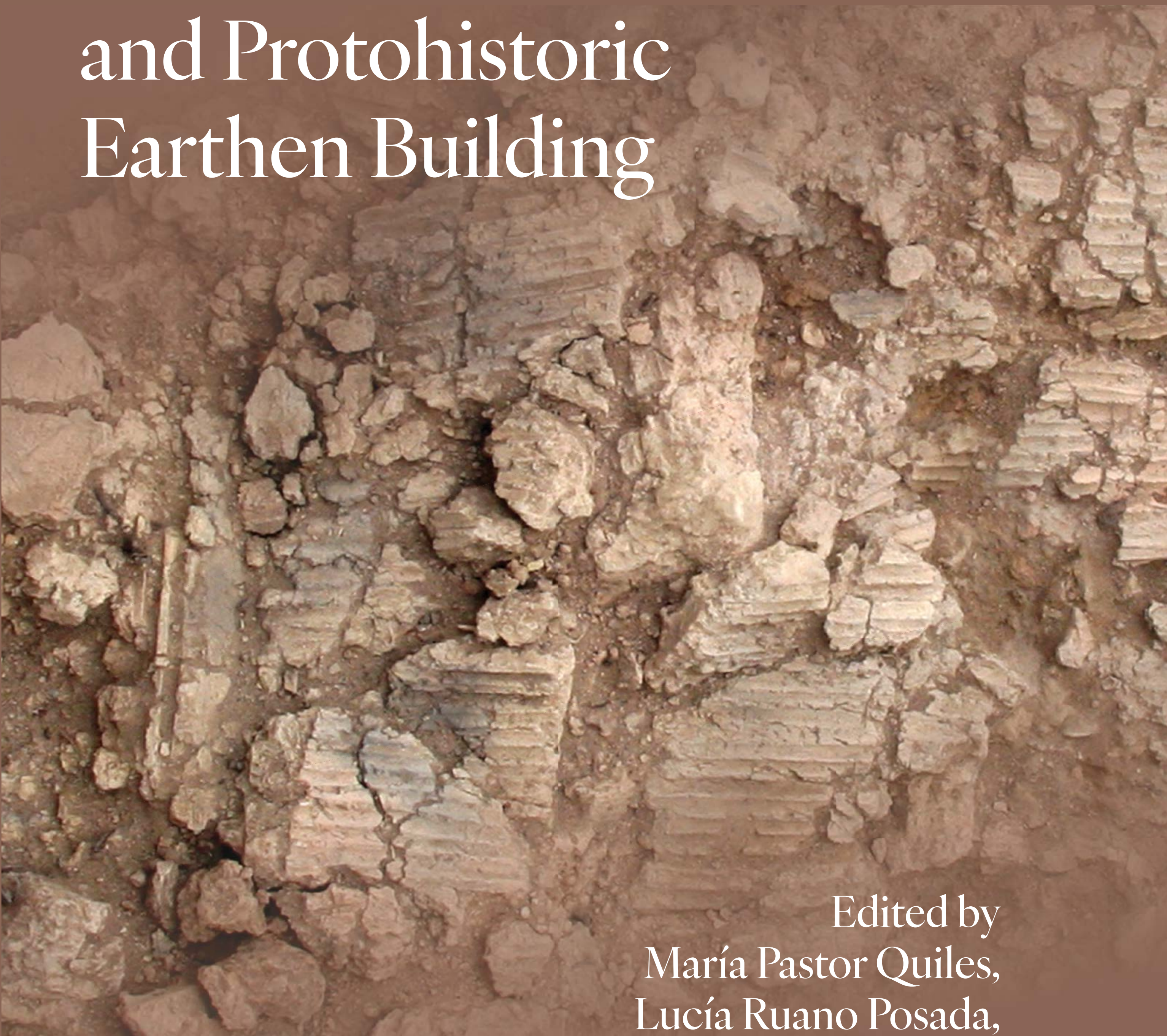
Productive and Social Practices in Prehistoric and Protohistoric Earthen Building



Edited by
María Pastor Quiles,
Lucía Ruano Posada,
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Earthen Heritage in the Eastern Mediterranean between Archaeology and Sustainability

