quartz |
| 1075 | - | Clay |
| - | 1022 | Phosphate |
| 871 | 873 | Calcite |
| 795 | - | Quartz |
| 777 | - | Quartz |
| - | 710 | Calcite |
| 691 | - | Quartz |
| 535 | 555 | Phosphate |

**Table 6.9** Wavenumber values and mineral assignments for the peaks in the IR spectra of calcined and charred herbivore dung deposits at Pınarbaşı.

# 7

# DISCUSSION

*In this chapter, results from all the different analytical methods are integrated in discussing the key themes of this research, that is, the range of ecological strategies employed by different households and communities, use and division of space within settlements, and the definition of intra- and inter-site socio-economic dynamics. The microstratigraphic sequences of specific buildings and open spaces are discussed individually for each of the study sites.*

## 7.1 Introduction

The present study was designed to shed light into the nature and extension of socio-economic transformations in the Konya Plain during the Neolithic period through the microscopic examination of occupation sequences in buildings and open areas. Prior archaeological investigations have highlighted the importance of Central Anatolia for our current understanding of the development of Neolithic lifeways (Düring 2013b; Özdoğan 1999), with a number of scholars currently postulating the existence of a distinctive path to sedentism and cultivation in this region (Baird 2012a; 2012b; Fuller *et al.* 2011; Price and Bar-Yosef 2011; Zeder and Smith 2009). This study, focused on investigating settlement configuration, use of resources, and social complexity at the sites of Boncuklu Hüyük, Çatalhöyük, and Pınarbaşı, contributes to this debate through a high-resolution approach to these questions, which allows for a fine-grained spatial and temporal comparison of ecological strategies and social practices.

An initial objective of the project was to develop a methodological approach that would combine detailed field information through the microstratigraphic excavation, digital recording, and on-site analysis of finely stratified occupation sequences, with the microscopic evaluation of archaeological deposits through thin-section micromorphology and elemental analyses. Although previous high-resolution geoarchaeological works have been carried out at both Boncuklu and Çatalhöyük (Anderson *et al.* 2014a; Goodyear 2012; Matthews 2005b; Matthews *et al.* 2013; Rowe 2011; Shillito and Matthews 2013), these have only occasionally attempted to address the interpretative potential and practical challenges involved in the integration of field and laboratory data obtained at a range of different analytical scales. It has been hypothesised here that excavation methods focused on exploring the vertical dimension of occupation sequences in the field by leaving sections, strategic plinths, and baulks, would aid in the sampling and subsequent multi-disciplinary interpretation of the stratigraphy. The results of this experimental approach have been reported in Chapter 5, and are further discussed in section 7.3.1.2.

The first question in this research seeks to determine the extension of intra-site variability in ecological strategies and household networks at the early agricultural settlement of Boncuklu. This issue has been considered through the examination of a standard domestic structure, Building 12, and a non-standard structure, Building 16, to explore the architecture, use, and organisation of space in these built environments. Additional consideration has been given to middens, which have been observed to constitute important activity areas in this community (Baird *et al.* 2012b). It is interesting to note that this is the first geoarchaeological study to examine both building and external sequences from this site.

The second question in this research addresses the nature and extent of variability in floor architectural materials and environmental resources present in different buildings at Çatalhöyük, with particular focus on small-sized built environments, greatly overlooked in previous studies of the social geography of this mega-site. Daily practices and activities in open areas, comprising rooftops and middens, are conceived here as important contexts for the understanding of community organisation, and have also been examined in this research.

Another important research question concerns the nature and periodicity of occupation surfaces and activity residues at the Neolithic campsite of Pınarbaşı in order to understand the full range of economic strategies employed by this community, possibly involving seasonal activities.

In addition to these site-specific research issues, this thesis seeks to contribute to current global debates on local developments in sedentism during the Neolithic by critically discussing and comparing the micro-contextual evidence gathered from the geoarchaeological analysis of Boncuklu, Çatalhöyük, and Pınarbaşı. The location of these sites, in the alluvial landscape of the Konya Plain, in addition to their rich archaeological sequences, excavated with modern methods and recorded using state-of-the-art technologies, are key factors that contribute to making the joint study of these Neolithic settlements highly significant for our understanding of socio-economic dynamics in early agricultural communities. As such, it is important to stress here that this investigation constitutes one of the very few recent attempts at transcending site-specific research boundaries to provide insight into settlement networks during the Neolithic of the Konya Plain, and the first micro-contextual study of archaeological stratigraphy encompassing Boncuklu, Çatalhöyük, and Pınarbaşı.

Results from the microstratigraphic excavation of Space 87 at Çatalhöyük, and the micromorphological, x-ray, and spectroscopic analyses of occupation sequences at the three study sites have been reported in chapters 4 to 6. These methods have enabled the optical and chemical characterisation of archaeological layers and components, which has resulted in a highly detailed dataset that has been summarised through the classification of deposits and inclusions into types and sub-types according to specific microscopic features. This system allows a direct comparison to be made between different settlement areas and occupation levels, resulting in an informed examination of behaviours and practices.

In this discussion, results from the different analytical methods used are combined in assessing continuity and change in ecological strategies and community organisation within and between settlements. The microstratigraphic evidence for each individual site is first discussed according to context, with building sequences considered before open sequences. Summaries of microscopic observations including origin of materials, components, and post-depositional processes are provided for each sequence examined. The final chapter of this thesis is concerned with the key themes of this research, that is, variations in the selection of architectural and environmental resources, and continuity and change in concepts of space at Boncuklu, Çatalhöyük, and Pınarbaşı. This discussion demonstrates how these integrated results build on previous research at the three study sites, highlighting the importance of this new evidence for our current state of knowledge of the Neolithic of the Konya Plain.

## 7.2 Resources and networks at Boncuklu

Although the architecture of buildings at Boncuklu exhibits similarities to those of PPNA villages in the Fertile Crescent, with curvilinear plans and semi-subterranean foundations (Byrd 2000), micromorphological analyses of stratigraphic sequences at this settlement point to a community structure akin to that of the later site of Çatalhöyük, with domestic buildings following strict social conventions visible in the structured use of interior spaces, and the construction of houses atop one another (Hodder and Cessford 2004). However, the examination of architectural surfaces and accumulated occupation residues at Boncuklu has allowed the distinction of minor differences in ecological strategies across the settlement.

A discussion of the stratigraphic sequence of Building 12, a standard domestic built environment, is included in section 7.2.1 below, whereas Building 16/23, a non-standard structure in Area M, is considered in section 7.2.2. Communal activities in open spaces are examined in section 7.2.4, which comprises a discussion of the stratigraphic sequence of three external fire installations and a midden area rich in faecal inclusions. The contextual evaluation of the integrated results reported in Chapter 4 by building/area allows for a detailed exploration of this community's ecological and social basis.

### 7.2.1 Standard buildings

The standard domestic construction selected as the case study for this research is Building 12, situated in Area H, on the north side of the mound. This building, which displays a typical oval structure and an internal division of space into clean and dirty areas, is one of the earliest built environments exposed so far at Boncuklu (Baird *et al.* 2011a). During the excavation of the latest occupation phases of this structure the field team noted the presence of a distinctive sub-rectangular raised plaster feature on the south-central floor area, directly under a plaster basin found in front of the bucrania of Building 4 (Baird *et al.* 2011a). This later built environment is overlying both Building 11, which separates Building 12 and Building 4, and approximately 50 cm of accumulated midden deposits comprising multiple trampled external surfaces. Therefore, the small basin of Building 4 appears to have been deliberately placed on the same location as the raised plaster feature of the earlier Building 12. This behaviour implies the preservation of features, possibly embedded with symbolic meaning, for deployment in later structures in the same area, even where re-building events are not attested and a significant lapse of time has passed between occupations (Baird *et al.* 2012b).

As usual in domestic structures at this site, clean plaster floors occupy the south-eastern half of Building 12. Several human burials, which caused significant slumps in the latest floors of this structure, have been found in this area, including a child skeleton interred with a necklace consisting of over 180 marine shell beads, and an adult male individual placed on a basket (Baird *et al.* 2014; 2015). A micromorphological block, sample BK390, was collected from the section exposed by the cut of this grave to examine the sequence of calcareous floors in this area of the building at the microscale.


**Figure 7.1** Clean plaster floors and occupation surfaces in Building 12, facing east. The location of the collected micromorphological samples in this area is indicated.

The earliest deposit in this sequence corresponds to a thick layer of floor packing/make-up formed by moderately-sorted coarse calcareous aggregates and silty clay sediments, classified as sub-type BK1b after micromorphological observations. Very homogeneous in nature, this unit displays a random but even distribution of components. Overall, this thick deposit seems to have been produced through the mixing of at least three different alluvial sediment sources, although it appears devoid of added stabilisers. Overlying this unit lies a series of eroded coarse marl plasters (deposit sub-type BK2b) showing important accumulations of occupation residues consisting mainly of charred plants and bone fragments. Some of these plasters appear so severely disturbed that they consist of semi-continuous lenses of parallel-oriented and highly compacted calcareous sediments. The intensity of use and the thickness of the accumulated domestic residues on these floors are very unusual for the clean area of houses at Boncuklu, which were commonly well maintained and re-plastered on a regular basis. By contrast, the early clean floors of Building 12 were intensively trampled and poorly kept, allowing for the substantial accumulation of occupation debris.

Sample BK373, which comprises a sequence of floors by the boundary between the clean and the dirty areas of Building 12, was extracted from a location approximately 50 cm to the south-east of the main hearth. This sequence is formed by alternating microunits of prepared marl plasters and accumulated residues rich in phytolith remains (deposit sub-type BK4a), charred plants (BK4b), and calcareous sediment aggregates (BK4c). These fine layers of accumulated residues display strong parallel orientations, sharp boundaries, and a compacted microstructure that has been moderately altered by post-depositional bioturbation, all of which suggest that these highly organic, accumulated units were used as living surfaces.

Twenty-eight occupation surfaces, comprising both plaster floors and accumulated units, have been identified in Sample BK373, of which only six are moderately eroded marl plasters, similar to those found in Sample BK390. Accumulation of subrounded sediment aggregates, formed by *ca*. 25% calcareous types and 10% clayish types, are the most common units in this sequence. Ranging in thickness between 1.5 mm and 1.3 cm, these deposits also contain abundant inclusions of burnt bone, eggshell, and both charred and siliceous plant remains, although the relative proportion of these components varies between units. The nature of these layers points to their origin as re-deposited rake-out from the hearth, constituted by fuel and food remains, and swept particles from floors.  The microunits identified as deposit sub-type BK4a, displaying varying thickness from 1.5 to 3 mm and formed by up to 70% siliceous plants, appear to represent single depositional episodes of discarded herbaceous materials. Conjoined grass husks, stacked bulliform cells, smooth long cells, and jigsaw sedges are the phytolith types most frequently encountered in these deposits, in which leaf components are present in high proportions. Deposits classified as sub-type BK4b, accumulations of charred and silicified plant materials, *ca.* 2-6 mm thick, appear to consist of re-deposited mixed fuel. Heavy trampling in these units is obvious not only in the compaction of the micromass but also on the *in situ* fragmentation of charred plant remains, detected in all of these layers.

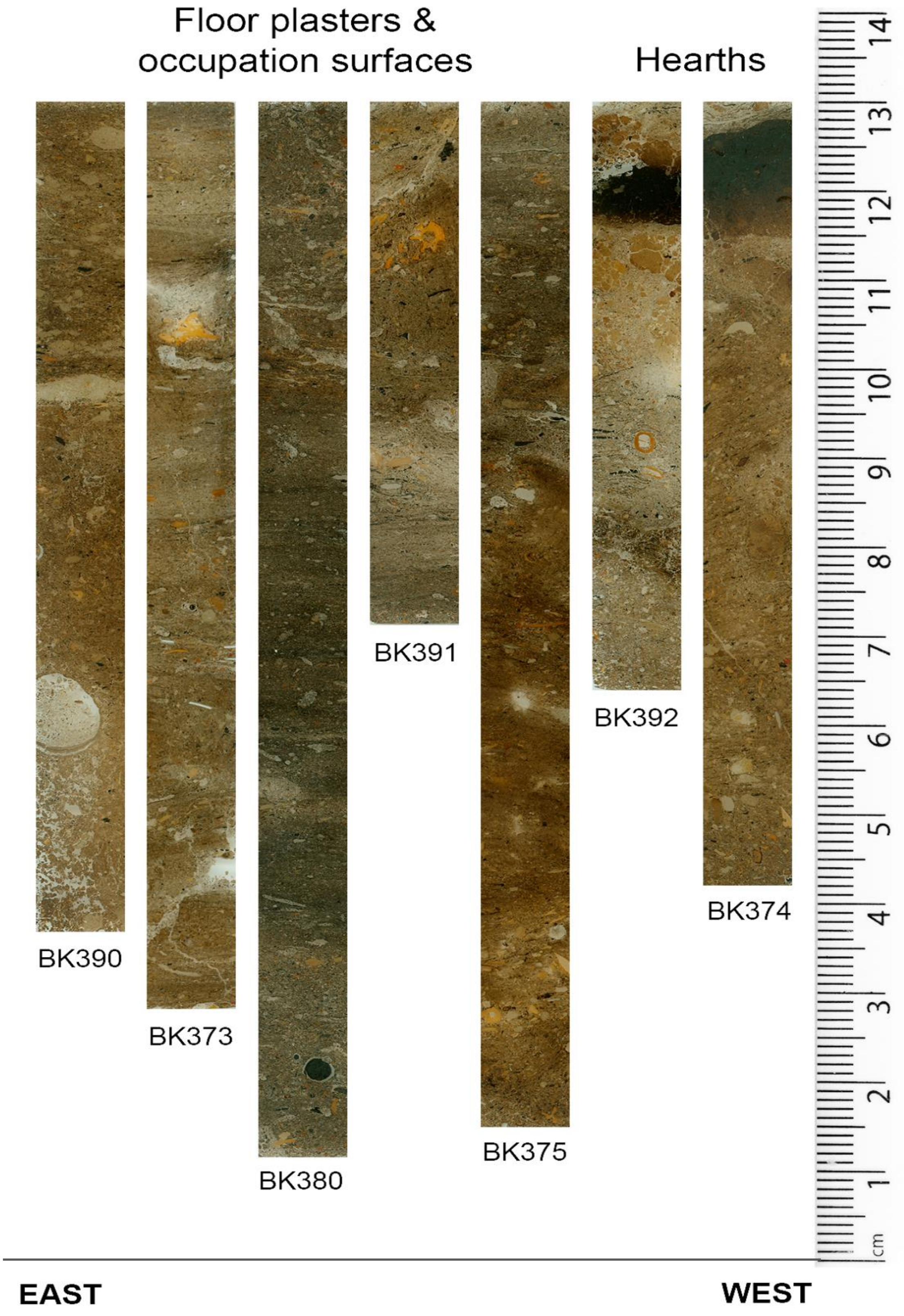



**Figure 7.2** Microstratigraphic columns illustrating the different contexts sampled in Building 12.

The sequence of dirty floors forming Sample BK380 extends towards the southern edge of Building 12. Displaying finely laminated stratigraphy, these 'ash floors', as they are frequently referred to by the field team (Baird *et al.* 2013b; 2014), are extremely organic, constituted by up to 90% plant materials and amorphous organic matter. It is interesting to note that although the fine layers that form this sequence were clearly distinguishable at the macroscale while in the field, striking compositional similarity has made the individual distinction of these deposits under the microscope extremely challenging. The boundaries between these layers, each of which measures 1-3 mm in thickness, are sharp but distinct to faint regarding contrast, and individual depositional events can only be distinguished by quantifying the relative proportions of the main components that constitute these units, that is, charred and silicified plant materials, the absolute numbers of which differ slightly between microlayers. Randomly distributed, unsorted sand-sized mineral inclusions of quartz and ash-derived calcitic silt constitute the surprisingly reduced mineral fraction of these deposits, which display an organo-mineral ratio of 10:1. The microstratigraphy in this part of Building 12 has been moderately to severely bioturbated by root action and soil fauna, as indicated by the abundance of channel, chamber, and vugh voids. Post-depositional gypsum, which precipitated as loose infillings of lenticular and hypidiotopic crystals, has caused further alterations in these units.

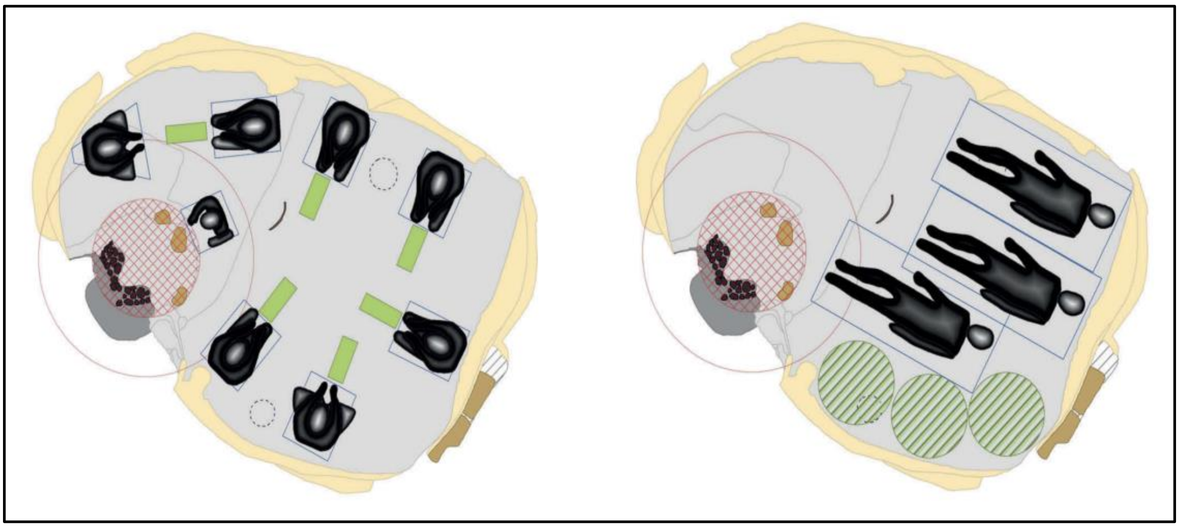


**Figure 7.3** Schematic plans of space use in a standard domestic building at Boncuklu, with to-scale human figures. (Source: Baird *et al.* 2016: Fig. 4).

Two additional blocks collected from the sunken surfaces by the edge of the large hearth, Sample BK391, and the small hearth, Sample BK375, show similar compositional patterns to that of the microstratigraphy in Sample BK380. Charred plants and herbaceous phytoliths are also predominant in these two sequences, although these deposits are generally more porous and considerably less trampled than the silty surfaces situated further away from the hearths. The random orientation and distribution of anthropogenic components, such as bone, shell, and plant fragments, suggest re-deposition and the occurrence of reworking and post-depositional disturbances around hearth areas. Overall, the microscopic examination of the stratigraphy in the dirty area of Building 12 suggest a continuous build-up of hearth rake-outs mainly formed by discarded plant fuel comprising grasses, leaves, and fine woods, and less abundant occurrences of calcitic ashes and food remains such as bone and shell fragments.


**Figure 7.4** Sample locations of micromorphological blocks BK 374, large hearth floors and fills (Feature 171), and BK375, house floors by the edge of small hearth (Feature 177) in Building 12 at Boncuklu.

As mentioned in Chapter 2, standardised arrangements in residential structures at Boncuklu entailed the occurrence of a fire installation in the sunken north-western cooking area of built environments. Building 12, however, displays an interesting variation of this pattern due to the occurrence of two hearths, one slightly smaller than the other, in its western area. Both features appear to have been extensively used during the life of the building, possibly indicating an increased scale of cooking activities in this household (Baird *et al.* 2012a). The constructed floors and accumulated fills of the main hearth have been studied in Samples BK392 (lower sequence), and BK374 (upper sequence). This fire installation, Feature 171, underwent at least two phases of renovation through the re-plastering of its surface with clay loam sediments that appear severely scorched and eroded. Thick (*ca.* 2-4.5 cm) accumulations of mixed fuel and food remains have been have been identified on top of these hearth floors, consisting mainly of organic aggregates, charred and siliceous remains of reeds and grasses, and randomly oriented and distributed burnt bone and shell inclusions (*ca.* 5-15% abundance). This ubiquity of herbaceous and reed remains in both hearth and rake-out contexts indicates a continuous and systematic exploitation of wetland environments for fuel sources. Dispersed calcitic ashes occur in the groundmass of some of these fills, whereas phosphatic aggregates displaying calcareous spherulites have only been encountered in low proportions (<5%

abundance) towards the base of the hearth, suggesting that dung was not considered an appropriate fuel source for its use in building domestic contexts. The components of these hearth fill deposits appear highly mixed, displaying random distributions and orientations, which indicates substantial post-depositional disturbances. Further, this fire installation has been severely bioturbated by root action and, especially, animal burrowing, often occurring in combination with gypsum re-precipitation and the deposition of secondary calcite in channels.

### 7.2.2 Non-standard structures

Non-standard structures, also referred to as 'light' buildings by the excavation team, are those displaying evidence for repeated long-term use, but defined by thin walls or boundaries (Baird *et al.* 2012b). While the standard buildings discussed above are characterised by relatively long occupation sequences, marked spatial divisions between dirty and clean activity areas, and formally installed fireplaces with evidence of intensive use, the occupation patterns of the non-standard structures identified in the course of excavations in Area M show a marked contrast with those of residential buildings. These structures display a much shorter occupation span, often lacking formal floors and consisting of thin (0.1-0.3mm) discontinuous trampled surfaces rich in extremely fragmented organic remains. Charred plants, burnt bones and shells are the most abundant inclusion types encountered in these deposits, with minerogenic aggregates of calcareous and silty clay sediments, likely trampled in from the surrounding land, present in lower quantities (10-30% abundance). In addition, these Area M structures show a variety of frequently repositioned features, including pits, plaster basins, and fire installations ranging from small hearths to larger fire pits (Baird *et al.* 2012b).

The latest occupation sequence in the north-western end of Building 23 in Area M, preceding Building 16, is characterised by finely-laminated floors and surfaces consisting of fine marl plaster floors (deposit sub-type BK2a) towards the top of the sequence, and multiple superimposed layers of accumulated organic materials described as sub-types BK4a, BK4b, and BK4d. Interestingly, the earliest deposits in this sequence, very heterogeneous in composition, unsorted, unoriented, and consistently thicker (*ca.* 0.5-2 cm) than the units forming the top half of Sample BK393, are more akin to the midden deposits observed in open area at Boncuklu, than to building contexts. This thick deposit seems to have accumulated gradually, and it contains abundant remains of burnt bone (*ca.* 10-25%) of up to 3.5 mm size. The faint, diffuse, and very irregular boundary of this unit, devoid of trampling or compaction indicators, is also consistent with those of midden contexts.

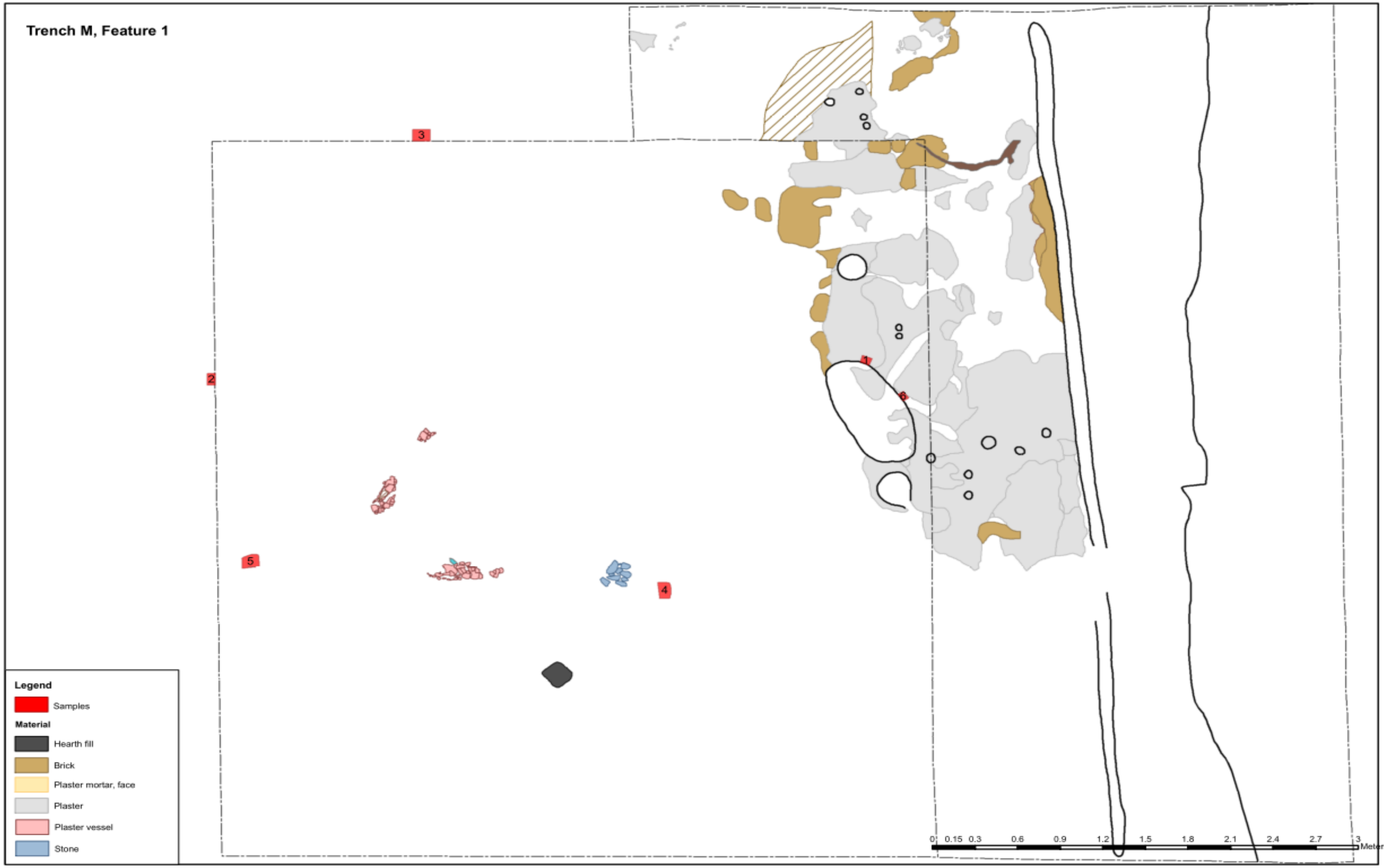



**Figure 7.5** Excavation plant of latest occupation deposits in a non-standard structure exposed in Area M (Source: D. Baird, pers. comm.).

The upper part of the sequence in Building 23, however, displays two eroded constructed floors (BK2a), and superimposed layers mainly constituted by calcareous aggregates and plant remains, including charred residues, melted silica, and siliceous remains of grasses and leaves. The high degree of fragmentation of these components, which frequently display a parallel orientation, in addition to the sharp, prominent, and slightly compacted boundaries observed in this part of the sequence, point to the occurrence of light trampling. These thin accumulated layers suggest single depositional events related to fire activities. It seems obvious that for these highly organic surfaces and plaster floors to survive, Building 23 would have been roofed. However, clear foundation features separating the earlier midden deposits from the later occupation floors have not been distinguished microscopically.

