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ΙΝΣΤΙΤΟΥΤΟ ΕΠΙΣΤΗΜΩΝ ΧΗΜΙΚΗΣ ΜΗΧΑΝΙΚΗΣ

Materializing the past: Narratives via Archaeological Science

Venue: Foundation for Research and Technology Hellas (FORTH), Institute of Chemical Engineering Sciences (ICE-HT)

Editors

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Introductory remarks

Welcome to the 9th Symposium of the Hellenic Society for Archaeometry (HSA).

This year's Symposium is co-organized with the KERAMOS Research Group of the Department of Geology, University of Patras, and the Foundation for Research and Technology – Hellas / Institute of Chemical Engineering Sciences (FORTH/ICE-HT). Continuing the successful legacy of the eight previous HSA meetings, this event aspires once again to provide a forum for the exchange of ideas, results, and experiences among researchers from diverse disciplines.

We are honoured to welcome Professor Mark Pollard (Emeritus Professor of Archaeological Science, University of Oxford) as Keynote Speaker, whose distinguished contribution to the advancement of archaeological science continues to inspire new generations of researchers and to shape the field of archaeometry worldwide.

This year, the HSA is also proud to honour excellence and contribution through four awards: the Myrto Georgakopoulou Award, the Kiki Polikreti Award, the Archaeological Science Merit Award, kindly sponsored by HERITAGE (MDPI), and the Travel Award, offered by the Society for Archaeological Sciences (SAS). These awards celebrate innovative research, interdisciplinary collaboration, and the international engagement of the community.

We would like to express our sincere gratitude to the members of the Scientific Committee, our sponsors and to all participants for their active involvement which ensures the continuing growth of archaeometric research in Greece and beyond.

We are confident that the 9th Symposium of the Hellenic Society for Archaeometry will once again provide a fruitful and inspiring meeting of our community, and we wish you a stimulating and enjoyable stay in Patras.

With warm regards,

The Organizing Committee

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Keynote Speaker

Professor Mark Pollard (Emeritus Professor of Archaeological Science, University of Oxford) is one of the top leading scholars in the field of archaeological science. His pioneering research has fundamentally shaped the application of chemical and isotopic analysis to archaeology, transforming our understanding of ancient technologies, provenance studies, and human-environment interactions.

As Edward Hall Professor of Archaeological Science and Director of the Research Laboratory for Archaeology and the History of Art (RLAHA) at the University of Oxford, Professor Pollard has led numerous interdisciplinary projects bridging the natural sciences and the humanities. His extensive body of work spans the analysis of ancient metals, ceramics, glass, pigments, and human remains, while also advancing theoretical and methodological frameworks for interpreting scientific data in archaeological contexts.

Author of over 250 scientific publications and several landmark textbooks- including *Analytical Chemistry in Archaeology* and *Archaeological Chemistry*- he has played a defining role in establishing archaeometry as a global and conceptually mature discipline. Professor Pollard's research continues to inspire innovation, collaboration, and critical reflection on the integration of science within archaeology.

Oral Presentations

Keynote Lecture

After 150 years of scientific studies of provenance, where are we now?

Mark Pollard

School of Archaeology, University of Oxford, Oxford, UK

Provenance has been one of the major scientific applications in archaeology for more than a hundred years. The 'golden age' began in the 1950s, when large programmes were initiated focusing on bronzes, ceramics, glass and lithics. However, these have had varying impact in archaeology, ranging from warm approval to outright rejection. This presentation considers how the complexity of these materials and the combined effects of human behaviour can impact on such studies. The conclusion is that provenance studies of lithic materials and obsidian are highly likely to be reliable, but those on ceramics, glass and metals are increasingly complicated (but not impossible), especially in the light of mixing and recycling. An alternative theoretical model is suggested, which focusses more on using scientific studies to understand the relationship between human selectivity and processing and the range of resources available, rather than on the simple question of 'where does this object come from'. In other words, it becomes a study of the effectiveness of ancient materials quality control.

Foreign Archaeological Schools in Greece

A geoarchaeological investigation of ritual practices in the Temple of Artemis Amarysia in Amarynthos, Euboea

Dimitrios Roussos[1], Panagiotis Karkanas[1,*], Myrsini Gkouma[1], Tamara Saggini[2], Jérôme André[2], Samuel Verdan[2], Thierry Theurillat[2], Angeliki Simosi[3], Sylvian Fachard[2], Olga Kyriazi[3]

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[3] Ephorate of Antiquities of Euboea

Excavations at the sanctuary of Artemis Amarysia in Amarynthos, Euboea, have brought to light a large temple with a rich occupation history. Erected at the center of the sacred space, upon the remains a Mycenaean building, the temple underwent continuous reconstruction and modification, featuring several architectural phases from the Geometric and Archaic periods. It was composed of three distinct rooms, each containing its own hearth, with the entrance room containing an elaborate altar where a grand pyre was maintained and animal sacrifice took place. Moreover, the stratigraphic sequence of the same period is composed of multiple floor surfaces and occupation deposits linked with the use of the altars. The geoarchaeological investigation of the altar and the deposits, using archaeological soil micromorphology and Fourier Transform Infrared Spectroscopy (FTIR) has allowed us, on one hand, to confirm the elaborate use of the main altar and assess in more detail how it was constructed and maintained. More importantly though, it has allowed us to identify a purposeful process of constant floor renewal and resurfacing linked with the use of the altars. The presence of many fine white floors made of lime, intercalated with layers composed of the altar's debris that bare evidence of careful sweeping/cleaning, showed us that ritual is not expressed only through the evident use of the pyres. It is also expressed through the application of other practices that were regularly repeated with a "ritualistic" devotion and care.

The Marc and Ismene Fitch Laboratory, British School at Athens: Advancing Archaeological Science through Ceramic Research and Beyond

Evangelia Kiriatzi, Sergios Menelaou

Fitch Laboratory, British School at Athens

Celebrating its 50th anniversary, the Marc and Ismene Fitch Laboratory of the British School at Athens stands as a leading centre for archaeological science in Greece. Since its foundation in 1974, the Fitch has played a transformative role in integrating scientific approaches into archaeological research, with a particular emphasis on ceramics.

This presentation highlights the Laboratory's contribution to the development of interdisciplinary, landscape-based, and multiscale ceramic studies in the Aegean and Mediterranean. Its pioneering work—combining ceramic petrology and elemental analysis with geological prospection and experimental replication—has deepened our understanding of production, mobility, and the transmission of technological knowledge in past societies.

Moreover, through its bursary programmes, research infrastructure, and long-standing collaboration with local Ephorates of Antiquities, the Fitch has played a key role in establishing and sustaining bioarchaeology and environmental archaeology as essential components of archaeological practice in Greece.

Beyond its research output, the Laboratory has been instrumental in training a new generation of archaeological scientists and in building a global network of collaborators. As it continues to push methodological boundaries, the Fitch remains at the forefront of addressing emerging challenges in archaeological science—from data sharing and integration to disciplinary fragmentation.

Archaeometry at the École française d' Athènes: a research program on Aegean Bronze Age burning utensils

Bastien Rueff

French Archaeological Institute

This paper aims to highlight the involvement of the École française d'Athènes in the field of archaeometry in Greece, through the presentation of a study focused on the function and functioning of Bronze Age Aegean burning utensils. These refer to a category of (mostly) clay vessels used for lighting, heating, and perfuming. Their distribution during the 2nd millennium BC is closely linked to the development of palatial administrations, first in Crete, and later on the Greek mainland. While most of these objects are easily identified and recorded in excavations, only recently have scholars begun to address questions concerning their function, functioning, and use. In this paper, I present results obtained through the application of multiple analytical approaches, including organic residue analysis, ultraviolet light observation, use-wear analysis, and, finally, thermal and photometric recordings. The goal is to offer a methodology that can be applied more broadly across different chronological and cultural contexts. In line with the École française d'Athènes academic tradition, I aim to showcase how scientific measurements can contribute to addressing historical and anthropological issues.

Ceramics and Beyond: Austrian Archaeometric Research in Greece

W. Gauß, V. Anevlavi, Chr. Baier, L. Berger, M. Brandl, B. Eder, E. Erkul, S. Fischer, P. Fragnoli, G. Forstenpointner, A. Galik, A. Hein, A. Heiss, Th. Jakobitsch, F. Kanz, E. Kiriatzi, G. Klebinder-Gauß, G. Ladstätter, W. Prochaska, W. Rabbel, A. Sokolicek, E. Trinkl, I. Trinks

Austrian Archaeological Institute

A review of the research history shows that archaeometric projects with a comprehensive and interdisciplinary scope were already initiated in the mid-1980s and, from the early 2000s onward, became an established and systematically applied component of fieldwork strategies by Austrian teams. Over the past decades, archaeometric research associated with Austrian excavations has focused primarily on ceramic analysis and geophysical prospection. More recently, the analytical repertoire has expanded to include studies on metallurgy and jewellery, reflecting a broader methodological diversification.

This presentation provides an overview of archaeometric research conducted within the framework of Austrian excavation permits in Greece - most notably at Aigeira, Kolonna on Aegina, and Lousoi. Due to time constraints, only selected case studies can be discussed briefly. Additionally, archaeometric work undertaken within collaboration projects, such as at Pheneos and Kleidi Samikon, as well as further research involving Austrian scholars and institutions, will be considered.

Ultimately, the paper aims to highlight the central role of archaeometry in advancing archaeological interpretation and to demonstrate how interdisciplinary approaches enrich our understanding of the past. In recent decades, Austrian archaeometrical research has focused primarily on the analysis of ceramics, mainly-but not exclusively-dating to the Bronze Age. More recently, the scope of investigation has expanded to include studies on metallurgy and jewellery.

This presentation aims to provide an overview of Austrian research activities and to discuss their contribution to the broader archaeological discourse. Among the projects presented, particular attention will be given to research conducted at the site of Kolonna on the island of Aegina, along with other case studies.

Archaeological Science at the German Archaeological Institute in Athens: The example of the Sanctuary at Kalapodi

Artemios Oikonomou, Kelly Christodoulou, Dimitris Grigoropoulos, Themistoklis Bilis, Katja Sporn

German Archaeological Institute, Athens, Greece

The German Archaeological Institute's Athens Department is engaged in the archaeological exploration of Greece and its neighbouring regions. Since its foundation in 1874, the department has developed into an integral part of the large international scholarly community based in Athens. Besides recording and publishing ancient monuments, the Athens Department from its very beginnings was also dedicated to carrying out archaeological fieldwork and the study of the history of architecture and topography.

The origins of the important excavations, which today still remain under the department's supervision, go back to the first decades of its existence. Among them are the excavations within the sanctuary of Olympia (since 1906, formerly the so-called Reichsgrabung 1875-1881), Tiryns (since 1905, previously excavated by Schliemann 1884–1885), the Kerameikos of Athens (since 1913), and the Heraion of Samos (since 1925, previously excavated by the Berliner Museen 1910–1914). In 1973 excavations were launched at the sanctuary of Kalapodi, while more recent developments include large-scale interdisciplinary regional surveys, such as the Greek-German Kephissos Valley Project and the landscape survey focusing on the periphery of the Heraion of Samos.

Archaeological science has long been fundamental to the research of the German Archaeological Institute, stressing out the Institute’s commitment to interdisciplinary approaches in close collaboration with various partners. Various applications ranging from material characterization and geophysical surveys to digital documentation and conservation, form a prerequisite of the Institute’s major excavation projects.

This presentation highlights archaeometric research and funded projects carried out at Kalapodi over recent decades, highlighting the Institute’s continuous contribution to archaeological science in Greece. It also underlines the Institute’s role in conserving and presenting standing monuments, work conducted under the auspices of the Greek Ministry of Culture and in close collaboration with local Ephorates, ensuring both preservation and public access to cultural heritage.

Beyond Timelines and Routes: The Social Significance of Chinese Millet Diffusion in Eurasia

Yufeng Sun

Chinese School of Classical Studies at Athens (CSCSA)

Institute of Archaeology, Chinese Academy of Social Sciences (IA-CASS)

The past two decades witnessed the major advancement in the research on the globalization of prehistoric food, which has vividly mapped out the routes and timelines through which cereal crops, originating in different parts of Eurasia, took root in new environments as they moved with people, materials, and technologies. However, the spread of cereals was never just about the plants themselves—it often involved ecological contexts, technologies, social practices, and ideologies that accompanied their cultivation, processing, and consumption. This study focuses on broomcorn and foxtail millet domesticated in North China and explores their movement through the lenses of foodways, agricultural strategies, and labor organization in order to uncover the broader social significance of their dispersal. Current research has concentrated mainly on the eastern parts of Eurasia, but in the future I hope to develop collaborations in Greece, the Balkans, and Eastern Europe to fully address this question.

Geoarchaeology

Assessing the evolution of the ancient coastal area at Kastrouli, Phokis, Greece

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As part of the *Kastrouli–Antikyra Bay Land and Sea Project* [1], marine remote sensing techniques were employed to investigate the seafloor, aiming to reconstruct the evolution of the ancient coastal area through time. The study area focused on four bays-Valtos, Potami, Sotirios, and Agios Isodoros-located in the Gulf of Corinth, seaward of the Late Mycenaean (Late Helladic IIIB–C) settlement of Kastrouli, situated near the sanctuary of Delphi.

The marine geophysical survey involved the use of an echosounder, a sub-bottom profiler, and side-scan sonar to assess seafloor topography, subsurface stratigraphy, and geomorphological features, respectively. The collected acoustic datasets were integrated with sedimentological analyses from marine and inland sediment cores [2,3] and with optically stimulated luminescence (OSL) dating of a submerged paleo-shoreline [3].

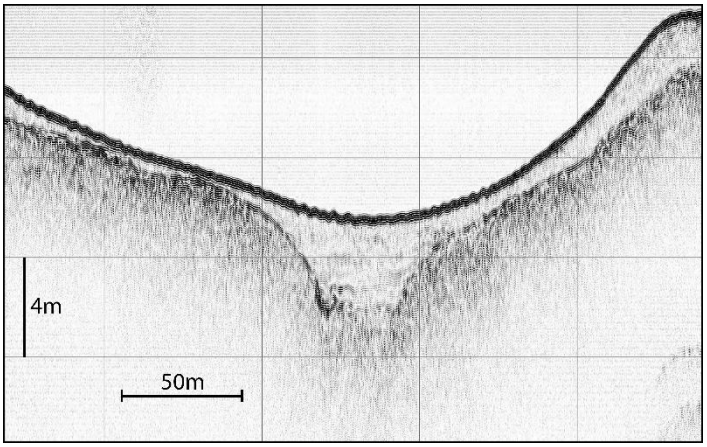

Fig 1. Profile illustrating the configuration of the ancient coastal landscape of Valtos Bay, shaped by fluvial processes.

The results indicate that sea-level rise, in combination with local geomorphological processes influenced by fluvial activity (Fig. 1), played a significant role in shaping the coastal evolution of the study area.

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Multi-Sensor UAV Remote Sensing Workflow for Detecting Buried Archaeological Features at Thermi (Lesvos) and Its Application to Arisvi (Lesvos)

Asvestas Alexandros, Vasilakos Christos

University of Aegean, Department of Geography, Remote Sensing and GIS Research Group

The study develops a multi-sensor Unmanned Aerial System (UAS) workflow to detect buried architectural remains at the prehistoric site of Thermi (Lesvos, Greece) and evaluates its transferability to the Arisvi region. By integrating high-resolution RGB, multispectral, thermal, and LiDAR datasets, we aim to establish a non-invasive prospection methodology capable of revealing subsurface features in unexplored areas, such as Arisvi in Lesvos.

The case study area was segmented into 5m. × 5m. grids and extracted three datasets: (1) multispectral indices (NDVI, SAVI, GRVI, GNDVI, TBVI) distilled via PCA to emphasize key spectral variations; (2) thermal anomalies identified through z- score normalization; and (3) LiDAR-derived terrain metrics (slope, curvature, hillshade, relief). Statistical screening (normality, rank tests, Spearman correlations) pinpointed which variables diverged most between grids with known buried archaeological features and grids without based on archaeological records from 1930 [1].

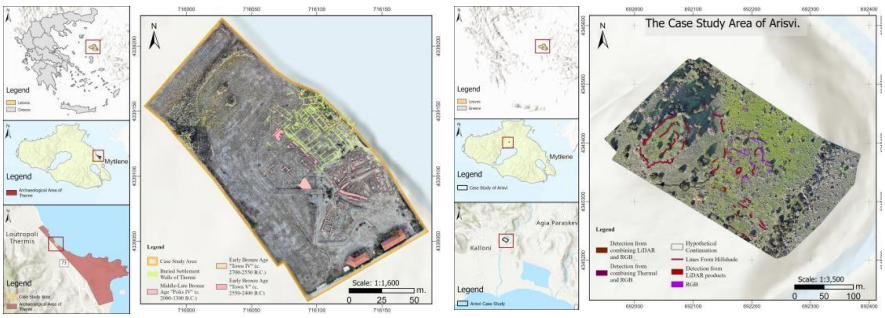

Figure 1. Left: The case Study of Thermi, Lesvos. Right: The Case Study Area of Arisvi, Lesvos.

In logistic models, thermal measures yielded > 95 % accuracy, perfect sensitivity, and 94.5 % specificity, underlining their strong contrast over subsurface features. PCA-combined vegetation indices improved over single indices (≈ 87 % vs. ≈ 82 %), indicating synergistic spectral signals. LiDAR metrics, though weakly correlated ($\rho < 0.35$), effectively mapped subtle depressions, suggesting their utility as auxiliary predictors in a multi-sensor prospection framework.

The combined UAS workflow therefore provides a powerful, non-invasive approach for subsurface prospection at Thermi and can be seamlessly transferred to Arisvi (Palaiokastro), the latter lacking any systematic survey beyond Koldewey's 19th-century plan [2]. By tailoring flight parameters, sensor setups, and 5 × 5 m grid dimensions to Arisvi's terrain and vegetation, this protocol can swiftly produce spectral, thermal, and microtopographic anomaly maps—delivering the first high-resolution archaeological reconnaissance of an otherwise unexplored site.

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Special Session: “By the Vehemence of fire: Exploring ancient technology through colour” / Ceramics-Glass

Maiolica from the "Well of Wonders" (Orvieto, Italy): exploring Medieval ceramic technology and color production

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The excavation of the "Well of Wonders" at Campo della Fiera in Orvieto has yielded a remarkable collection of ceramic materials that provide direct evidence of different phases of the maiolica's production process. Among these finds are numerous biscuit- fired ceramics, over 600 well-crafted maiolica pieces attributable to at least two distinct production periods- one in the 13th-14th centuries and the other in the 15th-16th centuries- defective maiolica that were discarded, production waste and a significant number of maiolica pieces that are entirely blackened.

In line with the session theme, this study focuses on reconstructing the technological cycle of maiolica production, with particular attention to the role of fire in determining color variations and surface transformations. A comparative analysis of materials from different periods will reveal possible technological evolutions and continuities in raw material selection, pigment application and firing methods.

A critical aspect of this study concerns the numerous maiolicas that exhibit a completely black and glossy surface. This phenomenon raises key questions about whether their appearance resulted from specific firing conditions-such as a high-temperature reducing atmosphere- or post-depositional factors related to their burial environment.

Archaeometric analyses, including polarized optical microscopy, scanning electron microscopy, electron microprobe and inductively coupled plasma mass spectrometry have been used to identify the specific materials and methods used in the production process, providing insights into the technological capabilities and artistic practices of the period.

By examining the intricate relationship between fire, color technology and production methods, this study enhances our understanding of the craftsmanship of medieval ceramists from Orvieto and nearby regions and advances knowledge of ceramic technology, production and trade in medieval Europe.

Islamic glazed ceramics from Mértola (Portugal). An archaeometric study of metallic lustre glazed wares

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The largest collection of Islamic metallic lustreware glazed ceramics of the Gharb al- Andalus (Western Iberia, during the Islamic period), has been discovered in Mértola (Portugal). This collection dates from the second half of the 11th century until the early decades of the 13th. The fragments belong to a set of metallic lustreware ceramics produced during the time of the Seville Abbey dynasty (in the second half of the 11th century) and in the Almohad era (12th and 13th centuries). Typologically, these fragments are quite diverse, including pots, small jars, cups and plates. Of this set, approximately half have a golden and reddish decoration with a very distinctive brightness, primarily applied closed shapes. The remaining half exhibits a more yellowish- golden colour, commonly found on open forms but also occurring in closed ones. In all instances, the golden decoration is quite fragile, leading to its deterioration in several pieces, where only small traces are visible.

The samples from Mértola were studied alongside lustreware glazed ceramics from Coimbra (Portugal) and Calatrava, la Vieja (Spain) to enable a comparative analysis of provenance and production technology of metallic lustre ceramics. This approach aims to provide deeper insights into the technological practices responsible for the various lustre colours observed in these ceramic samples using archaeometric methods.

Shades of blue in Mycenaean glass firing: The case of Voudeni

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Glass was a highly valued material in Mycenaean times, embodying both technological achievement and profound symbolic meaning. The deep cobalt blue, achieved through the inclusion of cobalt oxides, closely resembled lapis lazuli, associated with divine favor and elite status in the ancient world. Copper blue glass, with its vibrant turquoise hue, likely evoked the natural elements of the sea and sky, central to Mycenaean cosmology and identity. These materials were not mere decorative elements but carried social and ideological significance, while their crafting required advanced pyrotechnological expertise.

The Mycenaean cemetery of Voudeni, in use for roughly 500 years (1500–1100 BCE), offers a compelling case study for examining the role of cobalt and copper blue glasses in funerary practices. The site includes 78 carved tombs and the ruins of a prehistoric settlement, possibly identified with ancient Mesatis. Most tombs were carved in circular, square, horseshoe, or quadrilateral forms, with domed chambers of varying sizes, often housing multiple burials. The largest tombs, such as numbers 4 and 75, likely belonged to officials or lords, reflecting the community's hierarchy. Grave goods included vases, jewelry, tools, weapons, and utensils, indicating the prosperity and trade connections of the locals.

The discovery of glass beads and inlays highlights their association with both elite and non-elite burials, symbolizing status and likely serving as offerings or protective charms respectively. These artifacts reflect the Mycenaeans' cultural narratives, blending technological innovation with symbolic meaning.

For comparison, samples from the Argolid, particularly Palaia Epidavros, have been included in this study. Their compositional consistency in terms of coloration and specialized character suggest a later-phase production system—perhaps involving fewer workshops or more standardized raw materials. When examined alongside the Voudeni assemblage, these Argolid glasses provide a regional perspective on technological specialization and evolving craft organization in the Late Bronze Age Aegean.

Moreover, two loners, represented by a copper- blue sample from the dataset (from Voudeni and Palaia Epidavros) stand out as a potential chemical intermediary in the evolution of glass colorants. Their hue reflect the delicate balance of copper redox states, kiln atmosphere, and alkali chemistry- conditions rooted in metallurgical practice. Rather isolated occurrences, these glasses could represent the chemical and conceptual bridge between copper-based reds and the fully stabilized blue technologies of glass and faience, reinforcing the idea that Mycenaean glassmaking drew directly from the metallurgical logic of fire and transformation and underlining the cross-craft links among different technologies.

Glass technology at the service of the dead? Blue glass jewellery and ornaments in Mycenaean burials

Kalliopi Nikita

Ephorate of Antiquities of East Attica, Hellenic Ministry of Culture, Greece

This work deals with the occurrence of blue glass jewellery and ornaments in burials of Mycenaean Greece during the principal Mycenaean period, namely 14th-13th centuries BC. This is the time when standardised forms of glass beads, plaques and ornaments principally in shades of dark blue, light blue and turquoise were produced in large numbers at the Mycenaean palatial workshops and were widely distributed throughout the Aegean. Emphasis is placed on glass assemblages found in the broader region of Attica. The blue glass jewellery found in the tholos tomb at Menidi and in the chamber tombs at Spata are representative examples owing to their outstanding quality and great quantity. A comparative study with published blue vitreous ornaments from contemporaneous cemeteries in Attica such as Athens, the Athenian Agora, Brauron, Varkiza-Vari, Voula-Alyki, Kalamaki, Eleusis will facilitate a more comprehensive discussion on the morphology, dating, spatial distribution and provenance of blue glass jewellery in the broader region of Attica. The range of glass colours and bead forms, the diversity of decorative designs on the moulded relief plaques as well as the modes of their stringing and arrangement in association with their burial deposition are presented and assessed. The paper aims to elucidate the role of vitreous jewellery as burial offering intended for the ritual of dressing and ornamentation of the dead in conjunction with the distinctive predilection for the use of cobalt and turquoise blue glass by the Mycenaeans.

Technology, provenance and colours of Byzantine glass bracelets from the 11th–12th century Braničevo and Morava (Serbia)

Roman Balvanovic [1], Žiga Šmit [2,3], Igor Sylachev [4], Milica Marić-Stojanović [5], Dragana Spasić-Đurić [6], Teodora Branković [6], Riccardo Avanzinelli [7]

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Glass bracelets were a popular decorative item across the Byzantine Empire from the 10th to 12th centuries, with multiple production centers identified. The 11th –12th century Byzantine towns of Braničevo and Morava in Serbia are particularly noteworthy due to their extensive collections of these bracelets, suggesting that the region was an important production hub. These bracelets were made from three types of flux: natron, plant ash, and evaporitic mineral soda. While the natron and plant ash glass exhibit characteristics typical of Levantine origins, the mineral soda glass comes from natron sources likely located in Anatolia.

