



9th Symposium

ARCH_RNT

Archaeological Research
& New Technologies

CONFERENCE PROGRAMME & BOOK OF ABSTRACTS

8-10 October 2026

Kalamata Greece

CO-ORGANISATION



Το Εύλογον



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SCIENTIFIC COMMITTEE

Aimilia Banou (*University of the Peloponnese*)

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WELCOME NOTE

On behalf of the Organising Committee, it is our great pleasure to welcome you to Kalamata for the 9th International Symposium on Archaeological Research and New Technologies (ARCH_RNT), held from 8 to 10 October 2026.

Since its establishment in 2008, ARCH_RNT has developed into an international forum bringing together archaeology, cultural heritage studies, the natural sciences and new technologies. Continuing this tradition, this year's Symposium features 104 oral and poster contributions, reflecting the breadth and vitality of current research in archaeological science and cultural heritage. The programme ranges from the study of archaeological materials and ancient technologies to digital applications, environmental research, bioarchaeology, as well as the conservation and management of cultural heritage.

A special place in this year's programme is given to a session presenting results from the interdisciplinary research project EVLOGON – “Model Interdisciplinary Development and Transfer of Know-how and Collaboration in the Restoration of Emblematic Monuments and the Promotion of Christian Values in Dialogue with Society”, in which the Laboratory of Archaeometry of the University of the Peloponnese in Kalamata participates. The session, “Decoding Historic Building Materials for Monument Management,” highlights the contribution of interdisciplinary research and knowledge transfer to the study, protection and sustainable management of cultural heritage.

The Symposium is co-organised by the University of the Peloponnese, the Region of the Peloponnese and the Municipality of Kalamata. We warmly acknowledge their valuable support, which reflects a shared commitment to advancing cultural heritage research and engagement with the wider community.

We warmly thank all speakers, poster presenters, participants and collaborating institutions for contributing to the 9th ARCH_RNT. We hope that these three days will encourage stimulating discussions, the exchange of knowledge and new collaborations within our growing international community.

We wish you a productive and rewarding 9th ARCH_RNT Symposium.

Eleni Zimi

Chair of the 9th ARCH_RNT Symposium

PROGRAMME OUTLINE

Thursday, October 8

09:00-10:00	Registration	11:00-12:00	Session 5
10:00-10:30	Welcoming Remarks and Opening Ceremony	12:00-12:40	Session 6
10:30-13:10	Session 1	12:40-13:40	Lunch Break
13:10-14:10	Lunch Break	13:40-16:00	Session 7
14:10-16:10	Session 2	16:00-16:20	Presentation of SAS
16:10-17:40	Poster Session	16:20-16:40	Coffee Break
17:40-19:40	Session 3	16:40-18:20	Session 8
20:00	Welcome Coctail	18:20-19:40	Session 9

Friday, October 9

09:00-10:40	Session 4
10:40-11:00	Coffee Break

Saturday, October 10

09:00-11:20	Session 10
11:20-11:40	Coffee Break
11:40-13:20	Session 11
13:20-14:00	Closing Remarks

	Thursday, October 8
09:00 - 10:00	Registration
10:00 - 10:30	Welcoming Remarks and Opening Ceremony
10:30 - 13:10	<i>SESSION 1: Colour & Pigments I : In memory of Prof. I. Kakoulli</i>
10:30 - 10:40	<i>In memoriam: Ioanna Kakoulli (V. Kassianidou)</i>
10:40 - 11:10	<u>Invited Talk:</u> O1. Three decades of scientific research on Macedonian painting: An overview and new perspectives (H. Brekoulaki)
11:10 - 11:30	O2. Indigo, the forever colour (J. Didziulis, M. Rode, I. Karapanagiotis and M.S. de Vries)
11:30 - 11:50	O3. Tracing cinnabar beyond source attribution : Geological sources, isotopic evidence and cross-craft networks (E. Gliozzo)
11:50 - 12:10	O4. Pigment offerings for the gods? Red ochre traces from the Sanctuary of Apollo at Cumae, Italy (E. Di Virgilio, D.H. Lamparelli, F. Siano and E. Vasca)
12:10 - 12:30	O5. From pigments to painters: Scientific evidence for decorative phases and working practices in Hellenistic Tomb wall paintings from the Aigina Necropolis (A.P. Panagopoulou and K. Charatzopoulou)
12:30 - 12:50	O6. Polychromy and technologies of Qin Shihuang's Terracotta Army (S. Pagano, C. Germinario, E. Cantisani, M. Mercurio, B. Rong, X. Ma and C. Grifa)
12:50 - 13:10	O7. Dye technology and transition : A study of Geraki heritage textiles (N. Rosenkranz, T.S. Puglier and S.E.J. Gerstel)
13:10 - 14:10	Lunch Break
14:10 - 16:10	<i>SESSION 2: Decoding historic building materials for monument management</i>
14:10 - 14:30	<u>Invited Talk:</u> O8. Decoding historic building materials for monument management: An interdisciplinary methodology through the Evlogon Project (A. Moropoulou, M. Apostolopoulou, E.T. Delegou, E. Aggelakopoulou, St. Roumeliotis, Emm. Alexakis, K. Athanasakos, N. Moropoulos and K.C. Lampropoulos)

14:30 - 14:50	O9. Characterizing the historical mortars of the Holy Aedicule's Tomb Chamber, Jerusalem: Insights into production technology across construction phases (E. Aggelakopoulou, E.T. Delegou, M. Apostolopoulou, C.G. Mavrogonatos, Ch. Papatrechas, E. Zimi, N. Zacharias† and A. Moropoulou)
14:50 - 15:10	O10. Archaeometric investigation of historical building materials from the Museum of the Greek-Orthodox Patriarchate in Alexandria, Egypt (E. Zimi, E. Palamara, E. Mantzana, K. Stamoulis, E. Aggelakopoulou, D. Mitsos and M. Kyfafi)
15:10 - 15:30	O11. Comparative study of different decorative materials from the facades of 1850s to 1930s buildings in Athens (N. Kalamvoka and A. Stefanis)
15:30 - 15:50	O12. On the microstructural and compositional variability of marbles from the archaeological site of Pistiros using SR XRD (I.M. Siouris, I. Mantouvalou, D. Töbrens and S. Papadopoulos)
15:50 - 16:10	O13. Modern recreations of Roman concrete using recycled fly ash and quicklime: Mechanical and microstructural investigation (N. Amezcua, J. Xu, M. Balonis and I. Kakoulli†)
16:10 - 17:40 17:40 - 19:40	POSTER SESSION SESSION 3: Digital Applications
17:40 - 18:00	O14. The database we always needed: Detangling the archaeological 'mitos' of the excavation process (P. Kaplanis, A. Skarmintzos, A. Vomvyras and D. Vomvyras)
18:00 - 18:20	O15. Machine learning beyond legacy typologies: evidence from ceramic profiles in Western China (Y. Zhang)
18:20 - 18:40	O16. 2D similarity analysis of terracotta figurines using U-Net++, Elliptic Fourier Analysis and Zernike Moments (L. Odenwald)
18:40 - 19:00	O17. Comparative study of 3D scanning and photogrammetry (with consideration for 3D printing) for accessible/inclusive digital documentation of cultural heritage (N. Moralez-Glenn, G. Rigas, V. Panagiotidis, A. Antoniou and E. Zimi)
19:00 - 19:20	O18. 3D printing of composites for archaeological heritage monitoring using energy-efficient edge AI (R. Catamo, E. Vasanelli, R. Vergallo, D. Fico, M. Leone, S. Treviso and C. Esposito Corcione)

19:20 - 19:40	O19. Quantification of thermal events in Protohistoric architecture: An experimental protocol based on CIELAB colorimetry (A. García-López, A. Dorado Alejos, E. Rodríguez González and S. Celestino Pérez)
20:00	Welcome Cocktail

Friday, October 9

09:00 - 10:40	SESSION 4: Metals
09:00 - 09:20	O20. "Painting" or inlay? : A cross-cultural observation on bronze surface decoration (Y. Wen, A.G. Karydas, Y. Shi, K. Tsampa and X. Pan)
09:20 - 09:40	O21. Meteoritic iron tools from Morocco. A handheld Laser-Induced Breakdown Spectroscopy analytical study (G.S. Senesi, A. Jambon, O. De Pascale, L. Ouknine, H. Nachit, F. Khiri and A. Ibhi)
09:40 - 10:00	O22. Forging iron at ancient Abdera: Slags from the "Archaeological project of Abdera and Xanthi" (A.P.A.X) and their spatial distribution (N. Nerantzis, M. Georgiadis, A. Garcia-Molsosa, A. Mayoral, C. Kallintzi and E. Kefalidou)
10:00 - 10:20	O23. Technological insights into the deposition of copper-based votive offerings at the Archaic-Classical Sanctuary of Demeter at Thea Patras in the cult context of Early Greece (L. Pappa, S. Nestoridou, V. Orfanou, N. Nerantzis, N.K. Kladouri and A.G. Karydas)
10:20 - 10:40	O24. Manufacturing technology of a copper-alloy bangle from the early historic site of Tekttha, Naogaon, Bangladesh: An archaeometric and experimental approach (A. Abdul Mazed, B. Sabikun Naher, C. Md. Masood Imran and D. Bulbul Ahmed)
10:40 - 11:00	Coffee Break
11:00 - 12:00	SESSION 5: Sediments
11:00 - 11:20	O25. Quantitative spectroscopy for archaeological sediments (A. Santiglia, M. Sciortino, A.L. Tassi, L. Santagostini, S. Grimaldi, L. Lombardo and V. Guglielmi)
11:20 - 11:40	O26. Bridging the distance: What a combined multiscale analytical study can tell us about hearth features (L.M. Magno, C. McNamee, S.R. Stocker and J.S. Davis)

11:40 - 12:00	O27. Preserving earthen architecture through multiproxy micromorphology: reconstructing construction and degradation processes in Neolithic pithouses at Tamsagbulag, eastern Mongolia (C. Crasto, L. Janz and B. Butler)
12:00 - 12:40	SESSION 6: Dating
12:00 - 12:20	O28. New perspectives for dating anthropogenic carbonates in cultural heritage studies: ESR investigation of historical and experimental lime mortars (Z. Kabacińska-Booth and D. Michalska)
12:20 - 12:40	O29. Human presence, mobility and settlement in the wider Levant during prehistory: Evidence from published luminescence dates (N.C. Xenodocheiari, A. Vafiadou and G.S. Polymeris)
12:40 - 13:40	Lunch Break
13.40 - 16:00	SESSION 7: Pottery
13.40- 14:00	O30. Assessing early pigment application and use-wear traces on the pre-pottery Neolithic clay containers from North Mesopotamia (M. Daghmehchi, E. Kodaş, G. Şimşek Franci, H. Jahangiri, A. Reka, A.M. Ketabchi and R. Özbal)
14:00 - 14:20	O31. Making storage jars on Chios Island: A longuee durée petrographic perspective from prehistory to the present (S. Menelaou, A. Bevan, E. Kiriati and B. Hassett)
14:20 - 14:40	O32. What's what? Differences and similarities in pottery from Pheneos, Arkadia, and the area of Corinth (R.N. Klöckl-Zorić, V. Testolini and J. H. Sterba)
14:40- 15:00	O33. Assessing the impact of grog tempering on pXRF compositional signatures: A petrographic and geochemical approach to Bronze Age pottery from Cannatello (Sicily) (D. Serino, A. Vanzetti, S.T. Levi, V. Cannavò, N. Talotta, D. Gulli, P.M. Day, V. Kilikoglou and A. Hein)
15:00 - 15:20	O34. Ceramics, ritual, and mobility at the Sanctuary of Zeus on Mount Lykaion: Tracing changing communities of participation from the Late Bronze Age to the Classical period (E. Kiriati, S. Menelaou, N.S. Müller, G. Kordatzaki, M.E. Voyatzis and D.G. Romano)
15:20 - 15:40	O35. Athenian vs Lakonian Red figure: Pottery from the Kerameikos site - An analytical survey using handheld portable XRF (pXRF) (J. Stroszeck and Anno Hein)
15:40- 16:00	O36. Integrated technological and residue analysis of Roman jugs from Ancient Olympia: Preliminary findings (E. Triantafyllidi, S.C. Boyatzis, M. Roumpou, C. Schauer and E. Zimi)
16.00-16.20	Presentation of SAS (Society for Archaeological Science)
16.20- 16.40	Coffee Break

16:40 - 18:20	<i>SESSION 8: Remote sensing & environmental survey</i>
16:40 - 17:00	O37. Geophysical investigations at the site of the new Archaeological Museum of Sparta (G.N. Tsokas, A. Stampolidis, I. Fikos, S. Mountrichas, M. Tsouli and E. Pantou)
17:00- 17:20	O38. Material traces of Ascalon's urban water system: A multiscalar archaeological approach to the castellum aquae (S. Alinari, E. Mintz, S. Weiner, C.M.R. Luschi, R.Y. Lewis and E. Boaretto)
17:20 - 17.40	O39. Reconstructing first exchange networks in the Maya region: Integration of archaeometric and spatial data through RDBMS (D. Król and B. Hermes)
17:40 - 18:00	O40. Integrating environmental data into an analytical algorithmic workflow: A comprehensive framework for assessing air pollution-induced degradation of built heritage (D. Mitsos, E. Palamara, A.G. Karydas, E. Gerasopoulos and V. Pouloupoulos)
18:00 - 18:20	O41. Climate change impacts on cultural heritage in the Southwestern Peloponnese based on climate model projections (A. Matthaiou, G. Kitsara, C. Giannakopoulos and N. Mihalopoulos)
18:20 - 19:40	<i>SESSION 9: Bioarchaeology</i>
18:20 - 18:40	O42. NUTRIROOTS – A time travel through human past: Evolution's guide to healthy eating (A. Koutoula, E. Ganiatsou, A. Souleles, P. Koutra, I. Dimitriadis, G. Georgiou, E. Anastasovitis, S. Nikolopoulos, I. Kompatsiaris and C. Papageorgopoulou)
18:40 - 19:00	O43. Beyond 3D mandibular morphology: Investigating complex intersections of diet, status, and urbanization in Roman Northern Greece (C. Tsimopoulou, E. Ganiatsou, A. Aidonis, E. Kalliga, T. Protopsalti, C. Ziota, V. Nannis, F.A. Karakostis and C. Papageorgopoulou)
19:00- 19:20	O44. New insights into urban and rural biological standards of living in Byzantine Greece (C. Kakasa, S. Sadik, A. Koutoula, P. Xanthopoulou, S. Protopsalti, S. Tzevreni, S. Vasileiadou, K. Konstantinidou, V. Nanis, C. Koutsadelis, C. Karadima, A. Aidonis and C. Papageorgopoulou)
19:20 - 19:40	O45. Geochemistry, taphonomy and preservation of Early Medieval human remains on Maligrad, Prespa Lake (D. Fallu, A. Nafplioti, S. Oikonomidis and A. Bunguria)

	Saturday, October 10
09:00 - 11:20	<i>SESSION 10: Colour & Pigments II: In memory of Prof. I. Kakoulli</i>
09:00 - 09:20	O46. Mining, trading and transporting of coloring materials in the Roman world (A. Kalman, C. Germinario, M. Mercurio, V. Amoretti, G. Scarpatti, G. Zuchtriegel, P. Warnking, MMN. Franceschini and C. Grifa)
09:20 - 09:40	O47. The Purple Codex, MS 67: A multi-modal spectroscopic investigation at the Agios Ioannis Theologos Monastery in Patmos (E. Vassiou, I. Melianos, H. Brecolaki, S. Boyatzis and A.G. Karydas)
09:40 - 10:00	O48. Materials and skin-tone production technique in Byzantine mural paintings from Eastern Crete (Lasithi – 8 th -16 th c.) (Y.Z. Helvacı, M. Gulmini, G. Chiari, T. Cavaleri, M. Aceto, E. Costa, K. Zervaki and R. Giustetto)
10:00 - 10:20	O49. Non-invasive analysis of Cypriot composite icons: Preliminary results (D. Zaprzalska, R. Georgiou, A. Manoli, P. Hao and N. Bakirtzis)
10:20 - 10:40	O50. Reconstructing Roman trade networks through Egyptian blue: Archaeometric investigation of pigments from Noricum (A. Rodler, M. Jansen, S. Klein and G. Artioli)
10:40 - 11:00	O51. Egyptian blue painting techniques in the Palatial Complex of Herodium (A. Leviant, N. Sharabi, R. Porat and Y. Asscher)
11:00 - 11:20	O52. VIL Photography for Monitoring the Cleaning of Excavated Surfaces Bearing Egyptian Blue (P. Manti, A. Vartholomatos and K. Vasileiadis)
11:20 - 11:40	Coffee Break
11:40 - 13:20	<i>SESSION 11: Glass & vitreous materials</i>
11:40 - 12:00	O53. Egyptian blue everywhere: Exploring the uses of Egyptian blue beyond painting (H. Becker, D.H. Abramitis, L. Barro, E. Basso, S. Dilaria, K. Lapatin, S. Lepinski, J.T. Pietras, E. Purdy, C. Riccardelli, T. Rust, K. Stamm and G. Verri)
12:00 - 12:20	O54. Islamic glazed ceramic from Mértola: An archaeometric study of ceramic pastes and glazed decorations (M. Beltrame, M. Larson Coutinho, S. Nikologianni, J. Mirão, S. Gomez Martínez and E. Salinas)
12:20 - 12:40	O55. Mapping vitreous materials biographies through MA-XRF Imaging (M. Kaparou, A. Asvestas, A. Oikonomou, K. Tsampa, A.G. Karydas and D. Anagnostopoulos)

12:40 - 13:00	O56. Tracing glass supply networks in Early Byzantine Cyprus: SEM-EDS analysis of the Panagia Kanakaria mosaics (S. Chlouveraki, A. Oikonomou, S. Minetou, E. Charalambous and Th. Rehren)
13:00 - 13:20	O57. Glass from Hellenised Al Khanoum, Afghanistan: Evidence for local production and interaction across the Eurasia silk roads (J. Henderson, G. Lindström and S. Chenery)
13:20 - 14:00	Closing Remarks

Poster Session

P1. Chromatic symbolism in Early Neolithic Poland: Evidence from burial contexts (I. Sobkowiak-Tabaka and A. Kurzawska)

P2. Mineralogical insights into the processing of iron oxide pigments in Neolithic Servia: An EDXRF study (O. Palli and I. Nazlis)

P3. Pigment analyses on terracotta figurines and pigment residues from the Ancient Agora of Thessaloniki (E. Zografou and I. Nazlis)

P4. SERS-assisted multi-analytical investigation of wall paintings from Side Boyaliin Cave Church (Antalya, Türkiye) (B. Şen, H. Katircioğlu, F. Özbaş, A.A. Akyol, T. Koralay, N. Kıtır Şen and G. Liman)

P5. Through spectra and microscopes: The identification of painting materials and techniques of the Agios Ioannis Elaiona Byzantine church wall paintings (E.A. Thoma, D. Chatzigiannis, G.P. Mastrotheodoros, S. Boyatzis and M. Chatzidakis)

P6. Red and yellow pigments on wall-paintings from the Medieval Fortress of Koznik (Serbia) (A. Petrović, M. Bugar, M. Čeranić, B. Popović, M. Todorović, V. Andrić and M. Gajić-Kvašćev)

P7. Assessing workshop attribution in Post-Byzantine painting through non-invasive technical investigation: A case-study of two sixteenth-century icons (F. Marolli, A.G. Alexopoulou and G.P. Mastrotheodoros)

P8. Non-destructive characterisation of beehive panels from the Slovene Ethnographic Museum using advanced analytical techniques (M. Pivk and M. Humar)

P9. Archaeometric investigation of the artistic materials on the Lazar Vozarević's paintings (M. Todorović, A. Petrović, M. Vuruna, M. Gajić-Kvašček and V. Andrić)

P10. Unveiling Medieval Anatolian garments: Multi-analytical characterization of mummy textile remains from Çanlı Church (Aksaray) (Z. Atasayar, Ö. Ormancı, A.M. Büyükkarakaya and S.E. Çelik)

P11. Hand-coloring as a means of introducing color to Early Modern black-and-white prints (V. Kokla, L. Vazaka, D. Sotiropoulou and A. Batrinou)

P12. Electrochemical characterization of emissions of silver coins using Solid-State Voltammetry (A. Doménech-Carbó, C. Biscotti and M.T. Doménech-Carbó)

P13. Goldwork in the Palace of Nestor and the Grave Circle: An archaeometric investigation of composition and use (E. Samartzi, A.G. Karydas, S. Stocker, K. Tsampa and N. Nerantzis)

P14. Scientific analysis of ancient glass beads from the Mantai Port Site, Sri Lanka (P.R.A. Buddikasiri and H. Li)

P15. Archaeometric characterization of Byzantine window glasses from the Episkopeion at Olympos Ancient City (O. Ekinici, A. Tekin, B.Y. Uçkan and G.K. Öztaşkın)

P16. Provenance study of archaeological ceramic and obsidian flakes from the Acropolis of Agios Fokas, Kymissala, Rhodes using pXRF analyzer: A preliminary report (A. Vafiadou, V. Kounenou, N. Laskaris and M.I. Stefanakis)

P17. The emergence of Neolithic ceramic technology in Cyprus: Preliminary petrographic insights (S. Menelaou and O. Kouka)

P18. At the surface and beyond: An interdisciplinary study on the Eneolithic clay figurines from Cucuteni, Romania (M. Petruneac, A.-D. Popescu and M. Focșăneanu)

P19. Mesolithic pottery production at Khor Shambat 1 (Central Sudan): An archaeometric perspective (M. Szczepaniak, M. Jórdeczka, I. Sobkowiak-Tabaka and M. Chłodnicki)

P20. Early Iron Age ceramic production in Southern Serbia, Ranutovac-Meanište archaeological site (M. Gajić-Kvašček, O. Mladenović, A. Petrović, M. Đorđević and A. Bulatović)

- P21. Big questions for tiny black potsherds: Archaeometry and typology of black-glazed pottery in Southern Etruria, Italy** (T. Freixas Roig, E. Abbondanzieri, O. Cerasuolo and L. Pulcinelli)
- P22. Structural characterization and archaeometry study of the historic tiles of the Blue Mosque of Tabriz using instrumental analysis** (P. Soleimani)
- P23. Portable XRF and Optical Microscopy analysis of Islamic ceramic from Southern and Western Iberia** (S. Nikologiani, E. Salinas, J. Mirão, S. Gomez Martínez and M. Beltrame)
- P24. Early Islamic glazed ceramics from Málaga: Archaeometric evidence for the introduction and diffusion of glaze technology in Emiral Al-Andalus** (E. Salinas, S. Nikologiani, J. Mirão, S. Gomez Martínez and M. Beltrame)
- P25. A Thermo-Oxybarometric approach to understanding the firing conditions of Bizen ceramics (16th-17th centuries CE, Japan)** (G. Logothetou, J. Roqué-Rosell, E. Tema, C. Marini, S. Plana-Ruiz, J. Ibáñez-Insa, A. Jiménez-Franco, E. Zymi, S. Iwasaki, P.P. Das, S. Nicolopoulos and V. Pouloupoulos)
- P26. A Purification-Enhanced Graph Neural Network pipeline for archaeological provenance of Iberian pottery** (E. Jianan, M. Beltrame and T. Erseghe)
- P27. Biological deterioration of stone cultural heritage: The cleaning potential of Padina Pavonica for stone surfaces** (Ç. Özdemir, L. Emanuele, J. Tomasović Grbić, M. Narracci, S. Aurelio Bufo and L. Scrano)
- P28. Sustainable synthesis and in situ application of a new nanolime for the compatible consolidation of historic plasters. A case study in the Old Port of Genoa** (G. Taglieri and O. Spadaro)
- P29. Natural materials, cultural identity, heritage and housing in Mexico: Some ideas for city planning** (L. Bucio)
- P30. East meets West in 1933: Technical study of Fat Tat Tong (發達堂) in Hong Kong** (M.W. Tang, W.F. Lai, P.Y. Wong and Y.K. Wong)
- P31. An assessment of repeatedly replastered and red-painted floor of a newly identified public building at Çayönü Tepesi** (S. Sarialtun, F. Özbaş, B. Şen and B. Semiz)
- P32. Multi-analytical study of green paste mud from the Wuwangdun No. 1 Tomb, China: A comparison with ordinary rammed earth** (Q. Song, J. Song, H. Lian, Z. Chai, Z. Zhang, L. Fang, X. He and H. Guo)
- P33. Challenges, limitations and research design of luminescence dating for clay historic building materials in the Czech Republic** (M. Volejníková)

P34. Chronology and firing technology of Late Neolithic ceramics from Northern Greece (A. Ladas, E. Aidona, G.S. Polymeris and N. Kantiranis)

P35. The seasonality of festivals at Hellenic temples with skyscape archaeology: Method, database and inductive model (I. Cristofaro and G. Malaperdas)

P36. Diet and mobility: Preliminary stable isotope results from the Bronze Age site of Linou, Cyprus (T. Panagiotopoulou, G. Selempa, P. Chritophi and E. Nikita)

P37. Isotopic and machine learning approaches reveal increasing diversity in infant weaning practices in Byzantine Thessaloniki (F. Antoniou, E. Ganiatsou, A. Koutoula, C. Kakasa, A. Aidonis, C. Tsimopoulou, A. Souleles, V. Nanis, T. Protopsalti, S. Tzevreni, K. Konstantinidou, S. Vasileiadou and C. Papageorgopoulou)

P38. Elemental mapping of archaeological tattooed skin: A pilot LA-ICP-MS study of Pre-columbian Peruvian mummified remains (J. Bāk, E. Pollak-Kowa, D. Pawcenis, A. Telk and H.W.M. Castillo)

P39. A Mycenaean boar's tusk helmet from Messenia: An archaeometric investigation (S. Fritzilas, A. Katakos, P. Xirokosta, I. Lykidou, P. Giannakopoulou, M. Mitsa, K. Papamikrouli, D. Mitsos, R. Kordali, S. Boyatzis and C. Karydis)

P40. Ancient road network in the territory of Montepulciano (Siena, Italy): GIS modelling and Ground-Penetrating Radar investigations (L. Corti Peruzzi, M.C. Erricone, E. Guerrieri Canovi, M. Ravaglia and E. Gliozzo)

P41. Photogrammetric approach on the documentation of University Archaeology Collection: Early Bronze I EBI) high-loop handle juglet (J. Luo)

P42. Beyond the photograph: Photogrammetric documentation and preliminary analysis of two ivory plaques from Crete (Y.Z. Helvacı, K. Zervaki and R. Giustetto)

P43. Testing the capabilities of Artec Spider via creating 3D mesh of a fishbowl replica (K. Anagnostopoulou-Stamatopoulou and G. Rigas)

P44. 3D documentation and condition assessment of the Church of Agioi Apostoloi in Kalamata using Photogrammetry (N. Skoutaridis and V. Panagiotidis)

P45. The three states of matter. Modelling a Byzantine column from the church of Hodegetria, Mystras, Lakonia (A. Combry and V. Panagiotidis)

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ABSTRACTS OF ORAL SESSIONS

O-1. Three Decades of Scientific Research on Macedonian Painting: An Overview and New Perspectives *In Memory of Ioanna Kakoulli*

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More than three decades ago, the scientific study of Macedonian painting was only beginning to emerge as an interdisciplinary field. Among the first monuments to be investigated through this new approach was the painted throne from the Tomb of Eurydice at Aigai, where Ioanna Kakoulli initiated the first technological investigation of its polychromy. At the same time, we independently embarked on complementary lines of research, approaching Macedonian painting from different disciplinary perspectives while sharing the conviction that archaeology, conservation and the material sciences should be brought together in the study of ancient painting.

Revisiting the painted throne today provides an opportunity both to honour Ioanna Kakoulli's pioneering contribution and to reflect on the remarkable development of the field over the past three decades. The lecture will present new results from recent interdisciplinary investigations carried out by my research team on the painted throne of Eurydice,

the Tomb of Persephone at Aigai, the Hunt Frieze of Tomb II at Vergina, and other painted monuments of Late Classical and Early Hellenistic Macedonia.