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Abstract: This paper presents the EARTHERITAGE Project, a two-year research programme focused on the analysis, documentation and development of preservation strategies for earthen architectural heritage in the Eastern Mediterranean, with particular attention to the island of Cyprus. The project was grounded in a synergic dialogue between archaeological, geoarchaeological and architectural approaches, involving multiscalar analyses of prehistoric earthen architectural evidence across the island. Research activities integrated archaeological and geoarchaeological investigations of prehistoric earthen building materials with detailed geomorphological and pedological studies of the natural environment of southern Cyprus, selected as the main study area. The resulting dataset supported a programme of technical experimentation on implemented earthen products, informed by ancient construction practices and local raw materials. Experimental analyses are currently ongoing and aim to contribute to the development of a research framework for evaluating the potential use of these materials as sustainable solutions for the conservation and preservation of archaeological earthen structures in Cyprus.

Keywords: Earthen Architecture, Prehistoric Cyprus, Cultural Heritage, Eastern Mediterranean, Geoarchaeology.

Riepilogo: Il Progetto EARTHERITAGE qui presentato rappresenta un programma di ricerca biennale i cui obiettivi primari sono l'analisi, la documentazione e lo sviluppo di strategie di conservazione del patrimonio architettonico in terra cruda nell'area del Mediterraneo orientale, con particolare attenzione all'isola di Cipro. Il progetto promuove un dialogo sinergico tra approcci archeologici, geoarcheologici ed architettonici, e si è focalizzato su un'analisi multiscala delle evidenze in terra cruda relative all'architettura preistorica sull'isola. Le attività di ricerca hanno integrato indagini archeologiche e geoarcheologiche sui materiali da costruzione preistorici con

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studi geomorfologici e pedologici dell'ambiente naturale della regione meridionale costiera di Cipro, selezionata come regione-chiave per lo sviluppo dell'indagine. I dati ottenuti dall'integrazione delle analisi archeologiche e geoarcheologiche hanno supportato un programma di sperimentazione tecnica su prodotti in terra cruda realizzati secondo pratiche costruttive antiche e materiali locali. Le analisi sperimentali sono attualmente in corso e mirano a contribuire allo sviluppo di un quadro di ricerca finalizzato a valutare il potenziale impiego di questi materiali come soluzioni sostenibili per la conservazione del patrimonio architettonico in terra cruda nell'area del Mediterraneo orientale.

Parole chiave: Architettura di terra, Cipro preistorica, Patrimonio culturale, Mediterraneo orientale, Geoarcheologia.

Introduction

Over the past decade, the rich archaeological and vernacular earthen architectural heritage of the Eastern Mediterranean has been the focus of interdisciplinary research involving archaeologists, geoarchaeologists and architects. A wide range of methodological applications has been developed to investigate this architectural legacy. These include environmental and geoarchaeological studies aimed at reconstructing the formation, use and degradation processes of earthen structures in both archaeological and vernacular contexts (e.g. Friesem *et al.* 2011, 2013), as well as analytical and compositional studies of mudbricks and earthen construction materials addressed to examine properties and technological choices (e.g. Devolder and Lorenzon 2019; Lorenzon 2024; Love 2012; Nodarou *et al.* 2008). In parallel, research programmes and conservation initiatives have addressed the protection and enhancement of the earthen Mediterranean landscape (e.g. Achenza and Sanna 2011; Costi de Castrillo *et al.* 2017; Germanà 2013), while experimental and interdisciplinary approaches have been increasingly employed to test sustainable solutions for the preservation of ancient and modern earthen architecture (e.g. Sadozaï and Gandreau 2020). Together, these studies have highlighted the need for multiscalar and integrative frameworks capable of bridging material analysis, environmental context and conservation practice.

