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Research Article

Melis Uzdurum*, Julia Schönicke, Moritz Kinzel, Marek Z. Barański

Studying the Use of Earth in Early Architecture of Southwest and Central Asia

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Abstract: Using case studies from Aşıklı Höyük, Çatalhöyük, Boncuklu Tarla, Göbekli Tepe (all Turkey), and Monjukli Depe (southern Turkmenistan), this study presents a framework for in-depth research on prehistoric earthen architecture in southwestern and central Asia. It demonstrates the challenges and potential for innovative and comparative studies based on interdisciplinary approaches and the use of architectural, microstratigraphic, and microarchaeological analyses. Furthermore, it sheds new light on issues related to various aspects of building continuity which is commonly recognised as a very important phenomenon in the Neolithic but could have different facets. The study attempts to discuss the reasons behind the local decisions to use and recycle specified building materials. In addition, it evaluates – in relation to particular sites – the usefulness of specific analyses for reconstruction of daily, seasonal, or annual practices. Advanced analyses of floors and fire installations, for instance, can contribute not only to the identification of indoor and outdoor surfaces but also to a better understanding of activity areas and the intensity of use within particular spaces. Variations and different combinations of mudbrick, mortar, and plaster recipes allow for insights into how earth and sediment material were used to mark collective and individual identity through the performance of a building. Recognising reused materials and features allows us to trace further the nature of prehistoric societies and local architectural dialects.

Keywords: Neolithic/Aeneolithic, Asia, building archaeology, microarchaeology, inter-/transdisciplinarity

1 Introduction

During the transition from Pleistocene to Holocene, climatic conditions recovered, which resulted in radical changes in the lifeways of nomadic groups. Human environmental adaptation, social, economic, and cognitive transformations had effects on people in time, thus they started to build permanent structures, designed and reorganised their habitats, invented and developed new tools and objects, and changed their diets. This process of experimentation continued for centuries, which resulted in manifold practices for different communities in different geographies (Cauvin, 2000; Hodder, 2018; Simmons, 2007; Whittle, 2003).

Being one of the subjects of this article, Central Anatolia is one of these regions, hosting such communities who transformed their lifeways with their own dynamics. The site of Aşıklı Höyük, where the transition to

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*** Corresponding author: Melis Uzdurum**, Archaeology Department, Ondokuz Mayıs University, Samsun, 55200, Turkey, e-mail: muzdurum@gmail.com
Julia Schönicke: Institute for Near Eastern Archaeology, Freie Universität Berlin, Berlin, 14195, Germany
Moritz Kinzel: Istanbul Department, German Archaeological Institute, Istanbul, 34437, Turkey
Marek Z. Barański: Faculty of Architecture, Academy of Fine Arts in Gdańsk, Gdańsk, 80-836, Poland

settled life can be followed uninterruptedly from 8400 until 7350 cal BCE, is of particular importance (Özbaşaran & Duru, 2015; Stiner, Özbaşaran, & Duru, 2021). The continuous habitation of the site enables the tracking of the cultural sequence uninterruptedly and provides a rich and detailed record of the architectural transformations (Esin & Harmankaya, 2007; Duru, Güral, & Özbaşaran, 2021; Duru, Özbaşaran, Yelözer, Uzdurum, & Kuijt, 2021; Özbaşaran, 2012; Özbaşaran, Duru, & Uzdurum, 2018), understanding of the cultivation of the crop plants (Ergun, 2016; Ergun, Tengberg, Willcox, & Douché, 2018), and husbandry and management strategies of the ovicaprids (Abell et al., 2019; Buitenhuis et al., 2018; Stiner et al., 2014; Stiner, Munro, Buitenhuis, Duru, & Özbaşaran, 2022; Zimmermann, Pöllath, Özbaşaran, & Peters, 2018). The chronological successor of Aşıklı Höyük, and Çatalhöyük followed a different trajectory, including the translocation of the settlement from the East to the West mound due to changes in the surrounding environment (Anvari, 2021; Hodder, 2006; Mellaart, 1967). Aşıklı Höyük (Level 2) and Çatalhöyük represent an agglutinative settlement tradition (Özbaşaran, 2011a) which emerged locally. These settlements were characterised by closely spaced buildings with mudbrick walls, flat roofs, and roof entrances. One of the most striking aspects of these sites is that the houses were often built upon each other in a continuous and uninterrupted sequence (Kinzel, Duru, & Barański, 2020; Özbaşaran, 2011a). In this study, the earthen architecture of the Aşıklı Höyük and Çatalhöyük is presented in the context of both microarchaeology of the construction materials including mudbrick and mortar (Aşıklı Höyük) and the building archaeology (Çatalhöyük) during the early and late Neolithic, respectively.

Boncuklu Tarla and Göbekli Tepe in the Southeast of Anatolia were part of other Neolithisation processes. Especially, Göbekli Tepe and contemporary with-it sites around the Harran Plain could be understood as a last answer of hunter-gatherers to avoid the transitions to agricultural driven societies (Clare & Kinzel, 2020; Zimmermann, 2020). But from a landscape archaeological point of view, these groups were quite successful in maintaining their lifeways for over 1,000 years as their environment provided rich hunting and gathering grounds (Braun, 2021b) so that shifting to agriculture may not have been necessary. The domestication of plants and animals may not have happened directly at the settlement of Göbekli Tepe but the Neolithic people collected and processed wild plants intensively (Dietrich, 2021; Neef, 2003) and hunted wild animals (Peters, Helmer, van den Driesch, & Saña Segui, 1999), which required profound knowledge of nature. This long experimental phase may have led to the later appearance of domesticated einkorn (e.g. at the nearby settlement of Nevali Çori [see Haldorsen, Akan, Çelik, & Heun, 2011]) and animal husbandry (e.g. at Gürcütepe [see Peters, von den Driesch, & Helmer, 2005]). Furthermore, the built environment at Göbekli Tepe displays long building biographies as it was permanently reshaped. In this study, the earthen components of stone architecture – floors, roofs, and mortars – and the deposits inside buildings are presented in context with macro- and microscale approaches.

Monjukli Depe is located in southern Turkmenistan at the northern edge of the Kopet Dag Mountains (Berdyev, 1972; Bernbeck & Pollock, 2016; Bernbeck, Pollock, & Öğüt, 2012; Pollock et al., 2011, 2013; Pollock, Bernbeck & Ögüt, 2019). Archaeological investigations have revealed an occupation from the late Neolithic period, starting around 6200 BCE, to the early Aeneolithic[1] period. The site is today situated in an arid alluvial plain, which is bordered by the Karakum desert to the north and the Kopet Dag to the south, marking today's political border with Iran but the region must have been more humid in prehistoric times (Berking, Beckers, Reimann, Pollock, & Bernbeck, 2017). In contrast to the other sites presented here, Monjukli Depe was abandoned and re-settled after a clear hiatus. In this study, the mudbrick architecture of the Aeneolithic Meana horizon is presented as the underlying Neolithic strata, which were only excavated in small areas.

Combining microarchaeological studies on earthen architecture expands the boundaries of the knowledge we produce about the lives of past communities. On the other hand, difficulties arise when evaluating the obtained results together. For instance, although micro-contextual sampling in microarchaeological studies is possible thanks to thin section analysis, the same is not the case for macroarchaeological methods. With archaeological micromorphology analysis, micro units that are too small to be identified in macroarchaeological studies can be detected and samples can be made for different micro-analysis under the microscope.

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[1] Aeneolithic is the regional terminology for Chalcolithic.

However, it is not possible for archaeologists to visually identify these micro-units during excavations. This results in a contextual gap in sampling strategies. One of the ways to overcome this difficulty is to evaluate the micro-results on earthen architectural materials together with the study of building archaeology and macrostratigraphy.

The built environment of humans always depended on locally available sources. Which plants, which stones, which soils, and building experiences were available to create early earthen architecture? Was the creation of earthen construction material related only to local environmental factors? Or were there also conditions in the human–environment–material triangle where socio-technological factors predominated? In this contribution, we will demonstrate the challenges and potential for innovative and comparative in-depth research studies on Neolithic earthen architecture in southwestern and central Asia based on interdisciplinary approaches and the use of architectural, microstratigraphic as well as microarchaeological analyses based on finds from Aşıklı Höyük, Çatalhöyük (both in central Anatolia), Boncuklu Tarla, Göbekli Tepe (southeastern Anatolia), and Monjukli Depe (central Asia) (Figure 1). This study provides insight into earthen materials and their past, present, and future potential through the range of case studies and materials analysed including mudbricks, mortars, plasters, floors, occupation deposits, and roofs. For this purpose, the results obtained from the earthen architectural sites in different geographical regions (all these sites are placed along the latitude of 37° north though) were brought together including the macrostratigraphic analyses, architectural analyses in the field, and microarchaeological analyses including micromorphology, particle size analysis, calcimeter, and inductively coupled plasma optical emission spectroscopy (ICP-OES) analyses in particular of P and Ca. Case studies are presented according to geographical regions (from western to eastern) where different Neolithisation processes were experienced. Settlements, which are located in the same region, are given chronologically.

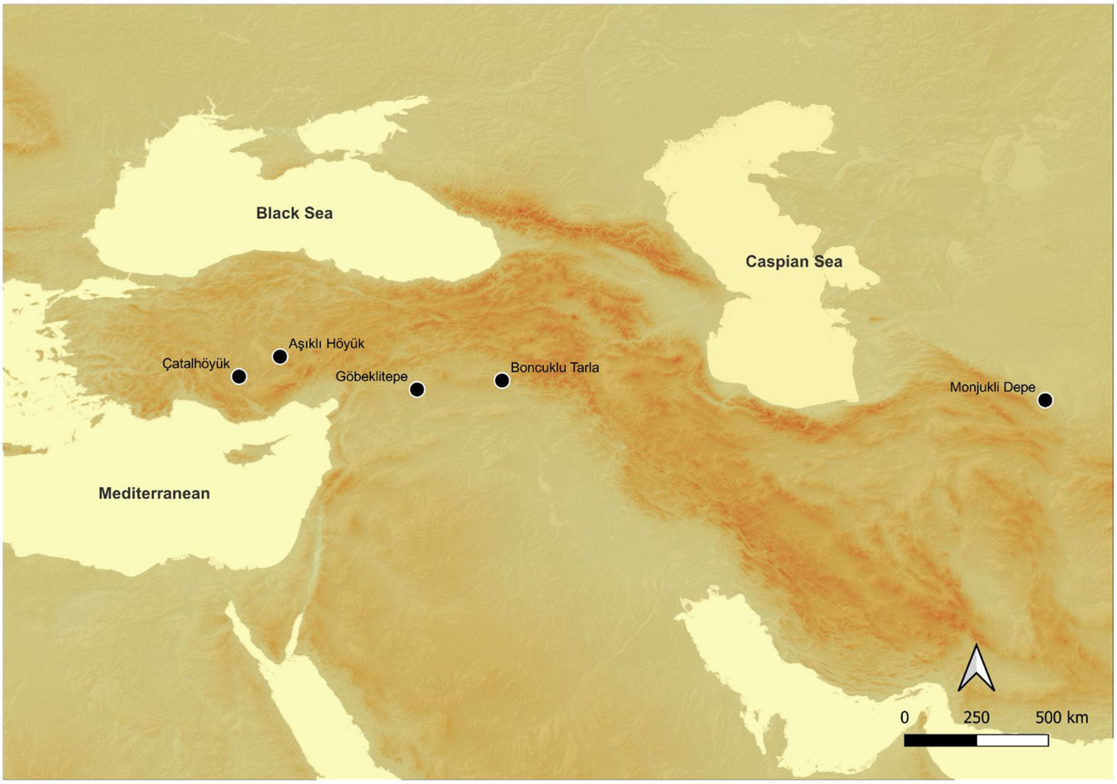


Figure 1: Map of the study area, southwestern and central Asian region, including the location of the archaeological sites Aşıklı Höyük and Çatalhöyük in Central Anatolia, Boncuklu Tarla and Göbekli Tepe in Southeast Anatolia (Turkey), and Monjukli Depe (Turkmenistan) (prepared by M. Uzdurum in QGIS).

2 The Uncertain and the Apparent

In several Neolithic sites, stone seems to be the most apparent and predominant building material. However, one component is often overlooked in this context – earthen building materials used in floors, mortars used in walls, plaster covering the wall surfaces, and last but not least earthen roofing. In most cases, those earthen materials actually still exist and are visible – but obviously out of our sight. In contrast, building materials like timber or reed are rarely preserved but considered to be part of constructions.

There are two things that create earthen building materials and establish their character in the first step of production: components including raw materials, temper, and binders, and their combination (Johnson, 2010; Jones, 2004). Both end up in the creation of an unlimited number of recipes in terms of various parameters such as the local environment which people live in, their social organisation, preferences, know-how, tools, design, time, labour, and more. For example, in mudbrick production, the material will be transported many times from the source of raw materials to the place where the pugging process will be done, from there to the area to be shaped, dried, and finally to the location of the building to be constructed (Facey, 2015; Keefe, 2005). This leaves the mudbrick makers faced with conditions that require them to make choices about raw materials, tools, energy, and technology (Love, 2013; Sillar & Tite, 2000). Moreover, even if all the tempers and other components used come from the same source, people will also change the recipe for making mudbrick while combining, proportioning, and shaping these materials. The final form of the mudbrick after drying is a unique result of choices involving hundreds of variables and possibilities. Although this entanglement seems difficult to resolve for earthen building materials, it seems possible to overcome this difficulty with a *chaîne opératoire* oriented approach and microarchaeological methods in prehistoric archaeology (e.g. Homsher, 2012; Lorenzon, 2021; Lorenzon, Nitschke, Littman, & Silverstein, 2020; Love, 2012, 2017; Riggs, 2001; Rosenberg, Love, Hubbard, & Klimscha, 2020).

Quite often we excavate apparently "empty" rooms that did not contain many artefacts. Hence, it is difficult to trace activities that might have taken place in these spaces or see how they differ from deposits from exterior areas (e.g. trampled surfaces and middens). Microarchaeological excavation methods including sieving, flotation, and volume measurements of excavated contexts as well as a systematic sampling strategy are most helpful when it comes to the reconstruction of daily practices – even in contexts without (macro) finds. The case studies of Göbekli Tepe and Monjukli Depe demonstrate that geochemical sediment analyses provide answers to the questions of the use of interior and exterior spaces and concepts of hygiene.

With microarchaeological studies on earthen architecture, it is understood that the remains we see in the field are only a part of the materials that have survived from the prehistory, and that these remains may be much smaller in size and can even be traced from the traces left behind. In this sense, microarchaeological approaches and methods that deal with the prehistoric past in a microscopic framework have proven that we have the potential to examine earthen material culture at the level of dust particles under the rug (Shillito, 2012; Weiner, 2010).

3 Methodology from Microscale to Macro- : Microarchaeology, Microstratigraphy, and *Bauforschung* (Building Archaeology)

People interact with their physical environment in various ways. This interaction leaves traces in material culture on a macro- and microscale.

3.1 Building Archaeological Methods

Building archaeology (German "Bauforschung") is investigating architectural remains, and spatial and structural contexts to understand a building's biography on a macroscale (Busen et al., 2015; Cramer, Goralczyk, &

Schumann, 2005; Großmann, 2010; Gruben, 2009; Kinzel, 2021b). An architectural or building archaeological study includes the identification of the construction process, the modifications according to joints and change in materiality or marked by tooling and differences in the treatment of surfaces or the order of construction. However, Neolithic building practice holds some challenges for the identification of building events. Most Early Neolithic structures are built in segments. Meaning that joints may not represent actual building phases, events, or later modifications, but just the daily or weekly work progress and the general order of building. Buttresses erected in front of wall faces – abutting blunt against it – may not represent later additions in the sense of a later building phase, but just later in the process of building. On the other hand, it could still be a later addition. Materials and elements used are not industrial products; meaning that they do not follow our current international agreed norms and shapes. Structural solutions show, accordingly, a wide range of individual solutions (Kinzel, 2013, in press; Kurapkat, 2014). This is also true for early earthen constructions. Due to very local building traditions, construction techniques in several cases are not clearly distinguishable from one another. Techniques blur into each other and lack standardised parameters for long periods of time. To investigate those differences, we need to zoom in from a macroscale to various microscale approaches. For our understanding of architectural and societal changes at Çatalhöyük, these approaches include excavations and building archaeology research in the Gdańsk (GDN) area (Barański et al., 2022b, 2023), which involved in-depth reinvestigations of a series of buildings and open spaces unearthed both in the 1960s and 2000s, in Mellaart and Team Poznań (TP) areas, respectively. Having been focused on stratigraphy and structural aspects of architecture, the GDN research offers an alternative perspective on the order and hierarchy of construction or remodelling works of buildings which were re-investigated in these areas. Furthermore, it sheds new light on issues of social organisation, including co-operation, co-residence, standardisation, and specialisation within a late contemporary group of buildings. Finally, the reopening of some of the trenches and reinvestigating the 1960s and TP stratigraphy and architecture enabled the sets of Mellaart's and Hodder's records to be used in a more integrated way.