Drawing on archaeological research, technical imaging, archaeometric analyses and digital documentation, these case studies illustrate how scientific investigation has transformed our understanding of Macedonian painting. Moving beyond the identification of pigments and painting techniques, it now offers new insights into artistic practice, workshop traditions, creative processes and the interpretation of ancient images. By looking back on three decades of research while presenting new perspectives, this lecture celebrates both the evolution of an interdisciplinary field and the enduring contribution of Ioanna Kakoulli to its early development.

O-2. INDIGO, THE FOREVER COLOR

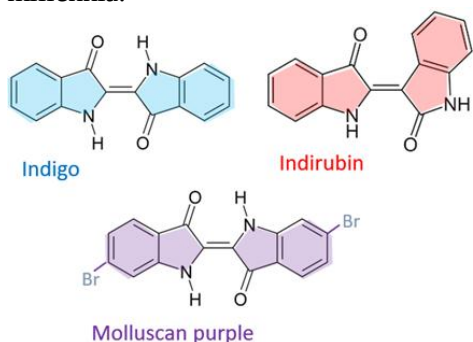
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For millennia, indigo has existed as the primary source of blue pigment for art and textiles across the world. We detect indigo with a form of 2-step laser mass spectrometry, which combines laser-desorption jet-cooling with resonance-enhanced multi-photon ionization (REMPI-MS). This technique selectively ionizes molecules through a resonant two-photon process and combines high sensitivity with isomeric selectivity. We also study the photochemistry that makes these compounds uniquely stable so they preserve their color over the course of millennia.



Indigo dye was used to color practically all blue textiles in existence, from workwear, to royal garments, to burial materials. Ancient materials include a 6,000-year-old blue fabric scrap found in Peru and a Mesopotamian cuneiform tablet recounting the process of blue

textile dyeing. Indigo held high value as a commodity and was commonly referred to as “blue gold,” cultivated in vast quantities around the world and featuring heavily on land and sea trade routes. For example, Ancient Egypt wrapped their mummies in indigo-dyed linens to both preserve the fabric and to represent immortality. Indigo was power, wealth, community, and identity.

Indigo has traditionally been produced from a variety of plants that contain specific precursors. The process produces characteristic side products, mainly indirubin, which adds a reddish undertone to the pigment. Indirubin is a structural isomer of indigo and may be more or less favored based on the balance of precursors in the plant of origin. For instance, the indigo plants historically favored in Europe and East Asia tend to produce indigo more highly enriched with indirubin. Certain processing methods and harvesting times are also known to favor indirubin production. Taking these factors into account, quantifying the relative amounts of indigo and indirubin in a textile sample can be a strong indicator of region and production method, shedding light on potential trade routes and cultural practices.

We have studied both indigo and indirubin extensively using REMPI-MS. Since this technique provides both mass and wavelength resolution, we can distinguish indigo and indirubin from a complex, crude sample based on their mass, and then we can distinguish these two isomers from each other based on their absorption of distinct wavelengths. We have recently demonstrated that strong indigo and indirubin signal can be obtained by direct desorption of a single indigo-dyed textile fiber. The technique

is highly sensitive, providing indigo/indirubin ratios, while being minimally destructive. No solvent extraction is needed and the fiber remains intact in the process.

We have also used REMPI spectroscopy to elucidate the photochemistry that underlies indigo's remarkable photostability. We found that upon absorption of light indigo undergoes a sequential double proton transfer that facilitates its safe return to the electronic ground state in the course of picoseconds. This process is so fast that it pre-empts any other potentially destructive photochemical pathways. We have found the same safe de-excitation process in dibromoindigo, which is the key ingredient of sought after ancient molluscan purple.

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O-3. TRACING CINNABAR BEYOND SOURCE ATTRIBUTION: GEOLOGICAL SOURCES, ISOTOPIC EVIDENCE AND CROSS-CRAFT NETWORKS

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Cinnabar was one of the most visually distinctive and symbolically charged pigments used in ancient societies. Its intense red colour, rarity and technological specificity made it particularly suitable for funerary practices, ritual deposits, body treatment, wall painting, artefact decoration and, in later periods, specialised craft production. Yet, despite the growing number of archaeological finds in which cinnabar has been identified, its provenance remains one of the most difficult questions to address. This is due not only to the limited number of isotopic analyses carried out on archaeological materials but also to the still incomplete characterization of potential geological sources.

The research presented here brings together published archaeological evidence, geological and mineralogical data, historical mining information and available isotopic results in order to reassess the current state of provenance research. The main focus is on the gap between the increasing number of known or suspected cinnabar occurrences and the much smaller number of sources and

archaeological samples that have been characterized through isotopic or otherwise discriminating analytical methods.

At present, provenance studies are constrained by a marked imbalance in the available data. On the one hand, archaeological identifications of cinnabar have multiplied, especially in funerary, ritual and craft-related contexts. On the other hand, only a small number of archaeological materials have been investigated through isotopic approaches, and the geological reference framework remains highly uneven. Sulfur and lead isotopes have provided useful information in some cases, but their discriminating power is often limited by overlapping values between different ore districts. Mercury isotope analysis offers an additional and promising line of evidence for distinguishing between major cinnabar sources, although it has still been applied only rarely to archaeological materials and needs to be integrated with broader geological baselines.

A further difficulty lies in the nature of cinnabar itself as a material embedded in wider productive and exchange systems. Cinnabar deposits frequently occur in geological and mining contexts associated with other metals and minerals, including mercury, antimony, arsenic, copper, lead, zinc and silver mineralisations. This raises important questions about cross-craft interaction, shared procurement networks and the possible circulation of cinnabar alongside other raw materials. In many cases, cinnabar may not have been exploited through independent pigment-oriented procurement, but encountered, collected or redistributed within broader mining and metallurgical landscapes. Provenance

research must therefore move beyond a simple “source-to-object” model and consider the economic, technological and social contexts in which cinnabar became available.

The aim of this contribution is to present a critical review of the current evidence and to outline future priorities for provenance research. These include (a) the systematic isotopic characterization of a much larger number of cinnabar occurrences, especially minor and regionally dispersed sources that are often absent from traditional mining histories, (b) the expansion of isotopic analysis on archaeological pigments and cinnabar-bearing objects, (c) the integration of Hg, Pb and S isotope systems where possible and (d) the construction of comparative datasets that take into account geological variability within individual mining districts. Particular attention should also be paid to archaeological contexts in which cinnabar appears together with other mineral or metal-related materials, since these associations may provide crucial information on cross-craft connections and patterns of circulation.

By reassessing cinnabar provenance as a problem of geology, archaeology, archaeometry and craft interaction, this study argues for a more integrated approach to the circulation of red mineral pigments. Rather than treating cinnabar only as a rare exotic substance whose origin must be traced to a single major source, it should be understood as part of complex mineral landscapes, in which availability, technical knowledge, mining histories and symbolic value intersected.

O-4. PIGMENT OFFERINGS FOR THE GODS? RED OCHRE TRACES FROM THE SANCTUARY OF APOLLO AT CUMAE, ITALY

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Recent archaeological excavations carried out at the sanctuary of Apollo, located on the upper terrace of the acropolis of Cumae, have brought to light a small group of ceramic cup fragments preserving traces of a red powder still adhering to their inner surfaces. This discovery raises important questions about the use of pigments within ritual contexts and about the role of colour in the material culture of Archaic sanctuaries. The study aims to identify the nature of these residues and to assess their possible function within the cultic practices associated with the sanctuary. A multi-analytical investigation was performed on a few milligrams of residue, combining X-ray diffraction (XRD), Fourier-transform infrared spectroscopy (FTIR), and scanning electron microscopy coupled with energy-dispersive spectroscopy (SEM-EDS). The results revealed the co-

occurrence of iron-bearing phases, quartz, and aluminosilicate minerals, a mineralogical composition consistent with natural red ochre. Red ochre was widely employed in the Greek, Phoenician, and Etruscan worlds, not only for technical purposes but also for its symbolic and ritual connotations. Comparable ceramic cups containing pigment residues are known from several sacred contexts in central-southern Italy and Sicily, where red ochre appears to have played a role in acts of consecration, in the colouring of votive objects, and in the marking of ritual spaces. The identification of red ochre at Cumae enriches our understanding of the cultic practices associated with the sanctuary of Apollo and provides new evidence for the role of colour within the ritual assemblage of the Archaic sanctuary. More broadly, this case study contributes to the discussion of pigments as active components of ritual practice and sacred material culture in pre-Roman Italy.

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O-5. FROM PIGMENTS TO PAINTERS: SCIENTIFIC EVIDENCE FOR DECORATIVE PHASES AND WORKING PRACTICES IN HELLENISTIC TOMB WALL PAINTINGS FROM THE AIGINA NECROPOLIS

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During his systematic exploration of the necropolis of Aigina between 1930 and his death in 1954, Gabriel Welter uncovered several Hellenistic chamber tombs, some of them lavishly decorated. In his brief reports, he provided the archaeological community with a first – and, for some monuments, apparently only – glimpse of their wall paintings. In this paper we present preliminary findings from the scientific investigation of the painted decoration of three chamber tombs (Tombs 1-3), the only surviving witnesses to what was once a large group of painted Hellenistic rock-cut chamber tombs in the necropolis of Aigina.

The tombs dated from the late 4th/early 3rd to the middle of the 2nd century BCE, combine rock-cut and built elements: the burial chamber and the stepped passageway (dromos), giving access to the burial chamber, are carved into the

bedrock, while features such as barrel vaults covering the dromos are constructed in the local limestone. In the two earlier examples, the burial chamber is decorated with brightly coloured monochrome zones, separated by a garland or a running scroll (Tombs 1 and 2). Masonry-style decorations are usually found in the dromoi and in the burial chamber of the later example (Tomb 3).

A comprehensive set of 38 paint samples, collected from representative areas of the painted decoration of the tombs, was analysed at the National Centre for Scientific Research “Demokritos” (Greece) using Optical Microscopy (OM), portable X-Ray Fluorescence (pXRF), Scanning Electron Microscopy with Energy Dispersive Spectroscopy (SEM–EDS), and Raman Spectroscopy. The aim of the analyses was to provide insights into painting materials and practices, particularly to identify pigments, preparatory layers, and painting techniques. The results, encompassing painting technology, materials, and techniques, reveal a high level of technical expertise and craftsmanship.

Natural inorganic pigments (red and yellow ochre, cinnabar) and synthetic pigments (Egyptian blue, red lead) were identified in the samples. Egyptian blue was applied in multiple ways: to create light and shadow effects, mixed with yellow ochre to produce green tones, and over a black underlayer to enhance colour saturation. Red lead, a less common pigment in ancient Greek painting, was mixed with red ochre in the running scroll decoration of Tomb 2. The use of pure pigments and mixtures demonstrates a varied colour palette, particularly in the red hues employed for

the myrtle garland sleeves in Tomb 1 (Figure 1).

Furthermore, what is particularly striking about the three tombs is the combination of shared features and marked divergences in their wall-painting technology, partly due to the chronological span between them. Variations are observed in the thickness of preparatory layers, surface finishing, pigment selection, and painting technique (a secco / a fresco). Do these differences reflect only separate construction and decorative phases, or do they also indicate distinct workshop painting practices over time? To investigate this question, comprehensive physicochemical and statistical analyses were undertaken to characterise and interpret the technological features of the wall paintings with greater precision.



Figure 1. Aigina, Tomb 1. Burial chamber, north wall. Detail of the garland with sleeve (Photo: N. and S. Stoumaras).

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O-6. POLYCHROMY AND TECHNOLOGIES OF QIN SHIHUANG'S TERRACOTTA ARMY

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The polychromy of Qin Shi Huang's Terracotta Army constitutes a key yet exceptionally fragile component of the first emperor's funerary program. Although every warrior was originally painted, only discontinuous residues survive, and the painted surfaces can deteriorate rapidly after excavation. This study investigates fragments of warriors recovered from Pit 1 to reconstruct the ceramic manufacturing process, pigment palette, and painting techniques, thereby clarifying the original polychrome appearance of the sculptures. The results also provide a scientific basis for conservation strategies that are compatible with the original materials and their degradation behaviour.

A multi-analytical archaeometric approach was applied, combining Digital

Microscopy (DM), Polarised Light Microscopy (PLM) on thin sections, Scanning Electron Microscopy coupled with microanalyses (SEM-EDS), Fourier-Transform Infrared spectroscopy in Attenuated Total Reflectance module (ATR-FTIR), micro-Raman spectroscopy, X-ray Powder Diffraction (XRPD), and Thermogravimetry - Differential Scanning Calorimetry (TG-DSC).

The ceramic bodies are homogeneous in texture and mineralogy. They consist of a fine-grained matrix dominated by quartz, feldspars, and phyllosilicates, with only a sparse, coarser fraction of comparable mineralogical composition. The preservation of illite/mica and calcite fragments, together with the absence of high-temperature phases, suggests moderate Equivalent Firing Temperatures (EFT), likely around 700-800 °C. After firing, the surfaces were coated with a thin layer of natural lacquer (urushi), identified by ATR-FTIR. This layer acted as an intermediate coating, isolating the ceramic substrate and providing an adhesive surface for the painted decoration.

Chemical and molecular analyses of the painted layers reveal a distinctive colour palette. The white paint layers consist mainly of carbonate-substituted hydroxyapatite, consistent with bone white, and are locally associated with gypsum. SEM-EDS mapping shows the co-localisation of calcium and phosphorus in both white and pink layers, while micro-Raman spectroscopy confirms the presence of hydroxyapatite. Cinnabar was employed for red areas and mixed with the phosphatic white to produce pink flesh tones. Green layers were instead produced using malachite, as indicated by their copper-rich

composition and diagnostic vibrational features.

Cross-sectional observations demonstrate that pigments were not applied using a single, uniform technique. Pictorial layers vary markedly in thickness and may be applied directly onto a compacted ceramic surface, locally showing pigment penetration into the substrate, or over one or more lacquer films. This technical variability is best interpreted as a flexible adaptation of the pictorial process to morphology and decorative function. By integrating ceramic and paint-layer evidence, the study provides new data on Qin colour technologies and establishes a material basis for the conservation of this exceptionally vulnerable polychromy.

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O-7. DYE TECHNOLOGY AND TRANSITION: A STUDY OF GERAKI HERITAGE TEXTILES

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Historically rooted in an agrarian economy, the village of Geraki in the Parnon mountain range in Laconia has a rich tradition of domestic textile production. Weaving formed an important part of household labor, providing both economic support for village women and textiles for dowries, including kilims (principally used as floor and bed coverings) and tagaria (rectangular bags). In the late nineteenth and early twentieth centuries, Geraki textiles incorporated images from the lived experiences of the villagers – musicians, dancing, marriage processions, etc. – combined with emerging European influences, which are exemplified in represented costume elements. These woven narratives embedded personal, familial, and communal histories within the textiles, offering insight into social relationships, connections across villages, and the community's negotiation between local traditions and broader modernizing influences.

This paper presents the technical and historical investigation of a Geraki kilim attributed to the weaver Marigo Stratakou and dating to ca. 1900 and a tagari. Additionally, the analysis incorporates evidence from a dye sample book and the sales records of the shop of Stavri Zafeiris, which operated in Geraki in the late 19th and early 20th century.

The study combines archival and ethnographic research with analytical methods to examine dyes, fibers, and the industrial evolution of dyes in Greece. Particular attention is given to the identification of colorants through multi- and hyperspectral imaging, optical microscopy, portable X-ray fluorescence spectroscopy (pXRF), and high-performance liquid chromatography coupled with diode-array detection and mass spectrometry (HPLC-DAD-MS).

In interviews collected by the ongoing Geraki Weaving project, a collaboration of UCLA and the Cultural Society of Geraki, weavers describe the traditional use of locally-sourced natural dyes, including walnut husks and dyer's madder (rizari), traditionally fixed using "saria," the residual water from washing raw wool. However, scientific analysis of the kilim and tagari indicates that several colorants instead derive from synthetic dyes or mixtures of dyes. The textiles therefore appear to embody not only a visual transition between traditional and Europeanized aesthetics at the turn of the twentieth century, but also a material transition from localized natural dyes toward commercial synthetic dyes produced in Athens and sold in the village. Through the combined study of imagery and materials, this paper explores how technological and cultural change was manifested in Greek village

weaving traditions at a moment when the country was rapidly modernizing.

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O-8. DECODING HISTORIC BUILDING MATERIALS FOR MONUMENT MANAGEMENT: AN INTERDISCIPLINARY METHODOLOGY THROUGH THE EVLOGON PROJECT

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The Evlogon project is based on the interdisciplinary methodology developed by the National Technical University of Athens (NTUA) through decades of research, documentation and conservation of internationally significant cultural heritage monuments. Its objective is to transform the scientific knowledge acquired through emblematic case studies into standardized methodologies, technical guidelines and best practices that allow evidence-based conservation and sustainable monument management. Within this framework, historic building materials are approached not only as construction components, but as sources of scientific, technological and historical evidence that contribute to understanding the evolution, authenticity and values of monuments.

The proposed methodology considers historic building materials through a holistic interdisciplinary approach which combines material characterization and diagnosis of decay, archaeometric

investigation, provenance studies, historical documentation, structural assessment and conservation science. Rather than treating these disciplines independently, their integration allows analytical results to be interpreted within the broader historical and structural context of each monument. Thus, the investigation of materials supports not only the assessment of compatibility, performance and long-term durability of conservation interventions, but also the interpretation of construction technologies, historical phases, cultural significance and evolution.

Since each monument represents a unique case, the same interdisciplinary methodology addresses different research questions according to its characteristics, conservation needs and historical significance.

Archaeometric investigations greatly contribute to reconstructing construction phases and validating historical evidence. At the Underground Museum of the Patriarchate of Alexandria, developed within a preserved section of the ancient hydraulic system of Alexandria, Optically Stimulated Luminescence (OSL) dating confirmed the initial construction during the Late Ptolemaic period, identified Byzantine interventions associated with the evolving water needs of the city, and documented later construction phases, highlighting the continuity and significance of Alexandria's water infrastructure over nearly two millennia. At the Holy Aedicule of the Holy Sepulchre in Jerusalem, OSL dating of the bedding mortars beneath the two marble slabs covering the carved burial surface provided the first direct scientific evidence that the Tomb of Christ was first enclosed within marble cladding already from the Constantinian

construction phase, shedding light on the earliest monumental configuration of the Tomb of Christ. Similarly, OSL dating of the bedding mortar beneath the opus sectile floor of the Monastery of Panagia Varnakova confirmed its construction during the early construction phases (12th–13th century) and demonstrated that the original floor survived the destruction of the Catholikon during the 1826 explosion, validating historical documentation through scientific evidence.

Provenance investigations complement archaeometric analysis, providing additional data. Stable isotope analysis combined with petrographic investigation demonstrated that all white marbles of the Tomb Chamber of the Holy Sepulchre - from the 4th century Constantinian construction to the 19th century restoration by Komnenos - originated from Proconnesos, thus highlighting both the symbolic significance of Proconnesian marble and the remarkable continuity of material selection across successive construction phases. Petrographic investigation of the Panagia Varnakova marble floor tesserae revealed the use of lithotypes originating from different regions of the Greek mainland, providing evidence for historical procurement networks and commercial exchanges. The archaeometric investigation of the glass tesserae of Hagia Sophia (statistical analysis of PGAA, XRF, SEM-EDS results) distinguished different construction/restoration phases, while identifying manufacturing technologies and provenance, offering new insights into technological evolution and workshop organization across historical periods.

The results demonstrate that the value of historic building materials extends far beyond their analytical characterization. Within the Evlogon methodology, archaeometry, provenance studies and material characterization are integrated with historical evidence into a unified knowledge-based framework that reveals the technological evolution, authenticity, historical continuity and cultural values of monuments. By transforming analytical data into scientific knowledge that directly supports decision-making, the proposed methodology establishes a transferable framework for documentation, protection and sustainable management, with emphasis on preserving and highlighting the values of cultural heritage assets.

Finally, the data generated through these investigations, alongside all interdisciplinary data from all scientific fields, are systematically organized and interconnected within the Evlogon Repository, an online platform that structures content according to monument rehabilitation project and/or thematic domain. By integrating textual, multimedia, tabular and 3D content at a fine level of granularity, the Repository facilitates transdisciplinary navigation, knowledge retrieval and the reuse of scientific evidence for monument documentation, conservation and management.

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O-9. CHARACTERIZING THE HISTORICAL MORTARS OF THE HOLY AEDICULE'S TOMB CHAMBER, JERUSALEM: INSIGHTS INTO PRODUCTION TECHNOLOGY ACROSS CONSTRUCTION PHASES

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This work focuses on mortar samples recovered from the Tomb Chamber of the Holy Aedicule in Jerusalem, collected during the comprehensive conservation project carried out by the multidisciplinary team from the National Technical University of Athens, with the goal of tracing how mortar-making practices evolved across the monument's construction history. An integrated analytical strategy combined optical and scanning electron microscopy (the latter with energy-dispersive X-ray

spectroscopy), X-ray diffraction, particle-size sieving, stereomicroscopic examination, thermal analysis (DTA/TGA), and vibrational spectroscopy (μ -Raman and ATR-FTIR), interpreted against the backdrop of the region's geological formations.

Findings show that gypsum functioned consistently as both binder and aggregate across most construction phases, pointing to a durable, long-lived building tradition. The identification of high-temperature mineral phases - wollastonite and a srebrodolskite-type compound - points to raw gypsum sourced from the pyrometamorphic Hatrurim Formation, while bioclastic limestone fragments align with the typical lithology of the Judea Group. Based on these data, the mortars cluster into three technologically and chronologically distinct groups: a Late Roman/early Byzantine phase (335–345 AD), marked by a gypsum-dominant binder with subordinate calcite, mixed aggregate types, and inclusions of charcoal, carbonized botanical remains, and a natural resin fragment suggesting notable technical sophistication; an 11th–16th century phase, defined by a gypsum binder incorporating calcite along with Si–Al and Si–Al–Mg phases likely derived from natural impurities in the raw gypsum; and a 19th-century phase tied to the Komnenos restoration, identifiable through its carbonate-rich matrix and aggregates with a strong ceramic component.

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O-10. ARCHAEOMETRIC INVESTIGATION OF HISTORICAL BUILDING MATERIALS FROM THE MUSEUM OF THE GREEK- ORTHODOX PATRIARCHATE IN ALEXANDRIA, EGYPT

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Alexandria, founded in the late 4th century BC, was a major political and commercial centre of the eastern Mediterranean throughout the Roman, Byzantine, and medieval periods. Its long history is reflected in its preserved monuments, a significant part of which lies beneath the modern city. Among these, underground cisterns formed an essential part of the city's water-management infrastructure and underwent successive phases of construction, repair, and reuse. Archaeometric investigation of their building materials can provide valuable evidence for reconstructing construction technologies and identifying different chronological phases. The presence of modern materials introduced during restoration and conservation interventions adds another dimension to

the study of historical structures. Scientific analysis can help characterize original building materials, distinguish them from later additions, and assess their state of preservation and possible alteration. Comparison with similar materials from Alexandria and the broader region can further contribute to understanding local construction practices, raw-material selection, technological traditions, and their development through time.

This study focuses on the archaeometric investigation of historical structural mortars, ceramic bricks, and plaster coatings from four different locations in the underground Museum of the Greek-Orthodox Patriarchate in Alexandria, Egypt. In total, seven mortar samples, as well as two samples of ceramic bricks from different areas of the structure, were prepared into polished cross sections and were examined under a stereomicroscope and a JSM-6510LV JEOL Scanning Electron Microscope with an energy-dispersive X-ray spectroscopy detector (SEM-EDS), in the Laboratory of Archaeometry of the University of the Peloponnese. The main objectives were the study of their morphological characteristics, the identification of the raw materials used, the investigation of their manufacturing technology. Furthermore, an attempt was made to compare and contrast with similar studies in historical remains in the broader area of Egypt.

Additionally, the samples were dated using the Optically Stimulated Luminescence (OSL) method, in order to establish their chronological framework and investigate possible successive phases of construction, repair, and modification of the structure.

The use of a calcareous (calcitic) binder was identified in all of the building materials, whereas the use of crushed ceramics without any medium-grained aggregates was observed in all pointing mortar samples.

The pointing mortars show different morphological characteristics depending on their sampling location. Specifically, the mortars from Location 4 contain dominating percentages of sodium chloride salts and are enriched with admixtures such as charcoal fragments. In contrast, the sample from Section 1 is finer-grained, without soluble salts or the same type of organically derived admixtures. The resulting dates also vary between mortars from different sampling location: One mortar from Location 1 was dated to the initial construction phase of the cistern (2nd century BC), whereas the samples from Location 4 seem to correspond to a later phase (12th century AD).

Among the plaster samples, similarities are observed between the sample from Section 1 and one sample from Section 2, while an additional sample from Section 2 exhibits different morphological characteristics.

The two samples of ceramic bricks do not share common morphological characteristics or chemical composition, indicating two different manufacturing methods for their production, but showing similar ages (700 ± 400 and 600 ± 300 years before present).

Regarding the comparison with similar studies in the broader area, there was a noted lack of purely archaeometric investigations, with the majority of the studies focusing on the similar architectural patterns found in medieval underground cisterns.

A comparison with the results from a petrological study on the Roman Mortars from the Kom El-Dikka archaeological site in the same area (Alexandria, Egypt) provided insights into the similarities in color and laying technique of binding mortars, the usage of quartz-rich aggregates, as well as the incorporation of crushed pottery sherds and calcitic aggregates in the mortar mixtures.

Acknowledgments

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O-11. COMPERATIVE STUDY OF DIFFERENT DECORATIVE MATERIALS FROM THE FACADES OF 1850S TO 1930S BUILDINGS IN ATHENS

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To finish and decorate the facades of the first neoclassical buildings in Athens, architects and craftsmen mainly used coloured lime plaster, while architectural elements like moldings and pillars were carved from pentelic and Ymittos marbles. Such buildings existing to this day are the Greek Parliament, the Arsakeio School and many private mansions of Greek merchants and politicians of the era. The application of colored coatings during the mid to the last quarter of the 19th century includes the very good leveling of the plaster by forming a smooth almost glossy surface imitating marble or limestone, often with lines imitating joints. This material was used so that the neoclassical buildings resemble the stone and marble constructions of classical antiquity that were studied and adopted as an architectural identity for the newly established Greek state by the emerging class of both European and Greek

architects.

The use of colored lime-based plaster for the rendering of facades subsided after the last quarter of the 19th century. Although the technique and material are not completely abandoned, it is significantly limited only in renowned residences and public buildings or in internal spaces, as highly decorative element. With the expansion of the capital and the evolution of the architectural rhythm towards eclecticism, the use of lime-based paints with mineral pigments became the main trend. Alongside the material the colour pallet evolved as well. With the turn of the century and the modernism movement, the use of coloured plaster cement lime based, became favorable again, with unlimited shaping possibilities moving forward the design of forms and decorations.

The documentation of the different materials used by period and architectural rhythm, leads to a deeper understanding of their application and choice of use and therefore is crucial for developing conservation approaches that maintain architectural integrity, while ensuring compatibility. To document the evolution of different decorative materials, samples were selected for comparative analysis from seven different listed ne-oclassical and eclectic buildings from late 19th to early 20th century and interwar structures. The buildings as well as the samples included in this study, are listed on Table 1. Samples were obtained from representative facade areas.

To characterize and compare the samples, the following analytical techniques were applied: Polished-section microscopy, X-Ray Diffraction (XRD) and Scanning Electron Microscopy coupled with Energy

Dispersive Spectroscopy (SEM-EDS) to identify aggregate-binder ratio, microstructural characteristics and determine mineralogical composition, Thermogravimetric Analysis (TGA) to assess binder composition, including lime and cement proportions and finally particle size distribution of the aggregates.

Table 1. List of buildings that are included in the study

<i>Building</i>	<i>Date of Construction</i>	<i>Type of material</i>
Greek Parliament	1848	Coloured lime plaster
Arsakeion School	1858-1864	Coloured lime plaster
Sotiros Dios 55 House	1880	Lime plaster with lime paint
Melas House	1895	Lime plaster with lime paint
Mpenakeios Library	1911	Lime plaster with lime paint
Mpenakeios Library new wing	1926	Lime plaster with lime paint
Elena Venizelos House	1932	Cement lime coloured plaster

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O-12. ON THE MICROSTRUCTURAL AND COMPOSITIONAL VARIABILITY OF MARBLES FROM THE ARCHAEOLOGICAL SITE OF PISTIROS USING SR XRD

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As marbles consist petrographically of a mosaic of calcite and dolomite grains, distributed in various proportions and frequently mixed with other minerals, they display diverse diffraction profiles and elemental configurations. Provided that a quarry consists of different, yet, homogenous marble zones, the XRD – XRF patterns may reflect the structural and compositional characteristics of it and can be used as markers in provenance studies.