Black bracelets produced of natron glass were colored using high concentrations of iron in an oxidizing furnace environment. In contrast, black bracelets made from plant ash, mixed plant ash, and evaporitic mineral soda contained lower iron levels and were produced in a reduced furnace atmosphere. Cobalt-blue bracelets were colored with a cobalt pigment, which appeared in two distinct variants: one with high zinc content, resembling the cobalt-zinc colorant used in contemporary Islamic plant ash glass, and another with low zinc content, sourced from a different cobalt ore.

The bracelets were categorized based on their shape, color, cross-section, and decorative elements into several types: Monochromatic bracelets – undecorated and available in various cross-sections; Spirally twisted bracelets – available in both monochrome and polychrome designs; Painted bracelets – featuring decorative painted elements; Profiled bracelets with transverse ribbing. Dark blue was the most common color, followed by light blue, light green, and turquoise, while dark green and black were less frequently found. Blue bracelets, being the most common, were likely the cheapest and widely available. However, it is important to consider the popularity of the color blue in Byzantine society at the time. Rarer turquoise and black bracelets were probably more expensive, indicating a wealthier clientele.

As Long as It's Blue: Crafting Arsenical Copper in the Bronze Age Balkans

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Copper metallurgy in the Balkans is famous for its massive copper metal implements circulating this area throughout the 5th millennium BC. The first known copper alloy, arsenical copper, occurred in the Balkan Late Chalcolithic cultures by the end of this period. However, very little evidence is found related to the production of this alloy, and the lack of findings is commonly ascribed to the slagless nature of the early metal extraction process.

Here we present copious evidence on the earliest documented arsenical copper smelting in the Balkans, from two sites in Serbia and Croatia, dated to the mid-4th millennium BC. Exceptionally well-preserved crucibles, slags and a few metal artefacts offer a rare insight into the technology of smelting and working arsenical copper in this part of the world.

After the completion of our mineralogical, compositional, microprobe and provenance analyses, we argue raw materials for smelting arsenical copper come from a very rich and colourful mixed oxidic ore, available locally. The enrichment of crucible slags with specific transition metals such as Mn, Zn and Fe, together with the occurrence of fayalite and delafossite in several slag areas, confirms the smelting of an original ore charge rather than the re-melting of pre-existing metal smelted previously elsewhere. Since arsenical copper was preferred during much of the Late Chalcolithic/Early Bronze Age in the Near East and contemporary cultures in central Europe, this research is of wide- ranging relevance to our understanding of the early stages of copper alloy metallurgy in Eurasia.

Metallurgical technology and the aesthetics for ritual deposition

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This study investigates the relationship between metallurgical technology and aesthetics within the context of ritual deposition, highlighting how ancient metalworkers were motivated not only by functional needs but also by the visual properties of metals. It focuses on the colour of copper alloys, which held ritual and social significance, as seen in the early adoption of gold-like metals and the specific hues of tin bronzes. Previous studies have demonstrated that minor compositional variations in Cu-As-Sn alloys can cause significant colour shifts: high tin content produces golden to silvery hues, whereas arsenic results in reddish to pink and eventually silvery tones.

To investigate these patterns, 247 artefacts from four sanctuaries in Tegea, Arcadia (9th-7th centuries BCE), were analysed using micro-X-ray fluorescence spectrometry (micro-XRF), and their compositions were correlated with published experimental colorimetric data to reconstruct their probable original colours. The analysis revealed that the pins, rings, and sheets of the assemblage fell within distinct compositional ranges.

The pins exhibited a more consistent alloy composition, suggesting stricter material control. The findings indicate a strong correlation between alloy composition, colour, and function, underscoring the role of aesthetics in ancient metallurgical practices. The persistence of specific alloy compositions, especially in pins, suggests a deeply rooted cultural tradition. Ultimately, this study highlights that aesthetic concerns, particularly colour, significantly influence the production and utilisation of copper alloys in ancient metallurgical practices.

Atramentum: crafting carbon-based black pigments in the Hellenistic and Roman worlds

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Among the colourants produced through pyrotechnological processes, one stands out as the direct outcome of fire: carbon-based black. Depending on the production process and starting materials, carbon-based black pigments can be divided into three categories: chars, cokes, and flame carbons, all of which were used as colourants in the Graeco- Roman period. Even though the production of carbon-black pigments mostly depended on commonly available materials and a seemingly simple process, ancient literary sources indicate the existence of an organised production and trade for (at least some of) these pigments. The production of an artificial carbon-based black pigment as described by Vitruvius, for example, is a rather complex pyrotechnological process that required specialised craft-knowledge and permanent workshop installations: a built structure lined with polished marble and interconnected to a furnace via vents. In this way, the soot produced by the carbonisation of the starting materials in the furnace could be directed into the structure, where it was deposited on the marble walls before being carefully collected to be used in painting or writing (De arch. 7.10). At the same time, alternative options for carbon-based black pigments are described, such as chars produced by burning a range of starting materials that would result in black pigments of various qualities. Given the importance of carbon-based black pigments in ancient polychromy, painting, and writing, this paper examines archaeological evidence of carbon-black production and reviews contemporary literary sources describing their manufacture and use in the Hellenistic and Roman periods. In turn, archaeological and literary evidence are compared to archaeometric analyses on paintings and manuscripts. In doing so, this paper's aim is two-fold: a) to contribute to our understanding regarding the organisation of the production, circulation, and use of these materials and b) to identify methodological advances and challenges linked to the characterisation of carbon-based black pigments.

Exploring the impact of firing time on Egyptian blue crystallization

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An innovation in the production of Egyptian blue occurred by at least the Hellenistic period when the pigment was made into small individual balls before firing rather than large blocks or bowl shapes that had been used in the millennia before. A recent study Kovalev et al. stated, “the transition from cakes to pellets may mark a technological innovation or reflect changes in the organization of the EB chaîne operatoire; the reason for this change remains unclear and needs further investigation” (Kovalev (2023)). What might be the reasons for this morphological change?

For all of the experiments on Egyptian blue since the late 19th century, no study has explored the production advantages and disadvantages of shaping Egyptian blue into the large block shapes utilized in the Bronze age compared with the later ball shapes. At first glance, forming Egyptian blue into balls seems less efficient since rolling material into balls takes time, material can be lost, and fewer can fit into a crucible. However, making large blocks of Egyptian blue takes care to prepare, including allowing time for the large blocks to air dry before firing. Furthermore, the crucibles were commonly destroyed while removing the block after firing because they become fused. Since the balls make less contact with the sides of the crucible, they can be more easily freed without damage. The ability to reuse the crucibles would have been an added economical advantage.

This study will review what experimental firings demonstrate about the differences in preparing and firing the larger shapes compared with smaller ones. Archaeological evidence of Egyptian blue, such as a cake from Amarna with scoring marks, as well as large groups of Egyptian blue balls that are found together in agglomerated “lingots” will be assessed for further evidence of the production and firing processes.

Vases from the Gruppo di Vanth: Analysis of the Chemical Composition of Pigments and the Symbolism of their Colours

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A group of red-figure vases from Orvieto, the s-c. Gruppo di Vanth, is dated to ca. 320–300 BC and contains approximately 12 vases. They are stored in museums in Orvieto, Chiusi and Palermo, but most of them are not on display. A brief description of some of them was given by Beazley (1947), some of them have been studied in more depth from an iconographic point of view (eg Dragoni 2006), but the whole group has never been systematically studied and published and that is the main goal of the authors. The contribution will mainly focus on their "materiality", which is the technology of applying pigments after firing, as some of them have red and blue pigments on the handles, a rather unique technique. Furthermore, the paper will include chemical composition (pXRF) of the pigments, fabrics and black gloss analysis to determine whether the vases, attributed to this group, were produced by the same workshop, possibly in Orvieto. Therefore, to determine the group's workshop not only on a stylistic but also on a scientific basis, it will be analyzed other vases produced in Orvieto. In addition, the contribution will present a reconstruction of the original appearance of the unpreserved parts of some vases. Hence, a part of the project is experimental: the ancient technologies will be reproduced aiming to reconstruct amphora No. 2645, which is quite known in terms of iconography, but no one has ever deeply studied its "materiality" and thus its original overall form, or how it was created and painted. The frieze depicts a journey to the underworld and the paper will also deal with the symbolism of the colours of the pigments and the plastic decoration of the handles and their relationship to the scene on the frieze.

Bioarchaeology

Organic Petrology as a tool servicing Archaeology

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Over the past six decades, the techniques of Organic Petrology have been successfully applied to the study of organic artefacts - such as jewels, ritual vessels, and other objects -recovered from archaeological sites. These artefacts were crafted from materials like jet (gagate), sapropelic coal, oil shale, and similar raw materials. In some cases, studies have enabled researchers to determine the provenance of the raw materials used in their manufacture, thereby shedding light on ancient trade routes (e.g., [1-3]).

In Coal Geology, the "Holy Grail" remains the identification of the earliest use of coal as a fuel. Despite numerous inaccurate claims in the literature over time, this question still warrants further investigation.

In this context, our laboratory has examined charred remains unearthed from two ancient sites: one sample set was collected from an Early-Bronze metallurgical workshop near Efes (Turkey), and another from the ruins of Hellenistic Helike (Greece). In the vicinity of both locations, a few lignite deposits are present, raising the question of whether the inhabitants were aware of and exploited lignite as a high-quality fuel. Microscopic examination applying Organic Petrology techniques revealed that, in both cases, the chars derived from plant biomass. Conversely, bibliographic examples illustrate how misleading conclusions can arise when Organic Petrology techniques are not employed.

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A taphonomic approach to human activity, from the Neolithic to the Helladic Period, in Cave of Lakes, Achaea, Greece

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The aim of this study is to better understand the function of the Cave of Lakes during the Neolithic and Helladic periods through a detailed analysis of the faunal remains recovered from the site. Following the initial study centered on taxonomic identification and herd management strategies, the present phase of research focuses on the taphonomic analysis of the faunal remains from Section C, near the cave entrance [1]. This analysis aims to distinguish between natural post-mortem processes and anthropogenic modifications to clarify the nature and context of human activity within the cave.

The faunal assemblage was examined for surface modifications, such as cut marks, burning, and breakage patterns, as well as for broader indicators of preservation and environmental impact [2], [3]. Due to the cave's corrosive environment and previous conservation treatments, many taphonomic features had been partially or entirely obscured, complicating efforts to identify agents of modification. Nevertheless, systematic recording of the most visible and recurring taphonomic traits was undertaken.

The analysis was carried out separately for the Neolithic and Helladic layers, allowing for a targeted investigation of human activity patterns. In the Neolithic layers, attention was given to butchery practices and disposal methods linked to domestic livestock. The Helladic material was assessed for potential ritual or funerary uses, including the presence of burning and bird remains.

This taphonomic analysis contributes to a further understanding of the cave's function across time, shedding light on both everyday subsistence activities and potential symbolic or ritual behaviors.

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2,000 years of urban dietary diversity in Europe though a thorough computational approach

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This study explores the evolution of dietary diversity in ancient European urban and rural societies by examining the interplay between social structure, religion, and biological sex. We analysed stable isotope data ($\delta^{15}N$, $\delta^{13}C$) from 2,872 individuals across 70 urban and rural sites dated between 500 BC and 1600 CE, a period marked by major transformations in the European landscape. Additionally, we present new isotopic and mobility data ($\delta^{15}N$, $\delta^{13}C$, $\delta^{34}S$) from 124 individuals from Thessaloniki, a city with continuous occupation since its founding in 315 BC. Dietary diversity was quantified using the Standard Ellipse Area (SEA), a metric that estimates the core isotopic niche of a population (40% of data points in bivariate isotope space e.g., $\delta^{13}C$ and $\delta^{15}N$). Comparisons were made across settlement type (urban vs. rural), biological sex, and chronological period by applying a sample correction factor to account for differences in group sizes.

Our findings indicate that urban diets became increasingly diverse after 1000 CE, driven largely by changes in female dietary practices. In Thessaloniki, the population exhibited strong reliance on C_3 plants and freshwater fish, and dietary differences between males and females began to emerge following the fall of the Roman Empire. In contrast to broader trends, males in Thessaloniki displayed greater dietary diversity than females, while younger males exhibit increased physiological stress as indicated by an inverse relationship between $\delta^{15}N$ and $\delta^{13}C$ values. These results offer new insights into how urbanization, gender roles, and ecological conditions shaped dietary strategies in the past, highlighting the complex social and environmental dimensions of food access in historical European contexts.

Urban Kinship and Genetic Diversity in Thessaloniki: A Genomic Perspective

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Medieval urbanization played a central role in shaping the economic, political, social, and cultural landscapes of modern Europe. Yet, the intra-urban social dynamics of this period remain elusive- particularly the impact of trade and military exchanges on migration and genetic diversity, and whether population structure was influenced by kinship, religion, neighborhood residence, or ancestry. To investigate these dynamics, we analyzed ancient genomes from individuals buried in Thessaloniki, a major urban and cultural center with nearly 1,800 years of continuous occupation.

Our study focuses primarily on the Late Byzantine period (13th to early 15th centuries), with additional genomes from the Middle Byzantine period (9th to 13th centuries) for comparative context. We used principal component analysis (PCA) and qpAdm for ancestry inference, READ and KIN for detecting genetic relatedness, and measures of genetic diversity (genome-wide θ, mitochondrial and Y-chromosome haplogroup diversity) to assess genetic structure.

The data reveal no close-degree relationships among individuals, even among those interred topographically close. However, we observe genetic structuring along ancestry lines, distinguishing clusters of individuals with predominantly southeastern European versus Anatolian ancestry. Overall, the observed high genetic diversity supports Thessaloniki's role as a multicultural hub.

Semi-automated histological tool for age-at-death estimation of inhumed and cremated human individuals (MICROAGE)

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Age-at-death of individuals is a key information for paleodemographical analysis and forensic investigations. Histological methods have been developed utilizing specific bone microstructures, e.g., secondary osteons and osteon fragments, for assessing the age-at-death with high accuracy. However, the application of these methods is time consuming and, in some cases, inter- observer analysis yields imprecise estimates. To streamline the histological analysis and reduce estimation error we generated MICROAGE, a semi-automated tool that performs a step-by-step histological analysis and provide highly accurate age-at-death estimates.

For assessing the age-at-death the tool performs partly a histomorphometric method based on the Haversian system density HD, and utilizes the corresponding regression equation, that results standard estimation error of ±3years (Bantavanou et al, 2025). Specifically, the number of secondary osteons and osteon fragments coupled with the ROI (region of interest) files of the microstructures were provided manually. Then, MICROAGE calculated the area off occupation in 1mm^2 and the HD value. Finally, the tool run the HD regression equation and provided age-at-death estimates. For the development of the tool data (number of secondary osteons, number of osteon fragments and ROIs) from modern individuals (n=24) of known age and sex collected from anthropological reference collections and forensic cases were utilized. The results of the tool, were thereafter validated for the accuracy of the HD values calculation and age-at-death estimation. Furthermore, the applicability of the tool was evaluated utilizing archaeological and modern material exhibiting taphonomical and diagenetic factors, such as bacterial activity and temperature.

Microage has upgraded the histomorphometric method through the exact calculation of microstructures' area, that consisted a weak point of the manual method. Furthermore, it is not affected by the taphonomical factors, since the identification of the microstructures performed by the expert scientist and therefore, the provided data for the calculations are reliable. By utilizing Microage the duration of histological analysis was reduced, assigning the majority of the process to the tool. Microage is a promising semi-automated tool that offers a standardize histological protocol of high accuracy age-at-death estimates.

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The essence of things! Investigations of oils and fatty substances in Minoan burning utensils through spectroscopic and spectrometric techniques

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Over the past three decades, systematic sampling and analysis of organic residues, preserved on the inner and outer surfaces of ceramic containers and adsorbed in their walls, has greatly advanced our understanding of the use and processing of natural products in antiquity, benefitting from improvements in chromatographic techniques (GC, GC-MS, HPLC, LC-MS). In parallel to the implementation of gas chromatography coupled to mass spectrometry, this study proposes a multi-analytical methodology integrating complementary spectroscopic techniques, Fluorescence and FTIR, hence exploring their potential for the rapid screening and molecular characterization of organic residues on and in pottery vessels, placing special emphasis on oils and resins that were widely used in antiquity

To this end, extensive sampling and analysis of Minoan clay utensils which were used for heating, lighting, burning incense, and possibly producing aromatic oils (such as lamps, braziers, incense burners, and fireboxes) is undertaken. Ceramic vessels from Malia, Zakros, Koumasa, and Sisi have been selected to shed new light on their highly debated function, also providing insights into the availability and use of natural products diachronically in Minoan Crete. Modern reference samples of oils, resins, and aromatic plants native to the Mediterranean are analyzed, as well as of their artificially aged counterparts to build a spectral library that will provide a valuable corpus of data in future studies. Through this threefold approach it is anticipated to explore the potential of spectroscopic techniques in the field of residue studies, enhance the identification of biomarkers and degradation markers and deepen our understanding of the use of specific vessel types and ancient recipes and practices in Minoan Crete.

Absolute dating and Paleoenvironment

Preliminary results on the calculation of the Marine reservoir effect during the Palaeolithic period based on samples from coastal caves in Karavostasi Manis, Peloponnese, Greece

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It is well established that samples from organisms living at the same time in the atmosphere and in the upper ocean (< 100 meters deep) often exhibit different conventional radiocarbon (^{14}C) ages. This discrepancy is known as the marine reservoir age, R(t), or the apparent age. R(t) varies over time (where *t* is the calendar age in years BP) due to differences in ^{14}C-specific activity between the ocean surface and the atmosphere. These differences arise from several factors: (i) ocean circulation, which brings ^{14}C-depleted water from deeper layers to the surface, (ii) fluctuations in atmospheric ^{14}C production, and (iii) the dynamics of CO_2 exchange between the ocean and atmosphere [1-3].

Excavations conducted by the Ephorate of Palaeoanthropology and Speleology in two coastal caves—Melitzia and Kolominitsa—located in the Karavostasi Manis region of the Peloponnese, uncovered materials of both marine and terrestrial origin in undisturbed archaeological layers dating to the Palaeolithic period, suitable for radiocarbon dating. For this purpose, five pairs of charcoal and marine mollusk samples (four from Melitzia and one from Kolominitsa) were selected. After species identification, they were radiocarbon dated at the AMS facility of the Istituto Nazionale di Fisica Nucleare in Florence. The samples date from approximately 40,000 to 10,000 BC. Although some results were unexpected, this study represents a pioneering effort to investigate the marine reservoir effect during the Palaeolithic period in Greece—possibly for the first time globally.

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Assessing site-wide events at multi-phase sites through the lens of ^{14}C dating: A pilot study from Prehistoric Phaistos, Crete

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Differently from the majority of Cretan prehistoric sites- characterized by frequent horizontal spatial drifting- Phaistos was formed through repeated human activity at the same location. This resulted in a deep archeological deposit comprising patches of floors, hearths and/or structures dating back to the Neolithic and Early Bronze Age, below the substantial remains of two superimposed palaces of Minoan type and of several buildings dating to different phases of the Bronze Age, Iron Age and Hellenistic period. Despite being subjected to the typical tell-like formation process, the site has never been specifically defined as a tell for two main reasons: (1) it was an elevated site to begin with; (2) except for some of the earliest phases of occupation, it did not use earthen architecture which is usually associated with a tell-formation. At Phaistos the superimposition of levels and structures was not a result of the necessity of levelling the collapse of earthen superstructures, in contrast to many other tell-site in northern Greece, but it was purposely created through dumps of pottery.

The stratigraphic re-assessment carried out by cross-correlating multiple stratified layers encountered over an area of 2 ha, identified 10 major phases of human activity at the site prior to the construction of the palace, and three major building projects. Recently, samples of charcoal and animal bones have been selected from each stratigraphic sequence to verify whether and to what extent episodes of construction/destruction in different parts of the site cluster into site-wide events.

This paper focuses on phases III and VIII, representing the end of the Neolithic and EBA occupations at the site, which respectively date to the last quarter of the 5th and the last quarter of the 3rd millennium BC. These preliminary results will be discussed in the wider context of the transition from Neolithic to EBA and from EBA to MBA in Aegean, periods which have been difficult to understand because usually associated with destructions and/or abandonments.

Absolute Dating of Cave Sediments Using Geomagnetic Field: New Insights into Paleoenvironmental Change and Human Occupation in the Mediterranean from Grotta Romanelli (Southern Italy)

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The dating of cave sediments is crucial for reconstructing past geomorphological, archaeological, paleoenvironmental, and human dynamics. However, establishing absolute chronologies for such deposits is challenging, as it typically relies on radiocarbon and optical luminescence methods, which are often limited by material availability and resolution. In this study, we present, for the first time, the application of Paleosecular Variation (PSV) of the geomagnetic field to date fine-grained cave sediments from Grotta Romanelli (Southern Italy), a site of exceptional significance due to its stratified deposits rich in both archaeological artifacts and paleontological remains [1].

This approach enables the construction of a continuous and independent age model for the uppermost stratigraphic unit (Unit IUS5), traditionally referred to as the “Terre Brune” [2]. Stepwise alternating field demagnetization yielded well-defined characteristic remanent magnetization directions, which were correlated with PSV reference curves derived from the SHA.DIF.14k geomagnetic field model, calibrated for the cave’s geographic coordinates. The resulting age-depth model spans from approximately 14,000 to 8,000 years BP, offering refined temporal constraints on the final phases of sedimentation and human use of the cave prior to its complete infilling. These new chronological insights enhance the interpretation of the associated fossil, human, and cultural remains and support a reassessment of the relationship between cave occupation and paleoenvironmental changes during the Late Pleistocene-Holocene transition. Moreover, our results highlight the great potential of PSV-based dating for fine-grained cave sediments, opening new prespectives for high-resolution chronological reconstructions in Holocene archaeological contexts.

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The end of the Neolithic period in central and southern Greece through the use of absolute radiocarbon dates: towards a better understanding of the 5th and 4th mill. BCE Aegean

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In this study we bring together absolute radiocarbon dates from Neolithic archaeological contexts in central and southern Greece (Phthiotida, Boeotia, Attica, Peloponnese) that have been collected throughout the years and published in several different venues. According to the regional chronologies, these contexts were dated at the end of the Neolithic period, known as Final Neolithic or Chalcolithic in the Aegean prehistory (ca. mid-5th mill. BCE - end of the 4th mill. BCE). This period covers the latter half of the 5th mill. and most of the 4th mill. BCE. It is described in the whole of SE Europe, including Greece, as a period of tremendous social and political transformations. Scholarship has focused on questions of depopulation, occupation gaps, and environmental changes that might characterize the 4th millennium BCE around SE Europe. Although significant work has taken place in Northern Greece and Thessaly over the past few years with absolute dating results [1, 2], in the southern parts of the country, the archaeological picture remains obscure. In this paper we present a) a synthesis of old and new data sets of absolute dates from archaeological sites of the end of the Neolithic period in the above region, and b) a preliminary analysis of the results, in combination with stratigraphic and material culture information from respective sites, in order to trace occupation patterns in the areas through the absolute dating evidence. This study provides for the first time a more holistic understanding of the evolution of landscape use on the central and southern Greek mainland and adds to previous archaeological research on settlement patterns in the study areas during prehistoric times.

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Beyond the Horizon - Transdisciplinary Approaches to the Early Settlement of the Canary Islands between Seafaring, Sacred Architecture, and trans-Atlantic Plant Dispersal

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This transdisciplinary presentation integrates recent findings from experimental seafaring research with archaeological, architectural and geobotanical investigations of prehistoric sites. While traditional archaeological discourse has long dismissed early settlement theories on the Canary Islands due to a lack of predictive models and datable material culture, recent discoveries call for a thorough reassessment of these assumptions [1]. The presentation draws on selected case studies from both the Mediterranean and Atlantic regions—particularly the Canary Islands—to present new evidence of intercultural contact zones, ritually motivated sacred architecture, and vegetation-based patterns of expansion [2]. Prevailing archaeological interpretations often argue that the Canary Current would have prevented pre-Phoenician settlers from reaching the Canary Islands, using the RA I and II expeditions by Thor Heyerdahl—both bypassing the archipelago—as indirect evidence for this claim. However, results from the ABORA reed-boat expeditions (2002–2019) challenge this assumption by experimentally demonstrating that vessels equipped with lee-board sail systems, inspired by Late Neolithic rock art, can efficiently sail upwind and even cross against currents with the support of prevailing winds [3]. These findings provide a solid experimental basis for re-evaluating the feasibility of early maritime colonization of the Canary Islands. As a consequence, this presentation also introduces a new research initiative with three further speeches aimed at reassessing deviant settlement theories across Macaronesia by placing them on a natural-scientific foundation, supported by predictive measurement strategies.

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Exploring the Archaeoastronomical Significance and Age of Tenerife's Stepped Structures: A Preliminary Multidisciplinary Approach

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The enigmatic stepped structures of the Canary Islands- especially on Tenerife- are among the region's least understood architectural phenomena. Their origin, function, and age remain unresolved, despite their striking presence. This lecture presents the first systematic effort to investigate these questions through a multidisciplinary project (2023-2025), focusing on cultural astronomy and archaeoastronomy, and supported by archaeometry, georeferencing, geology, archaeology, and biology [1-4]. The research consists of four interconnected parts: (A) High-resolution georeferencing-including LIDAR and panoramic imaging- analyses spatial context, architectural orientation, and integration into the topography. (B) Digital cartographic modelling and archaeoastronomical fieldwork explore orientations, sightlines, and potential celestial alignments in the design of the stepped complexes. (C) Combined with geological and archaeological dating, as well as cultural traditions and simulations, the project examines chronology and possible attribution of sites like the Güímar pyramids. (D) Archeometric studies on two structures (see related presentation) provide material data to support hypotheses on construction phases and cultural influences. The central question is whether these structures are of pre-European origin and, if so, which epoch and culture- potentially the indigenous Guanche- they can be linked to. Do they reflect ritual, astronomical, or social functions, or are they agricultural byproducts? Evidence of intentional astronomical alignment and pre-colonial ritual use could suggest broader implications for cultural exchange and transoceanic contact in pre-Columbian times.