3.2 Microarchaeology

3.2.1 Microarchaeology in Aşıklı Höyük

Methods conducted on mudbrick and mortars at Aşıklı Höyük include archaeological micromorphology, particle size analysis, and calcimeter to quantify calcium carbonate ($CaCO_3$). Archaeological micromorphology is a major component of geoarchaeological studies, using thin sections and the polarising microscope, where undisturbed soils and sediment samples are treated with impregnating resins before thin sectioning (e.g. Courty, Goldberg, & Macphail, 1989; Stoops & Nicosia, 2017). In the case of Aşıklı Höyük, thin section preparation was conducted either at the University of Arizona by Ray Lund, or the Institute for Archaeological Sciences at the University of Tübingen by Panagiotis Kritikakis. Dried samples were impregnated with a mixture of polyester resin and styrene in a ratio of 7:3, and a catalyst (MEKP), and then sliced using a rock saw into one or more 5 cm × 7 cm or 6 cm × 9 cm tiles. The samples were analysed at a variety of magnifications (10×–200×) using petrographic microscopes. A thin section description (Stoops, 2003) was then conducted by Melis Uzdurum and Susan M. Mentzer. The main parameters were fabric, voids, microstructure, groundmass, inclusions such as rock fragments, minerals, organic materials and their density, along with the particle size, shape, rounding and wear condition thereof, inclusions of fine sediment aggregates, and secondary minerals and additional additives.

Particle size is characterised by the formation process of the environment in which the sediments are found (Stein, 1987, p. 358). The characterisation of the sediments used in mudbricks and mortars is variable by the amounts of sand, silt, and clay (e.g. Clifton, Brown, & Robbins, 1978, p. 12; Love, 2017, pp. 356–357). Due to the differences in the measured parameters, different particle size measurement techniques are used because there is no ideal technique yet. However, supporting the results of particle size analysis with data obtained from archaeological micromorphology increases the reliability of the results obtained (Courty et al., 1989, p. 18). Particle size analysis was conducted at the University of Tübingen, Laboratory of Soil Science and

Geoecology by Melis Uzdurum. The samples were reacted with 50 ml of water–hydrogen peroxide mixture (diluted 30%) for 24 h and boiled at 60°C for 5–8 h in the first step, thus freeing them from organic material. In the second step, 5 ml of sodium-pyrophosphate was added to prevent the particles from sticking together, and it was then shaken for 10–15 h, and put through a wet sieve. The third step was to measure clay and silt fractions smaller than 20 µm using a SediGraph III 5120 (Micromeritics) + Autosampler MasterTech MT 052 instrument (DIN 19683-1 and DIN 19683-2 [1973]). Whether the obtained sedigraphy curves are usable or not was evaluated by Peter Kühn and his lab team.

$CaCO_3$ is a mineral in nature and occurs mainly in the forms of calcite (mostly in geologic contexts including limestone, chalk, etc.) and aragonite (in biologic contexts being formed by organisms) (Lippmann, 1973; Lowenstam & Weiner, 1989). It may also occur as faecal spherulites found in animal dung (Canti & Brochier, 2017). A study of carbonates in mudbrick studies including several sources of sediment with varying carbonate contents, and carbonate temper is relatively uncommon (e.g. Love, 2012; Rosenberg et al., 2020; Uzdurum & Duru, 2021). $CaCO_3$ measurement was conducted at the University of Tübingen, Laboratory of Soil Science and Geoecology by Melis Uzdurum using a calcimeter with the Scheibler method (Eijkelkamp 08.53, Standard NEN-ISO 10693). First, the samples were dried in a microwave MLS Start 1500 and ground using a ball mill Pulverisette 5 (Fritsch). Then, the carbonate present in the sample was converted into carbon dioxide (CO_2) by adding 10% diluted hydrochloric acid to the sample. Finally, the percentage of $CaCO_3$ was calculated by the released quantity of CO_2. Each sample was analysed in duplicate to verify the results. The four discriminating variables including percentages of sand–silt–-clay, and percentages of $CaCO_3$ were statistically analysed using JMP-14 pro (SAS).

3.2.2 Microarchaeology in Göbekli Tepe and Monjukli Depe

For selected contexts of Monjukli Depe and Göbekli Tepe, multi-element analyses using ICP-OES were conducted by Julia Schönicke at the Laboratory of Physical Geography, Freie Universität Berlin. In this study, the results of the particular phosphate analyses are presented. All organic matter enriches available organic phosphate in the sediment. A large amount of phosphate originates from anthropogenic activities such as storage and refuse, food preparation and consumption as well as excrement (Holliday & Gartner, 2007, p. 302; Middleton et al., 2010, p. 199). The varying phosphate levels can thus indicate settlement boundaries and areas of intensive or less intensive activities. Hence, phosphate analyses have been used for archaeological research questions for over a century (Arrhenius, 1929; Holliday & Gartner, 2007; Middleton et al., 2010; Zölitz, 1980). In contrast to other chemical elements concentrated by humans, phosphorus is relatively immobile once it has entered the soil system (Bethell & Máté, 1989, p. 9) and is therefore suitable for the study of past lifeways.

Amongst others, the sampled soil was used for geochemical sediment analyses to determine multiple elements as well as total (Ptot) and available phosphate (Pav) using an ICP-OES (for Monjukli Depe, see Rummel, Schönicke & Heit, in prep.; for Göbekli Tepe, see Schönicke, 2022). Ptot represents the total soil phosphorus content, whereas Pav is broadly indicative of human activity, especially in arid environments (Holliday & Gartner, 2007, p. 313). The ratio of Pav and Ptot represents the percentage of introduced phosphate through anthropogenic activities (Rummel et al., in prep.). Rather than absolute values, the ratio of P contents in spatial comparison within the settlement is crucial in interpreting the data.

For the Pav digestion, 1 g sample material was mixed with 30 ml of citric acid. The Ptot digestion was conducted using aqua regia (a mixture of 1/3 65% HNO_3 and 2/3 37% HCl). Here 8 ml of aqua regia was mixed with 0.1 g sample material. The digestions with both citric acid and aqua regia were measured with an ICP-OES Perkin Elmer Optima by the excitation and ionisation of sample atoms through an argon plasma.

For Monjukli Depe, phosphate analyses aim to identify activity areas in houses and compare the intensity of use with exterior surfaces and fire installations (FIs). By doing so, daily practices such as cleaning of spaces can be reconstructed. These, in turn, reflect the way people interacted and cared for their built environment.

Phosphate analyses (for methods see [Schönicke, 2022]) from samples from a floor, roof collapse, and room fill at Göbekli Tepe should provide the basis for a better understanding of activity zones in internal and exterior spaces, including (daily) practices and routines carried out inside rooms, on the roofs, and in abandoned buildings.

4 Mudbricks and Mortars at Aşıklı Höyük

Aşıklı Höyük is located on the banks of the Melendiz River in volcanic Cappadocia, which accounts for its distinctive topography of isolated mountains, basins, and “fairy chimney” formations in the eastern part of central Anatolia. The river developed a rich marshland towards the end of the Late Pleistocene, which occasioned clay deposition that formed a wide, flat valley floor around the site (Kuzucuoğlu, Dumoulin, & Saulnier-Copard, 2018). A drying trend beginning just prior to the Holocene allowed fertile soils to develop in the valley bottom and on the lower colluvial terraces. The site is situated 1,119 m above sea level. By the time of its abandonment, the site had expanded into a 4 ha mound roughly 16 m high (Özbaşaran, 2012). In this section, the results of particle size, $CaCO_3$ quantified using a calcimeter, and thin section analyses from mudbrick and mortars at Aşıklı Höyük are presented.

The Aşıklı Höyük Research Project stands out with a research history of more than 30 years, in which changing archaeological approaches and research methods have been applied (Özbaşaran & Duru, 2018). The first period of research at the site started in 1989 as a salvage excavation led by the pioneering archaeologist Ufuk Esin. Since 2006, a second period of research and excavations at the site continues under the directors Mihriban Özbaşaran and Güneş Duru in collaboration with international researchers as an interdisciplinary project shaped by new archaeological questions and methods.

Aşıklı Höyük provides remarkable evidence for continuity in the buildings, floor layouts, and spatial organisation of the architectural features, such as ovens, hearths, and platforms (for details on continuity see Duru, 2013; Duru et al., 2021; Kinzel et al., 2020; Özbaşaran et al., 2018). The cultural sequence is uninterrupted through Levels 5, 4, 3, and 2 (Özbaşaran et al., 2018) between the dates ca. 8400–7350 BCE (Quade, Stiner, Copeland, Clark, & Özbaşaran, 2018) (Figure 2). Level 5 (dated to earlier than 8350 BCE) represents a semi-sedentary settlement characterised by wattle and daub structures and a subterranean oval building with mudbrick walls (Özbaşaran et al., 2018). Buildings in Level 4 (8350–8050 BCE) and Level 3 (8050–7750 BCE) represent permanent occupation (Figure 3a and b). The buildings were semi-subterranean, oval in plan, and single-roomed. In Level 3, the aboveground walls were somewhat taller (c. 40 cm). Floor and wall plasters

Figure 2: Aerial photograph showing earthen architecture and the cultural sequence of Aşıklı Höyük. July 2021 (photo: G. Duru).

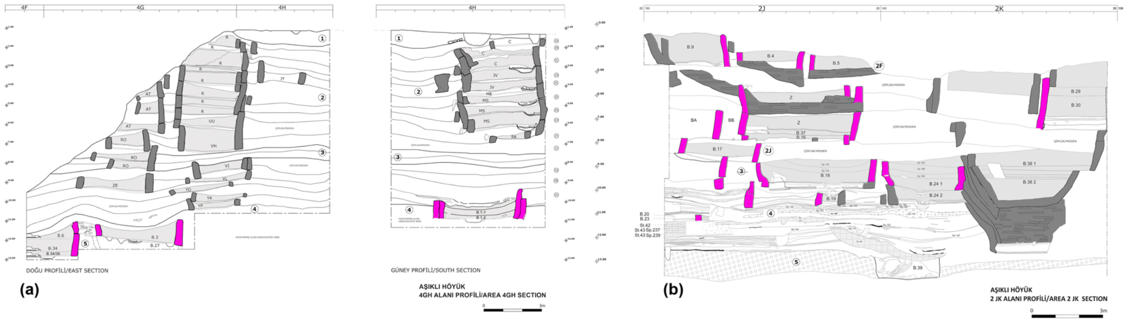


Figure 3: Stratigraphic section drawings for Area 4GH (a) and Area 2JK (b) at Aşıklı Höyük (Özbaşaran et al., 2018, Figures 3 and 22). The buildings where the samples were collected are marked in magenta.

Figure 4: Plan of the dwelling area of Aşıklı Höyük showing Levels 2DEF (a) and Levels 2ABC (b) (Duru, 2013, Figure 71; Özbaşaran et al., 2018, Figure 1). The buildings where the samples were collected are marked in magenta.

including mud and ash, and possibly lime plaster, were thicker (c. 0.2–5+ mm) than the examples in Level 5 and were prepared more elaborately (Mentzer, 2018; Mentzer & Quade, 2013). The walls were made of sun-dried mudbricks shaped by hands or moulds. The mortar between the blocks was of a similar thickness as the mudbricks themselves, measuring between 4–8 cm (Duru, 2013).

Level 2 (7750–7350 BCE) is characterised by quadrangular mudbrick buildings, which were constructed above ground with freestanding walls and were flat roofed (Özbaşaran, 2011b) (Figure 2). The walls were constructed with sun-dried mudbricks made by mould, without a stone foundation. The thickness of the walls was fixed for centuries (28–30 cm), but the length of the blocks differed (60–110 cm). Mudbrick and mortar sizes in regard to heights were the least diverse (mudbrick: 6–8 cm, mortar: 6–10 cm) (Duru, 2013) (Figure 4a). During the occupation of Level 2, the settlement was fully reorganised. The number of dwellings increased dramatically, much of the daily workspace was moved to rooftops; buildings were constructed adjacent to one another (Esin & Harmankaya, 2007; Özbaşaran, 2012), and corrals were presumably shifted off the settlement (Pearson et al., 2007; Peters et al., 2018; Stiner et al., 2022). By the last centuries of Level 2 (Levels 2C–2A) (Figure 4b), the settlement pattern was increasingly dense, and the tendency to rebuild residences became even more pronounced and widespread (Duru, 2018; Özbaşaran & Duru, 2015). Buildings may have been renewed at the same time in each rebuilding phase, and as part of a larger building group. Cooking and food preparation features and grain storage facilities were integrated with building specific rooms or storage features (Duru et al., 2021; Özbaşaran, 1998, 2012; Uzdurum, 2018).

Within this rhythm of transition, it is worth questioning the relationship between know-how of the community of mudbricks and mortars and their transfer for generations. What were the resources and tempers for making mudbrick and mortar? What was the relationship between the mudbrick and mortar recipes and the transformations observed in the settlement patterns and architecture? These research questions made it necessary to analyse mudbrick and mortar not only as an architectural element but also as part of the material culture and to identify the production chain diachronically.

What is meant by recipes is a combination of three steps, which are, respectively, (1) sourcing, (2) tempering, and (3) pugging. A total of 53 intact and 96 loose samples were collected from the mudbricks and mortars through Level 4 to the upper phase of Level 2 (Figures 3 and 4). Thin section analysis on all these three steps including sourcing, tempering and pugging, particle size analysis on sourcing step (sediment characterization), $CaCO_3$ measurement on sourcing and tempering steps, provided results.

During Levels 4 and 3, different sediment sources and additives were used both in mudbrick and mortars. One of the mudbrick recipes includes very few volcanic rocks such as feldspar, tuff, basalt fragments, and pumice while secondary minerals such as pedogenic carbonate and clay, calcite, and carbonate temper were abundant. The primary sediment source is coarse sand (40–60%) (Table S1). Another mudbrick recipe includes various anthropogenic materials such as ash, eggshell, mollusc shell, and hackberry. Dung spherulites are dominant among them. The primary sediment source is mainly clay in the latter (20–33%). There were multiple strategies for incorporating plant fragments into the construction materials (Uzdurum, Mentzer, Duru, Kuzucuoğlu, & Özbaşaran, 2023). The mortars include many types of anthropogenic materials such as animal bones, hackberry seeds, charcoal fragments, and ash remains. Organic materials are dense in mortars, and materials derived from animal faeces are dominant (Figure 5f). $CaCO_3$ measurements of both mudbrick and mortar show that 30% of the samples had more than 10% $CaCO_3$, and the rest of the samples had 8% $CaCO_3$ in their content. The aggregates in the mortars are quite dense in their concentration and much more diverse than those in mudbrick in terms of size and type (Figure 5a). Mudbrick recipes, temper, and binders were well harmonised and pugged for a long time with a large amount of water while mortar sediment was mixed with water, prepared quickly, and plastered on the mudbrick.

In earlier phases of Level 2 (2J–G), the variety in mudbrick and mortar recipes increases (Figures 6 and 7). Three different mudbrick recipes are identified. The first includes plant tempering while the second includes animal dung. In both, there are very few anthropogenic materials such as hackberry seeds and ash. The percentage of clay fraction is considerably higher when compared to all other samples (30–50%) (Table S1). The majority of the vesicular microstructure, an abundance of aggregates (some of them are clay aggregates BTW. 30–300 µm) and a homogeneous distribution of particles indicate a high degree of mixing of mudbrick (Figure 5e). The third recipe includes both plant and dung tempering. Geogenic material is dominant among them. Primary sediment source is silt or loam. Mortars contain much more dung spherulites than Levels 4 and 3, while the variety and density of anthropogenic materials decrease (Figure 5b). Some mortars were pugged like mudbricks with a large amount of water.