In the current work we present results which demonstrate that the combination of XRF and SR-XRD analysis can: Deliver the characteristic signatures of the structural and compositional divergence among the samples and correlate the determined parameters to the origin of the marbles.

A collection of 9 marble samples from the fortification ancient Pistiros, along with 2 reference samples from local quarries have been investigated using complementary XRF and SR-XRD. To address this issue, homogenized powdered samples were measured on the KMC -2 instrument at the synchrotron radiation facility BESSY II. High resolution diffraction scans were performed with monochromatic $\lambda = 1.5406 \text{ \AA}$ in the (2θ) range from 5.363° to 133.283° , for 2s with the step size of 0.0145° .

The characteristic diffraction patterns show clearly two (2) major marble categories: a) a calcitic type and b) a dolomitic type. On both groups the (104) peaks display a shift from the expected stoichiometric peak position, along with peak broadening, hinting to the presence of additional Ca-Mg carbonate phases of characteristic mineralogical variations which can be correlated to the different extraction sites. Rietveld refinement using FullProf and Amphoras software shows a characteristic variation on the crystallographic parameters of each sample. Profile fitting of the (104) peak, on each type of marble sample (Figure 1), displays different discrete Ca-Mg carbonate phases. While the calcitic type is fitted with calcite-magnesian phase models with different structural and compositional features, the dolomitic type is fitted with a more complex model consisting of a combination of ankerite-Fe ($x=0.1-6$), and Ca-dolomite phases. The XRF analysis confirms the finds from the mineralogical study, indicating 2 major groups of marbles, according to the measured elemental features (Figure 2).

The characteristic signatures of the structural and compositional divergence

among the samples have been identified and related to specific quarries. The calcitic type marble can be linked to Nestos quarries. The origin of the dolomitic type is the Saliara/Vathy quarries.

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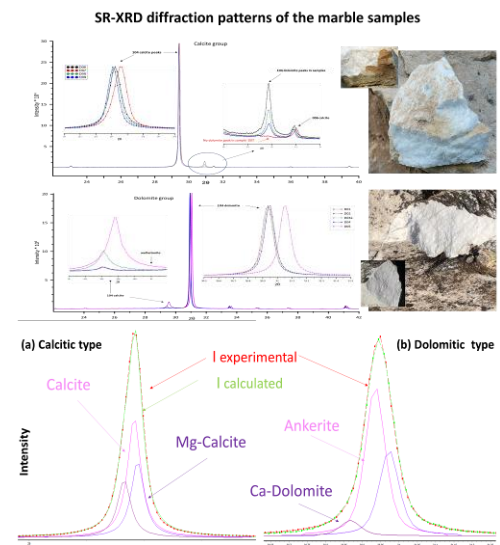


Figure 1. Profile fitting of the (104) peak in 2 samples.

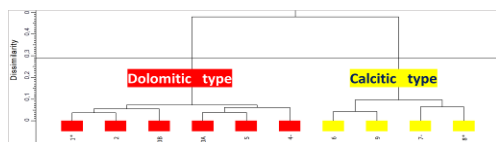


Figure 2. Dendrogram of 9 individuals +1 reference sample, after a cluster analysis performed on all the elemental sub-compositions found in the samples.

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O-13. MODERN RECREATIONS OF ROMAN CONCRETE USING RECYCLED FLY ASH AND QUICKLIME: MECHANICAL AND MICROSTRUCTURAL INVESTIGATION

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Ancient Roman concrete is a hydraulic cementitious material primarily developed during the Roman imperial period that has attracted scientific interest in recent decades due to its lower carbon footprint compared to Portland cement and its long-term durability in harsh marine environments. Ancient concrete developed by Roman engineers was created by mixing hydrated lime ($\text{Ca}(\text{OH})_2$), coarse aggregate, and volcanic ash. Recent research suggests that these formulations may also have included quicklime (CaO) in the mixing process, which provided a source of reactive calcium for long-term post-pozzolanic reactions within the material. In this study, we investigated the early microstructural and mechanical properties of modern recreations of Roman concrete using recycled fly ash as a pozzolanic material, with partial replacements of $\text{Ca}(\text{OH})_2$ by CaO . Compressive and flexural strength testing, along with powder XRD analysis, were performed at 7, 28, and 90

days to assess the mechanical and micro-structural effects of quicklime inclusion. Samples in this experiment were created using a weight ratio of 2.5 parts Class C fly ash to 1 part powdered calcium hydroxide ($\text{Ca}(\text{OH})_2$). Samples containing CaO maintained the same calcium content in the system through calculations based on the molecular weights of $\text{Ca}(\text{OH})_2$ and CaO, with part of the $\text{Ca}(\text{OH})_2$ replacement mass allocated to the mixing water content. The formulations of each sample used in this study are listed in Table 1. The compressive and flexural strengths of the samples were tested using an Instron 34TM-50 Universal Testing Machine. A summary of the strength testing results is presented in Figure 1. Powder XRD data were collected using a Panalytical X'Pert Pro X-ray Powder Diffractometer equipped with a Cu $\text{K}\alpha$ X-ray radiation source. XRD results for two samples are summarized in Figure 2. Quicklime replacement samples exhibited comparable strength relative to the hydrated lime samples but demonstrated significant differences in the major crystalline phases identified using powder XRD during the curing period.

Table 1. Formulas used in this experiment. FA25 = Control. Q30FA25 = 30% $\text{Ca}(\text{OH})_2$ replacement. Q100FA25 = 100% $\text{Ca}(\text{OH})_2$ replacement.

Sample	$\text{Ca}(\text{OH})_2$ (g)	CaO (g)	Fly Ash (g)	Sand (g)	H_2O (ml)
FA25	150.00	0.00	375.00	300.00	224.50
Q30FA25	105.00	34.06	375.00	300.00	233.69
Q100FA25	0.00	113.53	375.00	300.00	259.22

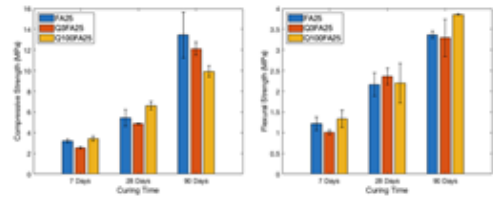


Figure 1. Strength measurements of samples created in this experiment at 28 days of curing (taken as the average of 2 samples).

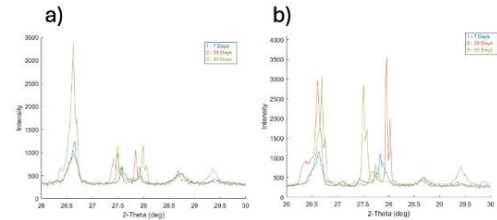


Figure 2. Powder XRD results for a) FA25 and b) Q100FA25 taken at 7, 28, and 90-day curing times.

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O-14. THE DATABASE WE ALWAYS NEEDED: DETANGLING THE ARCHEOLOGICAL MITOS' OF THE EXCAVATION PROCESS

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After many years of research we have developed a field to analysis system that turns excavation records into a single, navigable “digital stratigraphy”. Archaeologists can capture observations on site, keep context intact, and interpret the excavation as a coherent dataset rather than scattered notes, photos, and spreadsheets.

The system is implemented within Notion, a secure, online, collaborative “tool to build tools” environment, using interconnected, fully customizable databases that mirror excavation logic (i.e. Sectors, Trenches, Quarters, Levels, Strata, Findings, Periods, Context) and an archaeologist native interface that requires no programming skills, no specialized training, and no dedicated “database operator”. At the same time, it

also provides tools that can transcribe calendar notes and link them to the relevant contexts and findings. Promotes accountability and allows the user to organize logistics, quickly highlight data – entry errors, plan missions, generate charts and present the results accordingly.

This workflow reduces end of day data loss, standardizes documentation, preserves the sequence of field decisions, and makes the same structured dataset immediately reusable for organization and analysis (reporting, quantification, and cross checking), while supporting collaboration with colleagues in one shared workspace. Combining these features with AI agents, advanced accessibility, nuanced translator, and frequent updates, gives us a powerful virtual multi - purpose, “all - weather” tool.

Applying this system on a continuous research project on Maligrad island (Albania), shows that the most effective excavation “database” is a configurable, collaborative system that keeps excavation logic and interpretation continuously connected to the underlying evidence.

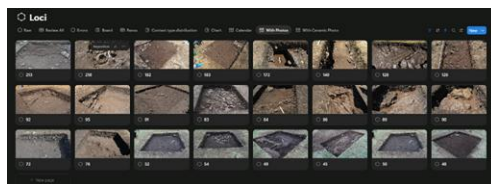


Figure 1. Example of excavational photos (trenches) that are implemented on the database.

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O-15. MACHINE LEARNING BEYOND LEGACY TYPOLOGIES: EVIDENCE FROM CERAMIC PROFILES IN WESTERN CHINA

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Ceramic vessels are a major source of evidence for studying cultural contact across western China, especially in southern Gansu and north-western Sichuan. However, many assemblages from this region are known mainly through legacy excavation reports, where profile drawings, measurements and typological labels were published with inconsistent scales, uneven figure metadata and divergent descriptive vocabularies. Forms with comparable profiles may be described as “slightly bulging”, “strongly bulging” or “hemispherical” in different reports, while vessels of similar geometry may be assigned to different categories such as bowls, basins or pots. These inconsistencies hinder reproducible cross-site comparison and obscure broader patterns of technological and stylistic interaction.

This paper presents a reproducible machine-learning workflow for transforming legacy ceramic profile drawings into reusable shape data. The study compiles a corpus of over 1,300 complete vessels with published profiles and reliable metric information for pixel-centimetre calibration, focusing on Late Neolithic assemblages from western China. Each vessel record is linked to

bibliographic provenance, figure metadata and calibration information through an image manifest. Local vessel terms are aligned with a controlled vocabulary using a term-mapping table that records confidence scores and rule versions. Profile drawings are extracted, normalised for orientation and scale, vectorised into standardised two-dimensional contours, and encoded as geometry-based descriptors suitable for large-scale comparison. Unsupervised clustering is then used to explore formal structure in the dataset, with robustness assessed through repeated subsampling and alternative normalisation strategies. Results indicate that machine-derived clusters only partially reproduce the type-series defined in excavation reports. Some clusters correspond closely to long-recognised vessel forms, suggesting that certain traditional categories remain morphologically robust. Others cut across named types, sites and report-specific labels, revealing shape continua and hybrid forms that had previously been fragmented by descriptive conventions. Degree-based categories such as “slightly” and “strongly” bulging often appear as gradual trajectories within morphospace rather than discrete formal divisions. Cross-site correspondences also emerge, indicating that vessels described under different local names may share closely comparable profile structures. The study demonstrates that machine-learning approaches can help diagnose subjectivity in legacy ceramic classification without replacing archaeological interpretation. By combining image processing, controlled vocabularies, provenance documentation and unsupervised shape analysis, the workflow provides an auditable

framework for testing existing typologies and comparing ceramic forms across unevenly published assemblages. More broadly, it offers a transferable model for converting legacy profile drawings into FAIR-oriented datasets that can support future ceramic research, regional interaction studies and extensible digital repositories.

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O-16. 2D SIMILARITY ANALYSIS OF TERRACOTTA FIGURINES USING U-NET++, ELLIPTIC FOURIER ANALYSIS AND ZERNIKE MOMENTS

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Cypriot Hellenistic terracotta figurines are widely dispersed across museum collections, often with uneven documentation and variable photographic records. This study asks whether accessible two-dimensional digital methods can support the identification of morphological similarity, typological relationships and possible mould connections when direct examination or 3D scanning is not feasible. The research is important because mould-made terracottas can preserve evidence for workshop practices, serial production, artistic transmission and wider Mediterranean cultural exchange.

The proposed workflow combines deep-learning segmentation with quantitative shape analysis. A U-Net++ model was trained on twenty-two hand-drawn image-mask pairs to extract clean contour masks from photographs of terracotta figurines. These masks were then analysed with Elliptic Fourier Analysis, which describes the external silhouette, and Zernike Moments, which add information from internal structures such as drapery, posture and applied details. The two descriptor sets were combined into a weighted distance metric and visualised through Principal

Component Analysis and Hierarchical Clustering Analysis.

The segmentation stage produced stable masks for both outer contour and major internal details, with an Intersection over Union score of 0.767 +/- 0.026. The similarity analysis correctly identified two Aphrodite figurines previously reported as derived from related moulds as the strongest match in the dataset. Broader groups were also detected, including hydrophoroi, draped female statuettes and kalathos-wearing female figures. The results indicate three practical interpretive ranges: distances below c. 0.4 suggest strong morphological or possible mould-level similarity, 0.4-0.8 indicates typological similarity, and values above c. 1.0 usually reflect broad or incidental resemblance.

The study demonstrates that 2D similarity analysis can produce archaeologically meaningful groupings from scattered and heterogeneous material. While the method does not replace expert typological interpretation, it provides a reproducible screening tool for comparing dispersed artefacts, testing suspected mould relations and tracing the circulation of coroplastic types across Cyprus and the wider Hellenistic Mediterranean.



Figure 1. U-Net++ prediction based on input mask.

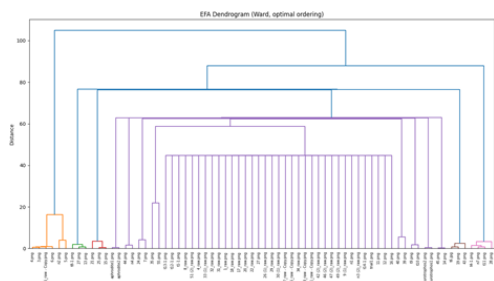


Figure 2. Dendrogram based on Elliptic Fourier Analysis values.

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O-17. COMPARATIVE STUDY OF 3D SCANNING AND PHOTOGRAMMETRY (WITH CONSIDERATION FOR 3D PRINTING) FOR ACCESSIBLE / INCLUSIVE DIGITAL DOCUMENTATION OF CULTURAL HERITAGE

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Museums remain largely inaccessible to Blind and Low-Vision (BLV) individuals. While 3D digitization is routine in archaeometry, systematic comparisons of which digitization method produces more effective tactile 3D prints for BLV users are lacking. This study presents a replicable workflow from digitization to 3D printing, comparing structured-light scanning versus photogrammetry for accessible object handling.

The primary research question asks: between 3D scanning and photogrammetry, which method yields 3D-printed replicas more accurately identified by BLV users? Secondary objectives assess cost, time, expertise, and workflow feasibility for museums. The importance lies in producing an evidence-based toolkit for inclusive heritage practice.

The test object is a stone Hekataion (Artemis in triplicate) from the Archaeological Museum of Ancient Messene. Two parallel digital models are

created via two methods; 3D scanning with Artec Eva Scanner that applies structured light technology and whose in situ scans are thereafter processed by Artec Studio 18 software, and photogrammetry with a Nikon DSLR and Agisoft Metashape Pro software.

Both models are post-processed in Blender (decimation, hole filling, solidification) and prepared for FDM printing (FlashForge Creator 3, PLA+, 10–15 cm height). Comparative metrics include geometric accuracy, detail fidelity, processing time, and printability. Handling sessions of 3D printed replicas are scheduled with BLV individuals. Printability analysis from digital meshes indicates that structured-light scanning captures undercuts more reliably, while photogrammetry requires more manual mesh repair but preserves macroscopic morphological features well.

The absence of completed BLV user feedback is explicitly acknowledged as a limitation. The contribution is a fully documented, replicable workflow from digitization to print-ready models. Formal BLV handling sessions with the Panhellenic Association of the Blind (Kalamata) and FAROS Lighthouse for the Blind (Athens) constitute the immediate next phase and will be presented at a future conference.

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O-18. 3D PRINTING OF COMPOSITES FOR ARCHAEOLOGICAL HERITAGE MONITORING USING ENERGY-EFFICIENT EDGE AI

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Preserving archaeological heritage today requires innovative solutions that integrate sustainability, digitalization and continuous monitoring of the artifacts' condition. In this context, the development of sustainable materials compatible with historical assets, combined with 3D printing and Artificial Intelligence (AI) technologies, creates a perfect synergy capable of processing vast amounts of data to ensure constant monitoring and predictive maintenance of the artifacts (Wu, P.; 2016).

Objectives and methodology: The project aims to create "digital artifacts" through additive manufacturing of eco-sustainable composite materials. The multidisciplinary research is an integrated system of three different topics:

1. The development of a new material: a sustainable mortar, without cement employment, which uses waste from the processing of stone materials as aggregate, promoting circular economy processes (Fico, D.; 2025). The mortar has characteristics suitable for use in archaeological contexts: durability, chemical stability and aesthetic compatibility. In addition, it will be designed to have the right workability for 3D printing technology (Vasanelli, E.; 2025).
2. Additive printing technology makes it possible to create shapes that are difficult to obtain through traditional processes and to reproduce geometries of archaeological and architectural elements, that may have been lost over time. 3D printing also makes it possible to design cavities for sensor housings and embedded devices, already in the digital modelling phase (Giacomobono, L.; 2024).
3. Finally, by querying the data collected by sensors and electronic devices, such as temperature and humidity, the energy-efficient AI integrated into the product makes it possible carry out continuous monitoring that can anticipate critical scenarios and allow timely intervention (Vergallo, R.; 2025; Cacciotti, R.; 2018).

A prototype has been developed that combines these three research objectives, imagining a real scenario: the Roman amphitheatre of Lecce (I BC – I AD). During recent excavations, an ancient

pentelic marble capital of the Pergamene type, from the Hadrianic period (117-138 AD) was found, which was remodelled, 3D printed in PLA and integrated with temperature and humidity sensors connected to AI processing. At the moment, the data collected is being processed to instruct AI to develop predictive scenarios.

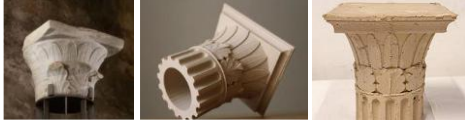


Figure 1. From left to right: real model, PLA reproduction, structural mortar model.

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O-19. QUANTIFICATION OF THERMAL EVENTS IN PROTOHISTORIC ARCHITECTURE: AN EXPERIMENTAL PROTOCOL BASED ON CIELAB COLORIMETRY

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The archaeological study of protohistoric monumental building complexes in the middle Guadiana River Valley (e.g. Cancho Roano, Casas del Turuñuelo) has traditionally focused on morphological and stylistic descriptions of their structures.

However, the formation processes of these records (frequently characterised by widespread burning events and an eventual earth tumular sealing) offer an exceptional research laboratory to investigate the construction and destruction of these structural complexes. This research introduces an experimental, interdisciplinary protocol designed to identify, record and quantify thermal alteration in architectural materials (stone, adobes, mud floors, etc.).

By mapping the spatial distribution of thermal decay, this project aims to provide a new proxy to evaluate the operational workflows, energy

expenditure and socioeconomic dynamics tied to these sites.

The proposed methodology integrates digital fieldwork recording with physico-chemical analysis. On-site, architectural structures are documented using photogrammetry to generate metric 3D models, and georeferenced spectrophotometric samples are systematically gathered under the CIELAB colour space system.

To cross-calibrate these optical signatures with specific temperature ranges, the sampled areas are subjected to FTIR, XRD and thin-section petrographic analysis (LD). Finally, a “rubefaction index” ($RI = a^* \cdot L^*$) (adapted from Torrent et al. 1983) is calculated using spatial interpolation within a GIS environment, yielding thematic surfaces projected directly onto the 3D architectural models.

Experimental testing has validated the correlation between CIELAB chromatic trajectories and mineralogical thresholds. Samples displaying low lightness and markedly elevated red parameters indicate high-intensity combustion zones. Conversely, moderate chromatic shifts highlight zones of indirect heat or areas with lower exposure to the thermal event. The resulting models enable an assessment of both the destructive sequence and its socioeconomic implications during the First Iron Age.

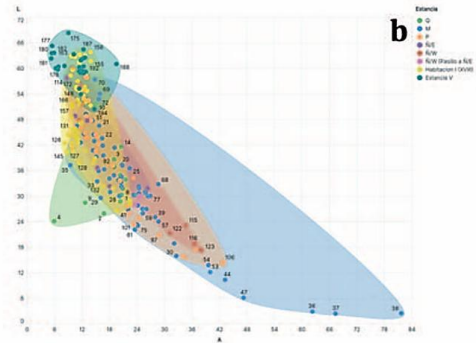


Figure 1. Distribution of L* and a* variables by room (practical case study at Cerro de la Cruz, Almedinilla, Córdoba) (Abelleira et al. 2025: fig. 4)

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O-20. “PAINTING” OR INLAY?: A CROSS-CULTURAL OBSERVATION ON BRONZE SURFACE DECORATION

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From the 2nd millennium BCE to the 3rd century BCE, craftsmen on both sides of the Eurasia during the Bronze Age engaged in decorating the surfaces of bronze artifacts. Interestingly, despite the existence of analogous bronze surface decoration, the aesthetic preferences and technical choices of craftsmen differed significantly. Cross-cultural observation and comparative studies on bronze surface decorations sheds new light on this practice.

Europe in Bronze Age: Painting on Black Partinated “Canvas”

The team studies some Mycenaean daggers, in order to understand their manufacturing process and sophisticated decorative techniques of “Metal Painting”. Special attention has been paid to the “black bronze”, a layer of bluish black alloys (Figure 1 left, formulated with copper, tin, gold and silver) applied onto bronze surface, and served as the “canvas” for later decoration. Experimental reconstructions were

conducted, towards a better understanding on this technical tradition.



Figure 1. Mycenaean Dagger, 1600 BCE, Shaft Grave IV Grave Circle A, HNAM II394. Left; Central Part of an Axe, 1800 BCE, Grave no. 1 in the Renzenbu'hl cemetery, Bernisches Historisches Museum, Photograph: Daniel Berger. Right.

Similar practice was also observed in other European regions, where craftsmen added reddish-black patina (Figure 1 right, predominantly composed of native copper) onto bronze surface, then inlaid gold, silver, copper or alloys of varying proportions onto the dark background to pursue striking colour contrasts and ornamental effects.

Ancient China: Inlay in Pre-cast Grooves
In contrast, Chinese craftsmen practiced a different decoration method based on the extremely sophisticated bronze casting system. They ingeniously utilized clay mould to cast elaborate decorative patterns directly onto bronze surfaces, before filling the carved grooves with turquoise, malachite, cinnabar, and later gold and silver to create intricate ornamentation.



Figure 2. bronze artifacts with metal inlay. Left: standing portrait K89:66 from Sanxingdui; right: Belt hook from Luoyang.

For instances, neatly arranged red filling materials were found within patterned grooves on bronzes from sacrificial pits at Sanxingdui (dated to 1100–1000 BCE). It is inferred that this decoration was conducted by a multi-layer filling process, where lacquer was applied within the grooves, and then a cinnabar layer was added for coloring before it got fully solidified. The cinnabar and lacquer layers were applied alternately till the grooves were filled with red. By the second half of 1st millennium BCE (the Eastern Zhou Dynasty), an innovative decorative inlay technique known as ‘Cuojinyin’ emerged, which delicately decorating the surface of bronze and iron wares in ancient China. Shallow grooves were cast or chiselled onto the surface of metal wares, where gold and silver wires or sheets were inserted.

Taking advantage of the ductility of gold and silver, they could be perfectly

embedded into the surface and filed smoothly.

O-21. METEORITIC IRON TOOLS FROM MOROCCO. A HANDHELD LASER-INDUCED BREAKDOWN SPECTROSCOPY ANALYTICAL STUDY

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Early cultures utilized iron meteorites to create jewelry, tools, and weapons prior to the smelting of iron from oxide ores (Waldbaum, 1980). Numerous iron artifacts from USA, Greenland, Canada, China, Egypt, and other Eurasian regions confirm the use of meteoritic iron (Comelli et al., 2016; Rovira-Llorens et al., 2023; Hofmann et al., 2023). Scientists debate whether meteorites were the primary source of ancient iron artifacts (Jambon, 2017).

The analysis of archaeological metals advanced with portable X-ray fluorescence (pXRF) and promising handheld laser-induced breakdown spectroscopy (hLIBS) enhancing capabilities for distinguishing iron types.

This study aims to: (a) show hLIBS's ability for rapid identification and quantification of Fe, Ni, Co, and minor elements on iron artifacts from Morocco; (b) compare hLIBS with pXRF for accuracy; (c) identify meteoritic iron presence; (d) record depth profiles; (e) create elemental micro maps; and (f) discuss genetic relationships with nearby meteorites.

In 2022, five significant artifacts were discovered in Morocco (Figure 1): three iron blades near Imilchil (sample #1; sample #2; sample #3), an axe found near Guelmime (sample #4), and another blade discovered between Imilchil and Missouri (sample #5). All specimens underwent hLIBS and pXRF analysis post-sample preparation.

Samples #1 to #4 primarily contain Fe, with minor C, S, Si, Al, Cr, Mn, Co, Ni, Cu, and Mo; sample #5 has major Fe, Ni, Co, and minor C, Cu, Sn. Fe + Ni totals 95-98 wt %. Al and Si may stem from contamination, while C could result from forging or slag inclusions. Handheld LIBS maps reveal compositional differences in iron artifacts and enhance understanding of elements' geochemical behavior at small scales.

Depth profiles from sample #5 show significant variations in Fe, Ni, and Co content, confirming real depth variations due to its high Ni and Co content, possibly from meteoritic origin. Artifact #5's genetic relationship with iron meteorites was assessed by comparing its composition to Agoudal, Oglat Sidi Ali, NWA 859, and NWA 11010, revealing similar chemical properties.



Figure 1. The five iron artifacts analyzed by hLIBS.

Specimens #1-4 exhibit low Co, Ni, Ga, and Ge levels, but high Mn content, indicating smelted, possibly corroded iron. Unlike corroded meteoritic irons, which show variability, no such evidence is found for specimens #1-4's composition. Specimen #5 differs markedly from specimens #1-4, showing high Co ($1.1 \pm 0.05\%$) and Ni ($20.6 \pm 0.4\%$), along with Ga (90 ppm) and Ge (2800 ± 160 ppm), while Mn is below detection. Its composition suggests it resembles NWA 859 and Oglat Sidi Ali meteorites, indicating meteoritic iron use.

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O-22. FORGING IRON AT ANCIENT ABDERA: SLAGS FROM THE “ARCHAEOLOGICAL PROJECT OF ABDERA AND XANTHI” (A.P.A.X) AND THEIR SPATIAL DISTRIBUTION

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Abdera was a flourishing city on the Thracian coast founded in the 7th century BC as a colony by settlers originating from Clazomenai and Teos in coastal Asia Minor. The city developed into a prosperous centre that controlled trade over a broader region in the Thracian interior and issued silver coinage since the late 6th century BC. Excavations between the 1950s and 1990s concentrated on the South Enclosure of the late Classical and Hellenistic times and the extended cemeteries of tumuli scattered in the immediate vicinity (Kallintzi et al. 2020). The North Enclosure of Abdera surrounds the early colony of Archaic and Early Classical

times and remains mostly unexcavated apart from a sanctuary, parts of the fortification wall and harbour. During the recent A.P.A.X survey project carried out by the Ephorate of Antiquities of Xanthi and the National and Kapodistrian University of Athens (Georgiadis et al. 2022; Kallintzi et al. 2022; Kefalidou et al. 2023; Mayural et al. 2024) important new finds came to light on that part of the city and its immediate vicinity to the north beyond the fortification wall. Among the collected material, several metallurgical finds were recovered, the study of which sheds light into applications of iron technology in the region.

A total of 153 pieces of slag has been registered and 10 samples have been selected for analysis using Optical Microscopy and Scanning Electron Microscopy (SEM/EDS). The results point to secondary iron working practices, namely refining the blooms, forging and smithing. The detection of spheroid and platy hammer-scale in the samples offer details into the practice of hammering (Figure 1). Additionally, variable contents of CaO point to certain metalworking practices including the welding of objects. EDS analysis of several inclusions in the slag revealed the presence of Pb and Cu pointing to impurities in the iron ores used for the production of iron. Such elements are present in the iron mineralization of the region, particularly the Kimmeria deposits 25 km north of the site. The spatial distribution of the finds provides further information on workshop organisation in the urban nucleus. Overall, the analysis provided valuable insights into technological applications for ironworking in this important city of the north Aegean.

