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EMAC

17th EUROPEAN MEETING ON ANCIENT CERAMICS

BILBAO 2025

SEP 10-12TH

BOOK OF ABSTRACTS

https://emac2025bilbao.com/
Open Access
DOI: 10.5281/zenodo.16944803

GPAC GRUPO DE INVESTIGACIÓN EN PATRIMONIO CONSTRUIDO

LTC SAREA Red de Laboratorios Transfronterizos de Cooperación

Université BORDEAUX MONTAIGNE

RSEQ Real Sociedad Española de Química El Sitio de la Química en España

GEQP Grupo Especializado de Química para el Estudio y Conservación del Patrimonio Cultural

ARKEOMAT

SAPaC Sociedad de Arqueometría Aplicada al Patrimonio Cultural

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HEZKUNTZA, UNIBERTSITATE ETA IKERKETA SAILA
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University of the Basque Country (UPV/EHU)
First edition: August 2025
DOI: **10.5281/zenodo.16944803**

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1.1. Welcome Address from the Organising Committee

On behalf of the Organising Committee, it is our great honour to welcome you to the ***17th European Meeting on Ancient Ceramics (EMAC 2025)***, hosted by the **University of the Basque Country (UPV/EHU)** in the city of Bilbao. Since its foundation in 1991, EMAC has consolidated itself as the leading European forum for the archaeometric and interdisciplinary study of ceramics, and its seventeenth edition reaffirms this vocation of excellence.

The meeting offers a privileged arena to present **frontline research**, to debate the theoretical and methodological advances that shape our discipline, and to foster an ongoing dialogue between archaeology, the experimental sciences, and the wider humanities. Through this interaction, EMAC not only refines our knowledge of the technological, economic, and symbolic dimensions of past ceramic production, but also reinforces the transnational community of scholars dedicated to these questions.

We are honoured to host participants from more than twenty-five countries across Europe, the Americas, Asia, and Africa, whose expertise encompasses **archaeology, archaeometry, materials science, chemistry, geology, conservation, and heritage studies**. The breadth and diversity of contributions — in chronological span, geographical range, and analytical approach — attest to the vitality of ceramic studies as a cornerstone of archaeological research.

It is our hope that EMAC 2025 will provide a rigorous and intellectually stimulating environment for the presentation of your work, the forging of collaborations, and the advancement of ceramic studies on a global scale. At the same time, we invite you to discover the cultural and social richness of Bilbao and the Basque Country, a region where **heritage, innovation, and community intersect**.

We wish you a productive and inspiring conference, and look forward to the new knowledge, partnerships, and shared experiences that will emerge from this gathering.

The EMAC 2025 Organising Committee

Bilbao, Spain

1.2. Message from the Scientific Committee

The **Scientific Committee of the *17th European Meeting on Ancient Ceramics* (EMAC 2025)** is honoured to welcome you to this edition, hosted by the **University of the Basque Country (UPV/EHU)** in Bilbao.

The committee brings together specialists from leading universities, research institutes, laboratories, and museums across Europe, the Americas, Asia, and Africa. Our expertise spans **archaeometry, analytical chemistry, materials science, geology, conservation science, experimental archaeology, and heritage studies**, thus ensuring that the scientific programme reflects both methodological depth and international breadth.

The thematic focus of ***Non-Destructive Techniques*** responds not only to a disciplinary trend, but to an urgent imperative in archaeological science and heritage preservation. Generating high-resolution compositional, structural, and technological data while safeguarding the material integrity of artefacts has become a **scientific, ethical, and curatorial requirement**. This orientation is especially critical in the study of *World Heritage sites*, museum collections, and unique archaeological assemblages, where the preservation of the physical record is inseparable from the advancement of research.

In evaluating the abstracts, the committee prioritised contributions that demonstrate methodological rigour, conceptual innovation, and relevance for the interpretation and preservation of **ancient ceramics**. The selected works encompass a wide range of approaches — including provenance studies, technological reconstruction, functional interpretation, conservation strategies, and computational analyses — all converging on the shared objective of advancing ceramic studies within a framework of **responsible heritage stewardship**.

We are confident that **EMAC 2025 will provide a fertile environment for scholarly exchange**, strengthening collaborations that extend beyond this meeting and reinforcing the global network of researchers committed to the scientific and ethical dimensions of archaeological inquiry.

The EMAC 2025 Scientific Committee
Bilbao, Spain

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3.1. Congress Venue — Bizkaia Aretoa, University of the Basque Country (UPV/EHU)

The **17th European Meeting on Ancient Ceramics (EMAC 2025)** will take place at the *Bizkaia Aretoa* Conference Centre of the University of the Basque Country (UPV/EHU), located on Abandoibarra Avenue, directly opposite the Guggenheim Museum.

- **Registration & Information Desk**: Ground-floor foyer.
- **Plenary Sessions**: *Mitxelena Auditorium* (ground floor).
- **Parallel Oral Sessions**: *Baroja, Oteiza, and Arriaga auditoria*.
- **Poster Sessions**: First-floor exhibition galleries (*Chillida* and *Axular rooms*).
- **Coffee Breaks**: Served in the ground-floor foyer and the first-floor poster area.
- **Restrooms & Accessibility**: Facilities available on all floors; lifts and ramps ensure full accessibility.
- **Cloakroom & Assistance**: Located next to the Registration Desk.

Internal signage will guide participants between rooms and conference activities.

Further details:

- **Venue webpage (UPV/EHU):** https://www.ehu.eus/es/web/bizkaia-aretoa
- **Congress website:** https://emac2025bilbao.com

3.2. Venue Facilities

The **Bizkaia Aretoa Conference Centre (UPV/EHU)** will host all EMAC 2025 activities, including plenary sessions, parallel oral communications, poster sessions, and the Summer School.

- **Ground Floor**
  - *Mitxelena Auditorium*: Opening Ceremony, keynote lectures, and plenary sessions.
  - *Foyer*: Registration and Information Desk, coffee breaks, and networking.
- **First Floor**
  - *Baroja, Oteiza, Arriaga auditoria*: Parallel oral sessions.
  - *Chillida and Axular rooms*: Poster sessions and exhibition space.

Room allocations and detailed schedules will be provided in the **final programme** and displayed on bilingual (English/Spanish) signage throughout the venue.

3.3. Registration, Accreditation and Participant Services

Registration Desk

The Registration and Information Desk will be located in the **main foyer of the Bizkaia Aretoa**. Opening hours:

- **8–9 September 2025** (Summer School participants): 08:00–09:00.
- **10–12 September 2025** (main congress): 08:00–09:30 daily, with limited assistance available during coffee breaks.

Accreditation:

Upon arrival, participants must:

1. Present proof of registration (digital or printed).
2. Collect their **official EMAC 2025 badge**, which must be worn at all times in the venue.
3. Receive congress materials (Book of Abstracts, programme-at-a-glance, welcome pack).

The badge grants access to:

- Plenary and parallel sessions.
- Poster exhibition areas.
- Coffee breaks and networking spaces.
- Social events included in the registration.

Participant Services

- **Information Desk**: General enquiries related to the congress.
- **Speaker Preparation Area**: Equipped with computers and audiovisual support.
- **Wi-Fi**: Network details and password will be provided on site.
- **Cloakroom**: Available next to the Registration Desk.

3.4. Transport Guidelines

For practical information on how to reach the venue and move within Bilbao, participants may consult the **Travel & Accommodation** section of the official EMAC 2025 website.

Quick Reference:

- **Venue Access**: The Bizkaia Aretoa is located on Abandoibarra Avenue, within walking distance from the city centre. It is served by the **Bilbao tram (Guggenheim stop)**, several **Bilbobus lines**, and taxi services.

- **Airport Connection**: Bilbao Airport (BIO) lies 12 km from the city. The **Bizkaibus A3247** links the airport to the central bus station (Termibus/San Mamés) every 15–20 minutes.

3.5. Social Events and Networking Opportunities

EMAC 2025 will include several occasions for informal interaction and professional exchange:

- **Boat Tour (11 September 2025, afternoon)** – Guided tour along the Bilbao estuary, focusing on the city's riverfront and industrial heritage. *Departure: pier near the City Hall (Bilbao).*
- **Conference Dinner (11 September 2025)** – Ticketed event at an emblematic venue in Bilbao, featuring Basque cuisine and opportunities for professional networking.
- **Coffee Breaks** – Served daily in the foyer and exhibition areas, providing space for informal dialogue.

3.6. Contact Details and Official Communication Channels

For any queries related to **EMAC 2025**, participants are invited to use the following official channels:

Email:

info@emac2025bilbao.com

Official Website:
https://emac2025bilbao.com

Provides the updated scientific programme, practical information, and general announcements.

UIK – Basque Summer Courses Platform:
https://www.uik.eus/es/curso/european-meeting-ancient-ceramics-emac2025

Registration services and institutional details.

Social Media
Instagram: https://www.instagram.com/emac2025bilbao/

4. Abstracts - Thematic overview

The corpus of contributions assembled in this edition of the **European Meeting on Ancient Ceramics** epitomises the current breadth, methodological refinement, and interpretative ambition of ceramic studies within the archaeological sciences. The oral and poster communications presented herein are the outcome of rigorous, multi-scalar research programmes that integrate archaeological context, archaeometric analyses, and advanced technological applications to interrogate the *chaîne opératoire* of ceramic production, distribution, use, and post-depositional transformation.

The thematic architecture of the programme encompasses **Raw Material and Provenance Studies**, where petrographic, mineralogical, and geochemical characterisation – often coupled with isotopic and compositional data modelling – elucidates procurement strategies, exchange circuits, and the technological embeddedness of ceramic manufacture within socio-economic landscapes. The section on **Experimental Archaeology, Ethnoarchaeometry, and Organic Residue Analyses** offers empirically grounded reconstructions of operational sequences, functional diagnostics, and sensory or symbolic attributes, thereby bridging past technological know-how with its anthropological significance.

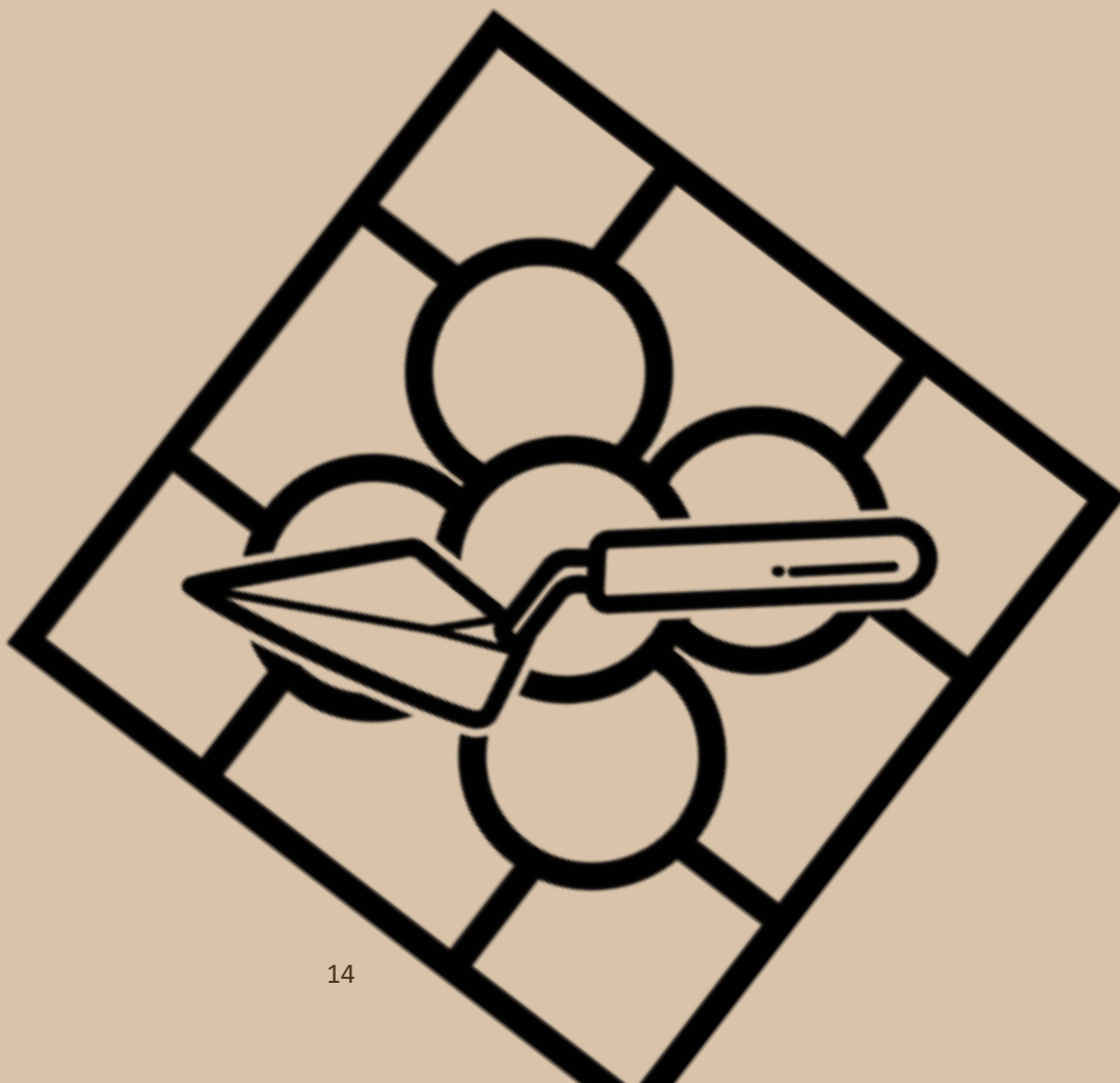
Advances in **Portable and Non-Destructive Analyses** attest to the consolidation of minimally invasive strategies as both a scientific and ethical imperative in heritage research, exemplified by the deployment of *in situ* spectroscopy, X-ray fluorescence, and imaging techniques optimised for diagnostic precision. In parallel, **Digital and Data-Driven Ceramic Studies** reveal how algorithmic approaches -from machine learning-based typological classification to high-resolution photogrammetry and 3D modelling- are reshaping taxonomic systems, refining chronological frameworks, and enabling comparative datasets of unprecedented scale.

Equally prominent are contributions dedicated to **Technology, Production, and Dating**, which interrogate cross-cultural technological transfer, adaptive innovations, and the temporal anchoring of ceramic assemblages through archaeometric dating protocols. Finally, **Theory and Methods** re-engage with the epistemological foundations of ceramic research, critically appraising analytical paradigms and interpretative models in light of emerging scientific evidence.

By integrating oral communications and poster presentations within coherent thematic axes, this section foregrounds the complementarity of analytical scales -from microstructural textural analysis to macro-regional comparative syntheses- reaffirming the role of ceramic studies as a privileged analytical vector for decoding human agency, technological ingenuity, and cultural entanglement across the *longue durée* of the archaeological record.

4.1. *Raw Material and Provenance Studies*

Oral Presentations



EMAC 17th EUROPEAN MEETING ON ANCIENT CERAMICS BILBAO 2025

Anything They Can Do, We Can Do Better: Imitation of Foreign Pottery Forms in Early Bronze Age Kültepe-Kaneš (Central Anatolia)

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The main objective of this study was the characterisation of ceramic assemblages from Early Bronze Age III Kültepe-Kaneš in Central Anatolia, through an integrated investigation of their chemical, mineralogical, and petrographical properties, compared against potential raw materials from the region. Multivariate statistical analysis methods, principal component analysis (PCA) and hierarchical cluster analysis (HCA) were employed to assess whether the archaeological samples represented imports or were produced on-site utilising local resources.

Fifty pottery sherds, two unfired ceramic, one hearth fragment and nine geological samples were investigated. Mineralogical characterisation was conducted by X-Ray Diffraction (XRD), supplemented by petrographic information obtained via thin-section microscopy and stereomicroscopy. Chemical compositions were determined via Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES) for major and minor elements, and Inductively Coupled Plasma Mass Spectrometry (ICP-MS) for trace elements, resulting in a dataset of forty-five chemical variables usable for statistical analysis. Experimental briquettes were made from potential raw materials, and controlled firings were carried out to test their viability. Their mineralogical and textural features were subsequently compared to those of the archaeological ceramics utilising XRD and petrographical analysis.

The pottery group archaeologically classified as local showed a high degree of compositional correlation with several geological samples collected from the site and its environs. However, three samples from the local reference group imply either a distinct raw material source or alternative production practices. The three samples could also possibly have originated in another Central Anatolian settlement. One of the four statistically defined groups –comprising six pottery samples– as well as a single loner and an outlier pair, discernibly deviating from local production modes, may represent imports from other regions. Notably, several vessel forms previously assumed to be imports were revealed to be locally produced.

Keywords: Early Bronze Age III, Kültepe-Kaneš, Chemical and Mineralogical Analysis, Ceramic Petrography, Experimental Archaeology

EMAC 17th EUROPEAN MEETING ON ANCIENT CERAMICS BILBAO 2025

Production and Distribution of Pottery in Iron Age Judah

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Judah was a kingdom in the Southern Levant during the Iron Age II (ca. 1,000–586 BCE). Its material culture illustrates several distinct components, as well as evidence for central administration and taxation. The paper will discuss the main characteristics of pottery production and distribution in Iron Age Judah. While very few pottery workshops were excavated from this region and period, the numerous excavations in the region yielded a large assemblage of pottery, and the research includes also large-scale compositional and technological analyses. These include petrography, Chemical analysis (INAA), and formation techniques analysis. The distribution and production of storage jars, included stamped ones, for example, may indicate a system of local taxation and redistribution. Cooking pots illustrate a production in specialized centers and traditional forming techniques. Their distribution and compositional analysis often shows a high mobility to marginal sites in the kingdom. Other forms illustrate a more localized production and distribution, while imports from neighboring and further regions is rather limited. Trade was possibly conducted in containers made of other materials in many cases, while several pottery forms show a restricted distribution within Judah, creating a distinction between its pottery repertoire and that of neighboring regions during the Iron Age. Methods used: Petrography, Typological analysis, Chemical analysis (INAA), Formation techniques Analysis

Keywords: Judah, Iron Age, Pottery distribution, Storage jars, Cooking pots.

References:

Ben-Shlomo, D. 2019. *The Iron Age Pottery of Jerusalem: A Typological and Technological Study*. Ariel University Institute of Archaeology Monograph Series 2. Ariel: Ariel University Press.

Bouzaglou, L., and Ben-Shlomo, D. 2023. A ‘Chaîne opératoire’ perspective on Iron Age II Judean cooking pots. *Archaeological and Anthropological Sciences* 15(6): 1–32, Article No. 75.

EMAC
17th EUROPEAN MEETING ON ANCIENT CERAMICS
BILBAO 2025

United in our differences: ceramics production and circulation in the south of the Iberian Peninsula between the Nazari Emirate and the Reign of Granada (15th-16th cent. AD)

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The end of the Middle Ages and the beginning of the Modern Age in the southeast of the Iberian Peninsula is a period of great changes which we can infer from the study of material culture. Different cultural (the Nasrid and the Castilian) and religious (the Muslim and the Christian) communities co-existed in the same territories. Ceramics, which embodies everyday life, traditions, social-economic organization and beliefs, offers a point of view in reconstructing this phase of cultural and political transition especially when the study is aided by an analytical study. These purposes are developed as part of the CEGRAM project which sees the collaboration of the University of Granada with the University of Barcelona, of Basque Country and Genoa.

In this paper, we will reconstruct ceramic manufacture between the 15th and 16th centuries AD in three areas of the southeast of the Iberian Peninsula (Cuarto Real de Santo Domingo, Bayra and Macael Viejo), a space occupied by the Nasrid Emirate and progressively by the Kingdom of Granada. 160 tableware individuals were examined with a sequential methodology which implies handheld X-ray fluorescence at the initial stage to further sampling of 60 individuals for petrographic examination to characterise the pastes. Based on these results, 70 ceramic samples were analysed by X-ray fluorescence and X-ray diffraction to refine the first characterisation and grouping and infer possible provenance areas and circulation of the materials by comparison with the ARQUB database.

The preliminary results of this research allow us to discuss whether the changes we observe in terms of shape and surface treatment implied changes in technology and modes of production brought by the new political and territorial organization of the Kingdom of Granada. The paper will discuss also the challenges and benefits of performing research in 4 different institutions where each one addresses an aspect of the research according to specialisation and experience.

Keywords: ceramic petrography, chemical analyses, XRF, p-XRF, XRD

EMAC 17th EUROPEAN MEETING ON ANCIENT CERAMICS BILBAO 2025

Between continuity and change: a preliminary archaeometric approach to handmade and wheel-thrown pottery at Kach Kouch (Oued Laou, Northwestern Morocco, c. 1300-600 BC)

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While the late prehistoric and Early Iron Age Mediterranean is known for its complex social and economic dynamics, including long-range mobility and interactions, the southern shores of the basin have historically been underrepresented in these discussions. Recent radiocarbon dating and fieldwork from the northwestern Maghreb shed light on this region's role in shaping the dynamics of the late prehistoric Mediterranean and inner Atlantic. Bridging the Mediterranean, Atlantic, and Sahara, this region acted as a central corridor for the movement of peoples, animals, plants, objects and ideas, fostering a diverse mosaic of lifeways and unique monuments that span imposed modern geographic and cultural divides. New archaeological research at Kach Kouch has revealed an early occupation phase from 2200–2000 cal BC, followed by a stable settlement from c. 1300–600 BC divided into two phases: KK2 (1300–900 cal BC), which corresponds with the Late Bronze Age in Iberia, and KK3 (800-600 BC), which corresponds with the so-called Mauritanian 1 period in the north-western Maghreb and the Early Iron Age in Iberia and is related to the establishment of Phoenician settlements along the Iberian and north-west African coasts.

This continuous occupation is based on wattle-and-daub architecture, a farming economy, distinctive cultural practices and extensive connections. However, the most relevant point is that findings at Kach Kouch underscore the agency of local communities, challenging the notion of northwestern Africa as essentially *terra nullius* before the Phoenician arrival. This communication presents the preliminary analysis of 21 ceramic sherds from the KK2 and KK3 phases. The pottery was chemically characterised using X-ray fluorescence (WD-XRF), mineralogically through X-ray diffraction (PXRD) and the microstructure and sintering state were evaluated by scanning electron microscopy (SEM-EDX). The results have enabled insights into the provenance and the production techniques associated with these artefacts. The analysed assemblage includes 4 handmade decorated sherds from the KK2 phase and 4 handmade sherds, along with 13 wheel-made sherds from the KK3 phase. The latter comprises 11 Phoenician amphorae, a carinated bowl and a pithos. The Phoenician wheel-made ceramics, excluding the pithos, which remains unassigned, were likely produced at sites along the Málaga coast (southern Iberia). In contrast, the handmade pottery displays a broader compositional variability and cannot be linked to any known production centres, suggesting the possibility of several local or regional manufacturers.

Keywords: Late Bronze Age pottery, Phoenician pottery, Mediterranean Africa, local communities, handmade pottery, wheel-made pottery, XRF, XRD, SEM-EDX

References:

Benattia H, Bokbot Y, Onrubia-Pintado J, *et al*., 2025, Rethinking late prehistoric Mediterranean Africa: architecture, farming and materiality at Kach Kouch, Morocco, *Antiquity*. 99(404), 354-374. https://doi.org/10.15184/aqy.2025.1

Benattia H, (in press), Beyond the Pillars: Northwest Africa in a broader Mediterranean, Atlantic and Saharan perspective c. 3800–500 BC, *Journal of Mediterranean Archaeology*.

EMAC 17th EUROPEAN MEETING ON ANCIENT CERAMICS BILBAO 2025

Collection of compositional data: Sharing and opening data to better understand amphora production strategies in the Hellenistic and Roman Aegean

Cantin, Nadia[a], Abdelgawad, Mai[a,b], Frugier, Camille[c], Lemaitre, Séverine[c], Marzec, Edyta[d], Müller, Noémi S. [d] , Kiriatzi, Evangelia[d]

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The MATEGEE project (ANR-23-CE27-0014) *Beyond the Stamp: Material and Production Strategies for Amphorae in the Hellenistic and Roman Aegean* aims to study the production sites for Aegean amphorae, which were widely circulated in both the Eastern and the Western Mediterranean between 4 BC and 3 AD. The study takes advantage of the extensive reference collections of Aegean amphorae housed in three research centers renowned for their long-standing expertise in the field, and based across the Mediterranean in Alexandria, Athens, and Poitiers. The project aims at the characterisation of the products of workshops or production areas, to shed light on production strategies and provide the reference for reconstructing the exchange networks in which the amphorae and their contents circulated. This will be achieved by analysing more than 1700 samples for their elemental composition by pXRF, with a subset additionally by WD-XRF, and more than 1000 samples for their mineralogical compositions by petrographic thin section analysis. This research focuses on stamped and unstamped amphorae, found mainly at consumption sites but also potting raw materials. Origin and dating are usually less ambiguous in the case of stamped material, but for unstamped amphorae, where this relies on typological and macroscopic fabric observations, secure provenance assessments can be challenging. The analysis of securely dated and provenanced material and the establishment of compositional reference groups will allow to more reliably determine likely origin also for those samples. The communication will focus on the selected methodological approach. This aims at the collection of new data, as well as the use of existing databases in an approach which integrates archaeometric, epigraphic and archaeological research to further our knowledge on an emblematic vessel type, but also the provision of access to gathered data for the scientific community, in particular through the creation of a new open relational database, to facilitate more efficient sharing, analysis, and utilization of research findings.

Keywords: amphora, Aegean, production strategies, elemental analyses, database

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Petrographic Insights into the Evolution of Ceramic Building Materials in Jerusalem and Its Hinterland After 70 CE

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The destruction of the Second Temple in 70 CE marked a turning point in the production of ceramic building materials (CBM) in Jerusalem. During this period, the use of CBM intensified, and roof tiles were introduced for the first time. Excavations across Jerusalem and its surroundings have uncovered numerous examples of these materials, tracing their evolution from the 1st to the 3rd century CE.

This talk examines the renowned CBM bearing the stamps of the Xth Roman Legion Fretensis, produced in workshops west of Jerusalem's Old City. While these legionary-stamped CBM are well-documented, recent excavations have revealed a broader array of CBM, including materials marked by private and municipal manufacturers, as well as unmarked examples. Petrographic analyses of CBM from several sites—including the military workshops near the Jerusalem International Convention Center (Binyanei Ha'Uma), as well as Moẓa—have uncovered a diverse range of materials and provided valuable insights into the producers and consumers of CBM.

The findings highlight the intertwined roles of military and civilian CBM production, shedding new light on the socio-demographic composition of Jerusalem and its surroundings. This research also underscores the complex interconnections between the region's diverse groups during this transformative period.

Keywords: Petrographic analysis, Ceramic Building Materials (CBM), Roman Period, Jerusalem,

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Port of destination: amphorae trade traffic to the Punic city of Qart-Hadasht (Cartagena, Spain)

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This communication presents the initial results from the project "Producing and supplying the new Punic capital of the Western Mediterranean: contextualisation and archaeometric characterisation of ceramic materials from Qart-Hadasht". We focus on the ceramic assemblages located at Qart-Hadasht, the town founded by the Carthaginians in 228 or 227 BC, identified under present-day Cartagena (Spain).

Scholars have mainly focused on typological and descriptive issues. However, our main objective is to complete this perspective with the application of characterisation analyses (e.g., XRF, pXRF, XRD, SEM-EDS, OM, TG) to determine the consumption, production, and exchange patterns of the Punic city. We seek to go deeper into the possibilities of the archaeological ceramics, being able to explore specific questions such as the areas of production, the raw materials selected, the technological strategies and *chaînes opératoires*, or the trade networks that were established at local, regional, and trans-Mediterranean scales.

Our contribution discusses the results of the chemical and petrographic analyses of amphorae found in the city, including individuals from the Atlantic to the eastern Mediterranean coast. After confirming the absence of local amphorae production, Qart-Hadasht presents itself as a unique consumption centre to explore commercial and economic transits, including those under the Second Punic War. The great advantage of having archaeometric characterisations is not only to identify broad regions of provenance but also to define recipes and technical gestures that led to recognise certain workshops behind the standardised types of amphorae.

Keywords: Iberian Peninsula, Amphorae, Archaeometry, Trade Networks.

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EMAC 17th EUROPEAN MEETING ON ANCIENT CERAMICS BILBAO 2025

Sourcing raw materials in the Bay of Naples area

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The Bay of Naples is renowned for its rich archaeological record, spanning from prehistoric times to the Roman era and beyond. It hosted numerous sites (e.g., Ischia, Cuma, Pompeii, Neapolis) that produced high-quality and utilitarian pottery as well as other ceramic materials. Identifying raw materials is crucial for addressing issues related to land exploitation, defining pottery provenance, and understanding the technological potential of clays used in producing diverse ceramics for different end uses. However, sourcing clay in this area has always been a struggle due to the geological complexity of a volcano-dominated landscape, subject to various transformations over time and heavy anthropisation.

Archaeometric research provided new data to depict a reliable overview characterized by a well-developed distribution system of pottery and even raw materials, including temper and clays. In particular, fine pottery productions primarily exploited Ca-rich clays from the nearby Island of Ischia. In the Roman era, there is evidence of imports of Ca-rich marine clays from the Apennine ridge at a few tens of kilometers away, for which one must think of a transport system by sea (i.e., Salerno) or based on internal communication routes, most likely rivers. However, important questions are still open, especially regarding certain types of clays (e.g., Ca-poor clays used for cookware). These can be ascribed to a peculiar type of volcanic-derived clays that have been employed until recently for the traditional manufacture of cooking ware and bricks in some locations in the area (i.e., Cascano in northern Campania and Sorrentine Peninsula). However, the role of alluvial clays (Volturno and Sarno rivers) or volcano-sedimentary materials associated with small ancient streams or marshes should not be underestimated. Research is ongoing to locate suitable geological resources, also with the help of geomorphology for the paleo-environmental reconstruction and core drilling to reach clayey sediments in historical levels.

Keywords: Clay sources, Bay of Naples, Types of clays, Ancient ceramics, Distribution system.

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Forging Connections in the Early Iron Age Western Mediterranean: An Examination of Local and Phoenician Pottery at Penya Negra (Alicante, Spain, 8th-6th Centuries BC)

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Penya Negra is a highly significant site in southeastern Iberia. Its earliest Late Bronze Age phase exhibits a rich material culture, indicating the circulation of goods from the Iberian Atlantic coast and various Mediterranean areas, alongside evidence of metallurgy. These connections may have originated during the local Chalcolithic at nearby Les Moreres. From the 8th century BCE, the site shows intense interaction with Phoenician populations, both via the new coastal settlement of La Fonteta and through the development of new urban areas within Penya Negra itself. A key innovation is a new quarter with orthogonal house plans, a clear shift from Bronze Age circular layouts. These changes extend beyond architecture to include new pottery production methods, such as the potter's wheel, and a new agrarian system. Furthermore, this settlement became part of an extensive exchange network.