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On the chronology and interpretation of occupational phases in Tenerife (Canary Islands, Spain); current status and future endeavours

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A great number of pyramid-like step buildings exist throughout the complex of Canary Islands, the majority of which are located in Tenerife; these are stepped buildings made of dry-stone blocks. While their functions are still unclear, both origin as well as construction chronology have risen controversial interpretations. Two are the dominant theories; the first counterpart suggests that these buildings were merely piles of stones stuck like that during preparation of the fields for agriculture following the arrival of Europeans (post-Spanish age) occupation. The second theory implies that these buildings are integrated into a superordinate cultic-astronomic, local social context of pre-Spanish chronology. However, there are neither studies nor direct absolute dating that support this chronology. On the contrary, first Hispanic conquerors refer to guanche (ancient Canary Iland inhabitants) rituals in the surroundings of such structures [1]. On the other hand, Guanche pottery fragments can be found between the stone blocks of some of the structures. The present study will present all available data so far, from a chronological point of view, based on geological and archaeological direct dating approaches, based mostly on lichenology and stimulated luminescence of these structures, in conjunction to radiocarbon of various organic findings [2, 3]. A previous presentation on archaeo-astronomical modelling provides hints for possible construction ages that can be as old as 2.900 – 2.800 BC. Finally, currently ongoing and future endeavours of a multidisciplinary research project will be presented, with special emphasis to (a) the construction age of two pyramid-like structures in north Tenerife, based on surface luminescence dating of stones and OSL of sediments taken from their foundations, (b) future attempt to perform a similar study to seven pyramids of the well-known Güimar Park located on the island, (c) radiocarbon dating to organic remains such as mummies collected from the area and (d) an attempt to date a rock-art by using surface OSL for dating petroglyphs. The aim of this research project is to assess whether there is a transfer of the Eastern Mediterranean’s cultural habbits towards west, reaching eventually Canary Islands, Cuba and Mexico.

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Chemical Traces of Guanche Mummification: Investigating Alkaloids and Plant-Based Balsamation Techniques

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The ongoing investigation into Guanche mummification techniques aims to uncover the possible use of alkaloids and plant substances by ancient Canary Islands embalmers. The remarkable state of preservation of these mummies—including intact fingernails and toenails and the use of leather wrappings—invites direct comparisons with ancient Egyptian mummification practices. Chemical analyses in Egypt have notably detected traces of nicotine in over 3,000 mummies and documented 108 cases of cocaine residues, as Svetlana Balabanova reports [1-2]. Our research investigates whether similar findings could be expected in the Guanche context, due to the apparent similarities in the mummification process. Previous studies have ruled out the hypothesis that such alkaloid residues could have originated from unknown European plant relics [3]. Since the Canary Islands are over 4,000 km closer to Mesoamerican cultural centres, where alkaloids such as nicotine and cocaine are known to have played a role in ritual embalming, a possible transatlantic cultural or botanical connection cannot be ruled out [4]. The upcoming first attempt to identify mummification products by liquid chromatography analyses will provide important insights into the chemical composition of the Guanche embalming materials and help us assess whether, and if so, which plant compounds contributed to the exceptional preservation of these mummies. This research could open a new chapter in the study of prehistoric intercultural knowledge exchange and early Atlantic navigation, raising the question of whether the Canary Islands were connected to the continental African cultures and maybe served as a cultural bridge between Africa, Europe, and the Americas in prehistoric times.

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Stones, Mortars and Pigments

Molluscan Purple: A Chromatic Journey from Red to Blue Shadows

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Molluscan purple (also known as Tyrian purple) has been used for over four millennia [1]. In the Mediterranean, the purple pigment can be derived from the hypobranchial glands of the following marine gastropods: *Murex trunculus*, *Murex brandaris* and *Thais haemastoma*. The colour originates mainly from seven key compounds (Fig 1) which are typically detected using Liquid Chromatography (LC) and are: indigotin (1), indirubin (2), 6-bromoindigotin (3), 6'-bromoindirubin (4), 6-bromoindirubin (5), 6,6'-dibromoindigotin (6) and 6,6'-dibromoindirubin (7) [2]. Notably, trace amounts of other colouring compounds have also been identified in the purple pigment through advanced hyphenated analytical techniques [3]. While molluscan purple may have served various purposes- including medicinal and artistic applications- its most prominent historical use was for dyeing textiles.

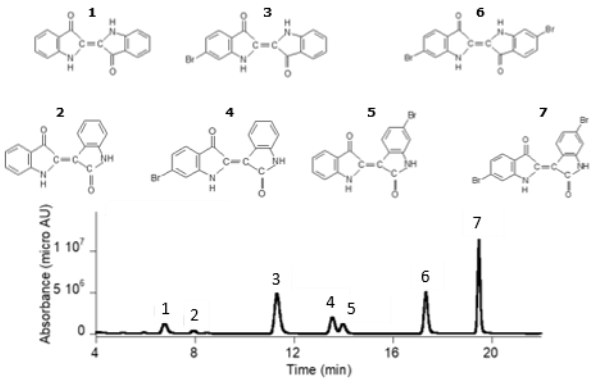

Fig. 1. LC analysis of Murex trunculus.

The precise colour of a textile dyed with molluscan purple can vary due to several factors, including: (i) the species of mollusc used, (ii) the concentration of molluscan extract in the dye bath, (iii) the nature of the textile substrate (e.g., wool, silk), (iv) the specific dyeing conditions applied, (v) degradation processes resulting from ageing, and (vi) any post-dyeing treatments the textile may have undergone.

The impact of these factors on the relative composition of the purple dye, and consequently on the resulting shade observed on dyed textile substrates, will be discussed. Additionally, the symbolic significance of molluscan purple throughout history will be examined. While it is commonly believed that purple textiles were reserved exclusively for royalty and high-ranking priests in certain historical periods, evidence suggests that this was not always the case across all eras.

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Physicochemical methods for the recognition and identification of inorganic and organic pigment compounds and binders from wall painting fragments of the Vlatadon Monastery of Thessaloniki

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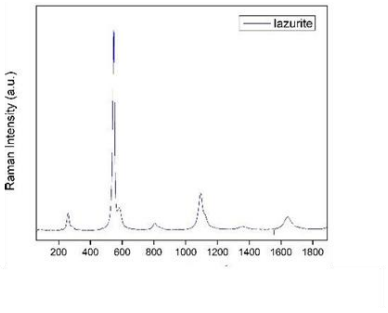
The Vlatadon Monastery of Thessaloniki (1351 – 1371), the only Byzantine monastery in the city that remains in operation, is one of the most significant monuments of the 14th century in Macedonia. Its historical importance to the city and its rich and well-preserved iconographic decoration have contributed to its lasting legacy. The present research focuses on the study of a wall painting fragment, discovered during the excavations that took place in 1982, and currently preserved in the wall paintings collection of the Museum of Byzantine Culture of Thessaloniki. The fragment was discovered on the southern exterior side (courtyard) of the church, a few levels above its foundation, and in close proximity to the masonry. The exact creation date remains unknown. The main objectives of this study were to identify the materials comprising the wall painting fragment, examine its micro- stratigraphy, and ultimately determine the painting technique employed. Additionally, the research aimed, where possible, to trace the origins of the raw materials and establish the indirect dating of the fragment.



Non-destructive and partially destructive analytical methods were applied to each individual layer of the wall painting. The samples were collected using a scalpel from an already detached part of the mural at three different spots. The selected samples were representative of all the layers and material types. Analytical techniques included Scanning Electron Microscopy (SEM-EDS), Fourier Transformed Infrared Microspectroscopy (μ-FTIR), and Raman Microspectroscopy (μ-Raman). Furthermore, prior to these analyses, the samples were examined under visible light using Optical Microscopy. The analyses revealed the presence of pigments such as ultramarine (fig. 1), yellow, and brown ochre, while the significant presence of calcium carbonate indicated that fresco was the primary technique. Finally, based on these results, insights into the chronological layering of the painting suggest that its creation most likely began in the 14th century and extended up to the 20th century.

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Restoration of the stoa at the diagonal road of the academic excavational area at Philippi: Archaeological documentation and column analysis

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The current research is the thesis topic for a Master's Program entitled: " Protection, Conservation and Restoration of Cultural Monuments" organized by the Faculty of Engineering of AUTH. The subject of the present thesis refers to the documentation and restoration study of the stoa placed south of the “Diagonal” road at the archaeological site of Philippi. It refers to an excavational research and a restoration-anastylosis and enhancement proposal for the studied stoa. The road and stoa are located within the research area of the academic excavation of the AUTH, with the stoa being the northern border of the 7th building block towards the “Diagonal” road. Through the excavational study, it is clear that the main interest of this essay is the marble columns found vertically to the stoa, indicating their original position. Furthermore, the extension of the “Diagonal” road through the latest excavations has provided the researchers with additional technical and manufacturing information for the stoa. Simultaneously, samples were taken from the marble columns of the stoa, which were studied at the Laboratory of Building Materials of the Faculty of Engineering AUTH. The analyses performed are stereoscopic study, color check analysis, density measurement, porosity, X-ray diffraction (XRD) and compressive strength determination. The sampling aims at formulating a restoration proposal for the stoa, according to the condition of the original material. The final goal is the formulation of a proposal for the conservation, restoration and enhancement of the stoa, included in the wider plan of highlighting the excavational area of the AUTH.

Analysing Pigments in Art: A Non-Destructive Approach

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The analysis of pigments in artworks is crucial for conservation, as it provides a detailed characterization of materials. This information is vital for dating and identification, and it informs potential conservation or restoration efforts.

This research specifically investigated the optical behaviour of pigment mixtures using imaging techniques. To achieve this, two prototype panels were created (Fig. 1a) according to the specific protocol proposed in the literature [1]. These panels featured various colour layer mixtures, made from either oil paints in tubes or handmade mixtures of powder pigments with an organic medium (linseed oil). The pigment selection was based on Greek and international literature, focusing on pigments used by Greek and foreign painters during the modern period (1835 to 1935). The prototype panels were constructed using industrially prepared canvas as a substrate, aligning with materials used by artists of that era.

The primary aim of this research was to study the optical behaviour of mixtures compared to pure pigments. The goal was to understand how pure pigments affect the optical properties of a mixture (Fig.1b). This addresses a gap in the international literature, which, despite extensively documenting the optical properties of pure pigments, lacks sufficient data on the optical behaviour of mixed colour layers. Ultimately, the project aimed to create a database with identification data for selected pigments and their mixtures. Such a file is essential for identifying mixtures when the constituent pigments are unknown. The methodology employed various non-destructive imaging techniques, such as Hyperspectral Imaging (HIS), Ultraviolet Reflection and Fluorescence Imaging (UVF), Infrared False-Colour Imaging (IRRFC) and Colorimetry. While analytical methods like spectroscopy (e.g., SEM, FTIR) can identify pigment mixtures, they typically require sampling. Therefore, the core purpose of this research was to develop a non-destructive process for identifying pigments within mixtures.

Fig.1a One of the prototype panels containing mixtures of red and blue pigments

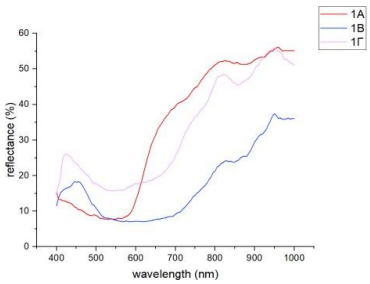

Fig.1b Reflectance spectra of 99,5% Alizarin 0,5% Titanium white + Zinc white (1A), 99,5% Ultramarine blue 0,5% Titanium white + Zinc white (1B) and their 50%-50% mixture (1Γ).

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The analysis of the mortar substrates of Roman floor mosaics in Chalkis. The use of thin section petrography and cathodoluminescence for materials identification and technological characteristics research

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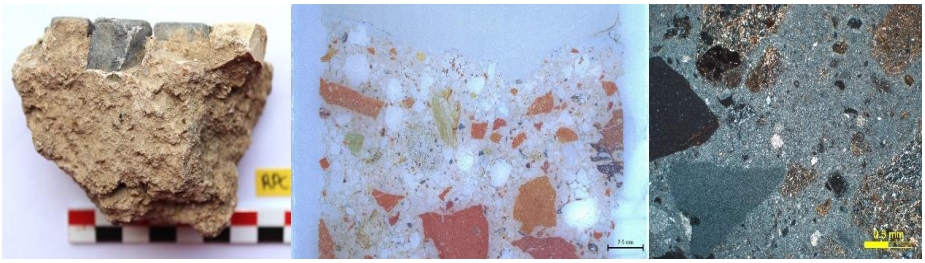

Mosaic supporting layer mortar sample (left). Two images of microscopic techniques investigation.

Despite the limited archaeological remains that have been preserved in situ, the city of Chalkis on the island of Euboea in Greece, presents evidence of a flourishing period during Roman times. Rescue archaeological excavations have brought to light a number of private and public buildings, some of which are decorated with mosaic floors. This study attempts to analyze mortar fragments from the supporting layers of mosaic floors in a Roman villa and the Gymnasium, a public building in the center of the Roman city. All samples were collected from mortar material discarded during the conservation project of mosaic surfaces. For their analysis, a specific methodology combining microscopic and analytical methods as well as techniques that investigate the physical properties of the mortars was applied.

The project main objective is to implement a specific methodology that utilizes at maximum the thin section samples and provides important information on the identification of materials and the characterization of historical mortars.

The specific analytical program applied the techniques of Petrography, cold Cathodoluminescence (CL) Microscopy, and Scanning Electron Microscopy coupled with Energy Dispersive Spectrometry (SEM/EDS) to thin section mortar samples. Furthermore, to compare and supplement the data, the physical properties of the mortars were investigated through the distribution of fine and coarse aggregates according to European Standard EN 933-1:2012. Additionally, the mineralogical composition of the binder and some of the aggregates after separation was determined using the X-ray Powder Diffraction (XRPD) method.

The study was conducted using a small amount of discarded mortar fragments and a consistent sample preparation technique. This was a small "sacrifice" in comparison to the results obtained, which allowed us to study the construction technology of mosaic floor mortars. This information synthesizes many conclusions about the methods Roman craftsmen used and the development of mosaic production.

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The Marble Inventory of the City of Roman Pautalia (BG) through the Lens of Archaeometric Results

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For the first time, a comprehensive archaeometric investigation was conducted into the white marble inventory of Roman Pautalia (modern Kyustendil, Bulgaria), marble used in the public buildings and sanctuaries of Pautalia and its surrounding urban area, a key urban centre in the province of Thrace. While many of the artefacts examined were discovered over a century ago and have been the subject of extensive stylistic, iconographic, and epigraphic analyses, the crucial question of the origin of the stone itself has remained unanswered. Given Pautalia's reputation, extending far beyond the borders of the province of Thrace- particularly for its celebrated thermal springs, bath complexes, and renowned Asklepieion- the results of this research provide important new evidence of the city's economic and commercial connections with distant regions of the Roman Empire. Through the analysis of 54 marble artefacts- including sculptures, votive reliefs, and architectural fragments- this study seeks to reconstruct the dynamics of marble supply, use, and trade in the western region of Roman Thrace. Combining petrographic analysis, stable isotope ratios ($\delta^{18}O$ and $\delta^{13}C$), and multi-element chemical profiling via ICP-MS, the project identifies the provenance of marble materials by comparing archaeological samples with a robust database of over 5,700 geological reference specimens from known quarries across the Roman Empire. The methodology employed demonstrates the necessity of a multi-analytical approach, particularly given the compositional overlaps in isotopic data among major quarry sources. Preliminary results reveal a complex picture of local and imported marble use. While regional sources- such as those near the Armira and Kamilski dol quarries- are well represented, significant quantities of imported marbles from Thasos, Prokonnesos, and Pentelikon indicate the city's integration into long-distance trade networks. The selection of material reflects a combination of availability, quality, and intended function, suggesting both elite patronage and a well-developed logistical infrastructure, as highlighted by Pautalia's role as a nodal point in the broader Roman marble economy.

Fig 1. An example of the sampled votive plates from the territory of Roman Pautalia.

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Thermal Cycling Effects on Structural Integrity and Porosity of Greek Marbles: Insights from Multiscale Experimental Analysis

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This study investigates the impact of accelerated thermal cycling under mild temperature conditions (<100°C) on the structural, mechanical, and microstructural properties of Greek marbles, with a focus on Naxos and Kavala types. Through a combination of experimental techniques- including uniaxial compressive strength (UCS) testing, ultrasonic pulse velocity (UPV), digital microscopy, scanning electron microscopy (SEM), X-ray micro-computed tomography (μ-CT), and portable XRF- both surface and internal deterioration were systematically assessed. Results show that thermal cycling induces anisotropic expansion and alters mechanical behavior, with UCS significantly reduced in both marble types- particularly under wet conditions. Rectangular specimens (h/d = 2:1) exhibited greater post-failure integrity but were more prone to tensile splitting, while cubic specimens showed brittle failure with higher resistance to deformation. UPV results revealed an initial compaction effect followed by exponential integrity loss under repeated wet cycles, especially in Naxos marble. SEM analysis identified “river” patterns consistent with trans-granular fractures, and μ-CT scans processed with MIPAR software indicated peripheral increases in porosity post-treatment. Notably, inclusions in Naxos marble, identified via XRF, were rich in iron, zinc, copper, and arsenic. The findings underline the differential vulnerability of marble types to climatic stressors and highlight the compounded effect of moisture on structural degradation. These insights are critical for conservation strategies in Mediterranean climates facing increased hydroclimate volatility. The study advocates for moisture control and material-specific interventions to protect marble heritage structures in thermally dynamic environments.

Μελέτη χρωστικών της εικόνας του Αγίου Ιωάννου (1674) στη Σκόπελο

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Η παρούσα μελέτη επικεντρώνεται στην ανάλυση των χρωστικών της εικόνας του Αγίου Ιωάννη με σκηνές από τον βίο του (1674). Η εικόνα αποτελεί έργα του Κρητικού αγιογράφου Αντωνίου Αγοραστού και φιλοξενείται στον Ιερό Ναό Αγίου Ιωάννου στη Σκόπελο.

Η ανάλυση των χρωστικών πραγματοποιήθηκε με μη καταστροφικές τεχνικές φασματοσκοπίας Raman και XRF. Με τη χρήση του συστήματος Thunder Optics - Gem Raman System και του φασματόμετρου Niton XLp 818, ταυτοποιήθηκαν ανόργανες χρωστικές όπως: το λευκό μολύβδου, ο αζουρίτης, το verdigris, η ώχρα του σιδήρου, η κιννάβαρη και το realgar. Η ανάλυση υποστηρίχθηκε από το λογισμικό Spectragryph.

Οι συνδυαστικές τεχνικές Raman και XRF προσέφεραν πολύτιμες πληροφορίες για τη σύνθεση των χρωστικών. Η μελέτη πραγματοποιήθηκε με την υποστήριξη της Εφορείας Αρχαιοτήτων Μαγνησίας και της Ιεράς Μητρόπολης Χαλκίδος, ακολουθώντας τις κανονιστικές διατάξεις του Υπουργείου Πολιτισμού.

Digital methods in Cultural Heritage

Η αρχαία Εγνατία οδός από τη δυτική Μακεδονία μέχρι την Αμφίπολη

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Η αρχαία Εγνατία οδός αποτέλεσε για αιώνες τον κύριο οδικό άξονα που συνέδεε τη Δύση με την Ανατολή, παραμένοντας ένας από τους σημαντικότερους στρατιωτικούς και εμπορικούς δρόμους της αρχαιότητας, ενώ συνδέθηκε στενότατα με την εξέλιξη της ρωμαϊκής αυτοκρατορίας. Για την προστασία και την ανάδειξη του μνημείου αυτού, απαραίτητη προϋπόθεση είναι ο εντοπισμός και η οριοθέτηση της. Το αποσπασματικό καθεστώς διατήρησης των λιγοστών τμημάτων της, τόσο εντός της ελληνικής επικράτειας, όσο και εκτός αυτής, καθιστά πιο δύσκολη την προστασία αλλά και την ανάδειξή της. Στην παρούσα εργασία επιχειρήθηκε ουσιαστικά μια συνολική αποτίμηση των δεδομένων για την Αρχαία Εγνατία οδό στο τμήμα της από τη Δυτική Μακεδονία μέχρι και την Αμφίπολη. Αυτό πραγματοποιήθηκε με τη χαρτογράφηση των σχετικών με την αρχαία Εγνατία αρχαιολογικών θέσεων χρησιμοποιώντας σύγχρονες ψηφιακές μεθόδους και συγκεκριμένα το λογισμικό ArcGISPro. Σε πρώτο επίπεδο πραγματοποιήθηκε η ιστορική έρευνα που περιλάμβανε την αποδελτίωση των αρχαιολογικών τόμων και γενικότερα τη συλλογή δεδομένων από το δημοσιευμένο υλικό των αρχαιολογικών θέσεων που βρίσκονται στην ευρύτερη περιοχή διέλευσης της οδού και σχετίζονται με την αρχαία Εγνατία οδό. Σε επόμενο στάδιο, όλη αυτή η πληροφορία, μεταφέρθηκε στη βάση δεδομένων του λογισμικού ArcGISPro, με στόχο την τεκμηρίωση και οριοθέτηση μιας ευρύτερης ζώνης εντός της οποίας μπορεί να εντοπιστεί η πορεία της αρχαίας Εγνατίας οδού με χωρική ακρίβεια. Από τα δεδομένα προέκυψε η δημιουργία ενός εκτενούς ψηφιακού αρχείου, μιας βάσης δεδομένων για την αρχαία Εγνατία οδό. Συνολικά εισήχθησαν στο πρόγραμμα πάνω από 145 αρχαιολογικές θέσεις, με την απαραίτητη περιγραφική πληροφορία, ενώ όπου υπήρχε η δυνατότητα, συνοδεύονται και από το αντίστοιχο φωτογραφικό υλικό, παρέχοντας την δυνατότητα όχι μόνο της αποθήκευσης της πληροφορίας και της εξαγωγής θεματικών χαρτών, αλλά και τη δημιουργία web χάρτη. Η οπτικοποίηση και ψηφιοποίηση της πληροφορίας καθιστά διαχειρίσιμη την οργάνωση του υλικού και κατανοητή, προκειμένου να πραγματοποιηθούν οι απαραίτητες ενέργειες για τη συνολική ανάδειξη του μνημείου.

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Integration of Structure from Motion Photogrammetry and Terrestrial Laser Scanning for Cultural Heritage Documentation: An Archaeometry Oriented Approach

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The integration of digital technologies, such as Structure from Motion (SfM) photogrammetry, Terrestrial Laser Scanning (TLS), and geospatial data analysis, has significantly enhanced the field of Archaeometry. The digital representation of archaeological sites, artifacts, even entire structures like buildings, provides several key benefits that improve research, preservation, and analysis. Both digital methods (i.e. SfM photogrammetry and TLS) offer unparalleled accuracy in capturing fine details of archaeological objects and sites. Moreover, both technologies have the ability to record 3D point clouds with centimeter and millimeter precision respectively. This precision allows archaeologists to document complex surface textures, micro-level features, and geometric properties that would be otherwise difficult or impossible to capture using traditional techniques. Once digital representations are created, they serve as a permanent record of the heritage object or site in its current state. These digital models can be stored, archived, and accessed for future analysis, ensuring the preservation of both the visual appearance and the associated geometric properties. Digital models can be enhanced with any kind of metadata such as date of construction, construction material composition, etc. This integration stimulates a more holistic understanding of the cultural and historical significance of objects or sites. In addition, digital models facilitate global access to cultural heritage, while GIS enables the overlay of digital heritage models onto maps and geospatial data, allowing researchers to analyze spatial relationships, environmental conditions, and site-specific factors (e.g., topography, weathering). In this framework, we present a complete workflow for 3D point cloud generation followed by 3D building information modeling (BIM), to create a digital counterpart of a historical building of Western Greece, the 'Old Hatzikosta Hospital' in Messolonghi, Greece. More specifically, a detailed point cloud was generated, based on data collected with a Terrestrial Laser Scanner. On the contrary, the rooftop was mapped through Unmanned Aerial Vehicle (UAV) imagery and SfM. The created point clouds were fused to derive a detailed 3D model of the monument, which was further enhanced with the appropriate metadata.

Figure. 3D point cloud of the 'Old Hatzikosta Hospital' in Messolonghi.

Materializing the Inaccessible: Structured-Light 3D Scanning, Digital Repositories, and 3D Printing for Inclusive Heritage Engagement

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Many museums prioritize visual display and preservation, making objects inaccessible to visitors who are blind or have low vision. Architectural remains placed in elevated positions in museums are clear examples. Reduced-scale 3D prints offer a tactile alternative, as showcased by successful models used in other institutions [1]. Furthermore, new technologies allow for non- destructive, hands-on engagement with heritage objects. They "provide new ways to experience our material past" and open multi-sensory exploration that can inspire new research questions [2]. Finally, digital models help overcome geographic barriers, making cultural artifacts available to scholars, communities, and the public worldwide. They allow repeated, detailed study without endangering fragile objects [3].

Corinthian capital. Archaeological Museum of Messenia.