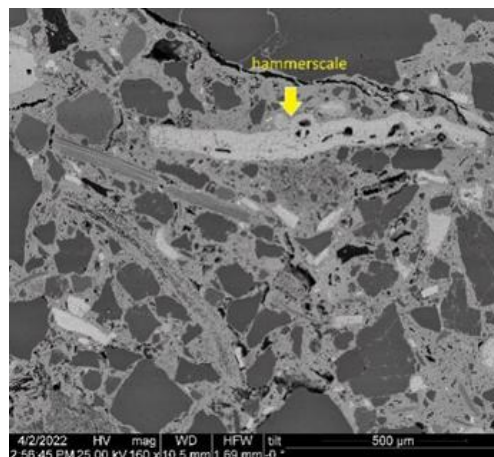


Figure 1. SEM/EDS photomicrograph of slag sample from Adera featuring platy hammer-scale.

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O-23. TECHNOLOGICAL INSIGHTS INTO THE DEPOSITION OF COPPER-BASED VOTIVE OFFERINGS AT THE ARCHAIC-CLASSICAL SANCTUARY OF DEMETER AT THEA PATRAS IN THE CULT CONTEXT OF EARLY GREECE

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This study presents the elemental analysis of a copper-based votive assemblage from the Sanctuary of Demeter at Thea Patras and examines it within a broader archaeological framework through comparison with published data from other early Greek sanctuaries in the Peloponnese, mainland Greece and the wider eastern Mediterranean basin. The aim is to provide further insights into technological choices and metallurgical

practices within the cult networks of the first half of the 1st millennium BC. As the only systematically investigated Archaic-Classical sanctuary in western Achaia, Thea offers important evidence for cult activity and communication patterns in the region. The assemblage includes personal adornments, such as pins, rings, and armlets, alongside utilitarian and other functional objects, reflecting diverse ritual practices.

The assemblage was analysed by micro-XRF spectrometry, a non-destructive technique that allows the determination of alloy compositions, including major, minor, and trace elements at concentrations below 0.1wt%. Due to the micrometric size of the incident beam (<0.1 mm), only targeted, minimal removal of surface corrosion was required. The results indicate a clear predominance of binary tin bronzes, with tin ranging between 3 and 18wt%. However, the compositional heterogeneity and the presence of minor lead and arsenic concentrations suggest the use of mixed metal sources and recycling practices. Comparison between the different artefact types shows that compositional variations are related to the objects' function and use, with personal adornments made of shinier binary bronze (<0.5wt% Pb), whereas most lead bronzes (>8wt% Pb) correspond to utilitarian objects. These observations correspond closely with published analytical data from the sanctuaries of Athena Alea at Tegea and Enodia and Thaulios Zeus in Thessaly. Comparison with these assemblages helps us to assess whether the metallurgical patterns observed at the Thea reflect local practices or broader technological traditions shared among early Greek sanctuaries, providing insights into how

metallurgical practices intersected with votive practices in early Greece.

Overall, elemental analysis results reveal compositional variability, indicating certain differences in alloying and technological choices, linked to metal availability, recycling, and desired material properties. Finally, this study highlights the value of a micro-destructive analytical approach in the contextual interpretation of ritual material culture.

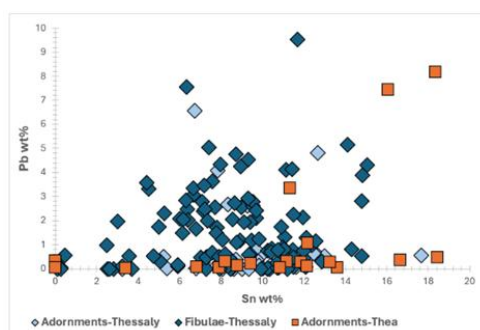


Figure 1. Scatter plot Sn against Pb for the personal adornments from Thea (n=21), compared to selected fibulae and personal adornments (rings, pins, armlets) from Thessaly (n=154).

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O-24. MANUFACTURING TECHNOLOGY OF A COPPER-ALLOY BANGLE FROM THE EARLY HISTORIC SITE OF TEKTHA, NAOGAON, BANGLADESH: AN ARCHAEOMETRIC AND EXPERIMENTAL APPROACH

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This study employs an integrated archaeometric and experimental approach to understand the manufacturing process of a fragmented copper alloy bangle recovered from the Early Historic site of Tekthta in Naogaon, Bangladesh, where the scientific knowledge of ancient metallurgical processes of the Bengal region is still in need of such a comprehensive investigation. The aim of the research was to (1) determined the elemental composition and material properties of the bangle, (2) identify the manufacturing techniques, (3) experimentally recreate the object by traditional methods, and (4) assess the technical skill of metalworkers in the Early Historic period.

It adopted a methodology that combines the use of the non-destructive ED-XRF analysis with SEM-EDS and elemental mapping to explore the micro-structural properties, physical documentation, and

experimental archaeology performed in collaboration with the traditional artisans from the village of Vakurta. ED-XRF revealed a complex brass alloy composition of copper (43.84%), zinc (38.31%), and notably high nickel (11.05%), along with lead (1.20%) and tin (1.10%). The SEM-EDS analysis revealed micro-structural features such as Cu, Zn and Ni elemental segregation, equiaxed grains with porosity, and lead-rich secondary phases; all of which are characteristic of casting as the major production method. The fragmentary bangle is estimated at a total circumference of ~131.5 mm, was physically reconstructed and is suggested to be a child's ornament.

In seven days the experimental replication successfully replicated the intricate design of the bangle which included the spherical elements in gradient patterns, a hinged fastening system and symmetrical decoration motifs, all of which were made using traditional tools and techniques. Visual and structural fidelity was confirmed by comparative analysis of the original and replica, the latter containing Cu 59.51%, Zn 32.78%, Ni 0.11% (difference in composition because of the use of modern commercial brass).

The results are the first empirical data that show deliberate nickel alloying in Early Historic Bangladesh, demonstrating advanced knowledge of metallurgy and the use of specialised ore sources or trading networks. Higher zinc brass alloy (with nickel) indicates more sophisticated knowledge of alloying practices to achieve increased tensile strength, corrosion resistance and appearance (reddish-gold). The casting technique, alongside complex assembly processes using different kinds of hinges,

as well as spherical decorations, demonstrates a degree of technical specialization that has never been documented in the region before. Such a multi-disciplinary approach (involving the archaeometry and experimental and ethnoarchaeological methods) not only helps in improving the methodology of archaeometallurgy in the South Asian context, but also helps in preserving the intangible cultural heritage by documenting the traditional knowledge of metal-working. The study highlights the importance of community involved research for heritage conservation and economic sustainability.

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O-25. QUANTITATIVE SPECTROSCOPY FOR ARCHAEOLOGICAL SEDIMENTS

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The study of past human groups has traditionally centred on the analysis of artefacts, while unmodified natural materials and incidentally altered waste products have often been overlooked. Yet archaeologists increasingly recognise that non artefactual components of archaeological deposits frequently preserve an equally rich - and sometimes even greater - amount of information compared to artefacts themselves. Among these components, the sedimentary matrix represents the most substantial and informative element, as it embeds artefacts, structures, features, and architectural remains. While traditionally described through macroscopic criteria such as colour, texture, moisture content, and compaction, analytical observations obtained through microscopy and spectroscopy allow for more direct and reliable inferential pathways linking sediment characteristics to the formation processes of archaeological deposits. In particular, FTIR spectroscopy has proven effective in identifying pyrotechnological and diagenetic transformations (H. Neff et al. 2016).

This research focuses on the physico chemical characterisation of sediments from the Upper Palaeolithic site of Riparo Mochi (Ventimiglia, Imperia, Italy), a key location for understanding early modern human presence in the north western Mediterranean. The project aims to refine our knowledge of how fire was used, managed, and structured by human groups during this period. To achieve this, the study integrates field observations, laboratory analyses, and experimental archaeology, investigating the construction and functioning of combustion features, the materials involved, and their chemical signatures.

A wide range of archaeological materials - including heated lithics, ashes, bones, reddened sediments, and pigments - has been examined through a multi analytical strategy based on techniques widely employed in cultural heritage science (S. Bruni et al, 2018). These include optical microscopy, SEM EDXS, XRPD, FTIR, and Raman spectroscopy, complemented by colourimetry and FORS for rapid in situ characterisation of coloured rocks (Guglielmi et al, 2020).

Building on this analytical framework, the project also incorporates a novel quantitative approach developed in previous work. In that study, a combined XRPD-FTIR qualitative analysis enabled the identification of the main mineralogical components of the sediments, defined as ARchaeological Markers (ARMs). Reference standards with known concentrations of selected ARMs - calcite, silicate, and quartz - were then prepared, and their FTIR spectra were used to build a large dataset for training and validating a neural network. This AI driven model demonstrated promising capabilities in estimating the concentration of individu-

al mineral phases, with relative errors of approximately 6% for calcite and 14% for silicate in single ARM pellets, once the variability introduced by quartz was excluded.

This innovative workflow is now being extended to the Riparo Mochi dataset. The present contribution therefore not only illustrates the chemical and mineralogical composition of selected samples through FTIR and XRPD, but also discusses the implementation of AI enhanced spectral post processing aimed at improving the quantitative interpretation of FTIR data. Ongoing work includes the preparation of additional ARM based reference pellets to expand the training dataset and further refine the neural network performance.

Acknowledgments

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O-26. BRIDGING THE DISTANCE: WHAT A COMBINED MULTISCALE ANALYTICAL STUDY CAN TELL US ABOUT HEARTH FEATURES

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A suite of scientific techniques is now utilized in archaeological projects, yet a disconnect often exists between the data recovered by archaeological scientists and the research questions of project directors. In this paper we present a case study where the distance existing between the analytical data and the archaeological research questions are bridged through a multiscale approach that integrates field data, analytical data, and broader archaeological research questions.

We present research on two Mycenaean hearths from the recent Palace of Nestor Excavations. Prehistoric hearths can serve multiple functions and understanding their construction and use life can inform on social practices, diet, technological developments, and environmental conditions. The understanding of these past behaviors and practices are some of the most common research objectives related to the study of hearths, especially in Mycenaean archaeology where the function of these installations is often

interpreted based largely on contextual information.

In this paper, we show how a combined approach can address questions related to construction techniques and materials, the number of burning episodes, the maintenance practices (such as relaying and cleaning), and pyrotechnic properties, including the temperatures reached and the duration of heat exposure. Our geoarchaeological study of hearth features utilizes macrostratigraphy, micromorphology, Fourier-transform infrared spectroscopy (FTIR), and X-ray powder diffraction (XRD).

The macrostratigraphy of hearth features provides information on context and can often identify the possibility of multiple use episodes. It is also fundamental to multiscale analytical studies because it acts as the anchoring point to bridge the macro-evidence with the microscopic record. While macrostratigraphy is important for determining appropriate sampling location and contextual information, a micromorphological analysis is often essential for understanding construction techniques, successive burning episodes, and pyrotechnic features. The micromorphological analyses of the two Pylos hearths confirmed the existence of multiple superimposed platforms, successive burning episodes, and different construction techniques. Ash layers overlying the burnt sediments, consisting of recrystallized ash with common crusts, helped to differentiate and characterize multiple periods of use and maintenance. In both cases, the platforms were constructed using a distinct recipe, demonstrating the deliberate selection and preparation of different materials. The combined

Fourier-transform infrared spectroscopy (FTIR) and X-ray powder diffraction (XRD) results provided data on the temperatures reached during the different burning episodes. Through this multiscale approach, we demonstrate how archaeological and analytical data can be combined to answer broader research question.

O-27. PRESERVING EARTHEN ARCHITECTURE THROUGH MULTIPROXY MICROMORPHOLOGY: RECONSTRUCTING CONSTRUCTION AND DEGRADATION processes in Neolithic pithouses at Tamsagbulag, eastern Mongolia

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Pithouse architecture represents one of humanity's most enduring architectural traditions. First appearing approximately 15,000 years ago, semi-subterranean dwellings have been constructed across diverse cultural and environmental settings, from the deserts regions of the North American Southwest, Arctic plains, and the wetlands of Eurasia. Their remarkable longevity reflects sophisticated adaptations to local climates, landscapes, and available construction materials. Yet despite their global distribution and archaeological significance, preservation efforts have largely prioritized more monumental architecture, while pithouse remains - often preserved as subtle earthen features - are especially vulnerable to erosion, biological disturbance, and accelerating climate-driven landscape change. Developing effective conservation strategies therefore requires a detailed understanding of both original construction technologies and the post-depositional processes that govern their

preservation. Although micromorphology is well established for studying site formation processes and occupation histories, its analytical reach into earthen domestic architecture and conservation science is still expanding.

This study evaluates how archaeological micromorphology can be employed not only to reconstruct prehistoric earthen architecture but also to identify the processes affecting its long-term preservation. Using the approximately 9,500-year-old Neolithic pithouse structures at Tamsagbulag, Dornod Province, eastern Mongolia, this paper presents an interdisciplinary framework that integrates micromorphology with complementary archaeological science datasets. Micromorphology - the microscopic analysis of undisturbed sediment thin sections - preserves sedimentary fabrics and microstratigraphic relationships that are often invisible during excavation, allowing architectural construction, occupation histories, maintenance activities, and post-depositional site formation processes to be investigated within a single analytical framework. Thin sections preserve sediments in situ and simultaneously record evidence of ancient building practices and the modern processes responsible for the preservation or deterioration of archaeological architecture.

Here, thin-section analyses of pithouse floors and walls identify extensive iron oxide and hydroxide pedofeatures, including hypocoatings and impregnations, throughout the architectural sediments, together with evidence of alluviation, rooting, and bioturbation. These pedofeatures reflect repeated oxidation–reduction cycles and pedogenic alteration associated with

fluctuating hydrological conditions, providing direct evidence of the processes driving the long-term preservation and deterioration of the pithouse structures. Micromorphological observations are integrated with complementary geochemical analyses, phytolith assemblages, faunal data, and microscopic characterization of construction debris to produce a multi-scalar reconstruction of earthen construction technologies and subsequent taphonomic alteration. Together, these independent yet complementary datasets constrain raw material selection, construction methods, occupation history, and degradation pathways, enabling the reconstruction of original building materials and architectural recipes while identifying the environmental and biological processes responsible for their alteration.

By demonstrating the dual value of micromorphology for both architectural reconstruction and conservation, this research highlights its potential application into preserving prehistoric earthen built environments.

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**O-28. NEW PERSPECTIVES
FOR DATING
ANTHROPOGENIC
CARBONATES IN CULTURAL
HERITAGE STUDIES:
ESR INVESTIGATION OF
HISTORICAL AND
EXPERIMENTAL LIME
MORTARS**

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Lime mortars and plasters are key components of historic buildings and archaeological structures, providing valuable information for the study, conservation, and management of cultural heritage monuments. Establishing the chronology of mortars remains challenging, as currently applied methods such as radiocarbon (14C) dating and optically stimulated luminescence (OSL) are affected by methodological limitations and are not yet routinely applicable in all contexts. This study explores the potential of Electron Spin Resonance (ESR) spectroscopy as an innovative approach for dating anthropogenic carbonates formed during mortar production. ESR, analogically to OSL and TL, gives the date of the last bleaching (emptying the traps by heat or light) or crystal formation, based on the fact that exposure of a crystal, such as

quartz or calcite, to ionizing radiation leads to the formation of paramagnetic centres by trapping of electrons. Since carbonate crystals are formed during the mortar production, this moment can be regarded as the zero point for the accumulation of trapped charges, and their concentration in a measured sample should reflect the age of the mortar (Kabacińska et al. 2012, 2014, 2020, Kabacińska and Michalska 2026).

The research combines ESR analysis of archaeological lime mortars from several archaeological sites with laboratory-produced lime binders prepared from limestones originating from Poland and Mallorca. Historical mortars, ranging in age from approximately 2800 to 500 years BP and previously dated by 14C methods, were carefully selected to isolate binder fractions representative of the original construction phase. Experimental binders were produced through thermal decomposition, hydration, and controlled carbonation, simulating traditional mortar manufacture. ESR measurements, microscopic analyses, and laboratory irradiation experiments were performed to identify radiation-induced paramagnetic centres and evaluate their suitability for chronological applications. Detectable ESR signals were identified in archaeological mortars, demonstrating the sensitivity of anthropogenic carbonates to radiation-induced charge accumulation. Signal simulation and spectral analysis enabled the identification of carbonate-, sulphate- and nitrate-related radicals and defects, pyrolysis-induced signals, and surface-located paramagnetic centres. Experimental binders displayed significantly different ESR characteristics compared to geological

limestones, notably lower crystallinity and enhanced radiation sensitivity. Artificial irradiation generated distinct carbonate-related signals in newly formed calcite phases, indicating promising dosimetric behaviour. These findings contribute to understanding the physicochemical evolution of historic mortars and support the development of ESR dating protocols for anthropogenic carbonates.

The study demonstrates the strong potential of ESR spectroscopy as a novel archaeometric tool for investigating and dating lime-based building materials. Beyond chronological applications, ESR analysis may provide important insights into the manufacture, preservation state, and long-term alteration processes of historic mortars, contributing to monument management, conservation science, and interdisciplinary archaeological research.

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O-29. HUMAN PRESENCE, MOBILITY AND SETTLEMENT IN THE WIDER LEVANT DURING PREHISTORY: EVIDENCE FROM PUBLISHED LUMINESCENCE DATES

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The wider Levant is central to prehistoric archaeology, as it connects Africa, Southwest Asia and the Eastern Mediterranean (Bar-Yosef and Belfer-Cohen 2001; Falguères 2020). It has been interpreted as a passage, filter, settlement area and contact zone between human groups, technologies and changing environments (Breeze et al. 2016; Shea 2001). Luminescence dating provides an important chronological framework for archaeological and geoarchaeological interpretation (Liritzis et al. 2013), and the present study examines whether published TL and OSL dates can help identify spatial and temporal concentrations of prehistoric activity in the wider Levant.

Published luminescence data from archaeological contexts were systematically compiled, classified and analysed in order to investigate long-term patterns of human presence, mobility and settlement. The chronological evidence was sorted by country, site, dated material, dating method, archaeological

period and Marine Isotope Stage (MIS), producing a structured dataset through which temporal and spatial patterns could be identified and analysed. The classification of the dataset by archaeological period and MIS also allowed the results to be compared with broader archaeological interpretations and palaeoclimatic frameworks.

The analysis of the corpus suggests that the Levant functioned repeatedly as a key corridor and settlement zone during major phases of prehistoric dispersal, including movements of early *Homo sapiens* populations out of Africa. Some records also indicate the cohabitation of both *Homo sapiens* and Neanderthal populations, highlighting the region as a zone of repeated settlement, contact and interaction during the Pleistocene.

Overall, the study supports the role of the Levant as a strategically important and repeatedly occupied landscape. It also highlights the value of luminescence dating, when combined with spatial, archaeological and palaeoclimatic synthesis, for reconstructing large-scale patterns of prehistoric human activity.

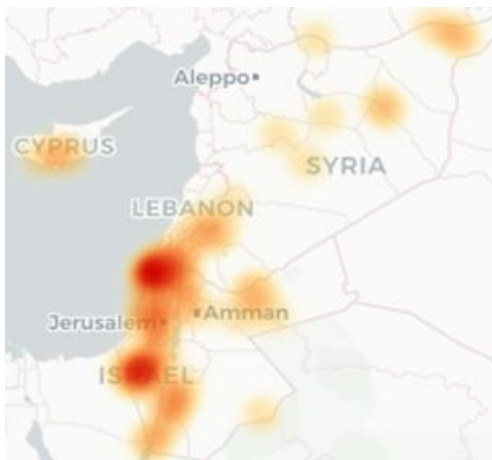


Figure 1. Heatmap showing the spatial concentration of published luminescence ages from archaeological contexts in the wider Levant.

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O-30. ASSESSING EARLY PIGMENT APPLICATION AND USE-WEAR TRACES ON THE PRE-POTTERY NEOLITHIC CLAY CONTAINERS FROM NORTH MESOPOTAMIA

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Pottery represents the appearance of a new technology and constitutes the main elements of Neolithization in Southwest Asia. The present study employs multi-analytical archaeometric investigations to establish past manufacturing technologies, examine the earliest use of pigment on clay containers and investigate their usage practice.

The archaeological excavation of Çemka Höyük (PPNA phase) and Buncuklu Tarla (PPNB phase) in Southeast Anatolia revealed some rare evidence of fired clay containers, dated around tenth millennium BC. Confocal Microscopy and Raman spectroscopy were conducted to examine the trace of use-wear on the

containers' surface and to characterize the earliest practical use of pigments on these fired clay containers. In addition, X-ray diffraction (XRD), X-ray Photoelectron Spectroscopy (XPS), The Fourier Transform-Infrared (FTIR) spectrometry and Scanning Electron Microscopy with Energy Dispersive Spectrometry (SEM-EDS) were used to assess the firing conditions and compositional characterizations of the fired clay containers. The results show inconsistent compositions among the containers, reflecting different levels of firing temperatures under the oxidizing condition and diagenetic alteration after burial. The SEM-EDS analysis exhibits deformation features, including intensive deformation bands of calcite associated with the calcite pseudomorph growing after vegetal fibre through post-depositional leaching. It shows the intentional addition of different plant-temperers within the clayey matrices of these deliberately-tempered fired clay containers. Laser Scanning Confocal Microscopy (LSCM) revealed the trace of directional micro-scratches due to repeated abrasion for polishing and the edge of intentional impressions, produced during the vessel shaping prior to the vessels' use. Raman Spectroscopy indicates a high concentration of deteriorated hematite-derived red pigment preserved on the exterior surfaces of the fired containers. These results provide some important evidence of the emerging stage of practical preparation and initial surface treatment of the fired clay containers during the Pre-Pottery Neolithic of Southeast Anatolia. The results highlight an early stage of technological awareness of clayey vessel production and surface treatment practices in the 10th

millennium, prior to the pottery adoption in the Pottery Neolithic period.

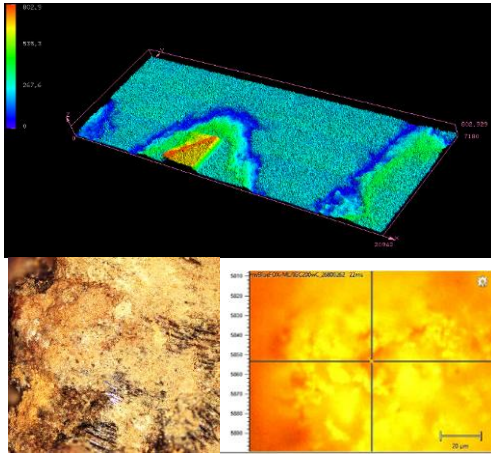


Figure 1. The Raman and LSCM image of the clay containers showing directional micro-scratches and trace of red pigment.

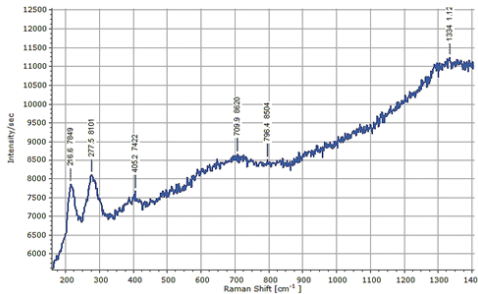


Figure 2. Raman spectroscopy revealing a deteriorated hematite, collected from the red pigment layer.

O-31. MAKING STORAGE JARS ON CHIOS ISLAND: A LONGUEE DURÉE PETROGRAPHIC PERSPECTIVE FROM PREHISTORY TO THE PRESENT

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Mediterranean islands are increasingly understood as dynamic settings where material traditions both respond to and actively shape long-term social, economic, and environmental change. This paper explores such processes through the longue durée study of large clay storage jars (pithoi) on the island of Chios, tracing their development from prehistory to the present. Rather than viewing pithoi as static functional containers, the study approaches them as materially grounded practices embedded in changing island lifeways. The analysis is based on a large, multi-period assemblage of pithoi recovered through intensive survey and places petrographic analysis at the centre of interpretation. Systematic petrographic characterisation of ceramic fabrics is combined with targeted sampling of local raw materials to investigate continuity and change in resource selection, production strategies, and technological knowledge. These data are further contextualised through

comparison with ceramic samples from earlier excavations at Emporio, the main prehistoric site of the island, allowing the integration of legacy assemblages into a unified analytical framework. By linking fabric variability with landscape use, storage practices, and long-term adaptation, the paper demonstrates how petrography can address key questions of resilience and insular continuity. In doing so, it shows how a single ceramic form can offer a distinctive material history of island life in the Mediterranean.

O-32. WHAT'S WHAT? DIFFERENCES AND SIMILARITIES IN POTTERY FROM PHENEOS, ARKADIA, AND THE AREA OF CORINTH

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The site of ancient Pheneos in Arkadia, Peloponnese, was the focus of a collaboration between the EFA Korinthias and the OeAI at Athens/University of Graz. From 2011 to 2015, they investigated the early Hellenistic fortification wall along the northern slopes of the settlement hill at Pheneos. On the hill's east slope, they uncovered an Archaic-Classical sanctuary that had been abandoned by the time work on the fortification began. Adjacent to this sanctuary and the fortification wall there is situated the major feature of the middle Hellenistic period, the "Hellenistic pit". Overall, the Greek-Austrian excavations on the settlement hill encountered numerous ceramic and other objects dating from the Neolithic to the Mediaeval period.

The ceramics from all chronological periods were studied in annual research campaigns following the excavations. In 2021/2022, samples were selected for petrographic and chemical analyses. A geological survey of the valley, aimed at locating and assessing raw materials,

completed the integrated approach of ceramic studies in the Pheneos valley, which was funded by the Austrian research foundation FWF in the frame of the project “6,500 years of solitude? Investigating pottery from Pheneos” (Testolini et al. [in press]).

While the scope of the FWF project is diachronic, the present paper focusses on the pottery from the 1st millennium BC. Petrographic, macroscopic, and chemical analyses have shown that Pheneatian potters from the Geometric through to the late Hellenistic period produced a broad range of pottery. Their output comprises fine and coarse ware vessels, utilitarian objects such as loom weights, and architectural ceramics such as roof tiles (Klöckl-Zorić 2025). The local fabric has been well characterised macroscopically, petrographically, and chemically (Burke et al. [in preparation]).

From a macroscopic perspective, however, the local fabric is at times indistinguishable from pottery that reached the Pheneos valley from the wider area of Corinth. This ambiguity most often affects very fine buff fabrics, but also occurs with larger coarse wares and objects such as perirrhanteria. The similarity derives not only from similar raw materials, but also from the typological and technological ceramic *koiné* that both, Corinth and its neighbours, and the Pheneos valley, are part of. For example, potters of both areas use clays that fire to a very pale brown colour, employ mudstone in coarse wares, apply glossy slips to fine wares, and produce a similar range of vessel shapes.

The results from petrography and NAA, however, have facilitated the detection of differences between pottery from the Pheneos valley and the area of Corinth,

with only few cases remaining uncertain. Thus, the analyses confirm that ceramics such as kotylai, lamps, skyphoi, and bowls were imported to Pheneos. These im-ports have probably inspired the local manufacture of items of the same shape and style. At present, however, it is uncertain whether all of the imported objects came from the city of Corinth, or from other production sites in the same cultural and geological setting. It is striking that a large chemical group apparently indicating “Corinthian” origin is currently known only from the pottery assemblage at Pheneos.

The scope of our paper, therefore, is twofold: to illustrate the various similarities of ceramic production in the Pheneos valley and the area of Corinth, and to present the results of our nevertheless successful attempt to differentiate between the local-Pheneatian and the pottery from the area of Corinth.