This study presents an integrated analysis of the ceramic assemblage from various areas of the indigenous settlement, including the acropolis. Notably, Department 3, with its abrupt abandonment and well-preserved record, offers detailed insights into the material conditions under which local communities, particularly elites, integrated into wider networks. These assemblages are also compared with earlier Late Bronze Age material.

Analysis of 45 samples using X-ray fluorescence, X-ray diffraction, and petrography reveals significant variability. Local calcareous pastes were dominant during the Late Bronze Age, followed by the emergence of new ceramic groups linked to maritime transport, especially from the Málaga region, a major agricultural production zone.

Keywords: Early Iron Age, Southeastern Iberia, provenance, technology

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EMAC 17th EUROPEAN MEETING ON ANCIENT CERAMICS BILBAO 2025

Ceramic technology and territorial dynamics during the Early Iron Age in the Sierra de Alcaraz (Albacete, Spain)

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The Sierra de Alcaraz, located in the southwestern sector of the province of Albacete, has traditionally occupied a peripheral position in archaeological and historical research. However, this marginality is now being re-evaluated through new research initiatives focused on the integrated study of the region from a diachronic and interdisciplinary perspective. This paper contributes to this framework by advancing the socioeconomic characterization of communities during the Late Bronze Age and Early Iron Age in this upland territory; a period still insufficiently understood due to limited data and the need to reassess local trajectories.

The study is grounded in the archaeometric analysis of ceramic assemblages recovered through systematic survey and excavation in the Madera River valley. Using macroscopic typology, macrotrace analysis, and geochemical characterization, the research aims to identify raw material procurement areas, reconstruct production and distribution patterns, and evaluate the potential existence of local workshops.

These data are contextualized within recent findings at sites such as Los Cucos (Bogarra) and El Peralejo (Paterna del Madera), which reveal significant shifts in settlement organization. The archaeological evidence points to a progressive occupation of riverine lowlands, likely linked to new strategies of territorial control and resource management. In this context, phenomena such as agricultural intensification, standardization of ceramic production, and the emergence of new exchange networks appear central to the transformation of social practices at the dawn of local protohistory.

Keywords: Sierra de Alcaraz, settlements, ceramics, technological studies, production processes

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Cypro-Cilician Iron Age White Painted Ware at Sirkeli Höyük: Investigating Provenance and Cultural Affiliation

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Sirkeli Höyük is one of the urban centers of the Iron Age kingdom of Que (Hiyawa), located in the Cilician Plain in southern Anatolia. The site offers a continuous stratigraphy of Iron Age layers, which represent the most substantial phase of occupation. The ceramic assemblages from these layers reveal diverse cultural influences and interactions with neighboring regions, particularly with Cyprus.

For this study, we selected "White Painted Ware" as a proxy, as it is widely distributed across Cyprus, the eastern Mediterranean coast, and the Levant, and represents one of the dominant ceramic groups at Sirkeli Höyük. The aim is to assess whether these wares were imported from Cyprus or locally produced, offering insights into local ceramic practices and Cypriot–Cilician cultural interaction. This study lays the groundwork for understanding maritime connectivity and cultural exchange in the Iron Age eastern Mediterranean.

This study is based on petrographic (OP), geochemical (LA-ICP-MS), and mineralogical (XRPD) analyses conducted on 40 samples of Iron Age White Painted Ware from Sirkeli Höyük. The primary objectives were to characterize the ceramic composition, clay procurement and clay processing and to investigate provenance through comparison with Iron Age pottery from the region, as well as with 52 local clay samples collected from the Ceyhan Plain.

Keywords: Iron Age, Cilicia, ceramic provenance analysis, petrography, chemical analysis

New Approaches to Roman Trade in Balsa (Torre d'Aires – Tavira): Chemical and Mineralogical Analysis on Terra Sigillata Fragments

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The port city of Balsa (Torre d'Aires – Tavira) is one of the most important and emblematic Roman archaeological sites in southern Portugal. Although it is mentioned in classical sources, its exact location remained unknown until the 19th century, when it was discovered by Estácio da Veiga, a pioneer in Portuguese archaeology.

Since then, numerous studies have been conducted on the city, and research to date has enabled the settlement to be dated from the 1st century BC to the 6th century AD. In particular, studies of materials such as Terra Sigillata have made important contributions to this dating.

This poster presents a study of some Terra Sigillata recovered during the recent excavations (2019-2021). In addition to traditional chronotypological and chronostratigraphic analyses, which provide insights into trade dynamics and chronologies, we have also included laboratory analyses to provide an innovative approach and generate new data.

To this end, we have applied chemical and mineralogical analytical techniques— - in particular X-ray fluorescence (XRF) and X-ray diffraction (XRD) — to examine selected fragments and enhance our understanding of the chemical composition of the clays and the materials formed during the firing process.

Keywords: Balsa, Roman Ceramics, X-ray fluorescence, X-ray diffraction.

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Trade and Local Production Networks in Iron Age Dalmatia: A Study of Large Storage Jars from Nadin and Rat Vičja Luka (Croatia)

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The Dalmatian region in the last millennium BCE was home to diverse communities with distinct social structures, cultural affiliations, and trading networks. The variation and commonalities between these communities, reflected in their hillforts, material culture, and burial practices, present a complex narrative enriched by their interactions and shared economic strategies. However, these dynamics have largely remained unexplored due to a fragmented approach to studying individual communities. This study aims to address the complexities of production and trade by focusing on two Iron Age communities—one along the northern Dalmatian coast and hinterland, and the other on the Central Dalmatian islands—examining the hillforts of Nadin and Rat Vičja Luka. Nadin, located on the largest fertile plain in Dalmatia, and Rat Vičja Luka, on the island of Brač, offer a unique perspective on ancient economic practices.

Material evidence dating from the 9th century BCE reveals that both communities were engaged in trade with the western Adriatic coast, reflecting economic surplus and societies with resources beyond their immediate needs. To better understand these economic dynamics, a comprehensive approach integrating archaeological evidence such as trade goods, settlement patterns, and trade routes is required. Among the most valuable archaeological indicators are large storage jars, central to this study.

This paper presents a detailed analysis of large storage jars from Nadin and Rat Vičja Luka, using them as key proxies to characterize local production and food storage strategies. Through typological, microstructural, geochemical, and ICP-MS analyses, we aim to reconstruct the technological processes involved in the manufacture of these vessels, identify raw material sources, and trace local production and trade patterns. The integration of these techniques offers a more nuanced understanding of Iron Age economies along the eastern Adriatic coast, shedding light on the interactions of these communities within broader economic networks.

Keywords: Dalmatia, Iron Age communities, trade, economy, large storage jars, ICP-MS, geochemical analysis

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Title African Terra Sigillata and common African pottery at the Roman site of Los Villares (Salamanca). Anaysis of the ceramic context and archaeometric study

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The province of Salamanca (W Spain) is traversed from south to north by one of the main communication routes of the Iberian Peninsula during Roman times: the Via de la Plata ("Silver Route"). Originally constructed to provide the Roman army with a reliable path for the conquest and control of Hispania, this strategic route gradually evolved into a vital corridor for travelers and merchants moving through Roman Lusitania from north to south. Along its course, numerous mansiones, villas, and rural estates emerged, forming part of the broader Roman rural settlement pattern between the 1st and 5th centuries AD. Within this historical and geographical context, archaeological surveys conducted in 2015 in the middle valley of the Tormes River uncovered a site of exceptional archaeological significance. Subsequent excavations in 2015, 2017, and 2018 revealed several structures—some featuring pavements made of opus tessellatum and opus signinum—which were part of a substantial Roman rural complex. In addition to the ceramic materials typically associated with such contexts, a significant number of fragments of African Terra Sigillata (ATS) and common African wares from Nabeul (Tunisia) were discovered during all excavation campaigns. These findings led to the initiation of an archaeometric study aimed at gaining deeper insights into the origin and production techniques of these ceramics. This study presents an archaeological and archaeometric analysis of the ATS found at the site, exploring its connections with the broader trade networks that operated along the Silver Route.

Keywords: Via de la Plata, Terra Sigilata, African Sigillata, African pottery, Roman period.

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Ceramic Traditions, Technological Diversity, and Provenance Study in the Elite Necropolis of Castillo de Huarmey, Peru

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The elite necropolis of Castillo de Huarmey, located on the northern coast of Peru, provides a unique opportunity to explore the technological diversity of ceramic production during the Middle Horizon (600–1000 CE), a period marked by the expansion of the Wari Empire. This study examines the variety of ceramic styles present at the site, considering them as reflections of multiple technological traditions, including hybrid forms that integrate local and foreign influences. Such hybridity suggests interactions between diverse artisan communities and may be associated with ceremonial banquets in honor of the ancestors, a key component of elite ritual practices.

By integrating macroscopic analysis with archaeometric methods such as Instrumental Neutron Activation Analysis (INAA) and petrographic thin-section analysis, this research investigates provenance and technological choices in ceramic production. The results reveal a complex interplay between locally produced wares and those crafted using non-local traditions, suggesting a dynamic exchange of materials and knowledge. This technological pluralism underscores the sociopolitical significance of ceramics in elite Wari-related contexts and contributes to broader discussions on the movement of artisans and ideas within provincial settings of the Wari sphere.

This paper highlights the role of ceramic analysis in understanding the mechanisms of cultural interaction, technological transmission, and identity construction in ancient Andean societies.

Keywords: Castillo de Huarmey, Middle Horizon, Wari Empire, Ritual ceramics, Andean archaeology

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Markers of Change: Tracing the Transition from Indigenous to Colonial Ceramics in 16th-18th Century Cartagena de Indias (Colombia)

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Cartagena de Indias, founded in 1533 on the Caribbean coast of present-day Colombia, emerged as a dynamic centre of cultural exchange during the 16th and 17th centuries. As a pivotal port connecting the Americas with the Iberian Peninsula, the city became a confluence of Indigenous communities, African slaves, and European colonisers. This intersection fostered the development of Creole identities, shaped by complex processes of cultural negotiation and technological transfer. Ceramic production exemplifies this synthesis as Indigenous artisans maintain traditional methods and integrated European techniques. This evolution was not simply passive assimilation but a strategic adaptation of existing traditions influenced by colonial encounters.

This study explores the technological impact of European colonialism in the Colombian Caribbean through a survey of 147 post-contact ceramics from Cartagena de Indias, primarily used as cooking, transport, and tableware. The focus is on Indigenous contact ceramics, particularly Crespo typologies, and Creole ceramics, including *Mayólica Cartagena* and *Rojo Compacto* styles. These ceramics, recovered from key archaeological sites such as the *Convento de San Francisco*, *Batería de San Ignacio*, and the *Museo del Oro Zenú*, offer insights into local pottery production's distribution, consumption, and circulation. The research employs analytical techniques such as X-ray fluorescence (XRF), X-ray diffraction (XRD), and optical microscopy (OM) to uncover the provenance and production techniques associated with these artefacts.

As the first comprehensive study of Indigenous Crespo-Contact and Creole ceramic typologies, this research enhances the understanding of Cartagena de Indias' ceramic evolution. It bridges pre-contact and post-contact ceramic traditions, highlighting how Indigenous communities adapted their practices amid colonial pressures. By tracing these transformations, the study underscores the resilience and agency of Indigenous people, emphasising their efforts to preserve cultural heritage while engaging with new European influences introduced during the colonial era.

Keywords: colonial contact, Spanish Atlantic expansion, XRF, XRD, petrography

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The project MUSEA: Unified Model of Study, Virtual Exhibition, and Analysis of Museum Ceramics Collections

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This project aims to develop an integrated scientific model for the study, preservation, and digital dissemination of partially inaccessible museum collections. It focuses on two museums in Florence, Italy, both connected to the first production of porcelain in Italy in the 18th century: the Ginori Museum and La Specola Museum of the University of Florence, linking their collections through archival research and advanced material analysis.

The Targioni Tozzetti mineralogical collection and its archive, held at La Specola, document early research on raw materials for porcelain production conducted by the naturalist Giovanni Targioni Tozzetti (1712–1783 CE) in collaboration with Marquis Ginori (1702–1757 CE); the Ginori Museum preserves the first porcelain tests of ceramic mixtures and pigments of the Ginori-Doccia manufactory. The project aims to virtually unify these materials and documentary archives integrating the contribution of analytical investigation on minerals and porcelains using a multi-analytical, non-invasive, and non-destructive approach. The studies and analyses will support the curators' conservation efforts and assist in the development of content for the forthcoming exhibition at the Ginori Museum, which is currently closed to the public. A virtual exhibition will provide access to previously unavailable materials, ensuring continued public engagement with the collection during this period of inaccessibility. The project also involves a critical evaluation of data acquisition processes aimed at creating a FAIR-compliant dataset, contributing to the European Collaborative Cloud for Cultural Heritage (ECCCH), a digital infrastructure designed to support cultural heritage data. Photographic documentation, analytical data, and metadata will be integrated into an open-access repository to enhance accessibility and facilitate broader dissemination of the information.

Keywords: Porcelain, Museum, Archival research, Non-invasive analysis, Open data.

Acknowledgements: This project MUSEA is co-financed by the Tuscany Region with resources from the European Social Fund 2021-2027 (FSE+) as part of the regional program for youth autonomy: Giovanisì and by the Fondazione Museo Archivio Richard Ginori della Manifattura di Doccia, under the supervision of Dr. S. Raneri. Authors acknowledge the invaluable support of the curators of the Fondazione Museo Archivio Richard Ginori della Manifattura di Doccia, Dr. Rita Balleri and Dr. Oliva Rucellai, and the participation of the Museum of Natural History – La Specola, University Museum System, University of Florence. The curator of the mineralogical section of the Museum of Natural History – La Specola, Dr. Vanni Moggi Cecchi, is acknowledged for its fundamental support.

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Mononuclear or polinuclear pottery production in the rural territory of Umayyad Córdoba (Medieval Spain, 9th-10th centuries)

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The KUWAR project is a systematic study of the economic relations of the rural area of the province of Cordoba in the Umayyad medieval period (8th-11th centuries) through the study of its ceramics. One of its objectives is to determine whether there was a centralised model of ceramic production and distribution in the kora of Córdoba, or whether it only supplied the urban market, and whether there were secondary ceramic manufacturing centres in other population centres, such as district capitals or towns.

Based on the sampling of ceramics from 8 medieval archaeological sites, and in the technological characterisation of the production macro-area of the pottery district of al-fajarin in Córdoba, with more than 100 kilns, three main functional categories have been distinguished: kitchen, table and water.

Following the application of analytical petrography, X-ray fluorescence, and scanning electron microscopy techniques, more than one production centre has been identified. The mononuclear or polynuclear production models of Andalusi ceramics and their relationship to their functionality will be discussed in this communication.

Keywords: medieval ceramic, urban production centre, cooking ware, tableware, rural distribution.

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A multi-analytical approach to ceramic provenance: building a clay raw materials database for Early Medieval Tuscany productions

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Determining the provenance of the clay used for ancient ceramics is crucial in archaeological studies, as it reveals patterns related to production, trade and exchange. In the frame of a project aimed at creating an atlas of pottery production dated to Early Middle Ages and focusing on trade dynamics in northern Tuscany (Italy), an integrated catalogue of local raw materials has been developed as a reference database. In detail, twenty-six clay outcrops were sampled from geological formations or deposits nearby documented production sites; clays were refined and fired at three different temperatures to create experimental briquettes. A multi-analytical approach, developed at the laboratories of the Universities of Pisa, Florence and Bordeaux Montaigne, was employed to characterize the raw materials: the study of compositional and textural characteristics of petrographic fabrics was conducted via thin section petrography, mineralogical compositions and transformations were analysed using XRD and Cathodoluminescence (CL) and geochemical compositions for site chemistry determination were obtained through XRF. Finally, a micro-chemical study of phases of interest was carried out using SEM-EDX.

This paper will present the workflow and the methodological approach, with an emphasis on integrating numerical and image analysis, in conjunction with an existing database of archaeological ceramics. Although focused on the Early Middle Ages, this study is also relevant to researchers working on other periods, as the raw material sourcing areas are likely to have remained largely unchanged over time. For this reason, the data generated will be structured to be stored and made available as open data (on the MOD Mappa Open Data Repository), following the FAIR principles. In the next phase, archaeological ceramic samples will be analysed to evaluate the applicability of this tool in real-world contexts, testing its ability to support provenance identification or if adjustments are needed.

Keywords: ceramic provenance; multi-analytical approach; Tuscany; raw materials; reference database.

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Pottery Consumption and Cross-Border Interaction: The common ware found at the Mendikute Fortress (12th–14th Centuries, Gipuzkoa, Basque Country, Spain)

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The medieval fortress of Mendikute (Gipuzkoa, Spain) was part of a defensive line between the Oria and Urola valleys, which included numerous fortified sites. These fortifications safeguarded a territory in constant dispute between the Kingdoms of Navarra and Castile from the 12th to the 14th centuries (Ramos Aguirre 2000). Beyond their military function (Álvaro Rueda and Travé Allepuz 2020), they were also spaces of daily occupation, with supply and interaction dynamics that can be analyzed through the archaeological record (Álvaro Rueda and Travé Allepuz 2019). By means of macroscopic and formal characterization of 120 ceramic fragments of common wares recovered at Mendikute, complemented by petrographic analysis of thin-sections and geochemical characterization, we have been able to identify various productions of different origins and technologies. These include fabrics with detrital inclusions, some of which were tempered, as well as others of igneous origin with a basic composition rich in amphiboles, pyroxenes, and basalts. The distribution of these ceramic types suggests production and supply networks linked both to the western area (Eibar-Bergara) and to the eastern region (Navarra) of the fortress's hinterland, reflecting a landscape of interactions that transcended political boundaries. This study contributes to our understanding of the territorial and economic organization of Gipuzkoa in the Late Middle Ages and its ceramic production and distribution networks. It highlights how ceramics not only document daily life within these fortresses but also shed light on the relationships between the Mendikute fortress and other sites in the region in terms of the circulation of goods and technological transfers within a constantly evolving landscape.

Keywords: Medieval pottery, Petrography, Geochemistry, Provenance, Technology.

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Beyond local – Nuragic pottery and the choice of raw materials in the Canai plain (Sant'Antioco, Sardinia)

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The study focuses on Nuragic pottery from the Middle to Late Bronze Age site of Grutt'i Acqua in southern Sardinia. Nuragic pottery is, as in this case, made from more or less local sediments and has seldomly attracted more interest in this regard. The specific choice of raw materials however reflects social and political norms and is likely influenced by other daily practices. The composition of the pottery is therefore seen as a product of decisions based on the knowledge and contextualization of the environment, the perception of the landscape.

To discuss this appropriation of raw materials, petrography and X-ray diffraction are used to characterize and compare the Nuragic pottery from Grutt'i Acqua to different local sediments, not only to identify those that were used but also those that were not. Furthermore, experiments were conducted to address the suitability of the available clays for basic forming techniques. In a second step, the results are integrated into the Nuragic Network of Towers, villages, tombs and other places of interest like agricultural plains and anchorages, in and around the Canai plain in southern Sant'Antioco. The aim of this paper is to discuss the potential of looking closer at the use of local raw materials for pottery production and go beyond mere provenance analyses.

Keywords: Sardinia, Landscape, Petrography, Raw Material Survey, Experimental Archaeology.

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Examples of Non-Destructive Medieval Settlement Analysis in the Rhine-Main Region with and without Waster References

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Non-destructive XRF analysis, provided of proper instrument calibration, allows for large scale settlement analysis of pottery remains, waster material from nearby potting sites as sources of household and utilitarian pottery, and wasters from important regional workshops, which were in a position to supply a larger customer basis with high quality export ceramics. The River Rhine in this respect will have supported the distribution of both people, goods and ideas.

Settlement debris found in medieval Frankfurt/Main, Seligenstadt/Main, the Imperial Palace at Ingelheim/Rhine as well as Worms and Basel upstream of the River Rhine was analyzed for eight discriminative elements and clustered with the exploratory graphic program Ggobi. For important regional pottery like the South Hesse Mica wares in the Frankfurt area and the North Alsatian painted earthenware its production sites are still unknown. Identification is then based on geochemical cluster formation, stylistic homogeneity and geographic abundance. Results of a broad screening of potential clay sources are also presented.

Keywords: calibration, red-painted yellow earthenwares, cluster analysis, clay sourcing.

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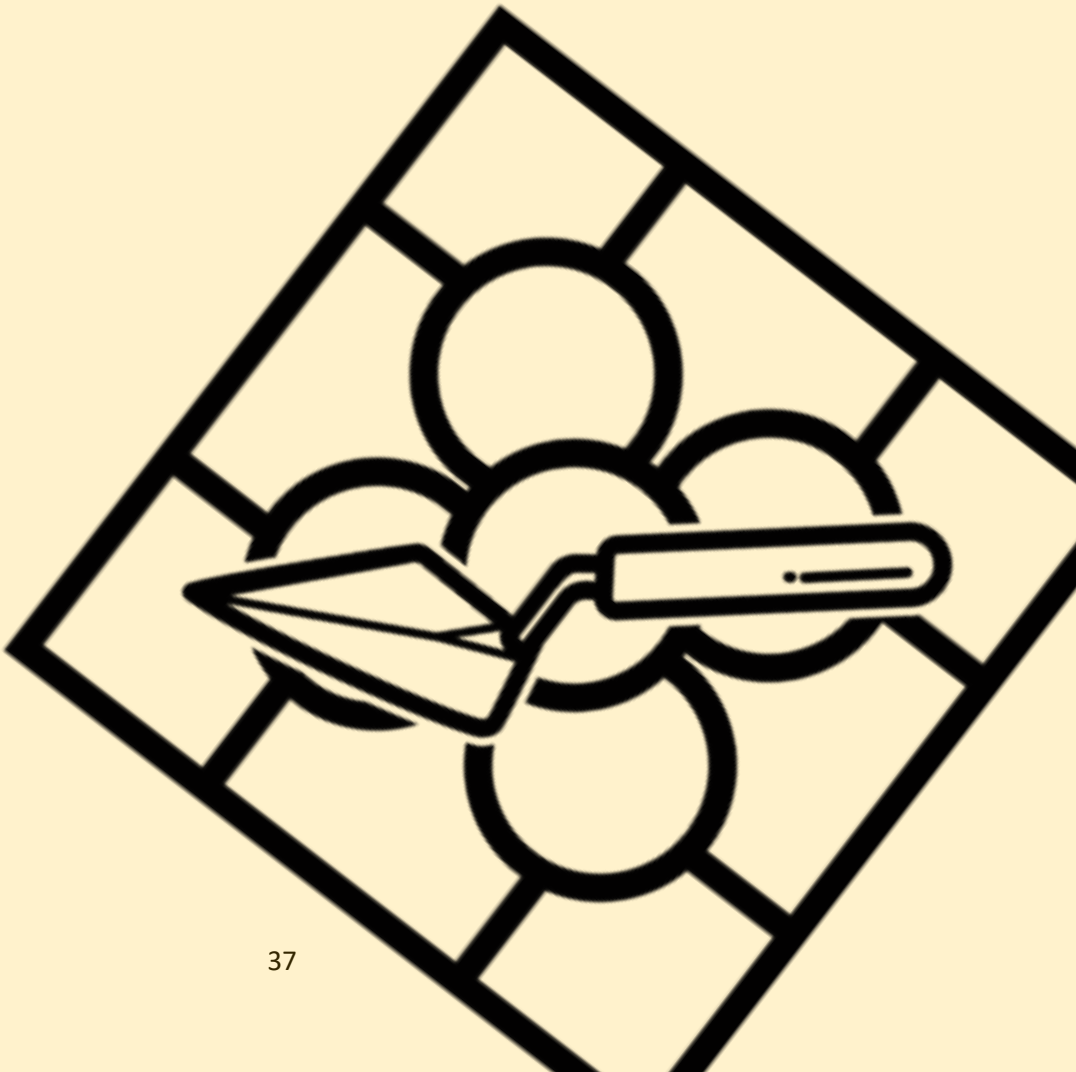
Raw Material and Provenance Studies

Poster Presentations



Tracing Clay and Craft: Petrographic Insights into Halaf Ceramic Technologies in Upper Mesopotamia

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Abstract:

This study presents a comprehensive, archaeometric investigation into the provenance of raw materials and ceramic production practices within the Halaf cultural tradition of Upper Mesopotamia, dated to the mid-6th millennium cal BC. Utilizing polarized light microscopy on thin sections of ceramic sherds from the sites of Chagar Bazar (Syria) and Banahilk (Iraq), we assess the mineralogical composition, matrix properties, and inclusion typologies of ceramic fabrics. The aim is to reconstruct chaînes opératoires and to elucidate patterns of technological behavior associated with raw material selection, preparation, and forming techniques. Petrographic data indicate the exploitation of multiple clay sources and a broad spectrum of tempering strategies, reflecting both in situ production and potential supra-regional interactions. These findings contribute to a refined understanding of technological standardization, resource management, and socio-economic organization in Halaf communities. Additionally, the study explores how technological choices embedded in ceramic manufacture may serve as indicators of cultural identity and transmission of technical knowledge across the Halaf cultural sphere.

Keywords: Mesopotamia, Halaf culture, petrography

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Soil Science applied to prehispanic ceramic from Chupicuaro, Mexico: the search of raw materials in volcanic contexts

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Ceramic petrography is a widely used in the study of artifacts; the most part of the technical descriptions are focus in the mineralogical characterization and quantification of coarse fractions (the most part sand size), not being free of certain uncertainty in the use of the "temper" concept. The regional geology afects in the mineralogical and geochemical footprint, however, in relative homogeneous regions (for example with certain dominance of intermediate magmas, as is the case of the Transmexican Volcanic Belt) the first approximations to ceramic petrogroups or petrofacies are difficult to define (Roux and Courty, 2005). An option to refine preliminar groups, is to apply concepts described by Soil Micromorphology, associated to stable elements or pedorelicts conserve despite the complex history of the artifact (Cabadas-Báez et al., 2018). Relict soil groundmass, clay fragments associated to illuviation, reductomorphic features, phytoliths, including secondary textures by weathering or hydrthermalism, are relevant to support a better characterization. A preliminary petrography characterization of ceramic pastes during the Chupicuaro occupation phases consider physically the dominance of sand fraction components derived from local geology (this include a general affectation by hydrothermalism). Particularly in the Chupicuaro Phase, samples with fine sand fraction components present Mica Group minerals and reworked clay illuviation pedofeatures.

Keywords: Chupicuaro, soil micromorphology, raw materials.

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Multi-Analytical and Comparative Archaeometric Study of Ceramic Amphorae from Çuka et Ajtoit and Butrint (Albania)

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This study focuses on the analyses and comparison of ceramic samples from the archeological sites of Çuka et Ajtoit and Butrint (Albania). Recent archaeological excavations at Çuka et Ajtoit, brought to light significant fragments of Corinthian amphorae dating from the 6th–4th centuries BCE. The objective is to characterize these ceramic sherds in detail to obtain information about production techniques, technological developments, and raw material provenance. The aim is to reconstruct the role of pottery at the site and potential connections between production centers, especially in comparison with the amphorae from Butrint. A multi-analytical approach is applied, including Optical Microscopy (OM), Fourier-Transform Infrared Spectroscopy (FTIR) and X-ray powder Diffraction (XRD). The analysis revealed a consistent mineralogical composition across ceramic samples, mainly characterized by inclusions of quartz, clinopyroxenes, plagioclase and silicate rock fragments. These components along with the analysis of clay mineral source suggest a local provenance of raw materials. Further comparative analysis with black-glazed amphorae from Phoinike (southern Albania) revealed strikingly similar mineralogical profiles, indicating possible technological and cultural connections among these archaeological sites and opening new perspectives for future studies on the diffusion of raw materials and manufacturing techniques. Finally, this study explores the potential of Terahertz technologies as an innovative approach to further investigate ceramic composition and properties in this still largely unexplored frequency range.

Keywords: Ancient ceramics, Black-glazed amphorae, Archaeometric characterization, Terahertz technologies

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EMAC 17th EUROPEAN MEETING ON ANCIENT CERAMICS BILBAO 2025

Characterization of Western Greek Amphorae in Naples: An Archaeometric Approach

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During the construction of the stations on lines 1 and 6 of the Naples underground, located in Piazza Santa Maria degli Angeli, in Piazza Nicola Amore and in Piazza Municipio, a significant number of Western Greek amphorae were discovered. A selection of thirty-seven fragments were selected, dated to the 6th and 4th centuries B.C., and classified according to the typological characteristics proposed by Sourisseau and Gassner for the rim shape variants and then subjected to archaeometric analysis. This type of amphora was produced in several centers across Magna Graecia (Sicily), in the Ionian-Adriatic region, the Aegean and Massalia, indicating its wide distribution throughout the central-southern Mediterranean. The presence of multiple workshops in different sites makes it challenging to pinpoint specific production centers. The selected fragments were analyzed using a multi-analytical approach with different techniques, such as thin section analysis with a polarized-light microscope (PLM) and chemical analysis via X-ray fluorescence (XRF). Mineralogical analysis by X-ray powder diffraction (XRPD) and scanning electron microscopy (SEM) were also performed to determine the technological features of the samples. By comparing the petrographic evidence with the chemical data, their possible origin areas were recognised. The thin section analysis allowed us to identify seven petrographic groups with homogeneous characteristics and four outliers. Chemical data, combined with Hierarchical Cluster Analysis (HCA), confirmed the results of the petrographic observations, grouping samples characterized by high concentrations of chromium and nickel and samples with lower concentrations of calcium oxide. The results of the analyses made it possible to identify a local production of Western Greek amphorae, as well as productions linked to the Paestum area, the Calabria region and the Aegean/Ionian-Adriatic region.

Keywords: Western Greek Amphorae, Naples, multi-analytical approach, provenance.

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Neolithic connectivity in central Italy: a study of raw materials and ceramics from the Grotta Battifratta site

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Ceramics have played a key role in the study of ancient communities from the Neolithic period onwards, providing insight into various aspects such as technological production, the provenance of raw materials, regional connectivity, and ancient mobility. The goal of this work is to reconstruct the potential interactions between human communities in current-day central Italy during the transition from the end of the 6th millennium to the beginning of the 5th millennium BC.

