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Geoarchaeological analyses of construction materials from the Neolithic site of Asıklı Höyük, Turkey

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Aşıklı Höyük is the oldest Aceramic Neolithic tell in the Cappadocia region of Central Anatolia, Turkey, an area of Central Anatolia which has a distinct geologic and geographic structure. The Aşıklı project first started in 1989, directed by Prof. Ufuk Esin of Istanbul University until 2001, then by Nur Balkan-Atlı between 2002-2004. The current work at the site, which started in 2010, is led by Prof. Mihriban Özbaşaran of Istanbul University.

The results of radiocarbon dating show that habitation started in the site in the beginning of the 9th millennium BC and continued until the middle of the 8th millennium BC. The site contains the earliest evidence for sedentism and adaptation of a new life style, and has a thick sequence that developed over 1000 years without interruption. Therefore, at Aşıklı Höyük, it is possible to observe the Neolithic process in one place. The many changes in human life that happened during this time are documented separately using many fields of research, such as studies of plant remains, animal remains, stone tools, human bones, and architecture. Aşıklı is also the only early Neolithic site in Cappadocia, Aşıklı is unique in its age, size, geologic context, and good state of preservation.

Aerial view of the site and Melendiz River.

RESEARCH AIMS

The main structural material used in the settlement from its first stages of occupation to its abandonment is the mud-brick. Mud-brick can be defined as building material formed from soil made using a mixture of loam and water with various additive and binding materials. Mud-brick is a convenient building material because it can be produced from many kinds of soil using different methods. Although it has a disadvantage in that it must be renewed and repaired due to weathering and natural disasters, it has an advantage in that it is a recyclable material. The process of mud-brick production, from preparing the raw material to making and using the bricks provides information about structures and traditions of the culture to which it belongs. For example, the preferred sources, the additives used, and brick shaping methods differ in certain geographies and time periods.