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O-33. ASSESSING THE IMPACT OF GROG TEMPERING ON PXRF COMPOSITIONAL SIGNATURES: A PETROGRAPHIC AND GEOCHEMICAL APPROACH TO BRONZE AGE POTTERY FROM CANNATELLO (SICILY)

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An integrated analytical approach combining thin-section petrography, scanning electron microscopy, and portable X-ray fluorescence spectroscopy (pXRF) aimed to examine the provenance and production technology of pottery from the Middle and Late Bronze Age settlement of Cannatello (Agrigento, Sicily; ca. 14th–12th centuries BCE). The settlement, located just inland from a major anchorage, lies in a strategic

position within the Central Mediterranean, and testifies to a high degree of connectivity, with imported materials from Sardinia, Malta, the Aegean, Cyprus, and the Levant. Of particular significance is the occurrence of both imported and locally produced Nuragic-style pottery, a distinctive feature of Cannatello among the sites with Sardinian connections across the Mediterranean at the end of the Bronze Age (Jones et al. 2014; Levi et al. 2017; Day et al. 2025). The local portion of this important ceramic assemblage is characterised by the practice of grog tempering and it is this feature which is investigated in this paper.

Grog tempering represents a key technological feature of the local ceramic chaîne opératoire in Sicily and the abundance of imported pottery at the site provides an opportunity to investigate whether imported ceramics, alongside local ones, were recycled as grog within the local production of Nuragic-style vessels.

Both Sicilian/Thapsos-Pantalica style and Sardinian/Nuragic style pots (n=70) were examined to explore the relationship between petrographic fabrics and pXRF compositional signatures. While pXRF provides a rapid and non-destructive means of identifying compositional variability (Cannavò et al. 2017; Hunt and Speakman 2015; Hein et al. 2021), petrographic analysis characterizes the mineralogical and textural features of both groundmass and grog inclusions (Cannavò et al. 2019). The integration of these datasets enables a critical assessment of the relationship between petrographic fabrics and geochemical signatures, while evaluating the strengths and limitations of pXRF for the analysis

of grog-tempered and compositionally heterogeneous ceramic assemblages.

Results show that multiple pXRF measurements on the same pots are coherent in 90% of the cases and that the locally made and imported pots are generally well separated geochemically. Special attention is devoted to vessels containing grog derived from imported ceramics, exploring the extent to which non-local grog may affect pXRF compositional signatures and whether geochemical data can contribute to a better understanding of their production and provenance.

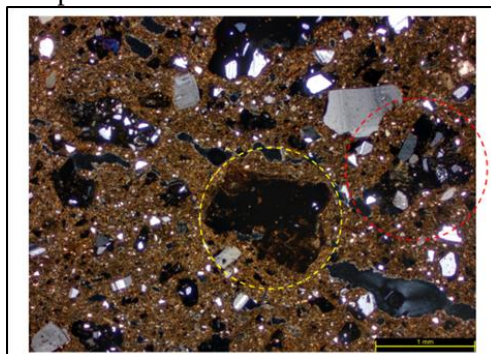


Figure 1. XP photomicrograph of pot CAN524 with grog from both local (yellow circle) and non-local (red circle) vessels.

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O-34. CERAMICS, RITUAL, AND MOBILITY AT THE SANCTUARY OF ZEUS ON MOUNT LYKAION: TRACING CHANGING COMMUNITIES OF PARTICIPATION FROM THE LATE BRONZE AGE TO THE CLASSICAL PERIOD

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The Sanctuary of Zeus on Mt. Lykaion in Arcadia provides a rare opportunity to investigate how ritual practice structured mobility and interaction over the long term, from the Late Bronze Age through the Early Iron Age. This paper presents results from an ongoing ceramic analysis project that explores how pottery deposited at the altar reflects changing patterns of pilgrimage, participation, and regional connectivity within the Peloponnese.

The current study has defined major fabric groups and their variation across key phases of ritual activity, characterised them technologically and compositionally, and reassessed the relationship between fabric, style, and chronology. Rather than treating ceramics primarily as indicators of exchange, the analysis approaches them as material components of ritual practice,

brought to the sanctuary as part of sacrificial and dedicatory acts. Shifts in ceramic provenance and technological traditions are therefore interpreted as evidence for changing communities of participants and evolving modes of engagement with the sanctuary.

Methodologically, the study combines WD-XRF analysis with multivariate statistics and targeted thin-section petrography, supported by newly acquired geological and archaeological reference materials from across the Peloponnese. The results reveal both diachronic changes in depositional practices - reflected in the types of ceramic objects placed in the altar - and shifts in the provenance of these 'sacrificed' vessels, with increasing diversity in ceramic origins over time. Together, these patterns highlight Mount Lykaion's gradual transformation into a supra-local ritual focal point and demonstrate how ceramic analysis can contribute directly to broader interpretative understandings of ritual practice, mobility, and social interaction in the ancient Greek world.

O-35. ATHENIAN VS LAKONIAN RED FIGURE: POTTERY FROM THE KERAMEIKOS SITE – AN ANALYTICAL SURVEY USING HANDHELD PORTABLE XRF (PXRF)

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An analytical study of an assemblage of fine ceramics from the Kerameikos site will be presented. The elemental compositions of 26 ceramic fragments belonging to 21 different artifacts, which can be dated to the 5th century BC, were analyzed using a handheld portable X-ray fluorescence device (pXRF). The measurements were non-invasive and they have taken place at the Kerameikos archaeological site, where the fragments are stored.

The investigated assemblage comprised plain miniature skyphoi and thymiateria as well as ten fragments of in total five red-figured vessels, which potentially had been manufactured in Laconia. Scope of the analytical study was an assessment of compositional variation, which was expected to indicate different production groups or the use of different clay pastes for the manufacture of different types of ceramics. Because the Kerameikos area in fact is known as an ancient pottery production centre, local origin was expected at least for a part of the pottery assemblage. Furthermore, the

analytical results were compared with reference data from former studies which included apart from fine ceramics also tiles and kiln tools supposedly manufactured on site using local attic clays. The study clearly indicated a distinct elemental composition of a part of the 'Laconian' red figured vessels, while individual fragments apparently belonged to vessels manufactured from local attic clays. The analytical results will be discussed in the context of stylistic classification and a potential extension of the present analyses collecting further reference data of ceramics and raw materials from Southeast Peloponnese.

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O-36. INTEGRATED TECHNOLOGICAL AND RESIDUE ANALYSIS OF ROMAN JUGS FROM ANCIENT OLYMPIA: PRELIMINARY FINDINGS

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This paper focuses on the technological examination of a group of semi-coarse pottery fragments, primarily of jugs and jars, from a well in the area of Leonidaion in Ancient Olympia. The Leonidaion was a large guesthouse located outside the sacred precinct, known as the Altis, on its southwestern side, near the workshop of Phidias and served as an accommodation space for the official guests during the Olympic Games (Mallwitz 1972; Arapogianni

2001; Mächler 2017, 2019; Schauer et al., 2024).

The assemblage consists predominantly of jugs and storage jars dating to the 2nd and early 3rd centuries AD. The vessels which have been analysed were recovered from the lower fill of the well. Originally intended for storage and transport of liquids, these vessels were subsequently reused for drawing water from the well. After breaking during use, the vessels remained at the bottom of the well, forming part of its use-related deposits.

Typological analysis indicates that the various jug forms may have been associated with different functions or contents, including the storage and pouring of water, wine and oil (Schauer, 1997). Ten samples from two wheel-made jugs (K12961 and K12965), both bearing a black-brown layer of variable thickness on their interior surfaces, were subjected to macroscopic and microscopic examination. The study had two main objectives: (a) to assign the jugs to specific ceramic fabric groups and (b) to investigate the nature of the black-brown layer preserved on their interior surfaces. Optical microscopy (OM-LED) and Munsell Soil Color Chart were used to determine the ceramic fabric of the jugs and the layer observed. Based on parameters such as hardness and porosity the sample material was classified as OL-FWIII fabric, a pale-buff fabric with chalky texture, quite porous with high frequency of medium to coarse, granular/angular, calcareous inclusions.

The light colour of the ceramic fabric has previously been attributed to the combined effect of the naturally calcareous clay deposits of the region of ancient Elis. (Michailidis et al., 2010; Rathossi and Lang, 2024), or to oxidising

firing conditions (Molera et al., 1998). Elemental micro-analysis of the jugs with SEM/EDS revealed a highly calcareous ceramic body (CaO >15 wt.%), correlating mainly with secondary calcite (Maritan, 2020) as showed through micromorphology and confirmed through ATR-FTIR analysis, as well as with post-depositional alterations. Its formation is favoured by the low porosity of the ceramics (resulting from low firing temperatures, <800–850 °C), and also by the repeated flood events that have been documented at Olympia throughout time (Slabon et al., 2025).

SEM/EDS of the visible black-brown layer revealed high carbon concentrations (C = 72–85 wt.%) indicative of organic material. Furthermore, its porous microstructure shown under the SEM microscope also supports an organic material, typically, that of a resinous coating (Font et al., 2007, Giampaolo et al., 2025). Similar coatings have been identified mainly on Roman amphorae, where they were used as a waterproofing agent to ensure the better preservation of the goods transported (e.g., wine, oil, olives, fish sauces, etc.) (Heron and Pollard, 1987).

ATR/FTIR was also implemented for the investigation of the visible layer following a dedicated protocol. Samples of approximately 5–10 mg. were examined both directly in ATR-FTIR, (a) in powder form without further preparation and (b) after selective extraction with specific organic solvents (Boyatzis, 2022). Traces of tar from a diterpenoid resin were detected. The above were also verified with GC-MS (showing oxidation products of abietic acid) which was additionally employed as a molecular identification technique. In addition, ATR-FTIR in certain cases showed

strong indication of organic salt traces, possibly calcium acetate or tentatively tartrate, an important biomarker of potential wine residues.

The results of this research successfully shed light on the technological choices and organic residues associated with the domestic pottery assemblage from the Roman-era Leonidaion. As such domestic vessels have previously escaped detailed archaeometric attention, particularly regarding residue analysis, the preliminary findings presented here provide essential new data that enhance our understanding of Roman domestic life in the western Peloponnese.

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O-37. GEOPHYSICAL INVESTIGATIONS AT THE SITE OF THE NEW ARCHAEOLOGICAL MUSEUM OF SPARTA

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A geophysical investigation was conducted at the site selected for the construction of the new Archaeological Museum of Sparta, located near the Eurotas River bridge at the entrance to the city, with the objective of detecting and delineating buried remains associated with ancient settlement activity. The survey was carried out exclusively using the resistance mapping method. Numerous subsurface resistivity anomalies were identified, several of which may be interpreted as indicative of buried ancient architectural remains. Some of these anomalies exhibit well-defined linear geometries, suggesting that they have anthropogenic origin.

It is worth noting that the investigation was carried out in a completely non-invasive and non-destructive manner, without causing any disturbance whatsoever to the site.

Resistance mapping: The method is also referred to as the electrical, or electrical resistivity mapping, or simply as DC method. It is based on the injection of

electric current into the ground through a pair of electrodes, and the measurement of the resulting potential difference between a second pair of electrodes. These measurements provide an estimate of the electrical resistance of the subsurface, which can subsequently be converted into a resistivity value for the investigated volume through a math formula.

A detailed description of the method is omitted here, since it is a well-established technique. For a comprehensive introduction, the interested reader is referred to Tsokas et al. (2009) among others.

Conduct of the survey and data processing: The survey area was subdivided into a series of 20 m × 20 m square grids. Measurements were acquired on a sampling grid with a spacing of 1 m, which was established separately within each survey square. The separation between the mobile electrodes was kept constant at 0.5 m, whereas the fixed electrodes were positioned at conventionally infinite distance, by themselves spaced approximately 0.5 m apart.

Data were subjected into a series of processing modules whose principles and goals were given by Scollar et al (1986). Figure 1 presents the resulted spatial distribution of electrical resistance. Numerous high-resistivity anomalies are seen, indicating the presence of relatively resistive subsurface features. Some of them display distinct linear alignments, suggesting the presence of subsurface structures that may be associated with architectural remains related to the ancient occupation of the site. However, the alignments do not appear to be well organized.

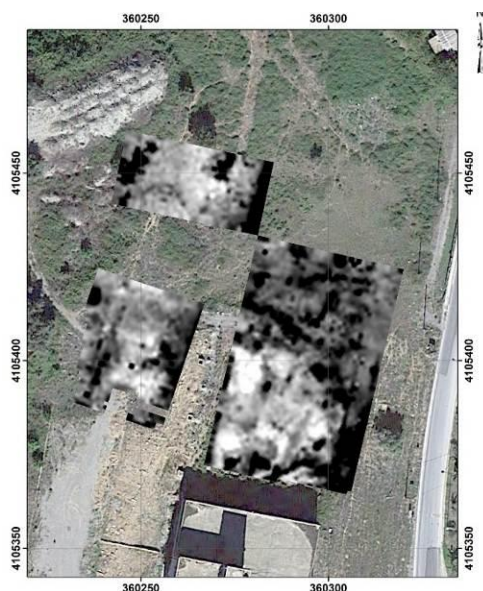


Figure 1. Distribution of resistance within the surveyed area. The grayscale tones are scaled between predefined minimum and maximum values.

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O-38. MATERIAL TRACES OF ASCALON'S URBAN WATER SYSTEM: A MULTISCALAR ARCHAEOLOGICAL APPROACH TO THE CASTELLUM AQUAE

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Traditionally, Ascalona has been interpreted as a chronologically stratified city, where water supply depended mainly on a multitude of wells connected to the aquifers; however, the evidence currently under study points to a planned water system of roman origin, articulated into strategic tanks, cisterns, fountains, and interconnected channels, in which the castellum aquae assumed a crucial role in the distribution and management of resources. The reconstruction of this layout requires a multiscalar and interdisciplinary approach, in which the interpretation of constructive traces and material characterization can reveal the logic of a complex and monumental water-management system.

The research adopts an approach that proceeds from the territorial context to

the archaeometric microscale. After a phase of graphical restitution, territorial and architectural analysis allow the spatial organization of the structure to be read according to modular principles of ancient construction practice. Archaeological, stratigraphic, and technological-constructive analyses distinguish phases, reuse, and transformations. The interpretive hypotheses are tested through FTIR, SEM, optical microscopy, thin sections, diatom analysis, and radiocarbon dating of controlled samples, while ancient sources guide the research questions and the validation of the material evidence. The investigations on the fortification walls have revealed atypical constructional features for this kind of system, including vertical and horizontal terracotta pipes and a stratified sequence of mortars and plasters that subdivides the masonry into functional and diachronic sections, allowing it to be reinterpreted as part of an integrated water system. Microarchaeological analyses show clear differences among the mortars, which are overall composed of a chalk-like calcitic carbonate matrix: the load-bearing wall phase is characterized by silicate aggregates in a proportion compatible with a 2:1 ratio relative to calcite; the later cistern infilling phase presents a more quartz-rich component with phytolithic inputs; while the foundation phase is marked by a higher presence of bioclastic fragments, especially marine shell fragments, suggesting different recipes according to structural function and broadly consistent with Vitruvian prescriptions in a coastal environment. The variations in the ratios between matrix and aggregates, in binder morphology and alteration state, therefore indicate the intentional use of

distinct preparations, coherent with a sequence of building phases and transformations of the water system. Radiocarbon dating, currently in progress on well-contextualized organic inclusions, may ultimately transform this relative sequence into an absolute chronology.

These findings allow the monument complex to be reinterpreted. The study informs conservation and restoration strategies through a reliable stratigraphic and material reading, helping identify compatible materials from both a chemical-physical and a philological point of view, providing a scientifically grounded framework for the protection and restoration of the monument.

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O-39. RECONSTRUCTING FIRST EXCHANGE NETWORKS IN THE MAYA REGION: INTEGRATION OF ARCHAEOMETRIC AND SPATIAL DATA THROUGH RDBMS

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Although compositional and spatial analysis are methods that had been widely used by archaeologist, they are rarely used together for studying trade networks. This is particularly true in case of Maya archaeology, a field that in recent years had experienced a revolution thanks to the implementation of LiDAR. It rapidly accelerated the process of site identification in the depths of tropical Maya Forest. Process that previously was an arduous and expensive, now can be conducted in front of a computer without even leaving a room. Access to LiDAR data allows for preliminary spatial analyses that can suggest which areas are particularly worth excavating. Also for decades, pottery from this area was a subject of a meticulous sample collection, that resulted in big reference set of NAA data. Compositional analysis of pottery using NAA is a good method for determining samples provenance. This in turn can be a basis for the reconstruction of long-distance exchange routes that occurred at the dawn of Maya civilization and later fuelled its rise. In the present study emergence of exchange

networks is viewed through the lens of Mars Orange Paste Ware. This class of fine paste pottery from Middle Preclassic Period is thought to be one of the first commodities that were a subject of long-distance exchange in the Maya Area. Mars Orange pottery is being found all over the Maya Lowlands, with some sherds recorded hundreds of kilometres from its proposed production centre in Central Belize.

The aim of this paper is to present a workflow and its operating environment through which compositional data can be efficiently integrated with spatial analysis. Relational database management systems like PostgreSQL can store multiple types that can be used in multivariate analyses of sites and objects. Moreover thanks to dbplyr package compositional data stored in PostgreSQL can be easily processed in R and later georeferenced in GIS through PostGIS extension. So while dealing with exchange networks, chemical groups that are a result of NAA data processing can be spatially oriented and then used as waypoints in least-cost path analysis. RDBMS allows not only to store all of the data in one place, but also to trace data origin through extensive reference system. Well-designed environment enables efficient data migration and smooth workflow despite the use of multiple types of software.

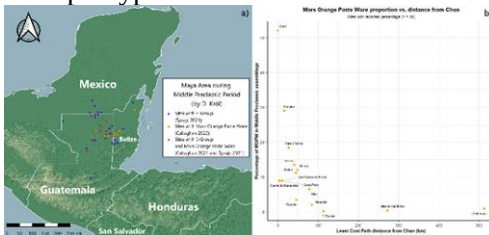


Figure 1. a) Map of sites with reported Mars Orange pottery; b) Scatterplot illustrating relation between Mars Orange percentage at Middle

Preclassic sites and their distance from the production centre.

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O-40. INTEGRATING ENVIRONMENTAL DATA INTO AN ANALYTICAL ALGORITHMIC WORKFLOW: A COMPREHENSIVE FRAMEWORK FOR ASSESSING AIR POLLUTION-INDUCED DEGRADATION OF BUILT HERITAGE

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Air pollution and climate change degrade archaeological building materials through the complex synergistic action of exposure, deposition, and moisture-assisted material chemical alterations. A methodological fragmentation is apparent through the focus of atmospheric studies on describing ambient concentrations and sources, whereas material analyses characterise an accumulated surface record. Although these quantities are related, they are rarely interchangeable. Building on an established Raman-micro-XRF workflow (Mitsos and Pouloupoulos, 2025), this study develops a non-circular framework connecting four monuments across the Athens metropolitan area with independent source-resolved atmospheric evidence. It aims to test whether

monument material states preserve transformed chemical patterns concordant with urban aerosol source families, while accounting for substrate contribution, surface geometry, and cumulative black-crust formation.

Raman spectra are encoded as binary peaks and phase groups, namely carbonates, sulphates, mineral dust, soot, and aromatic/organic signals. Processed micro-XRF cross-section line scans are similarly converted into descriptors, such as surface-to-interior enrichment, integrated excess of specific elements, and elemental co-localisation, considering that depth cannot be uniformly treated as chronology (Bergomi et al., 2025). Material states are derived through Gower-distance mixed-data analysis. Robustness is assessed by grouped resampling of complete scans and sensitivity to pre-processing, scaling, and exclusion of substrate-derived elements. Contextual variables - height, shelter/rain exposure, surface orientation - are introduced after analytical patterns are established.

An independent environmental layer combines long-term/seasonal pollutant trends, temperature, relative humidity, precipitation, source-bearing winds, surface-to-source alignment, and PM2.5 receptor-model profiles. It defines traffic/fossil combustion, biomass burning, secondary/regional aerosol, heavy-oil/shipping, mineral dust, and marine salts. PAH/OPAH evidence supports broad carbonaceous and oxygenated-organic states, without referencing individual compounds (Theodosi et al., 2018; Tsiodra et al., 2024).

The presented framework therefore separates exposure, deposition, and material transformation, testing whether

sample and monument differences agree with independent atmospheric evidence. Traffic-associated particles with Cu-Zn-Pb/carbonaceous signatures and sulphate/gypsum content form the strongest shared pattern. Their different weighting in air and crust plausibly reflects local deposition patterns, past accumulation, and seasonal variations. Ultimately, the study reports the stability and uncertainty of source-concordant patterns instead of assigning airborne source percentages directly to degradation layers, providing a reproducible basis for pollution-aware diagnosis and monitoring.

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O-41. CLIMATE CHANGE IMPACTS ON CULTURAL HERITAGE IN THE SOUTHWESTERN PELOPONNESE BASED ON CLIMATE MODEL PROJECTIONS

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To examine the impacts of climate change on cultural heritage sites in the South-Western Peloponnese a climate data-analysis was performed at three culturally sites selected on the basis of regional environmental variability and proximity.

The selected sites were: (a) Methoni, a coastal site, at sea level, with the risk of seawater intrusion, and exposure to strong winds and waves, particularly the semicircular tower at the northern fortification, (b) Ancient Messini, an inland site, at 320m, that may suffer from structural damage due to floods, prolonged droughts and wild fires, and (c) Ancient Olympia, situated on a riverine/complex terrain at 29m that may suffer from the overflow of the Kladeos river also in addition to landslides and wild fires.

The climate parameters used in our analysis, are: (a) Mean daily temperature, (b) number of days with temperatures above 35°C for the period June-

September, (c) number of tropical nights (nights when temperature does not drop below 20°C), whereas for precipitation (d), the number of days with precipitation lower than 10mm, between 10-20mm and above 50mm corresponding to intense rain events prone to floods were selected. The projected climate parameters for the period 2030–2060 have been compared with the historical baseline (1970–2000), using simulations from selected regional climate models (RCA4 MPI-ESM; Muller et al. 2018) and for two RCP scenarios (RCP4.5 and RCP8), providing the means to investigate site-specific climate projections.

Our results bring evidence for significant variations of the climate expectations among these relatively nearby sites, facilitating the identification of site-specific protection policies and adaptation measures, and they are in general agreement with Kapsomenakis et al. (2023) and Nastou and Zerefos (2023) and Mavrakou et al. (2025). As an example, we present in Figure 1 a comparison of the average number of days of very hot summer days between the two periods of interest and for two RCP scenarios.

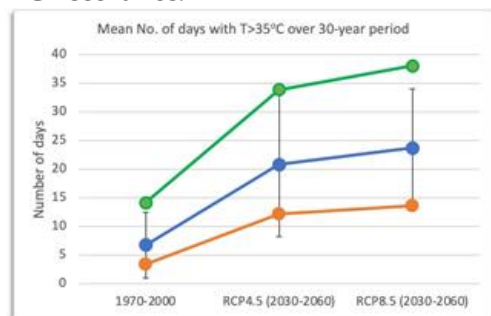


Figure 1. The increase of the mean number of days with $T_{max} > 35^{\circ}\text{C}$ of the 30-year period, between 1970-2000 and 2030-2060 for Ancient Messini (blue), Methoni (orange) and Olympia (green) and for the two climate scenarios (RCP4.5 and RCP8.5). The scatter around the mean is depicted

only for the case of Ancient Messini, in order to avoid overcrowding.

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O-42. NUTRIROOTS – A TIME-TRAVEL THROUGH HUMAN PAST: EVOLUTION’S GUIDE TO HEALTHY EATING

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Human dietary strategies have been shaped by millions of years of biological and cultural evolution, yet contemporary food environments differ radically from those in which many metabolic traits evolved. Bioarchaeological and evolutionary approaches increasingly provide critical insights into the long-term interactions between diet, biology and disease.

Stable isotope analysis and ancient DNA studies have transformed our understanding of population history, dietary change and gene-culture coevolution. At the same time, evolutionary medicine has highlighted how traits once advantageous may contribute to health risks under present-day dietary conditions, such as obesity and type 2 diabetes. These strands of research, however, are rarely combined with structured educational programmes aimed at translating scientific evidence into public understanding.

In NutriRoots we develop an interdisciplinary methodology that integrates archaeological, stable isotope and aDNA data with school-based learning and public outreach, in the context of a serious game. By actively engaging school groups as informal learning environments, we aim to foster awareness among younger age groups about the historical evolution, the cultural dimensions and the long-term significance of balanced dietary practices, in an edutainment way.

NutriRoots provides a scalable model for translating bioarchaeological research into evidence-based nutritional awareness while simultaneously generating new interdisciplinary datasets on the co-evolution of human diet, culture, and biology.

We compiled a curated set of diet-related genetic variants, including lactase persistence (LCT), glucose-6-phosphate dehydrogenase deficiency (G6PD), amylase copy number variation (AMY1), alcohol metabolism polymorphisms (ADH1B, ALDH2), and loci associated with food intolerance. Allele frequencies are tracked longitudinally across approximately 10,000 published ancient DNA genomes and analysed in parallel with 24,500 published stable isotope measurements ($\delta^{13}\text{C}$, $\delta^{15}\text{N}$, $\delta^{34}\text{S}$) derived from corresponding or contemporaneous skeletal assemblages.

To investigate temporal relationships between dietary behaviour and genetic adaptation, we applied a layered analytical framework combining hierarchical Bayesian spatiotemporal modelling, time-lagged cross-correlation analysis, and structural equation modelling. This framework enables testing whether shifts in isotopic dietary signatures precede, coincide with, or

follow selective changes in adaptive alleles across regions and time periods, thereby distinguishing cultural dietary change from genetically driven metabolic adaptation.

These findings are integrated into an interactive virtual game designed for students, in which users explore past environments to examine links between evolution, diet, and adaptation, with the broader aim of supporting informed dietary choices.

Our approach links paleodietary reconstruction with genetic variation related to food tolerance and metabolism, situating these patterns within their archaeological and environmental contexts. Rather than treating bioarchaeological research solely as retrospective analysis, NutriRoots embeds ongoing scientific work within an educational framework.

Acknowledgments

The project “NutriRoots - A time-travel through human past: evolution’s guide to healthy eating” is implemented in the framework of H.F.R.I.’s 6th Call of “Science and Society” Action entitled “Current Nutritional Awareness” (H.F.R.I. Project Number: 29369).

**O-43. BEYOND 3D
MANDIBULAR
MORPHOLOGY:
INVESTIGATING COMPLEX
INTERSECTIONS OF DIET,
STATUS, AND URBANIZATION
IN ROMAN NORTHERN
GREECE**

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The expansion of Roman networks (“Roman globalization”) reorganized food systems and local economies, but these changes did not affect everyone equally. Urban and rural populations, as well as individuals of different social status, likely consumed different foods and relied on distinct food-processing techniques. Over time, such dietary practices influence mandibular loading and skeletal functional adaptation. This

research investigates the relationships among diet, urban living, and social status at two Roman-period sites in northern Greece (1st–4th century AD) by integrating mandibular morphology and biomechanics, stable isotope analysis, and archaeological burial evidence.

The study sample comprises 118 individuals: 65 from urban Thessaloniki, the provincial capital (30 females, 35 males), and 63 from rural Mavropigi in western Macedonia (32 females, 31 males). Mandibular function was assessed using 3D shape analysis, cross-sectional geometry at the M1–M2 junction, and the size of masticatory muscle attachment areas. Adult dietary patterns were reconstructed carbon ($\delta^{13}\text{C}$), nitrogen ($\delta^{15}\text{N}$), and sulphur ($\delta^{34}\text{S}$) isotope analysis of femoral bone collagen. Social status was evaluated using gravegoods, grave types and overall burial practices.

The larger mandibular size, the specific shape changes, such as wider bigonial breadth and a broader vertical ramus, and more developed masticatory muscle attachments indicate that individuals from Thessaloniki experienced greater chewing forces. Although differences between the two settlements exceed the sexual dimorphism observed within either population, high-status males from Thessaloniki clearly stand out. Their significantly larger mandibles cannot be explained solely by greater body size, nor by the wider chronological span of the Thessaloniki sample. Furthermore, they are not associated with specific burial areas that might suggest a shared genetic background, though genetic factors cannot be entirely excluded. In contrast, lower-status individuals from Thessaloniki cluster closely with the rural Mavropigi population with both

groups exhibiting smaller and less robust mandibles. By combining morphological, isotopic and burial evidence, we explore the dietary practices and food-processing techniques that likely underpinned these distinct patterns of functional adaptations across social strata.