The Battifratta Cave is an ideal location for these investigations. Located in Sabina (Lazio region), the site is at the heart of the peninsula between the middle Adriatic and the middle Tyrrhenian areas. Furthermore, the Neolithic pottery found there exhibits morpho-typological similarities with pottery from both regions. Initially, petrographic analyses were carried out on thin sections of archaeological samples from the Battifratta Cave using optical microscopy. The aim was to identify the materials used and try to reconstruct the production technologies employed. Subsequently, a multi-analytical protocol was adopted to provide a more comprehensive analytical framework. Combining cathodoluminescence imaging (CLI) and portable X-ray fluorescence spectrometry (pXRF) provided new data on the mineralogical and chemical composition of the analysed material. These archaeological samples will be compared with analyses of raw materials sampled near the site under study.

Preliminary results suggest a high degree of variability within the ceramic assemblage, indicating the use of different sources. Some of the identified ceramic fabrics are compatible with local raw materials. Other samples, however, show no affinity with the clay sampled locally, suggesting an exogenous origin of the pottery. In order to gain a fuller understanding of the provenance of the raw material in central Italy, other clay deposits are being mapped and analysed, both locally and in areas where there are similarities in ceramic production.

Keywords: Neolithic, Central Italy, Archaeometry, Ceramic, Raw material.

EMAC 17th EUROPEAN MEETING ON ANCIENT CERAMICS BILBAO 2025

Reinterpreting the Neolithic in the Tagus Basin: Pottery characterization and chronology

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Abstract

In the early 20th century, research on the Neolithic in central Iberia began, guided by Bosch Gimpera's *Cultural Circles* theory (1932), which classified the Plateau within the *Cave Culture*. By the end of the century, new discoveries, expanded evidence, and radiocarbon dating led to a revision of this model, opening new research avenues. The middle Tagus basin exemplifies this evolution.

In this poster, we present a systematic review of all published dates for this period, following their recalibration using the latest calibration curve (IntCal20). The aim of this study is to characterize the earliest ceramic productions in the middle Tagus basin through a comprehensive review of the available absolute dates. The analysis will focus on the relationship between the obtained dates and the ceramic material record to define the characteristics of Neolithic ceramics in this region.

Additionally, this study will be complemented by the results of a macroscopic analysis of the ceramic assemblages from Neolithic sites in the Tagus basin, along with the first data obtained through the application of an innovative methodology in this region, including ceramic petrography, X-ray diffraction (XRD), and X-ray fluorescence (XRF). This analysis will focus on the correlation between the obtained dates, associated structures, and the ceramic material record, with the aim of defining the characteristics of the earliest Neolithic ceramics in the area and reinterpreting its role in the Neolithization process of the Iberian Peninsula.

To what extent can the Iberian Plateau be considered a marginal territory dependent on other Iberian regions, such as the Levant or the South? The goal is to reassess the role of the Tagus basin, a key region due to its geographical position as a link between the Atlantic and Mediterranean areas, within the Neolithization of the Iberian Peninsula and its broader European context.

Keywords: Neolithic, Pottery, Technology, Characterization, Petrography.

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EMAC 17th EUROPEAN MEETING ON ANCIENT CERAMICS BILBAO 2025

A ceramic assemblage from the Augustan-Tiberian period in the Roman city of Pollentia (Mallorca, Balearic Islands, Spain): archaeometric characterization of amphorae and common wares

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Excavations conducted in recent years at the Roman city of Pollentia (Mallorca, Balearic Islands, Spain) uncovered several archaeological contexts that help to better understand the long occupation sequence of the site. Part of this recent research has been focused on the forum area, from which the context presented in this study originates. It corresponds to the infill level of a cesspit from the Early Imperial period, cut into the east-west street that runs along the northern edge of the city's forum. This context (SU 9804) is exceptional, both due to the large quantity of recovered ceramic materials (more than 9,000 fragments) and the relatively short chronological timeframe of its formation, which has been dated between 15 BC and AD 20/30.

From this extensive ceramic assemblage, a sample of 53 common wares and 62 amphorae was analyzed, with the aim of determining their provenance and gaining insight into some aspects of their production technology. For this purpose, the selected ceramic samples were archaeometrically characterized using a combination of techniques, including wavelength dispersive X-ray fluorescence (WD-XRF) for the chemical characterization, thin-section optical microscopy for the mineralogical and petrographic characterization, and X-ray diffraction for further information on the mineralogical composition of the ceramics. The results confirm the imported provenance of most of the amphorae, with materials from various sources, particularly the current Catalan coast, but also Ibiza, the Italian Peninsula, and southern Hispania, among others. In contrast, the common wares are mostly of local/regional provenance, which expands our knowledge of Balearic ceramic production during the Roman period. The exceptional nature of this Augustan-Tiberian context documented in the city's forum provides a unique opportunity to gain insight into the different ceramics that circulated and were consumed in Pollentia at a time of great prosperity for this Hispano-Roman city.

Keywords: Mallorca, Balearic Islands, Roman pottery, petrography, WD-XRF

EMAC 17th EUROPEAN MEETING ON ANCIENT CERAMICS BILBAO 2025

Late Roman amphora production in northwestern Spain: archaeometric characterization of materials from the kiln site of Bueu (Galicia)

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The coastal town of Bueu in Galicia, Spain, holds significant archaeological importance. Excavations conducted between the late 20th and early 21st centuries revealed the principal Roman amphora production site discovered to date in northwestern Spain. The site includes a pottery workshop —featuring kilns and related structures— dating to the 3rd–4th centuries AD, as well as an associated fish-processing facility, underscoring the region's prominence in the ancient halieutic industry. The amphorae produced in the *figlina* (workshop), which correspond to at least two main types (San Martiño de Bueu 1 and 2), were intended for packaging and exporting local salted fish products. In order to determine the extent of the commercial distribution of these fish products, it is crucial to analyze the compositional characteristics of the transport amphorae so they can be identified in both regional and extra-regional consumption centers. For this reason, this study presents a combined petrographic (thin-section optical microscopy) and chemical (WD-XRF) analysis of a set of 36 amphorae found in the excavations of the pottery kilns in Bueu, with the aim of characterizing local amphora production and obtaining further evidence regarding aspects of their manufacturing technology. The results showed the presence of one main compositional group, associated with local production, along with three less represented groups corresponding to amphorae made from different raw materials, and which could also be local or possibly from other nearby workshops. The results of this study are significant for achieving a better understanding of amphora production during the Late Roman Empire in the northwest of *Hispania* and the magnitude of the salted fish trade from this region.

Keywords: petrography, WD.XRF, amphorae, Galicia, Late Roman pottery

The Valencian sugar industry: study of sugar ceramic production in the territory of La Safor

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Sugar production in the Iberian Peninsula began in the 10th century in the Al-Andalus region (modern-day southern Spain) and later expanded eastwards across the peninsula during the 12th and 13th centuries, reaching its greatest peak between the 15th and 17th centuries. The eastern region was an area where several sugar production sites have been documented. The area under study is in the Comunitat Valenciana, where a major production center has been identified in the Comarca de La Safor, with three key production sites: Gandía, Oliva, all of which have yielded numerous remains of sugar production.

This study focuses on a set of ceramic pieces used in sugar production, originating from the town of Potries and dating to the 15th and 16th centuries. In the following presentation, we will analysed how these pieces were produced, as little information is available regarding production in Potries.

A total of 30 ceramic samples were analysed. These were studied through the analysis of the chemical composition of the clays using X-ray fluorescence (XRF), the mineralogical composition using X-ray diffraction (XRD), the mineralogical and textural characterization using petrographic analysis, and statistical comparison of these 30 samples with others from the towns of Gandía and Oliva.

The results of the study revealed two distinct compositional groups. Furthermore, by comparing the 30 samples from Potries with those from Gandía and Oliva, we were able to identify several that shared the same composition. This suggests that Potries was a production center that supplied these towns. These findings provide valuable information about sugar production in Potries, an area where such information was previously lacking.

Keywords: X-ray fluorescence, X-ray diffraction, Potries, La Safor, ceramic.

EMAC 17th EUROPEAN MEETING ON ANCIENT CERAMICS BILBAO 2025

Early Modern Tin-Lead Glazed pottery from Zamora, Spain: Petrographic and geochemical analysis of ceramics from the Olivares workshops

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This study presents the first integrated petrographic analysis of Early Modern ceramics from the Olivares workshops in Zamora (NW Spain), focusing on eleven tin-lead glazed wares excavated beneath the Ethnographic Museum. These samples, dated to the 16th–18th centuries, were previously analyzed using ICP-MS, XRD, SEM-EDS and Raman spectroscopy, defining their compositional and mineralogical profiles. This contribution involves a detailed thin-section petrography of all samples, enabling the identification of three fabric types (F-IIa, F-IVa, F-IVb) and their corresponding firing temperatures. The data reveal significant technological variability, including differences in illite and plagioclase content, mineral transformation (gehlenite, diopside), and vitrification levels. Calcareous pastes dominate the assemblage, suggesting controlled firing strategies and workshop specialization. These results refine previous compositional groupings (notably group Z-3) and confirm the use of two distinct Ca-rich clay sources. The petrographic evidence supports the hypothesis of specialized, high-temperature production practices and provides new insights into local technological choices within the broader context of post-medieval ceramic traditions in northwestern Iberia.

Keywords: Archaeometry, Ceramic petrography, Thin-lead glazed pottery, Early Modern archaeology, Zamora (Spain).

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What to drink in Medieval Kyiv? Shaping Trade and Consumption through Archaeometric Analysis of Amphorae

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Analysis of archaeological material confirms the role of medieval Kyiv as a key hub in the trade networks connecting the Scandinavian world, Byzantium, Medieval Orient and Western Europe. As an importer and distributor of luxury goods, Kyiv played a crucial role in redistributing Byzantine products further north, reinforcing its status as a major economic centre along the "route from the Varangians to the Greeks." Kyiv has one of the largest collections of amphorae material. These ceramic transport vessels, primarily used for wine, oil, and other valuable commodities, reflect the extensive commercial connections that linked the Mediterranean with Eastern and Northern Europe.

Chemical and petrographic analyses of amphorae provide insights into their production centres, trade logistics, and the mechanisms of long-distance exchange. For the first time, this study presents the results of characterisation of amphorae import to Kyiv based on integrative archaeometric approach of 116 amphorae samples*. The greatest diversity of compositional groups was noted, compared to the six other analysed sites within Ukraine and Poland, which indicates the greatest diversity of economic contacts of the capital. Using the Lyon Laboratory's reference database, four compositional groups were linked to specific amphora production centres - the European coast of the Dardanelles Strait, Chalcis, Corinth, and the unidentified Günsenin II-minor Group production centre. Production centres are represented by both mass and single finds, suggesting different patterns of consumption. By examining amphorae through archaeological and scientific methods, this research contributes to a deeper understanding of medieval trade networks, the transmission of artisanal knowledge, and the economic structures that connected Byzantium with the northern frontiers of Europe. The results were obtained within the framework of the project 'From Byzantium With Love. Byzantine amphorae finds from East-Central, Eastern and Northern Europe (10th - 13th century). An archaeometric approach', funded by the Alexander von Humboldt Foundation.

Keywords: amphorae, Byzantine Empire, Medieval Kyiv, trade, archaeometry.

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Heat-modified shales as temper in QPW 1-2 pottery from Qurayyah, NW Arabia

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We present the first petrographic study of the final MBA-initial LBA pottery from Qurayyah, NW Arabia, the oasis site excavated by the Joint Archaeological Project of the Saudi Heritage Commission and the University of Vienna. The study incorporates 36 pottery samples from the production context of a firing kiln. A combination of ceramic petrography and geochemical analyses (NAA) established a solid reference group for Qurayyah, marking a milestone in pottery provenance studies from Arabia, a region still underrepresented in current research.

Three distinct petrogroups were identified, all characterized by a non-calcareous clay matrix with quartz inclusions and shale temper. These are consistent with the surrounding geology, while differences in frequency and size of inclusions reflect distinct patterns of raw material selection and processing. This poster explores a notable feature observed in the samples: heat-modified dark shales with vesicular structures.

Previous analyses of comparable pottery have attributed vesicular structures to alterations caused by the firing process. However, vesicular shales do not appear consistently in all samples, which show no clear differences in firing temperatures based on other indicators like the optical activity of the matrix and the alteration of mineral inclusions. An alternative hypothesis is that the shales underwent a pre-treatment involving heating before being mixed with the clay to enhance the material properties of the final artifacts. Otherwise, the shales could originate from the recycling of by-products from other pyrotechnological processes. Both hypotheses align with field observations at the site, where the intentional heating of shales is suggested by circular-shaped structures in the landscape, whose function is currently jointly analyzed by ceramic specialists and micromorphologists. These hypotheses raise questions about technological choices related to tempering materials in challenging environments like desert oases and open a discussion on the possible involvement of recycling strategies in the chaîne opératoire of this assemblage.

Keywords: Ceramic Petrography, Shale Temper, Recycling Practices, Chaîne Opératoire, NW Arabia

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Late Roman Amphoras from the Kounoupi Workshop, Southern Argolid: New Petrographic and Elemental Investigations

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This paper presents the results of a multi-method fabric analysis of 30 fragments of Late Roman amphoras collected during intensive archaeological surface survey in the Mazi Plain, northwest Attica (which comprises the sites of Eleutherai and Oinoe). This study was undertaken under the auspices of the Mazi Archaeological project, a collaboration between the Ephorate of Antiquities of West Attika, Piraeus, and Islands and the Swiss School of Archaeology in Greece. The sampled sherds are attributable to the Late Roman Amphora 2 and other related types that were in use from the early 4th to the mid-7th centuries AD. The combined petrographic and WD-XRF analysis of the fabric suggests a homogeneous composition and a provenance of the sampled sherds from a single location in the northeastern Peloponnese, attributable on geological and archaeological basis to the Kounoupi workshop in the southern Argolid. The archaeometric, typological, and archaeological data obtained from our sample set, and their comparison with previously published data pertaining to various findings from the western, central, and eastern Mediterranean, allow for a detailed reconstruction of the production history and production strategies of this major amphora industry in the Late Roman Mediterranean. In particular, our study highlights the early date of the operation of this workshop (from the 4th century AD) and its survivance into the early Byzantine world (7th century AD), with a wide distribution network reaching remote areas such as northern Italy and northern Spain, and a larger range of production types than hitherto suggested, with not only LRA2 but also fruit amphoras, small versions of LRA2, and a local imitation of the widespread LRA1 (probably around the 7th c. AD).

Keywords: Late Roman amphora, Mazi Plain, Kounoupi workshop, petrography, WD-XRF.

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New Insight into Iberian Ceramic Production: the study of the Fontscaldes Kiln

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Despite its significance, Iberian ceramic production remains largely under-characterized from an archaeometric perspective, with only a few studies addressing this issue. The Iberian ceramic kiln of Fontscaldes (Valls, Catalonia), dating to the first half of the 2nd century BC, was discovered in the 1920s and is one of the most important kilns in northeastern Iberian Peninsula. However, its production has never been systematically analysed. Archaeological excavations at the site have uncovered a variety of ceramic types, including *kalathoi*, storage jars, plates, cups painted with reddish colour, and a significant assemblage of amphorae.

This study aims to characterize the ceramic production of the Fontscaldes kiln, focusing on the Iberian amphorae. To do that, a total of 30 ceramic individuals from the kiln's excavation were analysed using X-ray fluorescence (XRF) to determine their chemical composition and define a reference group for this production centre. Additionally, X-ray diffraction (XRD) was employed to provide insights into firing conditions and technological choices.

To contextualize these findings, the results will be compared with the ARQUB (UB) research group's database to assess whether Fontscaldes amphorae can be identified at distribution sites. Notably, ceramics with similar decorative traits have been found in several settlements, including Empúries. This comparative approach will contribute to define the regional distribution network of Fontscaldes' ceramic production. Furthermore, this study will serve as a key reference for future archaeometric research, enabling comparative analyses with other Iberian ceramic production and reception centres and enhancing our understanding of regional ceramic manufacturing and trade dynamics.

Keywords: Iberic ceramic, amphora, kiln, provenance

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BILBAO 2025

Title African Terra Sigillata and common African pottery at the Roman site of Los Villares (Salamanca). Anaysis of the ceramic context and archaeometric study

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The province of Salamanca (W Spain) is traversed from south to north by one of the main communication routes of the Iberian Peninsula during Roman times: the Via de la Plata ("Silver Route"). Originally constructed to provide the Roman army with a reliable path for the conquest and control of Hispania, this strategic route gradually evolved into a vital corridor for travelers and merchants moving through Roman Lusitania from north to south. Along its course, numerous mansiones, villas, and rural estates emerged, forming part of the broader Roman rural settlement pattern between the 1st and 5th centuries AD. Within this historical and geographical context, archaeological surveys conducted in 2015 in the middle valley of the Tormes River uncovered a site of exceptional archaeological significance. Subsequent excavations in 2015, 2017, and 2018 revealed several structures—some featuring pavements made of opus tessellatum and opus signinum—which were part of a substantial Roman rural complex. In addition to the ceramic materials typically associated with such contexts, a significant number of fragments of African Terra Sigillata (ATS) and common African wares from Nabeul (Tunisia) were discovered during all excavation campaigns. These findings led to the initiation of an archaeometric study aimed at gaining deeper insights into the origin and production techniques of these ceramics. This study presents an archaeological and archaeometric analysis of the ATS found at the site, exploring its connections with the broader trade networks that operated along the Silver Route.

Keywords: Via de la Plata, Terra Sigilata, African Sigillata, African pottery, Roman period.

EMAC 17th EUROPEAN MEETING ON ANCIENT CERAMICS BILBAO 2025

In and out material culture: Corsican potential goals

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Former and more recent archaeological finds in Corsica Island emerge as a potentially worthy camp to subject to new investigation: starting from macroscopic observations, collection of sub-regional data, and in wait for eventual archaeometric evaluations; here, some hints of the main possible cases of study mostly belonging to the Second Iron Age and the Roman Period.

The recently focused means of investigation elaborated within the SHERDS Project, developed by Silvia Pallecchi (University of Genoa) and colleagues, might offer a new 'reading' of a manifold sample of re-uses and secondary uses of amphoric containers with traces of rearrangements on the pottery bodies and on the objects themselves, but they might also throw a new potential light upon possible treatments of the ceramic bodies and about particular uses during their original life, eventual 'overstructures' carried by them and / or eventual traces of containing - primary or not -, beside their usual classification. Under this point of view, the containers coming from burial findings (e.g. Sagone, Ajaccio, Propriano, Pianottoli, Aleria, Mariana and so on) will be precious, but also – with the shared caution – the ones from former and recent underwater finds. It will be interesting also to verify eventual lower technical standards of some 'burial-dedicated' ceramic products, once conjectured on the I Palazzi site.

Besides the main pottery considered as locally produced (mostly decorated with comb lines and set in the Second Iron Age), often with asbestos fibres inside (whose supplying basins remain to be sharply detected), a widened archaeometric screening might eventually detect local 'table' or 'common' productions between Hellenistic and Roman Ages (once supposed e.g. at Aleria); to date, some recent evidence of Roman fictile production seem not related to vessels.

Another possible case of study would concern the hoped widening of investigations about raw glass material and the various 'glass' objects found on the island, usually attributed to primary or secondary ateliers, working at least from the Late Bronze Age up to the Late Iron one (e.g. Teppa di Luciana, San Simeone, Grotta Piatta in Balagna).

Always in the dialectic between local and external supplies of raw materials, the use of the local stones (e.g., the one exploited at Cavallo Island) in Roman buildings – especially in coatings and floors (e.g. at Aleria and occasionally elsewhere as at Piantarella *villa* or at Ajaccio) - and the eventual outside circulation remain just sketched until now, beside the scattered documented stone imports.

Keywords: Corsica; classical archaeology; uses and traces; raw material; provenance

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EMAC 17th EUROPEAN MEETING ON ANCIENT CERAMICS BILBAO 2025

Non-invasive and invasive XRF analysis of clay sources and ceramic sherds from the Late Nordic Bronze Age in Southeastern Norway

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Pottery is one of the few sources of information about the Nordic Bronze Age in Norway. To shed light about this period, this work examines the relationship between raw clays and ceramics dating to 1100-400 BCE in Østfold, Norway. With archaeological sites spanning a 30 km area, the study investigates whether prehistoric potters from sites across the area used similar or distinct clay sources. The region's geological setting, with granitic rock and a terminal moraine, as well as multiple water sources, presents a challenge: can significant compositional differences be detected within the region? If so, can these variations establish clay provenance and reveal exchange between the prehistoric sites in question? To answer these questions, this contribution presents and compares the results obtained both non- and invasively by p-XRF. The study, conducted on a set of about 70 sherds from 12 sites, aims also to highlight the influence of compositional differences related to the contribution of tempers and the clay matrix. Specifically, the non-invasive analysis has been performed averaging the results of 5-7 acquisition points chosen on broken edges of the fragments. Additionally, invasive analysis was carried out on powdered samples before and after three sieving steps at increasing mesh size. This approach aims at exploring ceramic and clay sample preparation, as well as to determine the extent of resource variability and its implications for understanding prehistoric clay sourcing and ceramic distribution in the region.

Acknowledgments

The authors are grateful to the Museum of Cultural History of the University of Oslo for making the ceramic sherds available for this study and allowing their scientific investigation.

Keywords: Late Nordic Bronze Age, Norway, p-XRF, PCA.

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EMAC 17th EUROPEAN MEETING ON ANCIENT CERAMICS BILBAO 2025

First archaeometric characterization of late medieval ceramics from Murcia (15th–16th centuries)

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The ceramic production of late medieval Murcia (15th–16th centuries) remains largely unexplored from an archaeometric perspective. Existing studies have focused primarily on typological and documentary approaches, leaving a significant gap in the compositional and technological understanding of these materials. This research presents the first archaeometric characterization of ceramic production from this period in the city of Murcia (Spain), based on the analysis of 31 fragments recovered from the excavations at Plaza Yesqueros (Robles Fernández & Navarro Santa-Cruz, 1999, pp. 571–600). The goal is to establish a reference framework that serves as a basis for future provenance and distribution studies.

The analytical methodology involved the application of optical microscopy (OM), portable X-ray fluorescence (pXRF), cathodoluminescence (CL), and scanning electron microscopy with energy-dispersive spectroscopy (SEM-EDS) on the selected fragments. This combined approach enabled the identification of compositional groupings, the characterization of ceramic pastes and glaze technologies, and the determination of firing conditions, thus defining the main technological features of these productions.

The results provide a solid foundation for advancing the identification of Murcian ceramics in consumption contexts, deepening the understanding of local technological practices, and assessing their potential distribution within the ceramic networks of the late medieval Iberian southeast.

Keywords: Archaeometry, Late Middle Ages, Murcia, Technological characterization, Iberian Peninsula

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Urns Under the Microscope: Petrographic analysis of eight Iron Age pots from Funen, Denmark

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This project is a small petrographic case study of eight ceramic pots used as urns at a burial site in Bellinge Fælled near Odense in Denmark dated to around 300-500 AD (Younger Danish Iron Age). Four pots with ornamentations and four without were chosen to investigate any mineralogical and technological differences between the two groups of ceramics in order to examine whether they could have been produced by different potters in different local areas. The petrographic analysis of the eight pots has shown that there is a difference between the urns with and without ornamentations. The pottery with ornamentations has been carefully produced from similar clay- and temper sources with uniform technology which reflects a specific recipe and technology for this type of pottery. The four studied pots without ornamentations, on the other hand, show variations in the clay- and temper sources and in the production process. These pots could have been produced by different individuals and might have been reused from the household pottery. The eight pots have additionally been analysed with the geochemical analysis ICP-MA/ES to investigate their provenance. This has shown that the ceramics were all produced locally on the island of Funen but with clay from four different clay sources. Based on this, the pottery must have been produced by different potters with extensive knowledge of the materials and resources, who were able to select and use different resources for different types of pots with different purposes.

Keywords: Ceramic petrology, ICP-MA/ES, Danish Iron Age

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EMAC 17th EUROPEAN MEETING ON ANCIENT CERAMICS BILBAO 2025

Technological Traditions of Bronze Age *Impasto* Ware at Torre Castelluccia (Apulia, Southern Italy): A Comparative Study of Domestic and Funerary Contexts

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The coastal site of Torre Castelluccia in Apulia (Pulsano, TA) is a rare example in Italian protohistory where both settlement areas and adjacent burial sites—including grotticella-type tombs and a cremation cemetery—have been identified (Gorgoglione 2002). A recent re-examination of over 1000 pottery sherds has produced a reliable chronological sequence spanning from the South Italian Middle Bronze Age (1700–1300 BC) to the Greek colonisation around 700 BC. Building on this dataset, further research has explored the technological characteristics of *impasto* ware from both settlement and funerary contexts.

The aim is to investigate the technological choices made by the community of practice responsible for pottery production at Torre Castelluccia, focusing on raw material procurement and paste preparation methods. By analyzing analogous functional shapes from different contexts of use—domestic and funerary—we can conduct a comparative study that significantly enriches this research, especially given the rarity of such diachronic and contextual analyses. The methodology combines macroscopic and archaeometric approaches. Macroscopic observation of various vessel types from both contexts and different phases enabled the preliminary classification of 180 potsherds (Pizzuti et al. 2025). Out of these, a representative sample of 50 sherds was selected for thin-section petrographic analysis.

This poster presents the petrographic results, highlighting the relationships between petrofabrics, chronological phases, vessel function, and context of use. The results offer new insights into the technological traditions and social organisation of pottery production at Torre Castelluccia during the Middle and Late Bronze Age. Moreover, the project significantly expands the regional dataset, as only a limited number of samples had previously been analysed for this area (Cannavò et al. 2018).

Keywords: Bronze Age Apulia, Impasto Ware, Pottery production, Petrographic analysis, Contextual Comparison.

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EMAC 17th EUROPEAN MEETING ON ANCIENT CERAMICS BILBAO 2025

Looking for clays: A geoarchaeological study of ceramic raw materials from Naxos (Greece)

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The island of Naxos, situated at the center of the Aegean Sea, has maintained a continuous historical presence from antiquity to the present day. Over the course of its history, Naxos has undergone numerous transformations, with its diverse geological landscape playing an integral role in shaping its historical narrative. The island's geological resources have provided raw materials for the construction of structure and the production of a wide range of artifacts, reflecting the rich cultural heritage of the Cyclades.

The doctoral research project 'MATCH: contextualizing ceramic raw MATerials exploitation and pottery distribution, a transdisciplinary approaCH', examines the ceramic traditions of Naxos in both ancient and modern contexts. The project aims to explore technological choices and human agency in pottery production through the study of raw materials (clays and tempering agents) suitable for ceramic manufacture. The research employs a transdisciplinary methodology that integrates archaeology, ethnography, and archaeological science. A large-scale geological prospection and inter- and intra-source sampling of clayey raw materials is conducted. The collected data are subsequently compared with ancient and modern ceramics through mineralogical, petrographic, and geochemical analyses. The primary objectives of the study include a deeper understanding of factors such as intra- and inter-source variability, provenance, and production technologies.

This paper presents the preliminary analytical results of raw materials collected from Naxos. The data obtained through various analytical techniques, including X-ray diffraction (XRD), X-ray fluorescence (XRF), and petrography, are examined comparatively to investigate the geochemical variability of geological deposits. Finally, the results of this geoarchaeological study are discussed in relation to evidence from ancient ceramics, offering insights into the technological and material choices made by past potters.

Keywords: Aegean archaeology, Ceramic studies, Production technology, Raw materials.

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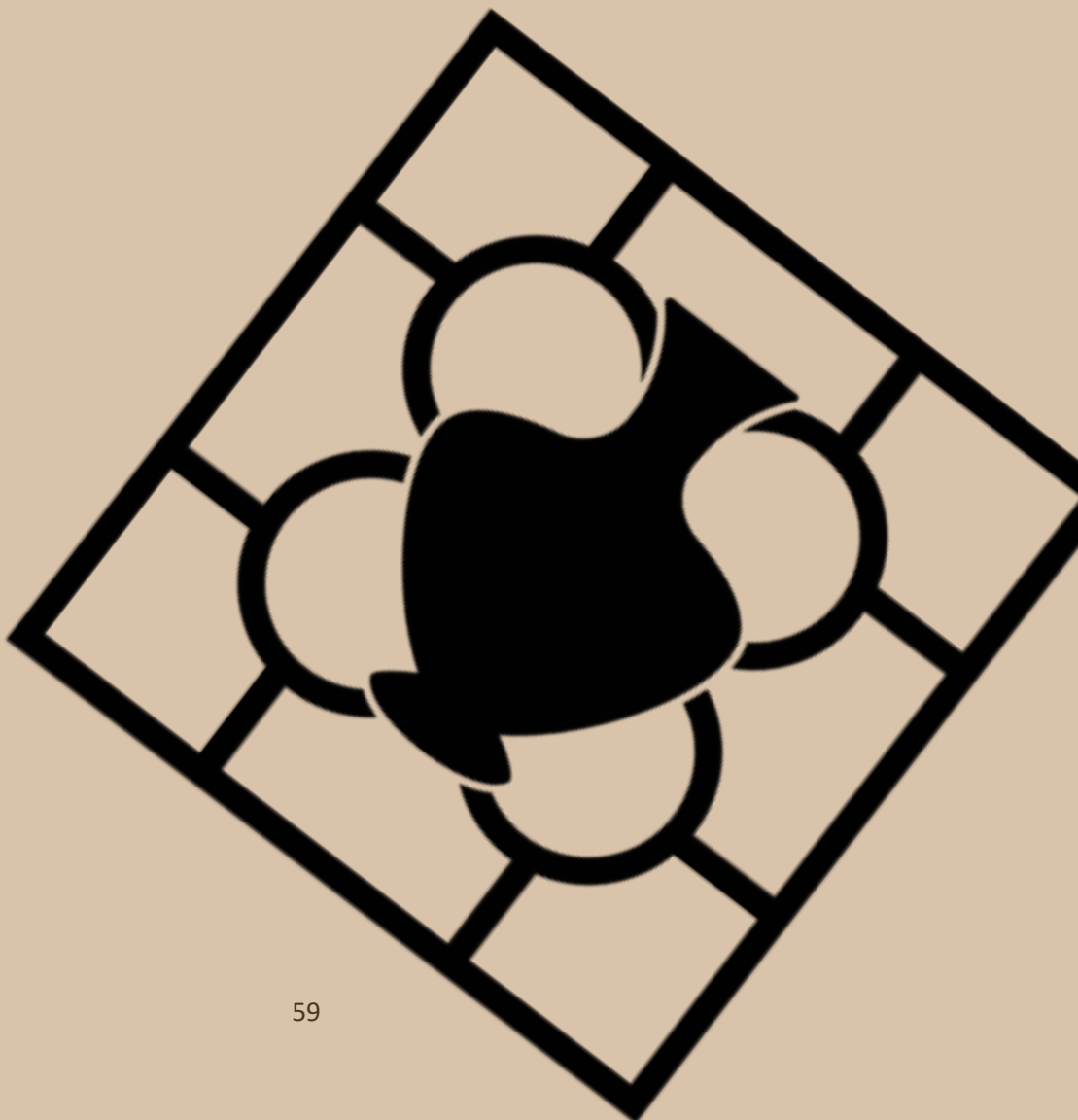
4.2. *Experimental Archaeology, Ethnoarchaeometry and Organic Residue Analyses*

Oral Presentations



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In Search of the Lost Pottery Workshops: Use-Wear Analysis of Lithic Tools Associated with Ceramic Production in Indigenous Contexts and Traditional Workshops of Gran Canaria

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The indigenous pottery of Gran Canaria, handmade and technically refined, stands out for its high quality and typological variability. Its study has yielded precise information on the technological strategies employed in vessel production, including the preparation of distinct clay pastes tailored to specific functional uses. The wide formal variety of the vessels, along with their decorative techniques and compositions, suggests cultural patterns that may be associated with different aspects of their everyday use, as well as with symbolic practices.