Over time (2F–2E), the variety of recipes almost disappeared (Figures 6 and 7). Sandy and silty sediments were dominant in both mudbrick and mortar. Plant tempering became dense in both (Figure 5g). Dung spherulites decreased in all samples, and completely disappeared in later phases (2C–2A). There is no limestone, except in one mudbrick sample. The percentage of $CaCO_3$ decreases below 2% in all samples (Table S1). Anthropogenic materials, including dung, ash, animal bones, and hackberries, seen previously in mortars, are replaced by geogenic materials and plant temper (Figure 5d). Mortars are similar to mudbricks in terms of raw materials, contents, and composition. Towards the abandonment of the settlement (2C–2A), temper and binder and the mixing process continues in a similar way (Figure 5c). In contrast, loam-sized sediments are dominant both in mudbrick and mortars (Figures 6 and 7).

The results show that the early Aşıklı Höyük community prepared various mudbrick and mortar recipes, modified them over time and never used the old recipes again. What was the reason for this change? Did the

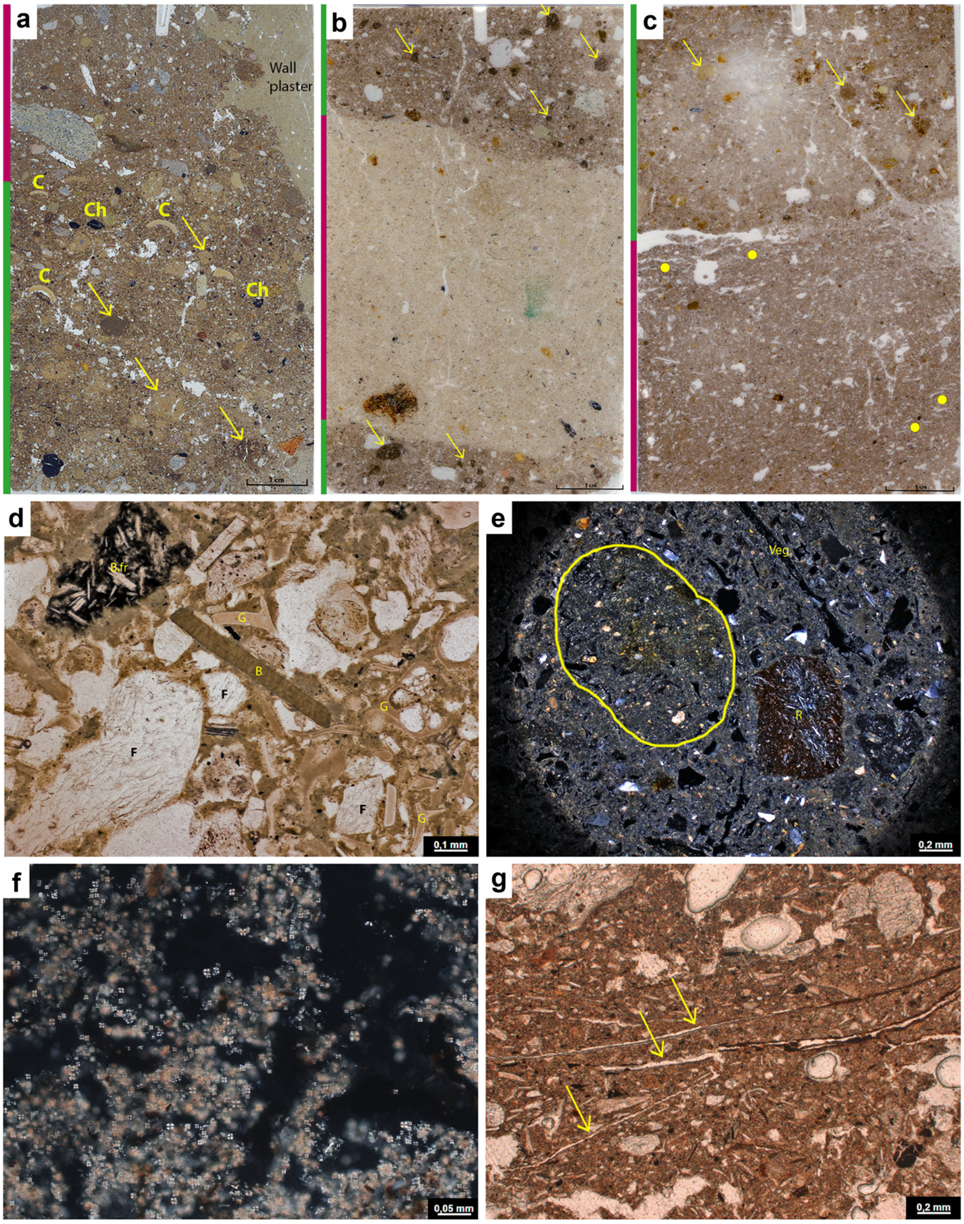
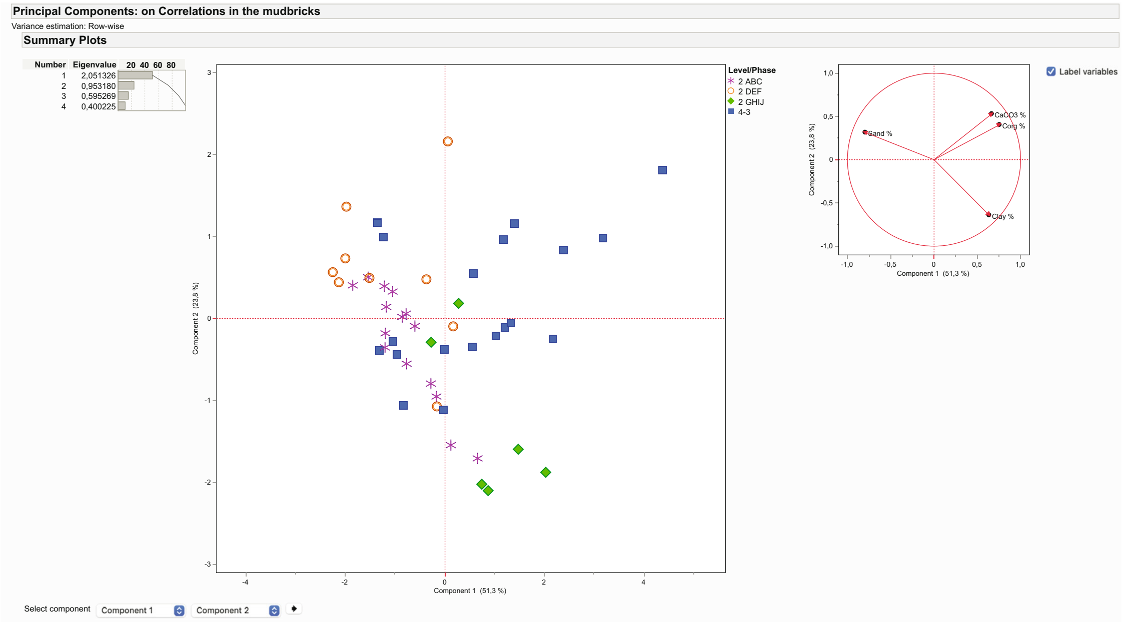


Figure 5: Comparison of thin sections of the mudbrick/mortars belonging to the different levels at Aşıklı Höyük (green: mortar and pink: mudbrick): (a) aggregates in the mortar are quite dense in their concentration and much more diverse than those in mudbrick in terms of size and type (arrows) in Levels 4 and 3. Mortar includes many types of anthropogenic materials such as charcoal fragments (Ch), hackberries (C), plane polarized light (PPL). (b) Dense aggregates (arrows) in the mortar show that mudbrick was pugged with a large amount of water in Levels 2J–2G, PPL. (c) The similarity between mudbrick and mortar in terms of the mixing process and tempering in Levels 2C–2A. There are many more plant materials in both the mudbrick and mortar (yellow dots), PPL. Some of the geogenic, biogenic, and anthropogenic materials described in the thin section: (d) Geogenic materials including a basalt fragment (B.fr), biotite (B), volcanic mineral grains (G), feldspar (F) in mudbrick through Levels 2F–2D, PPL. (e) Clay aggregate (in the circle), vegetal void (Veg.), and volcanic rock (R) in mudbrick in Levels 2J–2G, crossed polarized light (XPL). (f) Dung spherulites identified in the mortar, XPL. (g) The majority of the voids (arrows) are vegetal in form. The vegetal voids (white areas) exhibit horizontal orientation in the mudbrick, PPL. (M. Uzdurum).

environmental and climatic conditions have an effect on their preferences? Or were the socio-technological advancements the driving force?

Many types of deposits were readily available for making mudbrick and mortar across the early Holocene landscape within a few kilometres of the site and at depths of up to 3.5 m below the surface. However,



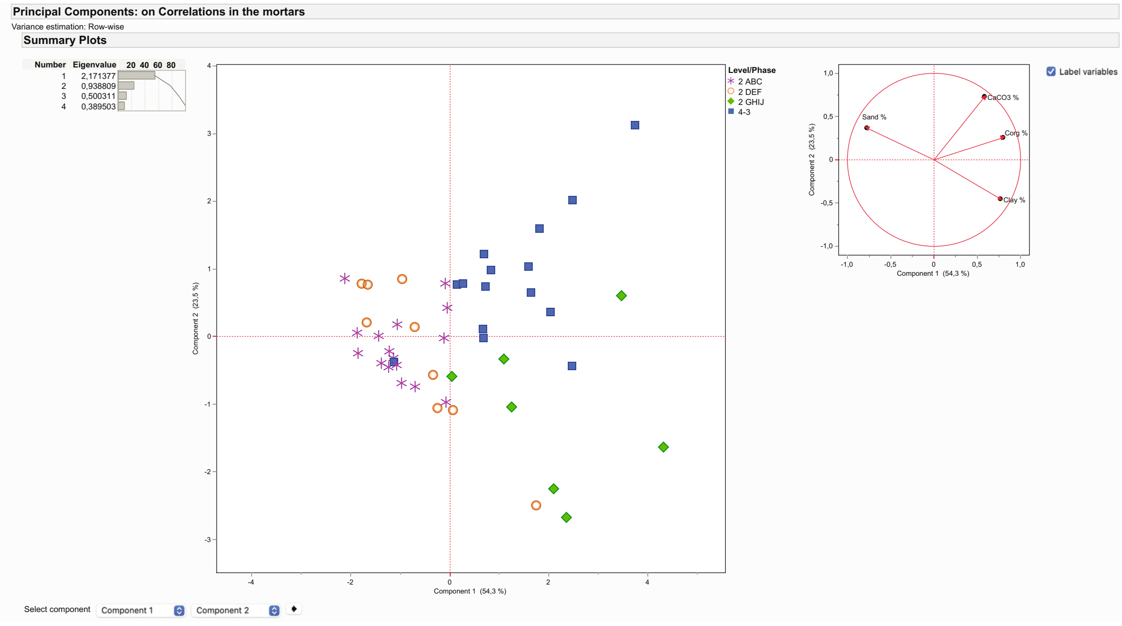
Principal Components: on Correlations in the mudbricks

Variance estimation: Row-wise

Summary Plots

Number	Eigenvalue
1	2,051326
2	0,953180
3	0,595269
4	0,400225

Figure 6: Principal component analysis illustrating diachronically distinct mudbricks from levels 4, 3, 2GHIJ, 2DEF, and 2ABC at Aşıklı Höyük. The measured variables include $CaCO_3$ determined with a calcimeter, organic carbon (C_{org}), clay, and sand determined with a sedigraph. *N* = 49 (analysed using JMP-14 pro by M. Uzdurum).



Principal Components: on Correlations in the mortars

Variance estimation: Row-wise

Summary Plots

Number	Eigenvalue
1	2,171377
2	0,938809
3	0,500311
4	0,389503

Figure 7: Principal component analysis illustrating diachronically distinct mortars from levels 4, 3, 2GHIJ, 2DEF, and 2ABC at Aşıklı Höyük. The measured variables include $CaCO_3$ determined with a calcimeter, organic carbon (C_{org}), clay, and sand determined with a sedigraph. *N* = 47 (analysed using JMP-14 pro by M. Uzdurum).

inhabitants did not make direct use of resources throughout their occupation. Instead, they sought or produced in some way a finer textured raw material. One notable local sediment source that was not used for production was the colluvium that formed the ground surface on which the earliest archaeological deposits rest. According to thin section results, the colluvial sediment is much sandier than any of the sediments used to produce construction materials (Uzdurum et al., 2023). Paleoenvironmental records evidenced off-site suggested that Melendiz river activity weakened in Level 4, and it was eroding the Late Glacial-Early Holocene terraces in the valley during Level 3 (Kuzucuoğlu, 2013; Kuzucuoğlu et al., 2018). Here we can observe on-site anthropogenic sediments produced from open spaces and middens for making both mudbrick and mortars (Mentzer, 2018; Uzdurum et al., 2023; Uzdurum & Mentzer, 2018). During the transition from Level 3 to Level 2, erosion also re-activated an old (eastern) branch of the Melendiz river, and the river invaded the eastern Late Glacial terrace that had been preserved until then from river erosion and incision through the ignimbrite obstacle on the other side of the site (Kuzucuoğlu, Özbaşaran, Dumoulin, & Saulnier-Copard, 2020). It is possible that clay heaps were formed in the locations where the river flow rate decreased after the erosion. This environmental process could have been one of the reasons why mudbrick and mortars were made from very clay-rich sediments in Levels 2J–2G.

Clay, the most important component in sundried bricks, makes mudbricks compact, functions as a binder, and increases resistance. The structural integrity of a mudbrick can hold as little as 5% clay (French, 1984). The ideal mudbrick recipe is composed of ca. 25–45% clay. But more than 45% clay may cause them to crack when drying, and also, make the mixture hard and pugging take longer (Rosen, 1986). Sand, which is a perfect substitute for the straw, reduces crack formation during the drying process, thus improving the strength of the final products (Emery, 2009; Kemp, 2000). A certain proportion of sand, silt, and clay – called loam – which is slightly ductile, can be handled quite freely without breaking (Blake & Steinhardt, 2008, p. 507; Minke, 2006, p. 20). The Aşıklı Höyük community must have experienced the pros and cons of clay-rich sediment (up to 50%) while preparing their recipes in terms of both durability and labour when constructing earlier quadrangular free-standing architecture (2J–G). Then, they tended towards sand-sized sediments when the number of buildings increased (2F–D), and larger multi-roomed buildings (ca. 8.75–10.40 m^2) were built. Finally, in the last centuries (2C–A), different grades of sand clay were mixed relatively evenly.

Tempers include both vegetal and non-vegetal inclusions. Vegetal temper is (e.g. straw, chaff) added to the matrix to minimise shrinking during drying and to increase tensile strength (e.g. Homsher, 2012; Kemp, 2000; Lorenzon et al., 2020; Lorenzon, 2021; Nims, 1950). Non-vegetal tempers contain a wide variety of inclusions (e.g. animal bones and potsherds) and carbonate (e.g. lime, ashes, and shells). Carbonate temper is used as a stabiliser for earthen architecture, whether through the intentional selection of calcite-rich sources or through the addition of lime in its various manufactured forms (e.g. quicklime and lime putty) (Oliver, 2008, pp. 98–99). In Aşıklı Höyük, the most common vegetal inclusion is animal dung in mudbrick, especially in mortars in Levels 4, 3, and 2J–2G. It was possibly known by inhabitants that the dung naturally contains various plant residues. After that (from Level 2F), both mudbrick and mortars contain vegetal remains with no dung and without additional waste products. Although plant sources could not be identified in thin sections, phytolith analysis shows that they were straw, husk, and by-products obtained from agricultural activities (i.e. free-threshing) (Tsartsidou, 2018, pp. 155–165). The straw, along with sand, must have compensated for the high clay content of the matrix, reducing the risk of the mudbrick and mortar breaking.