Acknowledgments

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O-44. NEW INSIGHTS INTO URBAN AND RURAL BIOLOGICAL STANDARDS OF LIVING IN BYZANTINE GREECE

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This study investigates Biological Standards of Living (BSL), which are assessing health and wellbeing beyond monetary measures, using indicators stature, enamel hypoplasia (EH), and life expectancy to examine urban and rural living conditions in Greece during the Middle to Late Byzantine period (10th – 15th century AD). Skeletal remains from 622 individuals analyzed from recently excavated cemeteries, representing one of the largest Byzantine bioarchaeological samples in Greece. The sample includes individuals from urban Thessaloniki (n=267) and the rural sites of Maximianopolis in Thrace (n=116) and Pellina in Thessaly (n=239). Stature was estimated from long bones (Martin, 1928), and calculated using population-specific regression equations developed by Koukli et al. (2023), while EH was recorded by type and severity

(FDI, 1982; Brothwell, 1981). Statistical analyses included descriptive statistics, ANOVA, chi-square tests, and demographic life table analysis. Urban individuals were significantly shorter than rural (160.6 ± 6.7 cm vs 164.2 ± 8.2 cm; $p=0.005$) and showed lower life expectancy ($e_{20}=23.2$ vs 27.1 years). LEH prevalence was similar between groups (48.4% vs 44.6%). Rural males were significantly taller than urban males ($p=0.028$), no significant differences were observed among females. Rural females showed higher EH prevalence than rural males (60.9% vs 37.5%). Mortality probabilities indicate earlier mortality peaks among urban females (20 years) compared to rural females (30 years), males showed similar mortality patterns. Overall, Thessaloniki individuals appear to have experienced greater growth stress and lower survival, likely related to urban disease burden and nutritional stress. Future biomolecular analyses (aDNA, isotopic), may further clarify health and lifestyle differences in Byzantine populations.

Acknowledgments

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O-45. GEOCHEMISTRY, TAPHONOMY AND PRESERVATION OF EARLY MEDIEVAL HUMAN REMAINS ON MALIGRAD, PRESPA LAKE

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Understanding past burial practices is often hindered by issues of data recovery. Looting, re-use, and the process of decay result in gaps in the mortuary record (Stodder, 2018). Importantly, the changes in soil characteristics can provide important clues as to the history of the burial in its local environment (García-López et al. 2022). In addition, chemical analysis of soil samples recovered during excavation has provided useful insights into identifying the traces of decayed objects, including objects that were partially or entirely absent at the time of excavation (Sulas et al. 2022). Here we present the results of combined geochemical and osteological analysis of

early medieval burials on the islet of Maligrad in Great Lake Prespa.

Soil samples, originally collected from 4 graves for general environmental sampling, were subjected to portable X-Ray Fluorescence (pXRF) and Fourier Transform Infrared (FTIR) analysis. The graves studied varied in their condition, number of individuals, and grave goods, with one grave (Grave 34) containing metal artifacts which were not present in other burials. The results were compared statistically to each other and to other contexts to determine the relationships between the elemental concentrations and the IR indices for organic, carbonate, and phosphatic content. These indices were compared against the preservation condition and contents of the graves in order to determine the factors driving preservation and deterioration.

Preliminary results show not only variations in mineral, organic, and metallic content, but the varied impact those components have on the burial microenvironment. The geochemical results show a relationship between organic content and elemental composition, with respect to S, P, and K. In particular, Grave 34, in addition to traces of Cu, Sn, Pb, and Cr from the metal artifacts shows a stronger signal for Ca (Figure 1), possibly related to alkaline or less microbial conditions created by the presence of copper/bronze. Further analysis will link the geochemical environment to the preservation of the remains, allowing for a better understanding of taphonomic processes and the conservation of ancient burials.

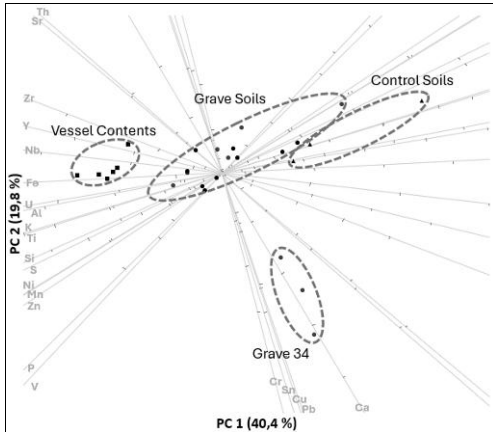


Figure 1. PCA of pXRF measurements from Maligrad.

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O-46. MINING, TRADING, AND TRANSPORTING OF COLORING MATERIALS IN THE ROMAN WORLD

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Coloring materials played a fundamental role in the economic, artistic, and technological development of the Roman world. Pigments such as cinnabar, ochres, and green earth were extracted from geographically diverse sources and distributed through extensive trade networks that connected mining districts, production centers, workshops, and consumers across the Mediterranean and beyond. While previous studies have provided detailed look into individual pigments or analytical techniques, coloring materials have rarely been considered as interconnected economic resources embedded within broader systems of resource exploitation, technological knowledge, and commercial exchange. Drawing upon historical sources, archaeological evidence, and modern analytical data, this study presents a comprehensive framework for understanding the extraction, production, circulation, and application of pigments within Roman economic and social landscapes. The value of this framework is demonstrated

through an ongoing case study of Pompeii, where pigments preserved in their original paint bowls that offer a unique opportunity to investigate coloring materials before their application to wall paintings. Following the earthquake(s) after 62 BCE, many decorated buildings were undergoing renovation when the eruption of Vesuvius in 79 CE abruptly preserved artists' work in progress. Within the framework of The American Institute for Roman Culture Ancient Rome Live program, these pigments have been analyzed using a combination of light microscopy, μ XRF, μ FTIR, μ Raman spectroscopy, and synchrotron-based 2D- μ XRD mapping, allowing the characterization of samples in microgram quantities and the establishment of compositional fingerprints for the most commonly used coloring materials. Results indicate that while some pigments originated from local geological sources, others were mined, traded, and transported over long distances from across the Roman world and the wider Mediterranean. Integrating these analytical results with archaeological and historical evidence demonstrates how pigment provenance reflects patterns of resource procurement, technological practice, and commercial exchange. Beyond their decorative function, coloring materials emerge as valuable proxies for reconstructing trade networks, economic connectivity, and the distribution of wealth and resources within Pompeii and the Roman world more broadly.

O-47. THE PURPLE CODEX, MS 67: A MULTI-MODAL SPECTROSCOPIC INVESTIGATION AT THE MONASTERY OF AGIOS IOANNIS THEOLOGOS IN PATMOS

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The Purple Codex, MS 67 (Codex Purpureus: Tetraeuangelium, fragmenta ex Marco, 33 folios) of the Holy Monastery of Agios Ioannis Theologos in Patmos Island is one of the oldest and rarest surviving Gospel manuscripts, dating to the 6th century CE. Its investigation provides valuable information on the materials, manufacturing technology, and preservation state. This study presents a non-invasive multi-analytical investigation of selected folios using micro X-ray fluorescence spectroscopy (micro-XRF), Attenuated Total Reflectance Fourier Transform Infrared Spectroscopy (ATR-FTIR) and UV–VIS–IR multispectral imaging (Aceto, Agostino, et al., 2014).

Micro-XRF was employed to investigate the elemental composition of the purple-dyed parchment and the ink. Particular attention was given to the detection of bromine as a potential indicator of the purple dye and to the characterization of the metallic composition of the script. The elemental analysis revealed that the ink consists of an Au–Ag–Cu alloy, while the upper marginal chapter title (titlos) was executed with a gold of higher, distinguishing it from the gold used in the main script (Aceto, Idone, et al., 2014).

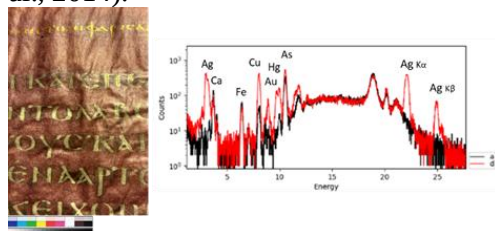


Figure 1. Detail of the Purple Codex (MS 67) (left) and representative XRF spectra of a. the parchment (black) and b. gold ink (red) (right), showing the presence of Cu, Au, Ag and Hg in the gold ink.

ATR-FTIR spectroscopy was employed to investigate the molecular composition of the collagen-based parchment support, the additives and binders associated with the writing material. The combined analytical evidence is consistent with the application of shell gold rather than gold leaf.

Multispectral imaging provided complementary information on both the writing materials and the manuscript support. The technique enhanced the visualization of the ink and revealed that the lettering remains visible from the reverse side of the folios due to the exceptional thinness and translucency of the parchment. This observation highlights the remarkable craftsmanship involved in both the preparation of the writing support.

To further investigate the technology of the ink, relevant recipes preserved in Byzantine manuscripts (Schreiner & Oltrogge, 2011) were examined and compared with the analytical findings obtained from the purple codex. The evidence provided by the recipes was subsequently compared with the results of the multimodal analysis of the purple codex, in order to evaluate possible correspondences between the prescribed Byzantine practices and the materials and technological features observed in the original ink.

The integration of elemental, molecular, imaging and experimental approaches demonstrates the potential of non-invasive archaeometric techniques for investigating Byzantine manuscripts. The results contribute to a deeper understanding of the materials, production technology, and exceptional craftsmanship of the Purple Codex of Patmos while establishing a methodological context for the study of similar illuminated manuscripts.

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O-48. MATERIALS AND SKIN-TONE PRODUCTION TECHNIQUE IN BYZANTINE MURAL PAINTINGS FROM EASTERN CRETE (LASITHI – 8TH-16TH C.)

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The execution of human flesh tones presented a distinct problem in Byzantine mural painting production. Unlike the monochrome areas that often characterise Byzantine painting, which are generally produced through uniform paint applications (Winfield 1968), flesh-tone (incarnatio, σαρκόχρωμα) can only be achieved through the layering and mixture of more than one pigment. This was already recognised in antiquity, when Pliny the Elder's account of the "tetrachromatic" palette of Apelles and Zeuxis - white, yellow ochre, red ochre, and black - framed flesh tone as a

question of technique, rather than material range. This theme resurfaces in later technical literature, from Cennini's step-by-step instructions, to Vasari's praise of painters for their masterful blending of flesh. Within the Byzantine tradition, the Dionysius of Fournas's Hermeneia catalogues a related workshop practice (proplasmos (dark base), glykasmos (progressive lightening), and final highlighting) offering a documentary framework for archaeometric analyses.

In this work, the focus is set on eleven churches in the Lassithi prefecture of eastern Crete, Greece, spanning from the 8th to the 16th century, for which archaeometric data have been interpreted with the aim of comparing techniques and materials used to produce flesh-tones. Building on the diachronic pigment survey previously conducted on this dataset (Helvacı et al. 2026), which centred on the characterisation of red pigments across the decorative programme, the present study includes additional cross-sections and painting areas which broaden the basis for discussing flesh-tone rendering, using the new data to reconstruct the technique and practice of the painters.

The analytical set-up consisted of technical photography (TP) in visible and UV light, digital optical microscopy, Fibre Optic Reflectance Spectroscopy (FORS), portable X-ray fluorescence spectroscopy (pXRF), and SmART_scan elemental mapping. Micro-samples from selected flesh-tone areas, prepared as cross-sections, were further examined through polarised light microscopy (PLM), SEM-EDS, and μ XRD, with the aim of developing a thorough understanding of the final pictorial effect through an integrated investigation of the

painted layers' stratigraphic structure and their elemental and mineralogical composition.

Close reading of the pXRF data, together with the PLM micrographs and elemental maps, revealed a limited pigment palette, consisting of red and yellow ochres, vermilion (cinnabar), red lead, carbon black, and lime white. Despite the few employed materials, their application reveals a high degree of technical mastery, by which a considerable diversity of pictorial effects was achieved through subtle variation in pigment combinations, layer structure, and paint thickness.

For instance, in the 15th century Church of St. George, in Epano Simi (Figure 1), flesh tones were built through the proplasmos + glykasmos protocol, with controlled pigment mixtures used at each stage to achieve subtle chromatic transitions. In the 14th century Church of St. Nicholas, in Ziros, different techniques were adopted even within a single painting campaign: while some figures still show the conventional proplasmos + glykasmos protocol (Figure 2), others show flesh tones that were executed through a balanced mixture of yellow ochre and carbon black, thus directly establishing the darker areas of the complexion and yielding a naturalistic effect with fewer superimposed layers (Figure 3). In the 16th century Church of St. Paraskevi, in Ziros, the treatment of flesh tones exemplifies the Cretan School approach, for highlights (psimythia) represented by dense, fine, parallel lines of lime white, which facial features through precise and geometrically ordered brushstrokes, were applied over a yellow-ochre ground.

This heterogeneity in the results indicate that the flesh-tone production functioned

as a site of technical negotiation throughout the corpus, rather than as a fixed or purely canonical procedure. The persistence of a narrow material palette, alongside considerable variations technique, suggests that painters retained meaningful freedom in solving the representational problem of flesh-tones, even within an artistic tradition governed by strong iconographic and technical conventions. Read alongside the textual tradition, this material evidence positions flesh-tone execution as a genuinely comparative category, capable of tracing technical continuity and change across the Byzantine and post-Byzantine periods, and situating the Lassithi corpus within the wider Mediterranean dialogue between Byzantine and Renaissance pictorial practice.

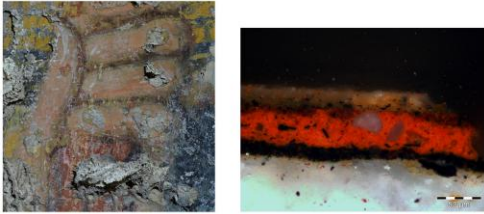


Figure 1.



Figure 2.

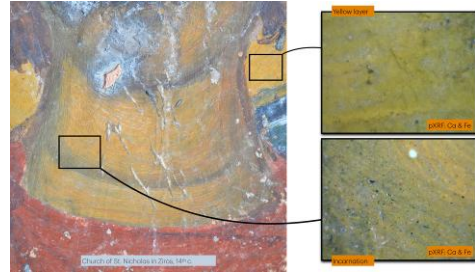


Figure 3.



Figure 4.

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O-49. NON-INVASIVE ANALYSIS OF CYPRIOT COMPOSITE ICONS: PRELIMINARY RESULTS

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The paper presents the research objectives, methodology, and preliminary results of the grant project Non-Invasive Analysis of Cypriot Composite Icons, funded by the National Science Centre, Poland (2024/53/N/HS2/01549). The project is conducted at the Institute of Art History of the Jagiellonian University in collaboration with the Andreas Pittas Art Characterization Laboratories (APAC Labs) of the Cyprus Institute.

The project focuses on so-called composite icons (Greek: σύνθετες εικόνες), that is, icons consisting of two panels – often created in different periods – inserted one into another. Byzantine and post-Byzantine icons of this type were first identified by Panagiotis Vocotopoulos (Vocotopoulos 2000; Vocotopoulos 2002). Since then, they have appeared only sporadically in scholarly literature, mostly associated with methods of preserving icons. Their unusual form, however, suggests a far more complex phenomenon.

The project examines a group of fifteen composite icons in Cyprus that were not included in Vocotopoulos's study. Most

of these icons date to the sixteenth century and display characteristics that clearly distinguish them from composite icons produced in other regions (Zaprzalska 2024). Its aim is to provide a comprehensive analysis of these objects and to reinterpret the phenomenon of icon reuse through insertion by investigating their materials, techniques, and historical development. Art-historical research is complemented by non-invasive technical methodologies led by the APAC Labs of the Cyprus Institute, combining advanced digital imaging and spectroscopic methods, including Ultraviolet Fluorescence (UVF), Infrared Reflected Imaging (IR), Infrared False Color processing (IRFC), Reflectance Transformation Imaging (RTI), X-ray Radiography (XRR), and X-ray Fluorescence Spectroscopy (XRF).

The approach employed was first applied in the study of the composite icon of the Virgin Mary and Child, known as Panagia Valieriotissa, from the Church of Saint Nicholas in Palodeia, as part of a previous project led by the APAC Labs of the Cyprus Institute and funded by the Excellence Initiative at the Faculty of History, Jagiellonian University. The results confirmed the great potential of non-invasive methods for analyzing composite icons (Zaprzalska et al. 2024). Unlike the earlier work, the current project involves research carried out in situ, with all analyses performed within the churches and monasteries where the icons are preserved. The choice of non-destructive methods was intentional, as they enable the acquisition of detailed analytical information while preserving the physical integrity of the studied objects. This is particularly important in the case of icons, which are regarded not only as works of art but also, by their

users and custodians, as sacred objects. This non-invasive approach provides valuable imaging and analytical data which, when appropriately interpreted, enable a deeper understanding of the composite icon as a complex material object, shedding light on the diverse techniques involved in its creation, modification, and reuse over the centuries.

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O-50. RECONSTRUCTING ROMAN TRADE NETWORKS THROUGH EGYPTIAN BLUE: ARCHAEO-METRIC INVESTIGATION OF PIGMENTS FROM NORICUM

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Egyptian blue is a complex silica–calcite–copper synthetic pigment that represents an important indicator of technological knowledge, cross-craft interaction, and long-distance exchange in the ancient world. As a material requiring expertise from pigment, glass, and metallurgical production, Egyptian blue provides valuable insights into economic and technological networks within the Roman Empire. Although it was widely used in Roman wall paintings, only a limited number of production workshops have been identified, leaving many questions regarding its manufacture and distribution unresolved. This study investigates the provenance of Egyptian blue pigments from Roman wall paintings in the province of Noricum and explores the implications for trade and production networks.

Egyptian blue samples were collected from wall painting fragments recovered from several sites in Roman Noricum. Trace element analysis and lead (Pb) isotope measurements were conducted to characterize the copper component of the pigment and to identify potential source regions. The analytical results were compared with published datasets from other Roman sites, particularly Pompeii, as well as with known ore deposits across Europe.

The trace element and Pb-isotope signatures of Egyptian blue samples from the earliest Roman settlement at Magdalensberg (1st century CE) show strong similarities to pigments recovered from Italian wall paintings. Samples from later periods (2nd–3rd centuries CE) at Teurnia, Flavia Solva, and Celeia form a slightly distinct but related compositional group. Nevertheless, all analyzed samples are consistent with copper sources associated with Hercynian-age ore deposits, including regions in the Southern Alps, Tuscany, Switzerland, and Slovakia.

The results support the hypothesis that a major Egyptian blue production hub operating in the Bay of Naples, Italy, from the 1st century BCE may have supplied pigments to Noricum. The compositional variability further suggests that this production hub obtained raw material from various mining regions. The occurrence of substantial quantities of Egyptian blue at major commercial centers in Noricum, without evidence of local production workshops, highlights the importance of trade in the distribution of this pigment. By combining archaeometric provenance data with archaeological context, this research contributes to the reconstruction of economic and technological connections

between Roman provinces and demonstrates the value of Egyptian blue as a proxy for understanding ancient production and exchange systems.

O-51. EGYPTIAN BLUE PAINTING TECHNIQUES IN THE PALATIAL COMPLEX OF HERODIUM

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Herodian wall paintings in the province of Judaea show a complex palette, consisting of various pigment of geological origin, organic pigments, and the synthetic Egyptian Blue, illustrating the traditions and technologies of Roman Empire paintings. A unique assemblage including wall paintings, ingots of Egyptian blue, and bowl fragments with pigments were found in the Royal Reception room of the palatial complex at Herodium, associated with King Herod (37-4 AD). The wall paintings show multi-layered secco applications with various pigments, overlying several layers of paints, providing various chromatic values. The painting techniques show to which extent color was manipulated when applying layers of pigments, versus when using a mixture of pigments in the same layer (Figure 1). The approach in this study integrated non-invasive analytical methods, including portable X-ray fluorescence (pXRF), fiber optic reflectance spectroscopy (FORS), and hyperspectral and VIL-imaging, with destructive methods including thin section analysis,

and Infrared and Raman spectroscopy. The analysis show that the pigments palette includes Egyptian blue, green earth, different ochres, Red lead, cinnabar, Madder Lake and carbon black. Egyptian blue mainly functioned as a discrete, chromatically dominant pigment, as a base for other pigments to be applied on. In some cases, it was found in mixtures with Madder Lake and green earth. The choice of using only secco, and applying Egyptian blue as a single colorant, allowed to determine the production technology, based on Infrared peak analysis. We also discuss how Egyptian Blue from pigments in bowls are purple in colour, perhaps imitating Tyrian purple from sea snails, which suggests a sophisticated color manipulation that mimics organic pigments. Significant amounts of sulphates are presented around the site, possibly altering the modern perception of colours via alteration and degradation of pigments, as detected by changes in the reflectance colorimetric values, showing whitening and saturation loss. Overall, the study demonstrates the broad possibilities of Herodian artisans applied at different design layers at the palatial complex.

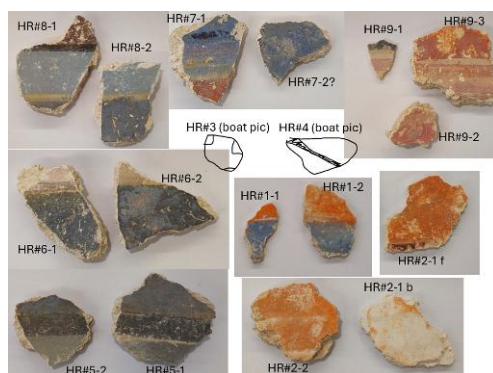


Figure 1. Painted wall paintings from Herodium.

O-52. VIL PHOTOGRAPHY FOR MONITORING THE CLEANING OF EXCAVATED SURFACES BEARING EGYPTIAN BLUE

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Building on the pioneering work of Ioanna Kakoulli and collaborators on the identification and mapping of Egyptian blue through visible-induced luminescence (VIL), this study examines the value of VIL not only as a pigment-detection method but also as a conservation documentation tool during surface cleaning. The research focuses on excavated inorganic substrates where pigment residues may survive as sparse or visually imperceptible particles and are therefore vulnerable to inadvertent loss during routine treatment.

White marble tokens painted in the laboratory with an Egyptian blue layer applied without binding medium were subjected to controlled brush cleaning under repeatable conditions. Visible and VIL images were acquired before and after intervention with a modified full-spectrum camera, IR-pass filtering and stable imaging geometry, and then processed in ImageJ using thresholding and region-of-interest analysis. The results show that VIL detects extremely small quantities of Egyptian blue and records changes that are not adequately visible in conventional photography.

Mild mechanical cleaning produced different responses, including partial loss, redistribution and local exposure of the pigment. A simple quantitative parameter based on luminescent area and mean brightness supported comparison between pre- and post-cleaning states. The study therefore proposes VIL as a practical, low-cost method for pre-cleaning assessment and stepwise monitoring of treatment, in direct continuity with the analytical and documentation legacy of Ioanna Kakoulli.

Figure 1 presents the comparative VIS/VIL documentation before and after cleaning, highlighting pigment redistribution and signal change that are not readily visible in standard photography.

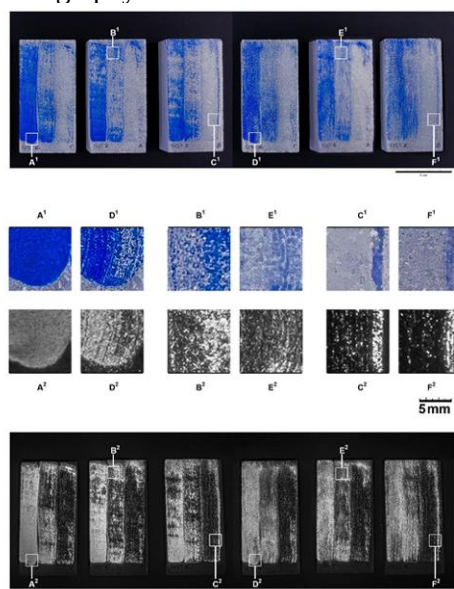


Figure 1. Visible and VIL images before and after cleaning.

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O-53. EGYPTIAN BLUE EVERYWHERE: EXPLORING THE USES OF EGYPTIAN BLUE BEYOND PAINTING

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Egyptian blue is a substance obtained by firing silica sand, calcium carbonate, and a copper-containing material. Primarily, Egyptian blue has been ground into a blue pigment and used for painting in the ancient Mediterranean world for millennia. However, over time, and amongst different cultures, Egyptian blue was also employed in a variety of applications in addition to its use as a

paint. The material properties of Egyptian blue prior to firing meant that it could be formed into different shapes, in a fashion similar to clays in the making of ceramics.

Egyptian blue was easily formed or molded into small objects, such as amulets. It was also used in a variety of different ways for mosaics – for example, blocks of Egyptian blue were directly used as tesserae – and Egyptian blue was used in mortars. A glass-adjacent material itself, Egyptian blue could itself additionally be applied to glass as an enamel.

This study brings to light the variety of ways in which the material properties of Egyptian blue could be employed in contexts beyond its best understood primary role in mural and sculptural painting. Whether it was used to mimic other materials, or used in place of traditional metallic oxides for the decoration of glass, the varied uses of Egyptian blue exemplify intercraft cross-pollination and reveal the adaptive and innovative ways in which craftsmen could work with a material that was clearly more than just a pigment for painting. Chronicling the diverse ways that Egyptian blue was used, across craft traditions, also helps to under-score, above all, the complex material properties of Egyptian blue-properties that we understand all the more richly thanks to the archaeological, textual, and experimental work of Ioanna Kakoulli on Egyptian blue.

O-54. ISLAMIC GLAZED CERAMIC FROM MÉRTOLA: AN ARCHAEOMETRIC STUDY OF CERAMIC PASTES AND GLAZED DECORATIONS

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This study presents the results of an analytical research program on Islamic polychromatic glazed ceramics recovered in the town of “Mértola” (Portugal), located in western Iberia (Garb al-Andaluz during Islamic time). It provides the analysis of several fragments of glazed ceramics (i.e. including green and brown, corda seca, and honey and brown glazed ceramics) recovered in different areas of the old Islamic fortified Mértola town (Alcaçova), inside the old Islamic castle and kiln rods and one sample of white painted ceramic. The chronology is comprised between the second half of the 10th century and the end of the 12th century. Kiln rods and the white painted fragment were recovered in an Islamic workshop from the middle of the 13th century. Considering the lack of information regarding glazed islamic ceramics production sites in the Garb al-Andaluz, most of the glazed ceramics are considered to be imported from the nowadays Spanish territory or from the North of Africa.

So, the final goal of the study is to understand pottery provenance and the glaze technology applied of the Islamic glazed ceramics recovered in the town of Mértola. Experimental replicas, to understand the adoption of different methods to opacify glazed decorations have been also prepared.

The study has been divided in three different parts. Namely, the characterization of the ceramic body, of the glazed decorations, and of the experimental replicas. In the case of the experimental replicas, glazes with different SiO_2/PbO ratios have been applied on pre-fired calcareous ceramic bodies and fired at different temperatures (700, 800, and 900 degrees). The application of tin oxide, quartzitic sand, and bone ashes have been evaluated as opacify agents in comparison to archaeological samples. Sample ceramic bodies have been analyzed by, OM, pXRF, XRF, XRD, ICP-MS and by SEM-EDS. Glazed decoration and experimental replicas have been characterized mainly by SEM-EDS and μ Raman spectroscopy.

The analysis of the ceramic bodies evidenced that glazed ceramic was produced using a calcium rich raw material. Nevertheless, some glazed ceramic (i.e. green and brown, honey and brown, and corda seca glazed ceramics) showed a very strong similarity with kiln rods and of the white painted ceramic, suggesting local production. Regarding glaze technology all decorations were applied on a fired ceramic body, and decorations were mainly composed by a silica-lead glaze.

Cu, Mn, Fe and Sb oxides were utilized on colored decoration. Sn oxide, and not melted quartz grains were employed as opacificant on decorations. In many

cases, both on white and on colored glaze, several Ca and P rich particles were observed inside not altered glazes, and Raman spectroscopy confirmed the identification of bone inclusions.