Despite over a century of intensive archaeological research, the precise locations of the workshops where these vessels were produced remain unclear. However, the ethnoarchaeological study of lithic tools—traditionally used in 20th-century pottery workshops on the island—has provided valuable insights into the *chaînes opératoires* of hand-crafted pottery production. While the morphology of the wares evolved over time, the technical know-how was preserved. The identification of highly similar artefacts in archaeological contexts represents a powerful tool for recognising those indigenous workshops that have so far eluded archaeological detection.

Keywords: Canary Islands, Archaeology, Traditional pottery, pre-European ceramics, use-wear

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Neolithic diet from ORA perspective: the case of Duero basin

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Organic residue analysis in prehistoric ceramics has provided critical insights into dietary practices and resource exploitation in these societies (Evershed et al., 1999). The application of gas chromatography coupled to isotopic ratio mass spectrometry, in particular, has enabled the distinction of residues derived from various animal and plant fats to be made, indicating a diverse exploitation of resources during the Neolithic.

The Neolithic in the Duero Basin marks a crucial period in the transition from hunter-gatherer societies to farming and livestock communities. Although archaeological evidence from this region has often been considered limited, numerous sites from this period have been identified. Early radiocarbon dates, such as those from La Lámpara (5470-5320 cal. BC, Soria, Spain; Rojo Guerra et al., 2008) and El Portalón (5320-5080 cal BC, Burgos, Spain; Pérez-Romero et al., 2021), suggest that the emergence of farming practices in the Duero Basin occurred close to the earliest evidence of Neolithization in the Iberian Peninsula (e.g., Cova Can Sadurní 5472-5328 cal BC; Edo, Antolín, Barrio, 2012).

This study presents new molecular and stable carbon isotopic data from the northeastern Duero Basin, analysing 18 ceramic fragments from both funerary contexts (e.g., Las Arnillas) and habitation sites (e.g., Los Cascajos-Fuenteblanquilla). These findings offer valuable perspectives on food consumption, including evidence of meat and dairy products, which are characteristic of this period. These data are compared with the available evidence for the Iberian Peninsula. This research provides a foundation for further investigations of ceramic use and consumption patterns, highlighting the importance of organic residue analysis for understanding dietary adaptation in prehistoric communities of the Duero Basin.

Keywords: Neolithic, Pottery, Organic residue analysis, Inland Iberia.

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Organic biomarkers, storytellers of the Neolithic age in El Mirador cave (Sierra de Atapuerca, Burgos, Spain)

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The use of ceramics as storage or cooking recipients was a breakthrough for the daily life of human beings since the Neolithic age. Besides, it is a useful tool for a better understanding of the consumed, stored, or transported food by the analysis of organic biomarkers adsorbed in the pores of pottery. Therefore, these biomarkers, such as betulin, fatty acids, fatty acid esters, sterols, phytosterols, *n*-alkanes… can help us to understand better the habits of the humanity.

This work presents the results obtained from the Neolithic ceramics of El Mirador cave located in Sierra de Atapuerca (Burgos, Spain). The analysis was carried out by gas chromatography-mass spectrometry in SCAN mode for identification of all the analytes. For this identification, an own library was built with the mass spectrum of each compound of interest. Additionally, all the ancient biomarkers available in the laboratory were used to carry out a single ion monitoring (SIM) analysis to detect the analytes at lower concentration which are not able to detect by SCAN mode.

Keywords: Pottery, biomarkers, Neolithic age, GC-MS.

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Amphorae from the Ancient Harbor of Neapolis: Technological and Provenance Insights into North African Trade Connection between the 2nd and 4th centuries CE

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Excavations performed during the construction of the underground station in the Municipio square in Napoli revealed the ancient harbor of Neapolis. This key finding has provided precious data for re-enacting trade routes via the study of the material culture and tracing connections among populations. Amphorae associated with the North African trade between the 2nd and 4th centuries CE made the fortune of African products in the Bay of Naples area and, more generally, of the ancient trade between the Campania and North Africa coasts, including Zeugitania and Byzacena (Tunisia), Tripolitania (S Tunisia-W Lybia), and Mauretania Caesarensis (N Algeria).

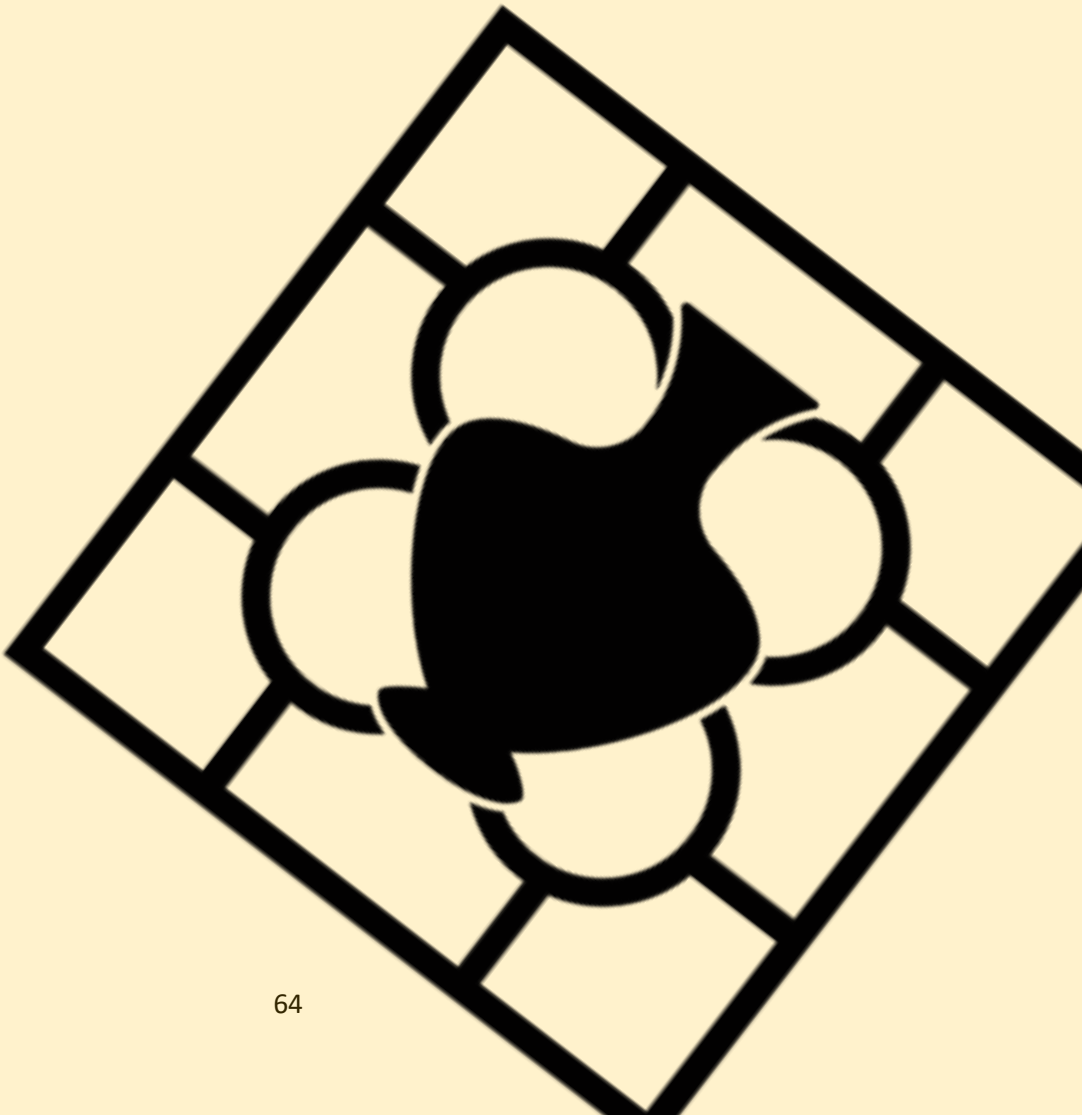
This study examines the definition of the provenance and technology of a set of 31 North African amphorae discovered at the seaport of Neapolis. It integrates a morpho-typological archaeological approach, mineralogical-petrographic techniques, and chemical analyses of the organic residue. Chemical analysis (XRF) indicated a high concentration of CaO in most samples, alongside a homogeneous chemical composition regarding both major oxides and trace elements, with only a few outliers. Polarized light microscopy identified four petrographic groups, which exhibit affinities with the geological features of the suspected production areas and with comparative materials (kiln rejects and reference groups of local ceramics, primarily from the Tunisian coast). Furthermore, the identification of microfossils corroborated the recognition of the raw materials employed. Collectively, these findings offered valuable insights into the association of each sample group with the production ateliers.

Pyrotechnological information was obtained by combining mineralogical data (XRPD) and microstructural observation of fresh fractured samples under the SEM. Chemical analyses of the organic residues are in progress using GCMS and proteomic approaches (funded by PNRR PE5 CHANGES (PE00000020), spoke 5) to get clues on traded goods, such as wine and oil, well attested in these types of vessels according to the archaeological literature.

Keywords: African Amphorae, Neapolis, African Trade, Minero-petrographic analysis, organic residue.

Experimental Archaeology, Ethnoarchaeometry and Organic Residue Analyses

Poster Presentations



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Late Neolithic pastoralism in the Cantabrian Mountains: biomolecular insights from Los Canturriales in Babia (León, Spain)

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Los Canturriales is a rock shelter in the vicinity of Las Verdes lake, near Torre de Babia (Cabrillanes, León, Spain) in the southern façade of the Cantabrian Mountains. The site is located in a subalpine grazing area at an elevation of 1,750 meters above sea level. The climatic conditions are characterized by harsh winters with substantial snowfall, that historically support a transhumant pastoral economy.

Since 2017, the Institute of Heritage Sciences (INCIPIT-CSIC) has conducted archaeological investigations in the region to identify and document evidence of pastoral settlements spanning multiple historical periods. Recent excavations at this small rock shelter have revealed occupation layers dated to the Late Neolithic, including well-preserved archaeological deposits containing fragmented ceramic vessels, lithic assemblages, and other material remains indicating prolonged and recurrent site utilization during this period.

To ascertain the functional use of the ceramic vessels, gas chromatography-mass spectrometry (GC-MS) was employed to analyze the biomolecular composition of organic residues preserved within the ceramic matrix. The biomarker analysis confirmed the presence of well-preserved organic compounds, demonstrating that the vessels were used for processing ruminant animal fats. The exceptional preservation of lipid residues suggests favorable depositional conditions, attributed to the stabilizing effects of high-altitude, low-temperature environments, as well as the sealing of stratigraphic units containing the ceramics beneath a large limestone slab that detached from the shelter's roof.

These findings provide direct evidence of vessel utilization for food preparation and storage, offering critical insights into subsistence strategies and resource exploitation patterns at the site during the Late Neolithic period, which are also informed by the examination of charcoal and faunal assemblages recovered in this upland site.

Keywords: pastoralism, Neolithic, biomolecular analysis, chromatography, ruminant animal fats.

From Relief to Recipe: Experimental Archaeology in the Reconstruction of Ceramic and Culinary Heritage from Viminacium

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This study explores the application of experimental archaeology in reconstructing ancient techniques of crafting and decorating ceramic artifacts, with a particular focus on the artisanal traditions of Roman Viminacium—one of the largest pottery centers in the province of Upper Moesia. Located in the eastern part of present-day Serbia, at the confluence of the Mlava River and the Danube, Viminacium stands as one of the most significant archaeological sites in the region.

By combining archaeological analyses, field findings, and practical experiments, the research aims to understand the materials, tools, and processes employed by Roman craftsmen. During excavations, ceramic vessels were discovered containing well-preserved carbonized cereal remains. Their analysis facilitated a more precise reconstruction of recipes and food preparation techniques from the Roman period.

Special emphasis is placed on reproducing decorative motifs (reliefs) from original vessels using modern 3D technologies, enabling the creation of precise molds. These molds are utilized not only for experimental replication of ceramics but also for crafting edible artifacts—cakes made according to ancient recipes.

Through this approach, the Amulum project bridges tangible and intangible cultural heritage, exploring the potentials of archaeology through taste, form, and touch. The results contribute to a new understanding of the technological and aesthetic skills of Roman potters and open avenues for inclusive, educational, and interactive approaches in contemporary interpretations of archaeological heritage.

Keywords: Viminacium, ceramics, vessel reliefs, plant remains, 3D printing

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Trade Networks and Pre-Roman Amphorae Provenance in Ancient Capri: An Archaeometric Study

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Aim of this research is to determine the technological features and provenance of a set of 16 samples of amphorae found in Capri. The island stands out due to its strategic position within the Gulf of Naples. However, due to the lack of specialized publications in the field of ceramics, the role of the island in the commercial dynamics of the Roman or pre-Roman period is still unknown.

The amphorae investigated were excavated in the area of Gasto and belong to pre-roman types, primarily the so-called "Ionian-Massaliote" amphorae, but also examples of the North Aegean type, belonging to the Miletus-Samos group, or classified within the tradition of Greek-Italian amphorae.
The investigation is based on a combined archaeological and archaeometric approach. After a morpho-typological study, the research went on with archaeometric analyses, via mineralogical-petrographic techniques. Two petrographic groups, well matching the archaeological types, have been identified via Polarized light microscope (PLM) analysis. Chemical analysis (XRF) revealed a Ca-rich concentration for most samples and, again, a division in two homogeneous groups that well reflect the associations made with previous analyses.

Technological information focused on firing dynamics was obtained through SEM observation of microstructures and mineralogical analysis (XRPD), which identified a group of samples with low-temperature mineral phases (calcite and illite-like phases) and another group of samples fired at higher temperatures, characterized by an abundance of newly-formed Ca-silicates (i.e., gehlenite, Ca-feldspar, pyroxene). These groups again demonstrate a connection with their chemical and petrographic counterparts. Lastly, by comparing petrographic and chemical data with literature sources, it was possible to trace these amphorae back to their production area, offering new insights into the trade routes that likely reached Capri during the ancient Greek period.

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Potential of Organic Residue Analyses on Roman Period Handmade Pottery

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In the early Iron Age, several distinctive vessel shapes emerged in Thrace, marking the continuation of a long-standing tradition of handmade pottery production in the area. These handmade pots persisted through the Roman period even when Roman wheel-made coarse ware became more prevalent. They have been found across a broad region encompassing modern southern Romania, Bulgaria, northern Greece, and European Turkey. The handmade pots are often seen as evidence of the continuation of the local Thracian tradition and commonly interpreted as evidence of local communities coexisting with the Romans during the 1st–4th c. AD. Our recent study suggests that these handmade pots were locally produced and traded (not published). However, questions remain regarding their use and the reasons behind their continued production after the advent of Roman wheel-made ware. To address this, we conducted lipid residue analyses (GC-MS, GC-FID and GC-C-IRMS techniques) on a subset of thirteen pots. The results revealed high content of residual lipids originating mainly from animal adipose fats together with plant lipids markers. Further, detection of high-temperature heating markers confirmed some vessels had been exposed to temperatures above 300°C, some pots showed also signs of beeswax impregnation.

These findings imply that the handmade pots may have been used for storing and/or transporting marinated meats, possibly seasoned with herbs, which could have been traded with the Romans. As such, these vessels may have functioned more as wrapping items rather than dedicated household goods. Consequently, the presence of handmade pottery in Roman settlements should not be necessarily viewed as evidence of the coexistence of local and Roman populations, but rather as an opportunity to re-evaluate the dynamics of local-Roman interactions and trade in Thrace during the Roman period.

Keywords: Roman, pottery, residue analysis, lipids.

Organic biomarkers identification to describe roman age customs in Aiatzio (Aralar range, Gipuzkoa, Spain)

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Since the beginning of the Neolithic age, ceramic vessels have been part of the culture of human groups, reflecting their economy, diet, cuisine, customs and social practices. The ability to absorb and retain chemical compounds for hundreds or thousands of years, due to their porosity and structural stability, makes ceramics a great container to look for biomarkers which can tell us about the products stored, or the food cooked in them. However, a degree of caution is necessary, owing to the possibility of contamination during excavation, transport and analysis, or the transformation of compounds over time (Hammann and Cramp, 2018; Whelton et al., 2021).

This work presents the results obtained from the study of Roman age pottery from Aiatzio, in Sierra de Aralar (Gipuzkoa, Spain). Wine, milk, fats (vegetal and animal fats), wax, resin and boiling ceramics biomarkers were studied using a gas chromatography -mass spectrometry technique, after previously optimized one-step ultrasound extraction and hydrolysis by KOH. Additionally, SCAN mode was used for the identification of all the analytes. For this purpose, an own library was built with the mass spectrum of each compound of the literature. The identification of the compounds was carried out by the deconvolution of the chromatogram for each sample.

Keywords: Pottery, biomarkers, GC-MS.

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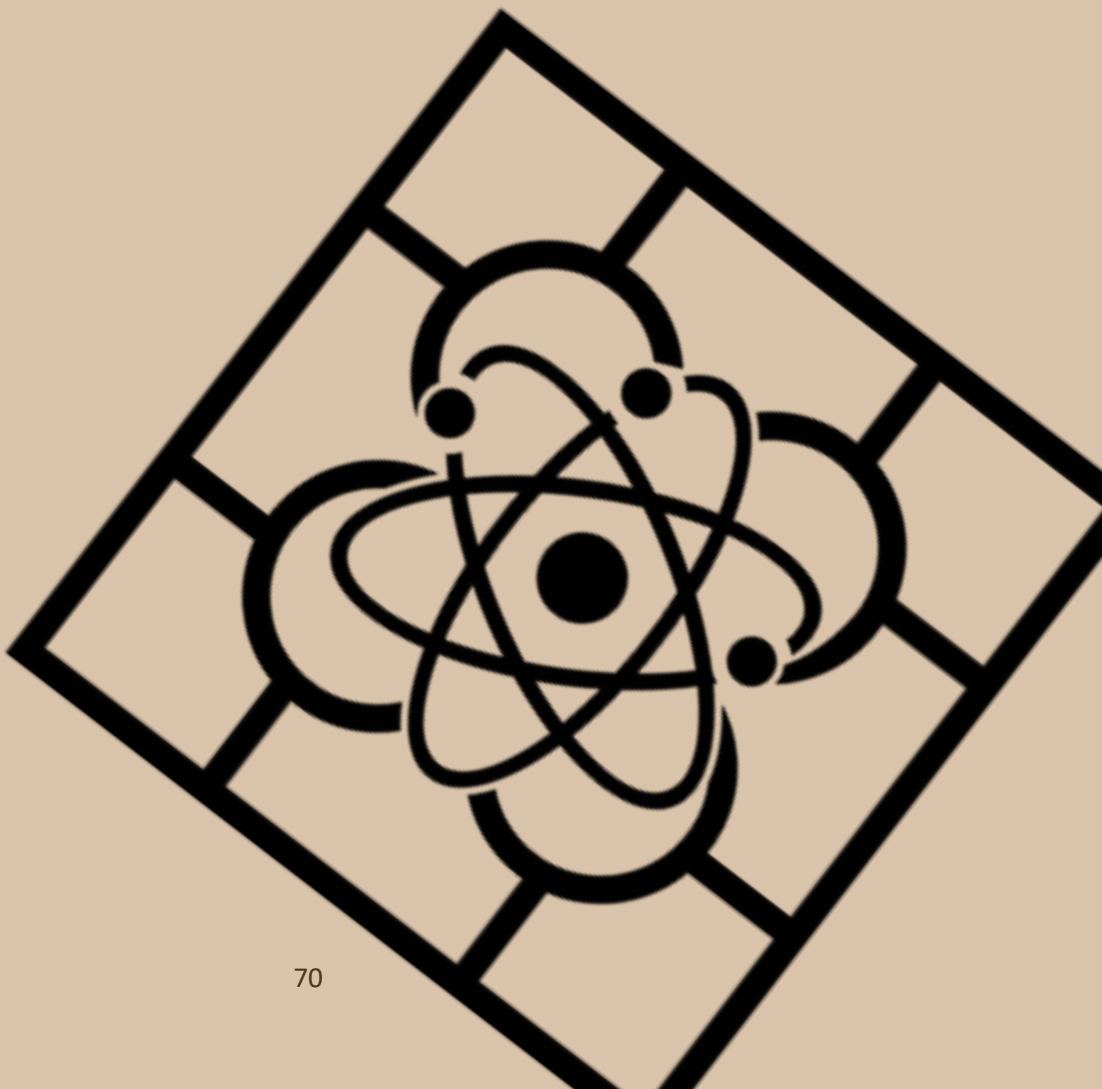
4.3. *Portable and Non-Destructive Analyses: use and development of portable and non-destructive technologies for archaeometric studies*

Oral Presentations



10 Years of pXRF Application in the CEAlex (Egypt): Monitoring Results and Improving Protocol of Measurement

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During the development of the materials characterisation laboratory of the Centre d'Études Alexandrines (CEAlex UAR 3134 CNRS/IFAO) in 2013, portable analysers were selected for XRF applications to overcome restrictions on the import and export of archaeological samples from Egypt and to enhance autonomy in data acquisition.

This has led the CEAlex to continue its research on ceramics, not only on Egyptian amphorae productions, but also on all the ceramics imported to Alexandria and found in large quantities on excavation sites. Consequently, over a period exceeding a decade, more than 10,000 samples from diverse provenances have been analysed using pXRF.

As a non-destructive technique, it enables both qualitative and quantitative elemental analysis while providing immediate results, making it particularly suited for in situ applications. Nevertheless, the application of pXRF, as well as the data treatment and acquisition remain controversial to this day. This presentation will provide a summary of 10 years of experience applying pXRF on ceramic materials.

Given the limitations in analytical accuracy of this equipment in comparison to other equipment traditionally used (WDXRF, ICP-MS, NAA, etc.), the protocol for data acquisition has been developed to achieve optimal outcomes from the analyses. However, this equipment requires regular calibration, causing variations in long term reproducibility of the same analyser, not mentioning the shift existing between the different analysers. This alteration has been the focus of the CEAlex for many years, which subsequently led to the development of an IRN pXRF Ceramic Users Network programme in 2021 for the purpose of not only intercomparing data obtained by different portable analysers and more precise laboratory methods such as WD-XRF and ICP, but also to try to solve the issue of intercalibrating pXRF equipment dedicated to the analysis of ceramic material.

Keywords: p-XRF, elemental composition, methodology, intercalibration, ceramic analysis.

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XRF analysis of Mleiha Pottery

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During archaeological excavations of the Mleiha site in the Emirate of Sharjah, a unique type of pottery shards and vessels were discovered. Their composition and design did not conform to other known pottery types discovered in the same location, whether Greek, Meluhhan (Indus Valley), or Mesopotamian. Therefore, archaeologists working the site decided to name the unknown pottery "Mleiha pottery". However, with absence of pottery maunfacturing locations in any of the excavated locations around Mleiha, it became important to determine the provenance of these unique pottery artifacts.

Energy dispersive X-ray fluorescence spectroscopy was utilized for the detailed analysis of the Mleiha pottery, including elemental composition of pigment used to decorate the pottery, as well as, determine the pottery's composition and mineral inclusions.

Quantitative XRF analysis show that the pigment used is composed mainly from Iron oxide (87% - 93%), Nickel oxide (5%e8%), with trace amounts (<1%) of Chromium, and Manganese. While analysis of the pottery's body showed that Silicon oxide cositituted approximately 56% of the clay mass, Magnisium oxide (12%), Calcium oxide (11%), Aluminium oxide (10.5%), Iron oxide (7%), in addition to traces of other elements.

Using Micro XRF, a total of 67 mineral inclusions of different sizes and colours were analysed. The majority of the sampled inclusions (94%) were silicates, and only 6% were calcites. A total of 35 inclusions from the former group were olivine minerals composed of a mixture of Mg, Si, and Fe oxides constituting 87–99% of the inclusions' mass, in addition to 13 inclusions composed mainly of Al, Si, and Ca oxides with sum concentrations ranging from 80% to 98%.

Keywords: XRF, Pottery, Elemental, Composition.

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The absence of evidence is not the evidence of absence: the case of Salt production in Portuguese Prehistory

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Salt has been a fundamental resource for human civilization since ancient times, as shown by historical sayings that emphasize its vital importance. Despite its enduring significance, the study of salt exploitation during these early periods has been somewhat neglected in archaeological research, particularly in regions like Portugal. This oversight stems partly from the methodological challenges associated with directly identifying salt production sites and distinguishing them from other types of archaeological deposits. Fortunately, innovative approaches focus on the direct identification of salt crystals and the detection of physicochemical markers indicative of past salt processing activities. Portugal, with its diverse geography and climate, presents a unique context for studying the evolution of salt exploitation. The dissolution of salts on sediments can alter sedimentary structures, which makes it difficult to determine the depositional origin of the sediment and misinterpret it. This highlights the relationship between geographic and climatic conditions, in particular, the availability of appropriate coastal and interior environments that have shaped production practices. The presence of brine sources and favorable tide conditions was essential to determine where salt extraction activities prospered. For example, regions such as Algarve and estuaries surrounding the Tagus River are noted for their important salt marshes, which have provided an ideal landscape for the development of salt. This study will encompass three main components: experimental archaeology with ceramics, geochemical analysis (pXRF) of both prehistoric and experimental ceramics, and geochemical analysis of the deposits from which these ceramics originate. The PortSalt project seeks to understand how salt was introduced, exploited, used, and transported into the diet, economy, and life of Proto- and prehistoric populations from western Iberia. Ultimately, it aims to find possible continuities and ruptures that characterized the food patterns of these communities, contributing to the knowledge about eating habits and taste that guided food choices over time.

Keywords: Salt Archaeology, Prehistory, Ceramics, Chemical Analyses, Diet

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EMAC 17th EUROPEAN MEETING ON ANCIENT CERAMICS BILBAO 2025

Non-desctructive XRF and m-CT techniques for the study of Neolithic ceramics in Eastern Europe

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This study represents results of comprehensive analysis of ceramics from the sites located in Dniper-Dvina area (NW Russia) dated to the 4-3rd mill BC and Lower Don region (southern Russia) dated to the 6-5th mill BC. Both assemblages are part of sedentary hunter-gatherer cultures with different procurement techniques and settlement systems. Former analysis revealed several chaînes opératoires for pottery production. The methods of archaeometric analysis implied both destructive and non-destructive XRF techniques and m-CT analysis of particular sherds in order to reconstruct paste recipes and possible raw materials sources. XRF analysis allowed revealing several geochemical groups pointing to various clay resources used for production of ceramics attributed to different cultural groups. Complete change of clay sources and paste recipes can be noted for assemblages attributed to different chronological horizons, which was due to cultural as well as environmental factors, e.g. accessibility of resources. The paper will discuss the possibilities of implying non-destructive techniques for the study of ancient ceramics, their level of accuracy and comparability with results of destructive analysis usually regarded to be more precise.

Keywords: Neolithic, hunter-gatherers ceramics, *XRF technique, m-CT, Eastern Europe*

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A new methodology for firing temperature estimation of ancient pottery using combined thermoluminescence and magnetic susceptibility measurements

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Firing is the final stage in the pottery manufacturing process, during which the vessels acquire irreversible physicochemical properties. Pottery production technology and the determination of firing temperature has been one of the most enigmatic questions to address in archaeometry. Among the plethora of analytical techniques that have been applied for firing temperature assessment, traditional approaches include mineral identification along with thermal analysis. Both thermoluminescence and magnetic susceptibility have been studied individually in that direction, as alternatives. The present study aims to exploit the usefulness of a combined study of these two aforementioned analytical techniques towards a new powerful methodology on palaeothermometry studies of fired clayey artifacts. The prehistoric settlement of Poliochni on Lemnos Island (Greece) serves as an excellent case study, presenting habitation from mid 5th to the end of the 2nd millennium BCE. Twelve sherds representative of all habitation phases were selected to estimate maximum firing temperature. Samples were initially subjected to both petrographic analysis and Fourier transform infrared spectroscopy (FTIR), for an initial, gross estimation of the temperature regions of interest. Magnetic susceptibility and thermoluminescence measurements were performed within specific temperature steps. The validity and resolution cross-check of each method's results led to the tailoring of the most fitting methodological approach to inspect ancient firing technologies. The results indicated that the majority of the samples were fired in fully oxidizing atmosphere and the maximum firing temperature reached 750oC, namely at temperature lower than the irreversible transition point from β-quartz to tridymite. Only one sample was fired in considerably higher temperature (ca. 850oC), and at least another one at fairly lower temperature (<700oC). The cross-check of each method's results regarding maximum firing temperature estimation was in accordance for 90% of the analyzed samples, thus confirming the reliability of the specific multi-analytical methodology for the cases of poor-calcium pottery matrix.

Keywords: Thermoluminescence, Magnetic susceptibility, firing temperature, ancient pottery.