Overlying Building 23 is Building 16, also a non-standard structure. The central area of this construction was sampled for micromorphology and its stratigraphy examined under the microscope. The base of the sequence, as observed in Sample BK397, is formed by a thick, heterogeneous, and highly organic deposit composed almost in its entirety by silt loam, differentially charred bones, and plant remains, materials likely representing fuel discards (deposit sub-type BK4d). The groundmass shows a high content of calcite and it is likely that ashes are contained in this matrix, although these are not clearly identifiable. The very variable degree of charring and weathering of the bones suggests different depositional routes and probably events. These remains are most likely food discards, accumulated in a random, gradual, and probably rapid manner, judging from the generally good state of preservation of these remains. Due to its nature, this deposit is likely to represent an open area between buildings where occupation remains were gradually accumulated. A number of crust-like formations have been identified towards the top of this unit. These are parallel-oriented compacted microlaminations, rather undulating and possibly formed through trampling under wet conditions. Natural features, such as wind- or water-laid deposits, characterised by the presence of well-sorted and oriented sediments in an aggrading environment, have not been detected anywhere in this sequence (Courty *et al.* 1989).

Highly eroded occupation floors formed by parallel-oriented, elongated calcareous aggregates, have been found on top of the thick layer of accumulated materials, often containing inclusions of fine sands, burnt bones, and charcoal fragments. These surfaces appear to have been substantially affected by trampling and compaction, as seen in their low porosity, and strong parallel orientation and fragmentation of their components.

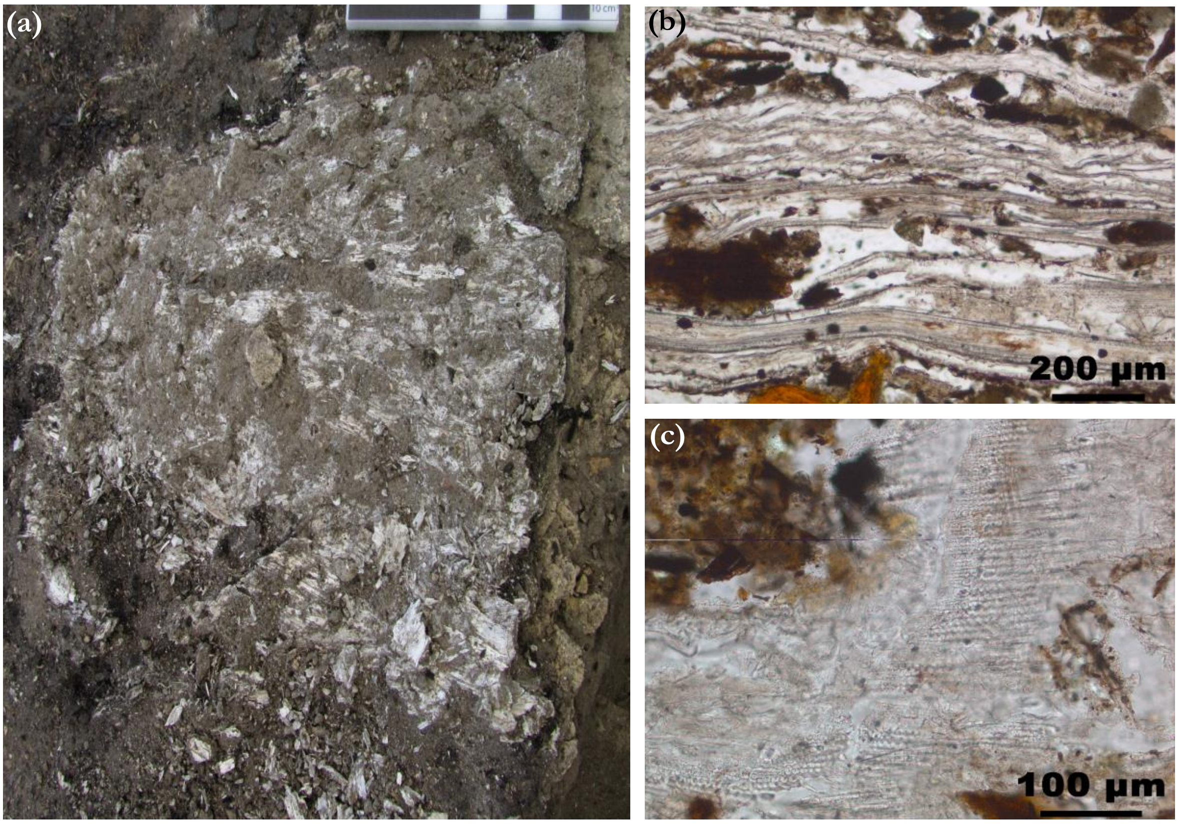



**Figure 7.6** Phytolith accumulation in Building 16: a) close-up of layer during excavation; b) photomicrograph of phytolith laminations, PPL; c) photomicrograph of articulated siliceous remains identified as barley husks, PPL.

On top of this unit, a charcoal layer was unveiled, consisting of extremely fragmented remains that have rendered wood species identification impossible. However, from the morphology of the remains we can conclude that these were probably light woods. Immediately on top of these remains, approximately five phytolith microlayers formed by highly articulated grasses and leaves have been found, separated by small sediment aggregates and charred materials. These continuous parallel laminations of conjoined siliceous plants seem to indicate *in situ* deposition. At least 40% of these are grass husks identified as barley (M. Portillo-Ramirez, pers. comm.), although it has been impossible to determine whether they derive from the domesticated or the wild variant of this species based on micromorphological observations. Future phytolith morphometrics on an extracted sample would be able to resolve this issue.

The continuity, articulation, preservation, and strong parallel orientation of these plant layers suggest *in situ* deposition and are therefore unlikely to represent collapsed remains. The low degree of fragmentation of the charcoal unit and the occurrence of accumulated remains between laminations, such as rounded aggregates and amorphous organic matter, support this interpretation. The installation of wood floor surfacing in these non-standard buildings by the inhabitant of the settlement is a possibility that was already suggested by the field team (Baird *et al.* 2012a). Following this view, the microlayers of highly articulated siliceous plant remains might represent residues from dehusking and plant processing activities performed in this structure, although the occurrence of leaf elements should not be understated. If this interpretation is confirmed by further research, such as the detailed study of the charcoal and extracted phytolith remains, these non-standard buildings might have to be seen as the scenario of communal activities, as opposed to standard domestic buildings.

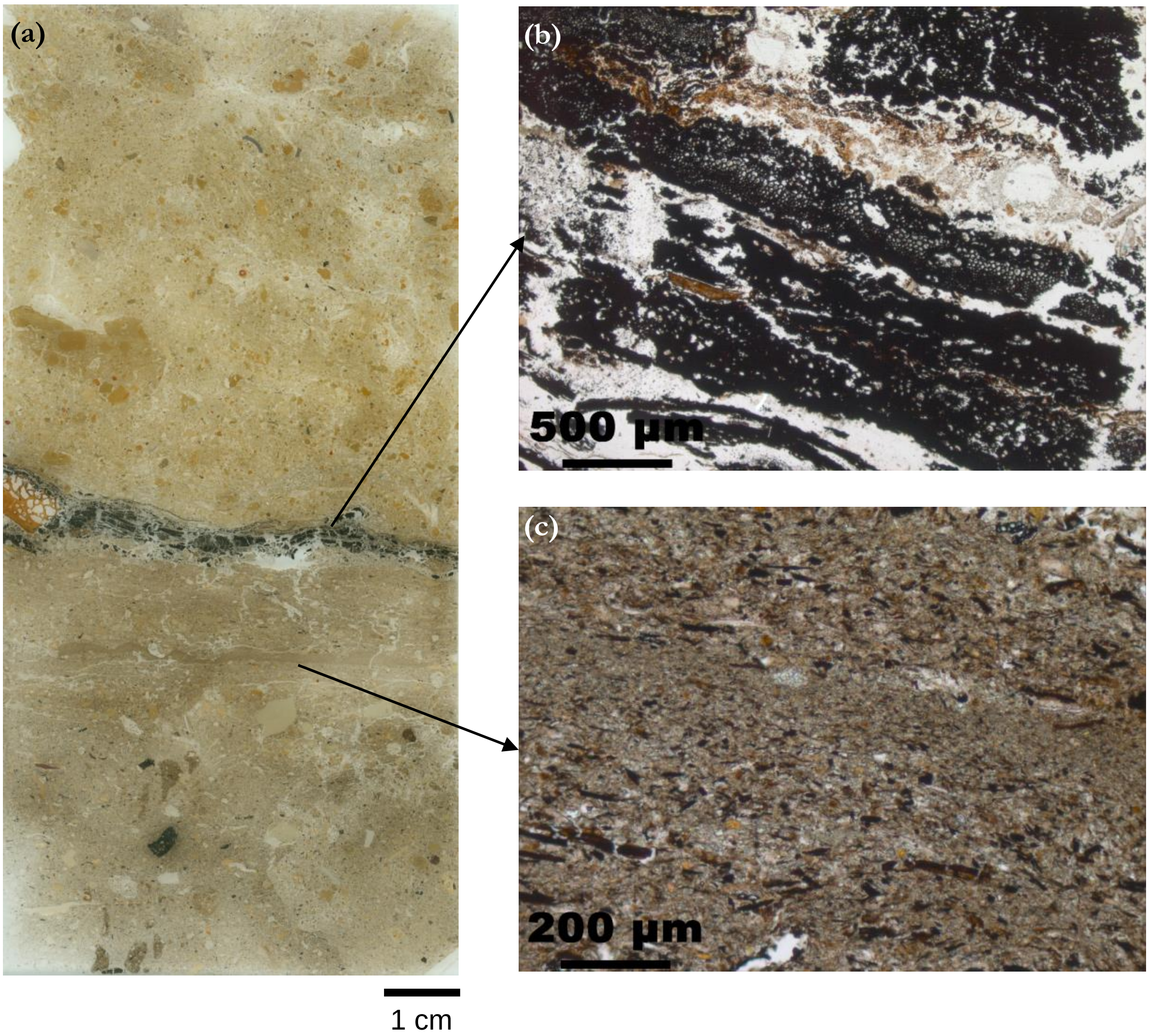



**Figure 7.7** Microstratigraphic sequence of Building 16/23: a) scan of micromorphological thin-section BK366, corresponding to occupation floors of Building 16/23 and collapsed structural remains; b) photomicrograph of wood charcoal unit laying immediately on top of living floors, PPL; c) photomicrograph of trampled deposit of accumulated materials, PPL.

The latest living floors of Building 16, sampled in its western end, comprise a thin (*ca.* 1.5 mm), well-preserved marl plaster floor (deposit sub-type BK2b). Three more moderately to well-sorted occupation surfaces were identified, constituted by accumulated charred plant materials displaying a very high degree of fragmentation (BK4c), and occasionally, calcareous aggregates, plant matter, and both bone and shell fragments (BK4d). These units display strong parallel orientations and a high degree of compaction, likely caused by trampling.

Wind- or water-laid deposits have not been identified in this sequence, and the collapsed materials found immediately on top of the latest floors of Building 16, formed by a layer of highly fragmented and moderately oriented charred woods and heated silty clay loam sediments (deposit sub-type BK5b), seem to indicate the existence of roofing above this structure. Although the ashy composition of the collapsed materials, detected through geochemical techniques, indicates extremely high firing temperatures leading to calcination, neither the latest living surfaces nor the wood layer present any signs of rubefaction or ash content. This could indicate that the fire event that resulted in the structural collapse and abandonment of Building 16 was initiated from outside the construction. Although it still remains unclear whether these non-standard structures were consistently delimited by walls (Baird *et al.* 2012a), this hypothesis seems highly plausible, as the excellent preservation of the occupation surfaces and absence of naturally-laid deposits appear to indicate.

### 7.2.3 Household differentiation and society

This microstratigraphic study has demonstrated the existence of marked differences in architecture, formation processes, and uses of space between standard and non-standard constructions at the early Neolithic site of Boncuklu Hüyük.

One interesting finding is that although fine and coarse marl plaster floors have been identified in both types of building, their periodicity is strikingly different. Standard domestic structures such as Building 12, examined in this study, display deeper sequences of floor plasterings, which seem to have occurred on a regular basis, perhaps annually. Non-standard structures, however, are constituted by a maximum of one or two formally-laid calcareous floors and show a much shorter occupation span, as inferred from the number and depth of living surfaces. Further, the more dynamic non-standard structures, characterised by a dense array of frequently repositioned features, such as pits and hearths (Baird *et al.* 2015), lack the marked division of internal space into clean and dirty areas typical of standard domestic structures at Boncuklu. These spatial distinctions, observed in Building 12, probably had a strong symbolic meaning, with clean areas containing burials, painted floors, and cattle horns inserted in walls (Baird *et al.* 2012b), whereas dirty areas comprise fire installations and silty surfaces formed through re-deposited rake-outs of domestic residues, mainly food and fuel discards.

However, although domestic buildings at Boncuklu display a high degree of standardisation in architecture and concepts of space, there were distinctive house-specific variations to these strict social conventions, possibly motivated by practical issues such as an increase in food preparation needs. This is evident in the case of Building 12, where two contemporary hearths were installed during the occupation of this construction. Microscopic examination of the sequences of these two features have not revealed any significant differences in the use, apparently focused on cooking activities, and fuel sources of these hearths.

Non- standard structures, so far only identified in excavation Area M and surrounded by open areas, lay directly on accumulated midden deposits and, due to the highly organic nature of these units, the transition from open space to roofed structure is not always evident in the microstratigraphic sequence of these constructions. Building 16 and Building 23, examined in this study, are constituted by trampled surfaces formed by re-deposited organic layers rich in charred plant remains and, occasionally, plaster floors. Interestingly, these trampled surfaces are remarkably similar in composition to the moderately compacted hearth rake-outs that characterise the areas around the hearths of standard buildings.

**Figure 7.8** Floors of non-standard structure in Area M with deep foundation cut for the installation of light organic boundary wall. Source: Baird *et al.* (2012b: Fig. 5).

Other examples of non-standard structures identified in the field include Feature 1, contemporary with the latest phases of occupation in excavation Area M. This construction consisted of a curved mudbrick short wall that enclosed a sequence of fine occupation surfaces made of dark silty materials (Baird *et al.* 2012b). The eastern side of this structure was delimited by a narrow slot with stakeholes at its base, interpreted by the excavation team as the foundation cut of a screen wall, likely constituted by interwoven reeds with added mud for consistency (see Figure 7.8 in the previous page). The interior of Feature 1 was scattered with a number of small post-holes, suggesting that this structure was roofed (Baird *et al.* 2012a).

Therefore, the macroscopic and microscopic evidence from non-standard structures at Boncuklu appears to indicate that these were in fact roofed, and possibly partially walled, open areas displaying a flexible pattern of spatial division and used as task-specific constructions. Micromorphological evidence from Building 16, where spreads of siliceous plant materials consisting of barley husks and leaf elements have been identified, suggest that the performance of plant processing, in addition to fire-related activities, was an important function of these structures. Micro-remains associated to industrial and refuse management activities, such as obsidian flakes derived from lithic production, or faecal aggregates, have not been detected in the sequences studied. Further, non-standard buildings do not display micro-stratigraphic evidence that could point towards a residential component for these structures. It is thus proposed here that these constructions, situated in the centre of the settlement, were communal spaces allocated to plant and food processing tasks.

### 7.2.4 Open spaces and external activities

Midden deposits are considerably extensive at Boncuklu, occupying virtually all the open space between and around buildings, in marked contrast with the situation at Çatalhöyük, where middens are circumscribed and contained within small spaces between constructions and abandoned building lots (Shillito 2011b; Yeomans 2006). This, together with the ubiquitous presence of fire spots and work platforms in open areas at Boncuklu, suggests the existence of very different living practices involving waste disposal and concepts of space compared to those of the later settlement at Çatalhöyük.

Thick midden deposits are dominant in excavation Area M, characterised by massive accumulations of organic materials mainly consisting of charred plant and bone fragments, and calcareous sediment aggregates. The south-western corner of this trench displays a substantial build-up of faecal aggregates of omnivore/carnivore origin (see section 4.2.3 in Chapter 4), although the species responsible for the deposition of these materials, likely pig/boar, dog, or human, cannot be ascertained based on micromorphological evidence. The lack of signs for trampling in these deposits is not consistent with a penning area. Therefore, this part of Area M has been interpreted as a latrine, where faecal waste, in addition to burnt discards from fire activities, was deposited.

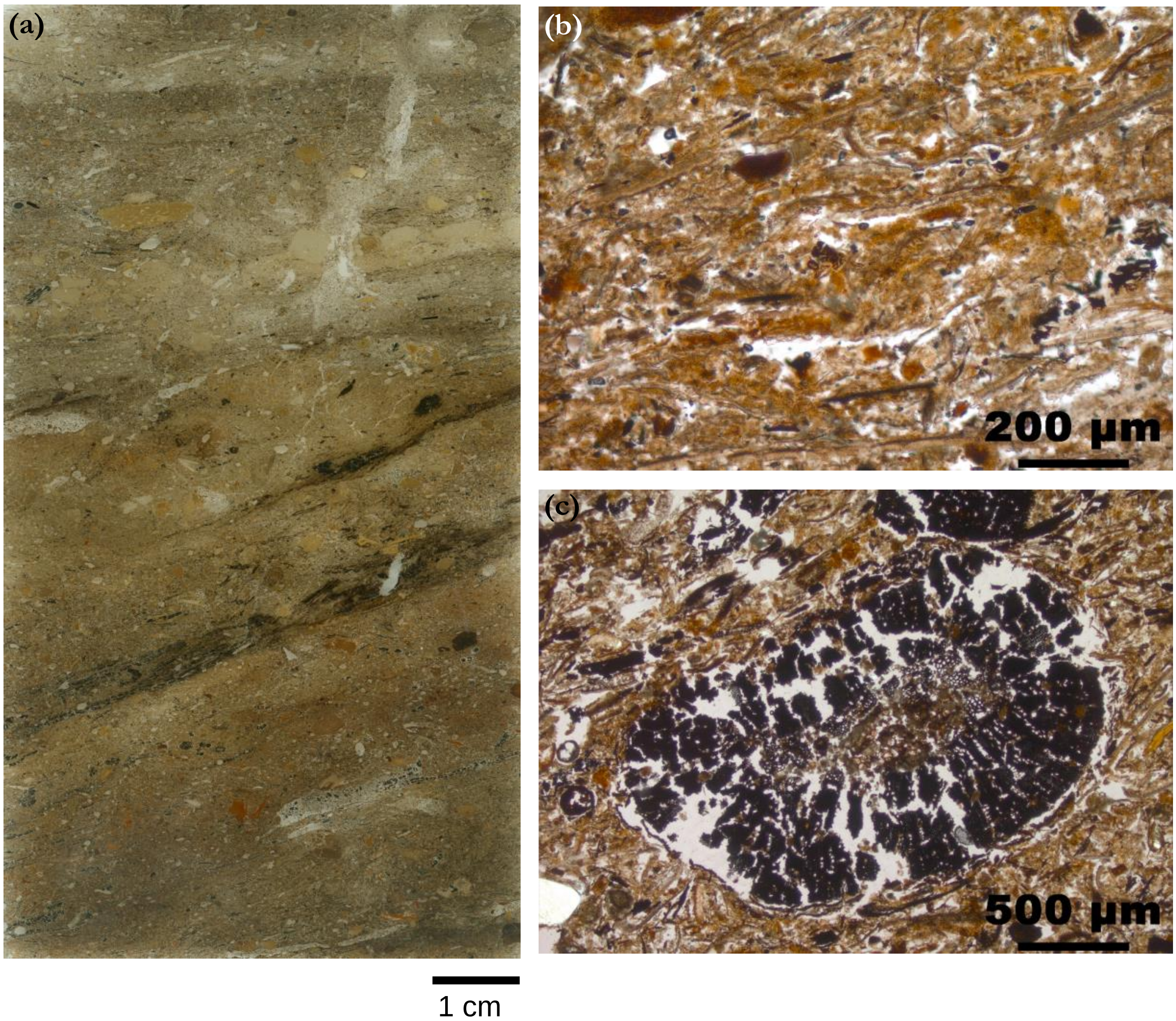



**Figure 7.9** Microstratigraphic sequence of hearth feature in Area M: a) scan of micromorphological thin-section BK376, corresponding to accumulated midden deposits and external hearth infills; b) photomicrograph of charred dung, PPL; c) photomicrograph of the radiant section of a charcoal fragment, PPL.

In addition to discard, burning activities have also been identified in Area M, as manifested by the several external fire spots unveiled during excavation. The most conspicuous one, studied as part of Sample BK376, was found by the south-western section of Area M. The microstratigraphic sequence of this fire pit appears to conform to that of a short-lived, albeit intensively used, hearth. No formal floors were laid down, in spite of which a distinguishable rubefaction gradient formed in the midden deposits that lay at the base of this fire pit. This, in addition to the presence of melted silica inclusions (2% abundance) within the pit infills, point to high firing temperatures, over 500-600°C. This hearth feature, which seems to have been re-activated multiple times, appears to have been fuelled with a combination of woody and herbaceous materials, in addition to animal dung. The charcoal fragments (*ca.* 20% abundance) observed were too fragmented to allow for species identification in thin-section, but the cross-sections of some of these remains suggest that these consisted mostly of thin, brittle branches, possible from shrubs or bushes. Herbaceous/reed phytoliths represent approximately 30% of these pit infills, comprising mainly monocotyledon grass husks and stacked bulliform cells, and fewer jigsaw sedges. Dispersed burnt dung aggregates have been found in smaller quantities (10%), containing abundant spherulites, indicative of their herbivore origin (Shahack-Gross 2011). The uppermost deposit of this feature is constituted by a substantial concentration of grass phytoliths embedded in calcitic dung ash (*ca.* 50% abundance), again suggesting high temperature burning. The preservation of this silty unit implies a prompt closure of the hearth after the last firing event, as observations from ethnographic experiments highlight the rapid dispersal of ashes by natural agents (Mallol *et al.* 2007). Immediately on top of this ashy layer and sealing the fire pit lies a thin (*ca.* 0.7-1cm), highly minerogenic deposit formed by subrounded marl crumbs (75% abundance) and silty clay sediment aggregates (15% abundance), at least some of which display signs of mild rubefaction. The sharp edges of these aggregates and the absence of coatings dismiss the possibility of sweeping and re-deposition. Instead, these seem to be the discards of plaster production activities occurring in this open space, a task that requires high firing temperatures.

**Figure 7.10** Western section of Area M displaying two lenses of ash materials, Feature 203, derived from the performance of fire-related activities in open areas.

Other external fire spots at Boncuklu display a different microstratigraphy. Feature 203, part of the midden sequence studied in Sample BK377 (see Figure 7.10 in the previous page), and also collected from the south-western profile of Trench M, is characterised by two massive accumulations of herbaceous phytoliths (50-75% abundance), formed mostly by grass husks and sedges. These plant remains are highly articulated and display a dominant parallel orientation, indicative of a primary context, in marked contrast with dumped deposits where randomly distributed and oriented inclusions are common. The homogeneity in the composition of both layers, separated by a thin (*ca.* 3mm) unit of midden materials, indicates that they deposited in two separate single events followed by fast midden accumulation, as the excellent preservation of plant inclusions and dispersed calcitic ashes suggest.

Another external hearth, Feature 303, located in an open area immediately to the north of Building 6, in Trench N (Sample BK369), shows a similar microstructure to that of Feature 203. The uppermost deposits of this hearth display a strong parallel bedding orientation, likely representing the remains of *in situ* activities, in this case reeds and grasses (herbaceous phytoliths, 40% abundance) and light woods (highly fragmented charred plants, 10% abundance) used as fuel. Disaggregated calcitic ashes (*ca.* 25% occurrence), in addition to large bone and eggshell inclusions (10% abundance), have a significant presence in the infills of this hearth, possibly indicating its use as a cooking installation. The absence of rubefaction in the basal deposits and the nature of the fuel remains are suggestive of low burning temperatures. This evidence, along with the absence of formally constructed floors or linings, hint at the ephemeral nature of this external hearth.

### 7.2.5 Conclusions: intra-site socio-economic dynamics in an early agricultural settlement

As it has been previously noted, standard domestic buildings at Boncuklu were internally divided into dirty and clean areas, with the former reserved for cooking and food preparation, and the latter for resting and sleeping. These boundaries remained constant throughout the life of each building and with its later reconstructions, frequently entailing the re-building of a new hearth in the exact same location of the older hearth. The distinction between dirty and clean areas was defined by the types of activities that were carried out in each part of the house, rather than by the quality of the materials used in the construction of floor plasters.

Building 12, as discussed in section 7.2.1, displays substantial differences between its clean and dirty areas, with the latter being characterised by multiple trampled hearth rake-outs rich in charred plant materials used as fuel, suggesting continuous deposition and accumulation. Some of these laminations are formed by over 70% compacted marl aggregates in strong parallel orientation and distribution, which could be the remains of heavily trampled and truncated plaster surfaces. By contrast, Goodyear (2012) described the dirty floors of the western half of Building 6 as consisting of thick, although fragmented, marl surfaces comprising both fine (silty clay) and coarse (clay loam) plasters. Here, the microstratigraphic study of this sequence resulted in the identification of small sections of floors that had been repaired with plasters that were slightly different in composition to their predecessors.

Considerable differences have also been observed between standard domestic structures regarding the quality and periodicity of floor plasters. Whereas the clean area of Building 12 was re-plastered on a regular basis, a preference for the use of coarse clay loam calcareous materials, as demonstrated by the micromorphological and geochemical results, has been noted. The clean floors of Building 6, however, display greater variation in plaster composition based on particle size, with overall thicknesses ranging between 0.8 and 0.1 mm. Both fine and coarse plasters occur in this sequence, although no temporal pattern appears discernible in their arrangement. As in the case of the clean areas in Structure K, sharp wavy boundaries and minimum floor breakage hint at the frequent use of matting in this building (Goodyear 2012), in contrast with the eroded plasters of Building 12.

Further, Goodyear (2012) has highlighted the occurrence of re-plastering events that did not extend across the entire clean half of Building 6, suggesting that these were probably restricted to areas in need of repair. Therefore, from the preservation and frequency of floor plasters in Building 6, we can conclude that this construction was particularly well-maintained by its occupants, especially if compared to the eroded plasters of Building 12. An alternative interpretation is that the intensity of occupation of Building 12 was substantially higher, a hypothesis that is further supported by the presence of two fire installations in this structure, a factor that would have had a negative impact on the preservation and rate of erosion of the floor plasters. It is also possible, however, that Building 6 was constructed and occupied much later than Building 12. In her micromorphological research of floor plasters at Boncuklu, Goodyear (2012) pointed out the occurrence of less tempered and slightly more damaged floors in Structure K when compared to the surfaces of Building 6, which appear to be some of the latest at Boncuklu. In fact, the high proportion of poorly-tempered (<5% stabilisers) marl plasters in Building 12, especially frequent in the earliest occupation floors, suggests that the shortage of temper, combined with intense trampling, may have been the causes for the disintegration of these surfaces. If radiocarbon dates confirm this hypothesis, it might be indicative of developments in plaster manufacture through time that resulted in more durable occupation surfaces. Otherwise, the marked differences observed in daily practices and house maintenance at Boncuklu would be suggestive of significant variations in the perception of domestic spaces by different households at this settlement.