Moreover, during the microstructural analysis of the ceramic paste many frit/glass fragments were observed. They were enriched on Ca, P, Si, and Pb, and some cases the bone structures were particularly evident. So, our observations indicate that bones were probably added to the glaze mixture, probably as opacify agent, and experimental replicas confirmed this observation.

In conclusion, results point to the existence of local production of some decorated glazed such as green and brown, corda seca, and honey and brown glazed ceramics at least during the latest periods of the Islamic domination. Moreover, different opacify methods were also employed including the introduction of bones on different glaze mixtures.

Acknowledgments

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O-55. MAPPING VITREOUS MATERIALS BIOGRAPHIES THROUGH MA-XRF IMAGING

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Mycenaean vitreous objects are important evidence for technological knowledge, craft organisation, exchange and the social use of colour in the Late Bronze Age Aegean. Their archaeological interpretation, however, depends fundamentally on the accurate recognition of the materials from which they were made. Following prolonged burial, glass and faience may lose their original colour, gloss and surface texture, developing visually similar alteration features. As a result, highly degraded objects can be misidentified as glass, faience, stone or ceramic (Kaparou et al., 2024; Kaparou and Oikonomou, in press).

Such misclassification has consequences extending far beyond terminology. It may distort the recorded distribution of vitreous materials across sites and contexts, obscure differences in manufacturing traditions and lead to misleading reconstructions of technological choice, specialised production and access to raw materials. It

may also affect interpretations of colour, value and object biographies, particularly when small ornaments from funerary assemblages have undergone extensive surface transformation.

This paper examines selected Mycenaean vitreous objects through MA-XRF elemental maps, interpreted in relation to their present appearance and archaeological attribution. MA-XRF is particularly valuable as it visualises the spatial distribution of detectable elements across an object, helping to distinguish surviving technological evidence from post-depositional alteration without damaging the artefact (Oikonomou et al., 2025). In several cases, features no longer visible macroscopically remain identifiable through their elemental distribution, allowing the material identity and technological character of the objects to be reconsidered.

The study argues that corrosion acts as an archaeological filter: it selectively conceals, transforms and sometimes recreates the characteristics upon which classification is based. MA-XRF mapping therefore contributes not only to material characterization, but also to a more critical reconstruction of Mycenaean craft practices, patterns of circulation and the cultural meanings attached to vitreous objects.

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O-56. TRACING GLASS SUPPLY NETWORKS IN EARLY BYZANTINE CYPRUS: SEM-EDS ANALYSIS OF THE PANAGIA KANAKARIA MOSAICS

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The Church of Panagia Kanakaria, located in Lythrankomi on the Karpasia Peninsula, Cyprus, is a late fifth-century monument of exceptional significance, renowned for its rare early Byzantine wall mosaics. The apse mosaic, dated to the early sixth century AD (ca. 525-530 AD), represents the earliest surviving Byzantine depiction of the Virgin Mary with the Christ Child (Megaw and Hawkins 1977).

Between 1976 and 1979, the monument was looted; the mosaics were illegally detached, fragmented, and dispersed through the international antiquities market. Following extensive efforts by the Republic of Cyprus and the Orthodox Church of Cyprus, sections of the apse mosaic were recovered and repatriated. These works are currently exhibited at the Byzantine Museum in Nicosia, standing as a testament to both early Christian art and the ongoing struggle for heritage preservation (Michaelides 2023).

This study investigates the manufacturing technology and provenance of the glass mosaic tesserae through the analysis of twenty-three samples carefully selected from the original Kanakaria mosaic. Chemical analyses were performed on prepared cross-sections of the tesserae using Scanning Electron Microscopy coupled with Energy Dispersive X-ray Spectroscopy (SEM-EDS). The results indicate that the tesserae were produced using glass belonging to the established compositional groups Foy 2.1, Egypt I and II, alongside a significant proportion of Levantine glass (Fig. 1) (Gratuze 1988; Foy et al. 2003; Freestone 2005). These findings elucidate the diverse supply networks involved in the production of this early Byzantine masterpiece.

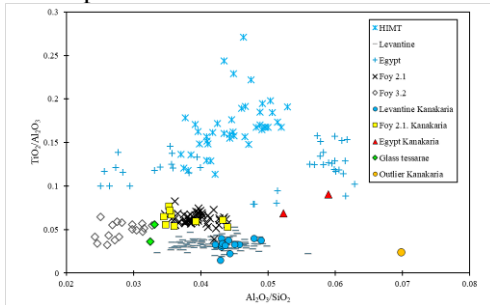


Figure 1. Typical compositional groups of the 1st millenium CE.

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O-57. GLASS FROM HELLENISED AI KHANOU, AFGHANISTAN: EVIDENCE FOR LOCAL PRODUCTION AND INTERACTION ACROSS THE EURASIA SILK ROADS

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The earliest evidence for interactions across Eurasia between the Mediterranean and China provided by ancient glass was in the early 1st millennium BCE. Somewhat earlier evidence for interaction between central Europe and central Asia is provided by faience, in the second millennium BCE. Far less attention has been paid to glass found in central Asia dating to the 1st millennium BCE.

This talk will focus on rare early (3rd century BCE) glass from the Hellenised site of Ai Khanoum founded by Alexander the Great in the 4th century BCE. The site is possibly that referred to as 'Alexander on the Oxus' and is claimed as the most important Hellenised site in central Asia. The architecture and small finds found there are Hellenistic, native Bactrian, or Graeco-Bactrian. The glass considered here (mainly highly coloured raw furnace glass) was found in the palace treasury along with a range of

other valuable materials including lapis lazuli.

This is the first detailed scientific study of the glass. We will discuss its provenance and evidence it provides for interaction along the Silk Roads. We employed electron probe microanalysis and LA-ICP-MS to do so. It might be anticipated that the glass was made with a 'Hellenistic' recipe, the fusion of sand with the mineral flux, natron, since this was the universal recipe used in the Hellenistic world. However, none was detected amongst the Ai Khanoum glass. Instead, the glass was mainly made from sand and plant ashes. This is important because it is apparently the earliest from a central Asian context. When compared to somewhat earlier Archaic Greek plant ash glasses (Oikonomou and Triantafyllidis 2018) and somewhat later plant ash glass from Dibba, UAE (Van Ham-Meert et al. 2019), along with variety of later central Asian glasses the Ai Khanoum plant ash glass appears to be of a 'local' central Asian production. In contrast, very unusual mixed alkali glass as well as high potassium glass were also found, providing evidence for interaction with south and east Asia.

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ABSTRACTS OF POSTER SESSIONS

P-1. CHROMATIC SYMBOLISM IN EARLY NEOLITHIC POLAND: EVIDENCE FROM BURIAL CONTEXTS

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This study investigates the symbolic role of color in Early Neolithic communities of present-day Poland (ca. 5350–3700 BC), commonly referred to as Danubian societies, with a particular focus on the significance of red and white in funerary practices and the construction of social distinctions. Within these communities, color functioned as more than a decorative element; it constituted an integral component of ritual and social frameworks through which cultural meanings were communicated, and social hierarchies were expressed. Red, frequently associated with blood, vitality, and life force, appears to embody concepts of power, prestige, and potential regeneration, or beliefs concerning the afterlife, as reflected in its recurrent presence in burials and ceremonial objects. Conversely, white may have symbolized purity, transformation, and spiritual transition, especially in mortuary contexts that emphasize

movement between the realms of the living and the dead (Kurzawska et al. 2024).

The study draws upon archaeological evidence recovered from burial contexts in present-day Poland, including personal adornments and traces of red pigments, to demonstrate that the intentional application of red and white formed a fundamental aspect of Early Neolithic symbolic systems (Figure 1). The use of valuable raw materials, obtained through both local procurement and long-distance exchange networks, further underscores the close relationship between economic practices and symbolic expression in these communities.

Methodologically, the research employs a multidisciplinary framework that combines microscopic examination, use-wear analysis, and chemical characterization with archaeological, anthropological, and ethnographic evidence.

The integrated analysis demonstrates that color played a significant role in the symbolic and social lives of Early Neolithic communities. The deliberate use of red and white in funerary contexts reflects complex systems of meaning through which identity, social distinctions, and cosmological concepts were expressed. These findings contribute to broader discussions on the role of material culture in the communication of symbolic values and the construction of social relationships in prehistoric societies.

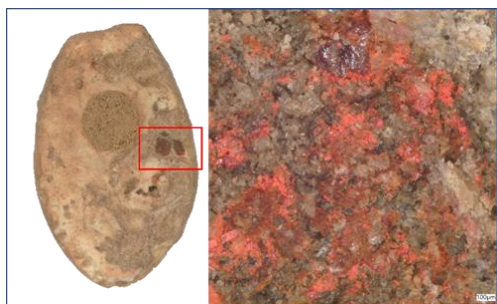


Figure 1. Red residue adhering to the surface of a white marble pendant (photo by A. Kurzawska).

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P-2. MINERALOGICAL INSIGHTS INTO THE PROCESSING OF IRON OXIDE PIGMENTS IN NEOLITHIC SERVIA: AN EDXRF STUDY

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The systematic investigation of prehistoric pigments offers profound insights into the technological choices, symbolic behaviors, and socio-economic networks of early farming communities. This paper presents the results of a recent re-examination of artifacts retrieved during W. A. Heurtley's landmark 1930 excavations at the Neolithic settlement of Servia in Kozani, Western Macedonia. The primary objective of this study is to characterize the nature, composition, and cultural significance of red pigment remains preserved on the surface of diverse material categories through non-destructive archaeometric methods. A targeted assemblage of nine artifacts was selected based on macroscopic and stereomicroscopic detection. The ochre micro-residues were photographed with a ZEISS Stemi 508 stereo microscope with 8:1 Zoom and magnification within 0,63x-50x range, equipped with a USB microscope Jenoptik Gryphax® camera. They were documented according to their characteristics (colour, structure, position, distribution and possible co-occurrence of use-wear on tools).

The sampled material reflects a wide functional and symbolic spectrum of Neolithic daily life, comprising stone and clay figurines, perforated pottery sherds, a stone whetstone, and a ground stone grinder/pounder. To determine the elemental profile and mineralogical implications of the pigments, Energy-Dispersive X-ray Fluorescence (EDXRF) spectrometry was employed. The instrument ARTAX 400 – Bruker AXS was used for the implementation of the micro-EDXRF spectroscopy technique.



Figure 1. Grinder/pounder MØ 28370 and detail of ochre micro residues on its surface.

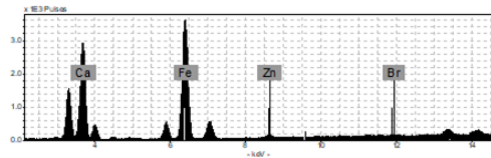


Figure 2. EDXRF spectra of residues documented in situ on tool MØ 28370.

The EDXRF analysis focused on identifying the major, minor, and trace elements within the ochre encrustations. Preliminary results reveal a high concentration of iron (Fe), confirming the widespread use of hematite-rich earth pigments. Furthermore, the correlation of ochre residues with specific tool types - such as the whetstone and grinder/pounder - provides direct physical evidence of pigment processing and preparation stages within the settlement.

By contextualizing these scientific data within the broader framework of the Middle Haliakmon valley, this study

discusses the multi-faceted role of red ochre at Neolithic Servia. The presence of pigments on both utilitarian tools and highly symbolic artifacts (figurines) highlights a fluid boundary between practical tasks, domestic crafts, and ritual activities.

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P-3. PIGMENT ANALYSES ON TERRACOTTA FIGURINES AND PIGMENT RESIDUES FROM THE ANCIENT AGORA OF THESSALONIKI

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During the archaeological research conducted in the Ancient Agora of Thessaloniki during 1990-2000, brought to light a substantial assemblage of terracotta figurines and figurine moulds, the majority of which are preserved in a fragmentary condition. Most of the finds derive from strata excavated beneath the level of the Roman Agora, where remains associated with workshop activities dating from the mid- or late 2nd century BC to the early 1st century AD were identified. In addition, several pits yielded earlier ceramic material dating to the foundation of the city in the late 4th century BC and the subsequent century. Within the framework of the doctoral dissertation of the first author, currently being undertaken at the National and Kapodistrian University of Athens, entitled *Terracotta Figurines and Figurine Moulds from the Ancient Agora of Thessaloniki*, ED-XRF pigment analyses were performed on a sample of 100 figurines preserving traces of their

original polychrome decoration, as well as on five pigment residues.

The selected sample derives from a corpus of approximately 1,500 figurines and was chosen on the basis of the preservation of painted decoration, with the aim of providing a preliminary identification of the pigments employed. Although traces of colour survive on the majority of the figurines, the examination of the entire assemblage was not feasible. Sample selection was guided by several criteria, including the frequency and/or rarity of specific colour tones, the quantitative distribution of figurines across excavation sectors, their typological classification, and the location of preserved pigments on the objects. Of particular significance was the discovery of pigment masses within the excavation area, which were analysed using the same methodology.

The analytical results indicate the use of pigments consistent with the chronological framework to which the figurines belong. The elementary composition of both the white slip of the surface, and the pigments employed to highlight specific features, was largely confirmed. Of particular significance is the identification of malachite and gold, materials rarely used in antiquity to decorate terracotta figurines.

The Energy Dispersive X-Ray Fluorescence (ED-XRF) spectrometry technique was implemented at the Laboratory of Physico-Chemical Studies and Archaeometry of the Archaeological Museum of Thessaloniki, utilizing the ARTAX 400 – BrukerAXS (Bronk, 2001) spectrometer. This instrument is specifically designed to meet the non-destructive analytical demands of archaeometry research. ED-XRF allows for the determination of elemental

analysis by detecting characteristic X-rays emitted from a sample. In this study, characteristic chemical elements of each pigment, which are "indicators" to infer the presence of corresponding pigments. The identified elements and their associated pigments include: iron (hematite and ochre), copper (Egyptian blue and malachite), mercury (cinnabar), calcium (calcium carbonate), lead (Lead white), and gold.

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P-4. SERS-ASSISTED MULTI-ANALYTICAL INVESTIGATION OF WALL PAINTINGS FROM SIDE BOYALIIN CAVE CHURCH (ANTALYA, T RKIYE)

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The Side Boyalıin Cave Church, located in the Yavrudogan district of Manavgat (Antalya, T rkiye), is a rock-cut sanctuary situated within a conglomeratic geological formation in a mountainous and forested area. Surviving wall paintings are preserved on the eastern and western walls, the entrance wall, and the ceiling of the cave. Art historical evaluations suggest that the paintings may date between the 5th and 10th

centuries CE. The monument is particularly significant due to the depiction of the Birth of the Virgin and Saint Anne scene, considered a rare example outside the Kariye Church in Türkiye (Jolivet-Lévy, 2011).

This study aims to characterize the material properties and painting technology of the wall paintings through a multi-analytical archaeometric approach. Particular emphasis was placed on the identification of pigments and possible binding materials in order to contribute scientific data to the understanding of Byzantine wall painting technology in southern Anatolia. In this context, the potential of Surface-Enhanced Raman Spectroscopy (SERS), which has gained increasing importance in cultural heritage studies due to its high sensitivity, was evaluated for the characterization of wall painting materials (Baglioni et al., 2018; Vahur et al., 2024).

For this purpose, Raman spectroscopy, Surface-Enhanced Raman Spectroscopy (SERS), X-ray Diffraction (XRD), Fourier Transform Infrared Spectroscopy (FTIR), and Scanning Electron Microscopy coupled with Energy Dispersive X-ray Spectroscopy (SEM-EDX) were employed. Raman analyses were used for the molecular characterization of pigments, while SERS was specifically applied for the detection of low-concentration compounds and materials exhibiting weak Raman signals. XRD analyses enabled the identification of crystalline phases, whereas FTIR analyses were used for the characterization of possible binding materials. SEM-EDX investigations provided elemental and microstructural data regarding the

pictorial layers (Şerifaki and Böke, 2026).

Preliminary results revealed the presence of mineral-based pigments associated with the cave environment and the geological structure of the support. The analytical data also provided important information regarding the stratigraphy and material technology of the wall paintings. The obtained results contribute to the documentation of Byzantine cave churches, which remain insufficiently studied in Türkiye.

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P-5. THROUGH SPECTRA AND MICROSCOPES: THE IDENTIFICATION OF PAINTING MATERIALS AND TECHNIQUES OF THE AGIOS IOANNIS ELAIONA BYZANTINE CHURCH WALL PAINTINGS

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The Church of Agios Ioannis Elaiona, located in Egaleo, Attica, is a designated protected monument of the late Byzantine period, which preserves numerous later architectural and decorative additions. At least three wall painting phases are identified within the church: the first - and oldest - phase, followed by two subsequent phases dating to the late 19th and early 20th centuries. All three wall painting phases consist of a substrate, comprising one or more mortar layers, and paint layers.

The purpose of the present study is to investigate the stratigraphy, materials, and construction technology of the wall painting phases within the main nave of the church. To examine the stratigraphy, samples were collected from the substrate and the paint layer of each phase. Polished cross-sections of the

samples were analyzed using optical microscopy and SEM/EDS. The aggregates and binding materials of the substrate, as well as the paint layers, were characterized via FTIR spectroscopy. Furthermore, in situ analysis of the paint layers was conducted using XRF.

The first wall painting phase differs significantly from the subsequent two. The substrate of the first phase is characterized by calcitic materials and the presence of organic fibers (straw), while no aggregates were observed. Earth pigments were identified within the paint layer of this same phase. The two more recent wall painting phases are characterized by a fine-grained lime mortar substrate, while gypsum was also detected in the substrate of the third phase. Modern synthetic pigments, such as artificial ultramarine and Prussian blue, were identified in the paint layers, alongside barite (BaSO₄) and zinc oxide (ZnO).

The resulting data highlighted the technological characteristics and specific features of the church's wall painting phases, thereby contributing to its enhanced understanding and documentation, while providing answers as well as opening new pathways for further research.

P-6. RED AND YELLOW PIGMENTS ON WALL-PAINTINGS FROM THE MEDIEVAL FORTRESS OF KOZNIK (SERBIA)

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The medieval fortress of Koznik, located in central Serbia, was an important administrative and military center of Morava Serbia during the late 14th and early 15th centuries. Built on the remains of an earlier fortification, the site comprises a citadel, defensive structures, residential buildings, and the remains of religious architecture. The wall-painting fragments analyzed in this study, shown in Figure 1, originate from archaeological excavations conducted within the Koznik fortress and represent important material evidence of medieval wall-painting practice.

The aim of this study was to identify red and yellow pigments used in the painter's original color palette, determine the painting technique used in the decoration of the walls of the Koznik fortress, and evaluate the compatibility of the identified materials with the proposed chronology of the site.

The elemental composition of the paint layers was determined using non-destructive EDXRF spectrometry, enabling identification of inorganic pigments. Additionally, ER-FTIR spectroscopy was used to identify organic materials, pigments, and potential binders. In addition, cross-sections of selected fragments were examined by optical microscopy to investigate the stratigraphy of the wall paintings and painting techniques.

The red-painted areas of the fresco fragments were analyzed by EDXRF and ER-FTIR spectroscopy, revealing pigments characteristic of medieval wall paintings. The identified pigment palettes include vermilion, minium, and iron oxide-based pigments such as burnt sienna, yellow ochre, and red ochre. Single-pigment usage is most abundant on the analyzed spots, but sometimes they were mixed, and interesting stratigraphies were also found. The cross-sections examined by optical microscopy showed characteristics similar to those typically observed in the fresco painting technique.

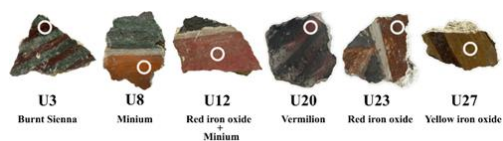


Figure 1. Representative wall-painting fragments used in the study.

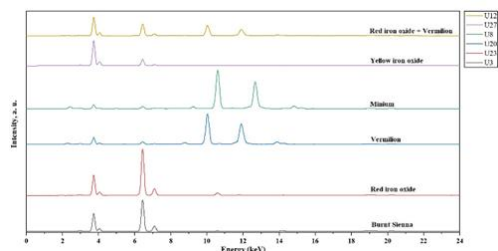


Figure 2. EDXRF spectra of pigments identified in selected wall-painting fragments.

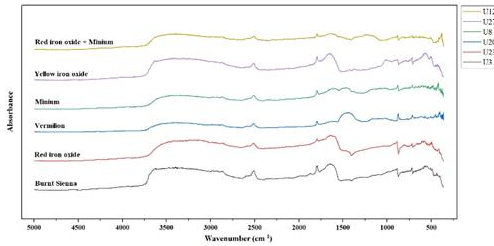


Figure 3. ER-FTIR spectra of pigments identified in selected wall-painting fragments.

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P-7. ASSESSING WORKSHOP ATTRIBUTION IN POST-BYZANTINE PAINTING THROUGH NON-INVASIVE TECHNICAL INVESTIGATION: A CASE-STUDY ON TWO SIXTEENTH-CENTURY ICONS

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The attribution of post-Byzantine paintings to specific painters or artistic workshops has traditionally relied on stylistic, iconographic, and historical evidence (Garidis 1989; Χατζηδάκης & Δρακοπούλου 1997). In recent decades, non-invasive and micro-invasive analytical techniques have significantly enhanced the technical investigation of paintings, i.e., the identification of the materials and techniques employed for their manufacturing. Since the painting materials and techniques reflect both the painters' personal preferences and their cultural framework, technical investigation can contribute considerably the attribution of works to specific workshops or painters (Mastrotheodoros et al. 2019).

This study attempts to assess the potentialities and limitations of a handy non-invasive analytical methodology towards documenting and comparing the technological and material characteristics of post-Byzantine icons. The current approach integrates macroscopic examination, digital microscopy under visible (VIS), ultraviolet (UV), and

infrared (IR) illumination, portable X-ray fluorescence (p-XRF) spectroscopy, and near IR photography.

The methodology is applied to two sixteenth-century portable icons originating from the iconostasis of the Church of Saints Anargyroi at Gymnasium, Kastoria, which have previously been attributed by archaeological / art historical research to the renowned painter Onouphrios of Neokastro and his workshop (Σίσσιου 2009; Τσιγαρίδας 2018). A comparative evaluation of technological markers-including support preparation, painting technique, pigment selection, underdrawing practices, and pentimenti were employed to investigate the degree of technological correspondence between the two icons and to further assess the evidence supporting their common workshop attribution.

The applied methodology provided data that strengthen considerably the attribution to a single workshop or painter, demonstrating thus the value of integrating complementary non-invasive analytical techniques to archaeological / art historical investigation of paintings. Additionally, the current work comments on the limitation of a merely non-invasive analytical investigation and highlights the importance of the latter for the proper selection of sampling spots for further micro-invasive investigation.

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P-8. NON-DESTRUCTIVE CHARACTERISATION OF BEEHIVE PANELS FROM THE SLOVENE ETHNOGRAPHIC MUSEUM USING ADVANCED ANALYTICAL TECHNIQUES

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Painted wooden beehive panels (front boards of traditional Slovenian beehives) represent an important part of Slovenian cultural heritage. Due to their complex material composition, long-term exposure to environmental factors, and previous conservation interventions, they often exhibit signs of deterioration. Effective preservation therefore requires a thorough understanding of their material composition, manufacturing techniques, and state of conservation. The aim of this study is to develop a comprehensive methodology for the non-destructive investigation of beehive panels by combining hyperspectral imaging in the visible, near-infrared, and short-wave infrared spectral regions with complementary techniques such as micro-XRF imaging, optical microscopy, wood species identification, and surface roughness measurements. Particular emphasis is placed on the spatial integration of analytical results, enabling the identification of paint layers, differentiation between original and later interventions, and detection of degradation processes.

The study was conducted on three beehive panels from the collection of the Slovene Ethnographic Museum. Following a macroscopic condition assessment, analyses were performed using micro X-ray fluorescence spectroscopy (micro-XRF) to determine elemental composition and hyperspectral imaging to identify and map materials based on their spectral signatures.

Table 1. Basic description of the beehive panels

Internal code	Year	Identified wood species	Motif	Panel orientation
PK015	/	softwood	Dove Representing the Holy Spirit	Semi-radial
PK016	/	softwood	Landscape	Radial
PK017	1882	softwood	The Fight for the Trousers	radial

PK015: The panel exhibits visible cracks resulting from drying and shrinkage. The lower section shows pronounced surface roughness caused by wood erosion, mechanical damage, and biological deterioration. The paint layer is generally well preserved; however, localized losses and a faded appearance are visible.

PK016: The panel is almost undamaged, exhibiting high dimensional stability and a relatively homogeneous structure. The painted surface is very well preserved, with only minor losses and isolated contrast changes. Overall, the panel is considered to be in good condition.

PK017: The wood is well preserved and dimensionally stable, with only minor cracks. The painted layer shows minor damage, and the motif remains clearly legible despite some loss of contrast; the outlines of the figures are still distinctly visible.

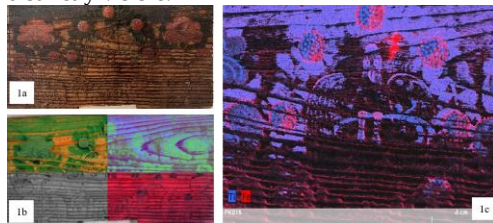


Figure 1. PK015 a) original, b) combination of hyperspectral imaging, c) micro-XRF results (Fe+Ti).



Figure 2. PK016 a) original, b) combination of hyperspectral imaging, c) micro-XRF results (Ca).

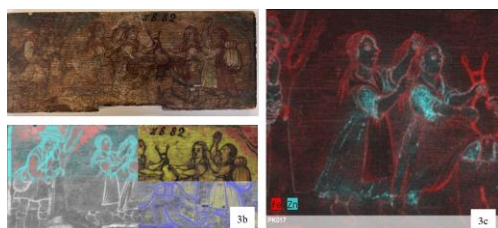


Figure 3. PK017 a) original, b) combination of hyperspectral imaging, c) micro-XRF results (Fe+Zn).

Preliminary results indicate that the combination of hyperspectral imaging, XRF analysis, and complementary microscopic and physico-chemical methods provides an effective approach for investigating painted wooden heritage. The research enables the identification of degradation processes occurring in wood and paint layers, reliable identification of pigments, binders, and surface coatings, as well as their spatial mapping across the entire painted surface.

P-9. ARCHEOMETRICAL INVESTIGATION OF THE ARTISTIC MATERIALS ON THE LAZAR VOZAREVIĆ'S PAINTINGS

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The research presents the results of the archaeometric investigation of the artistic materials used by Lazar Vozarević, one of the most important artist of Serbian and Yugoslav postwar modernism, inspired by Byzantine and spiritual influences and Picasso's innovations. His early period of work include figurative painting, presenting some social themes and family portraits. Second phase include enformel and postenformel artworks, experiments with texture and symbolism, unconventional materials (rivets) and vivid colors in three-dimensional space. His artworks are part of the collection of the museums in Serbia and Europe but majority is placed in Gallery in Sremska Mitrovica, his hometown. These artworks was never analyzed and lot of questions regarding used artistic materials was unanswered. Investigations are realized in two phases, first during conservation of the paintings in the Central institute for Conservation and later in the Gallery in Sremska Mitrovica on the paintings placed for the

exhibition in the permanent collection. The study was focused on the identification of the pigments and other artistic materials on the selected paintings and artworks, covering all periods and styles of his work. More than 20 paintings were analyzed with mobile equipment, macro EDXRF and FTIR spectrometer and with 400 acquired spectra.

Majority of the identified pigments and materials are commonly used by authors in that period, including zinc and titanium white, lithophone, cobalt blue, ochres, cadmium red etc. Artistic materials mostly include rivets of different metals or foils mostly from copper, applied on the canvas or wood and colored afterward. Canvas paintings are mostly made with white pigments and mixture of earth and organic pigments since XRF spectra did not identified some characteristic mineral pigments. Chemometric approach, based on the raw XRF spectra, was applied as tool for the identification of the possible grouping for future authentication of Lazar Vozarević artworks. Established chemometric model is partly tested with results of XRF analysis of the artwork offered on the auction which authenticity was questionable.



Figure 1. Some of the Lazar Vozarević artworks analyzed in this study.