Using structured-light 3D scanning (Artec Eva), the intricate complex acanthus leaves motifs and geometry of a Corinthian capital exhibited at the Archaeological Museum of Messenia were captured at 0.2 mm resolution and up to 0.1 mm accuracy, creating an archival-quality model for scholarly study. The scans were then processed through Artec Studio 18 with the final model being processed through Agisoft Metashape, producing an output to be used for 3D printing with the FlashForge Creator 3 3D printer. The scanned data serves several purposes: researchers can analyze tool marks and any erosion patterns remotely, while it also enables 3D printing of physical replicas for blind and low-vision visitors. The digital model will be deposited in the online digital repository for 3D imaging, SketchFab, allowing global access for those unable to visit physically due to mobility challenges, financial constraints, or mental health barriers.

This project suggests a framework for creating accessible, research-quality 3D models and 3D prints. Key challenges included adapting the Corinthian capital's intricate acanthus details for touch—balancing scan precision with simplified features for clear tactile reading. By combining scholarly accuracy with accessibility, the project contributes to expanding inclusive approaches in digital heritage.

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The Defensive Network of Samos During the Early and Middle Byzantine Period. Fortifications' Visibility and Connection

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The island of Samos, located at the eastern edge of the Aegean Sea, was a strategic maritime theme during the Early and Middle Byzantine period. In recent years, the byzantine landscape of the island has been examined and received systematic archaeological investigation. Of the defensive, religious and settlement landscape of Samos, the defensive presents more interest, since fortifications as a group are not often presented.

Scattered publications of the 20th century presented seven fortification sites (castles or fortified settlements). Recent research examined those sites and based on their characteristics was able to locate seven more, presenting in total 14 sites. The common characteristics were also the reason to start examining the fortifications as a network. GIS mapping showed that all of them have visual contact with each other and also oversee nearly every part of the island. Research then took a step further and examined visual contacts with other fortifications of the neighboring islands.

From the aforementioned examination new data emerged. It appears that Samos has not become one of the three maritime themes of the Byzantine empire by chance. The position of the island on the map is of strategic importance. The fortification network that we examined proves this point. The island has an inner and outer defensive network. The first, consisting of fortifications around the island oversee agricultural production and the latter, allows the military stationed on Samos to communicate with Icaria and Fournoi on the one side and the Asia Minor coast on the other. Such a network is being presented for the first time contributing significantly to our understanding of the Aegean visibility eligibility and defensive organisation mainly against the Arab attacks from the 7th century onwards.

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Emerging technologies in Orthodox monumental art: The case of St. Andrew's frescoes of Patras, Greece

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The deployment of emerging technologies in Cultural Heritage (CH) documentation is increasingly applied to Orthodox monumental art, where preservation and detailed study are of particular importance. This study presents the digital documentation of two key elements of Yannis Karousos's monumental artwork in St. Andrew cathedral in Patras, Greece: the central dome with its spherical triangles and the eastern niche housing the fresco "Our Lady of the Heavens" and the "starry skies". High-resolution photogrammetry was employed to capture the intricate iconographic and stylistic details of these surfaces, producing accurate three-dimensional models that can serve as a foundation for conservation, scholarly research, and new interpretations of Byzantine art through immersive and augmented environments [1].

The artistic program of St. Andrew is one of the most significant examples of modern post-Byzantine monumental painting, covering over 2,600 m² of surface. Karousos's work is particularly noteworthy for its reinterpretation of Orthodox monumental painting. The fresco of Our Lady embracing the modern city of Patras rather than a medieval Byzantine setting is considered as the most radical fresco of the 20th century. The starry skies of the south aisle domes (also documented), which visually connect the Roman mosaics of Galla Placidia's mausoleum in Ravenna with the expressionistic skies of Vincent van Gogh, demonstrates the painter's proficiency in the fusion of cultural heritage and modern artistic traits. [2].

This project was realized in collaboration with the Karoussos Archives and funded by the Greek Ministry of Culture under "The Arc-Hive Project" [3]. Beyond its technological achievement, this documentation constitutes an essential step toward the long-term preservation of one of Greece's most important post Byzantine monumental artworks, while also enhancing accessibility for researchers by introducing a unique creative process of safeguarding cultural heritage.

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Μελέτη χρωστικών νεοκλασικών κτηρίων στην Καλαμάτα

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Η παρούσα μελέτη επικεντρώνεται στην ανάλυση των χρωστικών νεοκλασικών κτηρίων στην Καλαμάτα. Ανεγέρθηκαν στα τέλη του 19ου αιώνα και στις αρχές του 20ου αιώνα στο εμπορικό κέντρο, όπως η οικία Αναστασίου Ψώνη, του Εφεσίου και στην παραλία της πόλης, όπως η θερινή οικία του Εφεσίου και των αδελφών Κοτταροπούλου κ.ά. Πρόκειται για λίθινες ή πλίνθινες κατοικίες με ξύλινη στέγη με κεραμίδια. Διαθέτουν λιτά και συμμετρικά χαρακτηριστικά, όπως φυτικά μοτίβα, ακροκέραμα, ξύλινα πλαίσια, προεξέχοντα γείσα, ψηλούς εξώστες με μαρμάρινα γλυπτά ή σιδερένια φουρούσια και περίτεχνα κιγκλιδώματα, αλλά και ανοίγματα με τόξα. Σπανιότερα συνδυάζουν τη κατοικία (όροφος) με το κατάστημα ή άλλο χώρο παροχής υπηρεσιών, όπως βιοτεχνικό εργαστήριο, αποθήκη, ιατρείο (ισόγειο).

Η ανάλυση των χρωστικών πραγματοποιήθηκε με μη καταστροφικές τεχνικές φασματοσκοπίας Raman και XRF. Με τη χρήση του συστήματος Thunder Optics- Gem Raman System και του φασματόμετρου μοντέλο X-200 της SCIAPS., ταυτοποιήθηκαν ανόργανες χρωστικές. Η ανάλυση υποστηρίχθηκε από το λογισμικό Spectragryph.

Οι συνδυαστικές τεχνικές Raman και XRF οδηγούν σε σημαντικότατα συμπεράσματα όχι μόνο για τα νεοκλασικά της Καλαμάτας, που αποτελούν στοιχεία υλικού πολιτισμού και χαρακτηρίζονται μνημεία πολιτιστικής κληρονομιάς, αλλά και για την οικονομική και κοινωνική ζωή της πόλης στις αρχές του 20ου αιώνα.

Role of digital payments and making Indian Cultural Heritage accessible to all

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With largest population of more than 1.4 billion and 4th largest economy in terms of GDP, India has been emerging at the forefront in new World order. With around 3700 monuments and archaeological sites of national importance under its control, the Archaeological Survey of India (ASI), India's oldest and most premier organisation for safeguarding built Heritage and archaeological researches has been maintaining India's some of most iconic monuments and archaeological sites, which include 26 UNESCO World Heritage Properties also. Among 3700 monuments under the jurisdiction of ASI, only 143 are ticketed with a nominal entry fee (appx. 4-7 US$ for foreign visitors and 0.2- 0.5 US$ for domestic and nine other SAARC and BIMSTEC members).

For last 10 years, Indian economy has seen a paradigm shift in incorporating use of Unified Payments Interface (UPI), which is indigenously developed revolutionary payment method utilising Internet - enabled - smart phones by connecting it through mobile banking system and making payment experience cashless, effortless and instant.

During COVID-19, UPI served as the major mode of payment when cash transaction was not possible and social distancing was being followed. Since then, UPI system has spread to the remotest corners of India and even extended to several other nations. In 2024 alone, around 172 billions digital transactions using UPI interface were done which was around 46% more than the previous year.

ASI has been working with several govt. agencies for incorporating digital payment system of ASI for all the 143 ticketed monuments through QR code Scan and online booking platforms. This step is making monuments easily accessible and also removing several socio- economic barriers by reducing the waiting period considerably, especially at some of the most iconic monuments like the Taj Mahal where 2500-5000 visitor enter the monument every hour in a normal day.

In today's fast-moving world, digital innovation and e-ticketing helps both Indians and global explorer to connect with our past in smoother and more meaningful manner. E- ticketing platforms and digital payments have made heritage sites not just easier to access, but more welcoming—especially for young explorers, senior citizens, solo travellers and international tourists who now experience India with fewer hurdles and greater confidence. Touch-free transactions, born out of necessity during the pandemic, have now become the new standard of safety and comfort.

Present paper focuses on the multiple advantages and improvement plans of Digital Payments and the enhancement of accessibility of built heritage sites under ASI. These digital payments helps to make the meta-data about the visitors of a particular monuments through which naturally future-ready data base can be prepared. Real-time visitor analytics also help Site Managers to protect fragile sites, through this data tourism boards can make better promotion plans and policymakers channel funds where they're truly needed. This data may also come handy to evacuate a crowded monument at the time of emergency.

Conservation Science

The Corrosion Scenario of the Bronze Antikythera Mechanism from the Time of Its Sinking (~87 BC) Until Its Recovery in 1900 AD and Beyond: Impacts and Consequences

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Due to specific and critical construction characteristics of the Antikythera Mechanism, its corrosion presents several unique and distinctive features. We studied the current condition of the Mechanism's Fragments. Random breakages with material loss, when compared to corresponding radiographs/tomographies, provided valuable insights into the present state of the fragments as well as their internal condition. A series of experimental simulations with sea water was conducted to replicate the corrosion conditions of the bronze Mechanism. This presentation highlights the effects of the Mechanism's ~2000-year residence on the seabed of Antikythera, the impact of corrosion on dimensional the reconstruction of its components.

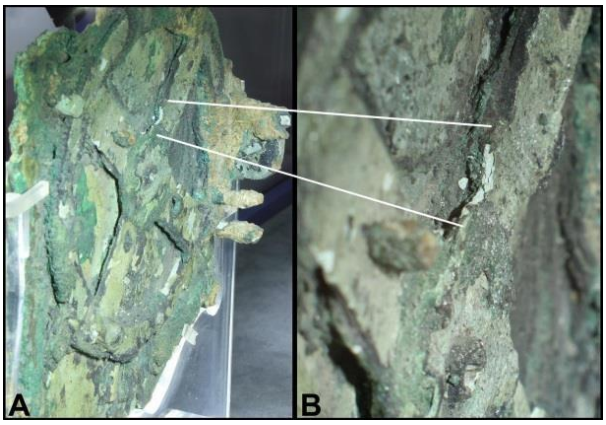

Fig. 1. A) Inclined side of view of the Fragment A1. B) On the 1 o'clock arm of b1 gear, a random part is missing, revealing the internal cross section of the arm. The deep inside corrosion product of Atacamite (instead of bronze) is today the current material of the Fragments (Voulgaris et al., 2018c and 2019b).

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Green and Sustainable Innovations in Cultural Heritage Conservation: The GREENART Project and the Role of Non-Destructive Testing

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The field of cultural heritage conservation is at a critical juncture, facing accelerating threats from climate change and environmental degradation. This paper explores the urgent shift towards green and sustainable practices in conservation-restoration, a movement now integral to preserving our shared heritage. As the use of plant proteins and biodegradable polymers to replace conventional ones is gaining more and more ground, the core concepts of “green” and “sustainable” are discussed. An emphasis is given to the outcomes from the GREENART EU Project, a three-year Horizon-EU initiative that brings together a multidisciplinary global partnership.

VIS and UVL, detail,of the areas after using ECO hybrid hydrogel loaded with a mixture of acetone and ethanol.

GREENART’s primary objective is to develop and validate innovative, low-impact materials sourced from renewable or recycled waste, creating a “safe-by-design” approach for a range of conservation needs. These include protective coatings, cleaning systems (gels and fluids), consolidants, packaging, and monitoring solutions. LCA and LCC analysis are also included. Furthermore, the paper presents a comprehensive evaluation methodology, which includes using both representative mock-ups and real-world artifacts to test and validate the effectiveness of these new products, ensuring they are not only environmentally friendly but also perform reliably. A cornerstone of this green approach is the adoption of Non-Destructive Testing (NDT). The paper discuss why NDT is a key enabling technology for sustainable conservation. These methods, especially imaging techniques, complemented when necessary by chemical analysis, allow for in-situ, real-time assessment of artworks without the need for sampling or moving the object, thereby minimizing environmental impact and resource consumption. Through representative case studies focusing on painting, metals and archival material conservation it is shown the variety of cases faced as well as the effectiveness, functionality and usability of new green materials.

Exploring Iconography and Materials: A Post-Byzantine Icon of Saint Anna with the Virgin and Child

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The current paper presents the results of an interdisciplinary study of a post-Byzantine icon depicting the enthroned Saint Anne holding the Virgin Mary and Christ Child, flanked by Saints John Chrysostom and Anthony, with the Annunciation scene shown in the upper register (Figure 1-left). This complex and theologically rich iconography, underscoring the Virgin Mary's central role in the history of Salvation, recalls Holy Trinity iconography and is rare in icon painting. The study integrates art historical interpretation with technical analysis aiming primarily at the assessment of the context and quality of the painting along with its materiality. Through meticulous macroscopic and stereoscopic probing, and by using X-ray Fluorescence (XRF) spectroscopy and imaging techniques (Hyperspectral imaging (HSI), Infrared reflectance false color imaging (IRRFC), Ultraviolet induced visible fluorescence (UVL)), the materials and techniques employed in the original painting were identified, while evidence of later restoration interventions were documented as well. Wood identification analysis was also performed, thus offering valuable insights into the technological features of the wooden panel of the painting.

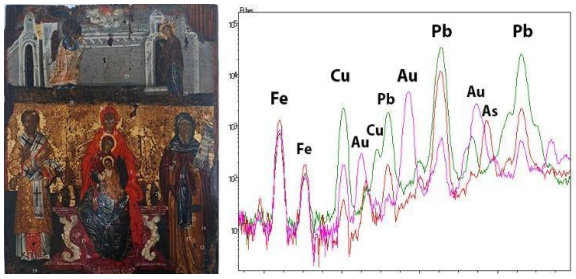

Fig. 1. Left: The icon under investigation; numbers mark the spots of XRF analysis. Right: XRF spectra from the gilded campus (purple), the green ground (red) and the green pillow (green).

The iconographic interpretation along with the analytical data indicate that the painting was executed by a skillful painter who worked within the broader framework of the post-Byzantine Cretan School of iconography. Interestingly, the panel was made using imported wood (Larix), while its technical characteristics indicate employment of the typical Cretan panel-making techniques. Subtle technical details of the painting such as the selective use of semi-transparent surface paint layers ("glazes") and the skillfully executed fine brushstrokes suggest a talented and experienced painter. Additionally, the identified pigmenting materials are more or less in line with findings from earlier relevant studies (1), yet the rather extensive number of employed pigments suggests an attempt to achieve a rich chromatic result. Moreover, the detection of arsenic in various green-colored areas hints at orpiment, which is indeed a particularly interesting pigment in terms of its dissemination among Greek post-Byzantine painters (2). These findings contribute to a deeper understanding of the icon's original context and add valuable information regarding post- Byzantine painters' workshop practices.

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The emblematic initiative 'Evlogon' and the significance of archaeometry in tracing the history of emblematic monuments of Christianity

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The emblematic action "Το Εύλογον" (Project n. 5225310) «Model Interdisciplinary Development and Transfer of Know-how and Cooperation in the Restoration of Emblematic Monuments and Highlighting of Values of Christianity in Dialogue with Society», is initiated by the Ministry of Development, funded by the National Program of Development through the General Secretariat for Research and Innovation. Addressing World Challenges for the Rehabilitation of Emblematic Monuments focuses on the model interdisciplinary development and transfer of expertise is preserving and promoting of Christian values in dialogue with society. The initiative "Το Εύλογον" leverages existing data from research, studies, and completed restoration projects of major Christian monuments, in which the National Technical University of Athens (NTUA) has contributed (Hagia Sofia) or was the chief scientific coordinator (The Holy Aedicule of the Holy Sepulchre in Jerusalem, the Monastery of Panagia Varnakova in mountainous Nafpaktia, one of the most important Byzantine monuments, center of the Greek War of Independence) . The goal is to create an holistic relationship between society and cultural heritage, while disseminating research findings through an interdisciplinary approach, methodology, and cooperation as well as societal awareness and engagement in preserving the cultural and spiritual heritage of Christianity.

In those cases, archaeometry was crucial in order to understand and trace the history of those monuments. The cooperation with the Laboratory of Archaeometry in the Department of History, Archaeology and Cultural Resources Management of the University of the Peloponnese, under the leadership of Professor Nikos Zaharias, of blessed memory.

In the case of Hagia Sofia, colored glass tesserae were studied, using non-invasive analytical techniques such as PGAA, XRF, FOM, and SEM-EDS to examine their conservation status and production technology, promoting a preservation strategy [1].

In the case of the Tomb Chamber of the Holy Aedicule in Jerusalem, the mortar samples were analyzed using sieve analysis, Differential Thermal and Thermogravimetric Analyses (DTA/TG), stereomicroscopy, optical microscopy, scanning electron microscopy with energy-dispersive X-ray spectroscopy (SEM-EDS), X-ray diffraction (XRD), and total soluble salts measurements, clarifying the historical sequence of the Tomb Chamber's evolution, from the Constantinian-era Aedicule to the structure as it exists today [2,3].

Aiming to document the historic materials of the Catholicon and design and select compatible and performing restoration materials for the Varnakova Catholicon rehabilitation project, similar techniques were followed that allowed the confirmation of the historical documentation regarding the interpretation of the available historical data and resulting construction [4,5]. The results were correlated with the archeological research conducted by Fokis Ephorate of Antiquities and specifically A. Psalti and M. Tsakoumaki.

Our cooperation with the Laboratory of Archaeometry in the Department of History, Archaeology and Cultural Resources Management of the University of the Peloponnese is continued under the leadership of Professor Eleni Zymi with the cooperation of Dr Maria Kylafi, and its, broadened properly, scientific team.

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Archaeometric analysis of ecclesiastical monuments within the EYLOGON project: The case studies of Hagia Sophia and the Holy Sepulchre

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Ecclesiastical monuments present unique characteristics as Cultural Heritage sites, such as the complexity of the structural and decorative materials used, the multitude of the construction phases or maintenance interventions over time, the continuous use of the monuments (as places of worship) during the study, the restrictions on sampling, the symbolic value of the monuments, etc. Therefore, their study, conservation and management is a complex and multi-factorial process.

Despite the above-mentioned challenges, the archaeometric study of ecclesiastical monuments can lead to the detailed investigation of important questions, such as the identification of the raw materials used and their possible origin, the production technology, the dating of the monuments and the evaluation of their successive construction phases. This information can then be applied to assist in the conservation and management of the monuments, allowing, for example, the application of better suited restoration practices and compatible materials, as well the more comprehensive promotion of the sites.

The Laboratory of Archaeometry of the University of the Peloponnese has collaborated with the National Technical University of Athens in multiple projects focusing on the archaeometric study of ecclesiastical monuments. In this presentation, two prominent case studies are presented, and more general implications regarding the efficient archaeometric study of ecclesiastical monuments are discussed. More specifically, the two case studies concern two of the emblematic ecclesiastical monuments of Orthodoxy which are addressed by the interdisciplinary, pioneering programme entitled 'EYLOGON': (a) the non-destructive analysis of glass tesserae from Hagia Sophia, Constantinople, which focused on the identification of the corrosion patterns and mechanisms and the determination of the raw materials and the production technology applied. Further suggestions regarding the likely dating, provenance and cultural exchange networks were drawn, based on comparisons with similar material from other sites, (b) the analysis and OSL mortar dating of the Tomb Chamber of the Holy Aedicule of the Holy Sepulchre in Jerusalem, which led to the determination of the materials used, indicating continuity in production technology. More importantly, four distinct chronological periods were identified, corresponding to the important construction and restoration phases of the 4th, 11th, 16th and 19th c.

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Glass and Glazes

Trace element analysis and Sr-Nd isotopic signatures of core formed glass from central Greece: New analytical data

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Glass having a long history of more than 4000 years from today began to be utilized for crafting beads and small decorative items. The earliest examples of glass vessels were produced using the core-forming technique in regions such as Mesopotamia and Egypt, dating to the late 2nd millennium BC (16th–15th centuries BC). This technique revived during the mid of the 1st millenium BC and was responsible for the production of glass vessels often referred to as Mediterranean core-formed bottles.

This study presents the investigation of core-formed glass vessels from the Cave of the Nymph at Koroneia in Central Greece, a site with a long-standing ritual significance from the Late Bronze Age to the Early Roman period. Located at a strategic crossroad linking Central Greece with Attica and the Corinthian Gulf, the cave yielded a rich archaeological assemblage of over 50,000 artifacts, among which a notable corpus of glass objects, mainly beads.

A subset of 48 fragments of core formed vessels, primarily amphoriskoi, oinochoae, aryballoi, and a few examples of alabastra and unguentaria, dating mostly to the 5th and 4th centuries BCE, was selected for a detailed investigation using state-of-the art analytical techniques. The main aim of this paper is to explore the technological traits of these vessels, identify the source of the raw materials and provide new insights regarding the provenance of glass and the location of secondary workshops.

A set of complementary techniques was applied for the full characterisation of the glass objects. Namely, LA-ICP-MS was employed for the identification of major, minor and trace elements, while TIMS was applied to determine the Sr and Nd isotopic ratios of both the glass and the core itself. Differences mostly in trace elements point to potential shifts in the sources of raw materials between the 5th and 4th centuries BC. In addition, the isotopic data reveal a tight clustering of samples, implying a common geological origin for the raw glass, while the core material has a different signature opening new avenues for identifying secondary workshops involved in glass production.

These findings offer new insights into the technological complexity and regional dynamics of glass production and distribution in Mediterranean, underscoring the need for further isotopic data to refine provenance interpretations and locate the secondary workshops of this very important category of glass.

Contributing to the study of early-glazed wares of Byzantium. An analytical approach from Greece and Cyprus

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Glazed ceramics represent one of the most recognizable and extensively studied pottery types of the Byzantine period. While their widespread production and distribution, particularly during the Middle Byzantine period, has received considerable scholarly attention, the earlier phases of glazed ceramic manufacture (7th–11th centuries CE), especially red- but also white- bodied wares, remain comparatively understudied due to the relative scarcity of material and published analyses.

This study presents analytical results on Byzantine early glazed wares, mainly chafing dishes, bowls, and dishes, from four sites across the Eastern Mediterranean (mainland Greece, Crete, and Cyprus). The investigation pursues three main objectives: (a) to document technological practices in Byzantine early glazed production; (b) to identify possible technological choices or variability within the assemblage; and (c) to explore provenance at both intra- and inter- regional scales.

A multi-method analytical approach is employed, including ceramic petrography (TL-OM, RL- OM) to assess fabric composition and texture, X-ray diffraction (XRD) for mineralogical characterization, and scanning electron microscopy with energy-dispersive spectroscopy (SEM-EDS) to examine glaze composition and microstructure. Results indicate continuity in glazing technology from Late Roman traditions, particularly the use of high-lead glazes, across both calcareous and non-calcareous local fabrics. While early glazed production appears regionally distributed and limited in scale, Constantinopolitan imports, which were identified within our sample set, appear to reach not only urban centres, but also second-ranking sites (e.g., emporia, fortresses).

By integrating material from diverse regions, this study contributes to bridging the gap between Late Antique and Middle Byzantine glazed ceramic traditions and advances our understanding of Byzantine early glazed ceramic technology, production, and distribution during the Early Middle Ages. These findings form part of a broader doctoral project on early medieval ceramics in the Eastern Mediterranean, conducted within the framework of the PlaCe-ITN project (EU Horizon 2020 – Marie Skłodowska-Curie Actions).

Glazes, pigments and slips in the ceramics from the production centre of Almazán (Soria, Spain), 16th–18th centuries

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The town of Almazán, situated in the Spanish province of Soria, boasts a rich history that has contributed to its prominence as a hub for pottery production during the early modern period. Almazán's location along the commercial and transportation routes between Castile and Aragon was advantageous during the Middle Ages and the Renaissance. This placement facilitated trade in artisanal crafts and cultural exchange. After the Christian reconquest, the presence of Mudéjar (Muslims who remained in Christian territories) artisans played a crucial role. Local manufacture was significantly influenced by their technical expertise and artistic traditions, particularly in areas such as tile work, glazing, and decorative patterns. During the Early Modern Era, Almazán became a significant hub for the production of ceramics inspired by the famous Talavera pottery, as well as from the production centres of the Crown of Aragon, especially Villafeliche, during the 18th century. Nevertheless, its ceramic output has not garnered the recognition it rightfully deserves in contemporary times.

This study aims to determine the technology of these ceramics and address this gap by providing new data on this ceramic tradition from an archaeometric perspective. To achieve this, 49 ceramics dating from the 16th to the 18th centuries (coarse wares, biscuit ceramics, majolica, saggars, and trivets) were archaeometrically characterised through X-ray fluorescence (WD-XRF) and powder X-ray diffraction (PXRD) to gain insights into the bulk chemistry and technology, and to define the reference group. In a second step, 21 glazed ceramic fragments with slip-painted and glazed decoration were sampled for examination in the context of technological advancements in ceramic production. Particular attention was given to the synthesis of the glaze and the ceramic body's structural and chemical characteristics. These aspects were explored through a comprehensive analytical process involving compositional analyses of pigments, slip coatings, and glazes using portable Optical Microscopy (OM), X-ray fluorescence (pXRF), Scanning Electron Microscopy (SEM-EDS), and Raman Spectroscopy. The results provide complementary evidence on the technology employed in Almazán and enable comparison with other production centres in the Crown of Castile, especially with that of Talavera de la Reina, which inspired the ceramics of Almazán from a decorative perspective.