EMAC 17th EUROPEAN MEETING ON ANCIENT CERAMICS BILBAO 2025

The Sound and Material Profiling of "Svilpaunieki" via Acoustic Measurements and X-ray Computed Tomography

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As part of an ongoing project at the Massachusetts Institute of Technology to study musical instruments, we have CT-scanned, acoustically measured, and reproduced the sound and dimensions of a series of ceramic svilpaunieks (Latvian “whistles”). These traditional, handmade instruments hold particular importance in Latvia, dating back to their early use in Baltic ritualistic contexts (Muktupāvels, 1999), and are now recognizable symbols of Latvian folk culture. Through CT, acoustic input impedance measurements, and numerical sound simulations, we comprehensively and non-destructively analyzed and digitally and physically reproduced the sound and dimensions of the whistles. Computed Tomography produces 3D volumetric images that reveal internal structures, evidence of manufacturing techniques, and material composition and density differences (e.g., Applbaum, 2005). Similarly, acoustic measurements capture and profile the resulting sound derived from the materials, geometry, and sound generation mechanism. These combined techniques are ideally suited for conservation efforts, resulting in digital copies with StereoLithographic (STL) files and sound recordings that capture the exact dimensions and tonal qualities.

Keywords: Svilpaunieks, X-ray Computed Tomography, Sound, Acoustic,

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EMAC 17th EUROPEAN MEETING ON ANCIENT CERAMICS BILBAO 2025

Colours of the Inka: pigments used for bichrome and polychrome pottery on the Bolivian Altiplano

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Local Pre-Inka, Inka imperial and Inka provincial pottery are coexisting ceramic styles in many different sites of the Inka Empire. Paria and Tambo de Sevaruyo, provincial centers in present-day Bolivia, also provide this phenomenon similarly to other imperial settlements in the Chilean, Peruvian and Argentinean territories. According to previous studies, bichrome and polychrome ceramic techniques applied iron or manganese oxide (rarely copper oxide or carbon) for black colour (Martínez-Carrasco et al. 2024). A change over time could be detected on Chilean sites where iron-based colourants were used in the Formative period, while manganese-based ones in the Inka period (Arriaza et a. 2025). Red colour was painted with red earth pigments (hematite or goethite, Lynch et al. 2022). Amorphous silica as white pigment was identified (Centero et al. 2012).Our study focused on the red, black and white (or even yellow) pigments of Local Pre-Inka, Inka imperial and Inka provincial style, bichrome and polychrome ceramic from the Bolivian centers. Non-destructive analytical techniques – which analyze the near-surface layers of the matter – were applied: FT-IR and HH Raman spectroscopy for the mineralogical composition, and HH XRF for the chemical composition determination. According to our investigations, for red and black pigments, there a strong correlation can be observed with the published compositions, i.e. iron oxides are typical. However, manganese oxides seem to appear on Inka provincial style pottery for black painting. For light-coloured pigments our preliminary results indicate silica-free pigment which was an unknown material in the polychrome Inka pottery until now. We draw correlation between the steps of pottery handicraft traditions (i.e. provenance of ceramic fabric and painting material).

Keywords: Inka pottery, pigment, handheld spectroscopic techniques, iron and manganese oxides, handicraft traditions.

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17th EUROPEAN MEETING ON ANCIENT CERAMICS
BILBAO 2025

The development and diversity of pottery forming practices in the Early Bronze Age of Eastern Bohemia: An analysis using novel computational tomography capabilities

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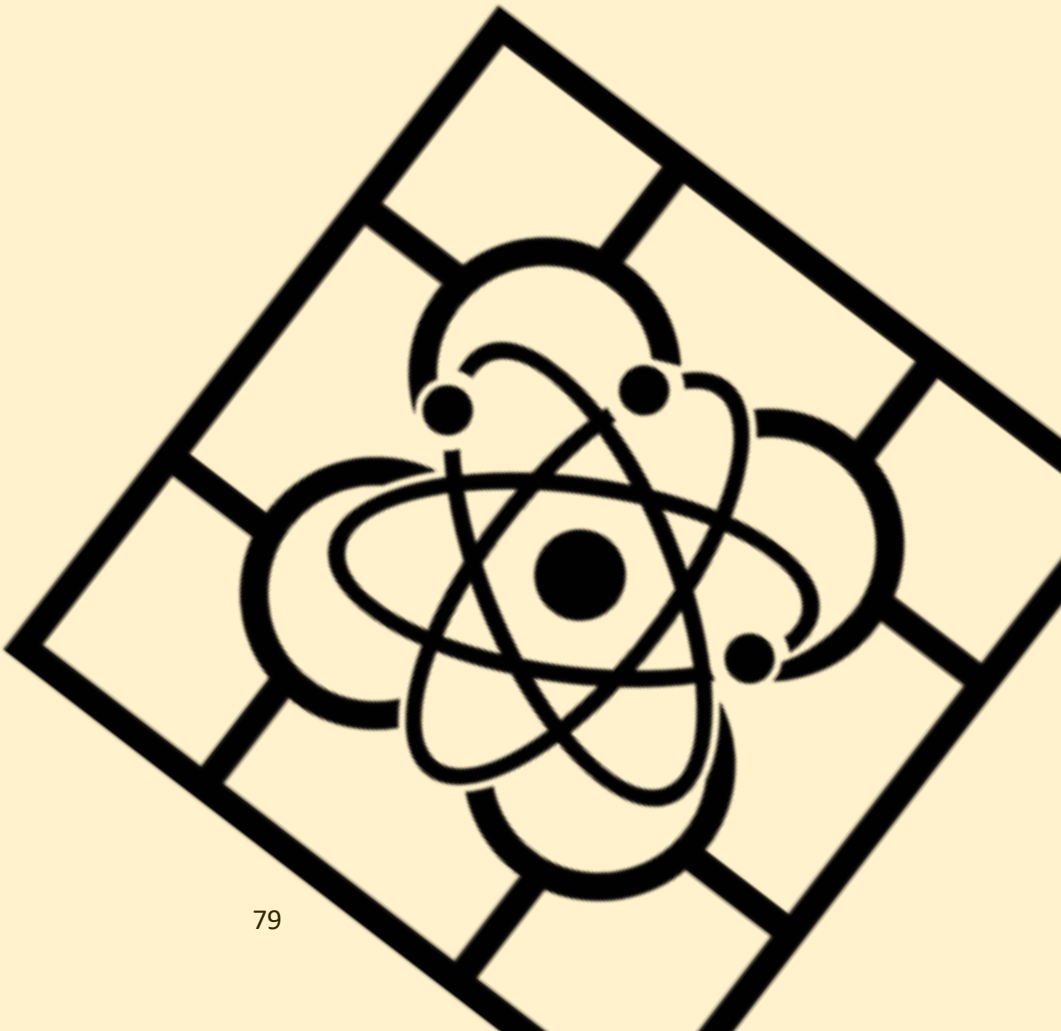
The presentation introduces newly developed computational tomography capabilities designed to visualize and quantify the structural characteristics of archaeological ceramics. These include defining non-planar sections, allowing for the mapping of structural phenomena at defined depths beneath the ceramic surface through 2D sectioning, and the 3D segmentation of components of the ceramic fabric developed with machine learning tools specifically for materials typical for archaeological ceramics. The presented techniques extend the possibilities of non-destructive analysis of the structure and composition of ceramic materials.

The utility of the new computational tomography capabilities is demonstrated in the case study aimed to describe the technological variability in pottery-forming practices during the Early Bronze Age in Eastern Bohemia. The forming methods of the individual parts of the vessels (neck, body, base) were distinguished, and the changes in the forming procedures between the two basic chronological phases of the period were traced. Significant population change is considered in the area during the transition between these phases. Forming methods, as a conservative cultural trait, may be an important marker of this population change.

Keywords: Computational tomography, Segmentation, Pottery forming, Early Bronze Age, Eastern Bohemia

Portable and Non-Destructive Analyses: use and development of portable and non-destructive technologies for archaeometric studies

Poster Presentations



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Preliminary Archaeometric Study of Historical Tiles in Jerusalem

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The art of decorative glazed tiles was introduced to Jerusalem in the mid-16th century during the reign of Ottoman Sultan Suleiman the Magnificent. One of the finest examples of this craftsmanship is the Dome of the Rock, where these tiles were used to cover its external walls.

Built between 687 and 691 CE under Umayyad caliph Abd al-Malik, the Dome of the Rock is a major religious site for Muslims, Jews, and Christians due to its location atop the Noble Rock (or Foundation Stone). Over time, it has undergone multiple restorations due to earthquakes and political changes in the region.

A major restoration occurred in the 16th century under Suleiman the Magnificent when decorative glazed tiles replaced the original mosaics. Additional efforts took place in the 19th century under the British Mandate, and after World War I, when the British Administration attempted, unsuccessfully, to restore the deteriorating tiles. In the mid-1960s, the Jordanian authorities commissioned Turkish artisans to install new tiles, preserving the monument's intricate and vibrant exterior.

Despite its religious and cultural significance, archaeometric studies on the Dome of the Rock's materials remain limited. Thanks to the collaboration of a private collector, this project represents a first attempt to analyze, in a non-invasive and non-destructive way, the coating and decorative system of a set of tiles from its external walls, dated before the 20th century restoration.

Keywords: Glazed tiles, Non-invasive analysis, Archaeometric study, MA-XRF.

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EMAC 17th EUROPEAN MEETING ON ANCIENT CERAMICS BILBAO 2025

Ceramic consumption in the Argaric Bronze Age period: preliminary results combining petrography and pXRF at the coastal site of Punta de los Gavilanes (Mazarrón, Spain)

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This poster presents the initial results of a characterization analysis of Bronze Age Argaric pottery using thin-section petrography and portable X-ray fluorescence (pXRF). The archaeological site of Punta de los Gavilanes (Mazarrón, Spain), located on a rocky promontory on the coast, has been selected as a productive settlement occupied from the end of the 3rd millennium BC until the third quarter of the 2nd millennium BC. After the review of the archaeological context and the macroscopic/typological study of the ceramic assemblage, 58 representative samples have been analysed by binocular microscopy, pXRF and OM. The identification of different fabrics and several loner individuals reveal a certain complexity of production and consumption in what comprise the first such analyses for this area and time period.

Our poster discusses the results of the chemical and petrographic analyses from a double perspective: on the one hand, it evaluates the degree of precision in the clusters proposed by pXRF using petrographic observations as a comparative basis; on the other hand, the identification of different fabrics and several loner individuals reveal the existence of complex pottery assemblages in which foreign and local products shared spaces and functionalities. This reveals a greater-than-expected complexity and demonstrates the integration of this insular site into the economic dynamics of the Iberian Southeast during the Bronze Age.

Keywords: Iberian Peninsula, Middle Bronze Age pottery, pXRF, Petrographic characterization, Connectivity

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EMAC 17th EUROPEAN MEETING ON ANCIENT CERAMICS BILBAO 2025

Portable XRF archaeometry of sugar production pots from Madeira Island

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The occupation and development of the Macaronesian islands were closely connected to the socioeconomic interests of the Iberian kingdoms. These interests drove the region's colonization from the early 15th century, a process later mirrored in the Americas. During the 15th and 16th centuries, several Atlantic islands began exporting sugar to European markets with varying degrees of success. Madeira played a pivotal role in the expansion of sugarcane cultivation in the Atlantic under Portuguese rule, becoming the leading sugar producer in the Western world at the time. This study aims to characterize ceramic assemblages related to sugar production archaeometrically, identifying raw materials, determining production centers, and reconstructing trade relationships between Madeira and continental suppliers. The integration of archaeology with advanced scientific techniques is crucial for gaining a deeper understanding of exchange networks and technological innovations associated with sugar production, as well as for contributing to a more comprehensive knowledge of the colonial economy within the Atlantic context. A set of 40 ceramic sugar molds recovered from several archaeological sites on Madeira, including Hotel Barceló in Funchal, Santa Casa da Misericórdia de Santa Cruz in Santa Cruz, and in Machico, Casa da Travessa do Mercado, and Junta de Freguesia, were analyzed using chemical (portable X-ray fluorescence). The data shed light on the technological knowledge applied in manufacturing and highlights connections between sugar production and broader colonial trade networks across the Iberian Atlantic. These findings offer new insights into the dynamics of production and circulation in early colonial economies.

Keywords: Sugar molds, Archaeometry, Macaronesia, Madeira, pXRF

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EMAC 17th EUROPEAN MEETING ON ANCIENT CERAMICS BILBAO 2025

Identification of Painted Decorations on Ceramics from the Ánimas Altas-Ánimas Bajas Archaeological Complex, Paracas Culture (Peru, 400 BCE–100 CE)

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The archaeological complex Ánimas Altas-Ánimas Bajas, located in the Ica Valley(Peru), plays an important role in the knowlege of the Paracas culture, offering an extensive collection of ceramics that were used in both everyday and ritual contexts. (Bachir Bacha & Llanos Jacinto, 2021). Nineteen ceramic sherds were selected for a first chemical and physical analysis, excavated from Montículo 1, Montículo 25, and El Panteón in the Ánimas Altas- Ánimas Bajas archaeological site. These ceramic pieces belong to Ocucaje Phase 8, dating from around 400 BCE to 100 CE, during the middle Paracas period. The samples show a wide range of decorative styles and colours, such as red, yellow, black, and brown, highlighting the diversity and complexity of the ceramic corpus. According to the field archaeologist (A. Bachir-Bach), these decorations were probably applied after the firing process. Complementary techniques, such as SEM-EDS, hyperspectral imaging (HSI), Raman spectroscopy, X-ray diffraction (XRD), and Fourier Transform Infrared Spectroscopy (FTIR), were used to identify the nature of the colourants and the ceramic matrix (Pareja et al. 2023; Teodorescu et al. 2021).

SEM observations revealed that the pigments are composed of both inorganic and organic materials. The presence of organic matter strongly supports the hypothesis that the decorations were applied after firing; otherwise, the organic components would have degraded during firing. These organic materials probably served several purposes: they contributed to the colouring, enhanced the surface gloss, and acted as a fixative to help the pigments adhere to the ceramic substrate like a binder. The analysis of the inorganic components shows the use of the elements arsenic (As) and sulfur (S) in the yellow decorations, suggesting the presence of orpiment or pararealgar, as well as the use of ochres (Fe, Al, Si.) for both red and yellow decorations. In addition, the hyperspectral (NIR-VIS) spectrum suggests the possible use of indigo in the black decorations, probably applied in high concentrations. The Raman spectra obtained with a 785 nm laser appear to show a mixture of carbon black and indigo. Further work is necessary to better characterize the nature of the organic components and their possible botanical or zoological sources, with special attention to whether local plant resources were used intentionally in pigment preparation.

Keywords: Paracas ceramics, pigments, organics components, nondestructive analysis, post-firing decoration.

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EMAC 17th EUROPEAN MEETING ON ANCIENT CERAMICS BILBAO 2025

Atlantic networks: Preliminary archaeometric analysis of pottery from Cape Verde using Non-Destructive X-ray Fluorescence (pXRF)

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The archaeological sites located on Santiago Island (Cabo Verde), provides a valuable context for investigating early material traces of the Iberian Atlantic expansion during the 15th and 16th centuries. This preliminary archaeometric research centers on pottery fragments recovered from Trindade, currently housed at the Museu de Arqueologia in Praia, with the aim of assessing their technological characteristics and potential provenance through *non-destructive* elemental analysis. *In situ* multi-elemental analyses were performed using portable X-ray Fluorescence spectroscopy (pXRF), focusing on low-fired, handmade ceramics associated with African manufacturing traditions, particularly those linked to local and trans-Saharan production systems. The resulting geochemical dataset was evaluated against established reference groups from Atlantic Africa and Macaronesia. Preliminary results reveal significant variability in elemental composition, suggesting the use of diverse clay sources and manufacturing practices. These patterns may reflect the co-existence of multiple cultural traditions involved in provisioning, exchange, and settlement processes during the early phases of the Atlantic slave-based economy. This research is part of the project *Archaeology and Archaeometry of Iberian Atlantic Expansionism in the Atlantic and Macaronesian Islands and the Americas (15th–16th Centuries): Ceramics, Technology, and Trade* (CERIBAM), which aims to build a comparative archaeometric reference framework for early colonial ceramic assemblages across Macaronesia and the African Atlantic littoral.The application of *non-destructive* archaeometric techniques not only ensures the preservation of museum-held archaeological collections but also enhances our understanding of technological hybridity, material circulation, and maritime connectivity in the early modern Atlantic world.

Keywords: Archaeometry, Ceramic analysis, Non-destructive techniques, Slave trade, Atlantic history.

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EMAC 17th EUROPEAN MEETING ON ANCIENT CERAMICS BILBAO 2025

The pXRF and m-CT non-destructive techniques to study the Bronze - Early Iron Ages ceramics from sites of Crimea

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The thin-section analysis, pXRF, XRF-WD analysis, SEM-EDX and m-CT were applied to study mineralogical geochemical compositions of ceramics from the Late Bronze-Early Iron Age sites at the Crimean Peninsula. These methods allowed to reconstruct the technology of ceramic production, as well as the raw source materials for its manufacture (Kulkova et al. 2022). The comparison of non-destructive pXRF and XRF-WD analysis of ceramics allowed to develop some correcting procedures for geochemical data obtained by pXRF technique. The comparison of geochemical composition of ceramic samples from Yarilgachskoe, Gusevka and Bai-Kiyat 1 sites with raw clay probes from coastal zone of the Black Sea showed that some ceramic samples were made of this type of clay material. The clay and ceramics of this type are enriched by association of such elements like (CaO, MgO, SiO_2, TiO_2, Zr, Nb). According to SEM-EDX analysis the local group of pottery made of local clay raw material could be differed on base of accessory minerals like barite, zircon, ilmenite, cuprite, monazite, iron oxides, carbonates. Some ceramic samples were made from clay of other geochemical province. Their mineralogic composition is characterized by present of leucoxene, chrome spinels, pumpellyite, epidote, amphibole. The non-destructive m-CT analysis of pottery gave possibility to determine open and close pores of ceramics and conduct the 3D reconstruction of pore space (Kulkov& Kulkova 2018). These investigations allowed to determine burned organic inclusions inside of ceramic pastes like corns (millet), grass, beetles etc.

Keywords: Ceramics of Crimea, Late Bronze Age, Early Iron Age, non-destructive pXRF, m-CT of ceramics.

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Comparison of chemical-elemental data obtained by pXRF, WDXRF and m-EDXRF – are the results compatible?

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The arrival of portable X-ray fluorescence (pXRF) equipment to the archaeological sciences opened new possibilities allowing for a fast, non-destructive, and in situ analysis, with little to no sample preparation of the retrieved objects. For these attractive reasons, a substantial amount of new data is currently obtained through this method. The reliability of these measures has sparked debate, leading to numerous publications improving methodological and calibration practices (Milazzo, 2004), and to the development of more capable equipment with smaller detectors, better detection limits, and built-in calibrations (Pradell & Molera, 2020). Nevertheless, more invasive methods still provide higher reliance on the obtained results and have been profusely used during the last decades. Comparing published data, obtained with variated equipments, with study specimens can provide significant archaeological information. A similar comparison is required when an artifact can't be sampled due to its value, but the data obtained still needs to be comparable with other fragments' information. To this end, the present study aims to develop a procedure for comparing chemical-elemental data obtained through 3 commonly employed methods: pXRF, m-EDXRF, both non-invasive, and WDXRF, requiring a small, powdered sample. Following the guidelines presented on ISO 13528:2022, for the determination of methods performance, a group of ceramic objects and Certified Reference Materials was measured three times with each of the referred equipment and, for each, a measurement result, i.e. a measured value and respective uncertainty was obtained. With this data, a standardized performance statistics method was used to evaluate the compatibility of the employed measurement equipments. This work was supported by FEDER funds through the COMPETE 2020 Program, European Social Funds and National Funds through FCT Portuguese Foundation for Science and Technology under the following project references: UIDB/50025/2020-2023 (CENIMAT), UIDB/00729/2020 (VICARTE), UIDB/04449/2020, UIDP/04449/2020 (HERCULES), LA/P/0132/2020 (IN2PAST) and 2021.04858.BD (Ana S. Saraiva).

Keywords: Non-destructive analysis, X-Ray Fluorescence, Comparison, Uncertainty, Statistical Consistency.
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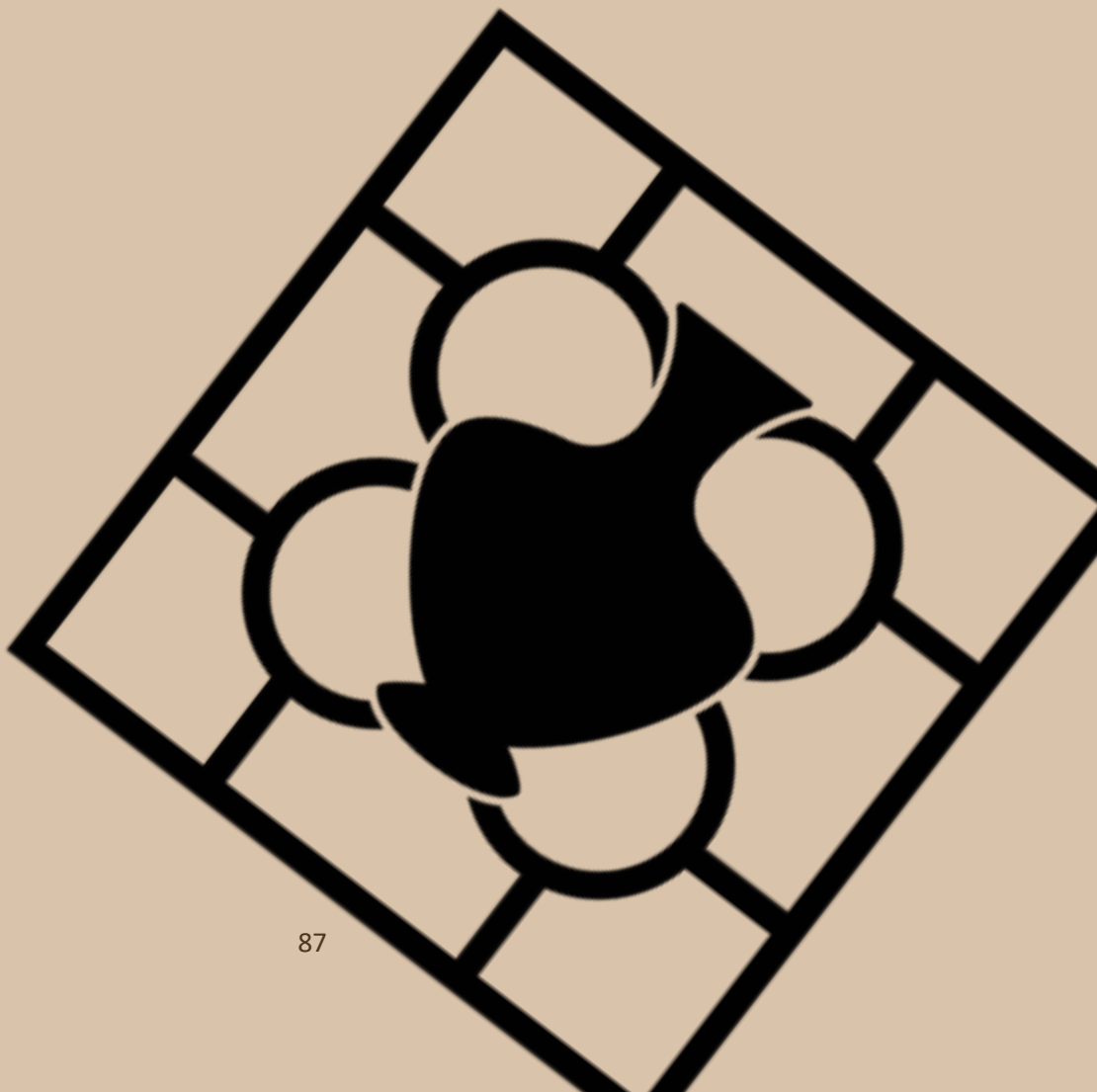
4.4. *Digital and Data-Driven Ceramic Studies (AI, machine learning, big data, photogrammetry, etc.)*

Oral Presentations



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Neutron activation and artificial intelligence in archaeological pottery analysis

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The present study aimed to provide a comprehensive characterization of archaeological pottery through neutron activation analysis (NAA) conducted at the IBR-2 reactor in the Frank Laboratory of Neutron Physics, Joint Institute for Nuclear Research in Dubna. NAA was employed to determine the elemental composition of the archaeological fragments, which serves as a unique fingerprint for each sherd. The data were subsequently employed to classify and group the archaeological samples according to their provenance, providing significant insights into their origins and interrelationships. This was achieved by analyzing the distribution patterns of both trace and major elements within the samples. A total of 149 archeological samples were analyzed using NAA and a total of 29 elements with their corresponding mass fractions (in mg/kg) were determined. The research was conducted in multiple phases, beginning with the classification of various sherds of archaeological pottery based on their geochemical composition. Ultimately, well-defined and valuable reference groups were refined and identified, enhancing the understanding of the samples' historical and cultural contexts. To do that, various machine learning algorithms were used to classify the fragments of different sites. In addition, univariate and multivariate statistical analyses were performed to get the descriptive and inferential statistical analyses (Badawy et al., 2023; Badawy et al., 2022). In addition, to calculate the geochemical background of the largest group of archaeological fragments, four statistical approaches were implemented. The background values of the geochemical composition of archaeological pottery were obtained. This work is considered one of the pioneer types of research in Russian archaeological ceramics that subjected to NAA and interpreted using machine learning and statistical analysis. The results obtained can serve as good baseline data for authentication, provenance, and classification of ceramic sherds.

Keywords: archaeological pottery, NAA, machine learning algorithms, multivariate statistical analysis, background analysis.

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Explainable vision transformers for the petrographic classification of Levantine ceramics

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The archaeological context of the Levant is particularly rich and complex, as numerous sites emerged starting from the Early Bronze Age, playing a strategic role in trade, cultural exchange, and technological innovation. The study and classification of ancient ceramics is fundamental to understanding the social and cultural identity of this region, offering important insights into technological practices, provenance of raw materials, and interactions between ancient societies. This study investigates the use of Deep Learning (DL), specifically Vision Transformers (ViTs), for the automated classification of Levantine ceramics based on their petrographic *fabrics*. A dataset composed of ceramic thin section images dated back to the Early Bronze Age and Iron Age was built to train and validate the models. The ceramic samples come from several archaeological sites across the Levant, including Bethlehem (West Bank), Tell el-Far'ah North (West Bank), Khirbat Iskandar (Jordan), Khirbat al-Batrawy (Jordan), Ebla (Syria), Jericho (West Bank), Tell Nebi Mend (Lebanon) and Tell Qasile (Israel). In particular, the study explores the application of AviT and DynamicViT models, which implement adaptive token selection to reduce computational cost while focusing on the most relevant image regions. These models are evaluated not only in terms of classification accuracy but also for their interpretability. Moreover, to improve model transparency, the study applies several explainability (XAI) techniques. In addition to visual tools such as attention maps, it also incorporates advanced semantic-probabilistic methods which allow a more structured and interpretable understanding of model behavior. By combining high-performing ViT models with diverse XAI strategies, this project aims to develop a robust and transparent framework for the classification of ancient ceramics, bridging artificial intelligence with archaeometric studies.

Keywords: Deep Learning, Vision Transformers, Levantine Ceramics, Explainability (XAI).

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Still looking for the ideal cooking pot - Digital multi-scale models of cooking vessels

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Food processing has always been one of the basic functions of ceramic vessels at latest since the Neolithic period (Rice 1987). For this, commonly available clayey raw materials are processed to a plastic clay paste, which can be formed to a functional shape. During firing the material properties are substantially modified. The dried clay paste, which always could be plasticized by moistening again, is transformed to a rigid ceramic body resistant to external thermo-mechanical loads. The intrinsic material properties of the ceramic body depend on features related to the selection of raw materials, the clay paste processing and the firing conditions. The thermo-mechanical performance of the finished cooking vessel, though, additionally depend on the vessel shape and design. In the present paper the material properties of cooking pot fabrics are discussed within the context of the workflow during manufacturing. These studies are integrated in a digital multi-scale modeling approach, in which the effective material properties estimated based on micro-structural models are applied in meso- and macro-scale models in order to simulate heat transfer and thermal shock resistance and to assess the thermal performance of different types of cooking vessels (Hein et al. 2015; Hein 2022). This is examined taking into consideration diverse cooking practices and the related conditions. After all, there is probably no ideal cooking pot but rather ceramic fabrics and vessel designs adapted to particular constraints (Tite and Kilikoglou 2002).

Keywords: cooking pots, thermo-mechanical performance, structural multi-scale models.

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Closed-loop machine learning of pigmented and glazed-ceramic mixture deconvolution using Kubelka-Munk theory and reflectance spectroscopy

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The study of ancient ceramics reveals critical insights into raw material selection, production techniques, and conservation strategies. Traditional analytical methods typically require invasive sampling, limiting their application to fragile or museum-held artifacts. This research expands the capabilities of the non-destructive techniques of fiber optic reflectance spectroscopy (FORS) and hyperspectral imaging (HSI), through the application of machine learning (ML) combined with Kubelka-Munk theory (KM), to better analyze mixtures of pigment and glazed-ceramic compositions. FORS and HSI have been applied in vitreous materials studies for the classification and characterization of pigments and glazes in ceramics and stained glass (Galluzzi, 2024). Previous studies of ML techniques—such as Random Forest (Gestels, 2024) and Neural Networks (Rohani, 2018)—have demonstrated increases in accuracy in deconvoluting spectra of mixed pigments in paintings, compared to traditional methods. However, there is limited application of these techniques on ceramics, as generating comprehensive ML training datasets through experimental replication of all possible pigment and glazed-ceramic combinations is impractical due to combinatorial complexity.
The KM model, a two-flux physics-based approximation, can relate concentration of pigments to artificial reflectance spectra, given that absorption and scattering coefficients for all components are readily available (Schabbach, 2009). This study proposes data augmentation techniques on KM-generated spectra to increase available training data that further enables ML models to deconvolute pigmented and glazed-ceramic surface compositions with greater accuracy. This methodology offers new possibilities for characterizing ceramic surface decorations and slips, as it automates both the pigment classification and pigment-mixture deconvolution processes. By bridging spectroscopy, computational modeling, and ML-driven analysis, this approach enhances archaeometric studies of ceramic technology, provenance, and conservation, aligning with the broader vision of integrating portable and non-destructive techniques in ceramics research.

Keywords: Hyperspectral Imaging, Data Augmentation, Machine Learning, Non-Destructive Analysis, Kubelka-Munk Theory.