Interestingly, layers of accumulated occupation microresidues at Boncuklu are remarkably similar in composition between domestic buildings, and even between these and midden deposits, indicating a common economic base for the residents of this early Neolithic settlement. The importance of meat within household diets at Boncuklu is highlighted by the increased levels of bone fragments observed within occupation residues, at least 80% of which are moderately charred and show angular to sub-angular shapes. These remains are especially abundant in accumulated midden deposits and in areas around hearths, indicative of their origin as food sources. A very interesting aspect of the microscopic bone assemblage at this settlement, however, is the extremely high degree of fragmentation displayed by these remains. This pattern of bone consumption and deposition is reminiscent of late Pleistocene sites in Europe, where the extraction of marrow from animal bones was a common practice (Bar-Oz *et al.* 2008; Enloe 1993). The processing of bone marrow usually results in large numbers of unidentifiable bone fragments of various sizes showing fresh breakages, as it appears to be the case at Boncuklu. Direct bone consumption is evident in the carnivore coprolites identified in Area M, formed by approximately 80% digested bones, at least some of which seem to derive from small animals, such as birds or amphibians. Unfortunately, the species responsible for the deposition of these carnivore coprolites, which occur in strong association with omnivore faecal matter that consist of dense phosphatic aggregates with embedded plant and bone inclusions, cannot be determined through thin-section micromorphology or techniques based on inorganic chemistry. The frequency of eggshells in the microstratigraphic sequences analysed points to the dietary importance of this resource for the Boncuklu population. Fish and freshwater and brackish mollusc remains have also been identified in occupation microresidues, although in lower concentrations.

Local grass- and marshland were likely to be the primary landscape sources for the cereals and reeds that dominate the plant microresidue assemblage detected in thin-section. Fruits and nuts were presumably gathered from river and lake margins, approximately 15-25 km south from the site, as inferred by the environmental conditions of their modern-day counterparts (Roberts and Rosen 2009). Hackberry endocarps, however, have been encountered in much lower proportions that at the later site of Çatalhöyük, where they are ubiquitous in midden and building contexts.

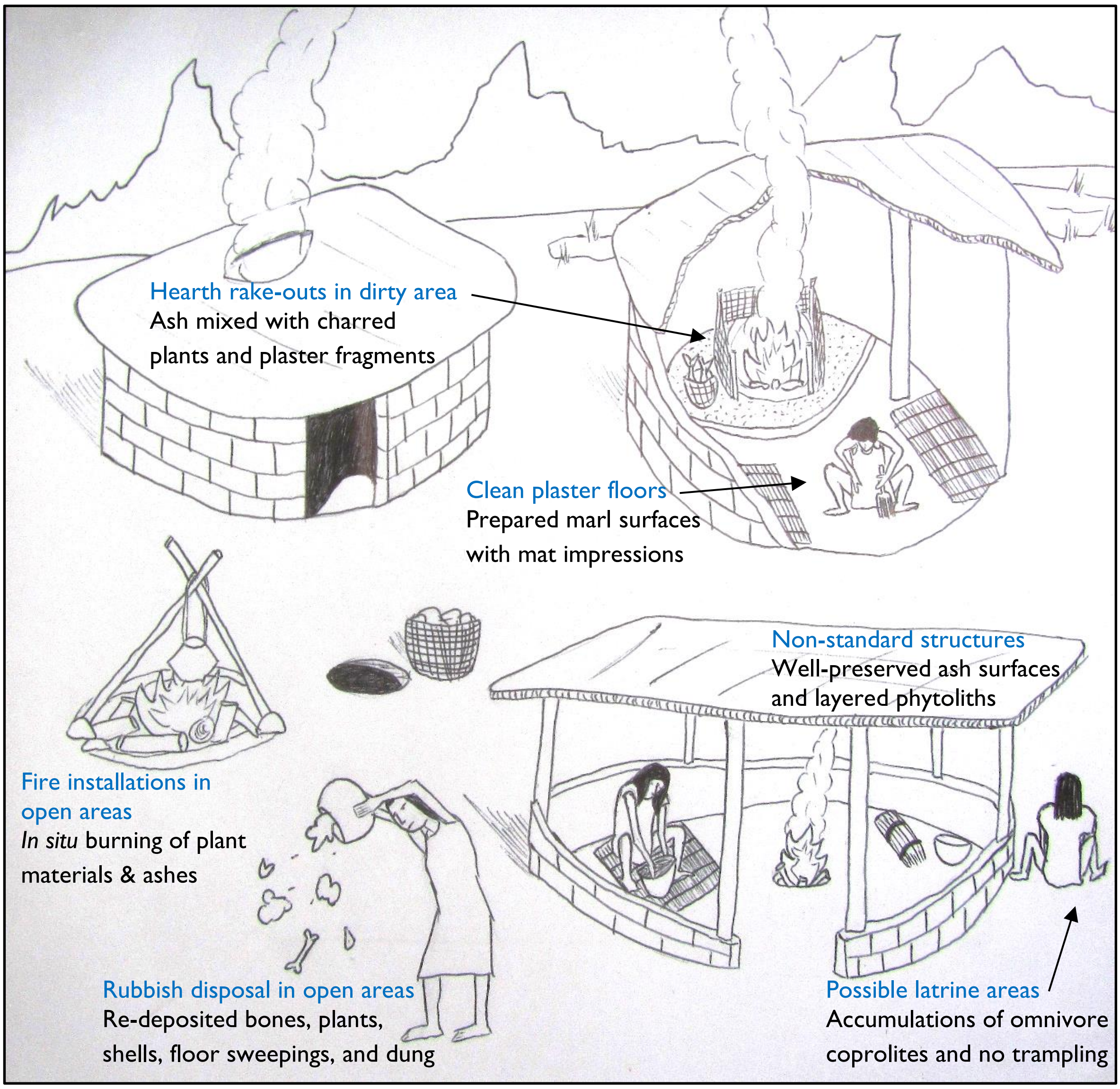



**Figure 7.11** Schematic reconstruction of activities and site formation processes in different spaces at Boncuklu.

Overall, the micromorphological evidence indicates a diversified diet in this community, which included both large and small animal preys, fruits, nuts, cereals, and legumes. This suggests that the inhabitants of Boncuklu regularly exploited a wide range of environments, extending as far as river and lake zones, and possibly the foothill and steppe areas of the Konya Plain. Further, the striking similarities in composition and relative proportion of components detected in accumulations of household discards found within standard buildings suggest a similar access to environmental resources by different households, perhaps even involving food sharing. Interestingly, isotopic studies on human skulls from individuals buried inside domestic buildings at Boncuklu have yielded very similar levels of carbon, nitrogen, and strontium isotopes, indicating that the inhabitants of this settlement had similar diets (D. Baird, pers. comm.). Therefore, the ecological strategies practised by different households appear to have been significantly homogeneous across this settlement.

## 7.3 Resources and networks at Çatalhöyük

After the first excavations at the Neolithic mega-site of Çatalhöyük, Mellaart argued that he had discovered an area of the site inhabited by priests, based on the remarkable degree of symbolic elaboration displayed by some buildings, that he classified as shrines (Mellaart 1962; 1965). A few years later, the research project led by Ian Hodder unveiled a striking architectural uniformity across the settlement, which comprises buildings that contain abundant evidence of domestic activities and vary only slightly in size and elaboration (Hodder 2007b). As a result, there seemed little to base any argument for social and economic differentiation.

However, recent studies of architectural complexity, and both artefact and bioarchaeological assemblages, have determined the occurrence of different types of buildings at Çatalhöyük: history houses, burial houses, large/elaborate houses, and other buildings (Hodder and Pels 2010; Hodder 2013b). It has been further argued that special buildings, in particular history houses, held a special socio-economic status at this settlement, and other investigations have noted the importance of social groupings beyond the individual house and its occupants (Bogaard *et al.* 2009; Düring and Marciniak 2006; Pilloud and Larsen 2011).

Current models on building complexity, social geography, and ecological strategies, are evaluated in the next pages through the integrated discussion of the individual building and midden sequences examined in this research. This work builds on previous micro-contextual research conducted by Wendy Matthews on the life-histories of individual buildings (Matthews 2005a; 2012c; Matthews *et al.* 1996), Emma Anderson and Joanne Wiles on the biographies of architectural materials (Anderson *et al.* 2014a; 2014b; Matthews *et al.* 2013; Wiles 2008), and Lisa-Marie Shillito on the formation processes of middens (Shillito *et al.* 2008; 2011b; Shillito and Matthews 2013) by adopting a more holistic view through the combined examination of both building and open air contexts. In addition, the present study aims not only to integrate the results of a range of micro-analytical techniques that include thin-section micromorphology and elemental characterisations of spot samples, but also the field methods and macroscopic data generated during excavation. In order to achieve these goals, the analytical focus has been directed towards new stratigraphic sequences, exposed in the last five years of fieldwork at Çatalhöyük, particularly those of small-sized spaces which have become, for the first time at this site, the focus of state-of-the-art methodological approaches aimed at investigating their occupation sequences at high-resolution.

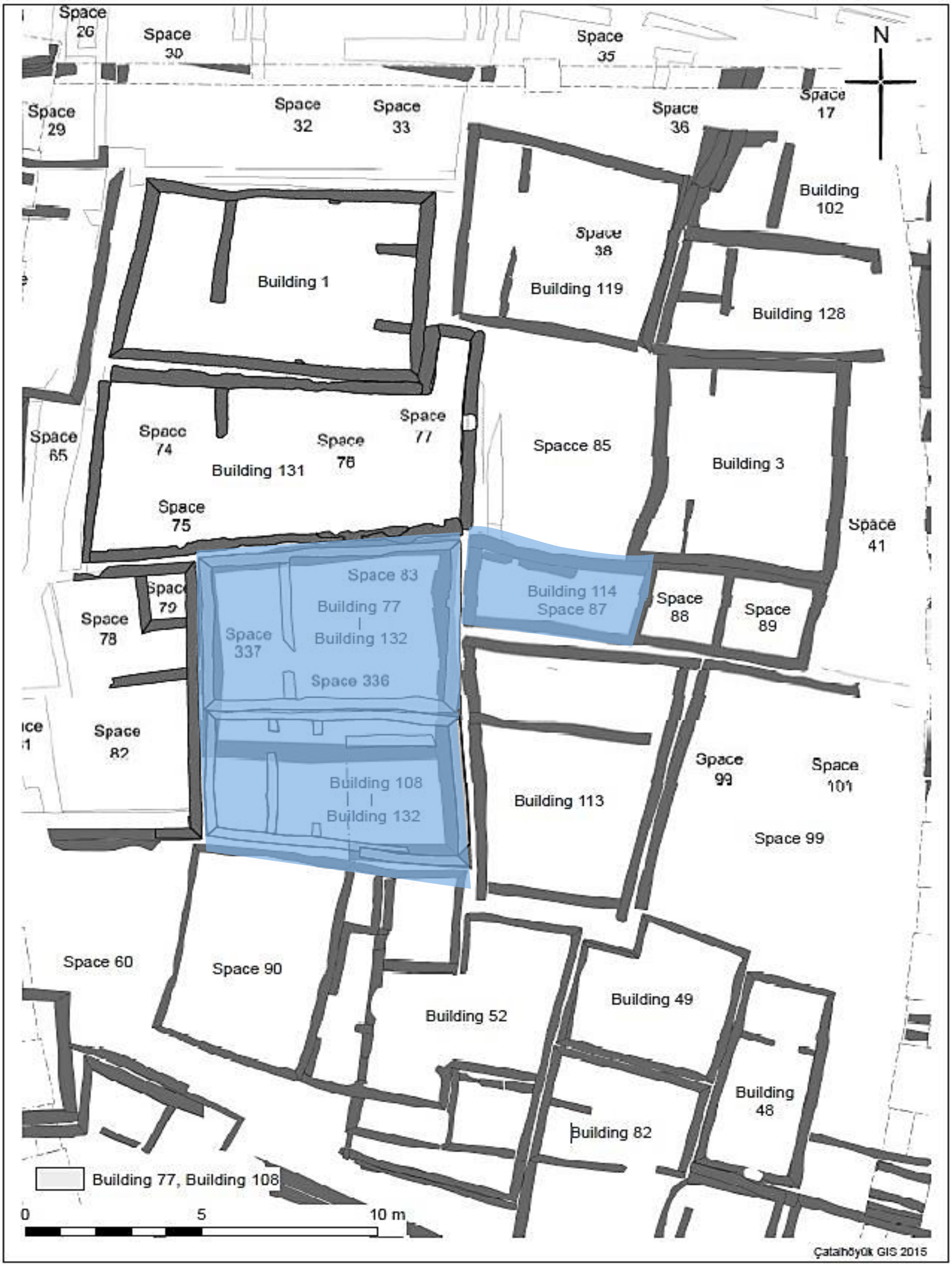



**Figure 7.12** Plan of the North Area at Çatalhöyük East. The building sequences examined in this research are shaded in blue. Source: Camilla Mazzucato for Çatalhöyük Research Project.

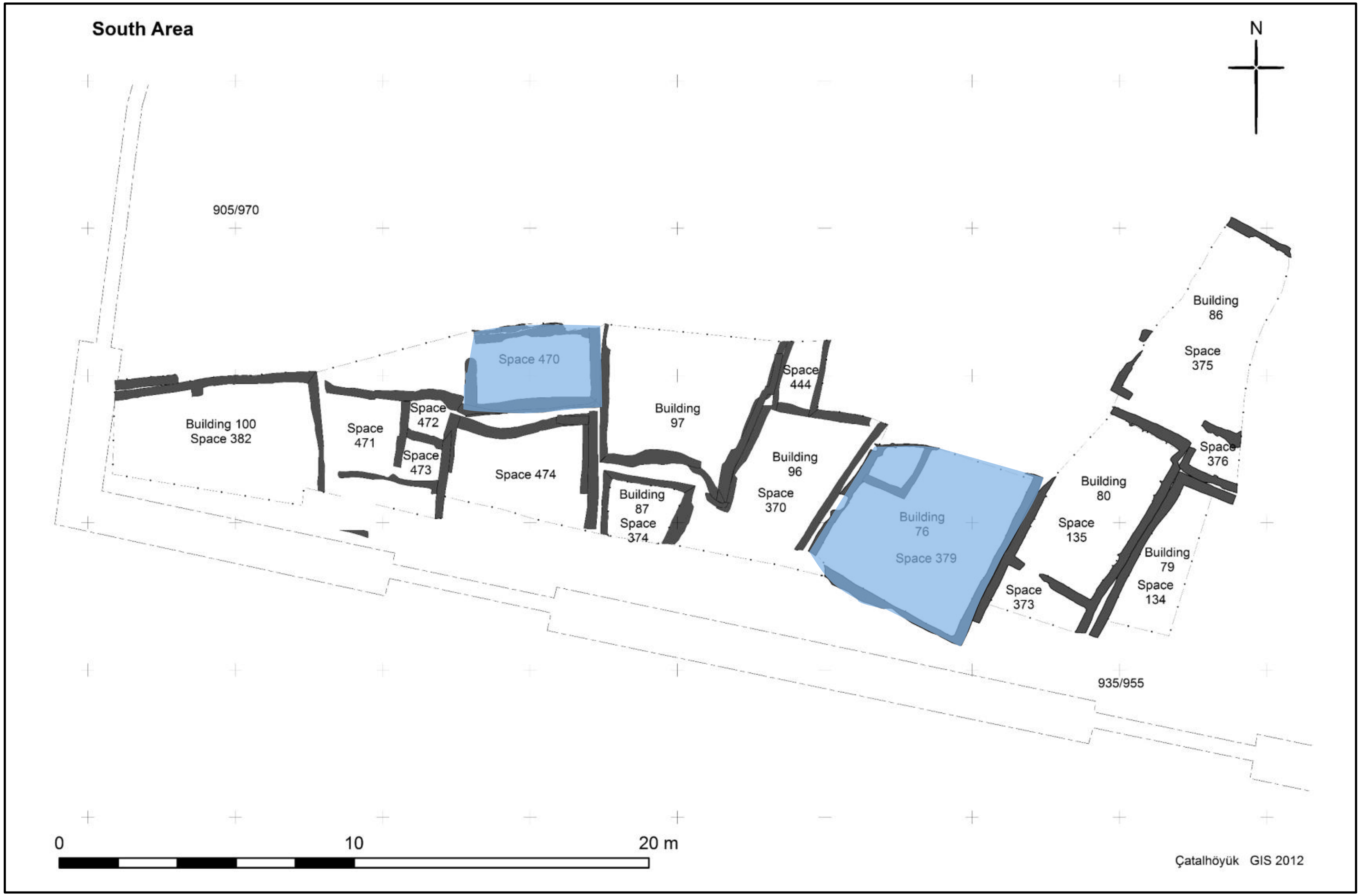



**Figure 7.13** Plan of the South Area at Çatalhöyük East. The building sequences examined in this research are shaded in blue. Source: Camilla Mazzucato for Çatalhöyük Research Project.

The excavation, micromorphological, and geochemical results reported in Chapter 5 are contextualised here through the assessment of the occupation sequences of small buildings in section 7.3.1, followed by large/elaborate buildings in section 7.3.2. The socio-economic importance of open spaces is discussed in section 7.3.3 through the examination of selected midden sequences from the TPC and GDN excavation areas. Lastly, microstratigraphic evidence of intra-site socio-economic dynamics at Çatalhöyük is evaluated in the final sections through a comparative study of all microcontextual data.

### 7.3.1 Small built environments

As it has been previously stated, the investigation of formation processes and activities in the insufficiently studied small-sized buildings (usually 9m$^2$ or less in extension) is considered in this thesis as crucial to expand our current understanding of the multiple forms in which built environments occurred at Çatalhöyük and the socio-economic dynamics that led to the variability in the architecture of living spaces at this settlement. The archaeological evidence from these buildings, usually interpreted as annexes to larger built structures nearby and considered too small to have functioned as independent units, has been widely overlooked in previous research.

In the following pages, key observations derived from the micro-stratigraphic examination of the occupation sequences of two small-sized built environments are highlighted. The first one is Space 470, located in the South Area of the site and part of the 'shrine 8 annex sequence' (Taylor 2012), arbitrarily associated to Hodder Levels South.L-M dated to *ca*. 6700-6500 cal BC (Farid 2013). The second case study is Space 87, the micro-stratigraphic excavation of which has been extensively described in section 5.2. Situated between Building 3 and Building 113, Space 87 appears to have been related to a small room located immediately to the east of it, Space 88, an interpretation supported by the wall crawlhole found connecting both spaces. Space 87 has been provisionally assigned to Hodder Level 4040.G, dated to *ca*. 6600-6500 cal BC, a chronological allocation that is only based on topographic associations with other buildings in the North Area.

#### 7.3.1.1 Space 470

Space 470, part of a sequence of small built environments that includes Space 492 and Space 487, has an approximate size of 7.5 m$^2$. This structure, which does not appear to share any part walls with the surrounding buildings, has been interpreted as the southern annexe of the 'history houses' Building 7 and Building 20, situated immediately to the north of it (Taylor 2012). These two buildings, excavated in the 1960s and named shrines E.VII.8 and E.VII.8 respectively (Mellaart 1964), have been recently re-classified as history houses on the basis of their long life-span, evident in the multiple rebuilding phases identified within their sequences and the remarkable continuity of their interior architectural features (Hodder and Pels 2010). Whereas the double-roomed Space 492 was connected to the larger Building 7 by a crawlhole cut into the respective walls of both of these built structures, the subsequent construction of Space 470 involved the blocking of this wall opening, which resulted in the spatial and functional dissociation of the two built environments. However, it is important to note that no evidence was found of any entrance into Space 470 in any of the thick walls (*ca.* 0.3m) that defined its interior, as well as no traces of ladder emplacement (Barański *et al.* 2015a).

The occupation phase of Space 470 lacked common architectural features, with only a bench and a beaten earth floor recorded during excavation. Micromorphological analyses revealed that the occupation surface was made of a clay loam sediment rich in fine-grained alluvial aggregates (*ca.* 10% abundance) and marl inclusions of up to 5mm in size. The bioarchaeological fraction was formed by charred fragments of woods and grasses (*ca.* 5% abundance) in the form of flecks (100-300μ), with few randomly dispersed millimetric plant remains found in association with sulphidic and ferruginous aggregates, indicating localised organic decomposition under wet and reduced conditions (Mees and Stoops 2010). The nature and distribution of the plant remains embedded in this surface hint at their incorporation as part of the building material sources and not through activities carried out in this space. The heterogeneous composition of this deposit and the poor sorting of its inclusions point to a coarse, roughly made floor, in marked contrast with the fine plasters found inside most buildings at Çatalhöyük (Matthews 2005b). However, the considerable thickness of this surface (*ca.* 5cm), is a feature commonly encountered in the stratigraphy of storage areas.

On top of this surface, several superimposed microlaminations of dung were identified. These were rich in partially digested plant remains, undulating and highly compacted, which suggests substantial trampling cause by animal hooves, probably small-sized herbivores such as goats or sheep. The unusually low occurrence of spherulites could be explained by the accumulation of urine, which has been demonstrated to increase sediment acidity (Shahack-Gross 2011). Whether this space was roofed remains uncertain, as naturally deposited wind or water-laid particles would have been largely reworked though the action of the animals that were kept in this space.

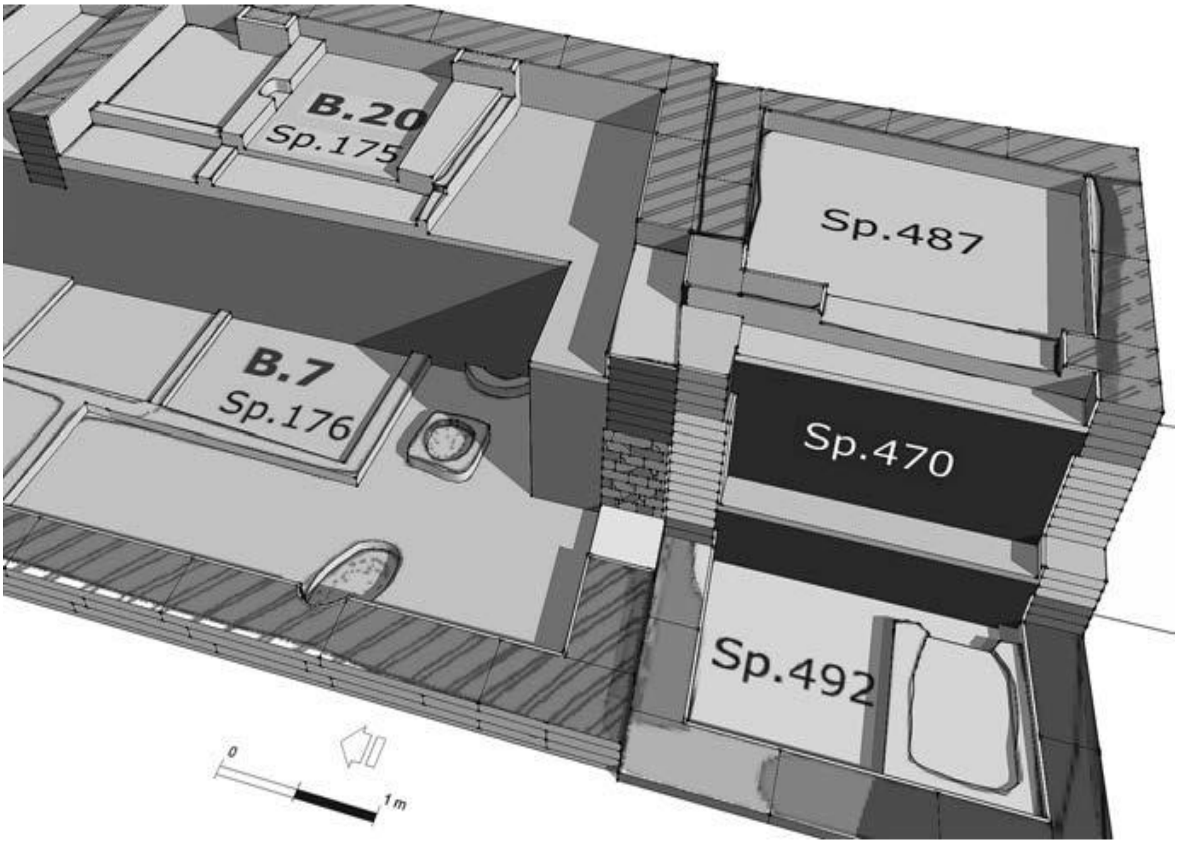



**Figure 7.14** Architectural model of the archeo-stratigraphic sequence of Space 470 and its surrounding structures discussed in this section (image produced by M. Barański for Barański *et al*. 2015: 112).

Although other cases of dung accumulations within other built structures have been documented (Matthews *et al.* 1996; Matthews 2005b), these show thicker, more continuous sequences accumulated in a cyclical fashion. In contrast, the modest deposit of faecal matter in Space 470 points to its short-lived use as an animal pen. Overlying this penning deposit was another thin floor on top of which an extensive layer of well-preserved phytoliths was found. These phytoliths were interpreted as dehusking waste from wheat and wild grasses (Ryan 2012), an activity that seems to have been performed regularly in this space, judging from the compressed and highly laminated disposition of these plant remains.

Overall, it appears that Space 470 was the scenario of industrial activities, mainly pastoral and agricultural in nature. Therefore, this structure could well have functioned as an, apparently independent, annexe for one or several households in the neighbourhood during its lifetime.

The closure of Space 470 was marked by the symbolic deposition of an artefact cluster containing a set of clay balls, several groundstones, a bovid horncore, and an antler (Taylor 2012). Interestingly, this type of artefact clusters is usually found at Çatalhöyük within domestic interiors. These finds were sealed by a dense packing material consisting of crushed mud-bricks, mortar, and plaster fragments that probably derived from the upper parts of the walls defining the space. In addition, a number of special artefacts, including a bone point and a figurine, were found within this abandonment fill (Meskell *et al.* 2012; Taylor 2012).

