



The earliest use of adobes in Cyprus: Issues of provenance and use

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SUMMARY

Adobe was one of the primary building materials around the world throughout antiquity. The appearance of adobes did not take place simultaneously in all civilizations. Although there is evidence for the production of adobes in Cyprus since the Neolithic period, which coincides with the first permanent habitation on the island, the use of moulds in their preparation was identified at later periods (Late Bronze Age). This paper is based on the first comprehensive research, involving microscopic and laboratory analyses of more than 40 samples, collected from various prehistoric sites. The macroscopic and microscopic examinations have shown that a variety of soils and additives were used for the preparation of adobes. The research has revealed the chronological development of earthen structures on the island and investigated the position of Cyprus with respect to the rest of the ancient world regarding the technology of earth-based building materials.

1. INTRODUCTION

In the prehistoric period, earth, in different forms (adobes, rammed earth), formed one of the most widely used building materials around the world. A number of studies have shown that the initial use of earthen structures did not take place simultaneously in all civilizations (Houben and Guillaud 1994). Due to the limited existing literature and in-depth investigation on the earliest use of earth-based materials in Cyprus, there emerges the need for a holistic approach regarding the first earth production technology on the island. Archaeological reports and recent research has revealed that adobe brick was the first earth-based material used during the Neolithic period in Cyprus (Philokyrou 1998).

A wide use of earth-based materials in the prehistoric period is also observed in the wider area of the Eastern Mediterranean, the Aegean and the Orient (Syro-Palestine, Anatolia, India, China - Houben and Guillaud 1994, 6-15). In the Aegean, the use of adobe bricks can be traced back to the Neolithic period while the use of moulds for the manufacture of adobes began during the Early Bronze Age (Guest-Papamanoli 1978, 8, 17). The existence of rammed earth has also been recorded in the Aegean, although at a lesser scale than that of adobes (Shear 1968, 433). Adobes shaped by hand are observed, on a large scale, in the area of Syro-Palestine, and date back to the Natufian-Aceramic period (8000 BC) (Thomas 1995, 134; Wright 1985, 350-351; Reich 1992, 5). In the area of Anatolia, Egypt and Mesopotamia, adobes, of regular shape, have been recorded at even earlier times (since the 6th millennium) (Wright 1985, 353). The use of rammed earth in the area of Mesopotamia and Syro-Palestine is likely to have preceded constructions made of adobe bricks (9th millennium), but continued to appear at later periods as well (Leich 1988, 165. Wright 1985, 353. Thomas 1995, 136).

2. METHODOLOGY

A systematic research was initiated aiming to provide information on the use of earth-based materials, and especially adobe bricks, in Cyprus and to compare the production techniques adopted in the island with similar procedures followed in other civilizations. For this purpose, archaeological reports were carefully studied and more than 40 adobe samples were collected from various archaeological sites of the prehistoric period. *In-situ* studies were conducted and photographs were taken, before removing the samples from the various structural elements. The collected bulk samples were initially observed in the laboratory by a stereomicroscope to collect information about the type of organic additives present therein. In order to determine accurately the composition of the soil used for the

manufacture of adobes, chemical and mineralogical analyses by X-ray diffraction were conducted in a smaller number of samples (Neolithic period: Kalavassos-*Tenta*: KT.29, KT.31, KT.33 and Khirokitia: KH.2, KH.5, KH.14, KH.16, Early Bronze Age: Marki-*Alonia*: MA.1, MA.3, MA.9, Middle Bronze Age: Alambra-*Mouttes*: AM.9 and Late Bronze Age: Hala Sultan Tekke: HST.1, Maa-*Palaeokastro*: MP.6, MP.10, Kalavassos-*Ayios Dhimitrios*: AD.2, AD.9, Maroni-*Vournes*: MV.6, MV.16). Samples from the soil around the settlements were also taken in order to determine the source of raw materials used.

3. RESULTS OF THE RESEARCH

3.1. Manufacturing method

The investigation showed that the process of soil selection and preparation for the manufacture of adobe bricks is essentially the same in ancient and more recent centuries. Initially, the soil is cleaned by removing the large stones contained therein and placed in a natural trench. Then the required water is added. In most cases, the addition of some organic material is also observed. The mixture is left in the pit for some time before its use, to mature and ferment. After fermentation, the paste is shaped either by hand or by means of suitable moulds.