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Integrating automation and advanced sensor technologies for the comprehensive study of archaeological ceramics in the AUTOMATA project

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The study of archaeological ceramics is undergoing a transformation through the integration of automation and advanced sensor technologies. AUTOMATA (AUTOmated enriched digitisation of Archaeological liThics and cerAmics), a Horizon Europe-funded project, seeks to unify these innovations into a comprehensive, automated workflow for ceramics artefact documentation and analysis. By combining robotics and multi-sensor digitisation with AI-driven processes, the project aims to streamline data acquisition, improve analytical precision, and ensure reproducibility. Current methodologies rely on separate applications of 3D modelling (structured light scanning, photogrammetry, laser scanning), and analytical techniques such as hyperspectral imaging (HSI), portable X-ray fluorescence (pXRF), and Raman spectroscopy. This fragmentation poses challenges in data correlation. AUTOMATA addresses these limitations by integrating these techniques into a single platform, ensuring seamless alignment of geometric, microstructural, and compositional data within a unified analytical framework. A key aspect of the project is the evaluation of existing protocols and the development of optimised workflows incorporating robotic scanning stations, automated positioning systems, and AI-assisted processing. The data collected will be integrated into a Referenced Information System in 3D (RIS 3D), which will not only serve as a structured repository but also enhance interoperability, enabling researchers to efficiently access, compare, and integrate datasets across different studies. AUTOMATA applies to a wide range of archaeological ceramics from different sites and institutions, demonstrating its flexibility and potential for broad application. By establishing standardised protocols that integrate digitisation and analysis, AUTOMATA enhances data comparability, facilitates cross-disciplinary research, and advances both the scientific understanding and the long-term preservation of archaeological artefacts.

Keywords: Enhanced ceramic digitisation, Automated workflows, Non-destructive analysis.

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Interpreting Philistine decorated pottery motifs through R programming language

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Philistine decorated pottery has been a subject of extensive archaeological inquiry, with scholars debating the stylistic, chronological, contextual, and regional variations of its motifs, as well as their origins. This study introduces an innovative computational approach to the classification and interpretation of Philistine motifs, utilizing R to analyze their stylistic evolution, distribution across different sites, vessel types, and chronological phases, and possible connections to motifs from Cyprus and Greece.

Using a dataset compiled from Iron Age I sites in the Southern Levant along with comparative material from Cyprus and Greece, this research applies statistical techniques, including Chi-Square tests to examine associations between motifs and sites, clustering analysis to identify workshop traditions, principal component analysis (PCA) to visualize stylistic variations, and correspondence analysis to explore motif relationships across regions. Data visualization techniques such as plots generated with ggplot2 provide clear insights into motif distributions and stylistic correlations.

By computationally interpreting Philistine decorated pottery motifs, this study seeks to uncover broader patterns of mobility and migration. The inclusion of motifs from Cyprus and Greece enables a comparative perspective, shedding light on artistic transmission, cross-cultural interactions, and the movement of artisans and ideas across the Eastern Mediterranean.

This study highlights the potential of computational methodologies in archaeology, demonstrating how R-based analysis can enhance traditional typological classifications and provide new insights into the transmission of artistic traditions in the Iron Age Southern Levant. These insights provide a new perspective on how the symbolic meanings of Philistine motifs relate to their origins and migration patterns, shedding light on broader cultural exchanges and influences in the Iron Age Eastern Mediterranean.

Keywords: Philistine pottery, decorated pottery, R programming, computational archaeology, Eastern Mediterranean.

EMAC 17th EUROPEAN MEETING ON ANCIENT CERAMICS BILBAO 2025

Rolling pots: a geostatistical and taphonomic ceramic study to investigate formation processes and the use of space at Takarkori rock shelter (Central Sahara, 10.2-4.3 Kya)

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The Takarkori rock shelter, located in the Tadrart Acacus Massif (SW Libya), offers a uniquely long and stratified archaeological sequence spanning ca. 10,200–4,200 cal BP. Within this palimpsest-like deposit, the fragmented and often loosely packed sediments pose a challenge to reconstructing high-resolution occupational phases. This study focuses on the ceramic record to investigate formation pro-cesses and spatial dynamics within the site.

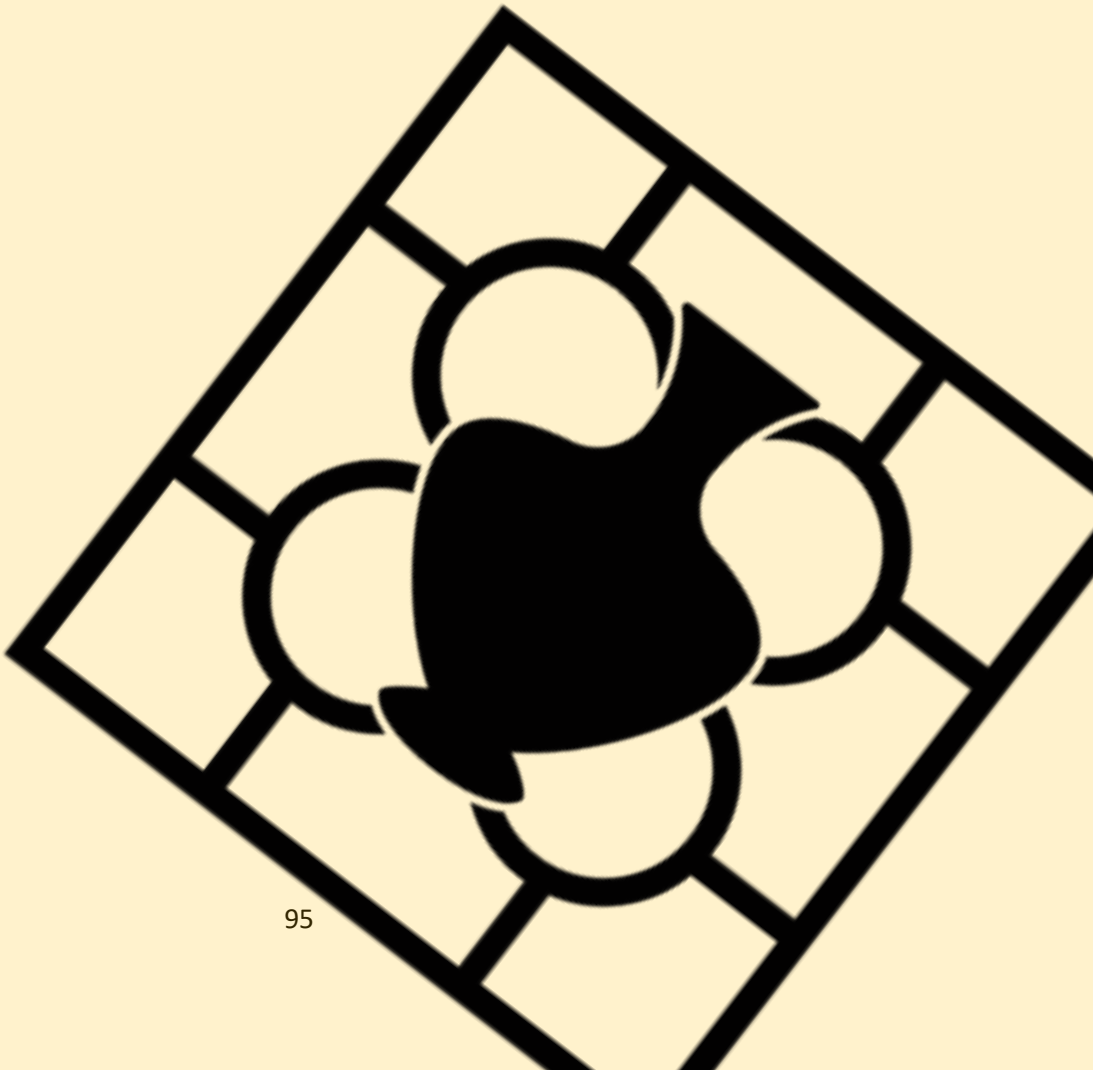
By combining geostatistical spatial analysis with taphonomic evaluation of pottery assemblages, this research sheds light on both the synchronic and diachronic dimensions of ceramic deposition. The spatial clustering and dispersion of sherds—when examined alongside structural features—provide insights into activity areas, discard behaviours, and potential reuse of space. Simultaneously, the anal-ysis of fragmentation patterns, surface alterations, and weathering stages helps to distinguish primary deposition from post-depositional disturbance, whether anthropogenic or natural.

Through this integrated approach, pottery becomes not only a cultural indicator but also a key proxy for understanding site formation dynamics and occupation intensity. The results contribute to refining the interpretation of the archaeological sequence, allowing for a more nuanced reconstruction of site use, the organization of domestic space, and the tempo of repeated occupations over millennia.

Keywords: Early-Middle Holocene, Central Sahara, Site formation processes, Spatial analysis, Taphonomy

Digital and Data-Driven Ceramic Studies (AI, machine learning, big data, photogrammetry, etc.)

Poster Presentations



EMAC 17th EUROPEAN MEETING ON ANCIENT CERAMICS BILBAO 2025

Methodological insights into 3D modelling and volumetric analysis: A case study of medieval and post medieval sugar cones from Iberian Peninsula

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This poster presents a methodological approach to the digital reconstruction and volumetric analysis of medieval and post-medieval sugar cones from various archaeological contexts in the Iberian Peninsula. Sugar cones are specialised cone-shaped vessels used in the last phase of production when the liquid sugar is left to crystallised inside these molds. Sugar cones enclose many aspects of the production, circulation and consumption of sugar of medieval and post-medieval times: their shape informs on the transformation of a standard design; their composition and technology tell us about on the choices made by craftspeople and on the circulation of ceramics and sugar; their volume and size enlighten on the production type and scale.

Despite their significances, volumetric and size reconstruction of sugar cones have been rare due to the often-fragmentary status of recovery. However, advances in 3d modelling can support research in this direction. This study presents virtual reconstructions of sugar cones created using specialised 3D modelling software, based on archaeological drawings, typological parallels, and morphological criteria. Emphasis is placed on 3D visualisation, which allows for more detailed and informative models that offer deeper insights into the ceramic's forms and volumes.

The sugar cones studied come from the east (nowadays Valencian community) and the south (nowadays Andalucia area) of Iberian Peninsula and span from the 15 to the 17th century AD. The proposed methodological workflow enables the generation of complete virtual models and the calculation of the sugar cones volume. The objective is to create a comparative framework for analysing shape and size variations over time and across different areas of the Iberian Peninsula through statistical analysis. While results are still preliminary, this approach provides a replicable method for exploring questions related to production systems, technological choices, and potential standardisation in medieval and post-medieval sugar pots manufacture.

Keywords: 3D reconstruction, volumetric calculation, standardisation, ceramic technology, morphological analysis.

EMAC 17th EUROPEAN MEETING ON ANCIENT CERAMICS BILBAO 2025

Analyzing and communicating: Digital techniques in the study of Ceramics from the Roman villa of Horta da Torre and its virtual museum

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The Roman *villa* of Horta da Torre is located in Cabeço de Vide (Fronteira, Portugal), directly on the route of the possible Via XIV of the Antonine Road, which connected the capital of Lusitania, *Augusta Emerita*, with the port city of *Olisipo* and was thus perfectly integrated into the various goods distribution networks. Although this site had already been mentioned by several authors, it was only studied in depth after its relocation in 1998. Since then, several works have been carried out on the site, from survey campaigns (since 1999) to archaeological excavations (since 2012). The progress of the work, both in the field and in the laboratory, has already enabled us to understand that the house was abandoned in the 5th century AD and reoccupied soon after. The pottery finds published so far come mainly from excavations, more precisely from the *stibadium* room. These studies have focused on the characterization of the site, the tastes and consumption preferences of its inhabitants and the understanding of its trade dynamics. Nevertheless, we felt it was essential to explore the archaeological material from a new perspective. That's why, in September 2024, we launched the Virtual Museum of Horta da Torre — an innovative project that makes the *villa*'s collection accessible to the public. It is available online 24/7 and offers open and free access for everyone through Sketchfab. This is a constantly evolving project that is being developed using digital technologies such as photogrammetry, 3D modelling and 3D virtual anastylosis. In the field of ceramics, these reconstructions improve our analysis of typologies while enabling the dissemination of ceramic data to both the general public and scholars. It also serves as a valuable tool for virtual data preservation.

Keywords: Horta da Torre, Roman Ceramics, 3D modelling, 3D virtual anastylosis.

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4.5. *Technology, Production and Dating: Cross-Cultural and Technological Innovations*

Oral Presentations

EMAC 17th EUROPEAN MEETING ON ANCIENT CERAMICS BILBAO 2025

Crafting with Carbon: Investigating Prehistoric Graphite Cones in the Balkans

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This study presents an interdisciplinary analysis of Neolithic and Chalcolithic (5th millennium BCE) graphite cones (Lestakov 2005), undertaken as part of the GRAPHTEC project, which offers a novel contribution to understanding the technology and circulation of graphite-decorated pottery.

The research focuses on artefacts recovered from various archaeological sites across the Balkans, examining their material composition, manufacturing techniques, and potential functions within the prehistoric communities of the region. Graphite objects, particularly cones, are relatively rare in the archaeological record, and their specific role remains insufficiently understood, likely connected to graphite-painted pottery, one of the dominant styles of the period. Employing a suite of analytical techniques, including X-ray diffraction (XRD), Raman spectroscopy, and organic residue analysis (ORA), this study investigates the structural and elemental composition of the cones to better understand their production technology and gain insights into their provenance.The analyses reveal varying compositions comprising natural graphite and clay minerals, suggesting the use of distinct 'recipes' and indicating a high level of craftsmanship, likely reflecting a specialised manufacturing process. This research deepens our understanding of material use and technological practices in prehistoric Europe, offering new perspectives on the socio-cultural and functional significance of graphite within these ancient communities.

The findings contribute to ongoing discussions (Amicone et al. 2020 and references therein) concerning the role of specialised ceramic production in early societies, and provide a fresh perspective on prehistoric artefacts in the Balkans.

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Contributions of Archaeometry to the characterization of Azorean pottery between the 16th and 18th centuries

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Early Modern Azorean pottery (16th to 18th centuries) was made using local clays, mainly from the island of Santa Maria. This production was largely for local consumption, although it could be exported as a complementary cargo to neighbouring archipelagos, like Madeira or the Canary Islands. This activity was regulated at a municipal level, and it must have had some impact on the economy of the towns that produced it. Different types of ceramic fabrics can be recognised, showing that there was some diversity in production. Research in Cultural Anthropology tends to show the usual mixing of clays from different islands and sometimes adding tempers to make the pastes. The production of unglazed pottery is dominant, as it often has a red slip, usually burnished. It also produced glazed pottery, however on a much smaller scale. Azorean pottery production mainly comprises kitchenware, tableware and storage vessels. The most common and diverse types are basins, cooking pots, frying pans, bowls, jugs and large storage jars. The aim of this work is to contribute to the archaeological study of Azorean pottery from this period, by using archaeometric techniques. We used pXRF to analyse the chemical composition of the samples; XRD to study the mineral composition of the fabrics; and SEM to analyse the structure of the clays and estimated firing temperature. This same technique, combined with EDX microanalyses, was used to characterize the slips and glazes.

Keywords: Azorean pottery, Archaeometry, Archaeology, Early Modern Age, Azores islands.

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EMAC 17th EUROPEAN MEETING ON ANCIENT CERAMICS BILBAO 2025

A technological study of Hungarian white earthenware

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White earthenware (also referred to as fine faience, *faïence fine* in French, and *Steingut* in German) is a white-firing, porous ceramic whose body is composed of an artificial paste made from clay, quartz, and flux, and is covered with a transparent glaze. Hard white earthenware made from non-calcareous (CaO-poor) paste was invented in England in the first decades of the 18th century, and later improved by Josiah Wedgwood. Soft white earthenware made from calcareous (CaO-rich) paste is a French innovation of the 18th century. A few studies on European white earthenware from England, France, Italy, Slovenia, and Switzerland have revealed the wide variety of the production technology (Maggetti 2018). White earthenware was produced in several factories in the territory of historical Hungary from the end of the 18th century. However, the production technology and material use have not yet been the subject of detailed scientific study. We analysed several white earthenware products manufactured by Hungarian factories (e.g., those in Kassa, Holics, Batiz, Tata, Pápa, Igló, Hollóháza, Budapest, and Pécs) and are stored in the ceramics collections of the three main museums in Budapest. White earthenware objects produced in Wilhelmsburg (Austria) are also analysed for comparison. Following an *in situ* non-destructive analysis using a handheld XRF spectrometer, small samples were detached from selected objects. The microstructure and chemistry of the bodies and glazes were determined by SEM-EDX analysis, and X-ray diffraction (XRD) analysis was applied to determine the phase composition of the bodies. Preliminary data suggest that the objects from Kassa, Tata and Hollóháza are Ca-Mg white earthenware, indicating the use of dolomite/dolomitic limestone for the paste, which was covered with a lead-alkali or high lead glaze. In addition, the Ignác Fischer factory in Budapest produced aluminous white earthenware as well.

Keywords: White earthenware, Fine faience, Steingut, Hungary, SEM-EDX.

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EMAC 17th EUROPEAN MEETING ON ANCIENT CERAMICS BILBAO 2025

Archaeometric studies on the evolution of ceramic fabrics in the long-lived production site of Medamud (Egypt)

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Despite the growing interest in archaeometric approaches, ceramic production sites in Egypt have received relatively little attention from a technological perspective. This study focuses on a specialized production centre, Medamud, dedicated to calcareous ceramic fabrics, a distinctive feature of Egyptian pottery. These well-known calcareous fabrics represent a very wide spread production feature of Egyptian pottery. The site, active for over 2000 years, demonstrates a remarkable continuity and adaptation in ceramic manufacturing. The exceptional long-term continuity of production (1800 BC – 400 AC) is accompanied by a dynamic evolution in ceramic manufacture. The production repertoire is highly diversified, encompassing tableware, large storage containers, and above all, decorated ceramics, which provide insight into aesthetic and functional trends over time. Marl fabrics have been only described and classified through a macroscopic approach, however cross correlating this classification with archaeometric studies represents a real challenge. For that, petrographic and pXRF analyses reveal shifts in fabric preparation techniques, temper selection, and firing conditions. The results reflect both technological advancements and responses to economic or environmental factors. The sampling comprises 50 specimens of clay raw material and both fired and unfired ceramic sherds, selected based on typological, functional, chronological and macroscopic observations criteria. Recent excavations have uncovered well-preserved workshops areas, including raw material processing zones, fabric preparation installations, and kilns, allowing for a comprehensive reconstruction of the chaîne opératoire. The combination of archaeological and archaeometric data provides a unique opportunity to examine the resilience and adaptability of this production system, shedding light on the long-term management of ceramic resources in Egypt. Although, the ceramic production of the site of Medamud has ended, the Theban region is still known for its marl pottery productions. In addition, the authors have documented the workshops that are still operational in order to compare the *modus operandi* and the sources of the clay raw material.

Keywords: petrographic analyses, pXRF, calcareous fabrics, workshop, Egypt.

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Pottery meets fibrework: analysing decorative knot and plait imprints in Stone Age hunter-fisher ceramics from Latvia

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The decoration of pottery using stamps made from cordage and other textiles emerged as a European-scale phenomenon starting from the 4th millennium BC – a tradition that encompassed not only agricultural societies but also hunter-fisher groups in Northern and Eastern Europe that used ceramics. This is apparent from the distribution of pottery with wound cord and "classic" cord impressions and various other kinds of stamped and rouletted ornamentation. Archaeological study of such imprints offers unique insights into the technologies for perishable materials and indicates the close ties between pottery production, fibrework and the provision of equipment such as fish-nets.

Building on the methodology developed in the author's previous investigation of wound cord impressions, this paper presents the initial results of an analysis of the characteristic knot and plait imprints seen on ceramics from c. 3000 BC in western Latvia, with the intention of recovering maximal information about the form, material and production techniques of the fibrework stamps and the ways they were applied to the pottery. The findings will be applied as a significant contribution to understanding the pottery decoration techniques and simultaneously also the knotting/plaiting/plying technologies of pottery-using hunter-fisher communities in the region, exploring the material and conceptual links between ceramic and fibrework technologies.

The study involves stereomicroscopy in combination with reflectance transformation imaging – a powerful tool for documenting the imprints that also facilitates additional observations and measurements. Experimental replication provides further insights.

Keywords: hunter-fishers, impressed decoration, cordage, textiles, plaiting.

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EMAC 17th EUROPEAN MEETING ON ANCIENT CERAMICS BILBAO 2025

Bridging the gap between the aboriginal and the popular pottery-forming traditions in the Canary Islands by integrating technological traces, X-radiography & micro-CT analyses

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The aboriginal ceramics of the first communities that inhabited the Canary Islands during the Prehispanic period (ca. 2nd – 15th centuries CE) and the popular Canarian-Hispanic pottery that developed after the European Conquest (16th – 20th centuries CE) belong to one of the most outstanding features of the social, cultural and historical processes that took place in the Canarian archipelago, distinguished significantly by maintaining the tradition of making pottery without rotatory kinetic energy. Most archaeological research and ceramic studies have focused on the systematization of the morpho-typological and decorative features (Tenerife and La Palma) and occasionally the characterization of their raw materials (Gran Canaria). Even so, it remains practically unknown which where the forming techniques and sequences that were used by the aboriginal communities and whether they survived in the popular ethnographic ceramics, such as the technique of drawing a lump of clay, exclusively preserved in the island of La Gomera, or the coiling technique by internal spreading, widespread in the rest of the islands. In view of the ongoing research that covers the global characterisation of the aboriginal and popular Canarian handicrafts, it is essential to provide new insights into the existent ceramic ways of doing and technical traditions of the aboriginal period and to detect their continuity, rupture, or specific adaptations in the recent ethnographic pottery. This oral communication aims to present the research project *Forgotten traditions* focused on an interdisciplinary analysis of this phase of ceramic technology following an Ethnohistorical and Archaeological perspective. By combining macroscopic, X-radiography and micro-CT analyses to identify technological traces of forming at different scales, this paper will present the preliminary results of the experimental program of the typical Canarian pot-forming traditions (reproduction & breakage) and its comparative with the aboriginal ceramic assemblages from the sites of Cueva de los Cabezazos (Tegueste, Tenerife) and Tejate (La Oliva, Fuerteventura).

Keywords: Pottery traditions; Forming techniques; Prehispanic; Canary Islands; Ceramic technology.

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17th EUROPEAN MEETING ON ANCIENT CERAMICS
BILBAO 2025

Technological transmission and artisanal mobility during the Greek colonization in Italy (8th-6th centuries BC). An overview of the "Pots and Pans" research: methodology, results and perspectives

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The "Pots and Pans" research ("Pottery production and consumption as indicators for the contributions of Greek migrants and local inhabitants to the so-called Greek 'colonization' in Italy"), under the auspices of Vrije Universiteit Amsterdam and the Institute of Nanoscience and Nanotechnology, N.C.S.R. "Demokritos", in collaboration with other renowned academic institutions, explores technological and cultural transfer, the movements of artisans and goods, and cross-cultural interplays in pottery production at the time of the Greek colonization and migration to southern Italy and Sicily. The focus is on ceramics that were used during the first contact phases of the Iron Age Greek colonization (8th – first decades of the 6th centuries BC), comparing pottery productions between key sites in Greece and in Italy. Pottery played a crucial role in the early subsistence economies, in the economic and cultural exchanges with the indigenous populations of Italy; for this reason both the incomers' and the indigenous traditions of manufacture are investigated. The paper presents an overview of this research, coordinated by the undersigned, it highlights the methodology and important results of the project and finally discusses future perspectives when a science-based technological approach is applied. The undersigned together with a team of colleagues have conducted original research on pottery by combining a range of macroscopic and science-based methods (including petrographic, chemical [NAA, WD-XRF, p-XRF] and SEM analyses), and investigation of the use of raw materials (mainly through petrography, combined in certain instances with XRD analysis). Targeted ethno-archaeological research, combining macroscopic and petrographic analyses, has also been applied. By bridging humanities and hard sciences, we can gain insights into the wide-ranging routes of knowledge transfer and the multiple technology practices, to achieve a deeper understanding of the wider social and economic relations between mother-cities, colonies and native communities.

Keywords: ancient Mediterranean, Greece and Italy, technological transmission, mobility, colonization.

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Chemical and multi-spectroscopic investigation for the study of firing technology of the earliest clay containers from Upper Mesopotamia

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In this study, physical and compositional properties of the fragments of fired-clay containers from the architectural spaces of Pre-Pottery Neolithic A (PPNA; c. 9500 cal BCE) at Çemka Höyük in southeast Anatolia were examined. A multi-spectroscopic analysis was used to investigate an experimental stage of achieving an earliest completed clay container in PPNA. X-ray fluorescence analyses of the samples and quantitative microanalysis of mineral grains indicate chemically consistent compositions of the sherds which are constituted by similar calcareous-iron rich sedimentary sources (CaO > 18 wt%, Fe_2O_3 > 10 wt%). *Scanning Electron Microscopic (SEM*) images show that the clay containers were minimally processed and had a less compact structure. The results of Laser Scanning Confocal Microscopy (LSCM) also show some similar surface treatments which were intentionally produced, demonstrating the earliest evidence of ceramic production in SW Asia. The nucleation of hematite started around 700°C under oxidising conditions. However, the *Quantitative analysis of X-Ray diffraction data* and the thermal reactions of carbonate vibrations of all containers in Fourier transform infrared spectroscopy (FTIR) show that the firing temperature was not high enough to favor the high vitrification and sintering processes due to the lack of a glassy network, whilst all containers fired with the same firing conditions, probably in the same production run. A progressive weakening of carbonate constituents, initial formation of hematite reflection notably from 650-700°C, and incomplete destruction of clay minerals established similar thermal properties of all clayey objects, ranging from 600-650°C and 650-700°C under oxidising conditions. However, two clay-based materials revealed very different and multiple compositions, indicating intensive asymmetric deformation bands of carbonate as a function of chemical alteration and the mineralization during the post-burial chemical leaching. The results may point to an awareness of the technology to produce ceramics experimentally in the 10th millennium.

Keywords: Clay Container, XRF, SEM, LSCM, XRD.

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Tol-e Chega-Sofla: Insights into the technology and provenance of pottery production in early 5th BCE, south-west of Iran

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Tol-e Chega-Sofla is located in the Zeydun Plain, south of the provincial city of Behbahan, southwest of Iran, a short distance from the northern shores of the Persian Gulf. Chega-Sofla is the largest known prehistoric site, dating to the 5th millennium BC (Moghaddam, 2016). Chega-Sofla contains a settlement and a cemetery section, with the height of the highest remaining ridge reaching more than 30 m from the surrounding land to the Zohreh River (Moghaddam & Miri, 2021). The scientific objective of the project is to investigate the mineralogical, chemical and microstructural evolution of the pottery through the production process and raw materials, which in turn have remained as important evidence to study the clay-based raw material consumption of an exotic culture in terms of its style, form, decoration and applied process technologies (Emami, 2020). Studies of early pottery production in Chega-Sofla have provided much valuable information on technological know-how in the past. In this report, common pottery has to be studied in depth by QXRD, petrography, SEM-EDXS and cathodoluminescence microscopy in order to characterize the production and provenance of these unique objects (Emami et al., 2021). Ancient potters gradually realised that inorganic materials in the ceramic paste increased plasticity and reduced the necessary firing temperatures. These ceramics were fired in oxidising and reducing cycles. Analysis suggests that ancient potters were able to raise kiln temperatures to 850-950 ◦C. However, they were unable to maintain consistent kiln temperatures in subsequent firings. Pottery is divided into 'low temperature' and 'high temperature' production. As a response variable, kiln temperature is influenced by several explanatory variables, some of which are beyond the potters' control. Many aspects of ceramic production have been standardised, including raw materials, additives and pastes. The pottery's Chaîne Opératoire has modified all these variables in Chega Sofla, which is reflected in the evaluation of technologies in south west of Iran.

Keywords: Archaeological Science, Pottery Production, Fabrication, Characterization, Mineralogy.

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Early Islamic Glazes and Glass in the Chu River Valley (Kyrgyzstan)

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Lead-glazed ceramics mark the first production of glazed ceramics in Central Asia and are among the most distinctive artefacts from early Islamic archaeological sites between the 9th and 12th centuries. While technological studies of Islamic glazed ceramics have expanded, peripheral regions of the Islamic world remain underexplored. This paper presents the results of archaeometric analysis of early Islamic glazed ceramics from Ken Bulun located in the Chu River Valley (Kyrgyzstan). A sample of 45 sherds was analysed using SEM-EDS to investigate their composition and production techniques. The study explores how glazing technologies were transmitted to and locally adapted in a region with no prior glazing tradition. By comparing these findings with previously studied ceramics from the Talas and Chu valleys, and production centres such as Chach, Samarkand, and Bukhara, we gain insight into the local and regional characteristics of glazed ceramics during this period. Additionally, production and consumption trends were compared with glass finds from the same site to assess broader technological patterns.

Keywords: Glaze, technology, glass, cross-craft, Early-Islamic

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Understanding the Manufacturing Technology of Japanese Stoneware from the 11th-17th c. CE

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The present study explores the technological aspects of Japanese ceramics excavated from the Kawaminetsuji (Ryūkyū Islands, Japan) and the Shikata (Okayama, Japan) archaeological sites dating from the 11th to 14th and 16th to 17th centuries CE, respectively. The Kawaminetsuji assemblage [1] consists of selected sherds from Kamuiyaki pottery, specifically tsubo or kame jars, while the Shikata collection [2] includes sherds from Bizen wares. Limited archaeometric studies have been conducted on these high-temperature-fired ceramics making this research particularly significant. This multiscale study seeks to enhance the understanding of the manufacturing technology of the analyzed sherds by integrating Petrographic Microscopy, Scanning Electron Microscopy and Electron Crystallography (PLM, SEM-EDS, FE-SEM, FIB-SEM, TEM-PED), X-ray Fluorescence (XRF), and X-ray Powder Diffraction (XRPD). The obtained elemental composition shows that all samples are non-calcareous. Bizen samples display higher SiO_2 content (above 70 wt%) than the Kamuiyaki samples (~61 wt% SiO_2), suggesting a clay source richer in silicon or a deliberate addition of quartz as temper. Additionally, Bizen samples contain lower Fe_2O_3 (3.5 wt%) and TiO_2 (0.6 wt%) than the Kamuiyaki samples (11 wt% Fe_2O_3, 1 wt% TiO_2). The presence of fluxing agents is also detected in similar amounts across most samples (~2 wt% K_2O, 0.7 wt% CaO). Mineralogical analysis identifies quartz, mullite, and cristobalite, indicating firing temperatures above 950 ˚C. Furthermore, both PLM and XRPD confirm a glassy phase, with the latter revealing an amorphous background. However, the iron oxide identification was challenging, complicating the assessment of the kiln's redox conditions from both sites. FE-SEM observations revealed the presence of iron oxide nanocrystals, embedded in an aluminosilicate glassy matrix, with minor Ti content. To further elucidate the distribution and type of magnetic minerals (e.g., hematite, magnetite, maghemite), X-ray Absorption analysis is planned at the ALBA Synchrotron. This research not only provides new archaeometrical insights into the manufacturing technology of Kamuiyaki and Bizen wares from the 11th to 17th centuries CE but also lays the groundwork for future ancient ceramics studies through a multiscale analytical approach.