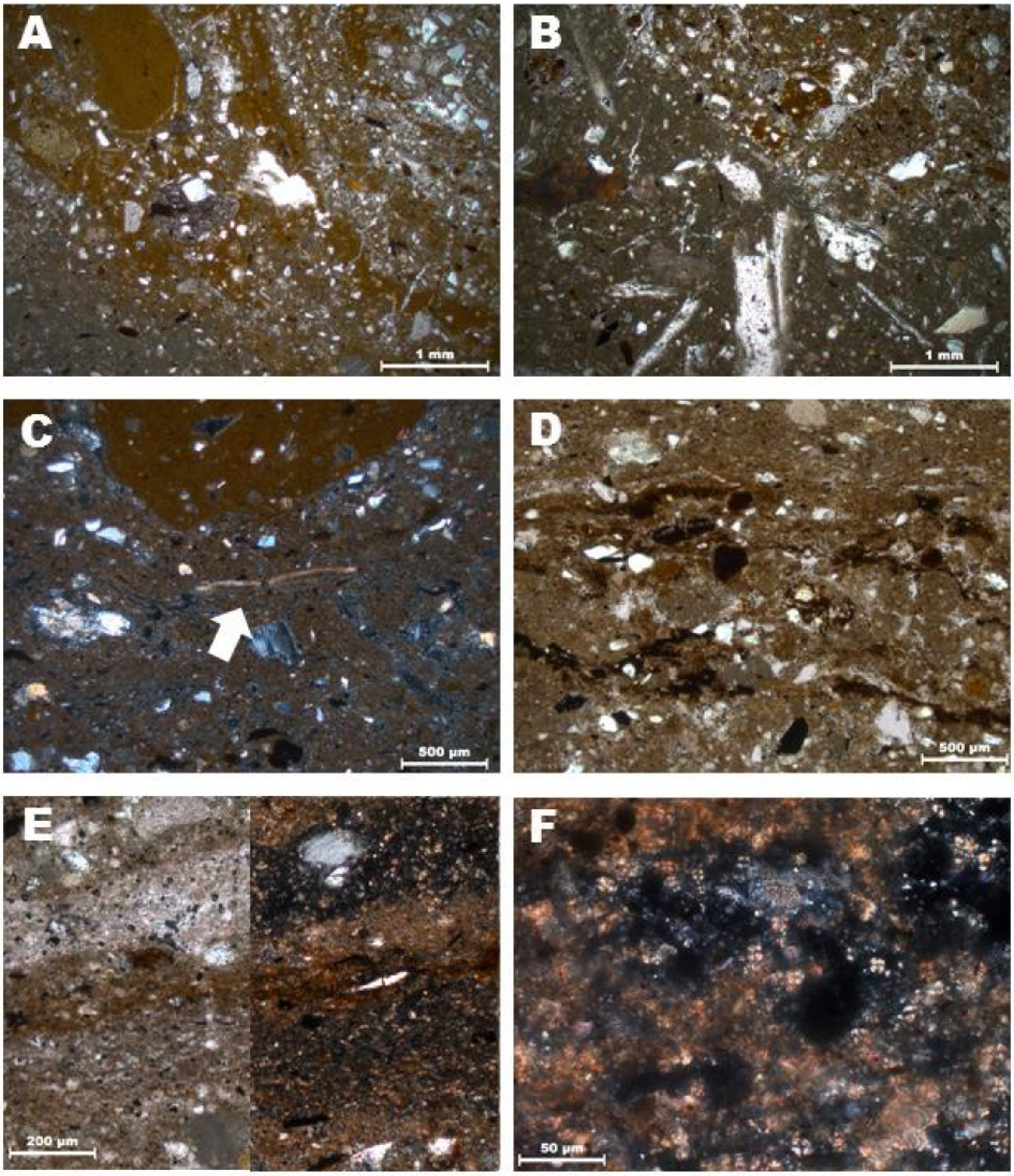



**Figure 7.15** Photomicrographs of microscopic components found in the occupation deposits of Sp.470: (a) fabric of coarse floor comprising alluvial aggregates, basaltic rock fragments and lime plaster, PPL; (b) fragment of plaster with plant-pseudomorphic voids, PPL; (c) break within eggshell fragment, caused by trampling, XPL; (d) iron (hydr)oxide impregnated groundmass, formed through organic matter decay and fluctuating water tables, PPL; (e) dung lenses separated by iron-impregnated sediment, PPL (left) & XPL (right); (f) calcareous spherulites within faecal matter, XPL.

#### 7.3.1.2 Space 87 (Building 114)

The earliest investigations in Space 87 were conducted as part of the BACH project, which linked the occupation of this space with that of Building 3 to the north-west of it (Stevanović 2012a), although the exact relationship of the occupants of Building 3 and Space 87 was not well understood. One argument against a direct relationship between Building 3 and Space 87 (and Spaces 88 and 89 to east) is the presence of a double wall separating them from Building 3. This type of wall could signify that Space 87, and possibly also Spaces 88 and 89, were associated with a different unexcavated house, possibly to the west, since the south walls are also double. Alternatively, these small constructions have been interpreted as annexes to other buildings, and as independent architectural entities, such as task-specific spaces used by a number of households within a neighbourhood.

The excavation of Space 87, situated in the North Area of Çatalhöyük, resumed in 2012, and it soon became apparent that this structure, which has a usable area of approximately $6m^2$, was far more complex than expected. Surprisingly, the main occupational phase of Space 87 reproduced spatial boundaries and activity areas similar to those in most buildings excavated to date at Çatalhöyük, in spite of its considerably smaller size. However, the location of these areas and interior furnishings within the building does not appear to follow the standard spatial conventions seen in the great majority of houses at this site.

Coarse, clay loam plasters containing abundant sediment aggregates and inclusions of charred plants constitute the earliest surfaces of Space 87, which appear to cover its whole floor extension. There was, however, a major break in the internal spatial arrangements of this built environment, when a double north wall, raised floors, fire installations, burial pits, and decorative wall features were constructed. The central platform of this space shows multiple layers of clay-based plasters and thin finishing coats. These surfaces were scrupulously maintained and covered with soft furnishings, judging from the absence of accumulated dust. The eastern end of the building was occupied by a burial platform displaying a sequence of six differentiated grey plaster floors. These two platforms show evidence of several structural modifications during their lifetimes, which hint at the high intensity of occupation of this built environment. The western half of Space 87 displayed a fine sequence of approximately eighteen silty clay floors, and thin grey plaster finishing coats. These surfaces appear almost completely devoid of artefacts, and microscopic analyses have confirmed the presence of trampled soot remains and mat impressions, the use of which undoubtedly helped maintaining these surfaces clean. No hiatus in occupation was detected during the microstratigraphic examination of these depositional sequences.

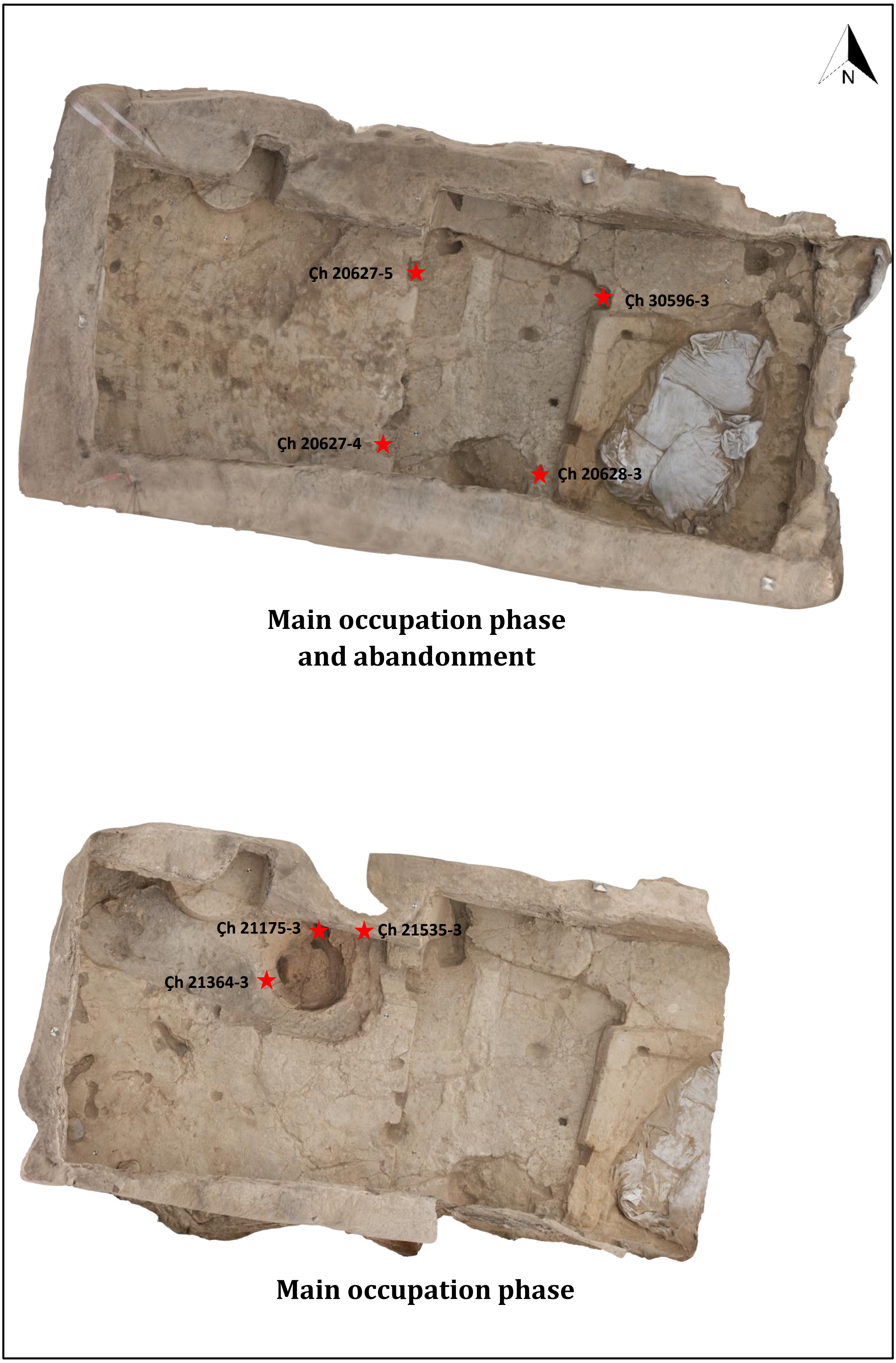



**Figure 7.16** Micromorphology sample locations in Space 87 (Building 114). Orthophotos by M. Perlińska.

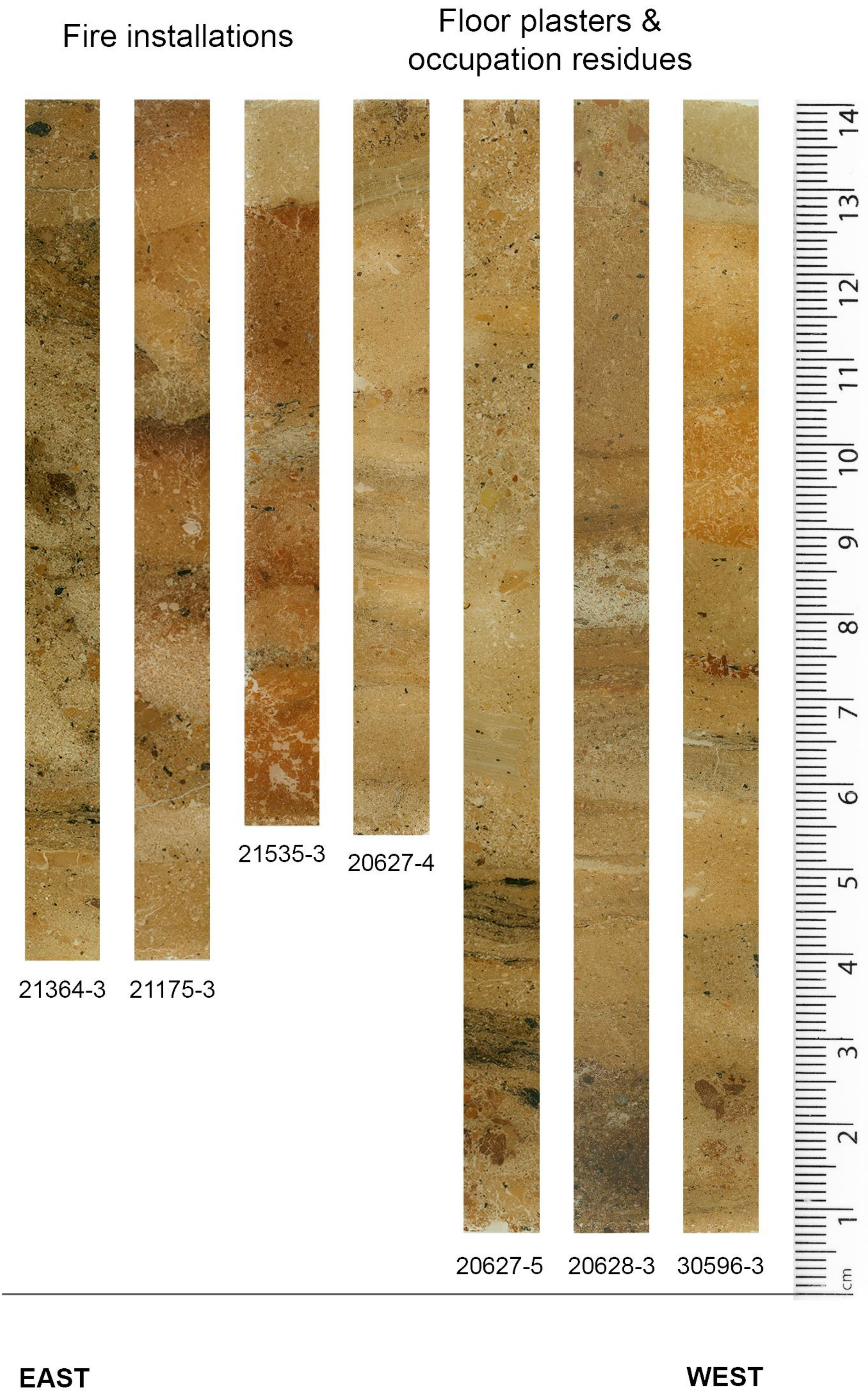



**Figure 7.17** Microstratigraphic columns illustrating the different contexts sampled in Space 87.

The raw materials used for the manufacture of these surfaces appear to derive from local alluvial sources, similarly to other, larger buildings of this period. However, the microstratigraphic sequence of Space 87 hints at a preference for mud floor plasters, as opposed to marl sediments. Multiple layers of clay loam, orangish silty clay and, especially, light brown silty clay loam, the most frequent plaster deposit found in this structure, form the clean central and southern areas of this built environment. These materials were tempered with approximately 5-15% plant stabilisers depending on their particle size, which indicates a good knowledge of the manufacture of floor plasters. Interestingly, and in marked contrast with other plaster sequences, in particular those of Building 77 discussed below, packing and make-up units, which commonly serve as the stabilising base on which light marl and softlime plasters were spread, are not readily identifiable in Space 87. However, two platform levelling units, classified as deposit sub-types BK2f and BK2g and constituted by sandy sediments, were detected. Although there is greater variation and apparent randomness in the types and periodicity of sediments selected for surface renders in this small built environment, some patterns are evident.

Firstly, fine light clayish plasters only occur as the finishing coats of the central platform, probably used for sitting and sleeping, and the eastern burial platform. This avoidance of the use of white clays may have been related to the perceived properties and even possibly contextual associations of these materials with particular places and events within domestic structures. Secondly, the settlement-wide social convention of rendering areas around ovens with orangish brown mud plasters where fuel rake-outs and floor sweepings accumulated was maintained in Space 87.

Three formal fire installations were found in this small built environment. The earliest one, an oven embedded in the original north wall of the space, was eventually sealed and another adjacent wall was erected, probably to reinforce the construction. A hearth then substituted the oven, but was itself later dismantled in one of the several refurbishment episodes that this space went through. The latest hearth, partly built on top of the previous one, was well-maintained, its floor made of high-quality silty clay tempered with 20% grasses in order to resist high fire temperature without cracking. The floors around these fire installations, consisting of silty clay and clay loam plasters, appear substantially eroded, likely due to sweeping and hearth maintenance practices. Several superimposed laminations of accumulated fuel rake-outs, of up to 3 cm thickness in total, were found in this area of the space, suggesting continuous use of the fire installations. Fuel sources consisted mostly of grasses and reeds, alongside local woods, such as elm and juniper. Very little evidence was found of the use of herbivore dung as fuel in this built environment.

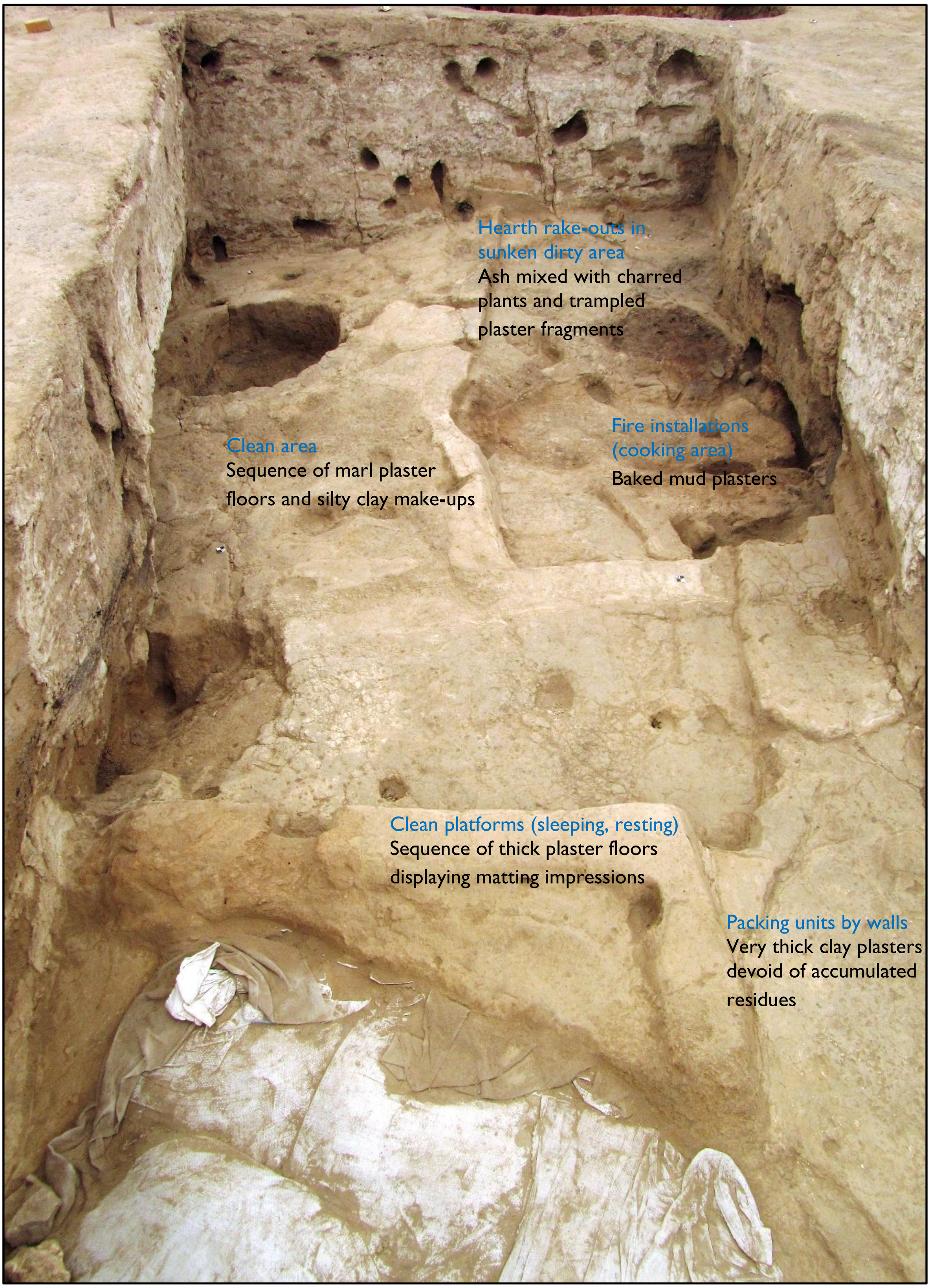



**Figure 7.18** View of the main room of Building 114, Space 87, looking west, and reconstruction of activities and site-formation processes based on excavation and micromorphological data.

The abandonment of Space 87 entailed first the infilling of the fire installation in the sunken north-eastern area of this built environment. Subsequently, a reddish brown clay sediment was used as packing material to fill the deep undercut of the south wall. Then, the upright wooden post situated against this wall was extracted, presumably to re-use it in new constructions. Finally, Space 87 was filled with a very heterogeneous and compacted fill, possibly partly derived from the dismantled upper walls and roofing materials. Microscopically, this building abandonment fill, analysed as part of Samples 20627-4 and 20627-5, was characterised by its heterogeneity, containing large numbers of semi-articulated animal and human bones, frequently occurring in clusters near the walls, and an adolescent male skeleton in full articulation, whose head was missing. Re-deposited construction materials, such as oven linings, mudbricks, wall plasters and fragments of mortar were all found in high frequencies within this extremely compacted deposit. Interestingly, the fill of unburned buildings is often very clean and sterile, and it has been argued that the upper walls and roof were carefully broken up and perhaps even sieved to produce this type of deposits (Hodder and Farid 2013). The deposition of these highly compacted and homogenous fills usually resulted in an improvement of the stability of the surrounding and subsequent built structures (Barański *et al.* 2015a). The fill of Space 87, then, deviates from the observed standard building closure procedures at Çatalhöyük. The large amount of animal bones found within the fill, some of which seem to have been carefully deposited on the latest occupation floors, is particularly intriguing, and could be indicative of feasting. The deposition of fourteen auroch horns, specifically, appears to be the result of dedicated abandonment feasts.

The more than probable existence of a crawlhole in the single wall between Space 88, interpreted as a storage room and activity area based on field descriptions, and Space 87 (Stevanović 2012a), in addition to the complex spatial configuration of the latter, suggest that these two built environments may have constituted a single house: Building 114. Immediately to the south, and likely contemporaneous with it was Building 113, of which only the walls remain. The dismantling of the remaining walls of Building 113 during excavation revealed the existence of a communicating crawlhole between this structure and Space 87, as seen in the cut and the white plaster patches still present on the northern face of the south wall of Space 87. The early blocking of this crawlhole resulted in a painted niche, as seen from the interior of Space 87, and probably marked the use of this space as an, at least, moderately independent building, with finer plaster floors beginning to be laid down, and developing decorative elaboration.

In fact, a number of factors can substantiate the view of Building 114 as a miniature version of a standard domestic building at Çatalhöyük, possibly inhabited by a single household. Firstly, the elaborate internal spatial arrangement of the main room of Building 114, Space 87, which contains over nine structural cuts and multiple documented architectural repairs or modifications during its lifetime, indicate extensive maintenance practices. The re-placement and transformation of the fire installation in Space 87, in addition to the evidence for continuous use of these features, indicate a high intensity of occupation. Further, the large number of individuals buried in this built environment, nineteen in total, in contrast with the eleven skeletons excavated in the much larger Building 3 (Hager and Boz 2012), hint at the important socio-cultural status of Building 114. Finally, the storage capacity of this structure, represented by the eastern side-room Space 88, is also a marker of socio-economic independence. This small (*ca*. 1.79 m x 1.81 m) annex contained several storage bins as well as other features associated with grinding and food preparation (Stevanović 2012b).

## 7.3.2 Large/elaborate buildings

Hodder and Farid (2013) identified large houses displaying multiple evidence of symbolic and architectural elaboration as one of the special building categories at Neolithic Çatalhöyük. In order to explore socio-economic differentiation at this settlement, the occupation sequences of two of these structures, Building 89 and Building 77, were examined through thin-section micromorphology and geochemical techniques. The focus of this analysis was on floor architectural materials, and both food and fuel micro-remains accumulated in the dirty area of these buildings. The microcontextual study of these domestic constructions allows assessing the extent of the claimed differences in the activities associated with these houses through the investigation of *in situ* bioarchaeological remains that are rarely retrieved during excavation.

The evaluation of this building category through these two case studies contributes to the wider goals of this research by allowing the exploration of ecological strategies and spatial conventions in large buildings, as opposed to small-sized built environments and open areas, thus increasing our understanding of the complex social geography of Neolithic Çatalhöyük.

### 7.3.2.1 Building 89

A team led by Maurizio Forte has been excavating this large building, measuring 5.80 m x 5.20 m and situated in the South Area of Çatalhöyük, immediately below the later Building 76, with the main goal of testing and developing new techniques of digital data capture and 3D recording of the excavation process (Forte *et al.* 2012). This building follows a typical interior layout with clean plastered platforms along the north and east walls, and hearths and dirty floors in the southern half of the main room. In order to explore choices of architectural floor materials and uses of space in this building, the clean central floors and the south-western sequence close to the hearth, were sampled and examined in this research (see Figure 7.19 below).

Only three types of floor materials were identified in the clean area of Building 89 through thin-section micromorphology: suspected softlime plasters (deposit sub-type CH2a), silty clay loam plasters (CH2d), and clay loam plasters formed by mixed materials (CH2h). The first type, suspected softlime plasters, is formed by calcareous clay tempered with 10% plant stabilisers. These floors, frequently only 1-2 mm thick, have been found to be consisting of marl sediments on the basis of the XRF, XRD, and FTIR data reported in Chapter 5. The silty clay loam plasters detected in this sequence are slightly thicker (*ca*. 2 mm to 1 cm) and display 10-15% plant stabilisers. The floor type identified in this area of Building 89, clay loam plasters, are the most common in this sequence. These deposits are formed by slightly oxidised alluvial materials and embedded aggregates of calcareous and silty clay sediments. All of these floors appear devoid of accumulated remains, suggesting regular sweeping of these surfaces, for the exception of very thin (*ca*. 100-300 μm) soot layers of charred micro-residues, probably accumulated under mats.

**Figure 7.19** Overview of Building 89 during excavation, facing north. The red stars mark the micromorphological sampling locations. Source: J. Quinlan.

By contrast, the dirty floors of Building 89, mainly formed by considerably thicker (*ca.* 0.5-2 cm) silty clay loam plasters (deposit sub-type CH2d), and few occurrences of silty clay (CH2c) and mixed clay loam (CH2h) plasters, display substantial accumulations of daily discards up to 2 cm in thickness. These layers, predominantly formed by highly fragmented charred plant materials (deposit sub-type CH4b), and occasionally burnt bones, shells, and swept particles (CH4d), are completely unsorted and unoriented, indicating re-deposition. Due to the nature of the components, suggestive of fuel discards, and the proximity of the fire installation to the sampled location, these layers have been interpreted as gradually accumulated hearth rake-outs. The substantial thickness of these deposits appears to indicate that this part of the building was not plastered as frequently as the clean area of the house. Further, thicker and more compacted accumulations of charred materials have been observed to occur towards the top and the very bottom of the dirty floor sequence analysed in this study, perhaps indicating periods of intensive use of the fire installation, or laxity in the performance of house maintenance practices involving sweeping and discard of daily residues.

#### 7.3.2.2 Building 77

Building 77, in the North Area of Çatalhöyük, is an elaborate domestic built environment that was destroyed by fire, either deliberately as part of ritual closure events, or accidentally. It has been suggested that this building, which displays multiple symbolic features such as wall paintings, mouldings, and bucrania, originally stood to over 3.2 m, possibly indicating the presence of a second storey (House 2013a). The main room of Building 77, Space 336, measures approximately 4.4 m x 4.4 m and is separated from the storage area to the south, Space 337, by an internal wall (see Figure 7.20 in the next page).

As in the already discussed Building 114 and Building 89, the clean floors of the central platform, Feature 6062, were sampled in order to investigate the materiality and periodicity of plastered surfaces in this area. Further, the cross-sectioning of the oven Feature 7108 during excavation provided an invaluable opportunity to study the composition and preservation of the baked floors that form this sequence, in addition to possible remains of fuel sources.

The most striking characteristic of the clean sequence in platform Feature 6062 is the remarkably regular pattern of plaster deposition it displays. This involves usually thick (*ca.* 2 mm to 2.5 cm), heterogeneous layers classified as deposit sub-type CH2h based on micromorphological attributes, overlaid by make-up units of coarse clay loam (CH2e) or oxidised alluvial silty clay (CH2c), on top of which thin (*ca.* 1-2 mm) finishing coats of marl plaster (CH2b) are deposited. The coarse CH2h plasters appear to have acted as levelling


**Figure 7.20** Plan of main occupation phase of Building 77, with the red stars marking the micromorphological sampling locations. Source: Camilla Mazzucato, Cordelia Hall and David Mackie.

**Figure 7.21** Oven Feature 7108 in Building 77, cross-sectioned during excavation and sampled for micromorphology.

units, possibly aimed at raising the height of the central platform at specific points during its lifetime, likely motivated by the seasonal plasterings of the central floor area, which eventually increased the height of these surfaces relative to that of the platforms. Several layers of deposit sub-types CH2c/e and CH2b are usually found on top of the thick levelling units.