During the prehistoric period, two methods were used for the manufacture of adobes with moulds. The first method, which was the most common one, involved placing the mould on the ground, which was then filled with clay, smoothing the upper surface, and leaving the mixture to dry. The second method involved placing an amount of wet mixture by hand on the ground, before pressing a rectangular mould on top of it to remove the extra material. The latter method was indeed faster, but resulted in the creation of adobes with straight sides, but with curved upper surfaces (plano-convex) (Leick 1988, 144; Guest-Papamanoli 1978, 7). The moulds were then removed and adobes remained in place to dry and become solid. After two or three days, the adobes were turned over so that the lower surface could dry and were then placed upright on one side (Adam 1989, 62-63).

3.2. Different types of earthen structures

The results of the present research indicate that the most common type of earth-based building material used during the prehistoric period in Cyprus was adobes (Fig.1). Wall construction made of amorphous clay in successive layers, a technique similar to rammed earth, is far more limited and appears in some dwellings of the Neolithic period (Khirokitia, Kalavassos-*Tenta*). This method coexisted with the use of irregular shaped adobes, while it was more widely used during the Chalcolithic period as the predominant method of earth masonry construction (Thomas 1995, 23).

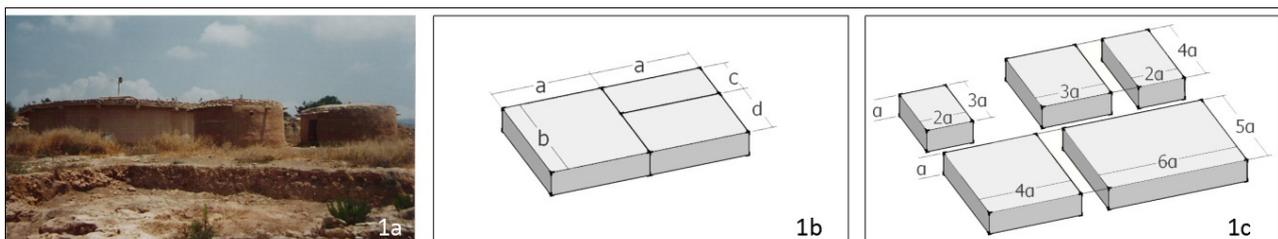


Fig. 1. Prehistoric adobes (1a: General view of a prehistoric site, 1b: Adobes from Dhali-Ambeleri, 1c: Most common ratios of prehistoric adobes)

The earliest adobes recorded on the island had a similar shape with rubble stones, since they were manufactured by people who knew how to build rubble masonry. These were irregularly shaped and of various dimensions, as they were in the form of hand-shaped loaves. A large variety in the dimensions of adobes in the various constructions, as well as in each masonry, has been identified in Khirokitia and Kalavassos-*Tenta* (Le Brun 1984, 23. Todd 1987, 35-36). The length of most of them ranges between 0.21 and 0.35 m., their width ranges between 0.12 and 0.26 m. and their thickness between 0.06 and 0.08 m. A layer of adobes on the upper part of a foundation of a rough stone construction came to light in Cape Andreas-*Kastros* with a hole on the top of 0.04 m. in diameter and 0.08 m. in depth. It is possible that these holes supported a lightweight sloping frame of branches (Philokyprou 1998).

Adobes of regular shape were always manufactured using rectangular timber moulds, and this explains why they, most often, have a normal rectangular shape (Fig.1b,c) with generally fixed dimensions. Adobes of this type appeared on the island during the Early and Middle Bronze Age and coexisted with adobes of irregular shape. Nevertheless, they were widely used during the Late Bronze Age.

Of particular interest are the dimensions of the adobe bricks found in Dali-*Ambeleri*. They can generally be divided into three types of such sizes that, when combined together, they create a compact construction (Fig.1b). The three types of adobe are equally thick; the width of type 3 is equal to the length of type 1 and 2, while the length of type 3 is equal to the sum of the width of type 1 and 2 (Philokyprou 1998).

The research has shown that adobes of rectangular shape are the predominant ones in most settlements. Adobe bricks generally have a substantial thickness of 0.10-0.15 m. There is a great range in their dimensions and thus the use of a fixed measuring unit cannot be clearly distinguished. It is likely that the human palm was used as a measurement unit which explains the lack of uniformity in sizes. However, some fixed ratios of 4:3:1, 4:2:1, 2:3:1, 5:4:1, 5:6:1 can be observed (Fig. 1c), with a relative preference to the dimensions of 0.40 m., 0.50 m., 0.60 m.

