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An Ethnoarchaeological Study on the Technology and Use of Adobe in the Jordan Rift Valley

The oldest use of sun-dried brick, or adobe, is found in the Jordan Rift Valley where the combination of semi-arid climate and abundant alluvial soils make it the most suitable choice for building material. The practice of making adobe structures and seasonally reconditioning them can be traced for 10,000 years in the archaeological record. Such evidence demonstrates the success of earth as a building material. It is also closely linked to the beginnings of agriculture and urbanisation.

The preference for the word 'adobe', rather than 'mud-brick', comes for the word's origin and because 'mud' is an unclear term. Adobe is a Spanish word transliterated from the Arabic 'aṭ-ṭūb' during the Moorish rule of the Iberian Peninsula. This had its origins in the Coptic word 'τωβε' (tobe) which in turn derives from the Egyptian word for brick, 'ḏbt' (Gardiner 1969: 497). All these refer to the sun-dried brick used as a building block, comprised primarily of common earth and usually mixed with some kind of tempering agent such as straw. Metaphorically, it can also be used to describe an entire structure built of this material.

The area in which this research was conducted was restricted to the Jordan Rift Valley, bounded by Lake Tiberias and the Yarmūk River Valley to the north and the Dead Sea to the south. The majority of the sites which were investigated lie on the two levels of the valley floor, the Ghawr and the Zawr. These *tall* sites, which were formed by consecutive layers of abandoned or destroyed adobe-built structures, are the best physical testimony for the importance and long-use of adobes as a basic building material in settlements of the Jordan Rift Valley.

The study of adobe in the Jordan Rift Valley was interdisciplinary, integrating archaeology, pedology, botany and ethnography (Politis 1993). It drew on engineering, architectural and socio-economic analyses in order to compare the ancient technology of adobe-making to the surviving one. The main objective was to trace adobe use through the ages, to quantify variation and attempt to explain the difference.

First, *in situ* adobe structures from recently exposed and on-going archaeological excavations were recorded in detail and sampled. The ancient sites studied include: Tulaylāt al-Ghassūl, Tall Iktanū, Tall al-Ḥammām, Tall as-Sulṭān/Jericho, Tall Umm Ḥammād, Ṭiwāl ash-Sharqī, Tall Dayr 'Allā, Katārat as-Samra, Tall al-Mazār, Tall Abū Ṣarbūṭ, Tall as-Sa'īdiyya, Ṭabaqat Faḥl/Pella, Tall Abū Ḥamid, Tall al-Ḥammah, Gilgal, Netiv Hagdud, Baysān/Scythoupolis and Munḥaṭa.

This fieldwork was done over a period of years during which time a series of mechanical, mineralogical, organic and chemical tests were conducted on the adobe components. These include particle size determination, phosphate testing, calcium carbonate testing, X-ray diffraction, grain shape analysis and Munsel colour charting. Similar analyses were applied to the natural soils and sediments surrounding the archaeological sites sampled in an effort to identify the sources for adobe production and help establish preference of soils. The results of these tests have also contributed to the reconstructing of the ancient landscapes in the Jordan Rift Valley.

The identification of tempering agents such as straw or dung is an important part of understanding adobe technology. A number of hypotheses can be made on the type of temper used or its total absence, which may reflect customary practices (as is described in the Old Testament), or economic factors (barley straw as opposed to wheat straw). The use of dung, which was evident in adobes from prehistoric as well as later periods, may also show a conscious choice of technologically better tempering agents. Furthermore, identifying impressions of organic tissues in adobe fabric has introduced a new technique to archaeology.

Finally, a catalogue was made which can be used as a reference on all future excavations in the Jordan Rift Valley. Recording adobe structures properly is of utmost importance, considering that they cannot be preserved once excavated and therefore information about them is lost forever.

The main soil groups in the Jordan Rift Valley are red

Mediterranean soils on old alluvium in the north; yellow Mediterranean soils on old alluvium in the middle part; Solonchaks on old and recent alluvium in the southern part; Regosols on eroded lacustrine sediments *(katār)* and on slope colluvium; and lurigated soils spread throughout the valley with profiles which are difficult to define but which partly belong to groundwater (grey soils) and 'Black Habitation' soils (Moorman 1959: 44). It is important to note that lacustrine sediments which are found in the basin of the Dead Sea and of the old Lake Lisan, have erroneously been named 'marls'. The strata consist mainly of fine textured sediments interbedded with numerous thin sand, clay and gravel layers. This is one of the most common sources of earth for adobe-making in the valley.

The basic component of adobe brick is earth. Although all soil types can be used for adobe production, the ideal soil should contain four elements: coarse sand, or aggregate, fine sand, silt and clay. The aggregate provides strength, the fine sand is a filler to lock the grains of aggregate, and the silt and clay act as a binder and plastic medium to glue the other ingredients together. Adobe structures are more vulnerable to erosion from rain. Adobe structures high in clay may be much more resistant to water and erosion, but less strong.