Non-vegetal temper is another addition in mudbrick and mortar at Aşıklı Höyük. As reported by Mentzer and Quade (2013), unreacted or partially slaked lumps of lime and wood ashes are two sources of calcareous plaster floors. Local freshwater limestone and ash are sources of carbonate temper in mudbrick and mortar (J. Quade, personal communication, October 20, 2018). There is micromorphological evidence that non-vegetal temper was procured from middens or open space deposits for making mortars (Mentzer, 2018; Uzdurum, 2019). Non-vegetal temper and $CaCO_3$ referred to as calcium carbonate temper, dramatically decrease in Level 2F–2D, but are more prominent in 2C–2A. It is seen that the practice of producing mudbrick and mortar from occupation wastes was ceased in Levels C–A.

The transformations in the recipes we follow in Aşıklı Höyük must have affected the physical and mechanical properties of building materials, increased the tensile strength, water holding capacity, flexibility, and durability of the walls, thus prolonging the life of the walls. Volcanic Cappadocia is a region that requires constant repair and renewal of earthen buildings, due to harsh winters and 400 mm of precipitation throughout the year. The part of the semi-subterranean buildings under the ground serves as a second wall, and the aboveground walls are easily reached from outside, considering the wide-open spaces between the buildings. Thus, the walls of circular buildings can be repaired both from the inside and outside. The same cannot be said for the quadrangular buildings. Because these are adjacent to each other, and the building groups and neighbourhoods are separated by very narrow spaces, it is impossible to examine the walls from the outside. The roofs were a living space, and built with compacted earth, so the force on the building was much stronger (Duru, 2014). When the density of the settlement pattern and the possible difficulties in collapsing and reconstructing the buildings were added to all these circumstances (Duru, 2013), it was inevitable that more durable buildings would be needed. Experiencing more convenient recipes that provide building durability over time resulted in abandonment of the previous ones. Therefore, mudbrick and mortar recipes played a key role in ensuring the continuity of the mudbrick house tradition.

Last but not least, the local environment was not a determining factor in manufacturing, it was just adapted to recipes by the Aşıklı Höyük community. The transformation in sediment compositions and tempering strategies as well as a decreasing significant distinction between mudbrick and mortar recipes is a result of the changing architectural requirements and know-how shared within the community and transmission through generations. In this context, it can be suggested that re-creating mudbrick and mortar recipes related more to socio-technological rather than environmental factors.

5 Mudbricks and Earthen Building Practice at Çatalhöyük

The East Mound of Çatalhöyük (ca. 7100–5900 BCE) is a Late Neolithic tell site in the Konya Plain in Central Anatolia. First excavated by James Mellaart in the 1960s (Mellaart, 1967) and then by Ian Hodder's international and interdisciplinary team between 1993 and 2017 (Hodder & Tsoraki, 2022), it gained renown for its size (13 ha), agglutinative settlement pattern, well-preserved mudbrick architecture, as well as for its rich symbolic art (Hodder, 2006; Mellaart, 1967). The 19 m of uninterrupted sequence of Neolithic deposits are seminal for our understanding of key developments in prehistoric life from the domestication of cattle and the adoption of a settled way of living, to the invention of pottery and metallurgy, and the appearance of long-distance trade. Furthermore, the entire Late Neolithic life span of the settlement offers a unique opportunity to place architectural traditions in spatial and temporal context. It allows archaeologists to reveal the complex histories that buildings at Çatalhöyük embodied and, consequently, to explore the world of the arguably egalitarian Neolithic community at this site.

Four main occupational periods: the Early, Middle, Late, and Final Periods, as opposed to Mellaart's 12 level system (Mellaart, 1967), can be currently distinguished and each of them was characterised both by continuity and change in architecture (Barański et al., 2022a). However, investigations of architecture at the site have focused mostly on buildings from the Middle and Late Periods, alongside the most common building techniques and strategies (Cutting, 2005; Düring, 2001; Hodder, 2006, 2012; Love, 2013; Matthews, 2005, 2012, 2018; Mellaart, 1967; Stevanović, 2013; Tung, 2013). The architecture from the other periods, the Final Period in particular, remains largely under-identified due to either widespread erosion of the architectural remains or limited excavations. However, efforts undertaken by a number of teams in recent years (Barański, 2017; Barański et al., 2023; Marciniak, Asouti, Doherty, & Henton, 2015a; Marciniak & Czerniak, 2012) have revealed important new information on these lesser known occupational phases and have thus contributed significantly to our understanding of architectural and societal changes at Çatalhöyük.

In general, the GDN research followed the advanced and reflexive field strategy that was characteristic of the Çatalhöyük Research Project led by Hodder (see Farid & Hodder, 2014 for details on the methods). However, modifications to this methodology were applied. These modifications included – in justified cases – departure from single-context recording in favour of observations in cross sections, which allowed for a better understanding of complex stratigraphy. For example, a few sections through selected and heavily eroded mudbrick structures made a significant contribution to the analyses of brickwork and structural relationships within and between buildings, as well as to the reconstruction of relative chronology of buildings. Consequently, a typology for mudbrick walls and foundations was developed, including simple and compound structures (Figure 8). Additionally, the GDN research focused on building archaeology, using direct observations of architectural features. Detailed architectural documentation methods were adopted from

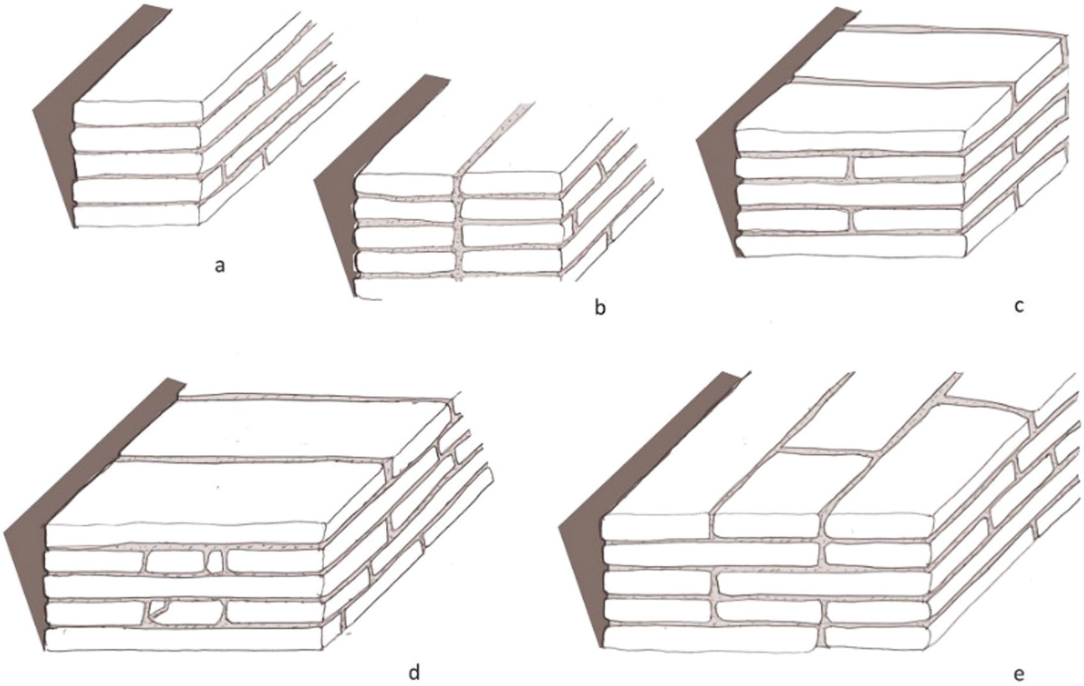


Figure 8: Types of mudbrick structures at Late Neolithic Çatalhöyük: (a) a simple wall, (b) a double wall, (c) a compound one-brick-thick foundation, (d) a compound one-and-a-half-brick-thick foundation with a rubble core, and (e) a compound one-and-a-half-brick-thick foundation with a solid core (Barański, 2020, Figure 6.3).

historic building-recording practices and were applied using both analogue and digital tools. These methods integrated descriptive 2D- and 3D-graphic documentation of architectural features.

An innovative aspect of the GDN research was the inclusion of geoarchaeological analysis which has been tightly integrated into spatial and functional analyses. These methods consisted of geochemistry (GC-MS, X-ray fluorescence [XRF] spectroscopy, X-ray diffraction analysis [XRD], etc.), sedimentological analysis, and thin section micromorphology (García-Suárez, Portillo, & Matthews, 2018; Love, 2012; Sobott, 2018 for details on the methods). These analyses identified compositional variations and the origin of building materials, examined the occurrence, nature, and frequency of domestic residues on occupation surfaces, and assessed the impact of post-depositional agents on the architecture. Furthermore, the GDN research formed part of the programme of radiocarbon dating and Bayesian chronological modelling at Çatalhöyük, which is designed to provide chronology for the Neolithic occupation of the mound on a generational scale.

In order to illustrate how the GDN research benefited from integration of multifaceted data with their context, we would like to focus on reinvestigations of Building 74 (B.74). It is an elaborate structure (75.4 m^2) which underwent a few major rebuildings of its interior. B.74 was only partly preserved, due to issues of erosion and significant Neolithic and post-Neolithic disturbance. Consequently, the floor layouts associated with different occupational phases of building use, as well as the relationships between neighbouring internal spaces and architectural features, were difficult to reconstruct. Hence, various views on the stratigraphy and the biography of this building exist (Barański, 2017; Barański et al., 2023; Marciniak, 2019; Marciniak et al., 2015a; Marciniak & Czerniak, 2012). The main difference lies in the number of individual and subsequent buildings being singled out, and the interpretation of architectural relationships (Figure 9), and duration of use of some of the architectural structures, including the burial chamber (Sp.327). In order to fully understand the twists and pitfalls of the B.74 stratigraphy, a general reference to the results of the Mellaart and TP excavations is necessary.

The southwestern corner of B.74 was partially documented in the 1960s (Mellaart, 1962, Figure 3) and most of the remnants of this building were excavated in the TP Area in the 2000s. It was only the northernmost part of B.74, including its northern wall that was unexposed. However, based purely on the TP results, remnants of

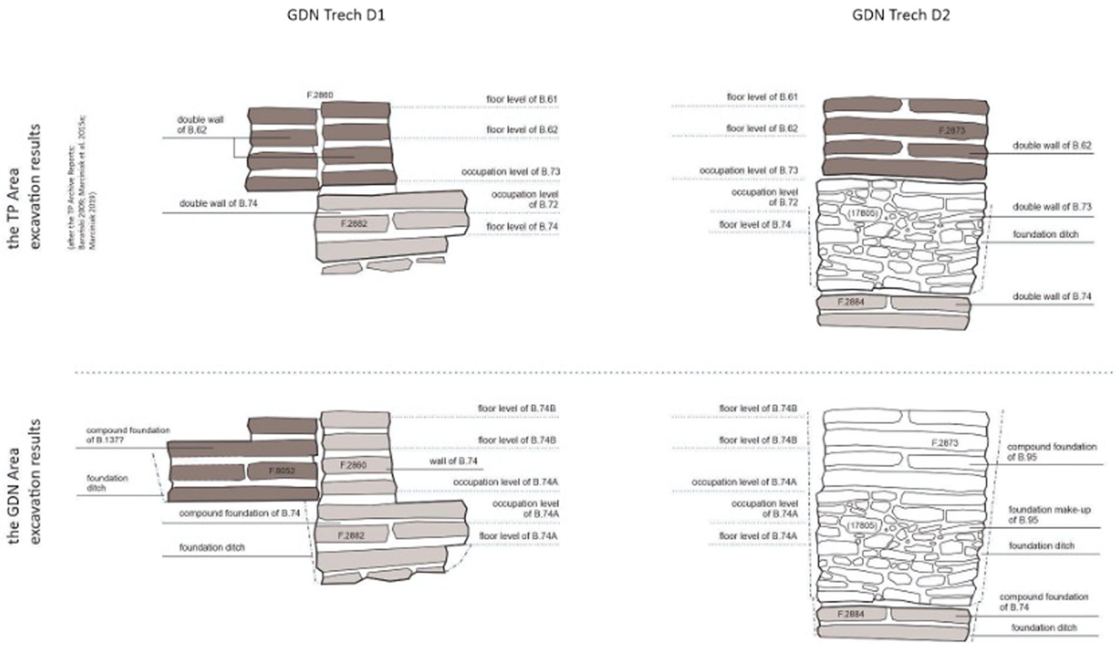


Figure 9: Comparison of the TP and GDN results with regard to the stratigraphy (after Barański et al., 2023).

this building were assigned to different structures: B.74, B.72, B.73, and B.62/61. Interestingly, B.73 was interpreted as a courtyard with built-in burial chamber Sp.327, which is believed to mark a turning point in burial practices at the site, i.e. burying people outside rather than inside houses (Czerniak & Marciniak, 2006; Marciniak, 2019; Marciniak et al., 2015; Marciniak & Czerniak, 2007, 2008). The GDN investigations of the northwestern and northeastern corners of B.74 together with reinvestigations of the northern TP cross section revealed new evidence regarding this building and allowed reinterpretation of the TP stratigraphy and consequently a new Bayesian chronological model to be constructed (Barański et al., 2023). In this study, we refer to the succession of B.74, B.72, B.73, and B.62/61 using only one building number, which is B.74. This is because all the above TP buildings had a common structural layout, which included the same compound foundation and simple load-bearing walls. However, a few of the TP compound foundations, which were initially assigned to B.73 and B.62/61, turned out to have been a part of the later B.95. This building was documented by Mellaart (1962, Figure 3), but its foundations were misinterpreted during the TP excavations due to reliance on the horizontal level system introduced in the 1960s and not taking into consideration the presence of foundation ditches and stepped foundations.

Based on a revised interpretation of the relationship between architectural features, B.74 most likely consisted originally of the main room and the southern annex (Figure 10a). Both these spaces were defined by a set of compound foundations and simple walls with the first of these structures being situated within foundation ditches of varied depth. This building strategy is a characteristic feature of Late and Final Periods of the Late Neolithic Çatalhöyük. These are the periods when the number of open spaces seems to have increased gradually. In fact, B.74 was to a large extent built on top of midden deposits which sealed the remnants of earlier B.81. This resulted in a general discontinuation in the direct use of the layout of B.81 as a template for its successor as well as in construction of B.74 on a slope, using stepped foundations. As a result, the difference in elevation heights between the bottom surfaces of eastern and western foundations of the building was at least 1.0 m.