Overall, this sequence appears almost completely devoid of accumulated domestic residues, for the exception of extremely thin (*ca*. 100-200 μm) soot layers found on top of some marl plasters. Bioarchaeological inclusions such as bones and charred plants, have been found in very low proportions (1-5%) embedded in the architectural materials, which point to their accidental incorporation at the place of manufacture, rather than through the performance of daily activities on these surfaces.

Interestingly, the marl plasters, CH2b, appear considerable eroded, possibly due to regular sweeping. These deposits contain more sands (*ca*. 15-20%) and less plant pseudomorphic voids (*ca*. 2-5%) than usual for this type of materials, possibly indicating the selection of specific, coarser calcareous sources for their manufacture distinct form those used by other households. The subrounded shape of the sand fraction in these layers dismisses the possibility that quartz and feldspar rocks were intentionally flaked in order to be added as stabilisers during plaster production. Interestingly, Love (2012) noted an increase in the sand content of mudbricks from buildings in the later occupation levels at Çatalhöyük. Therefore, it seems likely that the occupants of the site started to exploit different landscape areas for the extraction of sediments for construction materials in the mid- to late levels of Neolithic occupation at this settlement. It can be argued that it was the need for more clayish, fertile agricultural soils closer to the site what motivated this gradual change in the selection of architectural materials, although this hypothesis needs to be explored further.

The floors of oven Feature 7108 in Building 77 also display a regular depositional pattern, consisting of remarkably heterogeneous silty clay loam make-ups/levelling units (deposit sub-type CH3a), and sandy clay loam plasters (CH3b). The latter are heavily tempered with 15% plant stabilisers, probably to reduce cracking during heating and cooling. In fact, the very high temperatures reached in this fire installation have rubefied these plasters to a depth of more than 2 cm, charring some of the plant stabilisers *in situ* and causing others to burst, as the large, sharp-edged vesicle voids identified in some of these materials appear to attest. Significantly, these surfaces appear completely devoid of accumulated remains, probably due to scrupulous maintenance practices, thus impeding the study of fuel sources.

### 7.3.3 Open spaces

As it has traditionally been interpreted, the highly aggregated layout of Çatalhöyük suggests that, in addition to middens, building roofs were also used as passage routes between different parts of the site, as well as areas of outdoor activities of their own (Matthews 2012c; Shillito and Ryan 2013). Assuming that building tops were viewed as the external, visible parts of houses by the Neolithic inhabitants, roofs and upper storeys can be considered an intermediate sphere, a space between the domestic (private and concealed by house walls), and the public domains. Thus, roof sequences appear as highly significant for our understanding of Neolithic activities and the organisation of space within settlements. However, the preservation of these remains is rare, an aspect which, together with the difficulty of detecting possible roofing during excavation due to the high variability of the architectural materials used for its construction, contributes to the low archaeological visibility of these sequences. The unearthing of roof/upper storey collapsed deposits during the 2013 excavations of Space 511/489, in the North Area of Çatalhöyük, presented an invaluable opportunity to examine the nature of the construction materials, as well as the range of specialised activities that occurred on these rarely encountered architectural surfaces.

The next pages discuss the microstratigraphic evidence gathered from open sequences at this site, and their social and economic significance. Sampled sequences include collapsed roof materials identified in the fill of Space 511/489, assessed in section 7.3.3.1, and late Neolithic midden sequences from the TPC and GDN excavation areas, discussed in section 7.3.3.2.

#### 7.3.3.1 Roof sequences: Space 511/489

Space 511/489 at Çatalhöyük, delimited by walls to the north, east and south, comprises room infill deposits predominantly made of a variety of re-deposited construction materials and a midden sequence upon which Building 108 was built (Tung 2012). This sequence, arbitrary assigned to Hodder Levels 4040.F-G (*ca.* 6800-6500 cal BC), was cross-sectioned and only its eastern part was excavated. Space 511 corresponds to the earliest built structure in this sequence, interpreted as a southern annex of a main room within the exceptionally large Building 132, not yet fully excavated (Barański *et al.* 2015a). The succeeding Space 489 consists of an open space enclosed by the walls of surrounding buildings. It seems that as construction debris and midden materials accumulated within this later space, the preserved northern wall of Space 511 started to gradually lean towards the north under lateral pressure, resulting in its collapse.

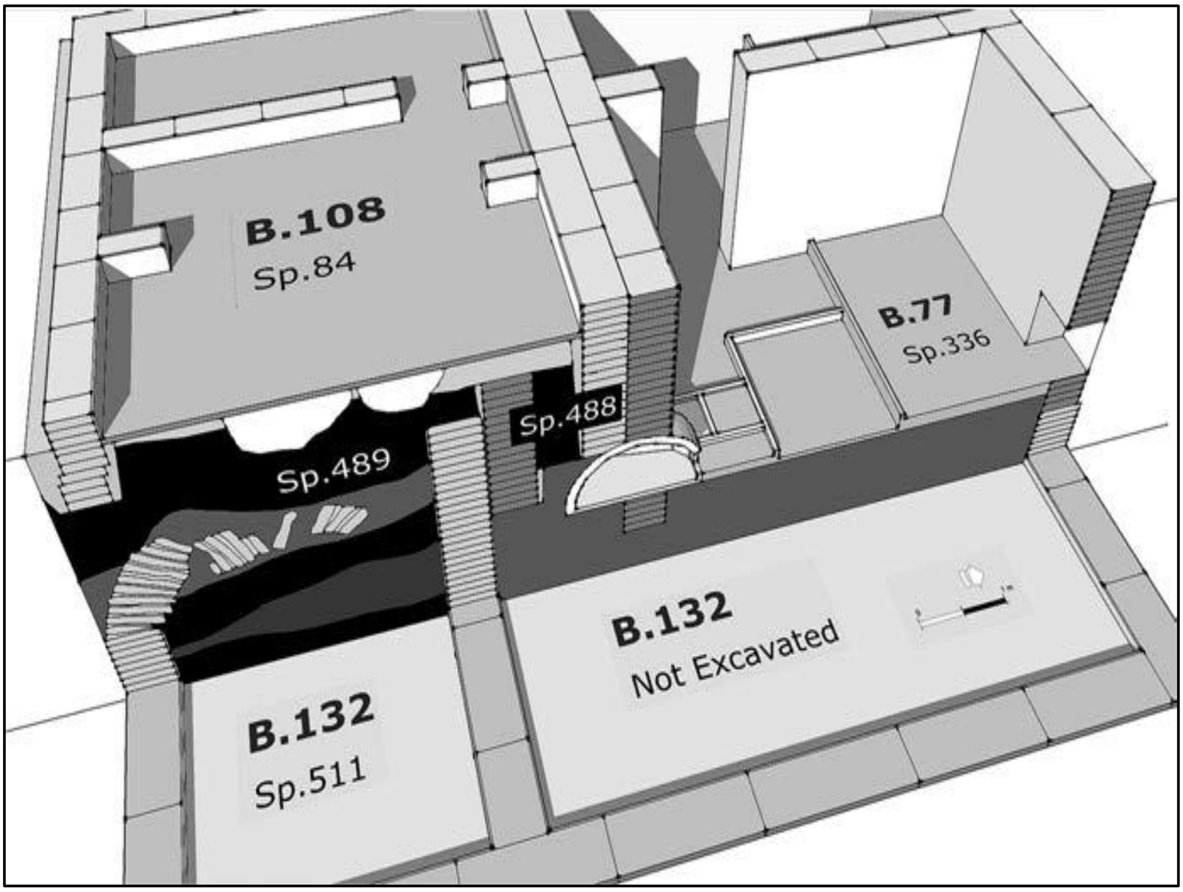



**Figure 7.22** Architectural model of the archeo-stratigraphic sequence of Space 511/489 and its surrounding structures discussed in this section (image produced by M. Barański for Barański *et al*. 2015: 116).

During the excavation of this sequence several large slabs of stratified sediment, up to *ca*. 0.5-1m$^2$, were unearthed. These slabs were similar to those interpreted as collapsed roofing during the excavation of Building 3 (W. Matthews, pers. comm.), showing intact stratigraphic sequences up to a thickness of *ca*. 20cm. Although it is likely that these collapsed slabs, found within Space 489, were once part of the roofing of the earlier Building 132 (perhaps its southern annex Space 511), the re-deposited nature of these remains precludes any conclusion in this respect. However, as it became apparent in the field that the depositional sequences of these slabs varied greatly in types of materials, thicknesses, and sediment aggregates, two block samples were collected after visual examination and later prepared into micromorphological slides for integrated microscopic analyses aimed at investigating the composition and depositional processes of these materials at high-resolution.

Due to the location of the collapsed blocks, found against the south-eastern corner of Space 511 and lying within fill deposits, the original geographical arrangement of the two stratified slabs sampled remains uncertain. Ethnographic observations of natural roof collapse illustrate that it is often the central timbers and supports to give way first. In these cases, deposits on the roof may then slide and collapse randomly from the surrounding areas. For these two thin-sections it has been possible to reconstruct the original orientation of the surfaces in each slab through the analysis of the nature and sequence of the surfaces of plasters and finishing coats and the impact of mat impressions on one side, and the grading of naturally accumulated sediments on the other.


**Figure 7.23** Collapsed remains within Space 511/489 (left) and sampling locations (right). The arrows point towards the original top of each sampled sequence as defined through thin-section micromorphology.

Both sequences display frequently plastered surfaces on which virtually no debris was allowed to accumulate. Up to 80% of the deposits analysed comprise floors of variable quality that consist of heterogeneous packing deposits (sub-type CH2h), silty clay make-up layers (CH2c), and thin finishing coats of grey plaster (CH2b). These floors are considerably thicker (*ca.* 1.5 to 2.5cm) than those within main room spaces, probably to prevent weathering and abrasion from both natural elements and trampling.

Ten floors have been identified in slide 20988/4, comprising both fine and heterogeneous packing deposits (1.5-2.5cm thickness), pale brown silty clay make-up layers of alluvial origin, and thin (*ca.* 2mm) finishing coats of grey clay plaster. Unworked aggregates of oxidised water-laid silty clay are present in all deposit types. All units were stabilised with plant material, attested by pseudomorphic plant impressions and voids. The finer silty clay plasters were stabilised with *ca.* 5-15% plant remains, the sandier packing deposits with *ca.* 5-10%, suggesting the manufacturers had a good empirical knowledge of the amount of plant stabilisers required by different sediment types (Norton 1986). All layers include charred plant remains in the form of flecks (*ca.* 50-200µ size), especially abundant (up to 20%) in the coarse packing deposits and probably incorporated to the sediments in the source area or during manufacture. This high concentration of charred plant flecks and grassy temper (*ca.* 5-10%) would have made these deposits considerably lighter, a desirable characteristic for flat earth-made roofs, which can weigh as much as 300 kg/m$^2$ (Houben and Guillaud 1994; Stevanović 2013). Virtually all bioarchaeological and microartefactual remains within sample 20988/4, however, are in secondary context, brought in building material sources and therefore not indicative of in-situ activities in this area.

Despite the cyclicity suggested by the sequence in this thin-section, with make-up units and finishing coats being laid on top of carefully placed packing deposits in a periodic basis, there is significant variation in the types of sediments selected for surface, in marked contrast with the high consistency and repetition of sources found in interior building sequences. The coarse, heterogeneous packing units are composed of multiple elements of diverse origin, from re-used floor plaster fragments to weathered bone remains, showing a similar microfabric to that of wall mortar.

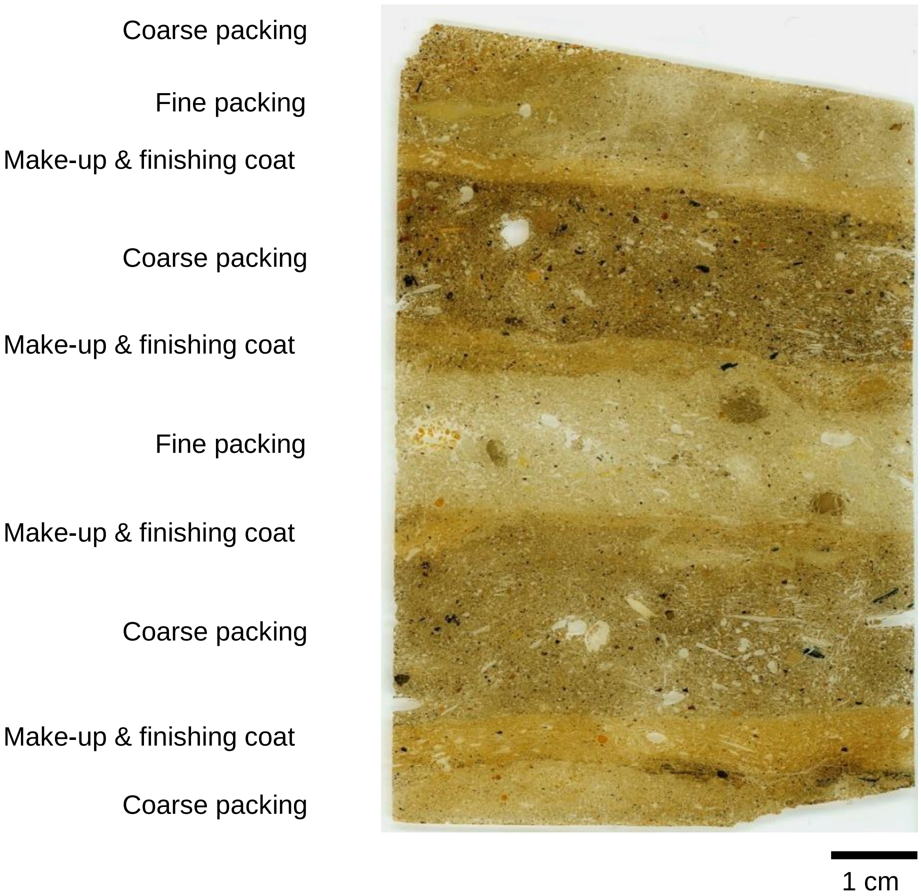



**Figure 7.24** Scan of micromorphology slide corresponding to sample 20988/4 annotated with a summary of the deposits identified in this sequence following excavation nomenclature.

In several locations the finishing coat appears eroded, and discontinuous bands of moderately sorted, rounded to sub-rounded coarse sands mark the boundary between the alluvial make-up and the packing deposit above. These sands seem to have been wind-blown and therefore naturally accumulated, which gives support to the hypothesis that this sequence was part of an external building area.

The fine packing units within slide 20988/4, composed of silty clay sediment, have a platy microstructure, rarely encountered in anthropogenic deposits at Çatalhöyük and probably due to shrinking and dilation caused by desiccation and frost-action (Stoops *et al.* 2010; Van Vliet-Lanoë 2010), probably as a result of the accumulation of snow on the roof during winter time. The absence of water-laid crusts in this sequence suggest the existence of roofing above these floors, but the occurrence of wind-blown particles, as well as erosion and frost features indicates that these areas were open and not walled, perhaps only covered with an awning.

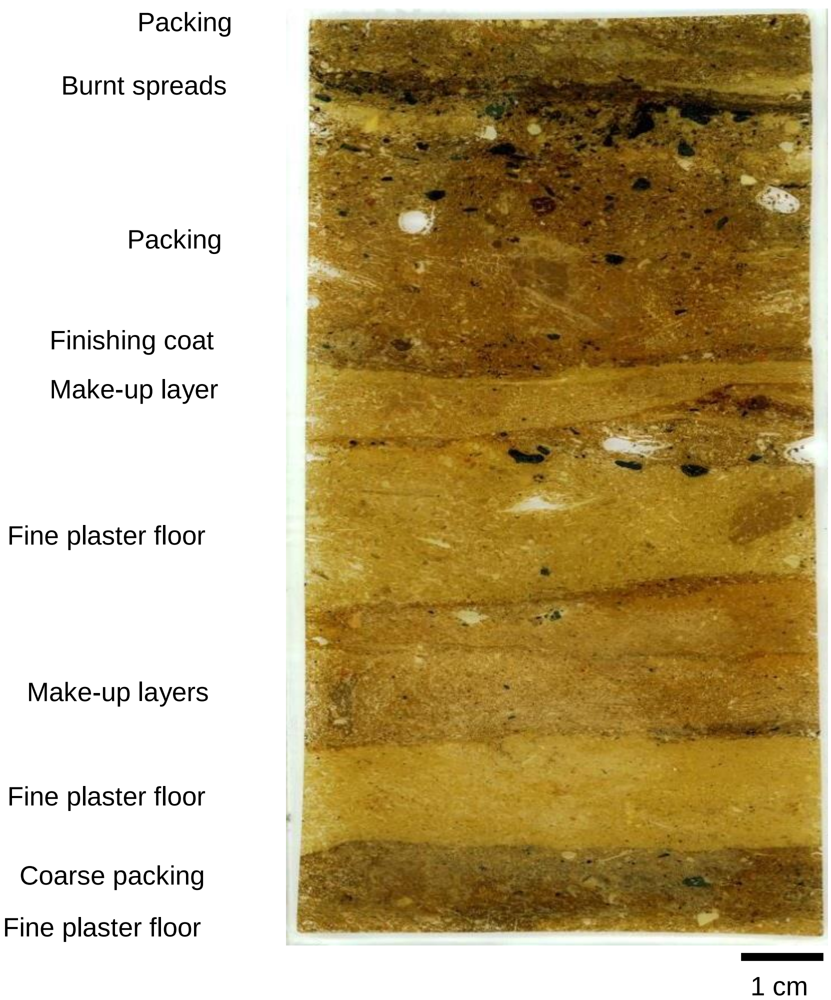



**Figure 7.25** Scan of micromorphology slide corresponding to sample 20988/3 annotated with a summary of the deposits identified in this sequence following excavation nomenclature.

The lower deposits of sample 20988/3 show marked similarities with those of thin-section 20988/4 described above, comprising a sequence of alluvial packing and make up layers alternating with thick plaster floors that appear to have been roughly made, with up to 25% of re-used wall plasters, and finishing coats.

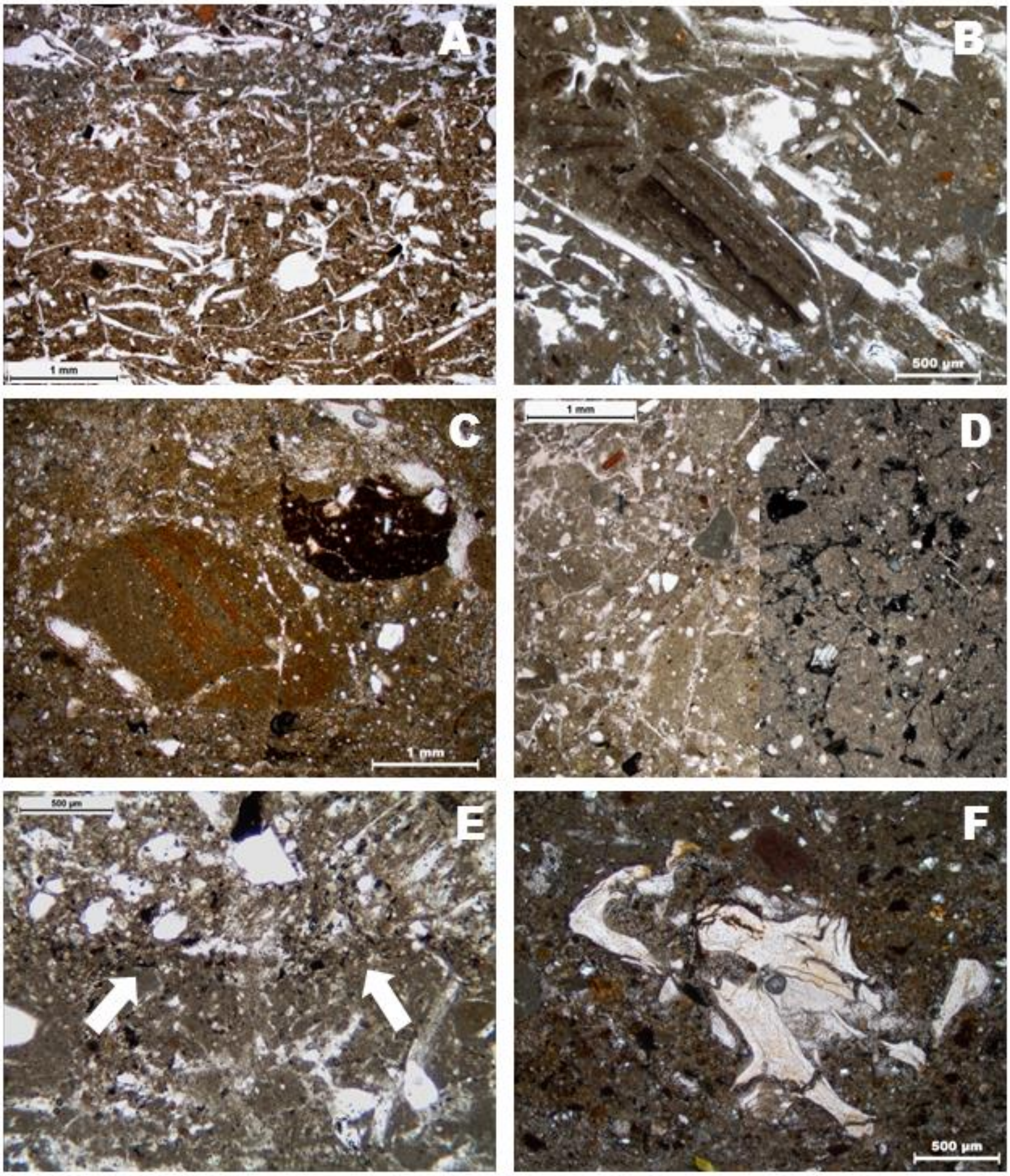



**Figure 7.26** Photomicrographs of microscopic components of floor sequences present in the collapsed materials of Space 511/489: (A) heavily tempered floor make-up (bottom), and finishing coat (top), PPL; (B) re-used fragment of wall plaster, PPL; (C) unworked alluvial aggregate showing original layering, PPL; (D) silty clay packing with moderately developed platy microstructure due to shrinking and dilation caused by water and frost action, PPL (left) and XPL (right); (E) soot accumulation on top of plaster floor, notice the regularly wavy boundary left by matting impressions, PPL; (F) trampled bone, PPL.

However, the top of this sequence includes alternating layers of oven/heart rake-out containing fragments of charred cereal and deciduous woods, and burnt bones, suggesting that activities related to food cooking were taking place on the roof. The increasing accumulation of swept deposits towards the end of this sequence points to a devolution in the maintenance of this area or perhaps to a change in the division of space and activity areas within the roof at this time. This might indicate that building tops were perceived as flexible spaces, not as strictly subjected to recurrent daily practices and divisions as ground floor, internal areas.

The top deposits in the sequence of this sample include alternating layers of oven/heart rake-out containing charred cereal, deciduous woods, and burnt bones. This evidence allows us to argue that cooking-related activities were performed on the uppermost part of the building. The increased accumulation of swept deposits towards the end of this sequence points to a devolution in the maintenance of this area or perhaps to a change in the division of space and activity areas within the roof at this time.

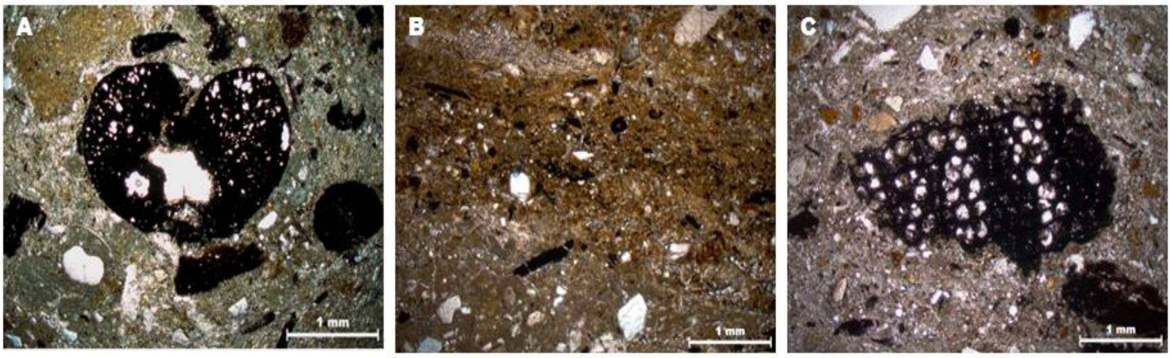



**Figure 7.27** Photomicrographs of ashy layers found towards the top of roof/upper storey sequence of sample 20988/3: (A) charred seed, PPL; (B) charcoal-rich ashy microlayer on top of a poorly preserved fine plaster floor, PPL; (C) fragment of elm charcoal, PPL.

Once again, the absence of water-laid crusts suggests that this sequence was roofed, an assumption further supported by the wavy impressions, articulated reed phytoliths, iron staining of the groundmass caused by the organic decay of plant fibres, and widespread compacted soot accumulations on top of the deposits, which hint at the systematic use of matting, a practice that probably contributed to protecting these floors against aeolian erosion.

The use of mats to cover the floors could indicate that these multiple layers of plaster had been laid in an upper storey room that was itself roofed. In this regard it has been noted that the upper part of the collapsed wall of Space 511 was originally constructed with different mudbrick materials from those found towards its base, which could also be indicative of the existence of a second storey (Barański *et al.* 2015a).

## 7.3.3.2 Middens: GDN and TPC Areas

Mellaart Area A, situated at the top of the East Mound and excavated in the 1960s (Mellaart 1998), was partly re-opened in 2013 as the research focus of a new project centred on the evaluation of Late Neolithic architecture and settlement layout, and re-named GDN Area (Barański 2013). A block sample was collected from Space 544 during the recent excavations, assigned to Mellaart Levels I-II (6200-6000 cal BC) and comprising several fine layers of midden. Situated between house walls, this context was originally described by Mellaart as a street, an interpretation based mainly on the substantial length and reduced width of this open space, tightly enclosed by the walls of Buildings 111 and 141 (Barański 2014).