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A Comparison between Athenian and Boeotian Black Glosses on Pottery Dated from c. 600 BCE to c. 100 BCE

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Black gloss was an essential decorative material for ancient Greek pottery, c. 600- c. 100 BCE. Different types of black gloss have been reported, and we compared two types that are discussed to be made in Athens and Boeotia, respectively. The Ashmolean Museum provided five Athenian samples and the Ure Museum provided another six Athenian and five Boeotian samples. Under a scanning electron microscope combined with an energy-dispersive spectroscopy (SEM-EDS), the two types appear similar to each other, and are comparable to those in previous studies on the Athenian and Campanian types [1]. Grains in our samples are smaller than 1 μm and are rich in Fe, and/or Ti, Mg, evenly distributed. These could be comparable to previous results, which described that the black gloss of the Athenian, Etruscan and Campanian types include carbon, quartz, wüstite, magnetite, hematite, maghemite, hercynite, sanidine, orthopyroxene (hypersthene), titanomagnetite, and compounds in the series magnetite-hercynite; many of these minerals show in [2]. Because the EDS results from the matrix of our black gloss samples showed presences of Al, Si, K, and trace Mg and Na, the raw materials are likely clay minerals. The previous studies [1] suggested that the raw material was illitic clay, with high and low concentration of iron and calcium, respectively. Although our X-ray diffraction (XRD) patterns of the two types samples showed overlapped peaks that are not clear to identify all phases, we have identified hercynite so far, which has been reported as well. The results of X-ray photoelectron spectroscopy (XPS) from the two types of black gloss, showed existence of Fe^{3+} and Fe^{2+}, while previous studies of XPS show Fe^{3+}, Fe^{2+} and Fe^{0} in the Athenian type [3]. This may be due to changes in the black gloss technique. Our results indicate that the Athenian and the Boeotian black glosses may have derived from similar raw materials which contained clay minerals, and that the differences between our study and previous studies could show the variation on the black gloss material and technique.

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Ceramics

Imaging μ-XRF in cultural heritage

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Imaging X-ray fluorescence (XRF) spectroscopy is a non-invasive, non-destructive analytical technique widely used in cultural heritage to analyze the elemental composition and distribution of materials found in artworks and historical artifacts. The method combines the elemental sensitivity of XRF with spatial resolution, enabling the creation of two-dimensional elemental maps. Imaging XRF spectroscopy is a vital technique for studying and conserving cultural heritage, providing unique insights into the materials, methods, and histories of invaluable works of human creativity. The research group's work at the Department of Materials Science and Engineering, University of Ioannina, on fluorescence imaging spectroscopy in the field of cultural heritage is presented. Case studies are examined through the analysis of religious icons [1-3], manuscripts, and archaeological artifacts. Various imaging XRF experimental setups are discussed [4] alongside complementary spectroscopic techniques such as multispectral imaging [5].

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Ritual Meals and Shifting Traditions: Culinary Vessels in the Sanctuary of Kalapodi from Late Mycenaean to Early Iron Age through Analytical Techniques

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This study forms part of the first author's PhD research, which focuses on the analysis of coarse ceramic assemblages from the sanctuary of Kalapodi – an important cult site in Central Greece that exhibits remarkable continuity of religious activity from Late Mycenaean (LHIIIB-IIIC) through to the Roman period. During the course of this research, an exceptionally large quantity of coarse ceramics was identified in layers dating from LHIIIB-IIIC to Early Iron Age (EIA), offering a unique opportunity to investigate long –term developments in ceramic production and use within a ritual context. The ceramic material was examined in two stages: an initial macroscopic investigation, which led to the establishment of a typology and a selection of samples for the subsequent archaeometric analysis, based on the macroscooic examination. Both stages were carried out following the chaîne opératoire approach, a powerful framework that enables the reconstruction of the entire lifecycle of the ceramic objects. This approach proved to be particularly effective in distinguishing twelve significant categories of coarse ware.

The first six categories comprise typical cooking ceramics, whose morphological and technological features align with known cooking vessels from both the palatial and post palatial periods. The rest categories consist of Handmade Burnished Ware (HBW), a well-documented ceramic tradition in bibliography, notable for its handmade production, dark burnished surfaces and uncertain provenance. This ware is present in layers spanning from LHIIIC to EIA period. An interesting observation is the absence of typical cooking vessels in EIA layers at Kalapodi. Instead, HBW appeared in substantial quantities, suggesting a functional and possibly symbolic replacement of earlier cooking forms during EIA.

For an integrated analytical investigation appropriate numbers of samples representing the aforementioned categories were selected and examined through the application of pEDXRF, NAA and petrography revealed a wide range of compositional patterns, both in terms of elemental composition and geological provenance. Both pEDXRF and NAA showed five distinct clusters, closely aligned with the macroscopic categories, validating the initial visual assessment. Petrography confirmed these findings and revealed further variation linked to different raw material and processing techniques. All three methods indicate that most LHIIIC cooking vessels were locally-regionally produced using volcanic fabric. Additionally, a local cooking tradition from late LHIIIB to early LHIIIC was identified, made in sedimentary fabric, alongside imports of Aeginetan cooking ware, made by volcanic matrix. In contrast, HBW from Mycenaean and EIA contexts display diverse recipes, predominantly using metamorphic fabric and less volcanic.

Characterizing a Rare Clay Feature from Early Helladic Helike: An Archaeological and Archaeometric Study

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Excavations of the Helike Project since 2000 onwards in the Helike plain brought to light, among other discoveries, the impressive remains of an Early Helladic (EH) coastal proto-urban settlement in the area of modern Rizomylos. The EH architectural remains excavated so far belong mainly to large rectilinear buildings including a number of spacious rooms containing rich pottery and other finds, specifically made storage areas housing a great number of large pithoi for storing agricultural products, and workshop areas for tool manufacturing. Their interior is furnished with architectural features showing advanced technological level such as stone benches holding big storage vessels, stone struts to support an upper storey of a Corridor House, clay hearths, pebbled/cobbled floors, in several cases made of colourful pebbles.

Among these features, a rare clay pi-shaped structure of significant dimensions and thickness was revealed in one of the excavated buildings in 2011 (Fig.1). The structure has no parallels so far from other contemporary excavated settlements in the Greek mainland, thus its character and function remain unknown. In the present paper, we describe this particular feature and attempt its identification by (1) examining and discussing the archaeological context and (2) studying its technological characteristics and components based on mineralogical, petrographic, and geochemical analyses. The comparative study of this structure with the established petrographic groups of EH Helike pottery based on a previous study and analysis, and locally sampled clayey raw material from the area under investigation have helped us to further infer about the character and function of this rare feature into its own context. Its calcareous nature bears some similarities to one of the main petrographic fabric groups identified previously during the archaeometric study of a pottery assemblage from the excavated EH buildings. However, the presence of abundant limestone lithoclasts combined with the absence of any radiolarite fragments, prevents their match with the analyzed pottery of the settlement, yet resemble fairly well the overall geology of the surroundings.

Figure 1 (a) Excavation site and (b) semi-circular construction.

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The Sino-Hellenic Project at Kastrouli: Comparative Study of Mycenaean Ceramics and Anyang, China

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We conducted a comparative study of ceramic assemblages from the Late Helladic site of Kastrouli in Central Greece and the Shang site of Anyang, China (both c. 1300-1000 BC). Our analysis aimed to assess technological and material similarities and differences, shedding light on the provenance, diffusion and adaptation of ceramic technologies in these distant regions.

At Kastrouli, petrographic and geochemical analyses of ceramic sherds revealed two main fabric groups, characterised by distinct inclusions and grain size distributions. The ceramics predominantly consisted of quartz, mica, and feldspar, sourced from local clay deposits around Kastrouli. Hierarchical clustering and principal component analysis (PCA) of the data indicated a strong correlation between local clay sources and ceramic production. Notably, ceramics from Kastrouli, including fine ware and storage jars, exhibited significant technological variation, with some samples showing evidence of different manufacturing processes. The Anyang ceramics were fired in reducing conditions reaching 850–900°C. Kastrouli fabrics showing micaceous matrices and fine inclusions, while Anyang samples displayed more controlled slip application, oriented porosity, and, in some cases, bimodal tempering with riverine sand

Comparing these findings to the petrographic results from Anyang, we observed that while both regions employed local clay sources, the compositional differences in their ceramics were evident, particularly in terms of firing temperature and inclusion types. Our study suggests that while Kastrouli and Anyang followed different ceramic traditions, there are similarities in raw material choices and firing techniques, which could reflect parallel technological developments and independent innovations in response to similar environmental challenges.

This comparative study of Kastrouli and Anyang ceramics provides insight for both Mycenaean and Shang ceramic productions as well as a case study for cross-cultural patterns in ceramic technology using archaeometry. The findings contribute to ongoing discussions on climate change and the mobility of populations, notably the Phocaeans and the Shang during the Late Bronze Age, particularly how these factors may have influenced ceramic production and technological adaptation in both regions. By examining these materials, we aim to better understand the environmental and social dynamics that shaped the ceramic traditions in Greece and China.

Investigating technological and cultural transmission between Greek metropolises, colonies and indigenous populations in Southern Italy and Sicily through ceramic production (ca. 800-550 BC)

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The research project 'Pots and Pans: Analysis and Comparison of Pottery Production and Consumption in Ancient Greek Mother-cities and in Indigenous and Colonial Communities in Italy, ca. 800-550 BC' (in the framework of the wider NWO-funded project directed by Prof. J. P. Crielaard 'What Went into the Melting pot? Land-use, Agriculture, and Craft production as Indicators for the Contributions of Greek Migrants and Local Inhabitants to the So-called Greek Colonization in Italy') has been conducted under the auspices of Vrije Universiteit Amsterdam and the Institute of Nanoscience and Nanotechnology (INN), NCSR 'Demokritos', in collaboration with other academic institutions. It investigates ceramic technology, production and consumption, examining technological and broader cultural interactions and transmission, local workshops and movements of artisans and goods during the era of Greek colonization and migration in southern Italy and Sicily. Emphasis is given on the ceramics used during the first phases of contact (8th – first half of the 6th century BC), comparing ceramic production between important sites in Greece and Italy. Ceramics played a decisive role in the economic and cultural exchanges with the indigenous populations of Italy. For this reason, both the manufacturing traditions of the colonizers-immigrants and the indigenous people have been investigated.

This presentation is a brief overview of the research that the undersigned coordinated and conducted with colleagues-collaborators of the project. The objectives, methodology and results of the project are presented. The original research conducted on the ceramic finds combines detailed macroscopic study and science-based analyses (petrographic, chemical [NAA, p-XRF], scanning electron microscopy [SEM]). Furthermore, reference materials were petrographically analysed, including rocks and sediments and various types of building materials from the areas under investigation. Targeted ethnographic research was also carried out. By bridging the humanities with archaeometry, we can gain important insights into the routes of knowledge transfer and multiple technological practices, achieving a deeper understanding of the broader social and economic interactions between metropolises, colonies, and indigenous populations at times crucial for the formation of Mediterranean civilizations.

Investigating Handmade Pottery in Roman Thrace through an Integrated Analytical Approach

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In the early Iron Age (ca. 1100 BC) several distinctive vessel forms of handmade pottery emerged in Thrace, broad region encompassing modern southern Romania, Bulgaria, northern Greece, and European Turkey. The same forms persisted in the area throughout the Roman period until the 4th c. AD despite the wheel-made coarse ware being prevalent. In the area, it is often seen as evidence of the continuation of local, Thracian, pottery making tradition, and it is commonly interpreted as evidence for local communities coexisting with the Romans in the same settlements.

Representative samples of such handmade pottery from three sites in Yambol District in south-eastern Bulgaria dated to the 2nd–4th c. AD were examined to address questions of production, location and circulation of the pottery, as well as of manufacturing technology and use. Different analytical methods were combined, including ceramic petrography, WD-XRF and XRD analyses, lipid analysis, computed tomography and 3D scanning. The ceramic fabrics were compared to geological samples collected from an area covering more than 40 sq km around the three sites. The results revealed three main fabrics corresponding to three main areas of possible origin but also indicated some circulation of those vessels within the studied area, suggesting that at least some of the pottery was involved in trade. The vessels of the three fabrics were produced in the same manner and the analysed samples suggest meat-based content.

The results raise the question of whether the vessels themselves were the primary traded goods, or whether they could have served as containers, e.g. for marinated meat, produced and distributed by the Thracian communities.

From Kiln to Clay: Tracing Local Amphora Production in Roman Patras through Archaeometric Analysis

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Recent archaeological excavations in the urban area of Patras have brought to light a Roman ceramic workshop, with a well-preserved kiln dated to the 2nd century AD. The recovery of numerous amphora fragments within the kiln chamber and in the surrounding area of the workshop, provides unequivocal evidence for in situ ceramic production, offering rare and direct insight into local manufacturing activities during the Roman period. This workshop represents one of the ceramic production sites within the city's territory, offering valuable insight into local craft organization.

In order to define a local fabric, selected amphora sherds recovered from the kiln were subjected to detailed archaeometric analysis. These ceramic samples were systematically compared with clayey raw materials collected from nearby geological outcrops believed to have been potential sources of raw material for ancient potters. Petrographic analysis, supported by mineralogical characterization (XRD) and chemical analysis, demonstrated a high degree of compositional similarity between the ceramic fabric and the local clays, strongly supporting the hypothesis of local resource exploitation and production continuity.

This study enhances our understanding of local ceramic production, resource exploitation, and economic activity in Roman Achaea. More broadly, they demonstrate the utility of integrated archaeometric approaches—combining stylistic, petrographic, and mineralogical data—in reconstructing ancient production processes, technological knowledge, and patterns of ceramic distribution. As such, this research provides a foundation for further comparative studies on ceramic production and exchange within the urban and rural landscapes of Roman Greece.

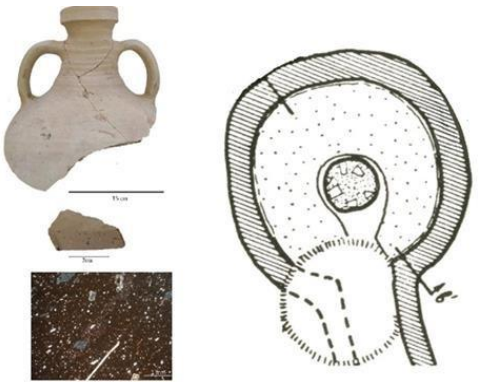

Figure 1: Reconstructed local amphora from the kiln context; thin-section photomicrograph of its ceramic fabric (left) and the kiln from which it was recovered (right).

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Metals

Kokkino Vouno, Akrotiri Thera: Archaeometallurgical Insights from a Prehistoric Site

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Situated to the west of the archaeological site of Akrotiri, Kokkino Vouno is a striking topographical feature that drew early archaeological attention through trial trenches conducted by Akrotiri's excavator, Spyridon Marinatos. The *Kokkino Vouno Survey Project*, initiated in 2024 and conducted under the auspices of the University of Ioannina, aims to contextualise Marinatos's original finds and numerous artefacts retrieved during the past twenty-five years, leading to the identification and systematic documentation of a wide range of activities that were taking place on this hill that was patrolling the sea routes connecting Thera and Crete. Among the retrieved artefacts are fragments of wall paintings that testify the existence of at least one cluster of buildings, abundant pottery spanning from the Late Cycladic I period until the Hellenistic times and lithics that document household and other activities. Of exceptional importance are crucibles with metallurgical residues and copper slags, indicative of metalworking activity in Prehistoric times, as well as a fragment of raw azurite. Preliminary compositional analyses of these finds suggest the processing of copper-bearing ores, potentially connected to wider Aegean trade and technological networks during the Bronze Age. This presentation will examine the archaeological context of the Kokkino Vouno site, summarise the findings of recent archaeometallurgical investigations, and consider their implications for our understanding of early metallurgy in the Cyclades.

Lead and silver isotopic signatures of mended pottery in LBA Ofrynio, Northern Greece

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Lead isotopic analysis has proven to be a powerful tool for tracing metal provenance in archaeological research [1], while recent advances in silver isotope analysis provide additional insights into primary ore extraction processes [2]. This study applies both methods to investigate Late Bronze Age (LBA) pottery repairs from Ofrynio Toumpa, a key settlement site in Eastern Macedonia, Northern Greece [3].

The analyzed material consists of lead fillers used to mend broken pottery vessels—a rare but significant practice indicating the value of these ceramics. By conducting lead and silver isotopic analyses on these repairs, we aimed to determine the provenance of the lead ore and explore its metallurgical characteristics.

The lead isotope signatures suggest a local or regionally proximate source, consistent with known LBA metal circulation patterns in the area. Notably, two lead fillers contain elevated silver concentrations, prompting further investigation through silver isotope analysis. The ε^{109}Ag values of these samples exhibit slight negative values (-0.7, -1.4), a possible indicator of the primary mineralization conditions of the ore source. These findings contribute to a broader understanding of metal procurement strategies in LBA Northern Greece, technological practices in pottery repair, and the potential exploitation of the local argentiferous lead ores in Pangaeon mountain and in northeast Chalkidiki.

This study highlights the value of combining lead and silver isotope systems in archaeological metallurgy, offering new perspectives on ancient resource management and craft specialization in the Balkans.

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Not every cloud has a silver lining: a study of complex extractive metallurgical practices at Pistyros, northern Greece during the Hellenistic period

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The systematic excavation of Pistyros (S. Papadopoulos-Ephoreia of Antiquities of Kavala, 2014-2023), a colony of Thasos in northern Greece, near present day Pontolivado, provided a rare opportunity to examine Pb-based extractive activities within an urban context; it also provided a basis for comparison with similar, near-contemporary activities (5th-3rd c. BCE), taking place within a more traditional setting, i.e near mining sites (for example at Petropigi/Perni, 2.5 km to the NE of Pistyros).

In juxtaposition to the above, the metallurgical activities within the Hellenistic phase (4th-2nd c. BCE) of Pistyros create a more complex picture which is yet to be thoroughly understood. There are a number of reasons for that:

a. the lack of clear evidence, so far, for high temperature metallurgical installations or others associated with metal processing (working, casting etc);

b. the polymetallic (Pb, Sb, Ag/Au) nature of the Pistyros silicate slags; and

c. the presence, of non-silicate 'slags' consisting of Pb-oxides and of Fe-arsenides

The varying composition of the small metallic inclusions within each slag type raises questions as to whether the three types form part of one process or multiple ones. The metal inclusions in the Pb-silicate slags consist largely of Pb-Sb suggesting, but not definitevely proving, the production of antimonial lead. On the other hand, when Ag and Au content was measured, via ICP-MS, iron arsenides showed particularly high values of Ag/Pb ratios, compared to those of the other two groups, thus opening the possibility for Ag recovery practices on site.

The nature and totality of metallurgical activities at urban Pistyros and their potential interdependence is yet to be fully elucidated; nevertheless, the Pistyros activities outline an alternative model to the more conventional one of 'smelting at the mine'; the latter has been the dominant model for interpreting metals production strategies in Greece during antiquity and it is time that this narrative is challenged.

Determining the Thickness of Gold Leaf in Post-Byzantine Icons Using X-ray Fluorescence (XRF)

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Gold leaf was widely used in post-Byzantine iconography to enhance halos, backgrounds, and other decorative elements [1]. Determining its thickness in a non-invasive way provides valuable insight into both the artistic techniques and the preservation needs of these works. This study presents an integrated approach that combines imaging micro-XRF, portable XRF, and clustering- based data analysis to investigate gold leaf stratigraphy with high accuracy. Through μ-XRF imaging, detailed elemental distribution maps are generated, enabling the visual identification of areas with single, double, or multiple gold leaf layers [2]. To reduce uncertainty caused by overlapping gold leaf layers, a spectral clustering method is introduced to group pixels with similar XRF characteristics [3]. This isolates regions with consistent coverage, enabling more accurate analysis by summing spectra within each group, rather than relying on manually selected areas that may contain mixed layers. To extend thickness determination beyond the lab, we incorporate portable XRF measurements for on-site analysis of artifacts that cannot be transported.

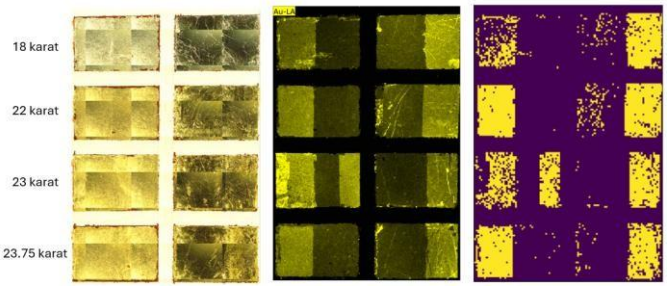

Figure 1: Left) Gilded mockup, middle) Au- Lα intensity distribution map, right) pixels corresponding to areas of double gold foil, according to automated cluster analysis.

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Study of ancient slags and metallurgical production process of copper-arsenic master alloys (speiss) from the prehistoric period at Laurion-Greece

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After a targeted effort with geological and technological criteria, we identified remnants of prehistoric arsenic copper (speiss) production activities in the peninsula of Gaidouromandtra-Lavreotiki and possibly in some other locations for which the study is still ongoing. On the peninsula of Gaidouromandra, on a slope exposed to strong winds and a short distance from the coast, there are scattered fragments of slag. In the same location, scattered pieces of obsidian and more rarely hard stones with a smooth and rounded surface are observed, which certainly served to break down the slag to small pieces. Macroscopic observation of slag fragments shows that very hard spherical inclusions of speiss with metallic appearance and light grey color - that are easily distinguished from the omnipresent soft and dark grey metallic lead-, protrude from their surface. Furthermore, the presence of a surface crust of green and blue minerals on the surface of fragments indicates clearly the presence of copper and in combination with the high hardness confirms the presence of arsenical copper. These are inclusions that were retained during the metallurgical process in the mass of slag and, in order to recover them, prehistoric metallurgists broke them into fragments of a size that usually does not exceed 3cm, following a common practice of their time. Slag fragments were examined under the scanning electron microscope (SEM) associated to EDS microanalysis. Based on the composition of the inclusions analyzed, it appears that the material produced is basically an alloy of Cu-Fe-As with approximately 35-40%As, 18-30%Cu and 20-30%Fe, which is characterized as speiss. It also contains up to 5% Sb, 4-7%Ni, 0-1.5%S and lead inclusions, but does not contain zinc. The slags contain in their matrix 15-20%Si, 20-25%Fe and 20-25%Ca and secondarily Al, Mg, Mn and possibly Zn, but they do not contain any detectable amount of either copper or arsenic. Tin is not detected in either the slag matrix or in the inclusions. The mineralogical composition of the slag consists mainly of olivine and/or wollastonite primary crystals and small crystals of magnetite. The arsenic material (speiss) produced was a copper raw material with 30-40%As, resulted from a sophisticated common smelting of local copper and arsenic ores, which were abundant at several places of Lavreotiki. With some exceptions, arsenic is the only alloying element of copper during the Early Bronze Age and continued to be used alongside tin during the Middle Bronze Age, then stopped. In this communication, after the full characterization of the slag and its components, a tentative description of the smelting process will be exposed: ores and mineral charge, operation temperature of the furnace, and mechanism of arsenical minerals' dissolution in the melt, leading to speiss formation, will be described.

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Late Bronze Age crucible fragments from the metalworkers' workshop at Gonur Tepe, Turkmenistan, Central Asia: An integrated archaeometric study

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Gonur Depe, a major centre of the Bactria-Margiana Archaeological Complex (BMAC) in present-day Turkmenistan, features one of the most extensive and well-preserved Bronze Age metallurgical workshops in Central Asia. In Area 9 of North Gonur—an industrial quarter situated near the main water pool—an architectural complex of more than 150 rooms was uncovered, several of which (notably Rooms 107, 108, and 109) yielded abundant evidence of copper-based metallurgical activity. These remains include crucibles, casting moulds, slags, and furnaces, as well as a variety of tools and symbolic artifacts, indicating intensive production and various aspects of craft activity.

This paper presents an archaeometric study of crucible fragments recovered from this area. The primary aim is to examine the technological parameters and operational conditions of copper processing and alloying. The analytical methods employed include optical microscopy, scanning electron microscopy (SEM-EDS), and X-ray fluorescence (XRF), which were applied to examine slag morphology, chemical composition, and ceramic fabric. By integrating these techniques, this research contributes to a deeper understanding of crucible-based copper technology during the Late Bronze Age and supports the broader investigation of ancient pyrotechnological systems.

The Iron Metallurgy in Ancient Eretria. First Results and Perspectives

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Iron and its alloys played a crucial role throughout Antiquity. Archaeological finds – from tools to construction elements, including weaponry – clearly attest to their importance. But what do we truly know about the manufacture of these essential objects? What can be said about the organization of work, production spaces, or the sourcing and management of raw materials?

The research presented here addresses these questions as part of a doctoral project entitled *Ironworking in Ancient Greece*, supervised by C. Hasenohr (Ausonius) and N. Dieudonné-Glad (HeRMA), in close collaboration with the Swiss School of Archaeology in Greece. The project also benefits from the support of the American School of Classical Studies at Athens and the GPR Human Past program at the University of Bordeaux.

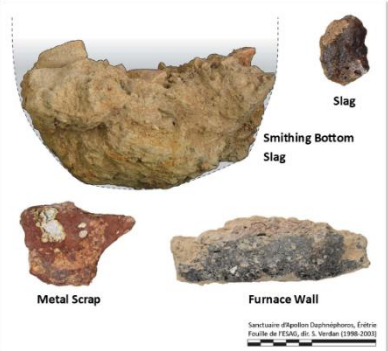

Fig. 1. Eretrian Ironworking Remains (Gravier 2023)

To this end, the city of Eretria presents considerable archaeological potential, yet remains largely understudied in terms of iron archaeometallurgy. Excavations – led primarily by the Swiss School and the Ephorate of Antiquities of Euboea – have focused on the *asty* and, more recently, the sanctuary of Artemis Amarynthia. These investigations have revealed significant ironworking remains, such as forge slags, fragments, and metal scraps (fig. 1), dating from the Late Geometric to the Hellenistic period (8th – 2nd c. BCE).

