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Tips and Tricks to Study Mudbricks. Experiences from the Protohistoric Site of Casas del Turuñuelo, Spain

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Abstract

The main construction *technique during the Protohistory in the southwest of the Iberian Peninsula was adobe. However, to date, there have been few sites with the necessary state of preservation to conduct studies that provide a holistic view of the architecture. In contrast, the discovery of the Tartessian building at Casas del Turuñuelo (Guareña, Badajoz, Spain) with its exceptional state of preservation has enabled the application of a wide range of interdisciplinary analytical techniques and methodologies—many of which have never before been used together at a single site. In this paper, we present a detailed synthesis of all the strategies, techniques and analyses applied over ten years of excavation, as well as those currently under development. Our aim is to share the insights gained from this specific case study and, more importantly, to provide methodological tools that can be applied to other adobe-using sites, regardless of their chronology or cultural context.*

Keywords: *adobe; archaeology; construction techniques; earth construction; Tartessus*

1. Introduction

Within the framework of the Protohistoric period of the Iberian Peninsula, adobe is one of the most widely used building techniques. However few holistic and comparative studies have been conducted in a comprehensive manner. This may be due to the poor state of preservation of earthen structures and the preponderant research focus on movable materials; as a result, there is currently no standardized analytical methodology for the characterisation and study of Protohistoric adobe. However, in recent years significant progress have been made through case studies centred on the 1st Iron Age, generating valuable works which, although with different objectives and approaches, share a multidisciplinary vision as the path forward.

Consequently, we are currently in a phase of experimentation and application of new methodologies, as well as the incorporation of resources from different disciplines.

Regarding the definition of adobe—a term that still generates some confusion—it refers to a construction technique involving the production of earth-based units mixed with both organic and inorganic additives. These units are shaped in molds (which may be standardized and suitable for mass production), are neither compressed nor fired, and are dried prior to placement. As such, they are prefabricated elements that can be stored and transported. They are typically assembled using mortar. Another important feature is its versatility allowing for its use in various types of constructions and contexts. The question of when adobe began to be used on the Iberian Peninsula remains a topic of debate (Belarte, 2011; De Chazelles et al., 2011; Pastor et al., 2024). While adobe has a long-standing presence in the eastern Mediterranean (Spencer, 1979), its widespread use in the Iberian Peninsula did not occur until the arrival of the Phoenicians, despite its occasional application in the Late Prehistoric period.

One of the most important discoveries in recent years for the for the study of earthen architecture in Protohistoric Iberia is the site of Casas del Turuñuelo (Guareña, Badajoz, Spain) (Figs. 1 & 2). It represents the best-preserved adobe building in the western Mediterranean (Rodríguez González et al. 2020: 426). This site is allowing us to delve deeper into the study of the architecture of the period (Celestino et al., 2023), and to implement both qualitative and quantitative methodologies, all organized according to the building's stratigraphy. Therefore, in this paper we offer a preliminary approach to the methodology and working protocol designed for the study of the adobes at the site. It is a proposal that, based on our experience, can be varied and adapted according to the results and peculiarities of each case study.

Fig. 1 – *Location of the site of Casas del Turuñuelo* (Proyecto Construyendo Tarteso).

2. Previous contextualisation, analysis and work carried out

In the Early Iron Age the construction techniques are, in general, easily identifiable, with adobe being present in the great majority of cases. Consequently, their study should be a priority, both because of the number of units available and because of the historical information they provide. To this end, the research objectives can be broadly divided into two main areas: 1. to investigate the process of manufacture, construction and architectural functions of the adobes; 2. to characterise the composition of the mortar and earth used, and to determine the chronology of each phase and event that left traces in the architecture in order to determine the evolution of constructions.

As a basis on which to carry out any study, we consider it essential to contextualise each of the adobes studied within the framework of the building, which implies identifying the construction element of which it forms part and its stratigraphic relationships through the application of the Archaeology of Architecture. It is true that the application of the theoretical and methodological principles of Archaeology of Architecture (Azkárate, 2013) encounters significant difficulties when applied to the study of earthen constructions. Thus, even if the state of conservation is good, there are always factors such as irregularities within the same constructive solution, the large number of repairs and

Fig. 2 – *Plan and profile of the site of Casas del Turuñuelo* (Proyecto Construyendo Tarteso).

modifications or the continuous maintenance, intrinsic to earthen architecture (Carranza, 2022). However, these steps are the ones that will allow us to situate the adobes within a specific moment and constructive element.