It seems likely that the initial floor lay out of the main room of B.74 reflected the common division into the northern “clean” and the southern “dirty” areas. The first of these spaces included a vast floor area which appeared sunken in relation to the remnants of the eastern platform(s). Additionally, it was truncated by a post-retrieval pit which – together with the size of the main room of B.74 (ca. 41 m^2) and the required minimum span of the roof beams (up to 7.5 m) – suggests that the uppermost part of the building was supported by a

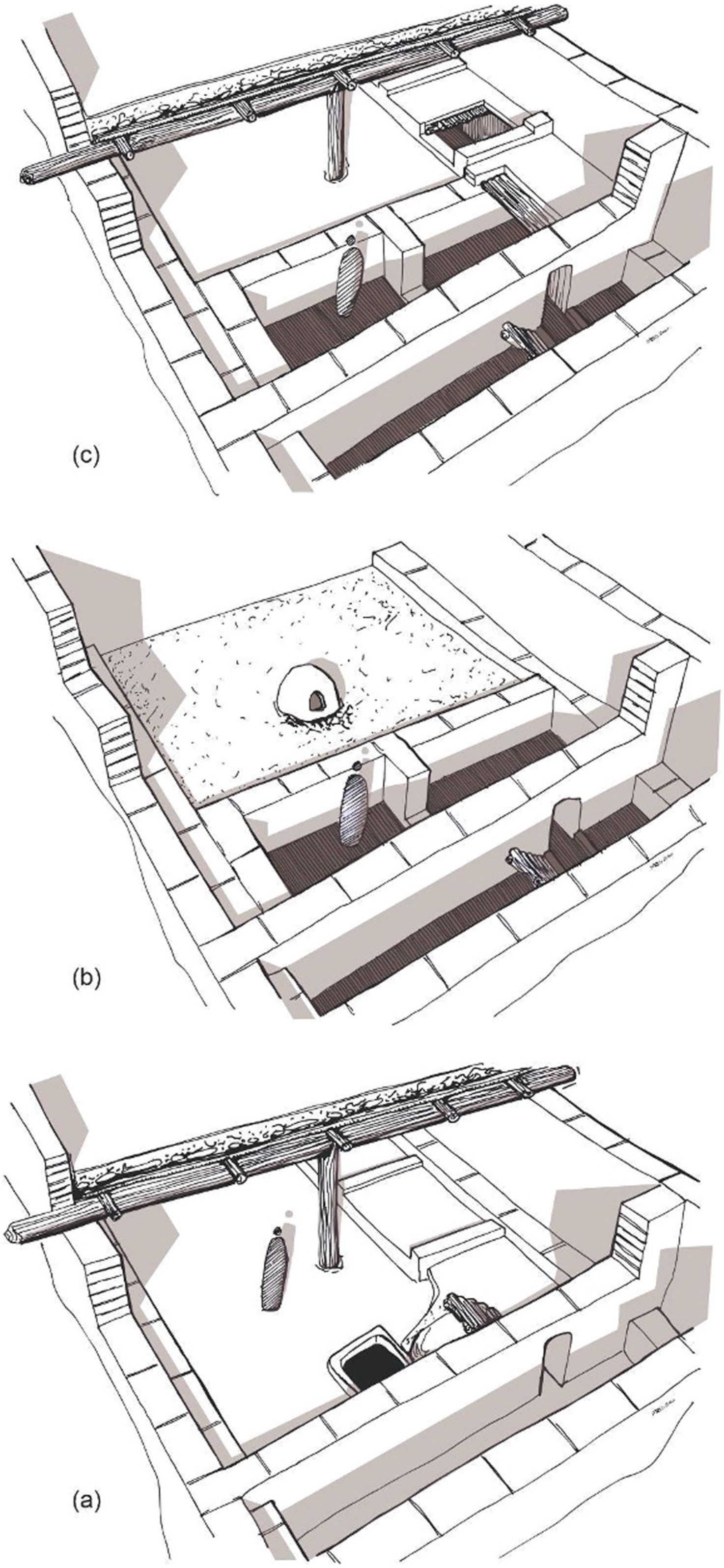


Figure 10: Reconstructions of Building 74 and its major re-buildings: (a) Phase 2a, (b) Phase 2b, (c) Phase 2c (after Barański et al., 2022a).

central post and a down stand beam. This type of construction has not been considered in the vast majority of studies of architecture at Çatalhöyük (Barański et al., 2022a), including the TP excavations. There is no evidence of any additional wall posts, although their presence within the interior of B.74 cannot be ruled out. The "dirty" floors were most likely around the hearth, oven, and entrance area to the south. However, none of these FIs were preserved.

As a part of the re-building phase, two partially subterranean spaces were built into the southern "dirty" part of the main room of B.74 (Figure 10b). These spaces were documented during the TP excavations – rather needlessly – as B.72. Their construction seems to have been followed by the introduction of a subterranean burial chamber (Sp.327), which, in turn, was dug into the eastern part of B.74 in the place where the earlier platforms (including platforms of earlier B.81) were situated. At this time, the initial main room seems to have been partially filled in and turned into a production area. This is suggested by the presence of an external oven and various fire spots. Furthermore, the repair or substitution of the roof is likely to have happened at that time.

How long the production area might have been used for – a month, a year, a decade – remains an open question due to the complexity of stratigraphy and limited or problematic radiocarbon data. Similar doubts also appear regarding the lifetime and use of the two partially subterranean spaces as well as the burial chamber itself. Particularly debatable is the relationship between these structures and the living space which appeared in the place of the production area (Figure 10c). The GDN results suggest that it is possible for all four of these spaces to have been used – at least temporarily – at the same time. If so, the burial chamber could have been an integral and internal part of B.74 and might have been used until the final occupational phase of the building. Both the partially subterranean spaces with limited access and no internal architectural features (platforms, benches, FIs, etc.) might have been used for storage (Barański et al., 2023). According to the TP results, the appearance of Sp.429/438 was associated with the start of B.62/61 with its distinct sequence of plastered floors and internal divisions. That being the case, this structure would mark a definitive end to the use of the burial chamber as well as both of the partially subterranean spaces (Marciniak et al., 2015).

Regardless of the above discrepancies, the fact of the matter is that all the spatial and architectural changes appear within the area defined by the very same mudbrick structures. There is no evidence of these structural features being dismantled or rebuilt at any phase of building use, be it B.74 or B.62/61. Furthermore, each of the floors of the initially distinguished buildings turned out in fact to be constructed against the same mudbrick structures, that is northern and western walls as well as the western foundation of B.74. Additionally, all these floors were truncated by the foundation ditch for the western foundation of B.95, which was previously and incorrectly associated with B.62/61.

Importantly, the GDN results served to recalculate date estimates for the use of B.74 to 10–95 years (95% probability) and 20–65 years (68% probability). The start of the use of the building was defined as 6265–6225 BCE (95% probability) or 6250–6230 BCE (95% probability) and the end was defined as 6220–6155 (95% probability) and 6215–6180 BCE (65% probability) (Barański et al., 2023). These calculations contrast with the TP results regarding the same sequence of floors and the same radiocarbon dates. The start of this sequence was estimated to be 6350–6245 (95% probability) or 6295–6245 (52% probability) and the end of it to be 6095–6020 (95% probability) or 6080–6040 (68% probability). As a result, the use of B.74 (as we understand it here) was calculated to last about 150–330 years (95% probability) (Marciniak et al., 2015), which is not only much longer but seems highly debatable regarding the mudbrick architecture.

Furthermore, the new stratigraphic and structural evidence regarding B.74 resulted in reinterpretation of some of the geoarchaeological data. At first sight, results of the analysis of mudbrick "recipes" from the neighbouring GDN and TP buildings indicate very little variation, pointing to strong compositional similarities (Love, 2013). The bricks, when considered all together, do not cluster into any meaningful pattern and it is clear that no one single building has a unique signature. However, if B.74 is considered as one structural entity (in contrast to the sequence of B.74, B.72, B.73, and B.62/61), mudbrick structures are divided into structural and non-structural features, as well as mudbricks grouped according to the excavation areas, there appears to be a difference between clusters of buildings as well as phases of occupation. The differences are also visible in the mudbrick dimensions, e.g. between B.74 and B.95, even though the average mudbricks from the Final Phases seem to be the least diversified in length, width, and height at the site (Barański, 2020). In addition, they are the thickest and the highest of the entire dataset. All these differences seem to serve as one of the bases for distinguishing neighbourhoods that were inhabited by people who could have jointly controlled specific resources regarding building materials and who might also have taken part in centralised production (Barański et al., 2022b; see also Love, 2013).

6 Earth and Stone at Boncuklu Tarla

The site of Boncuklu Tarla is located about 1 km away from the River Tigris on the south bank of the Nevala Maherk creek (Kodaş, 2019). Dates are ca. 10.470 to 7500 cal BCE according to available radiocarbon dates. A later occupation phase cannot be ruled out at the moment. Boncuklu Tarla is well-known for its great variety in architecture, which resembles elements from different regions, e.g. the Northern Levant, Upper Mesopotamia, and the Zagros. The architecture shows a wide range of shapes, concepts, and building techniques. Although the PPN architecture can be in general addressed as stone architecture, there is a substantial part in the construction that is made of earthen materials, e.g. wall mortars, floor plaster, and roofing.

In 2021, Building GD4 (Figure 11) was exposed in the south-eastern part of the site, close to the edge of the site (Kinzel, 2022; Kodaş, 2023; Kodaş & Çiftçi, 2022). It is just a few metres apart from Buildings GD1 and GD2, which were excavated in 2019 and 2020. All three structures resemble characteristics of buildings known from the Neolithic site at Nemrik 9, in what is now Iraq, further down the Tigris River (Kozłowski, 1989, 1990). Especially, houses 1 and 4 in their latest phase could be seen as role models for the examples at Boncuklu Tarla. In addition, there are some similarities in lay out and conception to e.g. Structure 7 at Gusir Höyük (Karul, 2011), the subsequent structures [3/267/298/350] in area H12 at Hasankeyf (Miyake, Maeda, Tanno, Hongo, & Gündem, 2012) and structures 7, 8, and 15 at Gre Filla from the Upper Tigris region (Ökse, 2022) as well as structure EA6 at Wadi Tumbaq 3 (Albukaai, 2016). The masonry pillars/buttresses also resemble structural features known from PPNB Kalavassos-Tenta in Cyprus (Clarke & Wasse, 2020).

Building GD4 has an ellipsoid ground plan, and it is oriented on an east-west axis and at least two major building phases have been attested (Kinzel, 2022). The interior space measures c. 7.25 m in an east-west direction and c. 6.25 m in a north-south direction. The wall tops show an average width of around 0.66 m.

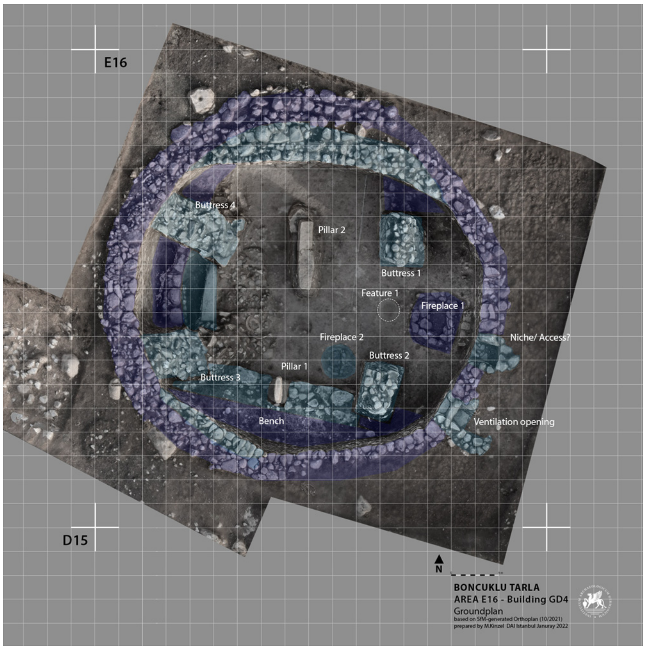


Figure 11: Boncuklu Tarla: Ground plan of Building GD4 – after Kinzel, 2022. (Graphic: M. Kinzel, DAI-IST).

The walls are built with rubble stone masonry using granite river pebbles and smaller limestone boulders. In the upper wall courses, the wall is constructed as double-faced rubble stone wall. It is unclear so far if the entire wall is constructed that way or only the upper parts, which initially may have been visible from the exterior. The walls are preserved up to 2.25 m above the floor surface. It can be assumed from the collapse material found inside the structure that initially they could have been around 0.2–0.3 m higher. The inner wall surfaces were covered with a thick mud plaster. Flat river pebbles were placed into the plaster and were still visible like inlays. Those visible flat, round, and river polished pebbles could be seen as decorative elements (Figure 12). The wet-in-wet technique of mud plastering makes it very hard to distinguish between the wall core and the plaster with the embedded river pebbles, as the materials blend smoothly into one another. An earthen bench, about 0.75 m wide, stretches along the southern, western, and northern wall. It was later made wider along the southern wall with a stone-built extension of about 0.70 m, making the bench in total over 1.40 m wide and at least 4.20 m long. In contrast, the preserved latest interior wall – on the opposite side of the building – was placed on top of the northern bench in a later building phase. The earthen bench is built in a technique known as pisé modelé, Zabur, or tauf (Dethier, 2019; Kinzel, 2018; Minke, 2006).

The initial building might have had a more circular plan hinted by some wall features and lines. However, the last building phase is more ovoid or ellipsoid and clearly oriented east-westwards. The interior of this final phase is dominated by two free-standing masonry pillars (Buttresses 1 and 2) made of river pebbles and rubble stones, two vertically placed free-standing limestone slabs (Pillars 1 and 2), and two masonry buttresses (Buttresses 3 and 4) built against the western exterior wall. The more northern of the two stone slabs has collapsed towards the south and is resting on accumulated sediment. Both stone slabs were originally placed in a slot/socket worked into a limestone boulder – resembling features of the rock-cut podia for the "central" pillars at Göbekli Tepe (Kurapkat, 2015). The floor of the structure shows a plaster-like surface. No further analyses have been conducted so far on the floor material but are in preparation. A series of fireplaces, roasting pits, and "basins/pits" were identified in the floor, some of which were sealed off and replaced in later use-phases of the building. The large roasting pit is placed directly against the eastern exterior wall and measures ca. 1.25 m by 1.34 m. The pit was filled with rubble stones before it was sealed with a layer of mud and replaced by a smaller roasting pit/fireplace in front of the southern bench (Figure 13).

The actual function of the building is still unclear. Equipped with roasting pits, fireplaces, and benches it may have served a larger "family" as a domestic structure. However, it may have been a multi-purpose building that turned into a "communal" structure at times or was used by a group of people. The presence of vertically placed stone slabs may indicate some symbolic-ritual component but does not imply that Building GD4 could be called a "special-, public, or communal building" as such. All architectural features point so far towards domestic use. The building was obviously cleaned regularly and kept tidy. On the other hand, some

Figure 12: Boncuklu Tarla: Building GD4, close up of mud mortar with embedded river pebbles. (Photo: M. Kinzel, 2021, DAI-IST).

Figure 13: Boncuklu Tarla: Interior of Building GD4 (Photo: M. Kinzel, 2021, DAI-IST).

animal remain deposited on a layer of river pebbles could hint as well towards ritual practices as the last activities taking place in the building. However, an accident related to the collapse of the roofing cannot be ruled out as the stone layer the bones are found on, could stem from the roofing. The floor material has not yet been studied in detail. It appears to be a (lime) plaster floor, which seems to have been renewed at least once. However, further future studies of the floor and the deposits on it may help understand the activities and practices inside GD4 and its construction during the Neolithic.

7 Göbekli Tepe: Living Ruins, Not Buried Buildings

In the following, a summary of the microarchaeological studies and geochemical sediment analyses conducted since 2017 at the PPNA + B settlement of Göbekli Tepe (ca. 9500–8000 cal BCE; Clare, 2020, p. 81) is presented. With the aim of refining the chronology of the site, reconstructing daily practices and abandonment routines and establishing house biographies, detailed building archaeological research, and room fill analyses have been carried out. As parts of the data are still being processed, this section provides an overview of the work of the interdisciplinary team.

The Neolithic site of Göbekli Tepe is located about 15 km east-northeast of the modern city of Şanlıurfa on the southeastern foothill of the Germuş mountain range on a star-shaped limestone plateau at around 800 m asl (Braun, 2021a; Kinzel & Clare, 2020; Knitter, Braun, Clare, Nykamp, & Schütt, 2019).

In 1963, Göbekli Tepe was recorded by Peter Benedict during a survey as part of a joint research project by Istanbul University and the University of Chicago under the direction of Halet Çambel and Robert Braidwood (Benedict, 1980; Çambel & Braidwood, 1980). In 1994, Klaus Schmidt revisited the site at the excavations, running since 1995 until today, under the direction of the German Archaeological Institute (DAI) and Şanlıurfa Museum. Between 2007 and 2014, the project was directed by Klaus Schmidt until his untimely death (Dietrich, Köksal-Schmidt, Kürkçüoğlu, Notroff, & Schmidt, 2014; Schmidt, 2010, 2012). Since then, the works have been under the directorship of the Şanlıurfa Museum in cooperation with the DAI, Orient Department, and Istanbul Department with Lee Clare as coordinator. At present, Göbekli Tepe has been integrated in the project "Göbekli Tepe and Karahantepe Excavations" under the direction of Necmi Karul (Istanbul University) and Lee Clare (DAI, Istanbul) as coordinator. In 2018, Göbekli Tepe was added to the UNESCO World Heritage list (Clare, 2020; Dietrich, Notroff, & Schmidt, 2015, Kinzel, 2021a; Schönicke, in press).