Thanks to its rich archaeological and vernacular earthen architectural heritage, Cyprus represents a key case study for advancing current knowledge on earthen architectural practices in the Eastern Mediterranean. In particular, the southern region of the island offers significant potential for investigating long-term continuities and transformations in earthen building traditions across prehistoric, historic and modern contexts. The local geology, characterised by white chalk and marl of the Pachna Formation (Noller 2009), has created favourable conditions for earth-based construction practices. In fact, soils and bedrock derivatives have been traditionally exploited for wall construction, roof systems and surface finishes, resulting in a diversified but technologically coherent earthen architectural tradition. The widespread use of *Havara* (surficial, soft and carbonaceous, clastic rock) and *Kafkalla* (calcium-rich duricrust of pedogenic origin) (Schirmer 1998) constitutes the primary material basis of earthen architecture on the island from the Neolithic period onwards.

Interdisciplinary investigations of archaeological and vernacular earthen structures in southern Cyprus have already demonstrated the analytical potential of combined archaeological, architectural and geoarchaeological approaches (Amadio 2024; Gkouma *et al.* 2021; Lorenzon and Iacovou 2019; Lorenzon *et al.* 2023; Hourani 2003, 2011; Mylona *et al.* 2023, 2021; Philokyprou 2018; Philokyprou and Limbouri-Kozakou 2015; Philokyprou *et al.* 2017). These studies have underscored the strong interdependence between geological resources, construction techniques and architectural performance, while also revealing the vulnerability of earthen structures to environmental and anthropogenic degradation. Nevertheless, despite the growing body of research, systematic and comparative investigations that explicitly integrate material characterisation, environmental analysis, experimental replication and conservation-oriented testing remain limited.

Within this research landscape, the EARTHERITAGE Project was carried out between February 2024 and February 2026 and was conceived to address this gap by developing a multiscalar and interdisciplinary framework for the study of earthen architecture in Cyprus. The project builds upon a long-term research trajectory at the Middle Bronze Age site of Erimi-*Laonin tou Porakou* (henceforth Erimi-*LtP*), where preliminary archaeological and geoarchaeological investigations of earthen materials have been conducted since 2013 (see Amadio 2017: 259-276, 2024). By combining archaeological and geoarchaeological analyses of prehistoric earthen buildings with detailed geomorphological and pedological investigations of the surrounding landscape, the project generated a comprehensive dataset on raw material procurement, material selection and construction practices. This dataset encompasses a wide range of earthen architectural components, including mudbricks, roofing materials and plasters applied to floor and wall surfaces. This formed the basis for targeted experimental programmes aimed at implementing and testing earthen products derived from local materials, with the explicit goal of evaluating their suitability for sustainable conservation and preservation strategies.

In doing so, the project contributes not only to the reconstruction of past building knowledge but also to the development of context-sensitive approaches for safeguarding earthen architectural heritage in Cyprus and more broadly in the Eastern Mediterranean.

Research framework and analytical approach

This study builds on the research activities carried out within a two-year programme dedicated to advancing current knowledge of earthen architecture in Cyprus. The research was centred on the integrated analysis, documentation and conservation-oriented assessment of earthen architectural heritage, combining archaeological, geoarchaeological and architectural perspectives. A multiscalar analytical framework was applied to prehistoric earthen architecture from the Middle Bronze Age site of Erimi-*LtP* (*c.* 1950–1650 BC) (Bombardieri 2017) (Figure 1), selected as a key case study due to the good preservation of its earthen structures. The research was conducted within the framework of the EARTHERITAGE Project. Activities were developed as a joint research initiative involving the Universities of Siena, Genova and Palermo, each contributing complementary expertise in archaeological investigation, geoarchaeological analysis and architectural and material studies. This institutional collaboration enabled the integration of field-based observations, laboratory analyses and applied architectural research within a coherent methodological framework.

The analytical strategy adopted in this study is structured around three interconnected sets of approaches, designed to address earthen architecture as both a material and cultural phenomenon and as a resource for sustainable heritage preservation. These approaches combine (1) archaeological and geoarchaeological analyses of earthen building materials and construction techniques, (2) geomorphological and pedological investigations aimed at reconstructing the environmental context of raw material procurement and (3) experimental and architectural studies focused on the implementation and testing of earthen products for conservation purposes. Together, these methods allow for the examination of production choices, technological knowledge and material performance, while also assessing the potential transferability of past building practices to present-day conservation strategies (Figure 2).