2.1. Study of the constructive aspects, manufacture and architectural function of adobe bricks

Once the stratigraphic relationships between the various constructive units of the building are established and the constructive elements are defined, it is possible to begin studying of the adobe (aka mudbricks) present within them (Fig. 3). The first step is the individual identifycation of the mudbrick preserved in situ, which requires addressing specific challenges such as deformations, distinguishing the mortar joints between the bricks, etc. Atn this stage, recording the mudbrick's measurements is essential, as the ddimensions are a representative physical feature of the adobes, in addition to the fact that its correct delimitation is what will later allow samples to be taken for the analyses to be carried out.

In the case of the work carried out at Casas del Turuñuelo, we have so far been able to record measurements of more than a hundred pieces preserved in situ. A key innovation in our approach is the use of statistical methods to process this data, which has allowed us to establish several clearly differentiated modules, as well as to know their distribution and differential use within the different constructive elements and stages of the building.

In this sense, one of the objectives is the reconstruction of the operational chain, which includes two key aspects: the actual manufacture of the pieces and their modes of use within the architecture. To do this, we must begin by defining the soils used and the ways in which the raw material was exploited, using analytical studies of material composition.

With regard to the moulding, it is important to record the marks and impressions related to the demoulding and drying of the adobes, which allows us to clarify and detail the process with a high degree of precision.

Fig. 3 – *Example of adobe facing analysed* (Carranza, 2022).

These lines of research are essential to determine the types of adobe used, their association with specific construction typologies, the various sources of clay supplies available and the estimated labour force involved at any given time. Through detailed documentation we can detect, among other aspects, the reuse of old adobe bricks and fragments for the remodelling of the construction in later phases, which undoubtedly leads to technological and cultural insights into the architectural and functional development of the building.

Ethno-archaeology and experiences derived from experimental archaeology are also valauble sources of information on the manufacture and use of adobes. In the first case, insights have been gained through the observation of vernacular architecture and fieldwork carried out as part of a research project in the Draa Valley in southern Morocco. The continued use of traditional land-based construction techniques in the region has offered a wide range of interpretative alternatives.

As for experimental archaeology, one of the future objectives within the framework of the 'Construyendo Tarteso' projects is the creation of a laboratory dedicated exclusively to the study of earthen architecture, given that the few works we have carried out so far have produced priomising results.

2.2. Physico-chemical characterisation of mortar composition: invasive methods

The application of archaeometric techniques for the physico-chemical study of archaeological materials is common for all types of movable artifacts. However, their use in the study of historic earthen architecture is relatively recent. As a result, a standardized protocol has not yet been developed, and each case is significantly influenced by the preservation state and specific conditions of the site.

In the specific case of Casas del Turuñuelo, which we will use in this section as an example of the work protocol put into practice, a methodology was designed using a combination of micro and macro approaches on the remains of different earthen constructive elements located at the site.

The basis of this recently published suite of techniques (Cutillas et al., 2024) was based on X-ray fluorescence (XRF), X-ray diffraction (XRD), thin-section petrography and combustion elemental microanalysis (CHN).

XRF and CHN elemental analysis were used to determine the chemical composition of mortar samples, and the data were processed through statistical modeling. XRD was also employed to identify the mineralogical composition of selected samples. These analyses enable us to establish a common "material fingerprint" among all the materials used in the construction of the building, which is particularly useful to know the different sources of raw materials (Cutillas et al., 2024, pp. 3-6, 12).

From the different diffractograms generated by XRD we were able to determine the mineralogical composition of the adobes. By analyzing samples from various areas of the building alongside local soils, we were able to confirm the use of three distinct raw material collection zones. These were exploited simultaneously by different workgroups, even though the sources were located at varying distances from the site and not necessarily adjacent to the building (Cutillas et al., 2024, p. 9). This finding is significant as it demonstrates that, although earthen architecture generally draws on the materials adjacent to the building to be constructed, the modular nature of adobe allows it to be transported over very long distances, which, in this case, is ruled out. What has emerged is a clearer picture of the of the logistical complexity, operational chain, raw material selection and processing, and the differentiation of recipes used over time and across different parts of the building.