Clay may be the most important component of adobe make-up, but too much of it can be detrimental. Clay tends to expand when wet and contract when dry, causing cracks. Therefore, clayey loams or sandy clays are the most suitable soil types for adobe brick-making (Agarwal 1981: 140; Hughes 1988: 2). It must also be noted that clay minerals have different bonding properties and that the calcium carbonate ($CaCO_3$) content as well as the organic content will affect the physical properties of soil (Rapp 1978: 227). Kaolinite, which has traditionally been chosen for adobe-making in the Jordan Rift Valley, is an inert clay type which does not expand with water and therefore does not cause cracking (McHenry 1984: 55). In contrast, montomovillinite, mica and vermiculite clays do not bond with water and have a negative effect on adobe brick strength.

An example of a good soil particle proportion is 60% sand, 20% silt and 20% clay.

A variety of other ingredients have been used traditionally in adobe brick composition, which may or may not be beneficial to adobe strength and durability. The most common is fibrous vegetable matter as a tempering agent and soil stabilisers such as calcium carbonates or asphalt. Other additives whose properties and attributes have not yet been clearly determined include urine, animal and human hair, sap, animal blood, animal milk and various plant juices (Hughes 1983: 179; McHenry 1984: 75).

Finally, adobe bricks are often composed of some coarse material which may not be intentionally added to the mixture. Fragments of bone, pottery sherds, flints and larger gravels may be found accidentally inside adobe bricks, but only as impurities which existed in the soil at the time when the earth was quarried for brick production. The coarser impurities in the earth do, however, sometimes contribute towards the building strength of the adobe blocks, especially when the natural soil has a high clay content.

Stabilising soil to be used for adobe brick-making can be achieved by one or more of the following ways: a) by increasing the strength and cohesion of the soil; b) by reducing the moisture content of the soil; or c) by making the soil waterproof (Tukan 1989: 14). By mechanically compacting soil (i.e. rammed earth) it is possible to change its density, mechanical strength, compressibility, permeability and porosity.

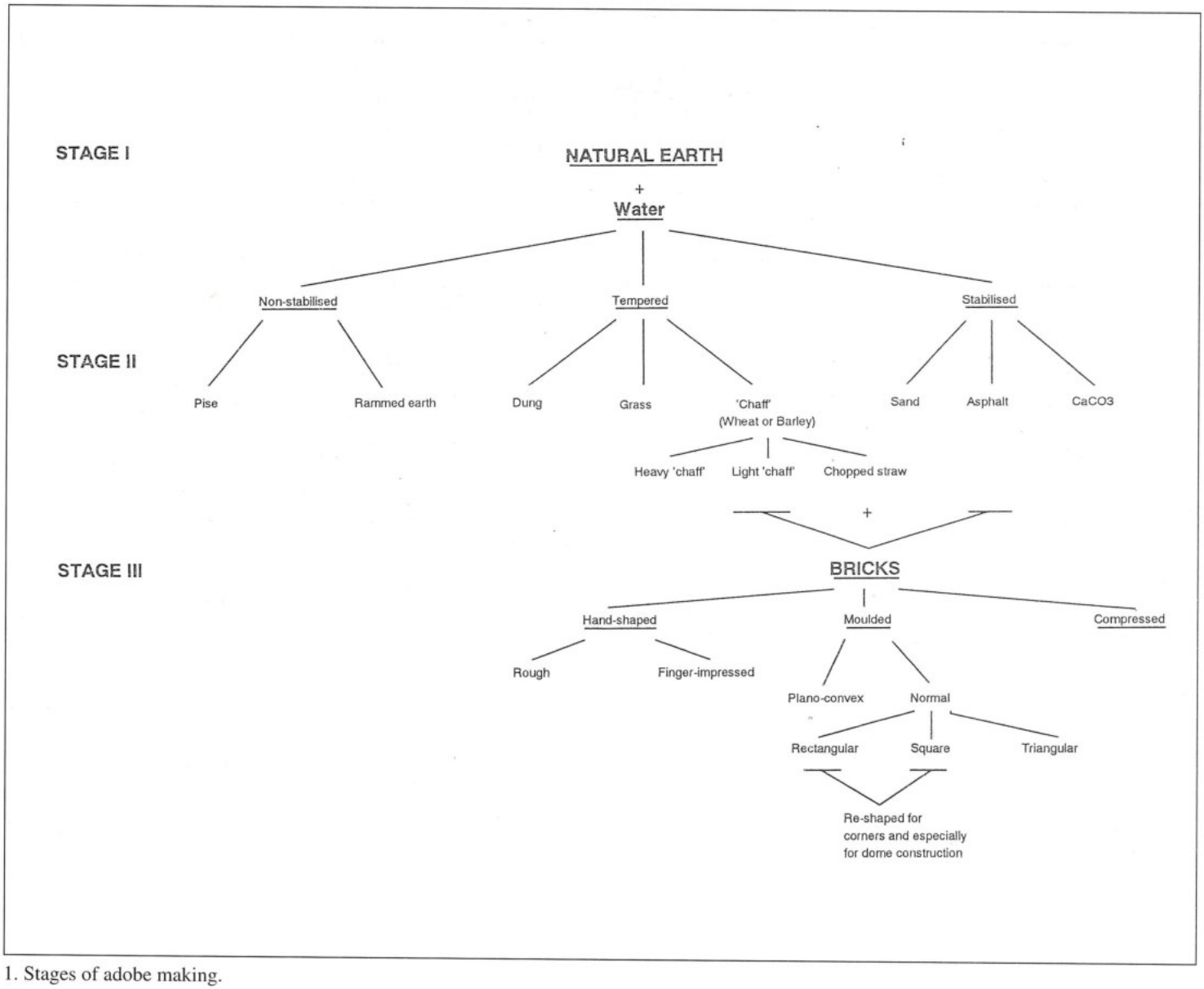
Physically, the properties of soil can also be modified by acting on its texture through, for example, the controlled mixing of different particle fractions (i.e. the addition of sand to clayey soils). Finally, materials or chemicals (i.e. asphalt) can be added to the soil to modify its properties either by a physical and chemical reaction between the particles and the additive, or by creating an impermeable layer which binds or coats the particles (Habitat 1988: 158).