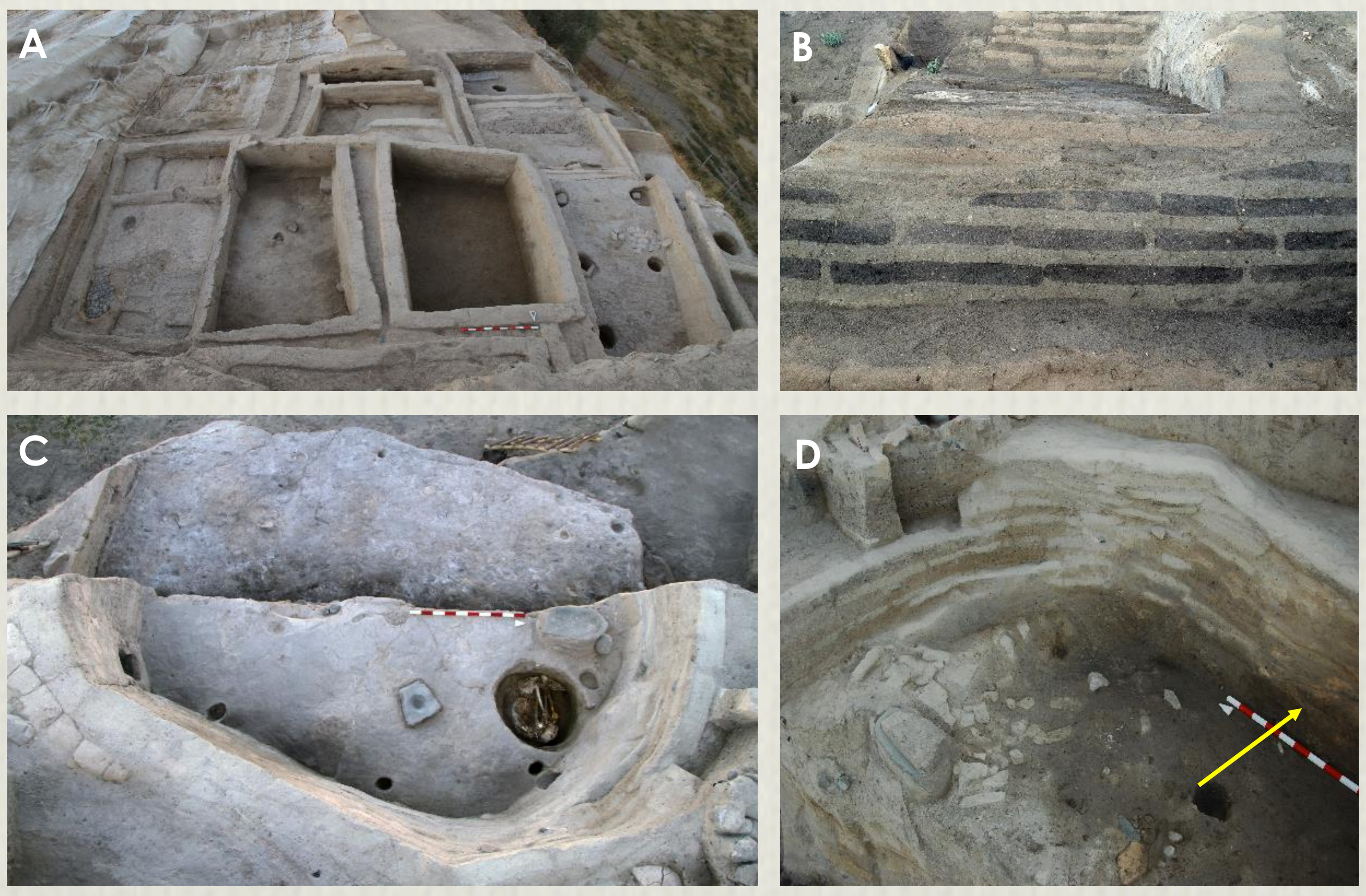
We aim to study: (1) how mud-brick, mortar and plaster were produced, (2) changes in production methods over time, and (3) the relationship between these changes and other aspects of sedentary life that are specific to the Aşıklı Höyük Neolithic community. In this context, we propose to analyze the changes in technological and social life by first understanding the use of construction materials in Aşıklı.

View of the deep trench, where three occupation layers are exposed.

SAMPLING STRATEGY

We collected 11 oriented blocks containing both mud-brick and mortar and 99 loose samples of mud-brick and mortar during the 2013 excavations. Loose mud-brick and mortar samples were taken from the each place where the block samples were collected. All of the loose samples were collected in the same amount (~200 grams) in order to ensure that there is enough material for multiple types of analysis. At present, only the walls of the buildings were sampled. Additional samples were collected in 2008-2012 as micromorphological blocks of brick, mortar and plaster, and associated loose sediment. The entire collection from 2008-2013 includes samples from all areas and occupation layers of the site.

The samples can be divided into two sets. First, samples were collected to understand vertical/time changes in two different areas: the Deep Trench and the Slope Trench, where the oldest layers of the site are exposed. We selected at least one building belonging to each construction phase from each layer (Layers 4, 3 and 2) for sample collection. Second, a set of samples was collected to understand horizontal/spatial differences in mud-brick in three dwelling areas (A, B and D areas; Layer 2). These areas are still being excavated and their stratigraphy studies are completed. Samples of mud-brick and mortar with different visible production methods, colours and fabric from the inner surfaces of the walls of the building from each dwelling group were collected.



A: Buildings in Layer 2 (youngest) of the site have rectangular morphologies.
B: Walls in Layer 2 are constructed of block mud-bricks and mortar. Plaster layers on the walls and floors are also preserved in some buildings.
C: Some buildings in Layers 3 (pictured here) and 4 are rounded in morphology.
D: Another view of the building in (C) with visible wall plaster (arrow).