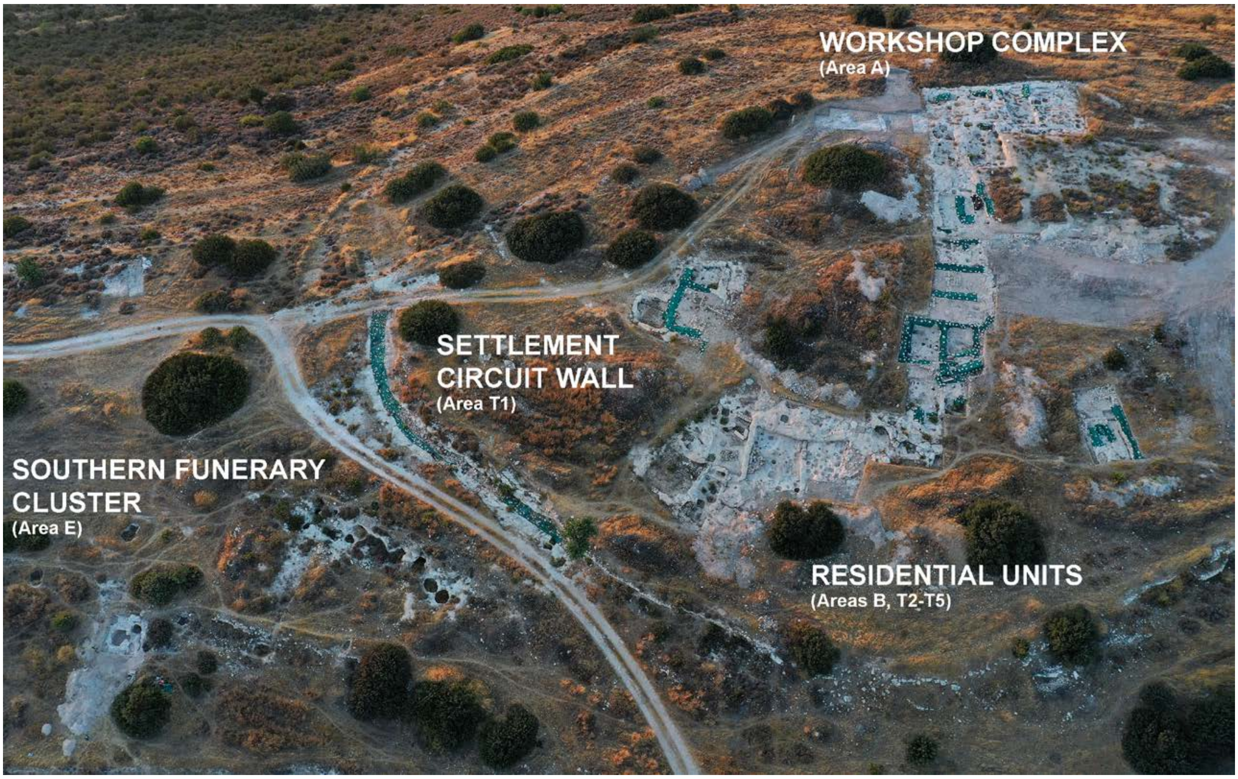

Figure 1. Aerial photograph of Middle Bronze Age Erimi, in the Kouris Valley, Cyprus (Erimi Archaeological Project Archive).