Adobes were mainly used for the construction of the upper part of load bearing walls. The construction was almost always combined with rubble or ashlar masonry that formed the base (lower part). Adobes were arranged in regular successive layers in such a way that the vertical joints of each layer bisected the underlying earth bricks, thus avoiding continuous joints. Masonry of the Neolithic period constructed with varying combinations of rubble stones and adobes, both at height and width, has frequently been recorded to have two, three or even four tangential rings; the external ones usually made of stone and the internal ones made of adobes, having an overall thickness of 0.70-1.70 m. In later periods, especially during the Late Bronze Age, adobes were placed either lengthwise (as stretchers) creating thin walls or as headers (*diatoni*) to achieve thicker walls. More complex arrangements were often achieved by placing two, three or even four rows of adobes laid in combinations of headers and stretchers.

3.3. Types of soil and organic additives used for the manufacture of adobes

The chemical analysis of the majority of samples showed that the manufacture of adobes involved the use of soil with high content of calcite (CaCO_3). In most adobes, the level of calcium oxide ranges between 30% and 40%. The samples also show high content of silicon oxide (SiO_2) with rates ranging between 10% and 20% (Table 1 and 2). There are however, examples of higher content of silicon oxide (samples KH.14, MA.3, AM.9, HST.1, MP.10). The proportion of aluminum oxide (Al_2O_3) usually ranges from 2% to 5%. In several cases, greater rates were reported reaching 7.45% to 10% (samples MP.10, MA.3, HST.1, AM.9, KH.14). Silicon and aluminum oxides most probably come from clay minerals, which assign the clay its cohesive properties. The mineralogical analysis also

revealed a high content in calcite, and frequent presence of other minerals such as quartz, feldspar (albite) and clay minerals (montmorillonite, kaolinite, nontronite, etc.).

The composition of adobes in Kalavastos-*Tenta* presents a peculiarity. The chemical and mineralogical analysis showed a rather high percentage of gypsum. The existence of gypsum in adobes is quite unusual and the research showed that this was attributed to the use of soil from the immediate surroundings of the settlement consisting of gypsum and covered by secondary deposits of lime and gypsum compositions (Todd 1987, 11). Another peculiarity revealed by chemical and mineralogical analyses is the existence of a high rate of strontium (sulfate celestite) in the adobes of Khirokitia (Table 2). This mineral is quite rare on the island and is mainly found in the geological strata of the area near the Neolithic settlement of Khirokitia.

The analyses of local soil from the surroundings of the prehistoric sites under study on the island showed that the manufacture of adobes was achieved using local soils that were available in the immediate environment of the settlements. The use of two, or more, types of soil (or their combination) for the preparation of raw material was a common practice, in order to achieve the proper amount in clay content.

Table 1. Chemical analyses of adobes from the Neolithic period

	KT.29	KT.31	KT.33	KH.2	KH.5	KH.14	KH.16
SiO ₂	12,21	15,24	15,24	23,03	10,32	49,03	11,17
Al ₂ O ₃	2,22	2,70	2,29	4,26	2,43	12,43	2,03
Fe ₂ O ₃	1,14	2,09	1,53	2,20	1,05	9,21	0,94
MgO	0,94	0,87	0,92	3,24	0,98	5,90	0,75
CaO	35,67	29,59	32,53	32,88	36,61	8,77	38,70
Na ₂ O	0,13	0,32	----	0,55	0,22	3,33	1,29
K ₂ O	0,31	0,56	0,48	0,84	0,38	0,64	0,38
MnO	0,03	0,05	0,05	0,07	0,08	0,17	0,03
SrO	----	----	----	----	11,23	0,21	6,42
SO ₃	29,18	25,17	20,39	2,05	7,35	0,29	5,02
L.I.	17,72	23,75	26,31	30,57	29,02	10,06	33,04
Total	99,55	100,3	99,74	99,69	99,67	100	99,77