METHODS

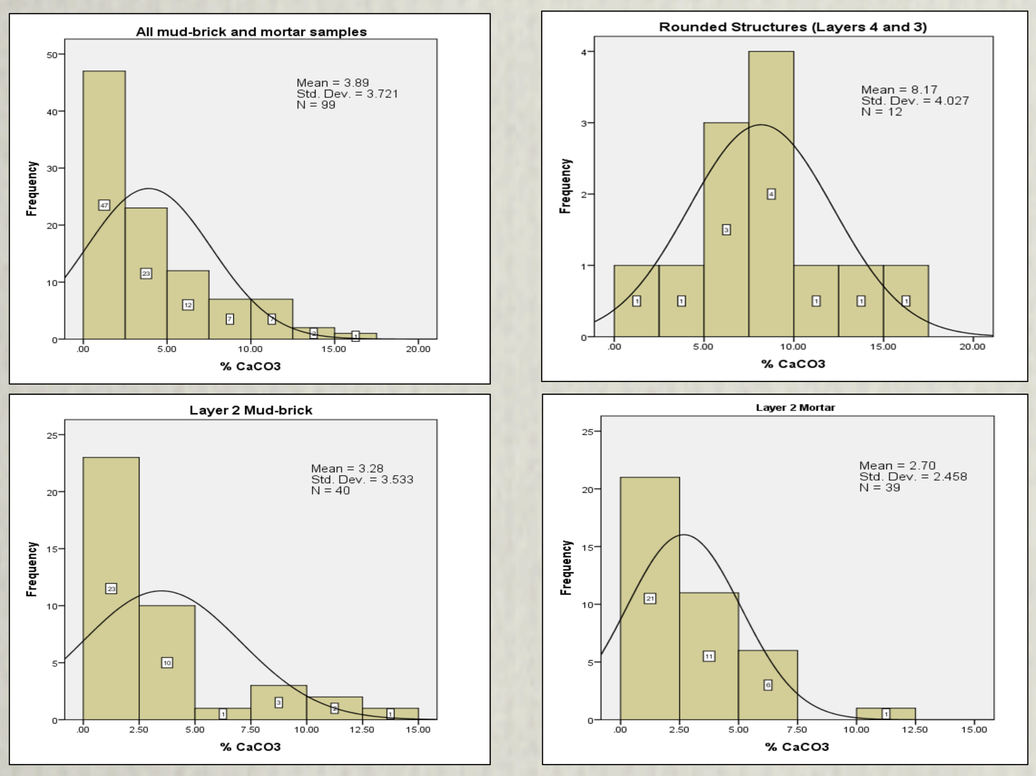
Preliminary analyses of the loose samples are presently limited to $CaCO_3$ abundance, which was measured using a calcimeter. Several grams of powdered samples were reacted with HCl and the percentage of $CaCO_3$ was calculated from the volume of evolved CO_2 gas.

Micromorphological thin sections were produced from oriented block samples of mud-brick and mortar from Layers 4, 3, and 2, as well as from floor and wall plaster sequences.

Measurements of the stable isotopes of carbon and oxygen were conducted on selected samples of mud-brick, mortar, plaster, and local reference materials that contained abundant calcium carbonate. Several micrograms of each sample were roasted in an oven at 250°C for 3 hours to remove organic material. The isotopic ratios were measured relative to internal standards using a Finnigan MAT 252 mass spectrometer equipped with a Kiel III automated sample preparation device.