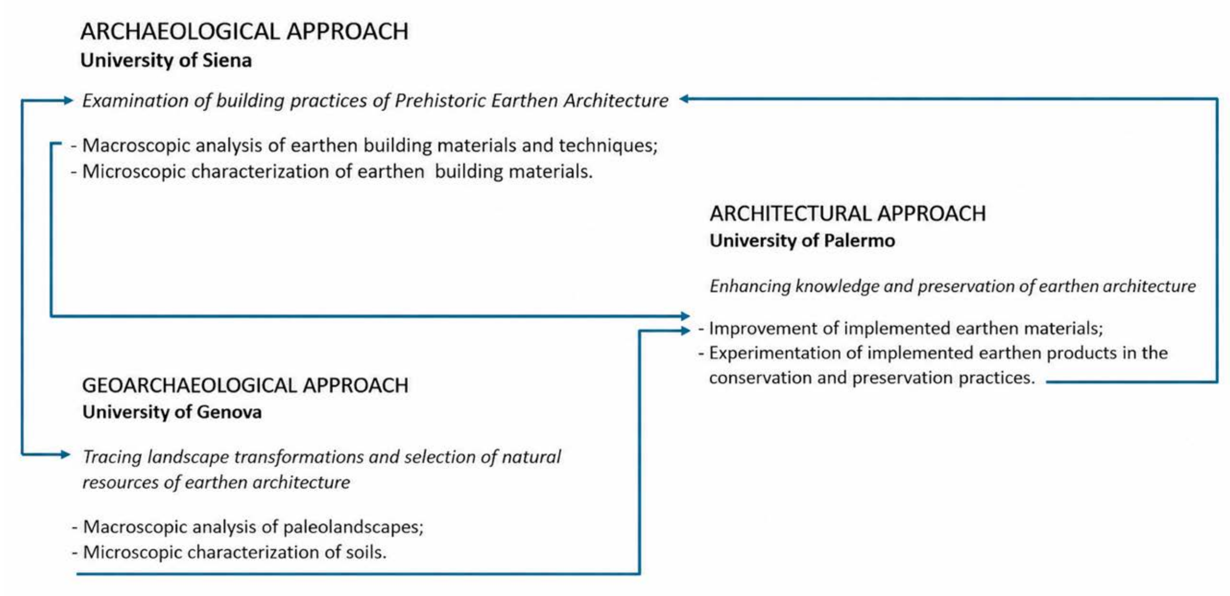

Figure 2. Graphs showing the three intertwined research approaches applied in this study.

Figure 3. Macroscopic analysis and documentation of mudbrick samples during fieldwork activities (EARTHERITAGE Project Archive).

Archaeological and material analytical approach

The archaeological component of this study focuses on the scientific examination of earthen architectural remains preserved in the prehistoric archaeological record of Cyprus. The Middle Bronze Age site of Erimi-*LtP* constitutes the primary context of investigation, serving as both a case study for the analysis of ancient earthen construction practices and a reference framework for evaluating preservation and conservation strategies. Rather than being treated solely as a conservation target, Erimi-*LtP* is approached as an analytical laboratory for examining the materials, techniques and organisational choices underpinning earthen architecture in antiquity.

Archaeological analyses were structured according to multiple and increasing scales of observation and combined in-field recording with laboratory-based investigations. Fieldwork activities included systematic macroscopic examination and documentation of prehistoric earthen structures at Erimi-*LtP*, with particular attention to construction techniques, architectural layouts and the main constitutive elements of walls, floors and associated features (Figure 3). This phase aimed to reconstruct technological practices and material choices related to the production and use of mudbricks and other earthen building materials, such as plasters and roofing components. Observations from Erimi-*LtP* were contextualised through comparison with published evidence from other prehistoric sites in Cyprus and the wider Eastern Mediterranean.

Field investigations also involved a targeted sampling strategy designed to capture variability in production modes and construction practices. Earthen building materials were sampled from both domestic units and productive or communal architectural contexts within the settlement. This comparative approach allowed for the examination of potential differences between household-level

Figure 4. Micromorphological sampling of a paleosol buried by a *Havara* deposit in the Kouris Valley during the geoarchaeological activities (EARTHERITAGE Project Archive).

and supra-household or communal building practices, contributing to broader discussions on labour organisation and social dynamics within Middle Bronze Age communities on the island. Archaeological fieldwork and sampling were carried out in close coordination with geological investigations, enabling continuous data exchange and the refinement of in-field analytical strategies.