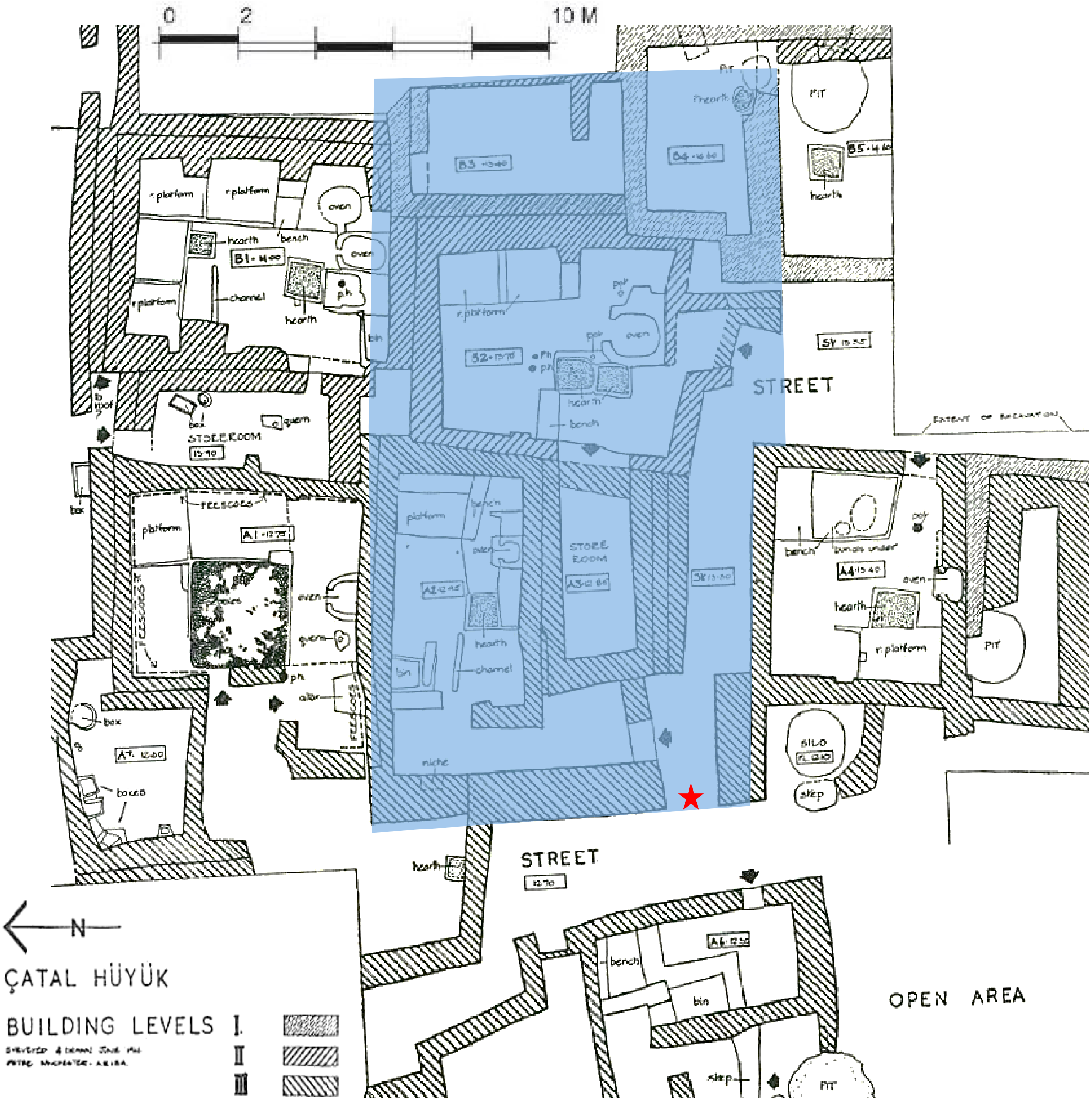



**Figure 7.28** Partial plan of Mellaart A/B Area with the extension of the newly-opened GDN trenches highlighted in blue. The red star marks the location of the micromorphological block. (After Mellaart 1962: 45 with data from Barański *et al.* 2015b: 249).

**Figure 7.29** Photograph of the midden in Space 544 during excavation, situated between the north wall of Building 111 and the south wall of Building 141 (from Barański *et al*. 2015b: 200).

The aims of the micro-stratigraphic analysis of this suspected street context were twofold: first, to characterise the midden deposits forming this sequence in order to shed light into their depositional and pre-depositional histories; and second, to investigate whether late middens could have been consistently used as places of passage or gathering, potentially involving deliberately constructed surfaces.

The deposit sampled corresponds exclusively to field unit 30407, described during excavations as a finely stratified midden context rich in bioarchaeological inclusions (Barański 2013). Some of the microlaminations that formed this layer appeared to be slightly more compacted than others, a feature that was initially considered to be indicative of periodic trampling in this space.

Minerogenic inclusions visible at the macroscopic scale ("white gritty nodules", most likely well-developed formations of gypsum salts) and bio-archaeological finds consisting of bone and shell fragments, charcoal, pottery sherds, and obsidian flakes, were present in abundance. A preliminary assessment of the faunal remains from this space concluded that this midden accumulated rapidly, following a short-term depositional pattern (Pawłowska, pers. comm.).

Interestingly, the laminated bedding pattern described in the field has not been identified at the microscale during the micromorphological analysis of this sample. Although this could partly be due to the high degree of alteration of this deposit, caused by intense bioturbation including animal burrowing and modern plant roots, the nature of this unit is different from that of other, almost entirely organic, later middens at Çatalhöyük, where multiple rapid discard events of plant fuel are clearly distinguishable under the microscope (Shillito and Matthews 2013). In the case of thin-section 30407/3, three microstratigraphic units (MUs) have been described, as shown in Figure 7.30 below.

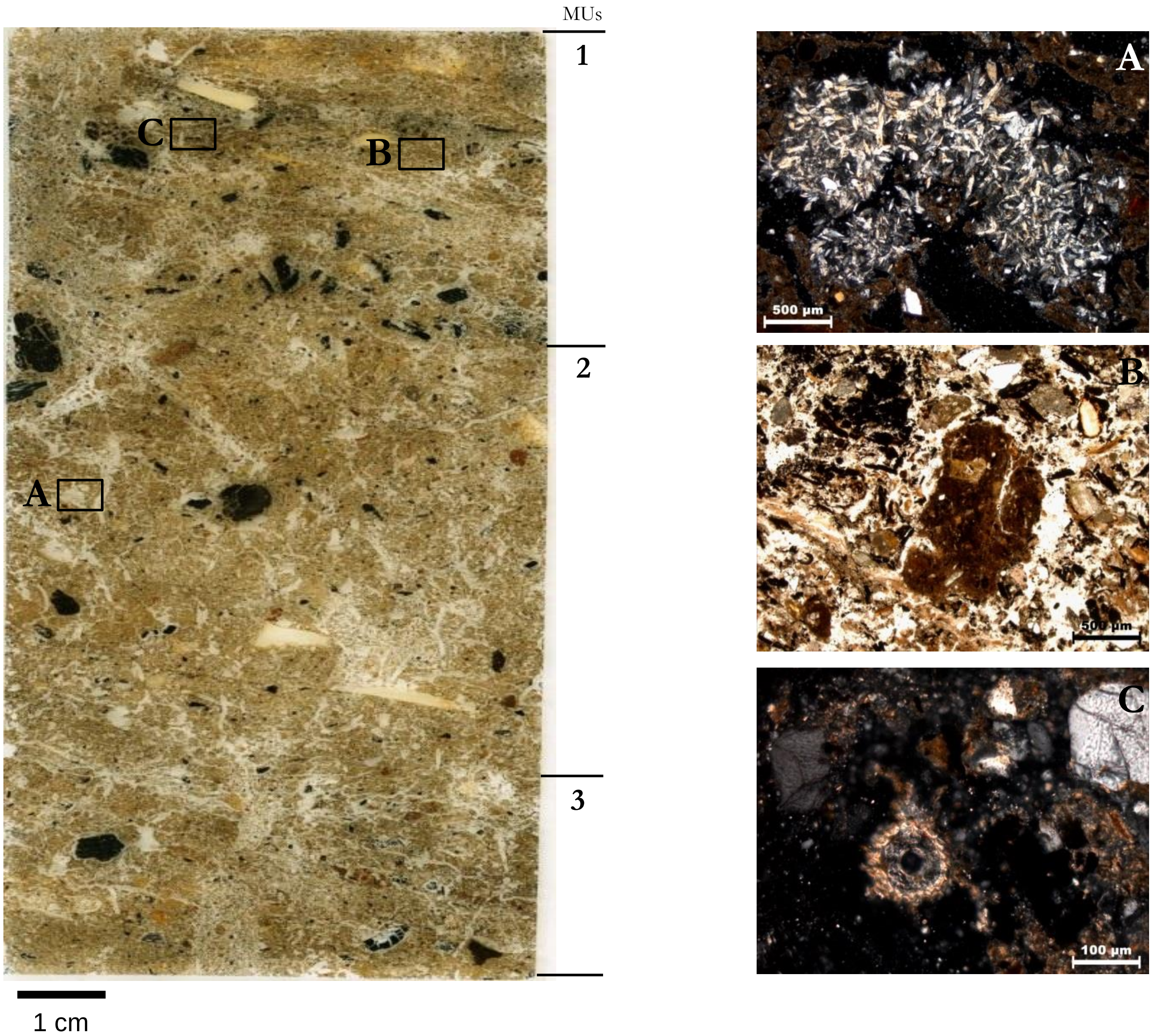



**Figure 7.30** Micromorphological slide 30407/3 (left) showing the locations of post-depositional features observed in thin-section. The microstratigraphic units identified during the analysis are marked on the left. (A) Channel infilled with well-developed lenticular gypsum, XPL. (B) Fine-grained dusty soil aggregates, PPL. (C) Section of modern plant tissue within void, XPL.

The uppermost deposit, MU-1, is characterised by the considerable intensity of post-depositional disturbance it displays. Situated 15-20 cm below topsoil, this unit is formed by silty clay loam and abundant inclusions of organic origin, mainly charred plants and woods.

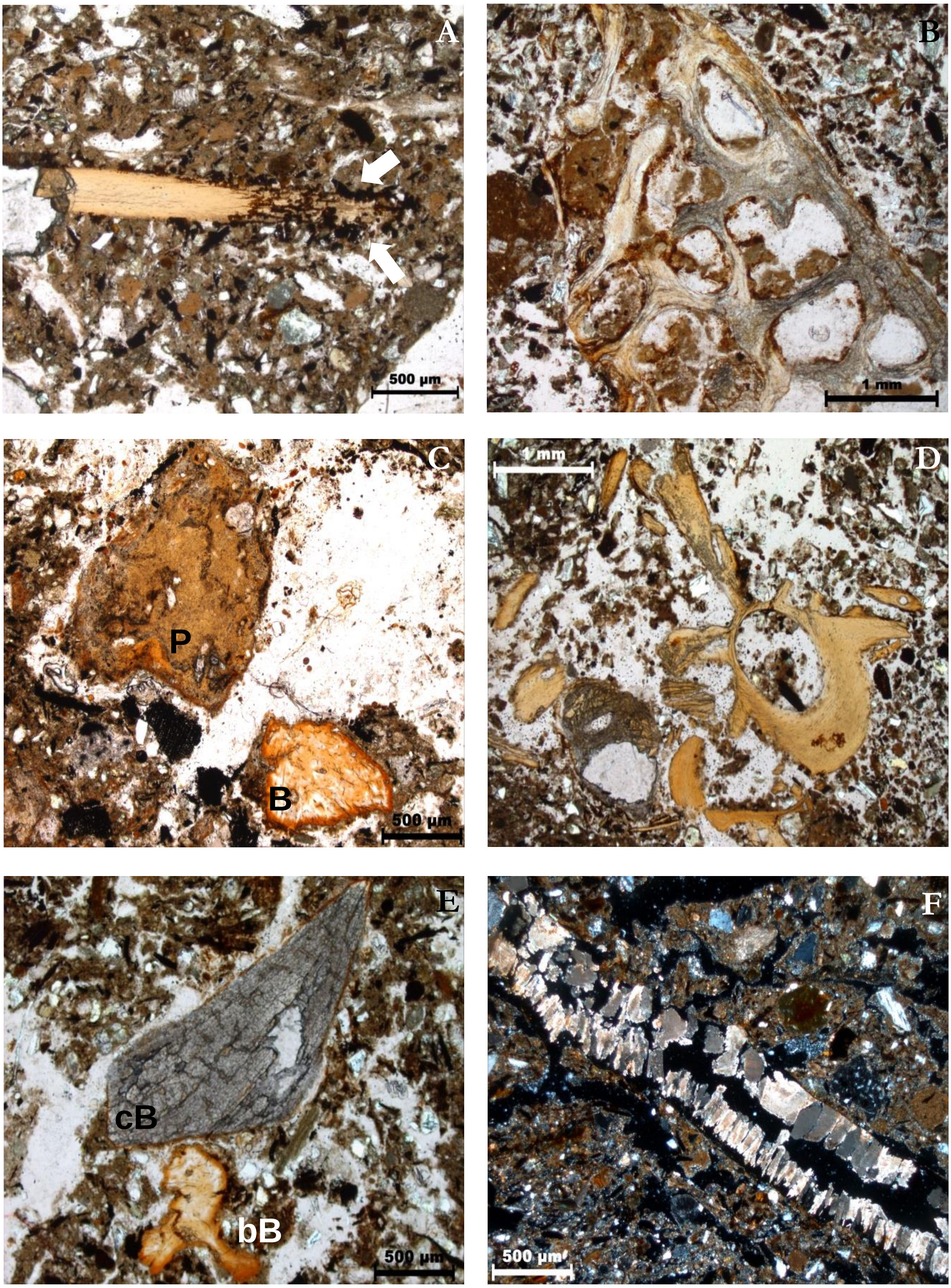



**Figure 7.31** Photomicrographs of organic inclusions. (A) Post-depositional iron staining of bone fragment, PPL. (B) Preserved porous bone showing severe superficial weathering and iron staining, PPL. (C) Phosphatic aggregate (P) and bone fragment (B) affected by taphonomic processes, PPL. (D) Fragmented bone remains showing a large number of microfissures, PPL. (E) Calcined (cB) and moderately burned (bB) bone fragments, PPL. (F) Fragmented eggshell, XPL.

These remains appear randomly oriented and distributed, with numerous large fragments of up to 5 mm size, indicating the absence of substantial trampling. The majority of the bones present are unburnt and in a good state of preservation. Vertebrae and few long bones of soil mesofauna have been identified towards the top of this layer in strong association with bioturbation features, suggesting that these remains could have been introduced into the deposit through reworking processes. Although the original bedding of this unit has been severely altered by post-depositional agents, some form of ill-defined internal layering is nonetheless visible in the distribution of charcoal remains, which appear grouped into two parallel microlayers within this deposit. Soil formation processes are evident in the presence of translocated clay nodules and channel voids, most of which show dusty clay coatings and well-developed formations of lenticular gypsiferous salts. The anisotropic, irregularly-shaped phosphatic aggregates encountered especially towards the top of this unit are derived from the decomposition of modern organic matter of plant origin, such as roots.

MU-2 is very similar in structure and composition to the layer above, with an important organic fraction formed mainly by charred plants and woods, the latter identified as *Juniperus* and *Ulmus*, tree species present in the local landscape and commonly found within the settlement as preferred firewoods (Asouti 2005b).

The mixed nature of the components forming this unit, including charred and calcined bones, burned sediment aggregates and charred plant fragments, suggests sedimentation by gradual accumulation of fuel discards. The original single depositional events, however, are no longer distinguishable due to the intensity of post-depositional alteration, which undoubtedly contributed to the homogenisation of this deposit, where no fine layering has been detected. Abundant gypsum formations have been found in association with bioturbation features.

The lowest part of field unit 30407, described as MU-3, appears slightly less disturbed than the deposits above. In this unit, intact peds showing original layering have been identified, consisting of parallel distributions of horizontally-oriented charred plant remains and herbaceous phytoliths, interspersed with aggregates of amorphous fine organic matter. The state of preservation of the organic fraction forming this deposit is remarkably better than in the units above.

The occurrence of pedogenetic processes is inferred from the high incidence of bioturbation and translocation features, specifically iron-enriched clay nodules and fragments of Bt soil. Well-developed gypsum formations are ubiquitous, occurring mostly as loose channel infillings.

A particular characteristic of this deposit is the presence of several parallel-oriented, superimposed and highly unaccommodated voids towards the top of the unit. These features are unlikely to have developed as a result of trampling, which typically causes the formation of vertical planes (Shillito and Ryan 2013). Although the processes behind the incidence of these voids remain unclear, it is suggested that they might be a consequence of the desiccation and decomposition of the plant matter forming this unit which, judging from the intact peds preserved, were originally disposed in horizontal laminations. The post-depositional development of gypsum infillings contributed further to the enlargement of these pores.

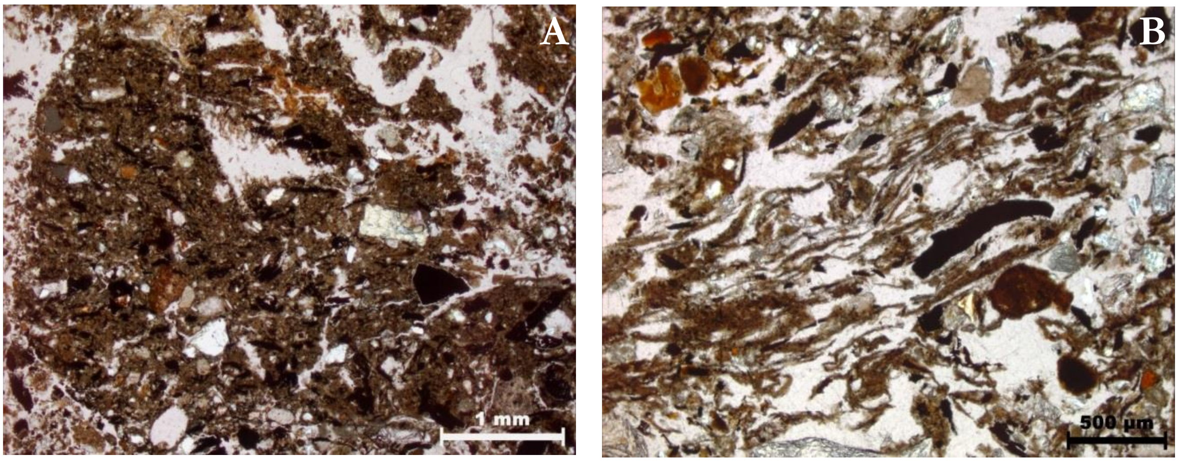



**Figure 7.32** Photomicrographs of inclusions found in midden deposits. (A) Preserved microfabric of midden ped showing a massive, non-porous structure, PPL. (B) Intact original bedding of microunit C with numerous plant remains in a strongly parallel to oblique referred orientation, PPL.

The nature and composition of the deposits forming the midden in Space 544 are consistent with the observations made from the same contexts in other parts of the settlement, also Late Neolithic in date (Shillito 2011b). Most of the midden appears to consist of homogeneous greyish material, a mixture of silty clay loam and burned plants, likely the discarded remains of fuel sources. Bones and shells were probably introduced into the deposits both during discard episodes and accidentally, having been transported from other parts of the site and re-deposited in open areas. Aggregates of faecal matter are absent from this sequence, in line with the microstratigraphic evidence gathered from several late middens on site (Shillito 2011a) and other fields of research (Doherty and Tarkan Özbudak 2013; Pearson 2013; Larsen *et al.* 2013), which point to greater mobility of humans and animals in the later levels of occupation at Çatalhöyük East, involving a drastic decrease in the amount of dung that was being disposed in open areas. The abundance of faunal voids and the poor orientation and porphyric related distribution of inclusions indicate that the homogeneous nature of this context is due to bioturbation and processes of reworking and mixing.

The abundance of secondary gypsum in this sequence is significant and probably a result of the periodic wetting and drying of the deposits, extensively formed by burned plant matter. This would have caused the dissolution and re-crystallisation of calcitic ashes that were probably present in this context alongside the discarded fuel materials (Dultz and Kühn 2005). Nevertheless, gypsum formations are commonly found in arid and semi-arid regions, including the Konya Plain, mainly as a result of the dissolution of calcium sulphates contained in rocks or sediments in the catchment and high evaporation rates (Herrero and Porta 2000).

These post-depositional processes have affected the state of preservation of the inclusions present in this context. Bones appear weathered and highly fragmented, probably due to reworking processes, and frequently coated by iron oxides, a result of the decomposition of phosphatic elements within the bone microstructure. Charcoal remains, although less affected by processes of weathering and dissolution, also show a high degree of breakage.

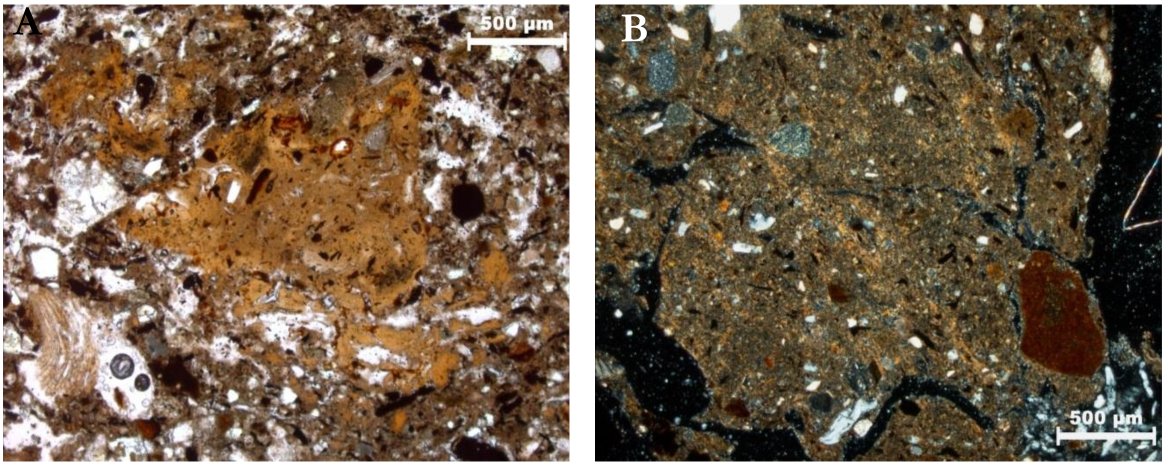



**Figure 7.33** Photomicrographs of inclusions found in midden deposits. (A) Phosphatic aggregate with microcharcoal inclusions, PPL. (B) Fine-grained minerogenic inclusion with striated b-fabric, XPL.

Overall, the midden in Space 544 has very little evidence for single activities suggesting, perhaps, a low intensity of deposition in this later period of occupation at the site. However, taphonomic processes at the top of the mound must be considered, as it is likely that any calcitic ash layers were altered. That been stated, it appears that the midden was entirely anthropogenic, giving the absence of wind or water-laid sediments. It is noted that this could be partly due to post-depositional mixing, and does not completely exclude the possibility of their presence, but it does imply that such deposits are not frequent and that midden accumulation was rapid, with no extended periods of exposure (Simpson and Barrett 1996).

If this area of the site was used during the Neolithic as a street or passage-way, the deposits here would have been subjected to a considerable degree of trampling and compaction. However, no trampling indicators have been successfully identified in the sample analysed. Some of these include *in situ*, post-depositional crushing of bones and plant remains (Miller *et al.* 2010), moderate vertical sorting of rocks and bio-archaeological inclusions (Nielsen 1991), compression of sediments, low porosity and crust formation (Goldberg and Macphail 2006), undulating boundaries, especially common in deposits with a high organic content (Shahack-Gross 2011), and vertical cracking of the surfaces (Shillito and Ryan 2013). Nevertheless, it is important to keep in mind that these attributes have been described largely for minerogenic deposits. There is still insufficient ethnographic and experimental data regarding the effects of intensive trampling on organic deposits, with the exception of stabling contexts, where massively compacted, non-porous laminated layers are predominant (Shahack-Gross *et al.* 2003). It is also worth considering that midden contexts, usually formed through continuous, gradual deposition, might not show the effects of intense trampling because insufficient time was allowed to pass for these features to appear on the midden surface at any given time before the next disposal episode. Rapid accumulation in midden spaces could have thus contributed to the absence of trampling features, although this would also cast doubts on the generally accepted idea of middens being systematically used and conceived as passageways.

Nevertheless, it appears clear that no deliberately constructed layers occurred in this context, in marked contrast with the formally laid trodden surfaces described by Shillito and Ryan (2013) for open spaces in the South Area of Çatalhöyük, or the monumental pebble streets of Aşikli Höyük (Özbaşaran 2012). Overall, there is insufficient evidence to support Mellaart's original interpretation of this sequence as a Neolithic street.

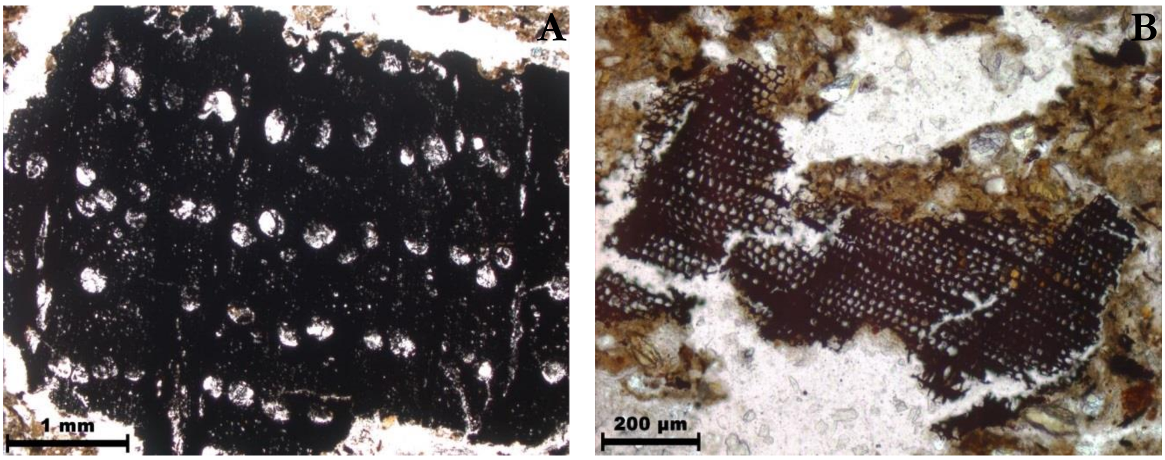



**Figure 7.34** Photomicrographs of charcoal remains identified in thin-section. (A) *Ulmus* wood, PPL. (B) *Juniperus* wood, PPL.

The three TPC middens studied, two of which remain unexcavated, represent the latest levels of Neolithic occupation at Çatalhöyük, assigned at present to Mellaart levels IV-I. The earliest midden deposits examined in this area are characterised by their considerable thickness, which ranges between 3 and 5 cm, and high minerogenic fraction, formed by gradually deposited sediments of various origins and rounded aggregates derived from sweeping activities. These features, in addition to the marked compositional homogeneity of these deposits, point to slow rates of accumulation. The brown colour of these layers appears to be due to the presence of organic matter associated with iron oxihydrates. Approximately 10% faecal aggregates of suspected omnivore origin have been detected in these sediments. Other anthropogenic inclusions identified in these deposits include variable proportions of charred plants (*ca.* 20-50% abundance) dominated by *Juniperus* and *Ulmus* charcoal, phytoliths derived from reeds and grasses such as stacked bulliforms and smooth long cells, and large bone fragments (*ca.* 5-15%) up to 6 mm in length. Overall, discarded fuel remains and other by-products of combustion appear to form the organic fraction of these deposits, whereas the inorganic aggregate material is mostly unburnt, possibly due to its origin as room sweeps and naturally deposited sediments.

However, a shift in depositional patterns has been detected by Mellaart level II-I in this excavation area. The uppermost midden deposits in the TPC sequence are characterised by their extremely high organic content, a result of the multiple plant microlaminations that constitute these contexts, representing a rapid build-up of materials in this later period. Situated between buildings, these middens appeared macroscopically as a very ashy discard area rich in charred and silicified plant remains. The major components of these deposits, as determined through thin-section micromorphology, are calcitic ashes (5-40% abundance), herbaceous phytoliths (10-60%), and *Juniperus* charcoal (10-50%), all of which display strong parallel orientations, although trampling or compaction indicators have not been found in this sequence. This might indicate that this area was mainly used as the setting for the lightening of open air fires, activities that resulted in a rapid build-up of materials, as the preservation of ashes and conjoined reed and grass phytoliths suggests. The abundance of siliceous plants is highly variable in each layer, forming up to 60% of some microunits where the articulation displayed by these residues has allowed the identification of *Cyperaceae* and *Phragmites* stems. The occurrence of these plant remains within these Late Neolithic levels suggests continuity in the use of wetland resources, in spite of the increasingly drier environmental conditions in the Konya Plain (Asouti 2005). Due to their proximity to the topsoil, however, a large proportion of these midden layers show evidence of bioturbation in the form of root action associated with gypsum re-crystallisation, channel voids caused by microfauna, and pedogenesis.