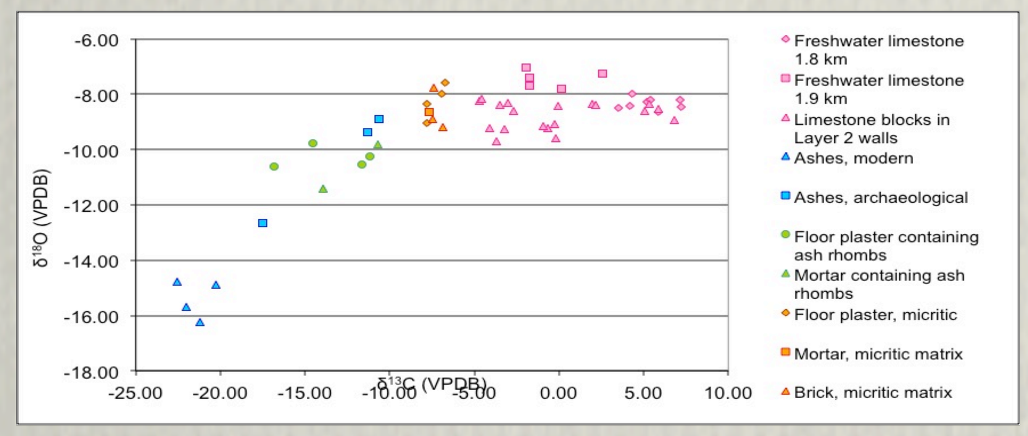
Fourier transform infrared (FTIR) analyses were conducted on loose samples of plaster, mud-brick and mortar. The samples were ground to a powder and embedded in KBr pellets for transmission measurements using an Agilent Cary 660 bench. Spectra were produced from 32 co-added scans collected in the range of 4000-400 cm-1, at a resolution of 4 cm-1. Analysis of calcite using the grinding curve method followed Regev et al. (2009).

Calcium carbonate abundance



In Layer 2, the distributions of carbonate abundance in mortar and mud-brick are similar. Samples from Layers 3 and 4 contain more carbonate, but our sample size is not large enough to compare distributions between materials. Rounded structures in these levels have a more normal distribution with a mean of 8% $CaCO_3$.

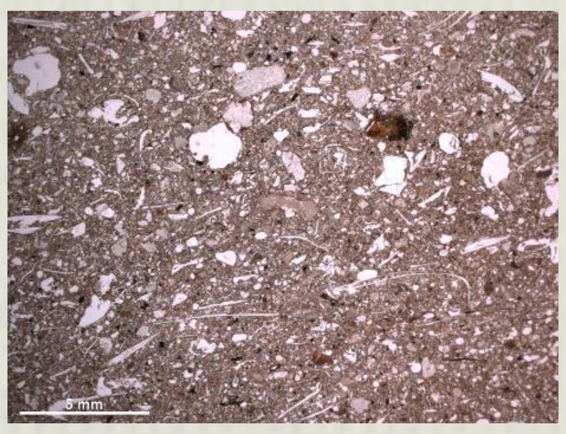
Stable Isotopes



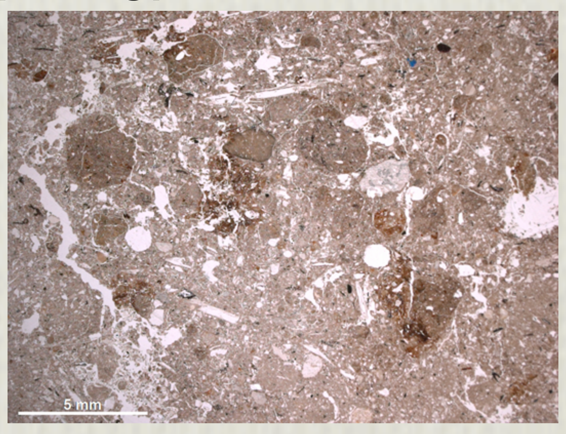
As reported by Mentzer and Quade (2012), some samples contain isotopic ratios that are consistent with ash, while others contain ratios that are consistent with local freshwater limestone. These are interpreted as possible use of lime.