Macroscopic observations were complemented by high-resolution laboratory analyses aimed at achieving a comprehensive characterisation of the sampled earthen materials. These analyses included: (a) micromorphological investigation of thin sections (Figure 4), (b) particle size analysis, (c) elemental characterisation through X-Ray Fluorescence (XRF) and Electron Microscopy coupled with Energy Dispersive Spectroscopy (SEM–EDS), and (d) mineralogical and molecular analyses using X-Ray Diffraction (XRD) and Fourier-Transform Infrared Spectroscopy (FTIR). The integration of these methods enabled the reconstruction of raw material selection, preparation techniques and manufacturing processes, providing a robust analytical basis for interpreting technological knowledge and construction practices in prehistoric Cypriot earthen architecture.

Geoarchaeological and landscape analytical approach

The geoarchaeological component of this study investigates human-environment interactions within the broader landscape of the Kouris Valley, where Erimi-*LtP* is located. Geomorphological and pedo-stratigraphic analyses were employed to reconstruct landscape evolution, sedimentary processes and soil formation dynamics relevant to both settlement development and raw material procurement.

The geomorphological analysis involved the production of a standardised geomorphological map, developed within a GIS environment combining the interpretation of stereo-aerial photographs and field survey in the selected area to characterise the different morphologies. This mapping strategy enabled the identification of landforms generated by fluvial, colluvial and other surface processes, the assessment of the spatial distribution of erosional and depositional dynamics, and the reconstruction of palaeo-landscape evolution during the Holocene. Chronological constraints on sedimentary processes were obtained through the combined use of artefacts embedded within alluvial and colluvial deposits as relative chronological markers and selected radiocarbon analyses, providing numeric age estimates for major landscape formation and infill events.

Soil chronosequences and toposequences (catenas) were analysed to establish stratigraphic control and to correlate geomorphic units across the study area. In parallel, statistical analyses of spatial relationships between archaeological site locations and mapped geomorphic units were conducted to assess potential correlations between settlement patterns and specific landscape features. These procedures allowed for the integration of geomorphological data with archaeological evidence at a regional scale.

Geomorphological results were combined with newly acquired pedological data to construct a pedo-landscape map illustrating the spatial and temporal distribution of soils within the Kouris Valley. This dataset provided a key reference framework for evaluating the provenance of raw materials used in earthen architectural structures at Erimi-*LtP*. Soil samples collected from stratigraphically described horizons (Figure 4) were analysed using a suite of complementary laboratory techniques, including soil micromorphology, particle size distribution, pH, total carbonate content, total organic carbon and nitrogen, cation exchange capacity and concentrations of extracted chemical elements, as well as micromorphological, XRD and SEM-EDS analyses.

The resulting pedological and geochemical data were systematically compared with analytical results obtained from archaeological earthen materials. This integrated approach enabled the identification of shared compositional and mineralogical signatures, contributing to the reconstruction of raw material sourcing strategies and to the definition of the geological ‘fingerprint’ of earthen building materials used in Middle Bronze Age Cyprus.

Architectural and experimental conservation approach

The architectural component of this study integrates technical experimentation on earthen materials with applied testing of their use in conservation and preservation practices. These two dimensions are closely interrelated and were developed to bridge material performance studies with conservation-oriented architectural applications. At a technical level, the research focused on improving the mechanical behaviour and durability of earthen bricks, while at a technological level, it explored the applicability of the resulting materials within experimental conservation contexts.

Technical experimentation was directed at enhancing the mechanical strength and reducing the vulnerability of earthen bricks through the controlled addition of stabilising agents to the raw earth mixtures. Building on previous research, this study investigated the use of nanoparticles as stabilisers, with particular attention to Laponite®, a ‘natural-synthetic’ layered silicate (Scalisi and Sposito 2015). Two stabilising formulations were tested: a commercially available laponite and a laboratory-modified variant obtained through chemical surface treatment. In order to maintain a sustainability-oriented approach, chitosan was selected as a green polycation derived from renewable resources and industrial by-products of shrimp processing (Aguilar *et al.* 2016; Cavallaro *et al.* 2021; Zavaleta *et al.* 2024).