The petrographic analysis (Fig. 4) carried out via thin sections microscopy, allowed us to identify the different petrographic fabrics (TP) and sub-fabrics. The vast majority of the observations resulted in a homogeneous structure in terms of geological composition, but different substructures were also identified in terms of colour parameters, texture, groundmass and vegetal temper. Interestingly, the presence of dung spherulites and reed phytoliths was also recorded, suggesting that dung may have been used as temper (Cutillas et al., 2024, p.7-8), which shows the potential of this type of analysis to understand aspects such as palaeolandscape and palaeofauna.

At the macro level, our analysis of the samples revealed various traces left by organic additives in the adobe bricks. These include: cases in which neither the vegetal matter nor the pore space is preserved due to their decomposition and variation due to the compression forces; other burned adobes that lost the vegetal content and preserved the pore space, and experienced physico-chemical alteration due to fire; and unburned samples that contain vegetal matter with the problem that they appear as part of the fills, so that they cannot be securely located to a specific construction element.

In terms of composition, in addition to the analyses already described, we also explored the organic content of adobe bricks by leveraging analyses initially developed for the site's ceramic materials. Thus, we selected eleven adobe samples to analyse, by searching for traces of lipids, whether stabilisers of organic vegetable or animal origin were added to the mortar mixture. For this purpose, gas chromatography coupled to a mass spectrometer (GC-MS) was used.

The previous techniques have made it possible to characterise materials on the basis of their composition without using large quantities of sample, although we must not forget that these are destructive techniques. For this reason, in this section we consider incorporating the application of physical, chemical and mechanical tests into the methodology. These include plasticity tests, to determine the plastic and liquidity limit; permeability tests, to evaluate the clay's capacity to allow water to pass through; and compaction tests, to determine the maximum density and optimum moisture content.

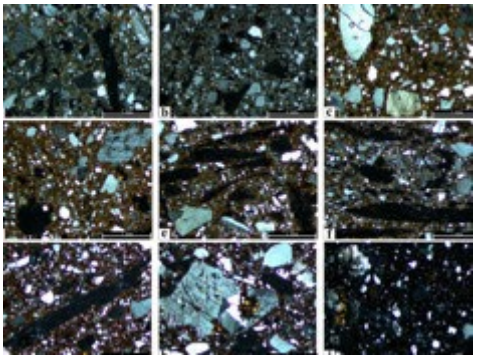

Fig. 4 – *Representative microphotographs of the petrofactories identified in the Casas del Turuñuelo building* (Cutillas-Victoria et al., 2024, p. 7).

In the previous tests, we have ruled out, for the moment, compressive strength tests, since the oversizing nature of the walls of the building makes it difficult to identify which parts of the structure had a load-bearing function.

However, we have carried out tests to determine the relative density of the adobe mortars, which has provided us with results that are consistent with the usual parameters for adobes. They should also be considered with caution and new methods should be sought, since, as we have indicated, the porosity related to the vegetal additions may have undergone significant variations over time.

2.3. Dating of historical mortars

The application of absolute dating techniques to historical mortars remains an underdeveloped area, as no standardized method currently exists for dating earthen materials. Nonetheless, these techniques are crucial for determining the construction timeline of different building phases—particularly since buildings are often subject to expansion, compartmentalization, or repair based on evolving needs.

There is a wide range of dating techniques, but not all of them will be suitable to answer the original questions: when, for example, were each of the phases of the Casas del Turuñuelo building constructed? Radiocarbon dating pesents a challenge as the organic matter in the adobe is not consistenly preserved. Given this situation, Optically Stimulated Luminescence (OSL) dating has been selected, and the technique has been applied to various parts of the building as test, selecting points which, thanks to the paramental analysis, we know belong to the same construction phase.

The results from the adobe samples have yielded magnificent results, with an accuracy with arcs of ± 12-21 years and totally consistent with the stratigraphic readings. We have therefore extended these analyses to other parts of the building, as this is the only technique which, although not without its problems, is offering us guarantees to know the exact time of placement of the pieces and mortars used in the building.