Keywords: Stoneware, Manufacturing Technology, Firing Temperature, Japan.
Acknowledgments: We warmly acknowledge the Isen Town Board of Education for providing the Kamuiyaki samples and Okayama University for providing the Bizen sherds.

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Insights into the Cucuteni pottery technology. Case study: Răucești-*Dealul Munteni* (Neamț County, eastern Romania) archaeological site

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The aim of this study is to investigate the pottery *chaîne opératoire* at the site of Răucești-*Dealul Munteni* (Neamț County, eastern Romania) using an archaeometric approach to add more knowledge on the interaction networks affecting pottery production and causing variability in the pottery recipes (Diaconu, 2019). This site from the Chalcolithic period is located in a key region at the fringe between the Subcarpathians and the Suceava Plateau and the *briquetage* pottery fragments identified within the pottery assemblage confirmed the site's strategic relevance within the salt exchange system developed in the region (Brigand, Weller, 2018). For the present study, we have selected potsherds representing the functional categories and decorative patterns of the Cucuteni A (4600-4000 cal. BC) and B (4000-3500 cal. BC) ceramic assemblage found at the site (Lazarovici, 2010). Methodologically, we have started with an extended macroscopic investigation followed by a petrographic study to determine the compositional and microstructural features of the clayey matrix and the added temper. To further investigate the mineral changes caused by the firing process, we conducted X-ray Powder Diffraction (XRPD) analysis. Additionally, we used Scanning Electron Microscopy coupled with Energy-Dispersive X-ray Spectroscopy (SEM-EDX) to analyze the chemical composition and microstructure of the samples. The composition of the red, white and black pigments was determined using Raman spectroscopy. The results showed the continuity of several recipes from Cucuteni A to Cucuteni B phase, along with a shift in clay sources and a narrower range of vessel types during the Cucuteni B phase. Additionally, various interactions with salt and black pigment exploitation systems in the region were identified.

Keywords (max 5): Chalcolithic, *chaîne opératoire*, continuity, change, interaction networks.

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Disclosing production process by the archaeometric analysis of Bronze to Iron Age jars from Qatna (central Syria)

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This work presents the current results of the archaeometric study carried out on 121 samples of jars from the site of Qatna (Tell Mishrifeh, central Syria), dated from the early Bronze age to the Iron age. The samples were characterized in terms of mineral composition by X-Ray Powder Diffraction (XRPD), petro-fabric by optical microscopy, chemical composition by X-Ray Fluorescence (XRF) and the results were then combined with the typological features (shapes). The data obtained from the XRPD and the XRF were statistically treated to analyse patterns of clustering and the mineralogical and chemical variables responsible for data variability by principal component analysis. This diachronic research enabled the identification of a change in the petro-fabric from the Early Bronze Age to the Iron Age, which can be interpreted in terms of modifications in the production recipe, firing, and production techniques of the jars. As the ceramic material here analyzed corresponds to the first in central Syria to be stratigraphically excavated and dated in absolute terms, this provides a significant step into deciphering the history of this important site.

Keywords: Ceramic Analysis, Ceramic Petrography, X-Ray Powder Diffraction, Bronze Age Syria, Qatna.

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Was Red the New Black? Exploring Fe-based Slips in the Roman World (3rd c. BCE- 1st c. CE)

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Few ceramic types define Roman material culture better than Black Gloss pottery and *terra sigillata*. More than just tableware, these ceramics reflect the development of large-scale industry, mass production and the expansion of trade networks that sustained the Roman world for more than four centuries. Their iron-based slips, achieved through different firing atmospheres, not only served an aesthetic purpose but also significantly protected the vessel and made it waterproof. Moreover, the transition from black to red, reflecting broader cultural and economic changes from the Late Republic to the early Roman Empire, is now considered an important chronological marker for archaeologists. This study presents a diachronic analysis of the technological features of the slips coating Black Gloss pottery (late 3rd c. BCE -1st c. BCE), *Eastern terra sigillata* (attested in the Western Mediterranean from c. 50 BCE), and *Italic terra sigillata* (from c. 40/30 BCE), based on samples from different archaeological sites. The goal is to identify the technological differences between these ceramic types, focusing on compositional and mineralogical aspects. The analysis includes Scanning Electron Microscopy coupled with Energy-Dispersive X-ray Spectroscopy (SEM/EDS) for microstructural and elemental composition studies and Micro X-ray Diffraction (μ-XRD) to identify mineralogical phases on slip surfaces. Additionally, to evaluate and compare the colour of the slips coating Black Gloss pottery, colourimetric analyses were conducted; further study is still in progress. This research builds upon provenance data previously obtained through X-ray Fluorescence (WD-XRF) and firing temperature insights through X-ray Diffraction (XRD) on the ceramic bodies. The results provide insights into raw material selection, clay refinement, and the possible use of additives in slip manufacture. Furthermore, the comparison between the different ceramic types revealed a shift in clay selection from Black Gloss pottery to *terra sigillata*. These findings provide new insights into the technological evolution of Roman tableware production.

Keywords: Fe-based slips, Black Gloss pottery, terra sigillata, archaeometry, ceramic technology.

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Compositional and lead isotopic study of tin-glazed ceramics from Pisa, Catalonia and Valencia (13th-14th century A.D.)

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The production of glazed ceramics was first introduced into Europe in Islamic Spain, brought over from the Middle East with the social and political expansion of Islamic populations in the western Mediterranean (Salinas & Pradell, 2020). The technology transfer followed the Christian wars of reconquest, which prompted the migration of Muslim populations to new territories across the Mediterranean during the Middle Ages (Coll Conesa, 2023). This emigration established new ceramic production centers in Catalonia, France and Italy in the 13th century (Bercero, 2007). In this study, fifteen sherds of archaic maiolica (tin-glazed ceramics) produced in Pisa (Italy) between the 13th and 14th centuries and twenty-six sherds of glazed ceramics, known as '*Pisa arcaica decorada en verd i manganès*' made in Barcelona (Catalonia, Spain) and Paterna and Manises (Valencia, Spain) during the second half of the 13th century and the 14th century were analysed through optical microscopy and SEM-EDS. Moreover, the origin of the lead used in glazes was investigated through mass spectrometry (TIMS). Notwithstanding lead is an important raw material used as a flux in glaze production, little is known as yet about its sources and the trade routes involved in its supply. Through the comparison between the ceramic production of these ceramic centers we aim to put forward new hypotheses regarding the commercial exchanges and cultural influences between Italy and Spain. This study provides the opportunity to reconstruct the factors that allowed the birth of glazed ceramic production in Italy and Catalonia during the Middle Ages.

Keywords: tin-glazed ceramics, SEM-EDS, lead isotope analysis

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EMAC 17th EUROPEAN MEETING ON ANCIENT CERAMICS BILBAO 2025

Adapt or Perish: Technological Transformations in Tin-Lead Ceramics from Barcelona, Catalonia (16th–18th Centuries)

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Between the 16th and 18th centuries, Barcelona's ceramic production underwent significant transformations, shaped by local demands and external influences, particularly from Valencia and Italy. This study examines the transition from local tin-lead ceramics known as *Blava de Barcelona* to *Blava Catalana*, analysing changes in glaze composition, firing processes, raw material sourcing, and technological innovations that contributed to the increasing standardization of pottery production. A key objective is to determine whether these changes in decoration, paste composition, and glaze production were driven by external influences or resulted from internal technological developments. To address this, an archaeometric analysis was conducted on over 200 ceramic individuals from various archaeological contexts in Barcelona (Catalonia), employing X-ray fluorescence (XRF), X-ray diffraction (XRD), Scanning Electron Microscopy with Energy Dispersive Spectroscopy (SEM-EDS), and mechanical property tests. XRF analyses examine the increase in CaO content over time, while XRD data provide insights into improving the firing process. Additionally, the study identifies the intentional addition of quartz to glazes, a strategy that reduces tin oxide consumption while maintaining opacity. Mechanical resistance tests further reveal that glaze modifications played an increasing role in enhancing ceramic toughness, particularly from the 17th century onwards, reflecting broader socio-economic and technological shifts. By integrating archaeometric data with historical records, this research highlights the impact of Mediterranean trade networks and guild regulations on Barcelona's pottery production. The arrival of foreign ceramics influenced local production, prompting adaptations in production techniques and decorative styles. These findings contribute to a deeper understanding of technological adaptation in early modern ceramic production and its relationship with economic and artistic trends.

Keywords: tin-lead glazes, ceramic technology, local production, archaeometry

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And after burial? Corrosion Structures of High-Lead Glazed Ceramics in Al-Andalus Objects from Palmela Castle (West Portugal)

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The Islamic arrival to the Iberian Peninsula not only brought the political stability needed in the 8th century but also a vast intellectual and scientific legacy, introducing novelties in various areas of human activity, including the production and use of ceramic objects, among them, the use of glazed ceramic was a key innovation, becoming an essential part of daily life (Bordoy, 1992). During this period, Iberia was a major supplier of galena (lead ore), naturally making high-lead glazes the most prevalent in this region and a defining feature of Al-Andalus Islamic glazing techniques (Camara et al., 2023). At 250 m altitude, the Castle of Palmela (Setúbal, Portugal) was a hub for trade and defense, controlling the Tagus and Sado rivers, and benefiting from fertile lands and resources. Its Islamic occupation lasted until 1165 when the city fell under Christian control. In the present work, 18 green and/or honeydew transparent glazed fragments from Palmela were studied by Optical Microscopy, pXRF, XRD and SEM-EDS to assess the glaze's corrosion structures and obtain its material characterization. The results showed the higher stability of the honeydew-coloured glazes, only presenting some fissures and environmental depositions at the surface, maintaining its glassy appearance, the original surface line, and a strong cohesion to the ceramic body. On the contrary, green glazes display a more advanced corrosion state, exposing some iridescence without the glassy appearance, cracks, and even material loss. These results point to the role of copper, the element responsible for the green colour, as a possible corrosion catalyst. This work was supported by FEDER funds through the COMPETE 2020 Program, European Social Funds and National Funds through FCT Portuguese Foundation for Science and Technology under the following project references: UIDB/50025/2020-2023 (CENIMAT), UIDB/00729/2020 (VICARTE), UIDB/04449/2020, UIDP/04449/2020 (HERCULES), LA/P/0132/2020 (IN2PAST) and 2021.04858.BD (Ana S. Saraiva).

Keywords: High-lead glazes, Glaze corrosion, Gharb Al-Andalus, Castle of Palmela.

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Cypriot Ceramics as Ancient Geomagnetic Field Recorders: New Insights from the Archaeological Site of Idalion

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Ancient ceramics not only offer valuable insights into past production technologies and trade routes but also serve as unique geomagnetic field recorders, preserving evidence of Earth's magnetic field intensity in ancient times. In this study, we present the archaeointensity results obtained from well-dated ceramic sherds excavated at the archaeological site of Idalion. The ancient Kingdom of Idalion, one of the most significant sites in Cyprus, was founded in the 13th century BCE and continuously occupied until the Roman period. Deep stratigraphic excavations have yielded thousands of well-preserved potsherds from sealed loci, systematically recorded and stored according to stratigraphic integrity. For this study, ceramic fragments spanning different stratigraphic levels, dated between the 12th and 7th centuries BCE, were analyzed. Palaeomagnetic, rock magnetic, and Thellier modified by Coe archaeointensity experiments were conducted to assess the magnetic mineralogy, thermal stability, and absolute archaeointensity recorded by these ceramics during their production. The results reveal high intensity values ranging from 60 µT to 80 µT, supporting evidence of the extreme and rapid geomagnetic field variations documented in the Middle East at the beginning of the first millennium BCE, known as the Levantine Iron Age Anomaly (Shaar et al., 2016). This study highlights the crucial role of Cypriot ceramics in reconstructing past geomagnetic field variations, bridging the gap between Eastern Europe and the Levant. Furthermore, the abrupt geomagnetic field variations recorded during the Iron Age present a potential tool for archaeomagnetic dating of pottery, offering an alternative to the Hallstatt radiocarbon plateau issue during the 1st millennium BCE. This multidisciplinary research underscores the significance of ancient pottery as precise geomagnetic field recorders, enhancing our understanding of rapid geomagnetic variations and their applications in archaeological dating.

Keywords: Pottery, Archaeomagnetism, Archaeointensity, Cyprus, Levantine Iron Age Anomaly

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Techno-Politics of Pottery Production during the Formative Period in the Atacama Desert, northern Chile (3000-1000 BP)

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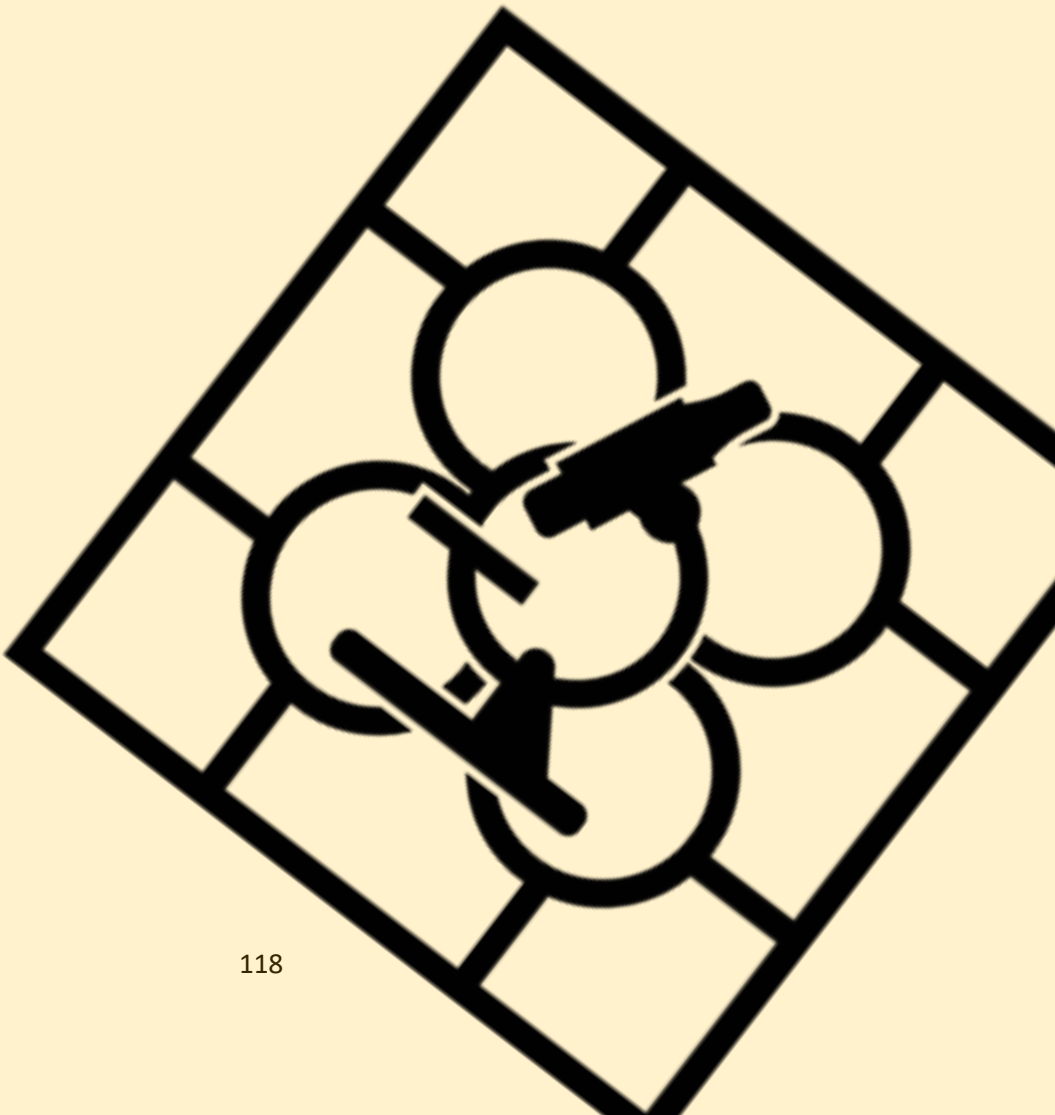
Recently, pottery studies have taken an archaeometric turn, leading to new advances and datasets that have expanded the interpretations of ceramic production. Nevertheless, the resulting data is often too technical and specific, isolating the information of the vessels from its social and political contexts in which they were produced. In turn, perceptual categories and sensory assemblages have been recognised for their potential to integrate diverse and complex forms of information, enabling us to address technological aspects of pottery production and sociopolitical dimensions of past societies. In this work, we propose an intersection of technological studies and a sensory approach to pottery technologies of the Atacama Desert to explore the lived and embodied experiences of the transition to a Formative/Neolithic world. Current proposals suggest that a cosmological transformation took place, generating new relationships between human groups, non-human agents, raw materials, elements, and resources in the driest desert in the world. A particularly eloquent material manifestation of these transformations was pottery technology. We propose an approach to technology as a set of practices that structure and reproduce social worlds, but also as a stage for intentionalities, tensions, and negotiations. This implies inserting the discussion of technologies into political fields. From this techno-political perspective, we explore perceptions and sensory experiences, as they mediate the relationship between actors (artisans) and technological practices. We address these technological and perceptual aspects through traditional and archaeometric analyses, combined with a visual and tactile sensory approach. This integrated perspective shows that these ceramic technologies materialise two social strategies practised to generate ideas and sensations of apparent equality through pottery technology (open and closed recipes). This, in turn, helped to reconcile personal and communal experiences of the transformations and inequalities of a newly formed Formative/Neolithic social world.

Keywords: Technology, Politics, Pottery, Formative, Neolithic.

Technology, Production and Dating: Cross-Cultural and Technological Innovations

Poster Presentations



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A Comprehensive Review of Glass and Glaze Techniques in the Arsacid-Sassanian Period

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Arsacid, Roman, and Chinese glazed pottery evolved through distinct technologies influenced by regional advancements and cultural exchange. Given the restricted distribution of Arsacid glaze, a comprehensive examination of the underlying factors influencing its technological transmission is essential for advancing archaeological research. Debevoise's analysis of Seleucia's blue-green glazes confirms that Arsacid pottery used lead-free alkaline silicate glazes. In contrast, Roman glazing employed lead-based compositions. Raw materials used for glazes, shared with glassmaking, were fundamental in faience and pottery production. Early glaze formulations included alkaline glazes (10–18% sodium oxide, 3–5% potassium oxide, and silica), followed by lead-based glazes (45–60% lead oxide) and lead-alkali glazes (20–40% lead oxide, 5–12% alkali oxides). Flux agents, particularly plant ashes combined with quartz-rich sands, were crucial in the glazing process, with metallic colorants added. Chemical analyses of glazes from Deh Luran Plain and Mesopotamian pottery reveal evolving glaze recipes and flux variations like natron and plant ash.

This study explores the similarities and differences between glass production and glaze technology in the Arsacid period, focusing on the Arsacid-Sassanian era. Analytical studies of Sassanian glass from Veh Ardeshir and the Deh Luran Plain reveal a strong correlation with previously documented Sassanian glazed pottery, with only minor compositional variations. These findings suggest a technological link between glass and glaze production while highlighting subtle differences in material composition and techniques. Additionally, the study examines the influence of Roman lead-glazed technology on regional practices, with evidence of Roman glass recycling at Ain Sinu contributing to cross-cultural material exchange. This research employs a comparative-analytical approach to examine glass and glaze production techniques during the Arsacid-Sassanian period. It synthesizes existing studies, archaeological data, and scientific analyses of glass and ceramics, identifying technological similarities, differences, and cross-cultural influences. An overview of these techniques is presented throughout the research.

Keywords: Arsacid Pottery, Alkaline-glazed, Lead-glazed, Sassanian glass.

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Potters' Skill and Practice in 50 BC – 200 AD southern central Europe (known as Noricum)

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The emergence of pottery wheel-throwing seems to have gone hand in hand with Roman expansion and is the hallmark of broad social change among practice communities in southern central Europe – a region that would become the Roman province of *Noricum*. The introduction of the fast wheel not only brought technological knowledge transfer, but also caused disruption and change in the learning traditions of craftsmen. Ethnographic studies have shown that ceramic technology is a conservative craft and that some steps of the production process are more difficult to change than others. For instance, while decorative motifs and firing procedures might vary within and between craft communities, it is more difficult to change their way of forming pottery (Gosselain 1998). The SPIN project, funded under the Marie Skłodowska-Curie Actions, investigates the impact of the development of wheel-throwing between 50 BC and 200 AD *Noricum*. Combining archaeological and anthropological approaches regarding potters' skills with material science techniques (petrography, XRF, XRPD, isotope analysis and SEM), the project will assess the typo-technology of common ware. It also incorporates SANS analysis (Gait et al. 2024), experimental data and digital humanities to gain insight in the production scale and output and to assess the impact of expanding Roman culture on the location and organisation of workshops. These data will be used to understand why some communities adopted wheel-throwing and why others rejected it. This poster presents the typo-chronology of tripod bowls - a common shape of common ware, which was widespread in *Noricum* between 50 BC and 200 AD. The first archaeological and SANS analysis results are presented, revealing differences in paste recipes and forming techniques of the potters. This provides an opportunity to distinguish different learning traditions and holds the potential to shed light on the traditions and norms that governed ancient craft communities.

Keywords: Pottery wheel-throwing, Roman era, common ware, Petrography, SANS.

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Technological choices for building Early Neolithic ceramics and their external mud coats for salt production in the Salt Valley of Añana (Basque country, North Spain)

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The Salt Valley of Añana has emerged as new representative site for understanding the development of the neolithisation process in the north of the Iberian Peninsula (Upper Ebro valley), and for gaining a better understanding of the economic strategies of these first farming communities around one of the oldest salt exploitations in the European continent. The NéoSal research project, launched by a French Spanish team, has revealed an exceptional stratigraphic sequence linked with the salt exploitation and processing dating back to at least 5200 cal. BCE, which has yielded a large quantity of potsherds associated with several Early and Middle Neolithic layers (more than 500kg). The analysis of the pottery assemblage of Valle Salado de Añana have provided a macroscopic and mesoscopic characterisation of the ceramic manufacturing phases that were performed in this site along the Early Neolithic: among which, the prevalence of the forming tradition of the patchwork technology, revealing the distribution of this Mediterranean tradition in the north Iberian Peninsula. In parallel, another key element from this Early Neolithic site corresponds to the mud coating sherds applied on the surfaces of those vessels that were used to process the brine coming from the natural springs by evaporation. This paper provides new insights into the technologies used for building the ceramic vessels and the mud coating sherds recovered in the Neolithic sequence of the Salt Valley of Añana by integrating the analysis of technological traces and the 3D scanning techniques. The aim is to address (1) what were the technological choices that were employed for forming, adding and using these mud coating sherds and (2) whether the community of practice that was producing the vessels followed the same operational scheme for building these clayey elements, shedding new light on their equal participation both in ceramic manufacture and salt production.

Keywords: Ceramic traditions, Mud materials, Salt production, Early Neolithic, North Iberian Peninsula

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Hybrid Technologies: A preliminary archaeometric analysis of decorative tiles from Panama Viejo

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Founded in 1519, Panamá Viejo was the first Castilian settlement on the Pacific coast of the Americas and evolved into a strategic hub for transoceanic trade, imperial governance, and cultural entanglement during the colonial period. Its pivotal geographic position fostered sustained interaction among Indigenous, African, and European populations, shaping a materially diverse and technologically hybrid cultural landscape that remains understudied from both archaeological and archaeometric views. This study presents a preliminary archaeometric analysis of a key ceramic category from stratified contexts in Panamá Viejo: glazed decorative tiles, which were instrumental in everyday domestic, architectural, and symbolic expressions of colonial life. A total of 66 ceramic samples were analyzed through instrumental Neutron Activation Analysis (NAA), enabling the identification of distinct compositional groups and their comparison with previously characterized reference materials from Spanish reference productions, including majolica tiles from the Santo Domingo Convent (Casco Viejo). Complementary *non-destructive* analyses via portable X-ray Fluorescence (pXRF) confirmed these groupings and supported initial provenance assessments. These datasets were further integrated with microstructural observations obtained through optical microscopy and scanning electron microscopy (SEM), revealing variation in raw material choices, firing regimes and surface treatments. The results suggest the coexistence of similar technological traditions and adaptations rooted in the complex socio-ethnic fabric of early colonial Panama.

Keywords: Archaeometry, Tiles, NAA, Colonial archaeology, Panamá Viejo.

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Research on the archaeological find of torsos of unused ceramic large-format tiles from the 16th century in Prague

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During the reconstruction of the Schwarzenberg Palace in Prague, various types of unused stove tiles were found in its foundations. A completely unique find were the torsos of four large-format tiles from first half of the 16th century. Three of these tiles featured polychrome decorations: a lunette stove tile with a relief decoration featuring the Czech lion inside a shield surrounded by a vegetal motif, a circular tile illustrating the Old Testament story of Lot and his daughters with burning Sodom and Gomorrah in the background and a square tile with the motif of an eagle. The fourth torso was a lunette tile with part of Czech lion covered only by green glaze. Additionally, dozens of smaller square and rectangular tiles, as well as triangular tiles with lids and mouldings were monochrome green. The main goal was to determine whether at least the part of finding was produced by one workshop and whether the torsos could have formed a single unit. The characterisation of the shard materials was carried out using optical and electron microscopy (OM, SEM/EDS), X-ray analyses (XRF, XRD) and thermal analyses (DIL, STA). Individual glazes were evaluated primarily by Raman spectroscopy (RS) and microscopy (SEM/EDS). It was proved that part of the finds really belongs to a single set, shows the same shard materials and very similar glazes, engobes and gilding on the coats of arms, respectively. The shards contained a higher amount of Al_2O_3, which is typical of stove ceramics, and some also traces of the mullite phase. The lead glazes were coloured with ionic dyes (metal oxides Cu, Co, Sb, Zn, Sn, Mn), cassiterite, Naples yellow, lead tin yellow (types I and II) were identified from the crystalline phases. After the restoration of the large-format tiles, including the addition of losses and the addition of other geometric shapes, the arrangement of the main part of the stove was proposed.

Keywords: ceramic stove tiles, glazes, dyes, X-ray analyses, Raman spectroscopy

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Mysterious jug in the grave of a Russian prince

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In 1965, during excavations inside a church in Pskov (city in northwestern Rus'), a few fragments of a jug with a relief image of a human head were found. These fragments were found at the burial site, belonged to one of the Russian princes of the 12th century (the grave survived, but the bones were removed from it at the end of the 12th century). The directors of the excavations believed that they had found a vessel made by a Russian potter (Белецкий & Белецкий (1979). However, all signs indicate that this is an imported jug, brought from Western Europe (Britain? Northern France? Germany?). It has a shape typical for European jugs, relief decor and a bottom with a specific design. At the same time this vessel is distinguished by the absence of a glaze coating on the surface, typical for European products with figurative images produced in the 13-14th centuries. Therefore, it can be assumed that this vessel was produced at an earlier time (in the 12th century) and brought to Pskov at the same time. This is one of the earliest examples of European artistic tableware that became the property of the highest Russian aristocracy. The purpose of the poster message is to clarify the origin of this vessel.

Keywords: archaeology, Ancient Rus', Medieval period, European import, ceramics.

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Glazing pottery in the late Hellenistic and early Roman Greece : Multi-technique analysis of "Megarian" bowls, eastern sigillata, and related wares

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This poster analyses black- and red-glazing techniques that were employed for affordable ceramic imitations of the expensive silverware in three pottery industries of the Aegean region in the late Hellenistic and early Roman period – that is, Athens (Attica), Corinth (Peloponnese), and Mytilene (Asia Minor). The study applies to a set of 48 samples of moulded glazed wares that are dated to the last two centuries BC : i.e. Hellenistic hemispherical bowls, late Hellenistic/early Roman eastern sigillata, early Roman relief bowls and portrait bowls. Based on a combined petrographic analysis of the pottery fabrics and SEM-EDS analysis of the fabrics and glazes, we explore technological choices for the aesthetic refinement of these drinking vessels that were most often used in socially-and politically-meaningful gathering events, at a time of emergence of new aesthetic standards under the increased (political, economic, cultural) influence of Rome in the Greek world. The results indicate that at Corinth and Mytilene, the arrival of Roman settlers in the mid-1st century BC corresponds in time with a shift in clay exploitation strategies (with the use of coarser, Fe-rich ceramic fabrics) and in glazing compounds (with Mg-, Si-rich clays) leading to thicker, shinier, and more adherent glazes. The firing conditions and temperature of the pots were also adapted to suit best these glazing compounds. By contrast, Athenian pottery industry stands out by the homogeneity through time in pottery types (hemispherical moldmade bowls of Hellenistic tradition), fabric composition, and the consistently low-silica and high-alkali content of their glaze. These results therefore suggest that in the wake of the Roman conquest of the Aegean region, the widely renowned Athenian pottery industry may have operated on different bases from provincial workshops aiming at covering local markets, with a stronger attachment to technological traditions of the Hellenistic age.

Keywords : black-glazed pottery, terra sigillata, petrography, SEM-EDS, early Roman Greece.

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Examining diachronic changes in forming techniques of Hungarian Whiteware between the 11th –17th centuries

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Soon after its emergence at the turn of the 12th–13th centuries in the Hungarian Kingdom, Whiteware, or Buda Whiteware (BWW, Höllrigl 1930, Holl 1956, 1963), became one of the most popular and common forms of pottery, continuing at least until the 17th century. It has a characteristic white fabric (from greyish or yellowish white to pale rose), and occurs as a range of both table wares (bottles, jars, cups, mugs, bowls) and cooking wares (pots, cauldrons). Based on previous macroscopic observations of surfaces, vessels of this ware were believed to have been made by coil-building followed by secondary shaping on a wheel. This archaic way of making Whiteware is considered to be common still even in the 15th c., when wheel-throwing was already widely used for both white and other ware types, e.g. red ware. Recent instrumental investigations (Gait et al. 2024), using specifically small-angle neutron scattering (SANS), proved to be effective in differentiating various forming techniques (e.g. coil-building, slab-building, wheel-throwing), especially in distinguishing between wheel-throwing and techniques using a combination of hand-building and secondary wheel-shaping. Using this new analytical approach, this study aims to reexamine the evolution or continuity of the forming technique of BWW through time (12th–17th c.) in the Hungarian archaeological record. Identifying continuity of coil-based techniques in an era facing the evolution and domination of wheel-throwing raises the question whether such seemingly archaic modes of production reflect fundamental limitations imposed by the physical properties of the raw materials used, and/or conservative, culturally embedded, technological traditions among the potters. By applying these recently developed material science analytical tools, this project aims to provide a fresh look at previously long-held archaeological interpretations regarding the production of Medieval–Modern Age Hungarian Whiteware.