The mound of Göbekli Tepe is densely covered with architecture, including oval and quadrangular buildings of various sizes, some of which are constructed directly on bedrock (Kinzel et al., 2020; Kinzel & Clare, 2020; Kinzel, Clare, & Sönmez, 2021; Kinzel, in press). Schmidt assumed that the settlement had been occupied by gatherers and hunters based on the results that no traces of domesticated plants or animals had been found in the archaeozoological and archaeobotanical record (Neef, 2003; Peters & Schmidt, 2004; Peters, Schmidt, Dietrich, & Pöllath, 2014). The architecture on site shows a high variety of shapes and functions. Besides domestic structures, several special buildings were also identified (Kinzel & Clare 2020; Kurapkat, 2015; Schmidt, 2006). The large oval (special) buildings were equipped with up to 5.5 m high anthropomorphic monolithic T-shaped pillars, which are decorated with reliefs of wild animals and abstract symbols and also had the practical function of carrying the roof (Banning, 2011, p. 629; Braun, 2021b, p. 215; Kinzel & Clare, 2020, p. 44; Kurapkat, 2012, p. 159; 2015, pp. 135–139; Schmidt, 2006). The special buildings underwent a series of modifications and re-building with long lasting use lives. They likely served multiple purposes, including communal meetings and ritual practices. Smaller T-shaped pillars, less or even undecorated, were also found in contemperanous rectangular (domestic) buildings.

Formerly interpreted as a purely ritual site, or “mountain sanctuary” (Dietrich, Heun, Notroff, Schmidt, & Zarnkow, 2012, p. 675; Dietrich & Notroff, 2015, p. 87; Schmidt, 2000, p. 46), the archaeological findings include domestic Neolithic artefactual and lithic assemblages (Breuers, 2022; Breuers & Kinzel, 2022), domestic features (FIs and burials) (Clare, 2020, pp. 82–85; Kinzel, in press), and water supply installations (Ernst, 2016; Herrmann & Schmidt, 2012), which clearly indicate the presence of a settlement, but with outstanding features. The size and longevity of the settlement can be seen as indicators for manifold occupation practices with multiple alternating use and abandonment phases. Through these findings, research interest shifted towards the dynamic formation processes and a new understanding of the long building biographies in Göbekli Tepe, which resulted in a very complex settlement stratigraphy (Kinzel et al., 2021; Kinzel & Clare, 2020, p. 34). After about 1,500 years of intense occupation, the people started to detach from the place and the site was – to our current understanding – only visited sporadically in post-Neolithic times.

The research currently carried out at Göbekli Tepe also includes the reconstruction of ruin interactions and room fill analyses. It was stated earlier by Klaus Schmidt and others that the large special buildings were intentionally backfilled at the end of their use or life (Dietrich, Köksal-Schmidt, Notroff, & Schmidt, 2013, p. 36; Özdoğan, 2018; Özdoğan & Özdoğan, 1998; Schmidt, 2006). This was conceptualised as ritual burying of the structures (Clare, Dietrich, Notroff, & Sönmez, 2018, p. 125; Özdoğan, 2018). However, recent research on site suggests that the filling of the structures is mainly caused by landslide events due to the settlement’s topography with its steep slopes, mounds, and hollows and also shows traces of anthropogenic stabilisation and repair measures (Kinzel et al., 2021, pp. 6–10; Kinzel & Clare, 2020, p. 35; Schönicke, 2022, pp. 219–221). With increasing loads and instability, the structures built on the slopes slid into the (communal) buildings placed in the depressions and damaged them severely. After each destructive event, the inhabitants of Göbekli Tepe tried to stabilise, clear, repair, or fully rebuild some of the buildings, while others were left in ruin and abandoned. The large quantities of reused building material indicate that it was extracted from ruins within the settlement rather than having it newly quarried and cumbersomely transported from the limestone plateau through the densely built settlement area (Schönicke, 2022, p. 224). But the reuse practices at the site are not only restricted to stone material. In fact, soil seems to have been recycled as well. The earthen mortar in between the wall stones contains not only the sandy silt chipped stone, but also bone, charcoal, lime, and stone in abundance. It is likely that it was also taken from ruins. Noteworthy is that younger mortars seem to contain less charcoal due to the repeated watering when recycled into new mortar.

Reused building material is commonly associated with practical (in the sense of being less labour intensive) and mnemonic (*spolia* as memory places; Meier, 2021, 2023) approaches that are usually based on conscious decisions. However, ruins are also a testimony of the unplanned, incidental, and unexpected encounters (Pétursdóttir, 2016, p. 377), e.g. a pillar fragment has a comfortable height for sitting if placed horizontally – it embodies the character of an affordance. In addition, repetitive practices tend to turn into routines and therefore generally happen unquestioned. Taking soil mixed with settlement debris from ruins might hence be addressed as an act of the incidental (“*Beiläufigkeit*)” and must not necessarily imply a special or ritual character, even if archaeology tends to put an (over) emphasis on meaning (Pollock, Bernbeck, Appel, Loy, & Schreiber, 2020, p. 142). This was and still is especially true for Göbekli Tepe due to the dominance of the special buildings in the discourse. Bringing light to the settlement character and people's daily practices in recent years of research has challenged this view fundamentally.

At Göbekli Tepe, the stone architecture has been at the focus of research since the beginning of the excavations. In particular, the monolithic T-shaped pillars are presented prominently in almost every publication. The actual architecture, the room fills, or exterior spaces, however, have rarely been published at all even though they represent the majority of the material that created the archaeological mound. However, to highlight the diversity of the settlement's character, small-scale documentation of structures is indispensable. Whereas the documentation of reused materials in buildings can be seen as indirect indicators for the existence of ruins in the settlement, the study of room fills highlights which activities took place directly in the abandoned structures. Here microarchaeological methods can provide a helpful tool kit to understand those contexts better.

In the course of the archaeological investigations since 2017, small-scale excavation methods and microarchaeological analyses have been established in the Göbekli Tepe project, including a systematic strategy for the sampling of soil, building material, macrobotanical remains, phytoliths, and dung spherulites, as well as off-site control samples. All excavated contexts were dry sieved, whereas primary contexts were sampled for flotation to gain small objects and macrobotanical remains. Deposits just above the floor and floor contexts were sampled in a checkerboard style with a 50 cm × 50 cm grid and every second square being sampled (Öğüt et al., in prep.). This constant approach provides contextual comparability in almost all excavated contexts and, if constantly applied, even between different settlements.

For the investigation of the lime plaster floor, often referred to as "terrazzo" (Schmidt, 2000, p. 49), mineralogical and petrographical analyses using XRD and energy dispersive XRF spectroscopy were performed by Robert Sobott (2020). Two PPNB contexts were analysed: a floor fragment northwest of Building F in area K09-87 and one from a niche in the north of Room 16, area L09-80. The predominant material of the floors is limestone embedded in a matrix of lime marl. It is difficult to identify the original binding product. According to the analyses, the binder was washed out partially when the building was left to ruin. Later a solidification of the floors reoccurred post-depositional by the formation of dogtooth cement (Sobott, 2020, p. 2). The lime material shows a high variety of unequal heating and by-products of this non-standardised production process. There was obviously an attempt to produce burned lime as a basis for lime plasters, but the technology was not fully developed. In contrast to samples from sites dating slightly later than Göbekli Tepe, e.g. at Çayönü or Nevali Çori (Affonso, 1997; Kalizan, 1998), the samples of burned lime at Göbekli Tepe are still far away from the later almost cement-like qualities of the terrazzo floors at Çayönü with burnished and polished surfaces. Nevertheless, there are hints and traces indicating that some of the floors had polished surfaces. In general, the floors at Göbekli Tepe dating to the PPNB should not be approached as "terrazzo," but more neutral as "lime plaster floors."

From the lime marl matrix of the floor Loc. L9-80-122 in Room 16 as well as from the superimposing fill and roof collapse layers, samples were taken for microarchaeological analyses, including determination of the pH value, phytoliths, and dung spherulites (performed by Birgül Ögüt, see (Öğüt et al., in prep.), particle size analyses using laser diffraction, total, organic, and inorganic carbon, XRD, and multi-elemental and phosphate analyses using ICP-OES (by Julia Schönicke, see (Öğüt et al., in prep.; Schönicke, 2022, in prep.). Further, the analyses of archaeobotanical remains (seeds/fruits/charcoal, by Ferran Antolin) and lipids/metabolites (by Barbara Huber) have been carried out recently (Öğüt et al., in prep.).

In the following, we will concentrate on the contexts sampled for phosphate analyses using ICP-OES. The performed phosphate analyses (for methods see Schönicke, 2022, p. 229) aim to give answers to the following questions: Were internal spaces kept cleaner than outdoor areas? Is it possible to trace anthropogenic activities in ruins after the inhabitants abandoned their houses? Does the geochemical composition allow assumptions regarding the roof constructions?

The results of the phosphate analyses can be best understood through an intra-site comparison and in the study of different contexts. In our case, an outdoor midden with an FI at the western edge of the settlement in Drainage Channel 2 (GT-DR2) (Clare, 2020, pp. 83–84; Lelek-Tvetmarken & Kinzel, 2017; Schönicke, 2022, p. 227) serves as a comparison to the floor and fill of rectangular Room 16 in area L9-80 (Figures 14 and 15). These areas differ diachronically, spatially, and contextually (Table 1).

Figure 14: Room 16 in Area L9-80 with modern wooden beams to reconstruct roofing. Photo: M. Kinzel, DAI Istanbul Department.

Figure 15: Reused materials in the mortar: bone, lithics, small stones, charcoal, and lime. Northern wall Loc. L9-80-23 of Room 16, area L9-80 (detail) (photo: Moritz Kinzel/DAI).

Table 1: Overview of the contexts that were sampled for geochemical sediment analyses using ICP-OES at Göbekli Tepe (J. Schönicke)

	Drainage Channel DR-2	Room 16/Area L9-80
Diachronic	Early settlement activity (PPN A–B transition) 9130–8796 BCE (68.3%)	Late use and abandonment (MPPNB) 8555–8351 BCE (68.3%)
Spatial	Western periphery	Eastern settlement centre
Contextual	Outdoor area	Interior space
Sampled loci	Slope slide layers, midden deposits, ash from FI	Floor, pit fill, roof collapse, room fill

At Göbekli Tepe, outside areas were only recently documented, hence, geochemical analyses of these contexts were not performed prior to this study. In GT-DR2, the accumulated midden layers sit at least 1 m below the slope slide deposits indicating a long and repetitive use of the area. An FI with a silty ridge was located in the midden together with the horn of an aurochs and the tail of a wild sheep (bones still in the compound), a lot of lithic debris, and animal bone. In a later phase, the fireplace was covered again by ashy deposits. In the upper layers of the midden, a structural collapse was found, which was, in turn, again covered by ashy deposits (Lelek-Tvetmarken & Kinzel, 2017; Schönicke, 2022, pp. 227–229). This area and its deposits date into the PPNA-B transition (9130–8796 BCE, 68.3%; Schönicke, in prep.). In addition, the southern section of DR2-Chimney 1 was systematically sampled. A total of 18 samples were analysed (Schönicke, 2022, Figures 9–11). Two reference samples were taken from offsite contexts at the surrounding limestone plateau (Schönicke, 2022, p. 232).

Figure 16: Location of samples in Room 16. Left: yellow = pit fills (to be discussed elsewhere) and red = silt plaster within the floor; right: samples from room fill and roof collapse (note: collapse already removed from the E part of the room). Photos: C. Lelek-Tvetmarken, DAI Orient Department.

Room 16 is a rectangular space located on the slopes north of Building D in area L9-80 and displays multiple phases of modification and re-building (Kinzel et al., 2020, pp. 15–17) (Figure 16). The radiocarbon data from room fill points to the abandonment of the room after 8555–8351 BCE (68.3%) (Schönicke, in prep.). Only little finds were recovered directly on the floor of Room 16; therefore, it cannot be deduced what activities took place there. The samples from Room 16 were taken from the compact lime plaster floor (Loc. L9-80-122), pit fills (pit fills Loc. 130, 132, 134) as well as fill over floor and roof collapse.

The small-scale architectural studies prove that the buildings of Göbekli Tepe contained large quantities of reused materials which have likely been extracted from ruins (Schönicke, 2022, Figure 6). This can be addressed as incidental practices or routines not ritual, with, of course, the exceptions of *spolia* creating memory spaces (Schönicke, in prep.). Phosphate analyses from Göbekli Tepe show promising results. However, due to the limited number of samples and the fact that only one room and one exterior space have been analysed so far, the data must be interpreted with caution. Yet, significant differences between indoor and outdoor contexts have become visible. As already discussed elsewhere, the ashy layers from the midden and FI area in DR2 show significantly higher phosphate values than the erosional deposits above (Schönicke, 2022, p. 229). The results from Room 16 indicate that this room was kept cleaner than the exterior activity area in DR2 (Öğüt et al., in prep.). The fill over floor layers displayed higher phosphate content, which points to activities in the ruins, such as waste deposition or use as a toilet. Yet, the roof collapse contained even higher levels of phosphate, which supports the assumption that roofs were used as working areas. These results might also originate from the use of organic building material on roofs or ceilings. The data from carbon measurements are still in the process of being evaluated (Schönicke, in prep.), but higher levels of total organic carbon (TOC) would support the assumption of wooden beams and other organic material as part of the roof construction (Kurapkat, 2012, p. 159) even if no macrobotanical remains have been preserved. Integrating more contexts in the intra-site analyses would be part of future research. The microarchaeological studies from Göbekli Tepe demonstrate that it is necessary to stress the importance of an underrepresented part of building material in Neolithic stone architecture – soil.

8 Keeping It Clean – Activity Areas at the Aeneolithic Settlement of Monjukli Depe

In this section, the results of phosphate analyses from indoor and outdoor surfaces at the Aeneolithic horizon of Monjukli Depe, Turkmenistan are presented. With the aim of identifying activity areas, microarchaeological excavation methods and systematic sampling strategies were constantly applied in the project. It turned out

Figure 17: Mudbrick architecture in the centre of the settlement of Monjukli Depe. In House 9, the floor sampled using the checkerboard method is visible. Berdiev street leading to the Eastern Midden is located in the north (photo: Monjukli Depe Project).

that mud plaster floors of apparently “empty” rooms store plentiful information on space use and daily practices, especially when compared to outdoor areas.

The late Neolithic to early Aeneolithic settlement Monjukli Depe (Pollock et al., 2018, 2019) is situated in the alluvial plains of the Kopet Dag piedmont zone in Southern Turkmenistan at around 280 m asl. The loess hills of the piedmont zone characterise the area to the south, whereas the vast Karakum desert opens towards the north.[2] The modern village of Meana is located about 3 km to the north and two seasonal streams, Meana and Chaacha, flank the site to the north and southeast. The wadis carry sand and gravel from the Kopet Dag towards the desert, which is why the lower lying parts of the site are covered under thick layers of alluvial and aeolian sediment (Berking & Beckers, 2018, p. 4; Pollock & Bernbeck, 2019b, p. 34). The arid region is only sparsely covered with vegetation although the area might have been more humid in the past as geomorphological analyses suggest (Berking et al., 2017, p. 9). The part of the mound that protrudes from the alluvial layers is 1.5 m high and c. 40 m in diameter.

Monjukli Depe was discovered in 1935 by Alexander A. Marushchenko during a survey that was followed by the excavation of a deep trench in 1959 (Heit, 2021, p. 37). Excavations of the uppermost stratum began in 1960 under the direction of Ovljakuli Berdiev (Berdyev, 1972). Work in Monjukli Depe was resumed from 2010 to 2014 with excavations carried out by a team from the Freie Universität Berlin under the direction of Susan Pollock and Reinhard Bernbeck. The project aims to investigate cultural techniques, daily practices, and technological changes, including pyrotechnologies, subtractive technologies, subsistence technologies, fibre working, food preparation, and ideological cultural techniques such as burial practices (Pollock & Bernbeck, 2019a, p. 30). Radiocarbon analyses yielded dates for the Neolithic occupation (Jeitun horizon, strata X-V) in the range of 6200–5600 cal BCE and the Aeneolithic occupation (Meana horizon, strata IV-I) in the range of 4800–4350 cal BCE with a 600 year hiatus (Heit, 2021, pp. 39–40; Pollock & Bernbeck, 2019b, p. 39).