Calcium carbonates ($CaCO_3$), which are naturally present in high percentages in the soils of the Jordan Rift Valley, can dramatically strengthen adobe bricks by reacting chemically with clay particles. The inclusion of ash in the soil mixture may also have the same effect. At the late Chalcolithic settlement of Tall Abū Ḥamid, hand-shaped bricks were uncovered which had a high percentage of ash mixed with calcareous soil. Another adobe brick wall was excavated in the Iron Age levels of Tall Iktanū which was comprised virtually completely of ash.

Tempering soil with fibrous vegetable matter such as grass, straw or even dung serves as an adhesive, binding adobe bricks together, distributing cracking more evenly or even preventing it altogether, and assist in the evaporation of moisture from the interior (Davey 1961: 19). The fermentation of these organic materials induce certain microbial products like extravacellular polysaccharides which are known to bind soils together (Hughes 1983: 179).

The production of adobe bricks is labour-intensive, depending largely on the skill of the brick-maker. It is characterised by a low technology and is not capital intensive. The basic tools needed include shovels, trowels and moulds (optional). The main stages are shown in FIG. 1.

After having selected the raw materials and bringing them to the site of production, the first step of adobe



1. Stages of adobe making.

manufacturing is pugging the earth. Because of the cohesive nature of soil, especially that with high clay content, the pugging process can sometimes be a long and tedious operation. The earth is piled up in a small mound, often with a depression at the centre. Water is then poured onto the mound a little at a time, and kneaded with bare feet until a consistent mixture is obtained and all the clumps of earth are broken and larger gravel inclusions are removed. Mixing is the key operation in the production process of adobes, especially if the earth used requires an admixture such as sandy soil, temper or stabilising agents. In the case of fibrous tempers such as chopped straw or dung, the process may be delayed for two to three days to allow the tempering material to rot and achieve the sought after gluey attribute.

The manual production of adobe bricks can be made either with or without a mould. When bricks are hand-shaped they tend to be more irregular and their size varies. They often have thumb or finger impressions on their surfaces which are intended for better mortar adhesion. The Neolithic "hogback" and "cigar-shaped" bricks from Tall as-Sulṭān/Jericho are of this type. The main problem with the hand-shaped adobes is that they are more labour-intensive and take longer to make than mould-made bricks.

When moulds are used, the earth is prepared to a semi-soft paste and the mixture is slopped into the mould on a level ground surface (which may be covered by straw, reeds or sand). When the mould is filled the earth mixture is levelled off. In between mouldings the mould is kept soaking in water in order to prevent the wet earth mixture from adhering to the wooden surface of the mould when it is being lifted. Mould dimensions vary. The basic rule is that a brick should have a size and

weight which can be easily handled by one man without the danger of it breaking.

The 'plano-convex' brick, first used in Mesopotamia in the third millenium BC, is similar to the normal moulded type except that one surface is rounded or convex.

The curing of adobe bricks is the final step before their use in building. The bricks should dry out as slowly as possible to avoid cracking or even disintegration due to shrinkage. It is during this time when the proportions and mixture of earth, water and tempers and/or stabilisers will be tested. The bricks are then left to cure for at least several days in the sun. This is one of the main reasons why adobe brick-making traditionally takes place in the summer months after harvest (when straw is also more readily available). Dried bricks are then put up right on their sides or stacked in such a way that air can circulate in between them. This dry storage should last at least two weeks but can often be kept for over a year.

Although adobe is characterised by a low technology, its constant widespread use as a building material in the Jordan Rift Valley from the earliest agricultural settlements to the twentieth century town is proof of it own success. Not only was earth as cheap and readily available as it is today, but its practical qualities made it the obvious choice for over 10,000 years.

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