PRELIMINARY RESULTS

Micromorphology

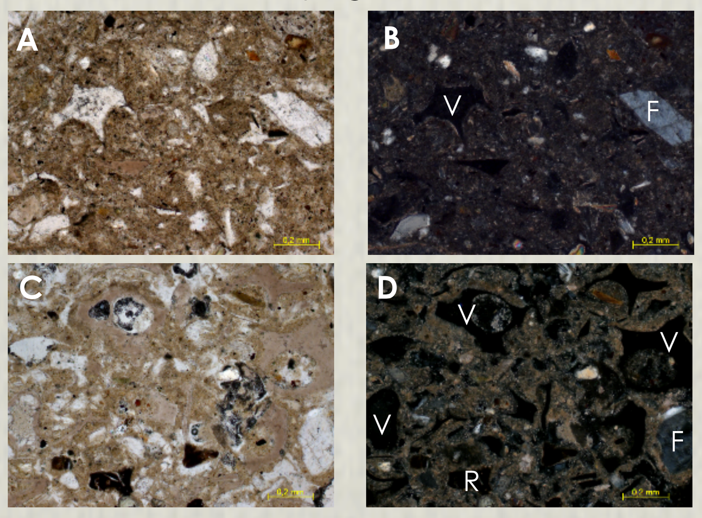


Mud-brick with vegetal voids and vesicles, PPL. Bricks are generally coarser in texture than mortar.

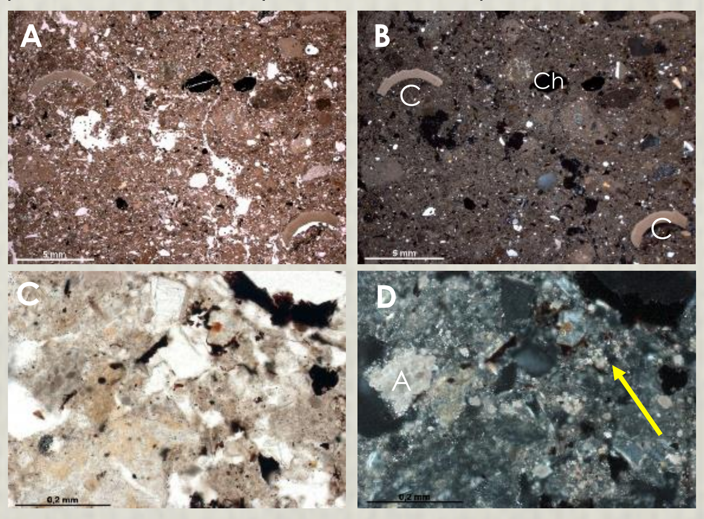


Mortar with vegetal voids, vesicles and aggregates derived from a soil, PPL.

Mud-brick and mortar samples are a mixture of sand, silt, and clay with the sand fraction typically containing a mixture of fragments of volcanic glass, pumice, and rocks, and volcanic minerals such as feldspar. Other inclusions are diatoms and humified organic material. Many samples contain aligned vegetal voids and phytoliths, which suggests that plant temper was added. A few samples contain dung. Carbonate is present in variable quantities as part of the fine matrix. Mortar samples from rounded structures contain inclusions of anthropogenic materials that are typical of refuse layers and occupation debris.