The study's first phase combined macro- and microscopic analyses to identify the working practices of ancient craftsmen. Examination of remains and their microstructures has provided insights into the techniques employed – such as material additions (intentional or accidental), the type of metal (from soft iron to steel), and the mechanical or thermal processes applied.

Since ancient iron was worked in a solid state, it also retains evidence of earlier stages of production – most notably in the form of reduction slag inclusions. Building on these initial results, the next phase involves compositional and geochemical analysis using SEM-EDS and LA-ICP-MS to characterize these inclusions. By comparing them to smelting slags and known ore sources across the Eretrian region, the study aims to reconstruct the *chaîne opératoire* and trace supply networks – expanding the scale of inquiry 'from mine to forge'. These results may ultimately shed light on broader questions regarding the circulation of raw materials, the degree of artisanal specialization, and Eretria's integration into regional exchange networks during Antiquity.

Metal Technology of Deccan Chalcolithic Culture: A Critical Review and Prospects for Future Research

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The beginning of Agricultural and settled life in the Deccan may be traced back up to last quarter of 3rd millennium BC. The discovery of first chalcolithic culture in India is made at the site of Jorwe in Maharashtra in 1950. Subsequently, number of chalcolithic sites have been reported in the Deccan region. These chalcolithic settlements have been grouped into four cultural traditions / phases, primarily based on the ceramic assemblages; Savalda, Late Harappan, Malwa and Jorwe Culture. Some of the important excavated sites are- Daimabad, Inamgaon, Nevasa, Jorwe, Prakashe, Chandoli, Kaothe, bahal etc.

These communities mainly followed farming and animal herding. However, archaeological findings also show that they practiced several crafts, including pottery making, bead making, lime processing, and working with metal- especially copper. These activities helped them trade and interact with other regions.

Metal use during this time was simple. Sites like Inamgaon and Daimabad show evidence of making copper objects locally. Many copper items such as axes, chisels, knives, rods, hooks, bangles, and beads have been found. But only a few of these objects have been studied scientifically. The limited studies done so far suggest that different types of copper ores were used, and that techniques like simple mould casting and hammering were common.

This paper reviews the scientific research that has been done on copper objects from Chalcolithic sites in Maharashtra. It discusses how copper was sourced and how metal items were made. It also highlights the need for more detailed scientific studies to better understand where the copper came from, how the objects were made, and why the use of metal was limited during this time.

The paper also suggests that more research can help to answer important questions, such as whether arsenic was added to copper on purpose or by accident1. The discovery of a copper-working furnace at Inamgaon shows that people were experimenting with metal production. Understanding these processes better could also tell us more about how these communities connected with others through trade and shared technology.

In summarizing past research and highlighting critical gaps, this paper aims to set a future agenda for interdisciplinary scientific studies that will enrich our understanding of early metallurgy in Maharashtra, India and its broader cultural implications.

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Poster Presentations

P1. You Are What You Eat: Materializing the Past Through Isotopic Analysis

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Nowadays, archaeology and other fields have rapidly aligned with natural sciences. However, the holistic advantage of the results offered by archaeological sciences is often limited due to significant gaps in interdisciplinary understanding and bare trust in “traditional theories” to a level that renders archaeology a traditional science.

This presentation explores how stable isotope analysis can be used to move beyond the traditional theoretical frameworks to reconstruct the lived experiences of individuals in the past. The common saying “you are what you eat” reflects a biological truth: our bodies incorporate elements from the food we consume. Different environments, ecosystems, and dietary habits leave distinct isotopic signatures, allowing archaeologists to understand what people ate, their social identity, status, and mobility.

An example will be given with the already published isotope data from Bronze Age Crete; this presentation will demonstrate how these data have challenged traditional narratives in Minoan archaeology regarding status, and mobility.

After illustrating an archaeological narrative, some statistics will be examined from survey data reflecting the familiarity of non-archaeologists and archaeologists with these techniques. Understanding and communicating the gaps is the first step toward fully incorporating archaeological sciences into archaeology.

This presentation aims for a more holistic and scientifically grounded approach to reconstructing the past by addressing both the analytical possibilities and the current gaps in understanding.

P2. ''Life stories within walls'': An osteobiography of two adult male skeletons from the LBA Mycenaean settlement of Chalandritsa, Greece

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An osteobiography enables the reconstruction of individual life histories based on their skeletal remains, bridging the biological information with the social context. This study employed an osteobiographical approach to investigate sex, age, stature, oral and general health of the two best-preserved skeletons recovered from single burials at the Mycenaean settlement of Chalandritsa, more specifically tombs 10 and 11. These rectangular cist graves were found inside two adjacent rooms of the settlement (X10 and X11), and at least tomb 11 postdates the use of the associated residential area. Although echoing burial practices associated with the early phase of the settlement, the later interment of these two individuals within the residential zone rather than in the extramural cemetery prompts questions regarding the specific socio-economic conditions that may have influenced this choice. A comprehensive osteological analysis was conducted to address these gaps. The skeletal elements were prepared, restored and examined macroscopically, following standard osteological protocols. The remains belonged to two male individuals in their late 40s, who exhibited several pathologies. Both men presented healed trauma: a small depressed fracture on the parietal bone of T10 and a Parry fracture on the left ulna of T11. These injuries might have been accidental or the result of interpersonal violence [1]. Furthermore, signs of osteoarthritis were found in the axial skeleton, hands, feet and long bone joints, suggesting heavy manual work. Other activity stress markers, such as enthesophytes, were also observed. Regarding oral health, both individuals presented dental caries and antemortem tooth losses [2]. Moreover, T10 presented severe attrition, while T11 suffered from periodontal disease. Other findings included a dental anomaly in T10, an impacted mandibular canine and an L5 spondylolysis in T11 [3]. Normal anatomical variants such as bilateral buccal mandibular depressions and arachnoid granules were also noted. Ultimately, this work offers a glimpse into a transitional period for this Mycenaean centre, from its glory days to its dusk, while highlighting the value of individual-level skeletal analysis.

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P3. A Multidisciplinary Osteoarchaeological Study of a Hellenistic Infant Burial in Lefkada

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This case study examines an infant burial found in the North Cemetery of the ancient city of Lefkada, Greece, dated to the Middle Hellenistic period. Lefkada was colonised by the Corinthians at the end of the 7th century B.C. and gradually developed into a powerful urban centre. Beyond the walls of the ancient city, two cemeteries have been discovered, the North and the South. In 2021, the excavation that was conducted by the Ephorate of Antiquities of Aitoloakarnania and Lefkada revealed a disturbed pit grave in the North Cemetery, designated as Tomb 60. In the tomb, infant cranial and postcranial elements were detected along with teeth. Several grave goods were found around the infant's skull, including two miniature decorated combs. The preservation of the skeletal material was poor as the remains were found disarticulated, fragmented, and scattered. To obtain further information about the individual, an osteological (including age-at-death estimation) and a palaeopathological study were carried out at the Laboratory of Palaeontology and Stratigraphy, University of Patras, Greece. Aiming to infer the genetic sex of the individual, ancient DNA analysis on the right petrous bone was conducted at the Ancient DNA Lab at the Institute of Molecular Biology and Biotechnology of the Foundation for Research and Technology - Hellas, Heraklion, Greece. Moreover, the presence of several autosomal and sex chromosomal aneuploidies was examined archaeogenetically, including trisomy X, Klinefelter syndrome, Jacobs syndrome, Turner syndrome, Trisomy 13 / Patau syndrome, Trisomy 18 / Edwards syndrome, and Trisomy 21 / the Down syndrome. Finally, the Scanning Electron Microscopy method was applied to identify the histological structure and composition of the combs. The analysis was performed at the Malcolm H. Wiener Laboratory for Archaeological Science, American School of Classical Studies, Athens, Greece. Although many significant and archaeologically valuable burials have been discovered throughout Greece, there are relatively few cases where a multidisciplinary approach has been applied. The significance of this study lies in its integrative approach combining cultural, bioarchaeological, osteological and archaeogenetic perspectives to provide a holistic view of infant mortuary practices during the Hellenistic period in Lefkada.

P4. Investigating the urban-rural dichotomy in Greek Roman times through the study of 3D mandibular morphology and biomechanics

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This case study examines an infant burial found in the North Cemetery of the ancient city of Lefkada, Greece, dated to the Middle Hellenistic period. Lefkada was colonised by the Corinthians at the end of the 7th century B.C. and gradually developed into a powerful urban centre. Beyond the walls of the ancient city, two cemeteries have been discovered, the North and the South. In 2021, the excavation that was conducted by the Ephorate of Antiquities of Aitoloakarnania and Lefkada revealed a disturbed pit grave in the North Cemetery, designated as Tomb 60. In the tomb, infant cranial and postcranial elements were detected along with teeth. Several grave goods were found around the infant's skull, including two miniature decorated combs. The preservation of the skeletal material was poor as the remains were found disarticulated, fragmented, and scattered. To obtain further information about the individual, an osteological (including age-at-death estimation) and a palaeopathological study were carried out at the Laboratory of Palaeontology and Stratigraphy, University of Patras, Greece. Aiming to infer the genetic sex of the individual, ancient DNA analysis on the right petrous bone was conducted at the Ancient DNA Lab at the Institute of Molecular Biology and Biotechnology of the Foundation for Research and Technology - Hellas, Heraklion, Greece. Moreover, the presence of several autosomal and sex chromosomal aneuploidies was examined archaeogenetically, including trisomy X, Klinefelter syndrome, Jacobs syndrome, Turner syndrome, Trisomy 13 / Patau syndrome, Trisomy 18 / Edwards syndrome, and Trisomy 21 / the Down syndrome. Finally, the Scanning Electron Microscopy method was applied to identify the histological structure and composition of the combs. The analysis was performed at the Malcolm H. Wiener Laboratory for Archaeological Science, American School of Classical Studies, Athens, Greece. Although many significant and archaeologically valuable burials have been discovered throughout Greece, there are relatively few cases where a multidisciplinary approach has been applied. The significance of this study lies in its integrative approach combining cultural, bioarchaeological, osteological and archaeogenetic perspectives to provide a holistic view of infant mortuary practices during the Hellenistic period in Lefkada.

P5. An Integrated Archaeomagnetic and Thermoluminescence Study of an Ancient Kiln at Ceva, Italy: A Model for Transdisciplinary Cross-Dating

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In this study, we present a cross-check dating approach applied to an ancient kiln excavated in Ceva, Northern Italy, by integrating new archaeomagnetic and thermoluminescence results with available radiocarbon dates and archaeological evidence. For the archaeomagnetic analysis, the full geomagnetic field vector, including both direction and intensity, was determined. Directional data were obtained through stepwise alternating field demagnetization of 20 oriented samples collected from various parts of the kiln. Archaeointensity was measured using the Thellier-Coe method, with corrections applied for magnetic anisotropy and cooling rate effects. Thermoluminescence dating was conducted on three baked clay samples using the standard laboratory multi-grain, multiple-aliquot additive dose protocol [1]. For archaeomagnetic dating, the experimental results were compared with the Italian reference secular variation curve [2], first using only the directional data and then using the full geomagnetic vector (direction and intensity). The independent TL data enabled a detailed evaluation of the archaeomagnetic results, particularly examining the added value of incorporating archaeointensity measurements alongside directional data. To integrate the various independent dating results, provided by the archaeomagnetic, thermoluminescence, and radiocarbon analyses, we employed Bayesian modeling using the Chronomodel software [3]. This multidisciplinary strategy yielded a well-constrained age for the kiln, consistent with the archaeological context. Our findings underscore the significance of cross-dating in establishing robust chronological frameworks and highlight the crucial role of transdisciplinary methodologies in advancing and refining dating techniques in archaeological contexts.

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P6. Atlantic Crossroads: First C14 Results from Pico Island and Their Implications for Pre-Colonial Settlement of the Azores

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In this contribution, we present the results of the first successful radiocarbon (C_{14}) dating of stepped structures on Pico Island (Azores), conducted in cooperation with the Leibniz Laboratory for Radiometric Dating and Isotope Research Kiel. The new data provide a robust chronological framework that significantly predates the official timeline of Portuguese settlement in the archipelago. These findings offer compelling evidence in support of a pre-Portuguese human presence on the Azores and contribute to the broader debate concerning the possibility of pre-colonial Atlantic navigation and cultural interaction [1-3]. By anchoring the stepped platforms of Pico within a calibrated historical context, the study opens new avenues for understanding the early occupation of the islands and challenges long-standing assumptions about their isolation prior to the 15th century [4]. The presentation also contextualizes these findings within parallel research of the partner team of Görlitz on OSL dating from Tenerife, underscoring the relevance of trans-archipelagic comparative approaches in Atlantic archaeology.

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P7. The painted decoration of the Derveni tombs, in Thessaloniki Region

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This paper refers to the archaeometric examination of Derveni's Grave I which began in 1995. This burial monument that dates back to the early 3rd century B.C., preserves a rich painting decoration of great importance. The decoration consists of four zones, the most interesting of which is the upper zone where on a blue background, objects related to the costumes of grooming are presented.

This study also refers to an exceptional stone palmette relief dated to the late fourth-early third century B.C., which decorates the lintel on the façade of a circular chamber tomb also found in Derveni's Necropolis. The stone palmette which consists of painted floral motifs that frame a central relief composition, now exhibited in the Archaeological Museum of Thessaloniki**.** All its construction materials, the stone, the white preparation and the pigments were analyzed.

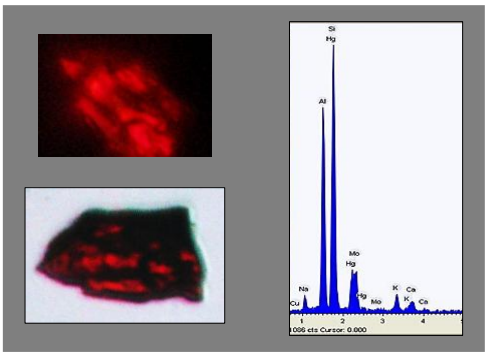

Fig.1. Cinnabarite. PLM image, N×, NII and spectrum SEM-EDX. (© Photo, S. Vivdenko, Ephorate of Antiquities of the Thessaloniki Region, Greek Ministry of Culture).

The first important information concerning the compositions of the pigments has been obtained during their examination under the polarizing microscope. The final determination of the components of the painted decoration was carried out with the help of physicochemical analysis by non-invasive techniques (XRF, SEM-EDX, Raman, FTIR and HPLCPDA).

From the results of the study the use of a) inorganic pigments with main chromophore minerals - hematite, goethite, cinnabarite, malachite, calcite, coal in plant black, cuprorivaite and glassy phase of the Egyptian blue and b) one pink organic pigment with a source of origin the *Rubia peregrine L*., have been identified.

For the application of the Egyptian blue on the background of the tomb's painting, lime was used as a binder ("fresco a' secco"). For the creation of the objects on the blue background a different technique was used. It is important to notice that the ancient painter depicted the objects by rendering their volume and not just by filling in their outlines with color. This "creation" was executed by different layers and brushstrokes of various shades, applied one on the top of the other. So it was assumed that the paint that was used for the depiction of the objects, should contain an organic binder. By analyzing the composition of a brown paint sample using FTIR spectroscopy, Arabic gum was identified. The same binding medium was discovered in the composition of the painting preparation of the stone palmette.

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P8. Examination of the organic pigments in the excavation findings and monuments of the Thessaloniki Region

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The study presents the examination results of the organic pigments that were detected on excavation findings and immovable monuments of the Thessaloniki Region. These are a) organic pigments from the decoration of terracotta figurines that were discovered in the tombs of the eastern and western cemeteries of the city during the excavations at the site of the 'International Exhibition of Thessaloniki' and the 'METRO' of Thessaloniki, b) a sample of an ancient fabric from a tomb in Lakkoma, Halkidiki, and c) organic pigments from the written decoration of two churches of the region of Thessaloniki (blue and pink colors in the iconostasis of the church of Agios Georgios in Sochos and pink color in the frescoes of the church of Agios Andreas in Peristera).

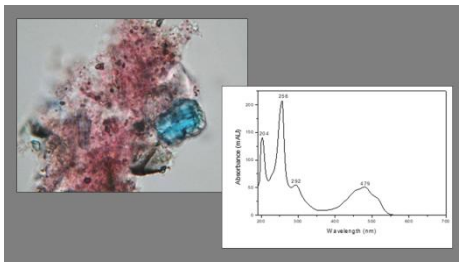

Fig1. Pink color on a terracotta figurine (madder) and Egyptian blue pigment grain. Polarizing light microscope and HPLC.

The analytical methods comprise evaluation of the sample using a polarizing light microscope and physicochemical studies, including m-XRF, Raman spectroscopy and HPLC. Examining the sample using the polarizing microscope enables the optical distinction of the organic pigments from the other components of the sample. It also provides information on the materials that serve as fillers for the organic pigments, such as microcrystalline calcite (chalk), lead white, kaolinite, and others. The polarizing microscope facilitated the first identification of the main chromophores and other minerals inside the sample. More specifically, the optical properties of the pigment grains in the samples, such as color, pleochroism, refractive index, birefringence, polarization color, extinction, etc [1], were examined. Thus, the distinction of the organic pigments in the sample and the initial identification of fillers were carried out optically. The pigments and other components of the sample were then identified with the aid of the physicochemical analysis, fig.1 (© Photography S. Vivdenko, Ephorate of Antiquities of the Thessaloniki Region, Ministry of Culture of Greece). In concluding, the following organic pigments were identified: 1) in the figurines: madder and Armenian cochineal, 2) in the fabric: shellfish purple, 3) in the pink of the mural of the church of Agios Andreas of Peristera: a red synthetic organic pigment of beta-naphthol and 4) in the pink and blue in the iconostasis of the church Agios Georgios in Sochos: madder, Armenian cochineal, and indigo. In the case of synthetic organic pigments, understanding the production date of pigments allows us to identify the earliest probable chronology of the painting's development.

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P9. Study of religious panel paintings using imaging μ-XRF

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Eastern Orthodox religious panel paintings, known as icons, have been created continuously since the beginning of Christianity and are still used in various rituals and worship services. In this study, Greek icons are examined using non-invasive imaging micro-X-ray fluorescence (MA-XRF) for large-scale dimensions. X-ray fluorescence (XRF) spectrometry has proven to be a vital, non- destructive method in cultural heritage studies because of its ability to rapidly determine the elemental composition of artifacts without causing damage. Imaging X-ray fluorescence analysis allows the production of elemental distribution maps for the elements present in the artifact. The ability of X-rays to penetrate to a certain depth gives this method the advantage of offering insights into paintings' stratigraphy through the detection of the elements present in the substrate. Therefore, MA-XRF can lead to the identification of the materials used in icon painting, such as pigments, metallic leaves, and priming materials, and ultimately to the assessment of the employed painting techniques and the artifact's state of preservation in a completely non-invasive manner. This work showcases the potential of MA-XRF in the technical investigation of icons through numerous characteristic examples.

Figure 1: The Pb Lα intensity distribution map (right) reveals the presence of an older painting that lies beneath the image of Jesus Christ wearing a crown of thorns (left).

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P10. Physicochemical analysis of anthropogenic sediments from the Neolithic layers of the Pan's Cave in Marathon

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The Cave of Pan is located on the N/NE slope of the hill of Oinoe, west of modern Marathon [1. 2. 3]. This study focuses on the investigation of the chemical and mineralogical composition of anthropogenic sediments originating from the Neolithic layers of the cave. For this purpose, sixteen soil samples were collected from the unexcavated sides of the excavation trenches based on their color differentiation. The color of these samples were firstly objectively determined using the Munsell color chart. Then their pH was measured and consequently analyzed by scanning electron microscopy with energy-dispersive X-ray spectroscopy (SEM/EDX), Fourier transform infrared spectroscopy (FTIR) and X-ray diffractometry (XRD). The results allowed us to distinguish which indications are presented by samples in which an anthropogenic activity is detected, or not. Specifically, an indication for the former is the detection in the FTIR spectra of baked - even partially - kaolinite, which indicates either the manufacture, use or corrosion of ceramic artifacts. The samples without evidence of anthropogenic activity consist entirely of hydroxyapatite, quartz, sand and calcium carbonate. Furthermore, the FTIR analyses did not give any indications of the presence of organic residues.

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P11. Preliminary Results of Mortar Analysis from Byzantine Monuments on Samos

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The island of Samos, located at the eastern edge of the Aegean Sea, was a strategic maritime theme during the Byzantine period. In recent years, its Byzantine period has received systematic archaeological investigation. However, some monuments on the island posed unresolved questions regarding their function and chronological attribution. Four monuments were selected for archaeometric investigation through mortar analysis. These were: (1) the Church of the Virgin Mary of the River, an 11th-century monastic katholikon with reconstruction phases; (2) the Church of Castle Lazaros, the only mortared building within a 7th-century fortification on Mount Ampelos; (3) the Dodekaporto structure, located in the southern plain of Chora, of uncertain function and chronology; and (4) the Castle of Pythagoreio, the medieval capital of Samos, with multiphase construction not yet securely dated.

Sixteen mortar samples were extracted from the masonry of these monuments. The samples were subjected to Optical Microscopy (OM) and Scanning Electron Microscopy coupled with Energy Dispersive X-ray Spectroscopy (SEM/EDS) at the Laboratory of Archaeometry at University of the Peloponnese. Analyses focused on micromorphological and chemical characterization of binders and aggregates.

All samples revealed a lime-based binder with aggregates of varying size and composition. Preliminary interpretation attributes these mortars to Byzantine craftsmanship, based on the presence of cocciopesto and a binder-to-aggregate ratio of approximately 1:2. This study, constitutes the first application of archaeometrical methods to Byzantine era mortars on Samos. It provides valuable data for the scientific study of historic building materials and offers a comparative foundation for broader research across the eastern Aegean region.

This project was implemented within the scope of the “Exceptional Laboratory Practices in Cultural Heritage: Upgrading Infrastructure and Extending Research Perspectives of the Laboratory of Archaeometry”, a co-financed by Greece and the European Union project under the auspices of the program “Competitiveness, Entrepreneurship and Innovation” NSRF 2014-2020.

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P12. Unlocking the Ras Serpentinite Quarry (Tinos, Greece): Provenance analysis, 3D Digital Documentation, and Educational Value

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This study applies a multidisciplinary archaeometric and digital approach to the Ras serpentinite quarry. A comprehensive fingerprint was established using petrography, XRD, FTIR, BET, LA-ICP-MS, and EPMA. The serpentinite, composed mainly of lizardite with chrysotile veins and relict antigorite, includes the first Greek report of minnesotaite. Geochemical evidence indicates a subduction-related origin, distinguishing it from other Greek serpentinites. Lichenometry dates quarrying to the 13th century AD, with limited extraction. To support the preservation and digital documentation of this historically rich site (Fig.1), a 3D digital documentation strategy was employed using Unmanned Aerial Vehicle (UAV) photogrammetry and Terrestrial Laser Scanning (TLS). Data collected via a DJI Phantom 4 Pro and Leica ScanStation P50 were processed and fused into a unified, high-resolution 3D model of the site. This digital reconstruction enables detailed analysis of the quarry's structure, extraction features, and excavation volumes, while supporting sustainable heritage management. In addition to its scientific value, the project can introduce students to Earth sciences, archaeology, and 3D mapping. The digital quarry model fosters STEM learning and cultural heritage exploration through interactive, real-world data.

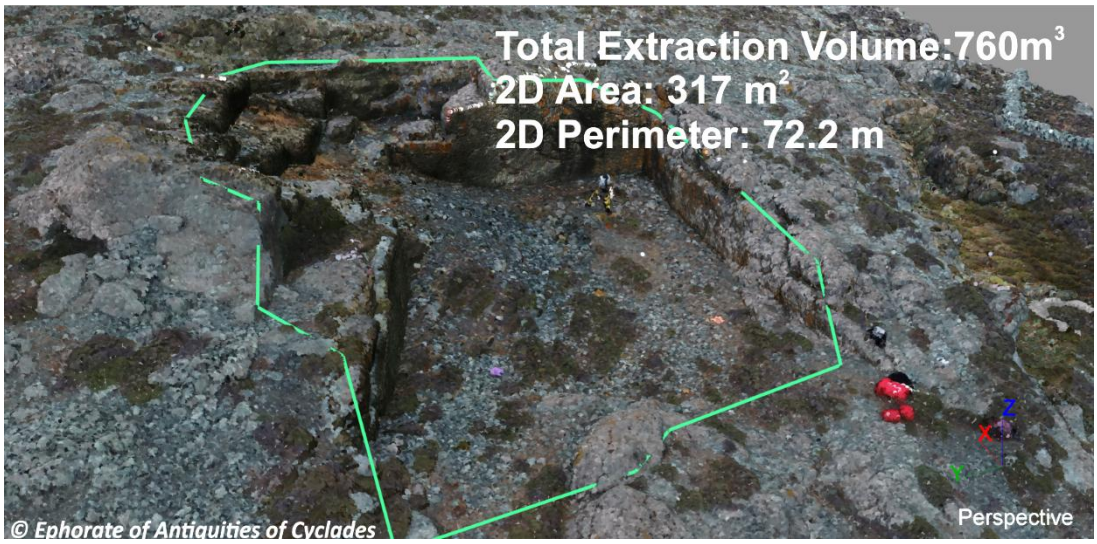

Fig 1. 3D view of the excavation area (Ras serpentinite quarry) and summary of geometric properties: Perimeter, Surface area and Volume calculation.