**Figure 7.35** Massive midden deposits in the TPC Area displaying a high proportion of minerogenic components.

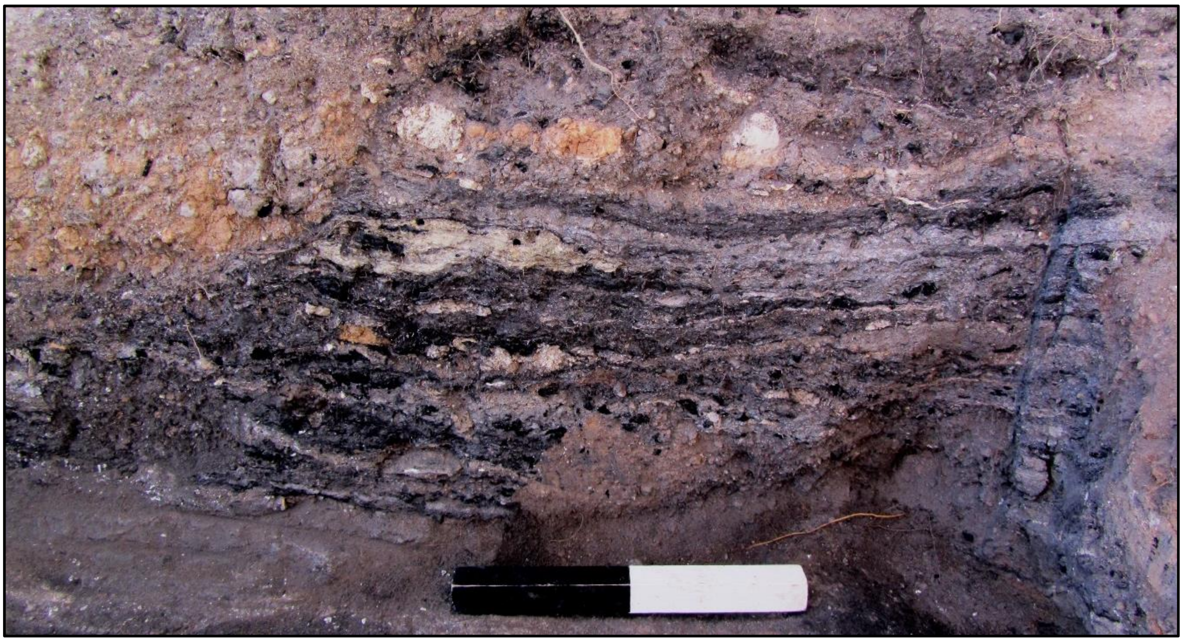


**Figure 7.36** Finely laminated midden layers, found in the uppermost levels of the TPC Area, formed by calcitic ashes, charred plants, and herbaceous phytoliths, representing build-ups of *in situ* plant fuel used in open fires.

The complete absence of dung and faecal aggregates in these latest middens at Çatalhöyük is intriguing. In fact, this pattern could be indicative that animals were kept away from the site during this period, perhaps taken to pastures situated a few kilometres away from the settlement, an ecological strategy that entails a significant increase in mobility. This hypothesis had already been suggested by other specialists based on skeletal, faunal, and isotopic evidence from these later levels of occupation at Çatalhöyük East, which indicate increased exploitation of the wider landscape during this period (Larsen *et al.* 2013; Pearson 2013; Russell *et al.* 2013).

### 7.3.4 Household differentiation and society

As it was mentioned in Chapter 2, Hodder and Pels (2010) identified the occurrence of special buildings at Çatalhöyük, categorised as 'history' houses based on the evidence for several reconstructions and history-making activities, such as the retrieval of murals and reliefs after the abandonment of these buildings. In his exploration of social differentiation at this large settlement, Hodder (2013b) developed this classification further to include two more categories of special buildings: burial houses, containing large numbers of individuals interred beneath their floors, and large/elaborate houses, buildings that display a high degree of symbolic elaboration manifested in the presence of ritual features such as bucrania, mouldings, and wall paintings. However, this classification of buildings into strict house types, i.e. 'special' or 'others' entails the risk of masking flexible strategies and blurring architectural variability at this settlement, forcing the classification of buildings into these fixed categories, a practice that eventually affects the way in which their evidence is interpreted archaeologically.

The microstratigraphic evidence from building sequences examined in this study demonstrates the existence of more similarities than differences between households in terms of the selection of architectural sources and concepts of space. The main rooms of buildings at Çatalhöyük display a marked division of space into clean, (usually towards the north), and dirty (southern part of the house where fire installations are commonly located) areas, both of which consist of a series of floors and raised platforms of variable heights coated with multiple layers of plaster. As the micromorphological categorisation reported in Chapter 5 has demonstrated, the origin of these floor plasters, dependent on the selected natural sediments used for their manufacture, was variable. In general, all plasters were prepared by mixing the sediment with water and stabilisers, usually plant chaff but occasionally also charred flecks and re-utilised fragments of architectural materials such as wall, floor, and oven plasters. Surprisingly, herbivore dung does not appear to have been considered an appropriate temper for floor construction materials by the residents of this settlement. The prepared mixture was then applied to the floor area, carefully compacted to produce a smooth and even surface, and left to dry (Houben and Guillaud 1994; Matthews *et al.* 1996; Matthews 2005b).

It has been observed, based on the assessment of plaster sequences from the main rooms of Building 89, 77, and 114, that mud-based plasters are generally more frequently selected that calcareous, marl-based plasters. It is here acknowledged, however, that this pattern can be due to the perceived properties and symbolic status of specific materials, possibly indicating that the use of this sediment as floor material was linked to the marking important events during the life-history of the building. In this regard, ethnographic studies have demonstrated the symbolic connection between the selection of specific materials for wall and floor plastering events, and the occurrence of particular household events or rituals (Boivin 2000).

Building 89, in particular, shows a very consistent choice of architectural sources, especially in its clean area. Here, cyclical patterns of floor construction involving the exact same sediment materials have been identified. Twenty-six occupation surfaces were detected in total, displaying thin soot accumulations and, occasionally, wavy upper boundaries that suggest the regular use of mats in this area of the building. Overall, only six calcareous floors have been identified, again demonstrating a preference towards mud plasters.

Previous research on the provenance of the Çatalhöyük architectural materials has allowed the sourcing of a range of floor and wall plasters to the local environs of the site, in particular the marl and grey reduced-backswamp deposits (Anderson *et al.* 2014a; Matthews *et al.* 2013; Wiles 2008). According to these studies, the white plasters found on some building platforms, as well as the finishing coats on walls are made of softlime sediments. Interestingly, whilst marl is present directly below and around Çatalhöyük (Roberts *et al.* 2007a), the nearest source of softlime outcrops 5-6 km away from the site (Driessen and de Meester 1969), so the collection of these sediments must have entailed a considerable amount of labour. Further, although softlime plasters were identified in this study based on micromorphological characteristics, the elemental analysis of these materials did not confirm this identification due to the absence of dolomitic minerals. Thus, the sparsity with which softlime floors plasters have been documented across the site in this, and previous studies (Matthews *et al.* 2013) denotes their special status, possibly related to their very light colour (white in the field and pale grey under the microscope), which could have conveyed concepts of purity (Matthews 2005b).

The source for the orangish brown silty clay plasters, classified as deposit sub-type CH2c based on micromorphological observations, has not yet been clearly established (Doherty 2007; 2009; Doherty *et al.* 2008; Matthews *et al.* 2013). Doherty (2013) argues that the environment around Çatalhöyük, interpreted as an extensive backswamp, must have included channels that flooded large areas where the sediments were better oxidised. These channel sediments, however, were not identified during the several geoarchaeological surveys that have been undertaken around the site's immediate landscape. Other explanations have been suggested, such as the occurrence of a change in the upper catchment of the Çarşamba river that altered the sediment supply, resulting in the availability of new reddish clays, and the human-induced exposure of deep deltaic sediments that interbedded with the marl in areas around the site, although these possibilities remain hypotheses to be validated.

Many of the floor plasters observed at Çatalhöyük were manufactured from a variable mixture of sediments, including marl, lower alluvium, and backswamp clays, resulting in a wide diversity of materials. Further, anthropogenic refuse from middens and hearth rake-outs, in addition to recycled materials such as fragments of wall plasters and baked floors, were often added to coarse clay loam plasters during the manufacture process, as attested by micromorphological observations, which greatly complicates the sourcing of these architectural materials.

In the case of oven and hearth plasters, post-depositional modifications including changes in colour and cracking due to heat impact, surface erosion, and the development of vesicle voids makes any attempt at sourcing these deposits impractical.

This overall patterning suggests that similar practices were taking place across contemporaneous buildings, and shows that although production was done at a house-based level and likely in different temporalities, the knowledge of this production was shared across households. Similarly, plaster sources, while numerous even within a single house, show considerable continuity through the different buildings studied here. The production of plasters then, although carried out at a household level, may well have been implemented through shared networks and collaboration.

### 7.3.5 Open spaces and external activities

The spatial configuration of a settlement is constitutive of the social order. In daily practice, it determines to a large degree in what manner people behave, and through their behaviour, how they constitute social networks. In addition to performing domestic and possibly group activities on middens and building tops, people would have regularly moved across these two types of open space on their way to and from their houses, probably also spending a considerable amount of time performing fire-activities in these areas, such as plaster production and pottery manufacture (Shillito and Ryan 2013; Shillito and Matthews 2013). We could argue, then, that interaction within these neighbourhoods must have been intense. Some scholars have suggested the existence of a social structure based on spatially segregated neighbourhoods at Çatalhöyük, arguing that people using the same roofscapes formed a social collective with a specific group identity grounded in shared activities and daily interactions (Düring 2010).

Although only two samples from rooftop sequences have been analysed in this research, partly due to the scarcity of this type of materials on site, current data hints at long-term changes in the nature and function of roofs within the site. This might indicate that rooftops were perceived as flexible spaces, not as strictly subjected to recurrent daily practices and divisions as ground floor, internal areas.

The openness of rooftops to surveillance would create a strong pressure to conformity, but it would also provide the possibility for cooperative labour in tasks that do not require a large amount of space, such as flintknapping and some stages of crop processing. The use and/or occupation of rooftops and upper storeys raises questions of property rights and obligations to share more clearly than middens and courtyards do, as it is possible that these spaces did not fit well in the traditional open/domestic divides.

Finally, the microstratigraphic evidence from Space 544 in the GDN Area has shown that, in spite of the importance of streets and pathways for understanding settlement architecture and general movement within the site, the safe identification of these contexts at Çatalhöyük continues to be elusive. The overarching absence of formally constructed surfaces, with few exceptions in the later levels of occupation, and the special nature of open contexts, consisting of gradually accumulated discards and generally very rich in organic materials, contribute to the invisibility of open streets at this site. Further research involving macroscopic observations of potential passageways during excavation combined with targeted microstratigraphic sampling on one side, and comparative studies comprising ethnographic and experimental street sequences on another, are deemed essential to widen our current knowledge of division and use of open spaces at Neolithic Çatalhöyük.

### 7.3.6 Conclusions: intra-site socio-economic dynamics in a Neolithic megasite

It is here considered that the most important contribution of this study has been the excavation and microstratigraphic investigation of the small Building 114. A number of factors supports this statement. Firstly, this built environment shows most of the traits of a 'special house', namely, symbolic elaboration, high number of burials – eighteen individuals in total, in contrast with the eleven found in the much larger Building 3 immediately to the north of it – and intense rates of occupation and renewal, with the exception of size. Secondly, the division of space found in larger buildings at Çatalhöyük is also found here, albeit in a different arrangement: the kitchen area is against the north wall, whereas decorative features such as reliefs and wall paintings are found in the south wall. The burial platform is in the eastern end of the house, alongside with clean floor plasters, which occupy the eastern half of the main room, and the area along the south wall. The storage room, Building 88, is situated to the east of the main room, Space 87, and accessed through a crawlhole. Overall, it appears as if the inhabitants of this built environment had to accommodate the maintenance of spatial and social conventions to the limits imposed by the size and layout of this space.

Building 114 is definitely an oddity within the settlement layout of Çatalhöyük, and the preliminary results from this building make it tempting to speculate on the form of the group of people associated with this built environment, especially giving its limited usable space for living and storing. There is a strong possibility that Building 114 was embedded in larger social associations in the form of corporate or neighbourhood groups, as suggested by Düring and Marciniak (2006), especially due to its earlier physical connection with Building 113 and/or its predecessor, and large number of buried individuals.

In this respect, it is interesting to note that the BACH team claimed that the evidence from Spaces 87, 88, and 89 demonstrated that some functions of the larger Building 3 to the north were transferred to these structures, albeit possibly on a temporal basis (Stevanović 2012a). Although this would be plausible in special circumstances, such as the time span during which an old house was abandoned and infilled and a new one constructed and inhabited, or when a building was undergoing major repairs, the occurrence of hiatuses in the occupation of these smaller spaces would have to be demonstrated. Further, although the interpretation of small built environments as available transitional habitable spaces for one or more households in a given neighbourhood during specific periods would be a reasonable mechanism of residential cooperation, the microstratigraphic evidence from Building 114, which displays a high intensity of occupation and a continuously occupied sequence with no discernible abandonment episodes, does not confirm this hypothesis.

In fact, the average building size in Level VI, to which Building 114 apparently belongs, is the smallest for the whole length of Çatalhöyük occupation, and this period, around 6 500 BCE, immediately precedes the demise of the clustered neighbourhood at this settlement in Level V (Hodder and Farid 2013), a process to which Building 114 is undoubtedly related.

What appears as clear is that this building, comprising Spaces 87 and 88, probably started its life as an annex of a larger house, likely Building 113, and later became a more independent and complex structure showing abundant traces of domestic use and continuous, intensive occupation, a transformation that highlights the diversity and flexibility of domestic practices and concepts of space at this large Neolithic settlement.

## 7.4 Resources and networks at Pinarbaşi

The rockshelter of Pınarbaşı, located 32 km to the southeast of Çatalhöyük, in the margins of the plain, has been interpreted as a seasonal campsite used by hunter/herders (Baird *et al.* 2011b; Watkins 1998). Briefly occupied in the Epipalaeolithic, the focus of this research is Area B, for which two $^{14}C$ dates are available (6,415-6,160 cal BC and 6,069-6,064 cal BC), indicative of the occupation of this rockshelter during the second half of the $7^{th}$ millennium (Watkins 1996).

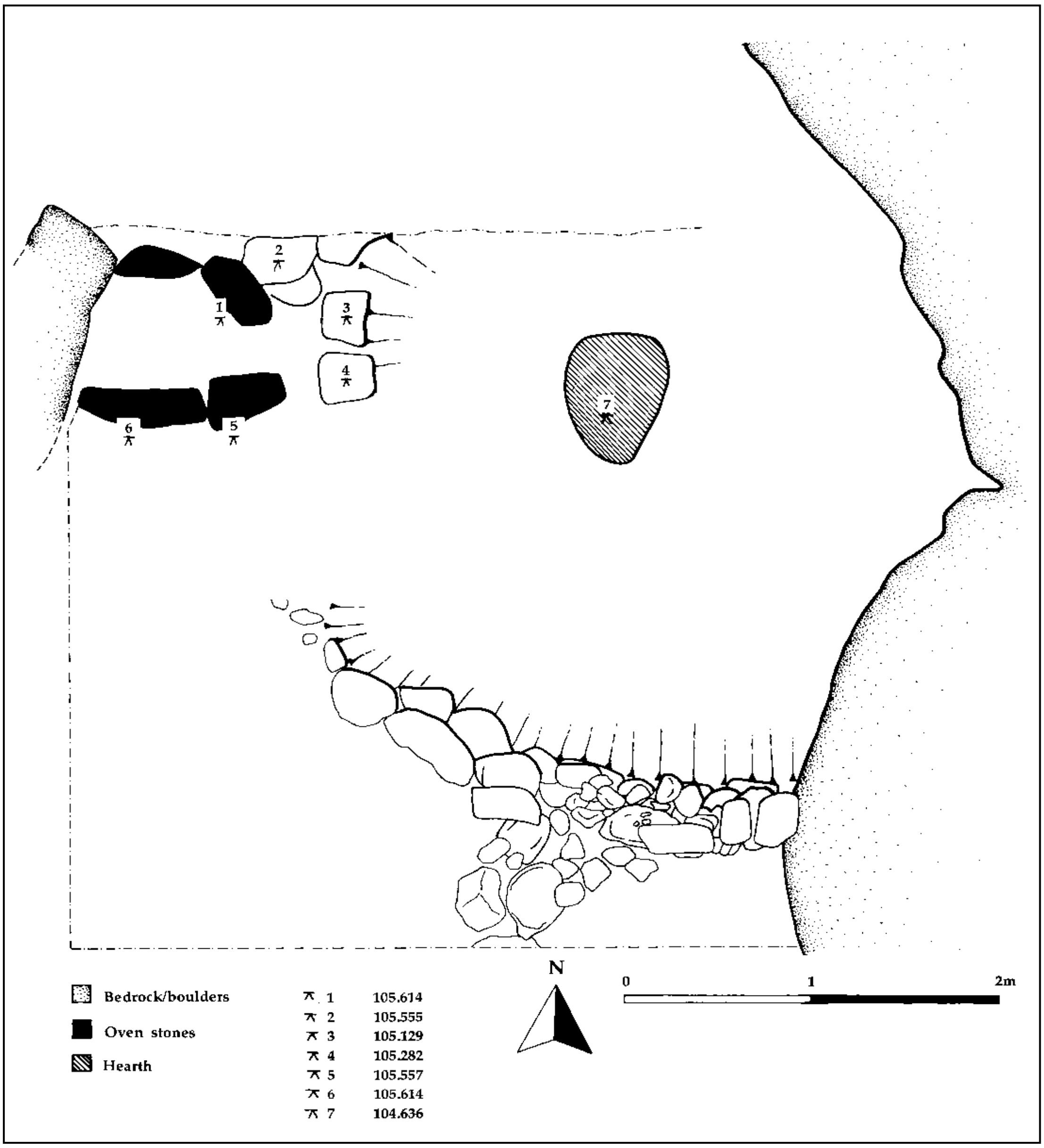



**Figure 7.37** Plan of Area B at Pınarbaşı. Source: D. Baird, pers. comm.

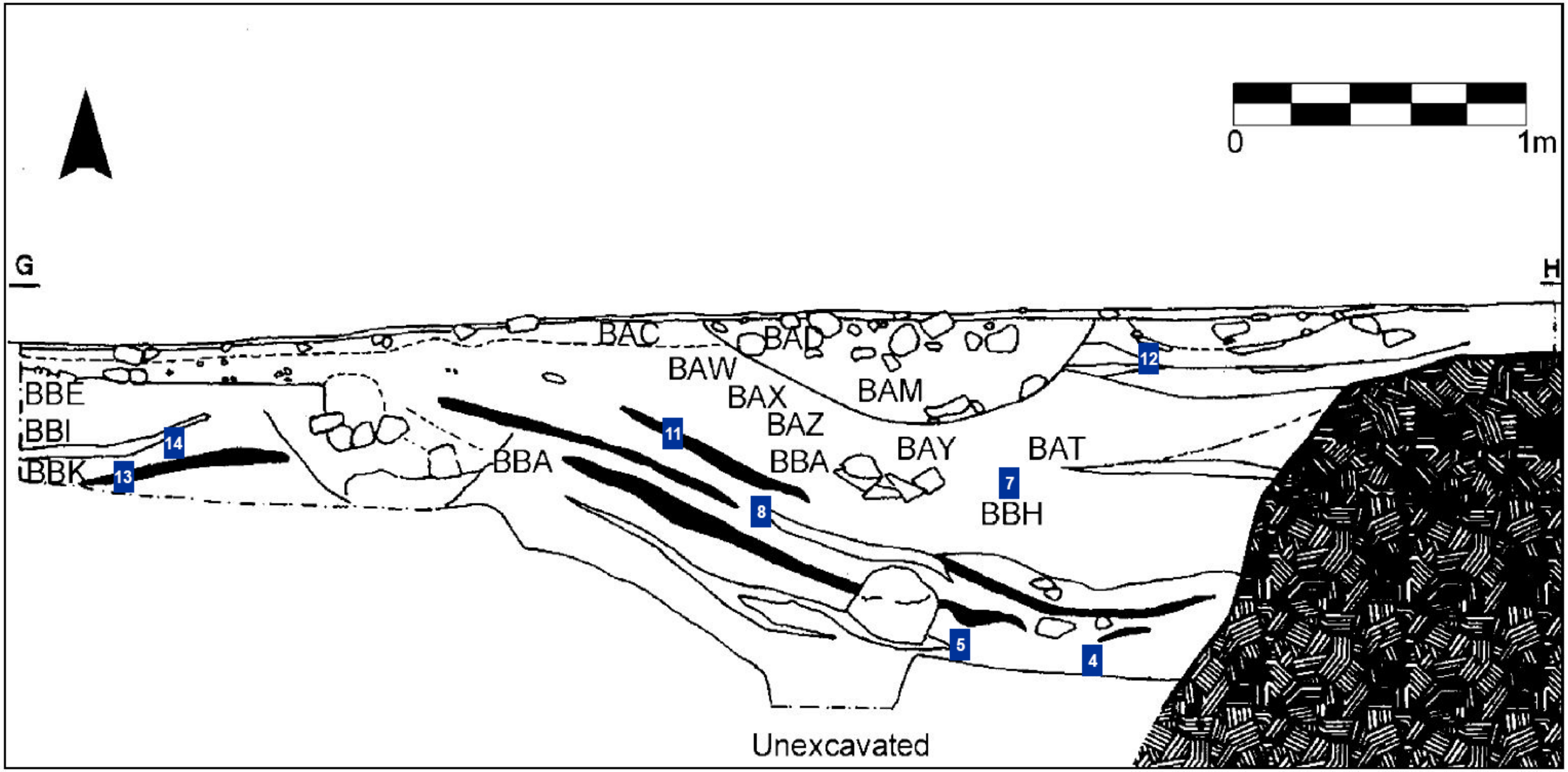



**Figure 7.38** North section of excavation Area B at the Pınarbaşı rockshelter displaying the location of the block samples analysed in this research.
Source: after D. Baird, pers. comm.

Due to the small size of this site, which occupies a maximum extension of 400 $m^2$, only one building was studied, although its sequence had been systematically sampled for micromorphology during fieldwork. Open spaces, which include accumulated midden deposits and activity areas, have also been examined to investigate daily practices and behavioural patterns that might not be present in building contexts.

### 7.4.1 Indoor spaces and internal activities

According to Baird *et al.* (2011b), the 7th millennium occupation of the rockshelter comprises three phases of activity: the first one, Phase F, is represented by a number of large fire pits filled with bones and stones; the second, Phase E.I, comprises a habitation that contains a central hearth and a mass of carbonised reeds, which has been interpreted as the collapsed plant cover of the roof. The last phase, E.II, consists of accumulated fills of natural and anthropogenic materials derived from both occupation and dumping practices.

The micromorphological evidence examined in this research corresponds to the last phase of activity in the rockshelter, comprising multiple thick layers of re-deposited materials with variable proportions of charred woods and plants. Although suspected prepared occupation surfaces, consisting of thin, minerogenic silty clay deposits, were identified through thin-

**Figure 7.39** Plastered bones at Pınarbaşı. Source: D. Baird, pers. comm.

section micromorphology (sub-type PB1a), results from the chemical analyses have failed to support this hypothesis, as no significant differences have been found in the elemental composition of these suspected floors and the accumulated layers of occupation remains. Remarkably, no deposits or components have been found *in situ* in this sequence, which is formed by massive, loose, and highly reworked sediments filling the habitation structure.

Perhaps even more significant is the absence of trampling or compaction indicators. Burnt materials of organic origin, in particular, do not appear particularly crushed or fragmented, which points towards quick transport and deposition, likely close to the locus of primary activity. Similarly, no natural deposits, such as water-laid sediments, have been observed in the

**Figure 7.40** Habitation structure in Area B at Pınarbaşı, displaying stone walls and massive units of accumulated remains. Source: D. Baird, pers. comm.

stratigraphy. However, it is important to note here that this sequence has been severely altered by post-depositional bioturbation and, especially, gypsum formation.

Overall, the microstratigraphic patterning of this building does not suggest permanent habitation. Floor plasters are absent from this record, even though this material was familiar to the occupants of the rockshelter, as seen in the several plastered bones excavated at this site (see Fig. 7.39). Further, interior divisions of space have not been distinguished microscopically. In fact, the continuous dumping of materials inside this structure is somehow reminiscent of discard practices in middens. The occupation deposits observed within this construction contain materials resulting from diverse natural and anthropogenic processes, such as charred plant and dung remains used as fuel, bone fragments indicating animal processing and consumption, and sub-angular limestone clasts pointing to the erosion and weathering of the rockshelter, incorporated into the sequence through slope movements and cleaning/filling activities performed episodically at the end of occupation periods.

This evidence contrasts with the highly maintained domestic structures at Boncuklu and Çatalhöyük, and suggests temporality in the occupation of this structure. In fact, this study has observed a clear pattern of interchange in the accretion of the accumulated layers that form the building sequence at Pınarbaşı. Although wind- or water-laid sediment crusts have not been indisputably identified, possibly due to the high degree of alteration of the deposits caused by gypsum formation, discontinuity in the intensity of use of this habitation is manifested in deposit type PB2c. The low concentration of materials of anthropic origin and high percentage of rock fragments and sediment aggregates that characterise these layers possibly correspond to periods of site abandonment. The anthropogenic nature of these units is not always explicit due to the substantial colluvial input and the important accumulations of eroded rocks and sediments. Thus, the alternation of deposit types representing specific discard events and episodes of general accumulation seems to indicate periodic variation in the occupation of this rockshelter, likely as part of a seasonal ecological strategy, as suggested in previous studies of faunal and macrobotanical remains (Baird *et al.* 211b).

In spite of these results, some conventions involving spatial boundaries appear to have been in operation at Pınarbaşı, as herbivore coprolites, ubiquitous in open areas at this site, are almost completely absent from this building sequence. The very few faecal aggregates that have been identified in thin-section were probably accidentally incorporated into the charred dumped materials or, alternatively, introduced through the soles of the feet of the occupants of this structure.

### 7.4.2 Open spaces and external activities

As indoor spaces, open areas at Pınarbaşı do not show clear spatial boundaries or structuring of any sort. Temporary fire spots have been identified on two locations within this rockshelter, displaying abundant charcoal remains and, to a lesser extent, herbivore dung aggregates rich in calcitic spherulites. These deposits are dominated by large (*ca.* 1 cm) fragments of tree bark, likely derived from branches and twigs, occurring in association with charred herbivore dung, indicating the use of mixed fuel sources. Thus, fuel choices at this campsite appear based on immediate availability rather than fuel properties per se, since both dung and firewood would have been abundantly and easily accessible to these herders on the hills surrounding Pınarbaşı by this period (Asouti 2003).