The excavations revealed well-preserved agglutinating mudbrick architecture that was documented in detail using microarchaeological methods (Figure 17). Additionally, the settlement plan of the 1960s that depicts the youngest stratum could be complemented and extended by both excavations and scraping of the mound’s surface. Since the Neolithic horizon was only excavated in small parts, no assumptions on the early settlement layout can be made. The Aeneolithic strata, however, display agglutinating rectangular

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[2] Southern Turkmenistan was intensively studied by archaeologists starting in the 1880s and followed by archaeologists from the Soviet Union with research questions regarding subsistence, economy and local networks (for an overview of the archaeological history and research questions see Coolidge, 2005, pp. 7–22; Heit, 2021, pp. 77–114; Kohl, 1984, pp. 17–23; Müller-Karpe, 1982; Pumpelly, 1908; Pollock & Bernbeck, 2019a, pp. 26–30).

Figure 18: Plan of Stratum I/II. House 2 is located in the northeast (Unit E). Berdiev street leading to the Eastern Midden is visible south of it. Houses 11 and 15 are situated in the northwest (Unit F) (after Pollock & Bernbeck, 2019b, Figure 2.46).

houses that were oriented along two streets (Berdiev and South streets) as well as around two large middens (Eastern and Central Middens) (Figures 18 and 19). All houses contained a lower part towards the entrance and an elevated part at the back of the space. This internal separation was enhanced by buttresses facing each other and was connected by a “threshold” or curve. It can be assumed that this separation indicates different activity areas within the spaces which is supported by the location of FIs in the lower parts.

Both walls and floors were repetitively plastered and coloured with either red ochre or white lime. In parts, the floors contained impressions of reed mats and wall paintings were found on some of the walls. A plastered floor revealed impressions of the feet of a child and a dog which demonstrates the close relationship of humans and (non-human) animals at the site during the construction phase (Egbers, 2019, p. 127).

The settlement inventory included various ground stone tools (Öğüt, 2020), chipped stone, spindle whorls (Keßeler, 2019), animal bones and figurines (Eger, 2022), beads of different materials, including lapis lazuli (Güneş, 2019) and clay tokens (Daitche, 2019). The amount of pottery decreased profoundly from the Neolithic to the Aeneolithic strata resulting in an almost aceramic Aeneolithic horizon indicating the neglect of an overall established cultural technique (Schönicke, 2019b, p. 323). Burials of individuals of different ages within the settlement offer insights into the local practices involving the dead (Rol, 2019).

Furthermore, the inhabitants of Monjukli Depe constructed a variety of FIs ranging from open fireplaces to hearths and large circular and two-chambered rectangular ovens that were documented inside the houses as well as in exterior spaces (Schönicke, 2019a). The intense use of fire is also reflected in the huge amounts of ash that were excavated in the Eastern Midden. In addition to daily disposal activities, findings of animal bones and pottery point to feasting practices that might have been carried out there (Eger, 2019; Schönicke, 2019b, p. 311).

Figure 19: Plan of Stratum III. House 9 is located in the centre of the settlement (Unit D). The exterior space south of the structure belongs to the abandonment phase of House 9 and is not depicted in this plan (after Pollock & Bernbeck, 2019b, Figure 2.30).

Excavations were carried out using the locus system. Microarchaeological methods were thoroughly applied during fieldwork. All primary and secondary contexts were sieved, and their volumes recorded. A systematic sampling strategy was used including samples for flotation, phytoliths, macrobotanic remains, ^{14}C, micromorphology, and soil samples. Floors and other surfaces were sampled in the checkerboard style with every second square being sampled. All finds were counted and weighed during primary processing, which allows, in combination with context volumes, for calculations of find densities and degrees of fragmentation. Altogether, these small-scale methods enable detailed intra-site contextual comparisons.

The analysed samples (*n* = 47) come from Aeneolithic contexts in Stratum I/II and III. In Stratum I/II, Houses 2 (Loc. E253, *n* = 5), 11 (Loc. F95, *n* = 12), and 15 (Loc. F 82, *n* = 7), two street contexts (Loc. D219, *n* = 1 and F93, *n* = 1), and FIs 39 (*n* = 2) and 41 (*n* = 1) were sampled. In Stratum III, sampled contexts include House 9 (Loc. D514, *n* = 7), House 10 (Loc. D445, *n* = 2), the exterior space (Loc. D363, *n* = 5), and FI 26, 28, 29, and 44 (*n* = 1 in each FI). Additionally, soil samples from the nearby wadi (*n* = 5) were analysed to determine the natural amount of P in the soil. Unfortunately, due to the heterogeneous composition of the sediments, they show indistinct results and are hence not included in the data evaluation.

In this section, the focus lies on a brief presentation of the results concerning the interior and exterior surfaces. Further details on this study as well as a presentation of the FI results are discussed elsewhere (Rummel et al., in prep.)

Houses 9, 11, and 15 contained plastered surfaces. The sampled floor in House 9 was attributed to the lower half of the room and contained a hearth (FI43) and the entrance to the space in the southeastern wall. In House 11, the upper part of the room was sampled. Due to the limited area excavated, it was not possible to determine whether the sampled floor in House 15 is the upper or lower part. In House 2, a soft, sandy surface was documented that differed both macroscopically and geochemically from the plastered floors in the other structures (Rummel et al., in prep.). The two samples from House 10 were not taken directly from the floor but from deposits above surface and ashy fill and are therefore not included in this intra-site comparison. Similar to the houses, the streets were equipped with plastered surfaces as well. The outdoor area south of House 9 had a trampled surface and is stratigraphically connected with the abandonment phase of the structure. After the abandonment of House 9, it was likely used as a midden or as fireplaces and ashy sediments were documented in the fill (Schönicke, 2019a).

The measured values are divided into low (0–4.9 mg/g Ptot or 0–29.9% Pav), medium (5.0–9.9 mg/g Ptot or 30.0–59.9% Pav), and high (>10 mg/g Ptot or 60.0–100% Pav) values.

Due to the systematic checkerboard sampling technique for floors that was applied in Monjukli Depe, variations in phosphate levels within rooms were visible which points to different activities carried out in the houses.

The elevated part of the floor of House 11 has the lowest levels of Ptot within the samples of the analysed contexts, whereas proportion of Pav lies in the low to medium range. This indicates activities with low P input such as sleeping. In adjacent House 15, slightly higher, but still low to medium, Ptot and Pav% have been detected, pointing towards low P impact activities such as sleeping or higher Ptot levels, indicating activities like food preparation. Both the floors in Houses 11 and 15 show similar P levels and distributions, indicating that they were kept clean in the same way without any rubbish being stored on the floor (Figure 20).

Ptot levels in House 9 are also low, yet Pav% varies significantly from low to high, with the highest concentration in the northeast corner of the room. There, a pedestal-like installation was located so it can be assumed that this area might have been used for food preparation and/or storage. As an FI is located in the room, it seems probable that the inhabitants stored fuel such as wood and/or dung there. Sweeping ash from the hearth would also result in higher P levels (Figure 21).

An exception marks the sandy floor of House 2. This part of the room was also equipped with a rectangular hearth (FI 36). Here the medium to high levels of Ptot and high levels of Pav% were measured, marking the highest P concentrations within the settlement. This can be explained by two factors: First, soft sandy floors

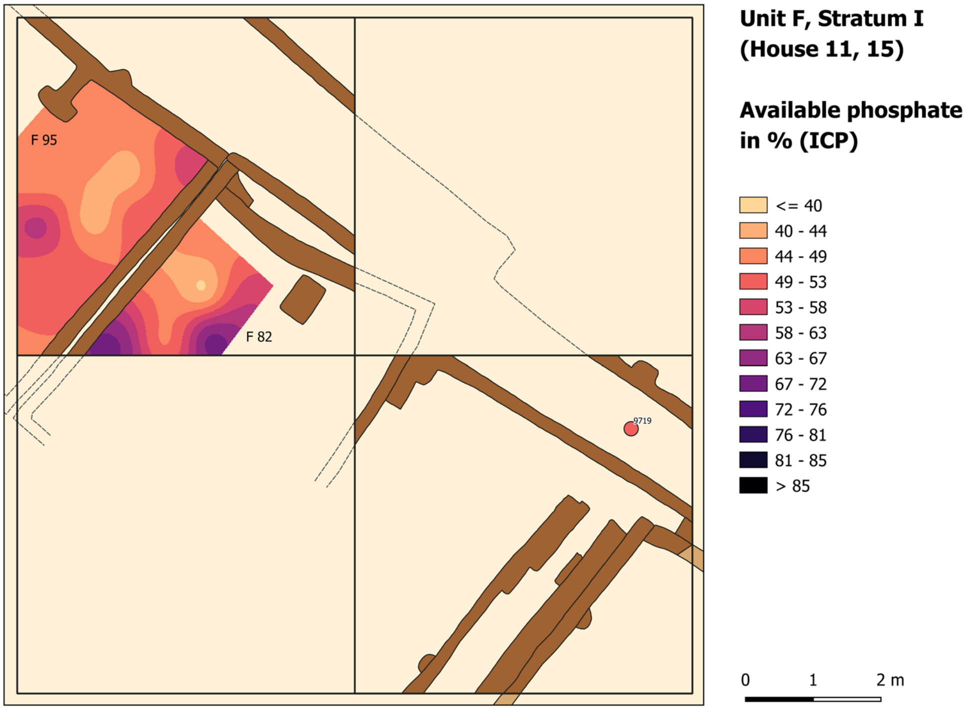

Figure 20: Pav content as a % of sampled contexts of Houses 11 and 15 (northwestern quadrant) as well as the sample from Berdiev street (southeastern quadrant) in Stratum I–II (QGIS plan: J. Rummel, base plan: N. Rol. After Rummel et al., in prep.).

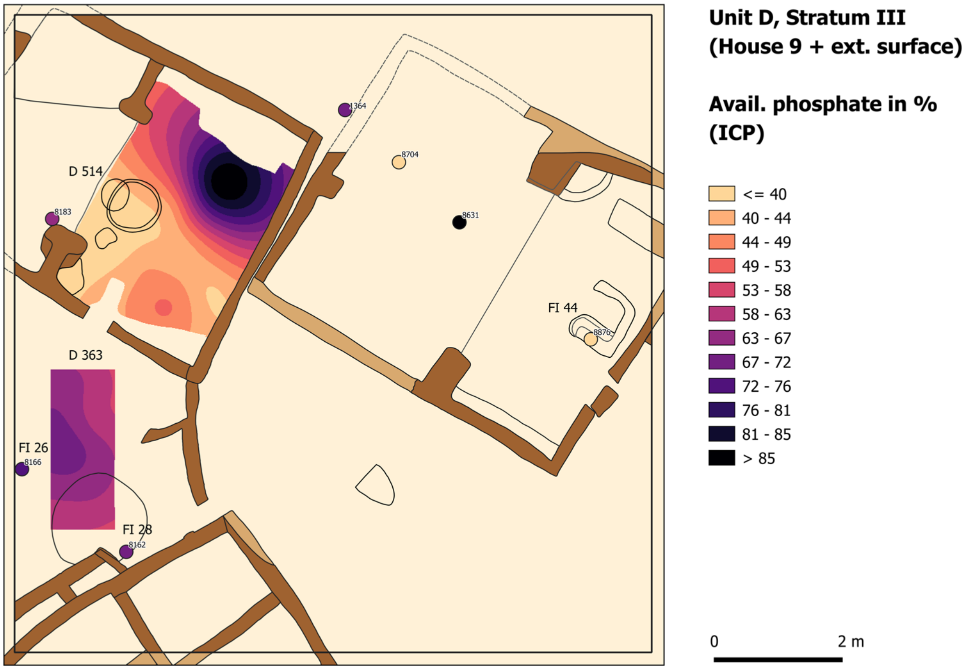

Figure 21: Pav content as a % of sampled contexts in Stratum III: Houses 9, 10, and an exterior space south of House 9 (QGIS plan: J. Rummel, base plan: N. Rol. After Rummel et al., in prep.).

cannot be kept clean as easily as compact plaster floors. Second, the large hearth or oven produced large amounts of ash that accumulated in the room (Figure 22).

Pav content as a % of sampled contexts in House 2, Stratum I–II is discussed here (Rummel et al., in prep., Figure 30). The exterior surface south of House 9 was likely a regularly frequented space, as numerous FIs in the vicinity suggest. Ptot values range from low to high, whereas Pav% values are high. The varying numbers indicate different practices, including the disposal and incineration of waste which is supported by the high values of TOC (Rummel et al., in prep.).

The samples from Berdiev street show different results. The sample close to the entrance to the Eastern Midden has high Ptot and Pav% values. The other sample was taken further to the northwest close to Houses 11 and 15 and has low Ptot and medium Pav% content. This might be explained due to the fact that the entrance to the Eastern Midden was heavily frequented in comparison to somewhat remote parts in the settlement.

The analysed contexts show distinct differences and cluster in the following groups: Plastered indoor floors with low levels indicating “clean” surfaces and/or activities with low impact like sleeping in the upper parts of houses – but also show punctual varieties maybe from storage or food consumption. P levels in the lower part of House 9 are higher and indicate activities with more P input such as food preparation and storage. The exterior surface has medium to high P levels that point to frequent activity and repetitive use but also to possible simple cleaning or less accumulation due to wind. The P values of Berdiev street are higher close to the Eastern Midden pointing to higher frequented use in this part of the settlement. Surprisingly, the highest P levels come from the sandy surface of House 2 close to the indoor hearth. This indicates an activity area characterised by heavy accumulation of ash that was due to its indoor location and composition of the floor which was not so easy to clean.

In conclusion, for Monjukli Depe, it can be assumed that the inhabitants used houses and outside areas differently and for multiple practices. Interiors were kept clean and were appropriately prepared through repetitive plastering indicating a concept of hygiene. Storage and food consumption might have taken place close to FIs and in exterior spaces.

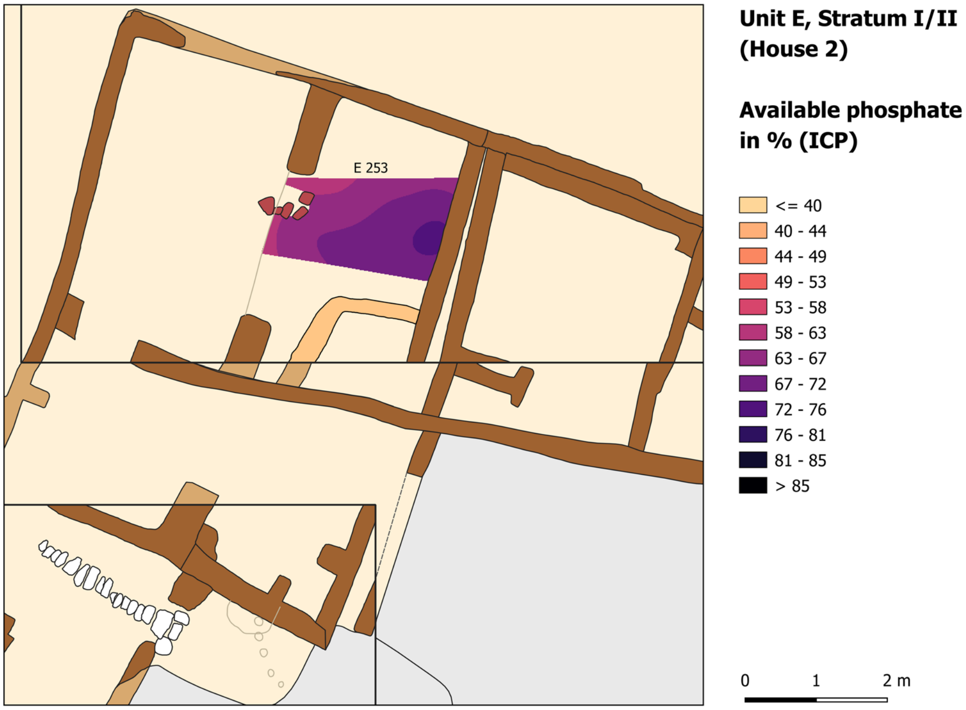

Figure 22: Pav content as a % of House 2 and the sample from Berdiev street in the southwest in Stratum I/II (QGIS plan: J. Rummel, base plan: N. Rol. After Rummel et al., in prep.).