Table 2. Chemical analyses of adobes from the Late Bronze Age

	MA.1	MA.3	MA.9	AM.9	HST.1	MP.6	MP.10	AD.2	AD.9	MV.6	MV.16
SiO ₂	16,59	30,84	9,06	38,46	32,28	17,09	26,71	19,01	15,94	15,18	13,70
Al ₂ O ₃	4,58	8,62	2,56	10,60	9,55	4,04	7,45	4,53	2,99	3,82	3,23
Fe ₂ O ₃	2,36	5,94	1,40	7,30	6,02	1,83	3,65	2,17	1,32	2,28	1,96
MgO	1,45	6,07	0,60	3,35	3,87	1,58	2,28	1,62	1,25	1,92	1,72
CaO	39,87	21,40	46,62	18,88	23,66	39,17	29,73	37,08	41,62	39,17	41,27
Na ₂ O	0,34	0,21	----	0,50	0,79	0,58	0,29	----	0,05	0,11	0,49
K ₂ O	0,88	1,32	0,32	1,54	1,30	0,70	1,29	0,72	0,30	0,51	0,46
MnO	0,11	0,17	0,06	0,22	0,12	0,03	0,06	0,06	0,06	----	0,04
SO ₃	0,30	0,24	0,25	0,24	0,10	0,12	0,15	0,39	0,48	0,33	0,16
L.I.	33,10	24,88	39,15	19,20	22,79	34,80	28,32	34,05	36,33	36,55	37,00
Total	99,58	99,69	100,1	100,2	100,4	99,94	99,93	99,63	100,3	99,87	100

Quite often, plant residues added in the mixture were detected in several adobes. The most common additive, often recorded in excavation reports and also found *in situ*, is straw and broken stalks cobs (Khirokitia, Kalavastos-*Tenta*). Traces of grass and other plant residues were found in adobes in Kalavastos-*Tenta* and in Hala Sultan Tekke, reeds in Morphou-*Toumba tou Skourou* and sea weed in coastal settlements, such as Maa-*Palaiokastros*.

4. CONCLUSIONS AND COMPARATIVE ASSESSMENT

In conclusion, it can be noted that the earliest use of adobes in Cyprus coincides with the first permanent habitation on the island during the Neolithic period. An evolution in the construction of earthen walls can be observed during the prehistoric period on the island. The main method of earth wall construction in the Neolithic period was hand-shaped adobes, while during the Chalcolithic period the prevailing method was wall construction with amorphous clay layers. The prevalence of masonry construction with clay in layers during the Chalcolithic period cannot be easily explained. Masonry made of layers of clay is a very primitive earth masonry construction and could have inspired the conception of hand-shaped adobes (Wright 1985, 351), as seems to have been the case in the region of Syro-Palestine and Anatolia.

The introduction of rectangular adobes seems to coincide with the introduction of rectangular buildings with linear elements (end of the 3rd millennium) in the Cypriot architecture, while their wider use is associated with the urbanization of the island, 1000 years later, as well as with the appearance of public and administrative buildings. This is a phenomenon observed in other cultures as well, such as in Anatolia, where the wide use of moulds is recorded as early as the Chalcolithic period, due to the earlier appearance of urban centres in this region.

The research revealed that the use (manufacturing and construction method) of adobes in prehistoric Cyprus shows similarities and differences, in individual construction elements, compared to the Aegean and Eastern Mediterranean. However, it seems that the use of earth-based materials appeared independently in the various cultures and thus the technology did not spread from one culture to the other (Houben and Guillaud 1994, 8).

Adobes, used at a large scale in Cyprus in prehistoric times, continued to have been reported until recently in traditional architecture (Fig. 2a,b). Traditional architecture shows a greater standardization and prevalence of adobes with fixed dimensions and reduced thickness compared to the prehistoric examples. In traditional architecture, very simple arrangements of adobe laying can be observed compared to the variety of set-ups observed in prehistoric architecture.



Fig.2. Adobes used in vernacular (2a, 2b) and contemporary architecture (2c)

The widespread use of earthen structures in Cyprus, both in prehistoric and traditional architecture, is associated with the fact that this building material is more economic, due to the abundance of raw material on the island suitable for this purpose. The wide use of adobes is also associated with the arid climate of the island which allowed quick drying and easy maintenance. At the same time, earthen structures exhibit many environmental and social advantages as they require limited energy consumption and consist of a material with significant thermal advantages (high thermal mass and capacity). For the above reasons, earth has more recently been taken up in contemporary architecture as well (Fig. 2c), especially in arid climates, contributing to a more sustainable built environment.

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BIOGRAPHY

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