Other activity features, such as the pits and the distinct concentrations of materials found in open contexts at the sites of Boncuklu and Çatalhöyük, indicating intensive use of external areas, are completely absent from the microstratigraphic record of this rockshelter.

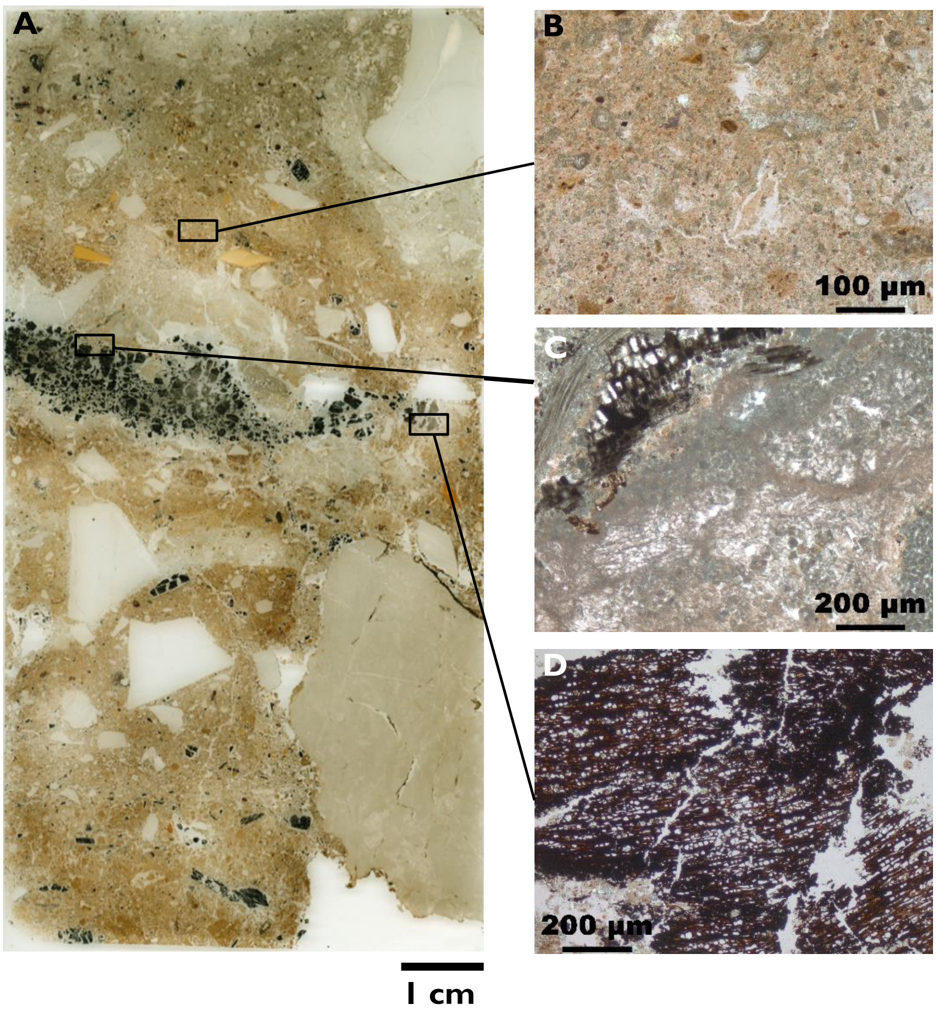



**Figure 7.41** Fire spot found in an open space at Pınarbaşı: A) scan of thin-section PB 1; B) dung ashes, PPL; C) wood-derived ashes, PPL; D) fragmented charcoal remains, PPL.

Midden deposits, formed by discarded and re-deposited materials, are substantially minerogenic at Pınarbaşı, especially when compared to similar contexts from Boncuklu and Çatalhöyük. These layers are characterised by very high percentages (>50%) of reworked and re-deposited herbivore dung, some of which is charred. These faecal aggregates are rich in phytoliths and calcium carbonate spherulites, and occur mixed with other materials such as dispersed ashes, charred plants, bone fragments, and limestone clasts detached from the rockshelter, indicative of dumping and re-deposition.

The faecal matter identified on site is suggested to derive from ruminant dung, particularly ovicaprines, as faunal remains from Pınarbaşı include a substantial proportion of herded sheep (Baird *et al.* 2011). These aggregates display abundant inclusions of siliceous plant remains, specifically single-celled phytoliths such as bulliforms and other short cells produced by reeds and grasses. These phytoliths belong mainly to the Pooideae subfamily, common in well-watered environments. The occurrence of diatoms and sponge spicules within the dung further attests the recurrent exploitation of local marshland to the north and west of the site for fodder and animal grazing.

The absence of trampling indicators in these layers such as compaction, massive or laminar microstructures, finely layered bedding, strong horizontal orientation of embedded inclusions, and crushing of bone, shell and charcoal fragments (Matthews *et al.* 1996; Milek 2012), dismisses the interpretation of these open sequences as penning areas. Rather, the occurrence of charred and partially calcined faecal matter strongly associated with calcitic ashes and darkened spherulites points to the recurrent collection and subsequent use of dung as fuel at 7th millennium Pınarbaşı.

Interestingly, although the faunal remains from Pınarbaşı, predominantly formed by sheep/goat, have been interpreted to indicate the processing of animal carcasses on site (Baird *et al.* 2011b), contributing to the characterisation of Pınarbaşı as a hunting/herding locality, microscopic bone fragments are generally sparse in the sequences analysed.

Finally, it is important to note that these midden deposits are characterised by extensive reworking and post-depositional alterations caused by gypsum re-crystallisation, factors that could potentially be masking anthropic indicators of specific *in situ* activities performed in open contexts at this site.

### 7.4.3 Conclusions: Intra-site socio-economic dynamics in a herder campsite

The microstratigraphic evidence from Pınarbaşı seems to render support to the initial interpretation of this site as a temporarily occupied herding locality (Watkins, 1998; Baird *et al.*, 2011). The midden samples analysed from the rockshelter in particular, show a very high concentration of faecal remains rich in calcareous spherulites, likely derived from ruminant species such as sheep (Canti, 1997; Canti, 1999). Other occupation materials found at this site include mixed ashes, charred plant remains, and few bone fragments, suggestive of the specialised economic nature of this locality, where only a small range of activities has been detected, as opposed to larger, permanently inhabited Neolithic settlements.

Overall, the composition of archaeological layers at this site seems to point to an episodic nature of deposition, specifically related to burning and massive dumping and including possible periods of abandonment represented by accumulations of limestone clasts from the cliff-face and natural sediments. Ecological strategies focused on the collection of fuel sources appear rather opportunistic in nature, motivated by immediate availability. As such, herbivore dung, in addition to woods from trees that were likely growing on the hills surrounding the site by this period (Asouti 2003), were the main fuel materials used at Pınarbaşı.

In light of this evidence it would be reasonable to hypothesise, based on the environmental model proposed by Roberts and Rosen (2009) involving a large nucleated settlement with fission and fusion of population aimed at exploiting a wide landscape region, that Pınarbaşı was regularly visited by task groups from Çatalhöyük focused on pastoral activities, a possibility already suggested by Baird *et al.* (2011b). Although it is impossible to test this hypothesis based solely on microstratigraphic data, the evidence for increased mobility in the later levels of occupation of the East Mound, in addition to the practical absence of herbivore dung in midden areas at Çatalhöyük and the ubiquity of these remains at Pınarbaşı, appear to support this view.

# 8

# CONCLUSIONS

## 8.1 Methodological, analytical and interpretative issues

During the course of this research, an integrated multiscalar methodology has been developed to investigate complex stratigraphies formed by finely layered deposits with the aim of extracting all the relevant information from these units. This methodology included a microstratigraphic excavation approach comprising also pXRF and digital recording systems, thin-section micromorphology, a technique that is becoming increasingly important in the study of prehistoric sites worldwide, and elemental characterisation techniques including XRF, XRD, FTIR, SEM-EDX, and IR microscopy.

The main aims of this research were to examine building and open sequences from three Neolithic sites in the Konya Plain, namely Boncuklu Hüyük, Çatalhöyük East, and Pınarbaşı, to investigate key research issues related to ecological strategies and settlement dynamics at high spatial and temporal resolutions. Floor construction materials and fuel sources, in particular, have been studied as evidence of landscape use and resource selection, whereas accumulated layers of occupation residues have provided indicators on activities and concepts of space. Further, the social role of open spaces at these three settlements has been explored through the examination of midden contexts and roof sequences.

From a methodological point of view, a full understanding of the limitations of each technique is essential to use them constructively. In the case of elemental analyses, for example, the chemical signals from the embedded organic remains and post-depositional features such as gypsum and carbonate infillings, affect the results. Micromorphology also poses similar difficulties, in particular the quantification of components, usually based on comparative charts rather than precise measurements. However, a combination of both approaches, focused on the integration of the contextual information provided by micromorphology with the precise chemical data obtained through geochemical techniques, has resulted in the formulation of robust interpretations of archaeological deposits and formation processes in this research.

Further, in order to avoid the scale problems that are present in every multi-scalar investigation, the micromorphological thin-sections were observed at the mesoscopic level by eye, and through scanned high-resolution images of the slides, which allowed visual comparisons with field sections and data before the microscopic analysis of the samples. This level of observation has been deemed essential to gain a better overview of the sampled context and its features, in addition to the interrelationships of different scales of analysis.

### 8.1.1 Excavation of finely laminated occupation deposits

1. How can we improve the excavation, recording, and analysis of finely stratified occupation sequences from archaeological sites?

Although it was originally hypothesised that the micro-stratigraphic excavation of occupation sequences, involving the use of field sections, baulks, and plinths to document the vertical dimension of the stratigraphic units forming the occupation sequence of buildings would result in a better understanding of their depositional histories, this approach proved inefficient when applied to Space 87 at Çatalhöyük. The vertical pattern followed during the 2013 micro-stratigraphic excavation of Space 87, consisting in leaving sections every 1m in order to enhance the visibility and differentiation of millimetric layers, was abandoned the following season. The arbitrary field sections, although displaying crucial stratigraphic relationships, proved to be a problem as complete phases of activity were never fully seen, thereby impeding significant interpretations on associations of features, deposits, and finds. Interestingly, the regular use of sections and baulks at Çatalhöyük was already criticised during the early excavations for entailing the arbitrary fragmentation of whole units and blocking the view of complete building phases. In the case of the micro-stratigraphic excavation of Space 87, the main disadvantage was that, although the presence of sections facilitated the extraction of micromorphological blocks, the difficulty involved in resolving the macroscopic interpretation of the often partly exposed excavated contexts in the field greatly affected the sampling process, as it was frequently very difficult to establish the extension and representativeness of particular deposits with respect to the occupation sequence of the space. This problem continued during the early analysis of the micromorphological thin-sections, when macroscopic (i.e. excavation) and microscopic data were brought together to achieve an accurate understanding of the contexts being examined. As the field information available was sometimes inconclusive regarding the nature and deposition of a particular context, so was the microscopic examination of the same context, making it impossible to develop a coherent idea of what it was as a whole. This proved to be a great disadvantage as in geoarchaeology, it is often only through the tight integration of field and laboratory data that the rejection of the least plausible hypotheses can be effectuated, which eventually results in the formulation of more solid interpretations of the archaeological record.

However, it is worth noting that Space 87 turned out to be far more complex than it was initially expected, displaying over nine structural cuts and multiple re-building and repair episodes of interior furnishings, which rendered this excavation approach very unsuitable. Some disadvantages involved the occurrence of finds by the section, which could not be fully excavated, and the impossibility of excavating full contexts, as layers would often continue beyond the section making their interpretation in the field almost impossible. To make things more difficult, a single layer could have up to three different unit numbers, as these were assigned exclusively to the deposits, whether fully or partly exposed, encountered in the small area of the building under excavation (approximately 1.7 x 1 m). This strategy, although logistically necessary to ensure the processing of each 30-litre standard flotation sample during the excavation season, made the elaboration of the Harris matrix for this building, crucial in the elucidation of stratigraphic relations of deposits and features, an extremely complicated process. It was because of these problems that this excavation strategy was abandoned and a new, more flexible one, involving permanent baulks and temporary plinths in key locations was adopted, allowing for both geoarchaeological sampling and microstratigraphic recording.

Ideally, this field approach would have resulted in liaisons with particular specialist teams, such as heavy residue, palaeobotany, and artefact studies, as the micro-stratigraphic excavation of finely-laminated deposits provides a better temporal and spatial resolution for the environmental and artefactual remains recovered from each unit, an aspect that could be of interest for specific lines of research focusing on micro-residues. In practice, however, the large size of the team at Çatalhöyük has made this impossible to coordinate due to logistic difficulties.

### 8.1.2 Evaluation of micro-analytical geoarchaeological techniques

This research has highlighted the methodological benefits of integrating contextual data gathered through thin-section micromorphology with elemental analyses to characterise deposits and components and to formulate more robust interpretations of the archaeological record. Therefore, it is suggested here that sub-sampling of micromorphological blocks, whether in the field or in the post-excavation laboratory, should be a standard procedure for this type of studies, as this strategy would allow further examination of key features and components in the cases where micromorphological observations remain inconclusive.

In this regard, although it would be advisable that *in situ* analyses are conducted on uncoverslipped sections to avoid the possibility of cross-contamination between deposits, in practice this procedure causes a series of difficulties. The most conspicuous of these is the major contribution of epoxy resin, used in the production of micromorphological thin-sections, to the SEM-EDX and IR microscopy results, visible in the overrepresentation of carbon. Although this bias is easily avoidable when analysing inorganic remains through the removal of carbon and the re-normalisation of the elemental data, in the case of organic components, which contain carbon, separating the sample input from the resin input is not straightforward. Thus, although SEM-EDX and IR microscopy have the potential to become very useful techniques in combination with thin-section micromorphology, mainly due to these being relatively quick and inexpensive methods of mineralogical identification, they present important limitations to their application. Block impregnation with other types of resin, such as polyester or crystal, could perhaps represent a solution to the problems posed by the use of epoxy resin in micromorphology if in situ micro-analytical techniques are to be conducted.

Infra-red and X-ray spectroscopic techniques comprising XRF, XRD, and FTIR, all of which were conducted on spot samples collected from the micromorphological blocks before their impregnation with resin materials, have enabled the overall mineralogical and elemental composition of the samples to be determined. WDRXF analyses, in particular, conducted in a laboratory environment, have proven far more accurate than their pXRF counterparts, partly due to the current limitations in the range and intensity of identifiable elements entailed by the use of small analytical devices. Nevertheless, both techniques have proven useful in allowing the quick comparison of elemental concentrations between samples. In fact, a larger body of samples would have allowed the application of statistical procedures that can determine the occurrence of specific relations between elements in the dataset, possibly correlated to spatial or temporal patterns. In this pilot study, the investigation of a few spot samples from each site has made the statistical analysis of these results impossible, although with an increased number of samples this could be overcome in the future. XRD analyses resulted in the identification of a greater variety of minerals in the spot samples analysed, formed by heterogeneous materials (archaeological sediments), than FTIR, partly because there is generally more overlap between peaks in the results collected form the latter method. However, FTIR has proven more effective in detecting the clay minerals that constituted a considerable part of the floor plasters analysed and that were not clearly identifiable in the XRD spectra.

## 8.2 Neolithic socio-economic dynamics in the Konya Plain: implications of the present study

In the course of this research an integrated multi-scalar methodology comprising microstratigraphic excavation, thin-section micromorphology, and inorganic geochemistry has been developed to investigate finely-layered occupation sequences at three Neolithic settlements in Central Anatolia in order to explore issues of settlement geography, ecological strategies, and concepts of space. The main conclusions of this study are presented below:

2. Is there significant variability in spatial boundaries, maintenance practices, and range of floor architectural materials and environmental resources present in different buildings across Çatalhöyük?

An important goal of this study was to explore the socio-economic significance of small-sized buildings at Çatalhöyük through the examination of the occupation sequence of two of these structures (Spaces 470 and 87) and their comparison with those of larger buildings (Buildings 77 and 89) and open sequences (TPC and GDN middens, and collapsed roofing in Space 511/489) for the detection of differences and similarities in floor plasters, activities, and spatial boundaries. Interestingly, while the stratigraphic sequence of Space 470, formed by thick beaten floors and thin layers of accumulated residues which included cereal phytoliths and trampled herbivore dung, displayed the characteristics of a side-room used for industrial purposes, Space 87 showed several sequences of floor plasters and marked internal boundaries equivalent to those of larger domestic buildings. Although a preference for mud plasters has been detected in Space 87 when compared to the clean sequences of Building 77 and 89, this study failed to identify marked differences in plaster preferences, maintenance practices or fuel sources, the latter generally comprising mixed materials such as woods, reeds and, to a lesser extent, herbivore dung, between this small built environments and standard houses. Further, micro-analytical data have concluded that Space 87 was intensively and continuously occupied during its main phase, showing very similar patterns of maintenance activities to those of Buildings 77 and 89, and challenging the previous interpretation of this small space as a task-specific room.

3. Were open spaces, including rooftops and middens, a common scenario for the performance of domestic or communal activities at Çatalhöyük?

The microscopic examination of roof sequences has allowed the identification of thick plasters and substantial accumulations of discarded remains consisting of charred plants and bone, attesting the performance of fire-related activities on rooftops. While this study has not been able to confirm the use of a midden context in the GDN Area as an intensively used passage route, it has been noticed that these Late Neolithic middens appear almost completely devoid of faecal materials. Although depositional rates seem to vary in these late open areas, they are almost exclusively constituted by calcitic ashes, phytoliths, and charred woods and plants, many of which appear undisturbed and in primary deposition, pointing towards the frequent occurrence of fuel burning in open spaces during the latest period of occupation of the East Mound, possibly related to ceramic production.

4. Are there any marked differences between standard and non-standard structures at Boncuklu regarding organisation of space, intensity of occupation, maintenance practices, and range of floor architectural materials and environmental resources present?

One of the main aims of this research was to investigate house differentiation at the early agricultural site of Boncuklu through the examination of ecological preferences as manifested in the choice of fuel sources and floor architectural materials, concepts of space, and daily practices. This study has found marked differences between standard domestic buildings and the so-called non-standard structures at this site. The former, which display a rigid division of internal space into clean and dirty areas, are constituted by deep floor sequences of marl plaster and accumulated residues suggestive of continuous, long-term occupation. However, although variability in floor plaster materials has been observed to be minimal, it is interesting to point out that maintenance practices appear to vary greatly between households. Thus, while the occupation surfaces of Building 6 appear virtually devoid of accumulated residues, displaying very few signs of erosion, those of Building 12 seem to have been heavily trampled and eroded, probably due to sweeping and the occurrence of less re-plastering episodes, with occupation residues allowed to accumulate to a greater extent than in other houses. Due to the extensive period of occupation of this settlement, it is still unclear whether these two houses were contemporary due to the absence of radiocarbon dates. Therefore, although these results could be pointing towards household differentiation, there is also the possibility that maintenance practices became more important at Boncuklu with time. The stratigraphic sequence of non-standard structures differs from that of domestic built environments in the presence of only one or two plastered surfaces, general absence of marked spatial boundaries, and occurrence of thick accumulations of occupation residues, characteristics that could be pointing towards the use of these constructions for communal activities. Interestingly, the nature and range of accumulated remains present in all the standard and non-standard buildings analysed is very similar, mainly including ashes, charred fragments of plants and bones, reed phytoliths, and burnt shells. This is indicative of similar access to resources by different households, as well of the intense exploitation of the marshlands by the Boncuklu community.

5. Were middens spatially organised at Boncuklu? What types of activities were performed in open areas?

Open areas at this settlement generally display slow rates of accumulation, although the composition of midden layers, formed by ashes and charred remains of plant and animal origin, are very similar to the accumulated units found in building hearth contexts. This characteristic is indicative of the importance of fire-related activities at this site. Cereal remains, specifically barley husks, have been observed to occur in low proportions in these contexts through thin-section micromorphology, although it has been impossible to determine whether these correspond to domesticated species or their wild variants. Further, spatial divisions are hinted at in open spaces at Boncuklu. Although the discard of fuel and food residues appears to have taken place indistinctively in open areas at this site, the occurrence of intensively used fire installations has been observed in some locations, and the disposal of faecal waste, possibly human, appears limited to a very specific area of the settlement. Importantly, penning contexts have not been identified in this micro-stratigraphic study of the Boncuklu sequence.

6. What is the nature, range, and use of environmental resources at Pınarbaşı? Can we detect seasonal indicators that suggest a periodical occupation of this site during the Neolithic?

The integrated microstratigraphic analysis of the Late Neolithic habitation structure at Pınarbaşı has resulted in the identification of several infilling events and episodes of residue accumulation, whereas no formal occupation surface has been detected. These features indicate the occurrence of periods of site abandonment, suggesting the temporal nature, possibly seasonally-driven, of the human occupation of this rockshelter. Here, open spaces are dominated by the occurrence of herbivore dung, wood charcoal and, to a lesser degree, charred bone fragments, indicative of a non-diversified, local environmental exploitation strategy focused on pastoral activities, devoid of microscopic traces of crop processing and consumption.

7. Are there marked differences in ecological practices between the three case studies with respect to the selection of floor architectural materials and fuel sources?

While occupation surfaces have not been identified at Pınarbaşı, as the geochemical results have demonstrated, a marked preference for marl-based plasters has been detected at Boncuklu. These vary in particle size from fine silty clay to coarse clay loam, and the very low proportion of plant stabilisers identified in the majority of these floor plasters is probably responsible for the high degree of superficial erosion observed in thin-section, caused by trampling and sweeping. Although marl-based plasters are also ubiquitous at Çatalhöyük, this site displays a much greater variety of floor plasters, including softlime, calcareous and non-calcareous silty clay, and coarse sandy plasters. Variability in floor plasters at this site appears to be determined by building area – for example, calcareous plasters have been found more frequently in clean areas, while mud plasters dominate the dirty areas around the hearth – and function, with side rooms and building tops, less frequently plastered than the main rooms of houses, displaying thick, heterogeneous plasters occasionally made from recycled materials. The proportion of plant stabilisers in the manufactured floor plasters examined has been found to be highly dependable on the particle size of the raw material, which points to the substantial technological knowledge of the makers.

Wood and herbivore dung have been identified as the preferred fuel sources at the Late Neolithic campsite of Pınarbaşı, materials that were readily available in the vicinity of this pastoral location. The community at Boncuklu also appears to have made use of the immediate landscape around the site, with reeds, grasses, and possibly small bushes and shrubs identified as the main fuel sources in both buildings and open areas. At Çatalhöyük, mixed fuel materials comprising woods, herbaceous plants, and herbivore are dominant in building contexts. In the Late Neolithic open spaces examined in the research, the widespread occurrence of alternating layers of wood and, especially, reeds and grasses, point to the use of these materials as the main fuel sources in open fires.

8. Are there similarities in the organisation of space within buildings and open areas between the three case studies? What types of daily activities were performed indoors as opposed to open spaces? What does this evidence tells us about settlement configuration and social geography at these sites?

The organisation of space in domestic built environments at Çatalhöyük, consisting of a marked division between the dirty area used for cooking, and the clean area used for resting and sleeping, is very similar to that displayed by standard houses at the early agricultural site of Boncuklu. Interestingly, open areas seem slightly less spatially structured at Boncuklu, where the discard of daily residues appears to have taken place all over the site, than at Çatalhöyük, where midden areas are commonly tightly enclosed between building walls. Fire-related activities were performed in open areas at both sites, although formal fire installations displaying a long and intense use have only been detected at Boncuklu in this study. Although *in situ* occupation surfaces have not been identified in the Pınarbaşı habitation structure, activities in open spaces are represented by fire spots, possibly used for cooking, and herding, as the ubiquitous presence of herbivore dung suggests. However, penning deposits, characterised by compaction and trampling caused by the enclosing of animals, have not been detected at Pınarbaşı, likely due to the temporary occupation of this rockshelter during the Late Neolithic.

In summary, the results of this investigation demonstrate the importance of surpassing site boundaries in archaeological research in order to gain a more holistic understanding of Neolithic transformations in a particular region. Significantly, the occurrence of widely different ecological strategies and patterns of landscape exploitation within this regional setting were identified in this study. At Boncuklu, where subsistence practices were mainly focused on the exploitation of the wetlands, Çatalhöyük, where a greater range of floor plasters and fuel sources is present, and Pınarbaşı, where seasonal pastoral practices appear to have been the main activity. In fact, the absence of dung and penning deposits in open spaces corresponding to the latest levels at Çatalhöyük together with the apparently specialised nature of the Pınarbaşı campsite might be suggestive of the use of this rockshelter by seasonal task-groups from the mega-site. However, in spite of the variability in landscape exploitation strategies displayed by these communities, this study points to the existence of a Central Anatolian cultural tradition during the Neolithic, best expressed in the division into clean and dirty areas of houses at Boncuklu and Çatalhöyük, and the use of calcareous plasters as means of spatial demarcation at these two sites.

## 8.3 Limitations and further work

Although the microstratigraphic excavation approach adopted by this research early on did not yield the results that were expected, it is argued here that the complexity of the building being excavated complicated the process substantially. Nevertheless, this strategy was successful in allowing extensive micromorphological sampling of key contexts, which is frequently a problem in field projects that favour horizontal excavations. Therefore, it is suggested that the microstratigraphic excavation of other types of context formed by units that are more continuous and display less spatial divisions, such as middens, would constitute a more successful experiment and, potentially, a very informative approach to understanding formation processes at the macro-scale in these spaces in much more detail than previously achieved.

In addition, a range of micro-analytical techniques would prove valuable for the high-resolution investigation of occupation sequences at these Neolithic settlements:

- Raman spectroscopy, for example, is a technique better suited for the analysis of pigments containing heavy metals, such as cinnabar or ochre, than FTIR. Thus, painted wall and floor plasters, such as those encountered at the sites of Çatalhöyük and Boncuklu, could potentially be analysed with this technique for investigating their minerological compositions and technological choices of raw materials.
- State-of-the-art micro-analytical techniques, such as μ-XRF and μ-XRD at a synchrotron source, could also be applied to in situ stratigraphic sequences through the analysis of polished block surfaces after impregnation in order to quantitatively measure the degree of heterogeneity of specific deposits, especially those that are too thin (e.g. 1mm) to allow for sub-sampling.
- Gas Chromatography/Mass Spectrometry, a technique useful for the investigation of organic components, such as coprolites, has the potential of identifying which compounds are present in phosphate-enriched sediments and aggregates, such as plant lipids and waxes, faecal sterols, and bile acids. Further, species determination might be possible for those components identified as coprolites and as such, this technique has the potential of making an important contribution to current debates on diet, health, and animal management in Neolithic settlements.
- Phytolith extraction of key deposits, such as accumulated layers of plant materials identified at Çatalhöyük and Boncuklu, would result in the identification and quantification of these remains, frequently observed in thin-section in discard and fire-related contexts, thus contributing to our current understanding of the changing nature of plant resource use and diet in the Konya Plain. This technique will work particularly well combined with micromorphology, as the former methods allows for the identification of single cells and small types, frequently obscured in thin-section, whereas the latter results in the observation of articulated pytholiths in their exact depositional context.

Finally, the presence of reconstructed Neolithic houses at both Çatalhöyük and Boncuklu provides an excellent opportunity for the performance of archaeological experiments aimed at improving our understanding of site-formation processes. Fire activities, trampling, and the decay of organic remains, in particular, are three research topics that would benefit from experimentation and subsequent micromorphological and geochemical sampling for comparison with archaeological materials from these sites.

# 9

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