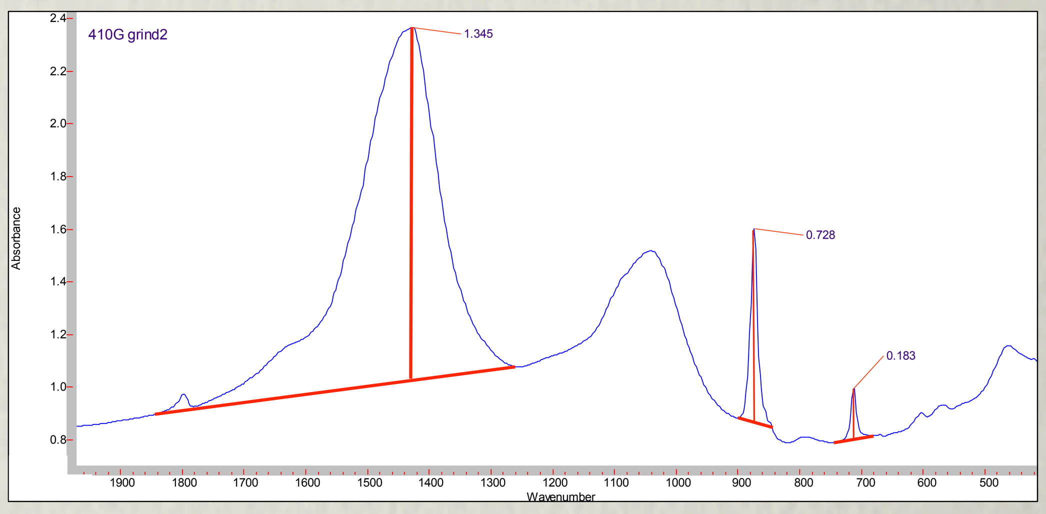


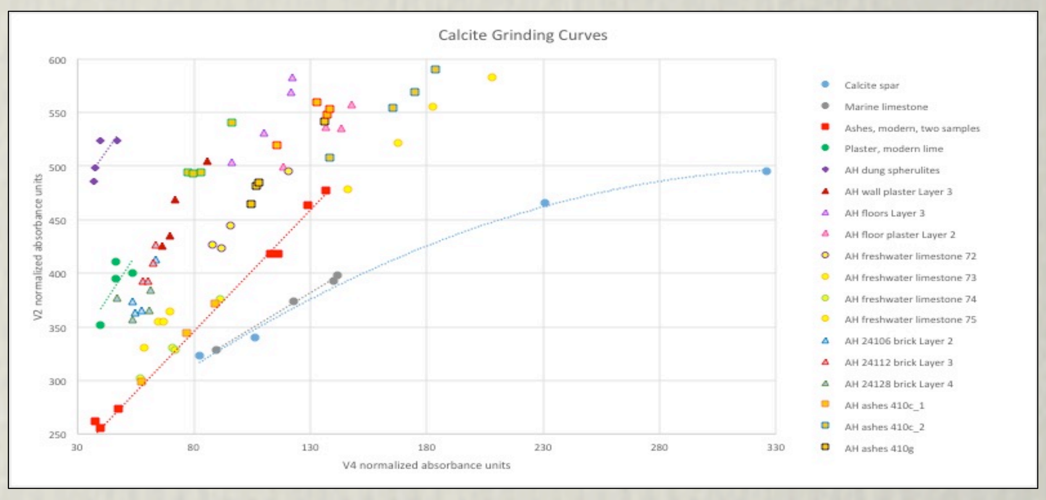
Mud-brick components
A and B: non-calcareous brick with volcanic glass (V) and feldspar (F) in the sand fraction; PPL, XPL.
C and D: calcareous brick with volcanic glass, feldspar, and rock fragments (R); PPL, XPL.



Mortar Samples: rounded structures
A and B: low magnification view of mortar containing fragments of *Celtis* (C) and charcoal (Ch); PPL, XPL.
C and D: close-up of ashes (A) and spherulites (arrow) in mortar; PPL, XPL.

FTIR





Analysis of calcite using grinding curves has been reported as an approach to distinguishing between calcites of pyrogenic origin (ash and lime plaster) and geogenic origin (Regev. et al. 2009). We produced a plot of calcite grinding curves using locally available calcareous materials, modern references, and construction materials from the site.

Our current results indicate that some of the construction materials plot within the range of ashes and lime plaster; however, the local freshwater limestone falls within the range of ashes. These results suggest that grinding curves must be employed cautiously at Aşıklı Höyük.

In the future, quantification of the frequency of use of lime and ash plasters at the site will likely involve a combination of isotopic analyses and grinding curves.

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