Hybrid laponite-chitosan nanomaterials were prepared following ratios defined by surface charge measurements and colloidal stability analyses of the mixtures. Experimental protocols were grounded in the characterisation of both raw natural materials and archaeological samples, ensuring methodological consistency with traditional earthen construction practices. Experimental brick specimens were produced using two manufacturing techniques: hand-moulded bricks formed by placing the mixture into moulds and compacting it manually, and compressed blocks manufactured using mechanical presses. All soil types employed in the experiments were sampled from the Kouris Valley area in southern Cyprus, ensuring coherence with the geological and pedological context of the archaeological case study.

The experimental samples were subjected to a series of physical and mechanical tests, and the results were compared both across sample types and with reference values reported in the literature. Material durability was assessed through exposure to natural weathering agents and through accelerated ageing tests conducted under controlled laboratory conditions. Following ageing procedures, specimens were re-tested to evaluate changes in physical and mechanical performance relative to unaged samples.

The results provide a basis for defining future directions in the sustainable conservation and valorisation of earthen heritage in Cyprus and the wider Eastern Mediterranean.

Results

The integrated archaeological, geoarchaeological and architectural analyses produced a coherent and multi-layered dataset that significantly advances current understanding of earthen construction practices in prehistoric Cyprus. Archaeological and material analyses of the Middle Bronze Age architecture at Erimi-*LtP* documented a high degree of technological consistency in the selection, preparation and use of earthen materials, while also revealing variability linked to functional contexts and construction scales (Amadio *et al.* forthcoming).

Geoarchaeological investigations in the Kouris Valley resulted in a detailed reconstruction of the geomorphological and pedological framework of the area (Rellini *et al*. forthcoming). The combined geomorphological mapping, soil analyses and stratigraphic correlations clarified Holocene landscape evolution and sedimentary dynamics, providing essential contextual data for interpreting settlement location, raw material availability and post-depositional processes. The pedo-landscape reconstruction demonstrated a strong correspondence between locally available soil resources and the compositional characteristics of archaeological earthen building materials, allowing for the definition of a geological and geochemical fingerprint for raw material procurement strategies (Ghislandi *et al.* forthcoming).

Experimental and architectural investigations are currently generating a growing body of data on the performance of stabilised compressed earthen blocks. Preliminary observations emerging from the analytical programme and the reviewed literature indicate measurable improvements in mechanical behaviour and durability, particularly in terms of compressive strength and resistance to weathering, depending on the adopted mix design and stabilisation strategy (Germanà and D'Amore 2025). These trends are being further examined through ongoing laboratory testing to better characterise material responses under standard conditions. Architectural experimentation at Erimi is ongoing and is conceived as an exploratory assessment of the potential applicability of the experimental materials within conservation-oriented archaeological contexts.

Conclusive remarks

Overall, the results highlight the potential analytical value of a multiscalar and interdisciplinary methodological framework for the study of earthen architecture. The integration of material characterisation, geoarchaeological landscape analysis and experimental conservation-oriented research enables a more contextualised interpretation of earthen building materials and construction practices, relating technological choices to environmental settings and architectural performance. While architectural experimentation and material performance assessments are still in progress, the ongoing experimental work is expected to contribute comparative data relevant to discussions of material compatibility and durability in conservation contexts. Taken together, these results support the applicability of integrated approaches for improving both archaeological interpretation and the development of informed, context-sensitive strategies for the conservation of earthen architectural heritage in Cyprus and the wider Eastern Mediterranean.

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Productive and Social Practices in Prehistoric and Protohistoric Earthen Building presents new perspectives on one of the most widespread yet historically undervalued forms of construction. Bringing together contributions from leading researchers, the volume explores the production, use and social significance of earthen architecture across a wide range of prehistoric and protohistoric contexts.

Drawing on evidence from the Mediterranean, Europe, the Near East and South America, the chapters examine construction techniques, architectural traditions, domestic and monumental structures, and adopt approaches including experimental reconstruction and the application of advanced archaeometric and micromorphological techniques. Together, they reveal how earthen buildings provide unique insights into technological innovation, cultural interaction, collective labour and the organisation of past communities.

The volume also considers the continuing relevance of earthen building traditions within contemporary debates on heritage management and sustainable construction, demonstrating the enduring value of these ancient practices in addressing modern challenges.

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