Keywords: white-body pottery, Medieval, Early Modern Age, primary forming technique, Small-Angle Neutron Scattering (SANS).

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Deciphering the past through ancient pottery: Archaeometric and archaeomagnetic insights into Prehistoric ceramics from Shimane, Japan

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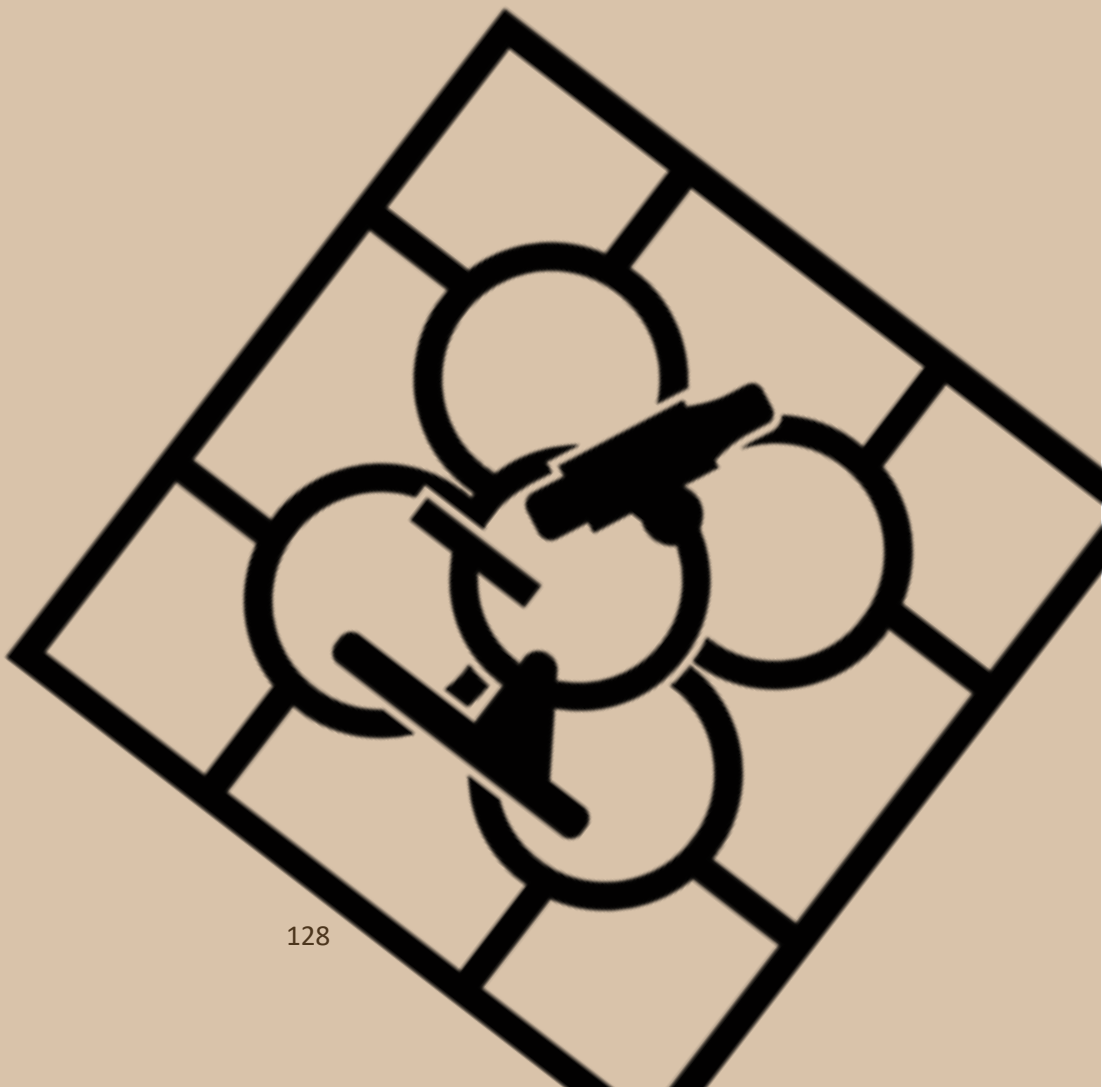
Ceramic fragments from Shimane Prefecture, Japan, collected as part of the BeArchaeo project (MSCA-RISE-2018, No 823826), were investigated using a combined archaeometric and archaeomagnetic approach to assess their production characteristics and potential as ancient geomagnetic field recorders. The samples are from three archaeological sites, Harada, Furuyashiki, and Nishikawatsu, and are dated from the final Jōmon to the early Yayoi period (approximately from 1000 to 200 BCE). The examined sherds, consisting of bowls, pots, and jars, are macroscopically characterized by a dark color, coarse texture, and diverse morphologies. Analytical techniques, including optical microscopy, X-ray Powder Diffraction (XRPD), and magnetic methods such as hysteresis loops, thermomagnetic curves, and First-Order Reversal Curves (FORCs), were applied. Additionally, a subset of samples was subjected to absolute archaeointensity determination using the Thellier-Coe method. Results reveal significant inhomogeneity within the sherds, observed both on the surface and in cross-section. Features such as carbonized organic material, sandwich layering, and coarse inclusions suggest non-refined pottery production. XRPD analysis confirms that all samples derive from non-calcareous clay sources and contain poorly crystalline iron oxides, indicative of firing temperatures between 400–450°C and 650–700°C. These findings along with the sherds' low magnetic stability and non-reversible thermomagnetic curves, further support evidence of low-temperature firing. Magnetic analyses indicate the presence of low-coercivity magnetic minerals, likely magnetite and/or Ti-magnetite, with FORC diagrams suggesting large multi-domain grains, consistent with coarse clay and insufficient firing, making them poor recorders of Earth's magnetic field. Archaeointensity experiments were unsuccessful, primarily due to mineralogical changes during laboratory heating. Inhomogeneous clay, large inclusions, coarse ferromagnetic minerals, and low firing temperatures contributed to this failure. To our knowledge, this is the first archaeometric study on these Shimane sherds, providing an initial step toward a deeper understanding of prehistoric Japanese pottery production techniques and their viability as archaeomagnetic field recorders.

Keywords: Ancient ceramics, Archaeometry, Magnetic mineralogy, Archaeointensity, Japan.

4.6. *Theory and Methods*

Oral Presentations



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A thermodynamic approach for the interpretation of phase assemblages in archaeological ceramics: Part II: Experiments, Phase Analysis and Reactivity Investigations

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The thermodynamic approach reported in part I of this session opens a number of challenges and difficulties for archaeometric interpretations. The prediction of solid solutions and liquid phases as equilibrium phases creates interpretation problems for commonly used phase analysis techniques like X-ray diffraction. The differentiation of low-symmetric solid-solution phases, exemplified by the feldspar family $KAlSi_3O_8$-$NaAlSi_3O_8$-$CaAl_2Si_2O_8$, is not trivial. In addition, the identification of amorphous phases from former melts, which by definition do not have a well- defined crystal lattice and therefore appear only as a more or less pronounced "glass-hump" in X-ray diffractograms, is a challenge. To make things worse, we may find intermediate structures: transformed former clay minerals like amorphous meta-kaolinite (largely a "disordered kaolinite"), developing nano-sized "X-ray-amorphous" phases at higher temperatures and potentially glass from a eutectic or peritectic melt. We show the problems to differentiate those by X-ray-diffraction and spectroscopy.

The distinction between active and inactive phases in clay mixes cannot be done only by theory. Whether a phase is reactive or not is foremost changing with temperature, grain size and reaction partner. A reaction with gases, liquids or solutions, which have a big or replenishing reservoir is always more effective compared to a reaction at solid state with an interphase region growing only by solid state diffusion and reaction. We present results on reactivity experiments based on $CaCO_3$ with clay-based material, which can either follow the lime cycle ($CaCO_3 \rightarrow CaO \rightarrow Ca(OH)_2 \rightarrow CaCO_3$), enter a melt phase or react to yield Ca-silicates (Anorthite, gehlenite, Wollastonite, ...). The distinction between equilibrium phases and local metastable phases is evaluated by thermodynamic calculations and quantitative X-ray diffraction. Equilibria with silicate melts indicate a low content of CaO at temperatures ≈ 1000-1100°C, a melting at lower temperatures by Ca-bearing phases is therefore inhibited.

Keywords: analysis, calcareous ceramics, reactivity, thermodynamic calculations

Ceramic petrography applied to post-depositional alterations in Central Mexico and Peninsula of Yucatan contexts

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Petrography is a well-established ceramic characterization technique since the late 19th century (Quinn, 2003). While epistemologically derived from sedimentary petrology, the specific characteristics of an artifact require certain modifications in its description and interpretation of components, with the use of soil micromorphology. These components, which are not frequently found in rocks, are associated with the presence of certain soil features, such as the accumulation of clay (illuviation), the presence of organic matter in granular microstructures, plant remains, and processes of oxidation-reduction, among others. The modifications present in the final "life cycle" of a ceramic have been poor addressed from a petrographic perspective; although, they are located through geochemical analysis (Schneider, 2017), the difficulty in interpreting them in thin sections, requires the development of observation criteria linked to the concepts of weathering and secondary mineral formation, topics barely addressed in the petrography of prehispanic artifacts in Mexico. Storing these types of characterizations and interpretations in a primary database can allow for better decision-making tools at the time of intervention, whether in the conservation or restoration phases (through the development of a future experimental perspective). This research focuses on particularly complex environments for archaeological studies such as volcanic-lacustrine and karstified zones.

Keywords: Ancient Mesoamerica, ceramic petrography, soil micromorphology, post-depositional alteration

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Thermo-mineral waters in the Roman age: Investigating the relationship between thermal sites and raw materials

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This study explores the general relationship between thermo-mineral water sources and the formation of clay and mineral deposits, with a specific focus on their potential use in pottery production within the core territories of the Roman Empire. By analysing the geological and hydrothermal processes that lead to the formation of specific secondary materials, this research aims to examine the spatial and functional relationship between Roman thermal sites and nearby deposits.

The study begins with an overview of hydrothermally altered clays, including kaolinite and hematite, as well as associated mineralogical transformations induced by thermo-mineral activity. It then explores the special distribution of Roman Thermae and the location of ceramic production centres, accessing the geographic convenience and their co-occurrence and the possible influence of nearby thermally altered clay deposits on pottery supply chains. This paper offers a comprehensive overview of these interconnections, contributing to a deeper understanding of resource exploitation practices in antiquity and the complex relationship between natural geological processes and technological advancements in Roman ceramic production.

Keywords: Pottery, Roman Thermae, Thermo-mineral sites, Clay production, Minerals.

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Unveiling glaze defect origins: Expert strategies for flaw detection

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A fundamental inquiry in any archaeological investigation of glazed ceramics is typically, alongside the possible provenance of the raw materials, the origin and source of the degradation processes affecting the surface layer of the ceramic product. This archaeological question could be answered through precise identification of defects by microscopy, XRD, and IR techniques, combined with an analysis of the evolution of stress relations within a two-component system over time (from initial formation to excavation) using thermal analysis and stress calculations. The lead glaze on Romanesque tiles from the Rotunda of St. Wenceslas exhibited a good fit to the ceramic substrate. However, mechanical abrasion during usage and moisture-induced expansion of the ceramic body accelerated its corrosion, resulting in the formation of cerussite crystals at structurally compromised surface sites. Research on Romanesque and Gothic tiles near Prague Castle reveals that early medieval potters in Central Europe produced high-quality glazed ceramics that served their purpose for centuries.

Furthermore, the comparison of the trace element and Sr isotopic compositions of tile bodies was introduced to identify the similarity of the raw material sources of these archaeological ceramics and to examine the potential of Sr isotopes in provenance studies. As a result, the $^{87}Sr/^{86}Sr$ ratios in Gothic tile products of different colour (red and grey ceramic bodies) are totally the same. This suggests that the raw materials used to produce these tiles are geochemically related, likely originating from the same source. However, during the production process, they were treated differently through varying firing conditions.

Keywords: glaze fit, defect origin, stress relations, hydrothermal aging, isotope analysis.

References: Any bibliographic references included must follow the APA style 7th edition *(https://www.mendeley.com/guides/apa-citation-guide/)*.

Kolářová, M., Kloužková, A., Kloužek, J., & Schwarz, J. (2020). Thermal behaviour of glazed ceramic bodies, Journal of Thermal Analysis and Calorimetry, 142, 217-229. DOI: 10.1007/s10973-020-09484-3

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Combining petrography and forming techniques analysis at the Postargaric settlement of Monteagudo (Murcia, Spain)

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Pottery manufacture studies usually focus either on provenance and processing practices on the clay, or the analysis of forming techniques, even though both are part of the same process. Each stage of the *chaîne opératoire* is influenced by the social context of the people involved and the technical knowledge associated with it. As technological traditions, *chaînes opératoires* are learned and transmitted within a specific social group, ultimately providing insight to labour organization and knowledge networks. In contrast, consumption choices follow distinct dynamics from the manufacture (Dietler & Herbich, 1994), shedding light on, for example, mobility and exchange processes.

This study combines optical petrography and macrotraces analysis to explore social, cultural and economic dynamics involving pottery manufacture and consumption during the Bronze Age. The interrelation of these two techniques makes it possible to investigate the choices taken throughout nearly the entire operational sequence, providing a more comprehensive perspective and a deeper understanding of the associated processes. The main objective is to assess the potential of combining these methods to better understand the processes involving pottery and ultimately past social groups.

For this purpose, the postargaric (ca. 1500-1300 BC) settlement of Monteagudo (Murcia, Spain) was selected. Two different phases within this period were identified here, associated with manufacture -unidentified workshop with a combustion structure- and domestic contexts. The approach mentioned can answer questions related to:

- How changes in clay management and preparation relate to those in forming, providing that forming techniques tend to be more stable over time than any other technical tradition of the *chaîne opératoire* (Roux, 2019).
- The social groups inhabiting the settlement, provided by the differences in manufacturing tradition.
- Consumption strategies carried out by the people of this settlement.

Keywords: Archaeometry, Bronze Age, *Chaîne Opératoire*, Forming techniques, Southeast Iberia.

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A thermodynamic approach for the interpretation of phase assemblages in archaeological ceramics: Part I: Equilibria and the Concept of Active Phases

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Important paths for the archaeometric interpretation of ceramics are based on their chemistry and phase assemblage. We show how to interpret conditions, in which parts of the raw material assemblage are kinetically inactive and how this helps to shed new light on both bulk chemical analyses and expectations about the appearance of phases.

The phase assemblages to be expected in simple and calcareous ceramics are evaluated with the aid of thermodynamic calculations for equilibria in complex systems. We use FactSage©, one of the largest fully integrated database computing systems in chemical thermodynamics. Those calculations are superior for the evaluation of systems with four or more components, in particular, because they are capable to handle solutions in solids, liquids and gases. Results give a complete list of equilibrium phases for a given bulk composition and firing condition. We present results on clay model compositions in the systems K_2O-SiO_2-Al_2O_3, CaO-SiO_2-Al_2O_3, K_2O-CaO-SiO_2-Al_2O_3 and K_2O-CaO-MgO-SiO_2-Al_2O_3.

The combination of the use of active ingredients and thermodynamics provide a scheme for improved phase assemblage predictions as a function of firing conditions and bulk chemistry. This includes the appearance of a first eutectic or peritectic melt at a given temperature. Our results suggest to exclude liquid phase sintering as a process working in early ceramics from a combination of common ingredients, which experienced firing temperatures below about 960°C. We discuss the consequences for the microstructure of early ceramics and their use.

New challenges arising from this approach are discussed in part II of this talk.

Keywords: calcareous ceramics, firing conditions, phase assemblage, thermodynamic calculations

Analysis of traces of use and reuse on pottery

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The research unit of the University of Genoa, within the framework of the SHERDs Project, conducts research focused entirely on the systematic study of traces identifiable on the body and surfaces of ceramics, to deepen the understanding of the actual ways in which artifacts were used and the ways in which, over time, they were often reused and repurposed, with the aim of enhancing the comprehension of practices associated with the use of pottery.

The ceramic artifacts examined come from excavations at Pompeii (Campania, Italy) and Nora (Sardinia, Italy). These sites have very different characteristics and histories, providing interesting case-studies for observing the phenomenon over a broad period (2nd century BC - 6th century AD and beyond). The selected contexts are mostly latrines and domestic waste disposal sites, variably managed but generally rich in ceramics as well as glass, bone, and metal objects, along with botanical and faunal remains.

A detailed documentation of these traces requires an integrated methodological approach that combines traditional techniques of data recording and analysis (study and classification of finds on a typological and functional basis) with the use of innovative instruments, software, and procedures (cataloging traces in a specific database; detailed photographic documentation, including high-resolution macro photos and, where necessary, digital microscopy images; use of a Laser Aided Profiler, capable of providing a digital model when needed). Updated instruments are also used for conducting and interpreting diagnostic analyses (bioarchaeological and archaeometric) of organic residues and inorganic deposits preserved both on the artifacts and in the contexts of recovery, which provide further important information.

The proposed approach for studying traces of use and reuse on ceramic artifacts is potentially replicable in a wide range of other archaeological contexts, even with different geographical, chronological, and cultural backgrounds.

Keywords: Traces, Use, Reuse, Pottery, Archaeometry.

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Juxtaposed pottery technologies of the Andean colonial worlds in the Atacama Desert, Chile (16th - 19th centuries)

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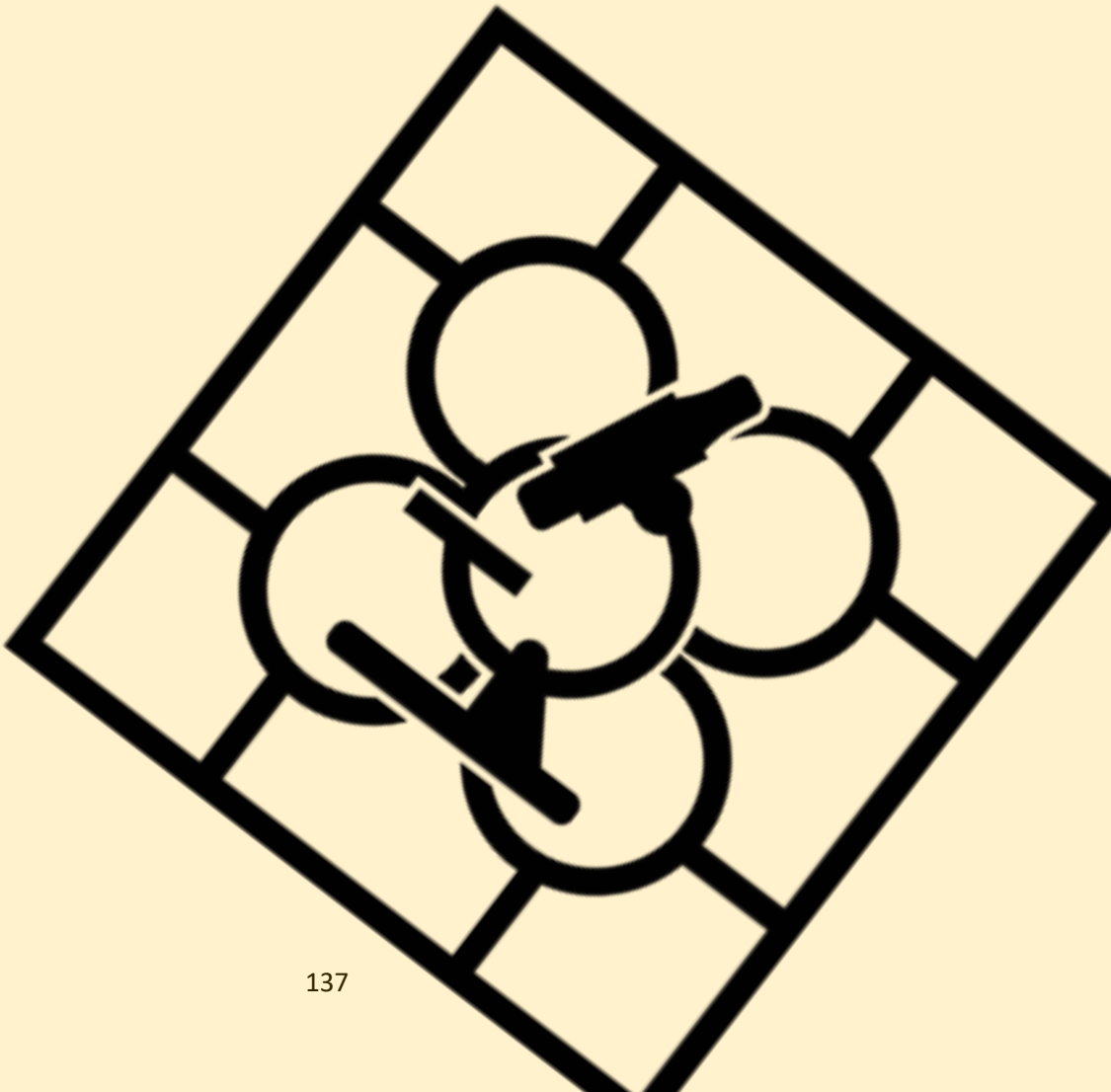
The study of European colonization in the Americas has primarily been approached from historical perspectives, undervaluing archaeological and material evidence in understanding these traumatic processes. This has led to partial perspectives and biased imaginaries due to the lack of material data in colonial narratives and documents, which were written from within the Spanish bureaucracy. In the Andes, this has generated notions such as the "Indios" being conceived as a "passive or residual recipient" or even as the "defeated" in history, erasing their agency in the reconfiguration of socio-economic systems in response to European civilization expansion. To address this, we propose a materializing archaeological approach to colonial encounters, where materiality serves to make visible the pasts and conditions that were hidden, erased, or even eradicated. Ceramics offer an excellent approach to this perspective, as it condenses agencies, intentions and active resistances, far from being an inocent practice. Through an archaeological perspective on the technologies and materialities represented by Hispanic and Indigenous ceramics from northern Chile at the colonial contact, we examine the materialization of these "colonial encounters" in key locations of the Atacama Desert. Considering traditional stylistic, morphometric and technological approaches with petrographic and archaeometric analyses, we expect to address the complexity of pottery production during colonial rule. With this set of techniques and theoretical framework we aim to contribute with substantive perspectives on syncretisms, violences, and resistances to discuss how indigenous, mestizo, and Iberic worlds were configured in the Andes. The ceramic technological evidence in Tarapacá, northern Chile, shows violent coexistences and juxtapositions that emerged in the margins of these imperial systems.

Keywords: Pottery, Technologies, Colonialism, Andes, Northern Chile.

Theory and Methods

Poster Presentations



Unhafting a Proposal. Stuck between a Chen mul modeled censer and an effigy idol

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My research interested in the artifacts collected from the Maya Sacred Well of Chichén Itzá by Edward H. Thompson and by the early Mexican expeditions led by Roman Piña Chan, for this presentation draws attention to the study of Chen Mul Modeled censers, a particular type of the Late Postclassic (A.D. 1200-1521) effigy ceramics, to approach one artifact, now in the Peabody Museum collection, which has been identified as a hafted axe, to argue the recognition took separate elements: the limb, covered in copal and rubber, of an effigy idol and a fragment of an effigy Chen Mul censer, the later misidentified as a stone blade, and stuck them together with rubber to identify a single tool and to propose the discovery of a previously archaeologically - unknown utilitarian application for rubber (Tarkanian 2003, p.59-60). This presentation proposal, beyond critique, instead, encourages scholarship from disciplines working in the field of Americanist studies to engage in multi-layered examinations; in this case to go beyond visual examination and consider the materiality through the un biased results of non-destructive analytical techniques to archaeological ceramic studies to obtain precise information on the composition of artifacts before reaching conclusions.

Keywords: Chen Mul modeled censers, Sacred Well of Chichén Itzá

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Protocols as a Path to Sustainability: Rethinking Archaeometric Analysis of Ceramics

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While sustainable practices have gained increasing attention in cultural heritage, systematic practices and analytical protocols are still scarce, if not absent, in archaeometry applied to archaeological ceramics. Ceramics are among the most frequently encountered materials in archaeological contexts due to their durability and ubiquity. Even a small fragment can reveal essential aspects of past societies, including dietary habits, technological development, and trade networks. Archaeometric techniques offer a deeper and more reliable understanding of these cultural practices when combined with archaeological interpretation. However, significant challenges persist in archaeometric practice, such as obtaining permissions from museums, concerns over invasive and destructive analyses, and laboratory logistical issues regarding sample preparation, documentation, and interpretation of results—including data processing and post-depositional contamination. Developing and implementing step-by-step analysis protocols within museums and laboratories is a sustainable approach to ceramic studies. Protocols help avoid unnecessary and costly analyses, reduce material and sample waste, and foster a collaborative environment between museum professionals and researchers. By engaging museum staff in the analytical process, misunderstandings can be minimized, encouraging a balanced perspective between preservation and scientific inquiry. Moreover, standardized procedures sensitize archaeometrists to the cultural and physical integrity of ceramic materials, promoting ethical and efficient data collection and analysis. This work presents a practical guide for creating such a protocol for archaeological ceramic analysis. It aims to support more thoughtful sample selection, streamlined documentation, and appropriate technique choice, and promote meaningful collaboration between institutions. Ultimately, it argues that sustainable archaeometric analysis is about preserving the artifacts and protecting the knowledge they can provide for future research.

Keywords: Sustainable archaeometry, ceramic analysis protocols, museum collaboration, cultural heritage.

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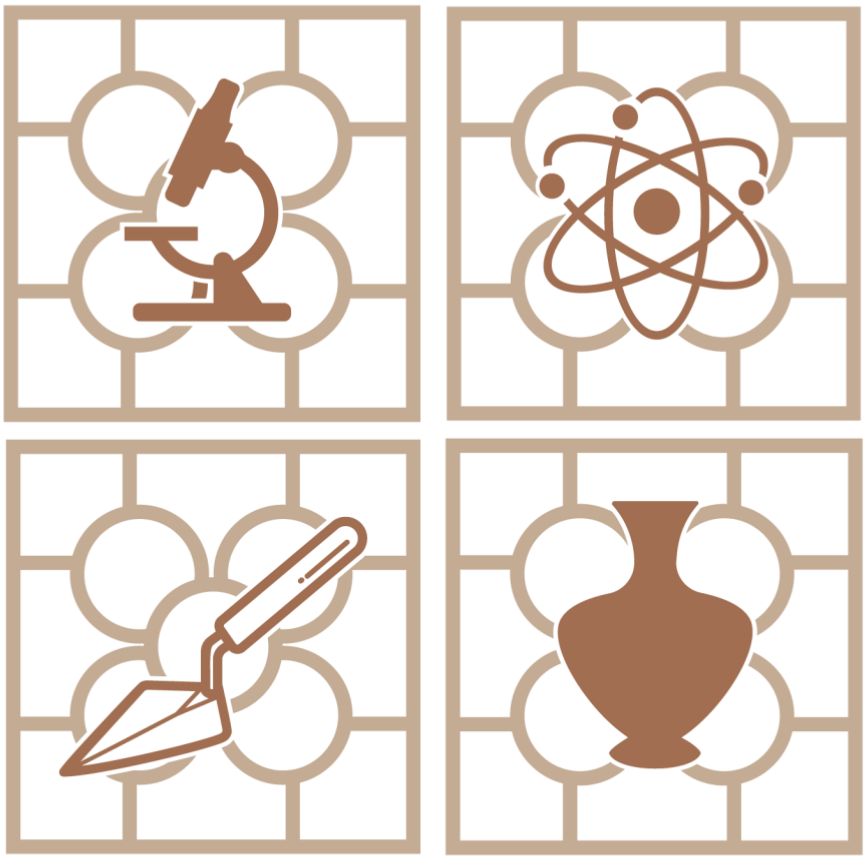

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5. Topic Index

6. Acknowledgements

The Organising Committee of the 17th European Meeting on Ancient Ceramics (EMAC 2025) expresses its deepest gratitude to all institutions, collaborators, and individuals whose commitment has been essential to the successful realisation of this event.

We are particularly indebted to the **University of the Basque Country (UPV/EHU)** for hosting EMAC 2025 at the **Bizkaia Aretoa**, providing not only state-of-the-art facilities but also an academic setting conducive to scholarly dialogue of the highest standard. Equal thanks are extended to the **Bizkaia Aretoa staff**, whose professionalism and logistical expertise ensured the efficient running of the congress.

We acknowledge with appreciation the work of the **Scientific Committee**, whose rigorous peer-review safeguarded the academic integrity and quality of the abstracts. Our gratitude extends to all **authors and contributors**, whose research advances the field of ceramic studies, and to the **reviewers**, whose critical assessments significantly enhanced the contributions published in this volume.

Special recognition is due to the **lecturers, tutors, and participants of the EMAC 2025 Summer School**, whose engagement exemplifies the values of academic mentorship and intergenerational knowledge transfer. We also acknowledge the support of our **partner networks, learned societies, and research groups**, whose collaboration has been crucial in promoting excellence in archaeometric research and heritage conservation.

Finally, we extend our heartfelt thanks to all **conference participants**, whose discussions and collaborations have enriched the scientific dialogue and reaffirmed EMAC's role as a leading international forum for the study, preservation, and dissemination of ceramic heritage. Our closing acknowledgment goes to the **student volunteers and technical staff**, whose discreet but vital assistance guaranteed the seamless development of the event, ensuring that every detail was carried out with professionalism and care.

EMAC Team

7. EMAC Awards

To recognise and promote scientific excellence, **EMAC 2025** will confer three awards during the Closing Session:

- **Best Oral Presentation Award** – awarded to the most outstanding oral communication.
- **Best Poster Presentation Award** – awarded to the most outstanding poster contribution.
- **Young Researcher Award** – awarded to the best contribution presented by an early career scholar.
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These distinctions are intended to acknowledge innovative research, foster high standards of academic dissemination, and encourage the active participation of the next generation of researchers in the field of archaeometry and ceramic studies.

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