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P13. Digital Landscapes: Storymapping the Archaeology and Archaeometry of Wine in the Peloponnese

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The Peloponnese preserves one of the most continuous landscapes of viticulture in the Mediterranean, where archaeological, archaeobotanical, and historical evidence trace wine production from the Early Bronze Age to modern appellations. Archaeobotanical analyses have revealed carbonized grape remains and pips in settlement contexts from Lerna, Tiryns, and Asea, demonstrating the incipient domestication and processing of Vitis vinifera by the 3rd millennium BCE [1]. Complementary archaeometric studies on pithoi and organic residues further confirm fermentation activity and wine-related residue signatures in ceramic assemblages across the northeastern Peloponnese.

Regional archaeological surveys such as the Nemea Valley Archaeological Project (NVAP) have mapped the evolving relationship between settlement systems, terraced slopes, and vineyard microzones from the Bronze Age through the Classical period [2]. These datasets illustrate how viticulture shaped and responded to the geomorphology, hydrology, and transport routes of central Peloponnesian valleys. From the medieval period onward, the **Monemvasia-Malvasia relationship** provides an exemplary case of the transformation of local viticulture into a trans-Mediterranean commodity. Genetic and historical work [3] traces the linguistic and varietal lineage of *Malvasia* wines back to the fortified port of Monemvasia, a key Venetian entrepôt whose output was widely exported to Western Europe. This continuity is mirrored in later records of **Mantineia** and **Nemea**, today designated as PDO regions, where altitude, soil texture, and varietal diversity (Agiorgitiko, Moschofilero) sustain ancient terroirs through modern enological practice.

The present project integrates these initial archaeological and historical data into a digital interactive map built with LeafletJS, linking excavation reports, archaeobotanical datasets, and current vineyard distributions. The accompanying HTML narrative situates each site within its chronological and cultural context, illustrating how geography, climate, and human craft have co-produced the Peloponnesian wine landscape over five millennia.

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P14. The assessment of the efficacy of paintings' cleaning interventions through p-XRF analysis

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In the framework of paintings' conservation, the term "cleaning" is used in order to refer to the intentional removal of unwanted material(s), including surface contamination and decayed varnish(es) [1]. Traditionally, various liquids like organic solvents and aqueous solutions are used for the dissolution and removal of an unwanted phase, while the gel-based cleaning interventions -which are a rather recent development- are considered advantageous in comparison to the latter, since they allow for better control of the fluid release and, hence, the cleaning procedure. Regardless, however, to the means of cleaning, these interventions may impart pigment pick-up, causing thus alteration to the layers of the paintings. This phenomenon might in some cases go unnoticed by the unaided eye; hence identifying better means of monitoring it is crucial. In the current work, the authors explore the potentialities of X-ray fluorescence spectroscopy, a technique characterized by its high sensitivity and ability to detect most of the pigment-related chemical elements [2], in both the cleaned area and the gels surface, for the assessment of cleaning interventions conducted using novel green gels. The relevant analytical data is interpreted under the light of past studies on the effect of varnish removal on XRF analysis [3]. Results suggest that XRF can indeed be utilized in this framework, and highlight the potentialities of XRF as a useful tool for the assessment of cleaning interventions.

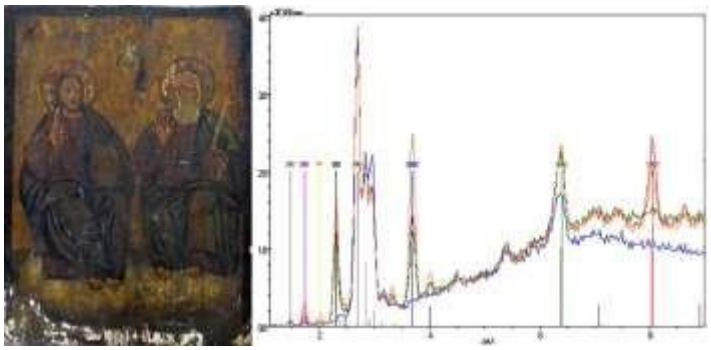

Fig. 1. Left: A late-19th century icon where cleaning tests were conducted. Right: XRF spectra from a pure gel (blue), and patches of the same gels used for conducting three successive applications on a given area of the painting (green, orange and red successively).

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P15. Conservation of a cooking pot from the Isthmia Archaeological Museum using 3D imaging and printing technologies

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The preservation of cultural heritage is one of the most significant challenges in modern society. As archaeological and cultural artifacts naturally deteriorate over time, the need for innovative, non-invasive preservation methods becomes increasingly urgent.

This study presents an innovative approach to the preservation of one vessel currently stored in the Isthmia Archaeological Museum. It is a deep globular cooking pot dating from the early 1st century C.E. that was found associated with a burial in the north cemetery at Kenchreai, the eastern port of Corinth.

This vessel (KP018), which represents a known type produced in the Corinthia during the first generations of the Roman Empire, was found broken into 92 sherds directly outside the tile-covered grave. It is an important artifact for understanding funerary rituals during the early years of the Roman port. Moreover, due to its condition, it offers a good test-case for new techniques of practical and digital conservation.

After bonding procedure of all fragments, material loss compromising the stability of the re- assembled object. Gap filling is considered one of essential stages in the restoration of archaeological pottery, primarily for aesthetic reasons, in addition to providing support for the body of the archaeological pottery.

To limit the intervention to its minimum, thus maintaining the object the closest possible to its original archaeological state, this study explores the use of advanced 3D imaging and printing technologies to digitally document and physically replicate the missing parts from the body of the archaeological cooking pot. By employing structured light scanning and additive manufacturing techniques, detailed digital model and precise physical replica of the significant artifact was created. A handheld 3D scanner was utilized for capturing intricate surface details, with post processing methods to refine and colorize the digital model.

P16. Μελέτη χρωστικών βιομηχανικών κτηρίων του 20ου αιώνα στην Καλαμάτα

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Η παρούσα μελέτη επικεντρώνεται στην ανάλυση των χρωστικών τριών βιομηχανικών κτιρίων, της καπνοβιομηχανίας «Καρέλια», των Κυλινδρόμυλων Μεσσηνίας «Ευαγγελίστρια» και του μεταξουργείου των αδελφών Στασινόπουλων, που τον 20ο αιώνα ανεγέρθηκαν κοντά στο Νέδοντα ποταμό και στο λιμάνι της Καλαμάτας. Σ΄ αυτά στεγάζονταν εύρωστες πρωτοβιομηχανίες, που επεξεργάζονταν κυρίως αγροτικά προϊόντα, που παράγονταν ή μεταφέρονταν στην πολίχνη.

Η ανάλυση των χρωστικών πραγματοποιήθηκε με τη χρήση του φορητού φασματογράφου XRF μοντέλο X-200 της SCIAPS. Ταυτοποιήθηκαν ανόργανες χρωστικές και η ανάλυση υποστηρίχθηκε από το λογισμικό Spectragryph.

Η χρήση φορητών μη-καταστροφικών τεχνικών αποκαλύπτει σημαντικότατες πληροφορίες όχι μόνο για τα τρία βιομηχανικά κτήρια της Καλαμάτας, που χαρακτηρίζονται μνημεία βιομηχανικής πολιτιστικής κληρονομιάς, αλλά και για την οικονομική ζωή της πόλης τον 20ο αιώνα.

P17. Multiscale investigation at the Kalo Nerò magoula (Larissa, Thessaly): from context to materials

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The archaeological survey project in the Karadagh district (1) (central-eastern Thessaly) has identified the *magoula* of Kalo Nerò (*Κορυφή*)(1) as a key site for investigating continuous occupation spaces in the region, as evidenced by the rich and diverse ceramic and lithic material collected from archaeological surface survey. The identification and morphological characterization of the site derived from the integrated use of a wide set of multiscale technologies spanning from remote sensing (satellite / aerial imagery), drone photogrammetry and fieldwalking survey, while its interpretation is founded on previous studies (some of which with stratigraphic data), particularly the work of K. Gallis (3).

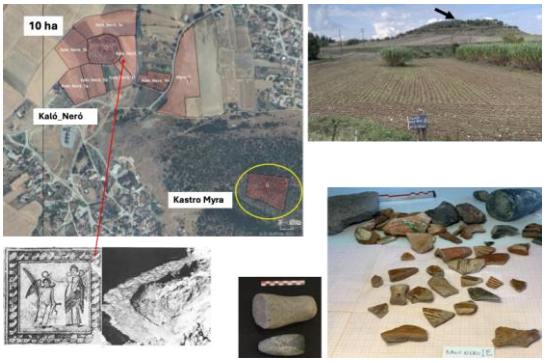

Fig. 1. Kaló Neró magoula: location, context and materials (b/w picture from Gallis, 1992).

The ceramic assemblage collected from the terrain covers a wide chronological range, from Neolithic to post-Byzantine periods. A preliminary multi-analytical study was experimented on a selected class of fragments, employing non-invasive and non-destructive techniques. Among these, portable optical microscopy and macrophotography were used to examine the ceramic fabrics, with particular attention to inclusions and voids in the matrix—features that can offer insights into production technologies and distinguish between local and imported wares.

The integration of traditional archaeological study approaches with advanced, portable diagnostic tools applied at different scales demonstrates a replicable strategy for the study of multi-period and stratigraphically complex sites within the landscapes of Thessaly.

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P18. The challenge of 3D Scanning and printing copies in Natural History museum exhibits

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Η εξέλιξη των εφαρμογών ψηφιακής απεικόνισης καθώς και η ανάπτυξη τεχνολογιών που βελτιώνουν την επεξεργαστική ισχύ καθώς και ελαχιστοποιούν τον όγκο των δεδομένων έχουν συμβάλει καθοριστικά στην ανάπτυξη των τρισδιάστατων εκτυπωτών. Το πεδίο εφαρμογής τους επεκτείνεται συνεχώς σε πληθώρα τομέων. Ο χρόνος συρρίκνωσης που απαιτείται για την ανάπτυξη προσαρμοσμένων προϊόντων με το χαμηλότερο δυνατό κόστος και η χαμηλότερη δυνατή πιθανότητα αποτυχίας είναι παράγοντες που αποδεικνύουν ότι οι δυνατότητες που προσφέρει αυτή η τεχνολογία για το μέλλον είναι αμέτρητες.

Η χρήση της τρισδιάστατης σάρωσης και της τρισδιάστατης εκτύπωσης κερδίζει έδαφος στον τομέα της διατήρησης και ανάδειξης της πολιτιστικής κληρονομιάς ως τεχνική για τη δημιουργία πιστών αντιγράφων αντικειμένων που μπορούν να χρησιμοποιηθούν για εκπαιδευτικούς και ερευνητικούς σκοπούς. Ιδιαίτερα τα εύθραυστα αντικείμενα πρέπει να διατηρούν την ακεραιότητά τους. Σε αυτή την ερευνητική εργασία, εκθέματα από Μουσείο φυσικής ιστορίας σαρώθηκαν προκειμένου να εκτυπωθούν πιστά αντίγραφα που θα χρησιμοποιηθούν ως εκπαιδευτικό υλικό στο μουσείο. Πρωτίστως, η χρήση αντιγράφων μουσειακών εκθεμάτων μπορεί να μεταδώσει στον επισκέπτη μιας έκθεσης πολλαπλά μουσειολογικά μηνύματα και να προσφέρει μια ολοκληρωμένη μουσειακή εμπειρία (όταν τα πρωτότυπα εκθέματα είναι αδύνατο να εκτεθούν λόγω υψηλού κόστους μεταφοράς από τις αποθήκες στην έκθεση, γραφειοκρατίας ή σπανιότητας της ίδιας της συλλογής). Επιπρόσθετα, η κακή κατάσταση διατήρησης ενός εκθέματος, η ευπάθεια του δομικού υλικού (συμπεριλαμβανομένων εύθραυστων κελυφών σε όστρακα, καρκινοειδή ή απολιθώματα της Συλλογής Helmi) καθώς και ο κίνδυνος επιδείνωσης της φθοράς τους λόγω κακού χειρισμού ή ακατάλληλων συνθηκών μικροκλίματος καθιστούν απαραίτητη την έκθεση αντιγράφων.

Η τρισδιάστατη εκτύπωση είναι μια εναλλακτική πρακτική - δεδομένου ότι αντιτίθεται στην «παραδοσιακή» απαγόρευση αφής αντικειμένων στα μουσεία, ενώ η χρήση μουσειακών αντιγράφων σε εκπαιδευτικά προγράμματα προσφέρεται στην περίπτωση ειδικών ομάδων κοινού, όπως μικρά παιδιά, άτομα με άνοια ή νοητική υστέρηση, άτομα με προβλήματα όρασης κ.λπ., που μπορούν να κατανοήσουν το έκθεμα μέσω της αφής.

Τέλος, η τεχνική τρισδιάστατης σάρωσης χρησιμοποιείται για την εικονική αναπαράσταση ενός πλήρους αντιγράφου ενός εκθέματος, διατηρώντας όλες τις λεπτομέρειές του, έτσι ώστε να υπάρχει μια ψηφιακή αναπαράσταση που μπορεί να έρθει σε φυσική μορφή χρησιμοποιώντας τρισδιάστατη εκτύπωση.

P19. Digitizing Hellenistic Thessaly: Techniques, Applications, Models and Use

Konstantina Karpeti

PhD Candidate, University of Messina

This poster will present some of the problematic, methods and results of my PhD project with the title *'La presenza macedone in Tessaglia tra l'età Classica ed Ellenistica'*, currently still in progress. The project's main goal is the study and better understanding of the large-scale changes attested by ancient sources to have happened to Thessaly after its annexation to the Macedonian kingdom in the mid-4th c. B.C. while also, documenting the Thessalian landscape of the Hellenistic period. 11 sites in Thessaly (in the jurisdictions of the Ephorates of Larissa, Trikala, Karditsa e Phtiotida and Evritania) have been subjected to rigorous investigation through non-invasive techniques in order to document and ascertain the changes that transgressed the region throughout the Macedonian occupation (ca. mid-4th c. - 197 BC). The aforementioned techniques are: satellite remote sensing, survey fieldwork, drone survey, photogrammetry, creation of 3D models, DEMs and high-resolution maps as well as the design of architectural remains, construction of a GIS database for the organization of the finds.

The use of the multi-disciplinary approaches of the so-called "Digital Archeology" combined with traditional archeological methods such as the use of ancient literary sources and archeological survey can maximize the results and potentially change the perspective of the study of this region. At the same time, the digitization process of the cultural heritage sites adds to the conversation of the digital preservation of archeological sites through databases as many sites in Thessaly, and many of the ones studied in this project are private lands cultivated or unreachable in mountain peaks or inside valleys.

P20. A first insight into clayey raw materials of Lesvos island through a petrographic and geochemical approach

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Over the last years several archaeological and ethnographic studies have been focussed on the investigation of pottery production in the East Aegean and Asia Minor (Hein et al., 2008). However, the determination of the origin of production of specific pottery wares particularly on Lesvos turned out to be a complex topic. The present study focuses on examining the petrographic and compositional variation of clayey raw materials potentially used for pottery production in Lesvos. After a detailed literature review, 39 clayey raw materials were collected from 23 deposits at different locations on the island, preferably in proximity to ancient and historic settlements. The samples were cleaned and sieved, and experimental briquettes were prepared and fired under controlled conditions (700°C, 900°C, 1050°C) in a laboratory muffle furnace. Petrographic analysis was performed on thin sections prepared from the briquettes using a polarizing microscope, whereas their elemental composition and micro-structure were examined with pXRF and SEM-EDS techniques, respectively. The petrographic assessment helped to establish the following fabric groups:

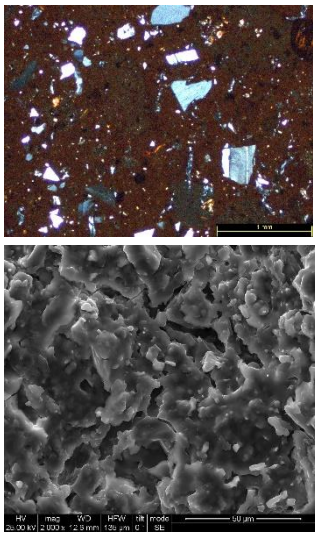

Fig 2. a) Photomicrograph from sample of Group A, b) Electron SEM micrograph of the same sample.

- Group A-Igneous group (the largest group): quartz, feldspars, biotite.
- Group B-Igneous-metamorphic group: quartz, feldspars (more plagio-clase), biotite, amphiboles.
- Group C-Metamorphic group: quartz, plagioclase, amphiboles.
- Group D-Calcitic group: quartz, calcite.

Preliminary results from pXRF indicate clayey raw materials with distinct elemental compositions presumably related to different geochemical contexts. Combined with the SEM-EDS results they have demonstrated 2 major chemical groups based on the CaO content of the clay paste. The first group includes samples from as the Agiasos and Thermi areas with a comparably high CaO content (7-20 wt%), while the second group encompasses samples from Mandamado, Mesotopos and Arisvi areas with a significantly lower CaO content (<4 wt%). The pXRF and SEM-EDS provided a more detailed categorization of the raw materials. For further analysis of the experimental briquettes complementary techniques such as X-ray Powder Diffraction (XRPD) and neutral activation (NAA), will follow to complement the research.

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P21. Pottery Production at Early Iron Age Gortyn, Crete: First Archaeometric Characterization on Ceramic Fragments from the Sanctuary of Apollo Pythios

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This poster presents the first archaeometric results from ceramic fragments recovered in 2019 at the sanctuary of Apollo *Pythios* in Gortyn, Crete. The assemblage spans from the Protogeometric to the Archaic period, providing an opportunity to study the development of ceramic production in Southern Crete during the Early Iron Age [1,2].

The analysis was performed on 46 ceramic sherds, consisting of a petrographic characterization through optical microscopy applied in 17 coarse-grained samples, chemical analysis through X-Ray Fluorescence to identify the major, minor, and trace elements of 20 of the samples; and all the samples were characterized in terms of mineralogical composition through X-Ray Powder Diffraction. The archaeometric data were statistically treated through cluster analysis and principal component analysis, and combined with the material's typo-chronological and macroscopic evaluation. The results reveal both continuity and transformation in paste preparation and fabric selection, hinting at a preference for typologically-driven ceramic recipes that seem to stay rather consistent throughout these archaeological periods. This work represents the first application of archaeometric methods in archaeological materials from Gortyn, offering valuable insights into local craft traditions and socio-cultural dynamics at a key site in the Messara plain in Southern Crete. This study also contributes to broader discussions on material culture, ritual practices, and community formation during the first centuries of the Cretan polis.

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P22. Tracing technological choices for pottery production in Late Bronze Age-Early Iron Age central Epirus: preliminary petrographic results

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During the Early Iron Age (EIA) (late 10th–late 8th centuries BCE), Etruria (central Italy) underwent significant sociocultural changes and fundamental innovations, leading to various social, political, and economic developments. Throughout these transformative shifts, numerous proto-urban sites appeared in the region exhibiting the so-called Villanovan material culture.

Villanovan pottery has been substantially studied from a stylistic perspective. However, significant research questions regarding its production and circulation in Etruria remain unaddressed. By analysing Villanovan pottery from this region, this study aims to shed light on pottery production and, through this, on the technological, economic, and sociocultural aspects associated with the development of proto-urban centres in Etruria during the EIA period.

To achieve this, an interdisciplinary approach—including thin-section petrography and WD- XRF—was applied to pottery samples from four key EIA centres in Etruria: Vulci, Tarquinia, Cerveteri, and Veio, as well as to geological samples collected around these settlements, based on a systematic sampling of all geological formations and clay sources. This approach aimed to investigate the technological characteristics and provenance of the pottery, elucidate the organisation of its production, and explore its potential circulation among the proto-urban sites.

The results of this study demonstrate a high degree of variability in paste recipes within each proto-urban centre, providing significant insights into raw material selection and processing, as well as the organisation of pottery production. Additionally, the findings indicate the circulation of pottery among different centres, highlighting patterns of inter-regional interactions. For the first time, this work provides a robust reference study for investigating pottery technology and circulation in Etruria and the broader Mediterranean basin during the early 1st millennium BCE.

P23. Experimental Clay Mixtures as a Diagnostic Tool for Ancient Ceramic Production in the Northern Peloponnese

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Several petrographic and ethnographic studies indicate that traditional potters often mixed different types of clay to produce composite pastes for pottery making. It is believed that this practice was also employed in antiquity but identifying it in archaeological ceramics remains challenging due to the thorough blending of materials and the natural heterogeneity of clay sources. Within the fields of ceramic petrography and ancient pottery technology, only a limited number of studies have examined clay mixing in detail, resulting in a lack of clearly defined diagnostic criteria and terminology.

The present study seeks to address this gap by investigating clay mixing through petrographic and mineralogical analysis of raw materials. A total of 18 clay samples from Corinthia and Eastern Achaea, two Northern Peloponnese regions well known for their ancient ceramic production, were used. The selection was based on their CaO content covering a wide range from non- calcareous to calcareous clays. To detect possible indicators of intentional clay mixing, 19 experimental mixtures were prepared following in-house established procedures. For each mixture, a total of 4 briquettes were produced using both wet and dry mixing methods and were fired at 700°C and 900°C.

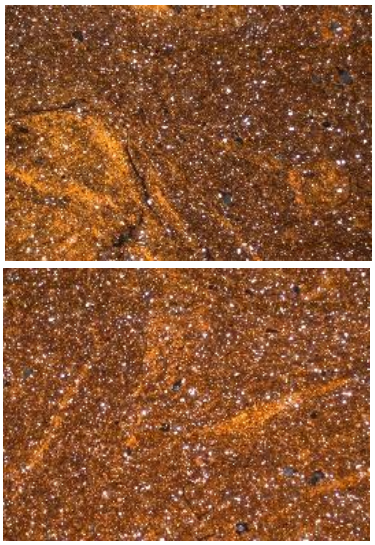

Figure 2: Photomicrographs of the experimental briquettes.

The analytical techniques employed included X-ray Powder Diffraction (XRPD) and petrographic analysis through thin sections observation employing a polarising microscope. The mineralogical analysis of the experimental samples showed that the clay mixtures could be classified into calcareous and non-calcareous types. Petrographic analysis allowed for the classification of these raw materials into distinct petrographic groups based on grain size and clay mixing textural features.

The study confirms the inherent difficulty in proving intentional clay mixing, as the resulting features can resemble those formed naturally. Nonetheless, the results offer valuable comparative data that may be applied in future studies of ancient ceramics from the broader region, contributing to the resolution of archaeological questions.

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P24. Early Iron Age and Archaic Pottery from Karabournaki of the Thermaic Gulf. Archaeometric Analysis of Local and Imported Pottery Samples

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The study presents the examination results of local and imported pottery samples from Karabournaki. The excavation of the cemetery of the Early Iron Age of Karabournaki in Thessaloniki offered us a set of pottery including vessels of all the so-called local groups of the ~~local~~ pottery production in the region of the Thermaic gulf. The following categories are represented: a. Wheeled-made pottery with geometric decoration, consisted mainly of pendent semi-circle skyphoi and one handled spouted phialae with the same decoration, b. Handmade pottery, including phialae with or without spout usually with incised decoration and rarely painted, c. Grey handmade pottery, consisted of a cutaway jug and d. Monochrome egg-shell pottery, which is represented by two of the most popular shapes of this class, a footless cup and an olpe. Two skyphoi with geometric decoration, are differentiated by the rest and characterized potentially as euboean imports.

There were chosen 23 small samples (with diameters 2-10 mm) from already damaged areas investigated using stereomicroscopy, polarized light microscopy (PLM), Xray- spectroscopy (XRF) and Scanning Electron Microscopy (SEM-EDX).

The ceramic assemblage under examination consists of two groups which differ typologically and technologically: 1) the first group includes two imported vessels from Evia and 2) the second includes 21 local vessels.

The local pottery is classified typologically into five sub-groups: 1) Corinthian imitations, 2) Geometric wheel thrown vases, 3) Egg shell pottery, 4) Handmade pottery, 5) Grey-ware.

Their chemical and mineralogical compositions present some peculiarities, which are mainly related to the difference in the quantity of non-plastic grains and not to their mineralogical type. The clay in all samples is fine-grained. Concerning the differentiation of the ceramic materials regarding the size and the shape of the vessel, it is observed that the fine grain composition is found also on conceivably bigger vessels. It was also observed that the same type of clay has been used from the LG period up to the late archaic times with the only change in the firing conditions. The early vessels were fired in oxidized conditions while the latter in reducing atmosphere.

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P25. Ceramic Identities and Cultural Interaction in Classical Western Achaea: An Integrated Archaeological and Archaeometric Study

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Recent archaeological investigations in the northwestern Peloponnese, particularly in the rural zone of western Achaea (Dymaia Chora), have brought to light a number of sites— predominantly cemeteries— characterized by substantial ceramic assemblages. Particularly noteworthy is the discovery of a large ceramic kiln situated in close proximity to burial contexts, indicating the presence of a local production center closely associated with funerary practices. The selected assemblage comprises ceramic vessels recovered from cemeteries, particularly those in the immediate vicinity of the kiln, dating to the 5th and 4th centuries BCE. These vessels are especially significant, as they represent a defining element of the local ceramic repertoire.