9 Discussion – Sustainable Building in Prehistory

Interdisciplinary research can – as shown in our case studies – provide valuable new insights into early human building practices. The prehistoric built environment had a direct impact on the socio-economic context, general health conditions, and related practices. The combined macro- and microarchaeological studies demonstrate that the inhabitants took good care of their (built) environment. They maintained structures and cleaned their interior spaces on a regular basis, which indicates a concept of hygiene. They defined and distinguished between interior–exterior activities as well as areas of extensive and less extensive use. At the same time, by routine, repetition, and ritualised activities, they created common memories, group identities, and traditions, and in the end maybe something we nowadays call heritage. In other words, they prepared the transfer of knowledge through both incidental and intentional practices. The use of earthen materials was a natural agent, but luckily for us turned out to be a store container for Neolithic practices that can be uncovered using inter- and transdisciplinary approaches.

In prehistoric buildings, social memory is built, maintained, and passed onto future generations. Earthen building materials, on the other hand, are filled with information that reflects both the natural environment and human choices. Microarchaeological studies show that even though all the additives, binders, and other components used in the construction of mudbrick and mortar are derived from the same source, people have changed the character and appearance of building materials while combining, proportioning, and shaping these materials. When we read backwards – taking a reversed engineering approach – every step taken during production has transformed people's experience with the material, and this situation has again physically changed the earthen materials. As we can see in the example of Aşıklı Höyük, natural and cultural, and plant and animal components obtained from inside and outside the settlement were brought together when it comes to the construction of mudbricks and mortars. Therefore, the contrasts of the materials provided in the construction of buildings and spaces are integrated in earthen building materials. Among these factors, of course, functional reasons such as the fact that earthen materials are recyclable and practical in terms of cleaning and grading can be mentioned. When all these combined activities are considered together with inputs such as creativity, the donkey-work, knowledge, and handicraft it can be suggested that earthen architecture gave people in prehistory a different experience to stone.

As explained above for the case of Aşıklı Höyük, although the changes in mudbrick and mortar recipes are gradual, three main stages come to the fore. Is there a relationship between these stages of change seen in the mudbrick and mortar recipes and in other areas of life during the settlement occupation? Are these three phases associated with other changes at the settlement? The results of macroarchaeological analysis, including archaeozoological, archaeobotanical, and architectural studies, contributed to interpretation of the reasons for the change in the recipes (Table 2). When the micro-and-macro archaeological results are brought together, the change in mudbrick and mortar recipes and the transformation of three different dynamics in the settlement are in harmony: animal domestication, an increase in the scale of agricultural activities, and the transition from oval to rectangular buildings. In the mid-ninth millennium BCE, when animal dung was used extensively as a temper and binder, indoor spaces where sheep and goats (caprines) were kept under control were located within the settlement (Stiner et al., 2014, 2022; Zimmermann et al., 2018). It is noteworthy that during the eighth millennium BCE, when caprines were domesticated and the areas where animals were kept clearly translocated out of the actual settlement (Peters et al., 2018; Stiner et al., 2022), the animal dung was continued to be used as fuel and in floor plasters (Mentzer, 2018, p. 119; Tsartsidou, 2018, p. 164), while its use in mudbricks and mortars almost came to an end (2F–2A).

Vegetal tempers – except animal dung – were added to mudbrick and mortars intentionally in the late phases of the settlement (2C–2A). Macro-botanical results show that wild plant species decreased, and the role of agriculture increased in these phases (Ergun, 2016). In most cases, plant sources could not be identified by thin section analysis because actual plant fragments are not preserved longitudinally. But then macro-botanical studies and phytolith analysis on a limited number of mudbrick and mortar samples reveal that straw, husk, and the by-products obtained from agricultural activities (i.e. free-threshing) were used in construction materials (Tsartsidou, 2018, pp. 155–165). When the macro-botanical and microarchaeological results are combined, it can be suggested that there is a relationship between the increasing agricultural knowledge of the residents and their experience in making mudbrick and mortar, even if not directly.

Architectural and stratigraphy studies on the continuous cultural sequence have provided a rich and detailed record of architectural transformations (Duru et al., 2021; Özbaşaran et al., 2018). However, it is quite difficult to identify micro-indicators of tempo and mode of the earthen building materials using macro-architectural studies. As seen in the case of Aşıklı Höyük (Table 2), the transformation from semi-subterranean circular buildings to aboveground rectangular ones, single to multiple rooms, and low to high settlement density during the occupation has a rectilinear mode with the mudbrick sizes, techniques, and recipes. However, microarchaeological studies show changes in raw materials, tempering strategies, and pugging phase in mudbrick production progressed at a much slower tempo when compared with mortars throughout the architectural transition. Moreover, the tempo of changes in tempering and pugging in mortar production rose rapidly while mudbrick sizes and recipes were relatively standardised during Level 2. In this whole table, it is noteworthy that the wall thicknesses did not change at all.

Any type of Neolithic masonry, especially mudbrick walls are supposed to provide structural support, but they need protection from extreme weather. The Konya Plain, Volcanic Cappadocia as well as the Harran plain provide settings that require constant repair and renewal of earthen buildings, due to harsh climate conditions. Due to the weather conditions, the construction of rectangular buildings, the formation of building groups, and the density of the settlement pattern may have led to the need to make the walls more durable. Durability can also mean in this context a change in roofing or surface treatment. All samples presented here show similar approaches to create climatically well-balanced interiors. All have reduced wall openings to exclude the bright sunlight, to ensure air circulation, or serve as a means of access. Walls have a certain thickness to minimise the changes in temperature and humidity. No building code had yet been established, but empirical experiences served as the basis of building practices.

For Aşıklı Höyük[3] and Çatalhöyük, mudbrick and mortar thicknesses had become generally standardised in later layers. Wall thicknesses did not change for centuries, but their lengths varied. Experimental

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[3] Level 2.

Table 2: Diachronic comparison of mudbrick and mortar recipes with other way of life indicators including architecture, environment, and domestication at Aşıklı Höyük (M. Uzdurum)

Level/ phase	Mudbrick and mortar recipes	Architecture, environment, domestication
2C–2A	– Tempering strategies standardised – Vegetal temper – from possibly agricultural by-product – Carbonate – temper dramatically decreased – Standardisation in pugging phase in both mudbrick and mortar – Differences between special purpose building area and dwelling area in terms of percentage of clay, organic carbon and $CaCO_3$, and nitrogen	– Rectangular, aboveground buildings (Esin & Harmankaya, 2007; Özbaşaran & Duru, 2015) – Architectural density (Özbaşaran, 2012) – Building groups and clusters (Duru et al., 2021) – Special purpose building area and dwelling area (Özbaşaran, 2012) – One, two, and rarely three roomed area 16–30 m^2 (Duru, 2013) – Large storage facilities (Duru et al., 2021) – Standardisation in mudbrick size, increasing in mortar thickness (Duru, 2013) – Livestock corrals moved off the settlement (Stiner et al., 2022) – Increase in cultivation of crop plants (Ergun et al., 2018)
2F–2D	– Sandy and silty sediments – Vegetal temper dominant – Dung is absent – Similarity between mudbrick and mortar in terms of temper, binder, and the mixing process	– Rectangular, aboveground buildings (Özbaşaran, 2012) – One or two roomed – Limited number of excavated buildings
2J–2G	– Change the raw material source – Clay-rich components in both mudbrick and mortar – Increasing animal dung in mortars – Decreasing variety and density of on-site anthropogenic materials such as hackberry seeds and ash	– Rectangular, aboveground buildings with freestanding walls and flat roofs (Özbaşaran, 2011b) – Limited number of excavated buildings – One-roomed (Özbaşaran et al., 2018) – Narrow spaces between buildings filled with debris (Esin & Harmankaya, 2007) – Mudbricks made by mould (Duru, 2013) – Erosion re-activate and river invading (Kuzucuoğlu et al., 2020)
3	– Vegetal temper from possibly agricultural by-product became more common – Animal dung still dominant in circular, semi-subterranean buildings, not in semi-rectangular ones – Multiple tempering strategies, – Deposits in the immediate surroundings of the settlement were preferred as raw material, – Mortar sediment was mixed with water, and prepared quickly	– Circular and semi-rectangular buildings (Duru et al., 2021) – Aboveground walls of semi-subterranean buildings are somewhat taller (Duru et al., 2021) – Increasing debris, midden accumulation (Stiner et al., 2021), and urine salt inputs (Abell et al., 2019) – Thick, weathered herbivore dung deposits widespread (Mentzer, 2018) – Much more abundant riverine plants (Ergun, 2016; Tsartsidou, 2018)
4	– Multiple plant tempering strategies (Uzdurum et al., in prep.) – Animal dung present in mudbricks, dominant in mortars – Differences between mudbrick and mortar recipes – Faecal and domestic wastes (recycling of anthropogenic materials) dominant in mortar – Carbonate-rich tempers in mudbricks – Temper and binders were well harmonised and pugged for a long time with a large amount of water in mudbricks	– Circular, semi-subterranean buildings (Özbaşaran et al., 2018) – Large outdoor activity spaces separate the buildings (Özbaşaran et al., 2018) – Single room, area 12.5 m^2 (Özbaşaran et al., 2018) – Mudbricks shaped by hands, or moulds (Özbaşaran et al., 2018) – Variability in mudbrick sizes (Duru, 2013) – Animal management on site (Stiner et al., 2014) – Microscale cereal domestication (Ergun, 2016) – River activity weakened (Kuzucuoğlu et al., 2018)

archaeology and architectural studies suggest that inhabitants did not demolish and re-build single buildings, but all the buildings that belonged to the same quarter simultaneously (Duru, 2013, p. 144). This indicates that the renewal was seen as a communal effort also resulting in the need of much more materials, labour, and time for construction at the same moment (Duru, 2013). In this context, little variation in mudbrick and mortar recipes for all features – structural or non-structural – could be a direct answer to this challenge. However, when the walls of (aboveground built) rectangular structures at Aşıklı Höyük are examined with the naked eye, the walls contain mudbricks that differ from each other in terms of colour and texture. This diversity in mudbricks can be observed between different walls of one building belonging to the same building phase, as well as between mudbricks belonging to the same wall. This multi-variability shows that – taking the recycling of the mudbricks into consideration – solid mudbricks were reused in the construction of new buildings.

The diversity and density of aggregates identified in thin section analyses confirm the macroarchaeological studies. At the same time the walls underwent a constant repair and renewal, involving a repetitive reuse of mudbricks. This makes it difficult to approach questions regarding the timing of renovations, which walls, buildings, or house groups were constructed simultaneously with what. Perhaps our sampling strategy of testing only one wall of mudbrick and mortar from each building blurs our sight. Although this sampling strategy does not prevent the determination of the mudbrick and mortar recipes in the residential area, it makes it difficult to put forward a pattern as to whether architecturally differentiated building groups use unique recipes.

At Çatalhöyük, Love (2012) interprets variability in tempering strategies of mudbrick in one neighbourhood of the site as evidence of production by single family units. In their model, specific recipes were created by households and passed down through family lineages, with the public aspects of mudbrick production serving as a way of performing household identity (Love, 2013). When examined spatially in the case of Aşıklı Höyük, the preliminary results show that both the buildings in the mid-ninth millennium BCE and the building and building groups identified architecturally differentiated in the mid-eighth millennium BCE did not have unique recipes. Current data indicate that the recipes at Aşıklı Höyük were prepared collectively, not by individual groups or households, but by specific working groups (mudbrick craftsmen) that had probably gained experience. In this respect, Aşıklı Höyük presents a different model from Çatalhöyük (Barański, 2020; Love, 2012; Uzdurum, 2019).

Sustainability of building practices is often linked to the amount of recycled and reused materials. However, reuse always has to be seen in relation to the efforts needed to procure old and new materials to construct or modify a building. In several cases, the reuse of material or a place may have too high price in terms of human resources, work efforts, economic aspects, environmental impact – e.g. in (dense) settlement contexts. On the other hand, there are also other concepts of sustainability: to maintain a place, a location, and an existing building may also help to maintain a society, a group identity, and cohesion. Any effort to do so is worth the social sustainability and resilience (Kinzel et al., 2020). Recycling of building material is not yet that evident in the findings at Boncuklu Tarla. The structures show some modifications and continuity, but less pronounced than at other sites. It is still unclear how the creeks nearby influenced the development of the settlement patterns as a response to regular flooding as well as the general shift from semi-subterranean buildings to buildings sitting on top of on-ground substructures better known from sites like Nevali Çori (Hauptmann, 1988), Çayönü (Schirmer, 1988), or Akarçay Tepe (Duru, 2013). However, the repeated rebuilding on the same location and inside earlier structures point towards the very same concept. In contrast, the architecture at Göbekli Tepe shows a high degree of reused materials, both stone and earth. It can be assumed that the same is true for wood/timber. However, it is especially the components stone and earth which were in high demand and constantly reused. This can be identified by e.g. the broken edges and corners of wall stones, the generally high fragmentation of stone materials, and the intense reuse of fragmented building elements – e.g. portal stones, pillars, and sculptures. The reused earthen mortars show low contents of organic components, charcoal is particularly rare, due to the repeated re-watering in the process of production. A high fragmentation of embedded settlement debris can also be observed. Geochemical sediment analyses from Room 16 show high levels of phosphate in roof collapse which indicates both organic materials in roof constructions and activity zones on roofs. In contrast, the limestone floor has lower levels of phosphate. This demonstrates that the room was kept clean. The compact smooth surface supports the easier cleaning of the surface. The intensity of caretaking of buildings during their use, maintenance, and repair of structures and the recycling of materials may well depend greatly on the availability of labour/workforce. Lacking the crucial number of people to actually respond sufficiently after a destructive event may have had a great impact on the resilience of a community and the settlement.

These differences of the intensity of use within activity areas could be presented by the data from Monjukli Depe in more detail. Similar to cases from Çatalhöyük or Aşıklı Höyük, spaces at Monjukli Depe can be differentiated into "clean" and intensively used areas. In contrast to exterior spaces, interior spaces at Monjukli Depe show very low levels of phosphate. On a macroscale, floors show various layers of compact clay plaster that were renewed repetitively. As surfaces were sampled using the checkerboard technique, differences of the intensity of activities could be identified. As phosphate levels are even lower in the elevated parts of rooms it can be assumed that activities with a low impact of phosphate took place here, e.g. sleep. It is conceivable that the lower lying parts of rooms were used for activities with more impact of phosphate such as food consumption and storage. In comparison, the sandy trampled exterior surface shows higher levels of phosphate which points to high impact activities such as food preparation and pyrotechnical practices. In addition, the loose surface was not as easy to clean as the compact plaster floors within the houses. An exception is marked by House 2 with its sandy floor and hearth that produced the highest phosphate sidewide. Not only did the hearth produce a lot of organic waste (ash) but beyond that, it might have been impossible to clean the trampled ashy surface in a closed space. All these activities and interactions can be traced and identified through microstratigraphic and geochemical analyses based on a systematic sampling strategy completing the archaeological and architectural studies on a macroscale.

As shown here, earthen architecture and earthen components of stone architecture are not only the subject of macroscale analyses but also very suitable for various microstratigraphic and geochemical/microarchaeological analyses, since they are successfully integrated in numerous projects. Systematic sampling strategies integrated into a context-based documentation system based on an exchange of knowledge regarding possibilities and limits and interdisciplinary communication are crucial for a better understanding and interpretation of the collected data.

10 A Short Epilogue

The presented data stemming from five prehistoric sites in southwestern and central Asia show that earthen materials were used in various ways throughout early human building history. Earth and *spoila* were not only used in very different ways to bind materials, but also by humans practicing the act of building together. The use of locally available materials bound them not only physically to a place, but also established a social connection allowing to create narratives that made human societies more resilient and coherent. Macro- and microarchaeological methods help us to identify these activities and practices providing us with insights into human–environment interactions during the Early Neolithic and beyond. Understanding the past may well allow us to draw some conclusions for the use of traditional, vernacular (earthen) building techniques for the future to find answers to the challenges of climate change and sustainable building today.

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