In addition to the extension of the OSL, we are currently beginning the process of applying palaeomagnetism dating, both to ceramic material and to the architecture affected by the fire. This technique also presents important calibration problems for the 1st Iron Age; however, the results obtained will allow us to determine the exact chronology of the fire that put an end to the occupation of the building at Casas del Turuñuelo, thus complementing the results obtained thanks to the radiocarbon samples taken from the seeds and bones of the courtyard linked to the massive slaughter of animals excavated in this space (Iborra et al., 2023).

2.4. Other non-invasive tests

Finally, we also highlight the use of non-destructive research techniques, or those that do not require sampling or management of materials in the laboratory, which we believe can provide important additional information. Within this group we are currently working on the development of methodologies and strategies based on the use of infrared thermography, humidity recording and the use of ground penetrating radar (GPR).

Firstly, thermography captures the infrared radiation emitted by bodies as a function of temperature, providing an image visible to the human eye (Fig. 5). In our case, we intend to start monitoring temperature variations throughout the year for conservation purposes, while in the specific case of adobes, we are testing the technique to see if the different mortar recipes emit differential radiation or not, which would allow us to distinguish them from each other.

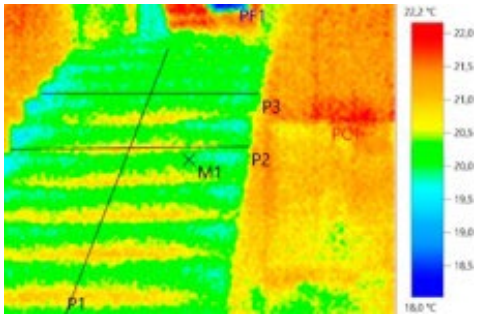

Fig. 5 – *Thermography applied to the west elevation of the site of Casas del Turuñuelo* (Proyecto Construyendo Tarteso).

Regarding humidity, we have also begun using the Munsell Color System tables as a quick method for the identification of mortars. These colourimetric parameters, recorded under specific light and humidity conditions, can indicate a wide range of characteristics of adobe mortars (Ferrer García, 2015), although they are proving particularly useful for the rapid differentiation of formulas used in a less subjective way. However, it remains to be assessed whether they are sufficiently accurate to differentiate formulae recorded through geoarchaeological studies.

Finally, within the framework of non-invasive analysis, we propose the application of ground penetrating radar (GPR). This portable device detects contrasts or variations in the density or compactness of a medium when electromagnetic waves are propagated. The georadar device allows a penetration of 50-60 cm, both in pavements and vertical surfaces. Similar to thermography and humidity, it is providing promising results for recording pavement overlays and possible buried structures at shallow depths. In the case of adobes, it does not allow us to differentiate the different recipes as they have densities within the same range, but it does clearly show the difference between quartzite plinths and adobe elevations, especially useful when they are not visible due to the preservation of the cladding.

3. Final reflections

The building at Casas del Turuñuelo and its exceptional state of preservation, together with the fact that it is an active site, offers a rare opportunity to develop and test methodologies for studying protohistoric earthen architecture. It is therefore time to contrast tools and methodologies whose results provide information on both the building itself and the broader cultural framework in which it is framed. For this reason, in addition to carrying out analyses at different points of the building, we have selected a specific area of the site on which we are applying all the analyses in order to centralise and directly compare the results across different techniques.

When it comes to adobe, our work has highlighted several ongoing challenges, such as the lack of standardized terminology and methodological consensus (Carranza, 2022). at the same time, it also shows the potential of the study of historical adobes to understand aspects such as the management of resources and raw materials, the degree of specialisation of the builders, the complexity of the work routines, the architectural function of the architectural elements and/ or the construction practices of the time.

The stratigraphic reading of elevations, the identification of constructive elements and the geoarchaeological characterisation are the basic works for the complete and precise study of earthen architecture. However, one of the most important questions to be resolved for the future, on which there is no consensus, is which parameters to choose for the characterisation of the adobes. The goal is to establish a set of criteria that will allow for the quick and reliable comparison of adobe characteristics across buildings. This will be critical for conducting comparative studies that group structures by chronology or cultural affiliation. From our experience, texture and colour may be the most

accessible in relation to composition, while dimentions and architectural function are culturally significant and commonly available physical parameters.

In conclusion, this work offers a methodological proposal grounded in our fieldwork and ongoing research on historic adobes. Moving forward, dialogue between disciplines and openness to new tools and methodologies will be essential, comparing the results of the different techniques and observations in order to make more reliable historical interpretations.

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