The study integrates stylistic analysis with a range of archaeometric methodologies to investigate the composition, production, and distribution of the ceramic assemblage. Petrographic and mineralogical analyses were employed to examine the characteristics of the ceramic fabrics, revealing notable variations in clay composition, inclusions, and texture. These differences indicate the presence of both imported wares and locally manufactured products, pointing to a complex pattern of ceramic circulation and production within the region. In particular, thin-section petrographic analysis proved instrumental in identifying the specific types of tempering materials used in the ceramic matrix, as well as in reconstructing aspects of the firing technologies applied during production. This analytical approach allowed for the systematic classification of ceramic groups based on their raw material sources and technological attributes, providing a clearer picture of their provenance and the chaîne opératoire behind their manufacture.

This interdisciplinary approach not only refines the provenance of the ceramics but also enhances our understanding of the organization of ceramic production in the region. Moreover, it sheds light on broader patterns of interaction and exchange, offering evidence for interregional connectivity and the integration of western Achaea into wider socio-economic networks during the Classical period. The results also enhance interpretations of funerary practices by contextualizing ceramics within mortuary settings, thereby contributing to the reconstruction of social identities, craft specialization, and economic dynamics within the rural landscape of western Achaea.

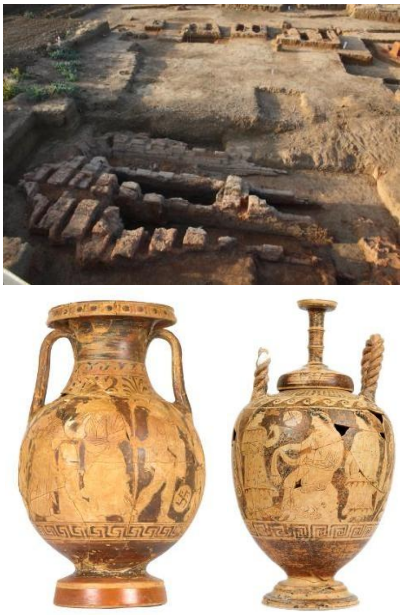

Figure 1: The large ceramic kiln of the local workshop (up) and red-figured vessels probably produced by the same workshop in Western Achaea (down).

P26. Seeing the Unseen: Machine Learning in Ceramic Petrography for Clay Mixing Identification

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Ethnographic and archaeometric studies have shown that potters used to mix clays to enhance performance characteristics of ceramic vessels according to their intended use. However, identifying such mixtures in archaeological ceramics remains challenging, partly due to limited petrographic studies and the absence of well-defined diagnostic criteria. This study investigates the role of the rapidly developing field of machine learning to archaeometric research with the goal of facilitating the detection of clay mixture through image-based analysis of thin sections. Selected calcareous and non-calcareous clays from the regions of east Achaea and Corinthia in the northern Peloponnese, Greece, were mixed under both dry and wet conditions, to produce experimental briquettes. These were fired at 700°C and 900°C and thin sectioned, permitting their recording as photomicrographs under the polarizing microscope. A supervised machine learning approach was followed by using Python and a combination of YOLOv11-cls models, a convolutional neural network (CNN) developed for image classification (Jocher G. et al., 2023). After 24 experimental runs, two distinct models, Model A and Model B, were selected based on performance across a test set and an inference set (which includes images with characteristics not seen during training such as coarser samples). Both models used the YOLOv11s-cls and were trained over 100 epochs. Also, both models utilized the SGD optimizer. They differed only in learning rate: 0.0003 for Model A and 0.001 for Model B.

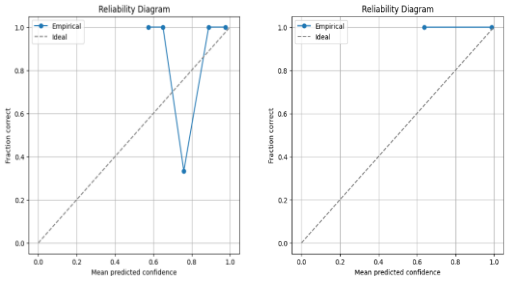

Figure 3. Reliability Diagrams: Model A (left), Model B (right).

Among the trained models, two (Model A and Model B) demonstrated high classification accuracy, exceeding 92%. While Model B showed slightly superior validation metrics, Model A exhibited more consistent and generalizable performance on unseen, complex samples. Model A shows a well-calibrated range of confidence scores with a reliability dip at 0.75, while Model B maintains high confidence aligned with validation accuracy but may be overconfident on unseen data. These results highlight the value of machine learning, particularly CNN-based approaches, in supporting ceramic petrography by identifying compositional patterns that may elude traditional observation.

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P27. Preliminary Results from Geometric Morphometric Analysis of the Mycenaean Shaft Graves: Investigating Standardisation and Diversity in a Synchronic and Diachronic Context

David Brown

National and Kapodistrian University of Athens

This paper presents some preliminary results from the first case study of an ongoing PhD project at the National and Kapodistrian University of Athens. The project investigates diversity and standardisation in artefact production during the Late Bronze Age of the Peloponnese.

This more exhaustive research combines three analytical approaches- Geometric Morphometrics (GMM), portable X-ray fluorescence (pXRF), and contextual analysis- applied to two distinct case studies:

- Case Study One (Synchronic): The metal artefact assemblages from the Shaft Graves at Mycenae (Grave Circles A and B) examine diversity within a relatively short time frame and single-site context.
- Case Study Two (Diachronic): A long-term perspective on shape and material variation in swords and daggers from multiple Late Helladic sites in the Peloponnese.

This presentation focuses exclusively on the preliminary results of the synchronic study, which used 2D Geometric Morphometrics to assess morphological variation in bronze swords from the Shaft Graves. High-resolution photographs and digitised illustrations were processed using landmark- and outline-based GMM, followed by multivariate analysis (including PCA and cluster analysis) to examine form diversity.

Initial results reveal a notable range of shape variability among swords traditionally grouped within the same typological categories. This suggests that the finer morphological characteristics differ significantly despite surface-level standardisation in the broad form.

These variations may point to workshop/men-level distinctions, individual craftsperson's preferences, or intentional variation reflecting social identity and symbolic meaning within elite burial practices.

The results also demonstrate the feasibility and robustness of GMM as a methodological tool for investigating formal variability across a diverse set of metal artefacts in a synchronic mortuary context.

These findings lay the groundwork for integrating material (pXRF) and contextual data, which will be addressed in later stages of the project. Ultimately, this research aims to produce an open-access digital database, refine typological frameworks, and enhance our understanding of craft production and elite material culture in the Aegean Bronze Age.

P28. Ceramics supply in Bronze Age Crete (1700- 1200 BC). An interdisciplinary approach to pottery traditions

Dauby Nikita

UCLouvain-FSR Fellow, INCAL/CEMA, Aegis

Minoan Crete is distinguished by its extremely abundant ceramic production. While this material has primarily been examined through typo-stylistic analyses aimed at establishing the chronological sequences of archaeological sites, it also offers valuable insights into the interactions between producers and consumers. In this context, ceramics serve as evidence for reconstructing the *chaînes opératoires* of production, as well as the practices surrounding the consumption of these vessels. By combining different levels of analysis in a multiscale methodology (macroscopic, petrographic and X- ray diffraction), our current research project aims to identify distinct production series within the ceramic assemblages studied, focusing on the tableware, in order to define the organisational structure of the pottery industries, and to document practices of ceramic tableware consumption and supply of local communities. The study focuses on two neighbouring settlements located on the north-eastern coast of Crete, Sissi and Malia, with a diachronic perspective, i.e. from the Neopalatial to the end of the Postpalatial period (ca. 1700-1200 BC).

This poster presents the preliminary results of the study and analysis of a single ceramic assemblage from Sissi. Located on the summit of the Bouffos hill, in the open area to the south of Building CD, the pit 87 consists in a homogeneous secondary ceramic deposit, dated to a middle stage of Late Minoan IIIB (ca. 1250 BCE). The petrographic analyses were carried out at the Malcolm H. Wiener Laboratory for Archaeological Science (ASCSA) and the X-ray diffraction analyses at the Minerals and Rocks Research Laboratory (University of Patras). The preliminary results have revealed two main petrographic groups among the tableware: one buff calcareous group and a red low calcareous one. According to estimated firing temperatures thanks to X-ray diffraction analysis, some subgroups have been identified. By comparing these results with the variety of the typo-stylistic repertoire, it is possible to discern specific patterns indicative of distinct production series.

P29. NDT measurements of Low-fired Native American Earthenware from Central Virginia, United States

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Native Americans used low-fired earthenware ceramics in the southeastern United States for domestic activities from about 2500 BC. In more northerly located Virginia, ceramic use begins around 1200 BC and approximately 50 regional styles of pottery have been defined for archaeological cultures that persisted to around AD 1600.

These materials constitute our data set for the development and application of ceramic rehydroxylation dating by infrared spectroscopy. Central to the development of this method is the recognition of changes in the ceramic molecular structure during firing that distort the crystalline structure of the matrix. These changes impact the rate of post-firing rehydroxylation (ambient hydroxyl diffusion) and the form of the diffusion coefficient.

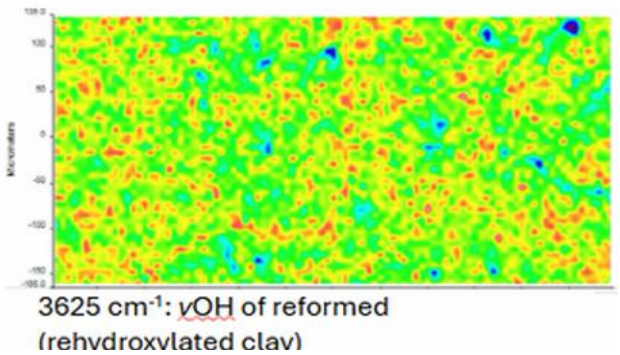

Fig 3. IR Reflectance Imaging 4000-650cm^{-1} Sample 6.

We employ external reflectance micro-Fourier transform infrared (ER-μFTIR) spectroscopy for the non-invasive analysis of the chemical composition of clay that includes the characterization of its crystal structure and presence of functional groups. It is proposed that the remaining crystalline/amorphous structure is critical to understanding the rehydroxylation process.

The main spectral analysis was conducted using transmission FTIR, while the identification of the peaks was further confirmed by ER μIR reflectance measurements. We also use Raman spectroscopy on 6 samples from different time periods to identify minerals that help us constrain the specific ceramic firing temperature and the amount of crystalline material remaining in the ceramic. The preservation of cultural heritage is one of the most significant challenges in modern society. As archaeological and cultural artifacts naturally deteriorate over time, the need for innovative, non-invasive preservation methods becomes increasingly urgent.

P30. Study of the manufacturing technology and physicochemical analysis of surface encrustations of ceramic sherds from the Early-Middle Neolithic site of Koutroulou Magoula excavation of Koutroulou Magoula near Neo Monastiri and Vardali in Fthiotida, Central Greece

Vasiliki Ioannou[1], Stamatios Boyatzis[1], Alexios Stefanis[1], Yannis Hamilakis[2], Nina Kuparissi-Apostolika[3], Styliani Katsarou[3], and Yorgos Facorellis[1]

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The Early-Middle Neolithic site of Koutroulou Magoula [1] is located near Neo Monastiri and Vardali in Fthiotida (39° 13′ 15′′ N, 22° 17′ 25′′ E) in central Greece [2]. This study focuses on the analysis of fifteen (15) Neolithic ceramic sherds recovered during the excavation at the site [3]. The aim is to investigate both their manufacturing technology and the nature of the black surface encrustations. The samples were recovered from a peripheral ditch surrounding the prehistoric settlement, and this study examines whether the surface alterations can be attributed to the prolonged presence of stagnant water within the ditch.

A multi-analytical approach was employed, involving X-ray diffraction (XRD), Fourier-transform infrared spectroscopy (FTIR), X-ray fluorescence (pXRF), and scanning electron microscopy with energy-dispersive X-ray spectroscopy (SEM/EDX). Additionally, optical microscopy was used for macro- and micro-morphological observation. The analysis included the conversion of elemental percentages to oxides, statistical evaluation, and the construction of comparative diagrams for interpretive support.

The results revealed strong variation in surface deposits, with high concentrations of Cl, P, and Mn in the outer layers, evidence of microbial activity, and formation of zeolitic phases such as Gismondine. The ceramic body analysis indicated homogeneity of raw materials, use of natural clays, presence of minerals like quartz and illite, and low firing temperatures (<850°C); interestingly, kaolinite in fresh state was detected in a number of encrustations, suggesting hydrolytical action on ceramic silicates. All findings support the interpretation that the encrustations are of post-depositional origin, not the result of technological treatments. Crucially, the multi-technique dataset confirms that their formation is directly linked to prolonged exposure to stagnant water.

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P31. Συγκριτική μελέτη τεχνολογίας Βυζαντινής εφυαλωμένης κεραμικής σε ευρήματα ανασκαφών στην πόλη και την περιφέρεια της Θεσσαλονίκης

Αλεξάνδρα Σοφιανοπούλου[1], Τηλέμαχος Γρηγόριος Σταμκόπουλος[2]

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[2] Εργαστήριο Ψηφιακής Καινοτομίας στη Θεολογία και στον Πολιτισμό, Τμήμα Κοινωνικής Θεολογίας και Χριστιανικού Πολιτισμού, ΑΠΘ

Η βυζαντινή κεραμική προσφέρει τα τελευταία χρόνια ένα ευρύ πεδίο έρευνας με ιδιαίτερο ενδιαφέρον τόσο αρχαιολογικό όσο και αρχαιομετρικό. Από τα βυζαντινά κεραμικά αντλούμε πολύτιμη πληροφορία για την ιστορία κάθε περιοχής της Ανατολικής Ρωμαϊκής Αυτοκρατορίας είτε αυτή σχετίζεται με σημαντικά ιστορικά γεγονότα είτε αφορά στον καθημερινό βίο και την κοινωνική διαστρωμάτωση.

Στην παρούσα εργασία γίνεται μία προσπάθεια σύγκρισης και ή δυνατόν συσχετισμού της τεχνολογίας κατασκευής εφυαλωμένων κεραμικών προερχομένων από το Ιστορικό Κέντρο της Θεσσαλονίκης με εφυαλωμένα κεραμικά από την Περιφέρεια της Θεσσαλονίκης.

Για την πλήρη αξιολόγηση της τεχνολογίας της διαθέσιμης βυζαντινής κεραμικής ήταν αναγκαίο να ληφθούν δείγματα και από τα τρία στρώματα των κεραμικών (πηλός- επίχρισμα- υάλωμα). Η δειγματοληψία πραγματοποιήθηκε κατόπιν άδειας του Τμήματος Έρευνας της Διεύθυνσης Συντήρησης Αρχαίων και Νεωτέρων Μνημείων του ΥΠΠΟΑ. Ένα τμήμα των δειγμάτων κονιοποιήθηκε για τη μελέτη της ορυκτολογικής τους σύστασης με την τεχνική της περιθλασιμερίας κόνεως ακτίνων-Χ (PXRD), ενώ το υπόλοιπο χρησιμοποιήθηκε ως έχει για τη στοιχειακή τους ανάλυση και τη μορφολογική τους μελέτη με την τεχνική της ηλεκτρονικής μικροσκοπίας (SEM-EDS).

P32. Compositional analysis of Early Iron Age pottery from Etruria: Insights on the development of proto-urban centres

Efraim A. Andreadakis[1], Bianca Costi Farias[1,2], Giulia Deimichei[1], Maria Diakatou[1], Simone Grosso[3], Lara Maritan[2], Lionello Morandi[1,5], Baptiste Solard[1], Silvia Amicone[1,4]

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During the Early Iron Age (EIA) (late 10th–late 8th centuries BCE), Etruria (central Italy) underwent significant sociocultural changes and fundamental innovations, leading to various social, political, and economic developments. Throughout these transformative shifts, numerous proto-urban sites appeared in the region exhibiting the so-called Villanovan material culture.

Villanovan pottery has been substantially studied from a stylistic perspective. However, significant research questions regarding its production and circulation in Etruria remain unaddressed. By analysing Villanovan pottery from this region, this study aims to shed light on pottery production and, through this, on the technological, economic, and sociocultural aspects associated with the development of proto-urban centres in Etruria during the EIA period.

To achieve this, an interdisciplinary approach—including thin-section petrography and WD- XRF—was applied to pottery samples from four key EIA centres in Etruria: Vulci, Tarquinia, Cerveteri, and Veio, as well as to geological samples collected around these settlements, based on a systematic sampling of all geological formations and clay sources. This approach aimed to investigate the technological characteristics and provenance of the pottery, elucidate the organisation of its production, and explore its potential circulation among the proto-urban sites.

The results of this study demonstrate a high degree of variability in paste recipes within each proto-urban centre, providing significant insights into raw material selection and processing, as well as the organisation of pottery production. Additionally, the findings indicate the circulation of pottery among different centres, highlighting patterns of inter-regional interactions. For the first time, this work provides a robust reference study for investigating pottery technology and circulation in Etruria and the broader Mediterranean basin during the early 1st millennium BCE.

P33. Preliminary study with pXRF of Byzantine gold jewelries from the Canellopoulos Museum in Athens

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The collection of the Paul and Alexandra Canellopoulos Museum (CAMU) in Athens offers an overview of 6,000 years of Hellenic and Mediterranean history, art and culture. In an effort to shed light on lesser-known artefacts from the CAMU collections for both scholarly and general audiences, we undertook a study of Byzantine gold jewelery pieces. The assemblage comprises pectoral amulets, rings, crescent-shaped earrings, and a bracelet adorned with niello decoration. These jewelery pieces date from the 6th to the 14th century, with the majority attributed to the 6th–7th centuries. Given the limited information regarding their provenance and manufacturing techniques, this case study aimed to conduct a combined archaeological, archaeometric and technological analysis of the artefacts in order to investigate Byzantine gold-working technology and its evolution over time. In order to assess the elemental composition of the ornaments, the physicochemical analysis was carried out using a portable X-Ray Fluorescence Spectroscopy (pXRF). The Byzantine goldsmiths produced intricate and symbolic metalwork, particularly gold, for various purposes, including jeweler and religious objects. During Byzantine period, gold was often used to represent divine light and spiritual transcendence. The results of the analysis of the Byzantine gold ornaments of the CAMU collection proved that the artisans used a high variety of alloys as well as complicated ways to depict the designs. It becomes evident that the archaeometric findings not only reflect the social and economic prosperity of each historical period, but also illuminate the intrinsic connection between artisanal techniques and technological development.

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P34. Detecting Alloys and Technological Choices in Archaic and Classical period Copper-Based Votive offerings from the Sanctuary of Demeter at Thea Patras

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This study examines an assemblage of copper-based votive objects from the Sanctuary of Demeter at Thea Patras, excavated by the ST Ephorate of Antiquities between 2003 and 2005. The sanctuary is the only Archaic-Classical site of its kind in western Achaia and holds valuable insights into ancient ritual practices, production methods, and trade connections in the region.

Using non-destructive micro-XRF analysis, I will characterize the elemental composition of these bronze artifacts, with a focus on alloy types, manufacturing techniques, and potential production sources and recycling. The surface analysis allows the identification of alloy types and contributing to an understanding of ancient technological choices. Additionally, by detecting trace elements like arsenic, silver, and nickel, micro- XRF analysis provides insights into the potential provenance of the raw materials and suggests possible trade routes and resource exchange mechanisms.

This research will enrich our understanding of the sanctuary's economic role, its interactions with external cultural influences, and its role within the Peloponnese, the Aegean and the broader Mediterranean trade networks during the Archaic, Orientalizing and Classical periods.

P35. Micro-invasive XRF analysis of copper-based artefacts from the Altar and Baths complex on Mount Lykaion in Arcadia, Greece

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The Pan-Arkadian Sanctuary of Lykaios Zeus is located on Mt. Lykaion in western Arcadia, Peloponnese, Greece. At the peak of the mountain lies the open-air Ash Altar, which served as the primary ritual site and exhibits evidence of continuous use from the Neolithic through the Roman period. Cultic athletic games were held in the Lower Sanctuary, which houses the Stadium, Hippodrome, and Gymnasium complex. Within the Gymnasium, a potential swimming tank was identified, surrounded by various rooms, one of which contained two stone basins. An area designated as the "Baths" was excavated in the northern square room of the Gymnasium. The excavations were part of a collaborative research program conducted by the Ephorate of Antiquities of Arcadia and the American School of Classical Studies from 2016 to 2022.

The copper-based assemblage recovered from the Altar and Baths included 55 artefacts and metal fragments dated from the 8th to 4th centuries BCE. Elemental analysis was performed using micro-invasive X-ray fluorescence (micro-XRF) spectrometry on corrosion-free surfaces. The results indicate that the majority of artefacts (42 out of 55) were composed of a binary copper-tin alloy. A notable object—a sheet bearing a 22-row *stoichedon* inscription inscribed left-to-right—is also composed of binary bronze. The average tin content across the assemblage is approximately 9.5 ±4 wt%. Trace elements, such as lead, arsenic, and others, commonly associated with ancient copper-based alloys, were also detected. The assemblage from the Baths' area is composed almost entirely of unalloyed copper, primarily rivet heads, which likely served as construction elements.

Beyond the compositional results, this study also examines the aesthetic dimensions of these copper alloys, particularly those deposited at the Altar, by correlating the XRF data with experimental datasets of modern copper-tin alloys. Through this comparison, it is possible to infer the original colour and appearance of these artefacts, offering further insight into the aesthetic and symbolic preferences that shaped ancient metallurgical practices.

P36. Technical Examination and Analysis of Roman Gold Jewelry from the Archaeological Museum of Thessaloniki

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Although early ancient goldsmithing technologies have been the subject of extensive scholarly research, Roman goldwork remains comparatively underexplored. This study presents the findings of a detailed technical examination and analysis of Roman jewelry housed in the collection of the Archaeological Museum of Thessaloniki (AMTh). The analysis focused on a corpus of about 37 gold ornaments dated to the early through late Roman period (1st-4th century A.D.), predominantly recovered from funerary contexts in Thessaloniki. For comparative purposes, a selection of Hellenistic jewelry of analogous typologies, likewise excavated from Thessaloniki or its wider environs and kept in the AMTh's collection, was also examined. As is commonly acknowledged, the elaborate gold jewelry characteristic of the Hellenistic period gradually gave way during the Roman era to simpler constructions that emphasized the use of semi-precious and precious stones. In addition, more modest forms of adornment were also produced during the Roman period, characterized by the use of thin gold foil and simplified designs. In this paper, the approximately 37 selected and representative Roman and Late Roman gold jewelry pieces are presented, with reference to their typology, archaeological context, and precise dating. Furthermore, the results of their technical examinations and elemental analyses are discussed in order to enhance our understanding of their manufacturing and decorative techniques, thereby shedding light on the distinctive characteristics of Roman goldsmithing in the Thessaloniki region. Given that non-destructive analysis is a fundamental requirement in the study of ancient goldwork, the examinations were strictly limited to the surfaces of the jewelry pieces. As gold is considered a homogeneous material- due to the good solubility of the Au, Ag, Cu- and can remain in relatively good condition after years of burial, it allows for a satisfactory surface examination of both the manufacturing techniques of ancient gold objects and the characterization of their alloys.

Thus, this study comprises essentially two stages: i) Visual examination using optical microscopy and ii) Determination of the chemical composition of the gold alloy through the non-invasive implementation of micro-EDXRF analysis. Measurements were taken from every different part of each jewelry in order to examine possible differentiations. Moreover, the chemical composition of the two chronological groups (Hellenistic and Roman) was compared.

Table 1. Micro EDXRF analysis results

Index Number	Photo	Description	Date	Metal alloy composition (%)
MTh 5438		Signet ring	Roman period 2nd – 3rd century	**Au** :90,75 **Ag**:8.33, **Cu**:0,91
MTh 5881		Signet ring	Early Hellenistic (323-275 AD)	**Au**:96.4, **Ag**:2.4, **Cu**:0.9

In conclusion, the examination of about 37 Roman gold jewelry pieces from Thessaloniki has revealed valuable insights into the continuity and transformation of goldsmithing practices from the Hellenistic to the Roman period. Despite the shifts evident in Roman era, in the design aesthetics and sometimes in the quality of craftsmanship, the composition of the gold alloys continued to contain a high gold content, a composition very close to that of the Hellenistic period (Table 1).

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P37. Study of the alloy composition of metal artifacts and analysis of slags from the excavation of the prehistoric settlement of Strofilas on Andros

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The Strofilas plateau is located on the west coast of Andros (37° 46′ 48.82′′ N, 24° 51′ 20.81′′ E). During the systematic excavation carried out by the Ephorate of Antiquities of the Cyclades, the ruins of an extensive settlement were uncovered, belonging to the cultural horizon of "Attica-Kephala", of the Final Neolithic period (4,500-3,200 BC) [1]. This is the best-preserved, densely structured settlement, unique in size since it extends over 30 acres. A section of its fortification wall was found in a good state of preservation, bearing embossed and carved rock figures with the oldest representations of ships in the Cyclades. Impressive movable ceramic, stone and metal finds were also discovered. The most impressive metal finds are arrowheads, handbooks, nails, jewelry [2], as well as metallurgical slag residues. This paper presents the results of elemental analyses of 34 metal artifacts and 5 slag samples. The study is based on a combination of analytical techniques such as X-ray Fluorescence (pXRF) and Scanning Electron Microscopy (SEM/EDS), while for the slags, X-ray diffractometry (XRD) was also used for their mineralogical analysis. The results of the analyses showed that the majority of the artifacts are made of an alloy with a high copper content and a low arsenic content, while one artifact made of a lead alloy and another one made of an iron alloy, as well as a gold bead, were also analysed. As for the slags, these are copper slags and one sample is iron slag with a high manganese content. While the origin of the copper cannot yet be known without first conducting lead isotopic analyses, the combination of iron and manganese in the last slag sample suggests the use of a local ferromanganese ore, fayalite [3].

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