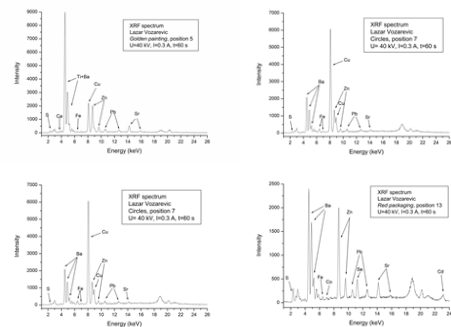


Figure 2. EDXRF spectra acquired on the analyzed artworks.

P-10. UNVEILING MEDIEVAL ANATOLIAN GARMENTS: MULTI-ANALYTICAL CHARACTERIZATION OF MUMMY TEXTILE REMAINS FROM ÇANLI CHURCH (AKSARAY)

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Excavations at the Çanlı Church in Aksaray yielded several child and adult mummies dating to the 10th-11th centuries, whose garments have been preserved over time (Efe, 2015). This study characterizes these Anatolian mummy textile remains using diverse analytical methods to identify the mordants, dyes, and fabric types used in the textiles and enlighten the textile technology of medieval Anatolia.

For this purpose, HPLC (high performance liquid chromatography), XRF (X-ray fluorescence), and FTIR (Fourier transform-infrared spectroscopy) were performed to identify organic dyestuffs, mordants and fiber type respectively. Addition to HPLC, the integration of an on-line HPLC-

CUPRAC (Cupric Reducing Antioxidant Capacity) system allows us to determine antioxidant capacity of each organic dye component in single injection. Two methods were validated for HPLC analyses: a method for flavonoids and phenolic acids was employed while a specific method for anthraquinones was utilized. The results show alizarin and gallic acid were the main colorant agents for the samples. Data obtained from the on-line CUPRAC method confirms the preservation of significant reducing activity in these ancient colorants. XRF findings enabled the characterization of mordants used since early periods to maximize dye retention on fabrics. The identification of iron (Fe) indicates the application of this metal salt as the primary mordant within the analyzed textile objects. FTIR results identified cellulosed based fiber type for all samples and further validation of fiber morphology was performed using SEM-EDS (scanning electron microscope-energy dispersive spectroscopy). Overall, these findings provide crucial insights into the material choices, dyeing traditions, and advanced textile technologies practiced in Middle Age Anatolia, offering a deeper understanding of period-specific burial customs.

Acknowledgments

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P-11. HAND-COLORING AS A MEANS OF INTRODUCING COLOR TO EARLY MODERN BLACK-AND-WHITE PRINTS

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During the 17th and 18th centuries, the need for color in black-and-white prints led to the widespread application of hand-coloring (Dill et al., 2021), a practice executed exclusively by hand prior to the introduction of mechanical methods in the mid-19th century. Coloring prints with aqueous solutions of diluted pigments (like watercolors) was crucial for the visual encoding of information and their aesthetic enhancement (Stillo, 2016). However, in many cases today, these colorations constitute one of the main factors causing oxidation and degradation of paper supports. Consequently, recognizing the materials and their application techniques is essential for accurate diagnosis, preservation and conservation.

Content: This study aims to investigate the pigments used for coloring printed works from the 17th and 18th centuries from Batrinos' Collection, to identify the materials and techniques of the era and contribute to the understanding of their degradation mechanisms.

The examination of the colorations was carried out using microscopic and multispectral imaging for the initial assessment of the hand-coloring (Kokla & Tselikas, 2025), as well as Scanning Electron Microscopy coupled with Energy-Dispersive X-ray Spectroscopy (SEM/EDS) to determine the elemental composition of the pigments.

The proposed methodology yielded valuable data on the composition and preservation state of red, green, blue, orange, pink, and brown color layers. Notably, the analysis indicated the potential presence of verdigris, a pigment known to cause severe oxidation in paper substrates (Hofmann et al., 2015). The analytical findings were validated through comparison with historical sources and contemporary technical literature.

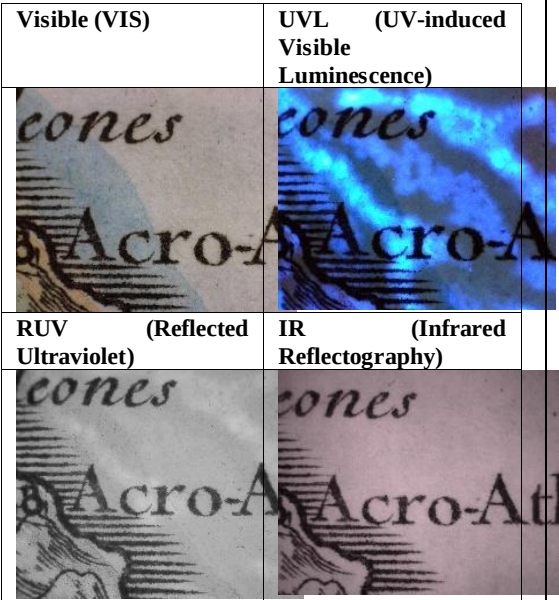


Figure 1. Micro-multispectral imaging in a detail of hand-coloring.

In conclusion, the results not only enrich historical knowledge about print production during the Early Modern Period but also offer a solid basis for

predicting oxidation phenomena and designing effective preventive conservation strategies and treatments.

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P-12. ELECTROCHEMICAL CHARACTERIZATION OF EMISSIONS OF SILVER COINS USING SOLID-STATE VOLTAMMETRY

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It is described the application of the voltammetry of immobilized particles, a solid-state electrochemistry technique, to characterize different emissions of silver coins. This is the case of a series of 18 Spanish silver coins (value 5 pesetas) minted during the Spanish reigns of Isabel II, Amadeo I, Gobierno Provisional, Alfonso II, and Alfonso XIII, between 1867 and 1903.

This study expands previously ones where this technique was applied to copper/bronze [1], gold [2], and lead [3]. This technique exploits the voltammetric response of nanoparticulate deposits extracted from the surface of silver coins after their attachment to paraffin-impregnated graphite electrodes put into contact with aqueous acetate buffer at pH 4.75. Under these experimental conditions, the voltammograms display well-defined signals (see Figure 1a,1b) corresponding to the reduction of silver and copper corrosion products and their oxidation at ca. 0.0 V vs. Ag/AgCl

(signal I), accompanied by the oxidation of different silver forms to silver(I) acetate at +0.25 (II) and +0.50 V (III). The intensity and position of these signals depend on the chemical/mineralogical composition of the sample transferred onto the graphite electrode, and also on the compactness, porosity, crystallinity, and degree of hydration. Accordingly, they can reflect the differences in composition of the base metal alloy, its manufacturing procedure and the “corrosion history” of the object. Under favourable circumstances, the objects under study experienced a quite similar “corrosion history” and the voltammetric response can reflect subtle differences in their manufacturing. This is the case of a series of 18 Spanish silver coins (value 5 pesetas) minted during the reigns of Isabel II, Amadeo I, Alfonso II, and Alfonso XIII, between 1867 and 1903. For discriminating purposes, it is worth noting that the absolute values of the peak currents ($i(I)$, $i(II)$, $i(III)$) depend on the net amount of sample transferred onto the electrode surface in each individual sampling. Then, data from five replicate measurements on different spots of each provided $i(II)$ vs. $i(I)$ and $i(III)$ vs. $i(I)$ plots which can be fitted to proximal but consistently different pairs of straight lines characterizing the different emissions (Figure 1c,1d).

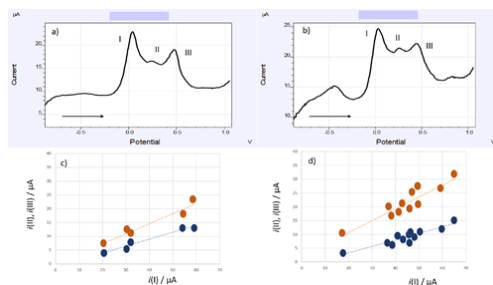


Figure 1. a,b) Square wave voltammograms of graphite electrodes modified with samples from 5

pesetas Spanish coins of the reigns of a) Isabel II, and b) Alfonso XII, in contact with 0.25 M HAc/NaAc solution at pH 4.75. Potential scan initiated at $\square$ 0.75 V vs. Ag/AgCl in the positive direction; potential step increment 4 mV; square wave amplitude 25 mV; frequency 10 Hz. The arrows mark the direction of the potential scan. Plots of $i(\text{II})$ vs. $i(\text{I})$ and $i(\text{III})$ vs. $i(\text{I})$ from replicate voltammograms on coins of the reigns of c) Isabel II, and d) Alfonso XII.

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P-13. GOLDWORK IN THE PALACE OF NESTOR AND THE GRAVE CIRCLE: AN ARCHAEOMETRIC INVESTIGATION OF COMPOSITION AND USE

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The Palace of Nestor is one of the most important archaeological sites in Messenia; however, little scientific research has been published on the gold artifacts discovered in the Palace area and in the tombs excavated by Carl Blegen and his team during the 1950s and 1960s. This paper aims to shed light on the manufacturing techniques of the gold artifacts found at the Palace and the Grave Circle and to explore whether the people living in the area used them in their everyday life. For this purpose, three gold artifacts were analyzed: one diadem and one decorative disc with wires, both found in the Palace, and a small fragment of a wreath discovered in the Grave Circle, south of the Palace. The artifacts were analyzed using Micro-XRF, SEM/EDS, and a Digital microscope in order to obtain a clearer understanding of both their alloy composition and microstructure. The results showed that all three artifacts were made from a natural gold alloy, as

the concentrations of silver and copper fall within the expected range for naturally occurring gold. SEM and Digital microscope images also allowed us to identify some of the techniques and tools used in the shaping and decoration of the artifacts. In addition, visible signs of wear were detected on the two artifacts found in the Palace, whereas no such traces were identified on the wreath fragment from the Grave Circle. These findings raise the possibility that the inhabitants of the Palace used gold objects in everyday life, while the early Mycenaeans may also have produced items associated with funerary practices. Although it is not yet possible to determine the provenance of the gold or whether the artifacts were manufactured locally on Eglianos ridge or elsewhere, the evidence highlights the importance of gold in the social and cultural life of the people associated with the Palace.

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P-14. SCIENTIFIC ANALYSIS OF ANCIENT GLASS BEADS FROM THE MANTAI PORT SITE, SRI LANKA

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The Mantai port site, located along Sri Lanka's ancient Maritime Silk Road, has yielded thousands of glass beads through several archaeological excavations. However, their chemical composition and manufacturing technology have not been fully characterized, leaving an important gap in the study of ancient vitreous production and exchange networks. This study investigates the compositional properties and technological features of ancient glass beads from Mantai and highlights their archaeological significance.

The research uses LA-ICP-AES analysis to identify the major elemental constituents of the beads, determine their technological classification, and examine the chemical basis of color variation. The results show that more than 80% of the analyzed beads are Indo-Pacific type, confirming Mantai's major role in Indian Ocean trade and bead circulation. The principal chemical components across the samples are silicon dioxide, aluminum oxide, calcium oxide, and sodium oxide. Coloration is mainly associated with metal oxides: red and orange beads show high copper content, while blue beads were produced by copper or trace cobalt, with deeper blue specimens consistently

linked to cobalt oxide. These findings indicate both the adoption of Indo-Pacific bead-making technology and local compositional variation at Mantai. The study contributes new scientific evidence to archaeological research on ancient bead production, maritime exchange, and cultural interaction in the early Indian Ocean world.

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P-15. ARCHAEOMETRIC CHARACTERIZATION OF BYZANTINE WINDOW GLASSES FROM THE EPISKOPEION AT OLYMPOS ANCIENT CITY

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In this study, eight window glass fragments in green, blue, yellow, and colorless window glass fragments belonging to the Episkopeion Building which is dated to the 5th-6th centuries AD, corresponding to the Early Byzantine period, uncovered during excavations at the ancient city of Olympos in the Kumluca district of Antalya, Türkiye, were analyzed using thin-section/stereo microscopy, SEM-EDX, and p-XRF methods. The main purpose of the study is to understand the raw material components, chemical composition, and manufacturing technique of window glass.

Macro-observations suggest that some samples were produced using the glass-blowing technique, while others were made using the casting technique. Chemical composition results indicated that the window glass group belongs to

the typical soda-lime-silica glass group of the Levant region. Particularly, the similar amount of aluminum oxide among the glass samples suggest that the same sand source was used in production. The low magnesium oxide and potassium oxide ratios in the glass samples indicate the use of natron mineral in glass production, thereby demonstrating trade activity from the Levant region to the Mediterranean coasts. It was determined that copper and lead were used as colorants in the production of window glasses which serve as a part of lighting while manganese was utilized in the production of colorless glass.

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P-16. PROVENENCE STUDY OF ARCHAEOLOGICAL CERAMIC AND OBSIDIAN FLAKES FROM THE ACROPOLIS OF AGIOS FOKAS, KYMISSALA, RHODES USING PXRF ANALYZER: A PRELIMINARY REPORT

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The ancient Demos of Kymissaleis is located on the southwest coast of the island of Rhodes about 70 km southwest of the city of Rhodes, in the wider area of modern Kymissala. It is an extensive archaeological site, which covers an area of about 10,000 acres comprising of multiple interconnected fields including an acropolis on the hill of Agios Fokas, and at least 11 rural settlements, some of them showing evidence of urban planning. Near these settlements lie cemeteries, the most important of which is the central necropolis, located between the hills of Agios Fokas and Kymissala. Minor graveyards and monumental burial monuments that reflect the existence of minor installations scattered in the area, social stratifications as well as a small fortress and various other sites and monuments are found in the territory of the Demos,

the occupation of which spans from the Neolithic period until Late Antiquity. The area has been explored since 2006 by the Department of Mediterranean Studies: Archaeology, Linguistics, International Relations-University of the Aegean and the Ephorate of Antiquities of the Dodecanese-Greek Ministry of Culture, in the context of the Kymissala Archaeological Research Project (KARP), with the participation of the National Technical University of Athens.

In the centre of the archaeological area emerges the hill of Agios Fokas. Its peak served as the acropolis of the ancient deme of Kymissaleis, with unobstructed views of the major part of the region. It is strongly fortified (Fig. 1a) while on the plateau at the top, within an enclosure, lay the ruins of a Hellenistic temple (Fig. 1b), enclosed within a retaining wall, covering an area of approximately 18x26.50 m., currently under investigation. The site has produced pottery from the Neolithic to the Roman period.



Figure 1. a) The heel of Agios Fokas. The wall is indicated by the arrow, b) The Hellenistic Temple at the heel of Agios Fokas.

The southern and southeastern wings of the enclosure are particularly interesting, since finds indicate two very distinct phases of use for this specific area: Pottery from archaic to Hellenistic period prevails on the upper stratigraphy, in accordance with the dating of the temple, while from the lower backfill layers removed from the rock cavities come numerous groups of sherds of unpainted handmade pottery, flakes and cores of obsidian and flint dating to a much earlier, Neolithic phase, a fact that indicates the process of working the raw material for the manufacture of tools.

In an attempt to study the provenance of the clay used and the obsidian cores that were excavated, by permission of the Kymissala Archaeological Research Project, the chemical composition of 5 obsidian blades and 25 non-diagnostic plain ceramic sherds was analyzed using a portable NitonXL5Plus analyzer. This is the first attempt to study and identify the finds of the site using analytic techniques.

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P-17. THE EMERGENCE OF NEOLITHIC CERAMIC TECHNOLOGY IN CYPRUS: PRELIMINARY PETROGRAPHIC INSIGHTS

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The emergence of pottery in Neolithic Cyprus represents a major technological and social transformation, marking the introduction of new practices of production, use, and consumption. Following the end of the Aceramic Neolithic tradition associated with Khirokitia, ceramic technology appears during the Late Neolithic period (c. 5200–4000/3800 BC), alongside broader changes in settlement organisation, subsistence practices, and community interactions.

This paper explores the emergence of pottery in Cyprus as a process of technological adaptation and local development. Through the study of ceramic assemblages from key sites, including Agios Epiktitos–Vrysi, Paralimni–Nissia, and Kalavassos–Agios, the research investigates how early communities selected raw materials, developed production practices, and established ceramic traditions.

Combining archaeological study, macroscopic examination, and selective ceramic petrography, the study examines

technological choices behind early Cypriot pottery production. Preliminary results indicate that ceramic manufacture was primarily local, with communities exploiting available clay resources while developing different technological recipes for specific vessel categories and functional requirements. Variations in clay preparation, composition, and firing practices suggest deliberate choices and specialised knowledge rather than the simple adoption of an external technology.

By approaching pottery as a technological practice, this paper explores how Neolithic communities in Cyprus negotiated innovation, transmitted knowledge, and created new material traditions shaped by both local experimentation and wider regional connections.

P-18. AT THE SURFACE AND BEYOND: AN INTERDISCIPLINARY STUDY ON THE ENEOLITHIC CLAY FIGURINES FROM CUCUTENI, ROMANIA

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The collections of the 'Vasile Pârvan' Institute of Archaeology include a group of 37 anthropomorphic figurines discovered in the late 19th and early 20th centuries at the Cucuteni–Cetățuia site. The site is well-known in Southeast European archaeology, its name being used to designate the remarkable material culture of the human communities that inhabited eastern Romania, the Republic of Moldova, and western Ukraine, beginning mainly in the second half of the 5th millennium BC and continuing until around the middle of the 4th millennium BC.

Unfortunately, the context of discovery for these artefacts has not been preserved. However, based on certain characteristics (e.g., body posture, decorative style), they could be arranged chronologically and attributed to the two major phases in the evolution of the Cucuteni culture within Romania: 10 figurines were attributed to the Cucuteni

A phase, and 26 to the Cucuteni B phase. One figurine dates from a slightly later period and can be linked to the Horodișteea-Erbiceni-type finds from the site.

This presentation aims to go beyond the traditional morphological analysis of this exceptional category of objects, exploring aspects related to their technological aspects as well. Thus, the 37 figurines were examined both on the surface and internally, using digital microscopy and X-ray micro-computed tomography (micro-CT). The paint adorning some of the figurines from the later Cucuteni B phase was analysed compositionally using the LIBS method at this stage, with further investigations such as SEM-EDX and FTIR to be conducted in the near future.

Special attention was paid to how the figurines were shaped. To achieve this goal, the objects were examined using X-ray micro-CT, a non-destructive method that allowed their structure to be visualized by virtually slicing through the body of the pieces. It was found that a simple surface examination can be misleading. Specimens that appeared to be made from a single piece of clay were, in fact, composed of several segments, while others, which gave the impression of being composite, had been shaped from a single lump of clay. At the same time, the shape, dimensions, and orientation of the cracks and voids in the clay were identified, some of which resulted from the burning of organic matter. Another point of interest was the observation of inclusions in the clay, as well as their shape and size.

Our study provides important insights into the quality of the clay used to make the figurines, as well as the methods used to shape, finish, and decorate them, while

also highlighting the skill and craftsmanship of those who created them. It is also worth noting that this is the first study in Romania to examine such a large collection of prehistoric figurines using X-ray micro-CT.

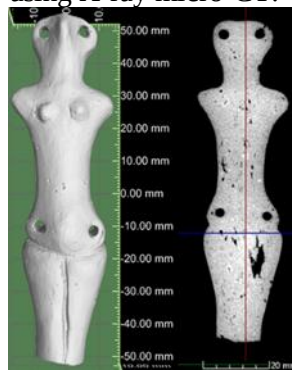


Figure 1. Cucuteni anthropomorphic figurine: 1. 3D rendering; 2. virtual cross-section through the artefact.

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P-19. MESOLITHIC POTTERY PRODUCTION AT KHOR SHAMBAT 1 (CENTRAL SUDAN): AN ARCHAEOMETRIC PERSPECTIVE

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Khor Shambat 1 (KSH1), located on the west bank of the Nile in Omdurman, is a multi-period archaeological site preserving evidence of occupation from the Mesolithic through later prehistoric and historic periods. Of particular significance is its well-stratified Mesolithic sequence, one of the few such records currently known from central Sudan. Excavations conducted since 2012 have documented occupation layers, domestic features, activity areas, and burials associated with the Khartoum Mesolithic tradition. This contribution focuses on the petrographic variability of the Mesolithic pottery assemblage and explores its implications for raw material procurement, ceramic production, and technological choices among hunter-gatherer-fisher communities of the Middle Nile Valley (Jórdeczka et al. 2026).

The ceramic sherds were analysed using petrographic microscopy and scanning electron microscopy (SEM) equipped with an energy-dispersive X-ray spectroscopy (EDS) detector for elemental and chemical characterization. The site chronology was established through a combination of methods, including radiocarbon dating.

The results presented here derive from an integrated programme of archaeological and archaeometric analyses, including inter alia lithic studies, pottery typology, petrographic analysis, lipid residue analysis, and radiocarbon dating. The ceramic assemblage, comprising approximately 1,500 sherds, reveals technological variability in raw material selection, temper composition, and firing conditions, suggesting diversified production practices and possibly multiple manufacturing traditions. Petrographic analyses identified differences in mineral composition of the temper, plant temper in single samples, and microstructure, reflecting both local resource exploitation and technological choices.

Seven ceramic samples were examined in thin section, while an additional twelve sherds were analysed with a digital microscope. The ceramics exhibit considerable variability in mineral temper, plant inclusions, firing conditions, and the occurrence of chamotte. SEM-EDS analyses confirmed the presence of carbonised plant remains, particularly in sample KSH2018, where an oriented fabric suggests specific vessel-forming techniques. The mineral fraction is dominated by quartz and feldspars, with muscovite and biotite occurring in varying proportions; the high muscovite content in sample 2538 may indicate the intentional addition of

crushed bedrock temper. Sample KSH2018 differs markedly from the others, containing predominantly well-rounded monocrystalline quartz grains. The pottery wall thickness corresponds closely to other Early Khartoum Mesolithic assemblages from central Sudan. Particularly noteworthy is the frequent use of plant temper and the high proportion of undecorated vessels, while decorated pottery is dominated by the dotted wavy-line motif characteristic of the Khartoum Mesolithic tradition.

Petrographic and SEM-EDS analyses reveal variability in temper composition, firing conditions, and manufacturing techniques, suggesting multiple production traditions rather than a fully standardised technology. Raw materials were probably obtained locally from alluvial sediments and nearby geological formations, although some mineral inclusions may derive from more distant sources. Overall, the KSH1 assemblage illustrates gradual technological development and adaptation to a broad-spectrum subsistence economy characteristic of Middle Nile Mesolithic societies.

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- P-20. EARLY IRON AGE CERAMIC PRODUCTION IN SOUTHERN SERBIA, RANUTOVAC-MEANIŠTE ARCHAEOLOGICAL SITE**
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- The archaeological site of Meanište is situated on the southern periphery of the village of Ranutovac, approximately 5 km northeast of the city of Vranje. The site was discovered in 2000 during the excavation of house foundations by a local resident, when a cultural layer dating to the Early Iron Age was identified. Rescue archaeological excavations conducted by the Institute of Archaeology in Belgrade in 2012, prior to the construction of the E75 highway, investigated the endangered section of the site, located approximately 200 m from a local resident's house. This excavation revealed a necropolis with cremation burials dating to the Early Bronze Age, together with settlement remains from the early and the late phase of the Early Iron Age.
- In this study, 35 ceramic fragments (Fig. 1) were analyzed with the aim of determining the origin of the raw

material. For this purpose, three clay samples found in clay pits near the archaeological site were analyzed in the same way as the ceramics. The material was first analyzed using the portable EDXRF spectrometry technique, and the results were processed using PCA analysis. It was determined that most of the analyzed fragments have the same characteristics as the local raw material, indicating long-lasting local production (Bulatovic, forthcoming, Fig. 2). However, additional research was required for 7 fragments. Therefore, the production technology was examined by determining the firing temperature using the ER-FTIR analytical technique. Based on the position and shape of the Si-O stretching bands in the FTIR spectra, which for all analyzed fragments were around 1044 cm⁻¹, it was concluded that most of the examined fragments were fired at temperatures between 600 and 800°C. Additional analysis determined that the calcite content (as indicated by weak bands at 1433 cm⁻¹) in samples A183 and B4/43 is extremely low, indicating a higher firing temperature, most probably around 850°C.

The repeated selection of this location for settlement during different prehistoric periods was undoubtedly influenced by the presence of a high-quality clay deposit in the neighboring village of Suvi Dol, located approximately 2 km southwest of the site. This clay source remains in use to the present day. In addition to the non-local origin of the raw materials, the different production techniques for the seven fragments were confirmed.



Figure 1. Ceramic fragments examined in the study.

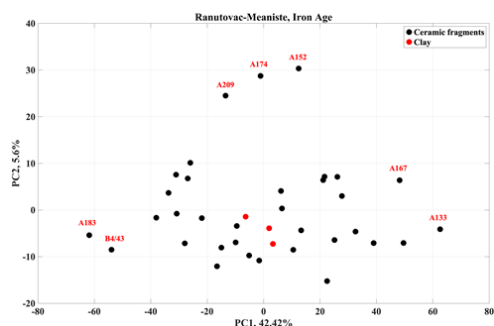


Figure 2. PC1-PC2 diagram of EDXRF spectral data on the elemental composition of potsherds and local raw material (Bulatovic, forthcoming).

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P-21. BIG QUESTIONS FOR TINY BLACK POTSHERDS: ARCHAEOOMETRY AND TYPOLOGY OF BLACK-GLAZED POTTERY IN SOUTHERN ETRURIA, ITALY

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This paper presents the first archaeometric characterization of Black-Glazed Pottery from the fortress of Rofalco (Southern Etruria, Italy), dating to the 4th–3rd centuries BCE. Conducted within the framework of the LE-BGP Project, the study combines archaeometric and typological analyses to investigate pottery production, technology and trade.

Rofalco, a fortified settlement located between the territories of Vulci and Orvieto–Volsinii (in central Italy), was occupied in the mid-4th century BCE until its destruction during the Roman conquest of Vulci around 280 BCE. As the first case study of the Late Etruscan Black Glazed Pottery Project (LE-BGP

Project), it offers a valuable opportunity to investigate production and exchange dynamics in Southern Etruria through the archaeometric characterization of a representative assemblage of black-glazed pottery and a granular chronological framework.

Black-glazed ceramics are considered key chronological and socio-economic indicators, providing valuable evidence for reconstructing patterns of production, consumption, and exchange. This study combines a typological analysis with X-ray fluorescence (XRF) and X-ray diffraction (XRD) to investigate its chemical and mineralogical composition. This first phase of the project aims to identify compositional groups within the assemblage and compare them with existing archaeometric datasets from coeval and slightly later black-glazed pottery from central Tyrrhenian Italy. In the absence of archaeological evidence for ceramic kilns at Rofalco, the study investigates whether the assemblage reflects local production or supply from external workshops. By integrating typological, chemical, and mineralogical data, it provides a first framework for reconstructing Late Etruscan black-glazed production and exchange, with particular reference to the territories of Vulci and Orvieto–Volsinii during the 4th–3rd centuries BCE, contributing to the definition of local production groups and technological traditions.

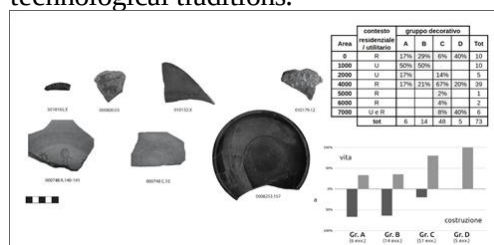


Figure 1. A selection of black-glazed pottery from Rofalco.

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P-22. STRUCTURAL CHARACTERIZATION AND ARCHAEOMETRY STUDY OF THE HISTORIC TILES OF THE BLUE MOSQUE OF TABRIZ USING INSTRUMENTAL ANALYSIS

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The Blue Mosque of Tabriz, dating back to the 9th century AH, is one of the most prominent monuments of the Timurid and Qara Qoyunlu periods, renowned globally for its diverse color palette and the richness of its mosaic tilework. A precise characterization of the physical, chemical, and mineralogical properties of these tiles is essential for understanding their manufacturing technology and developing effective conservation strategies. In this study, samples of mosaic tiles across various color groups were examined. A primary motivation for this research is that the selected case studies are derived from the remains of tiles recovered following the devastating earthquake in Tabriz and the partial destruction of the Blue Mosque. These samples offer significant insights for researchers in archaeometry and heritage conservation. By analyzing their structural composition and comparing the findings with previous studies on regional ceramics, this research aims to provide a comprehensive synthesis regarding the raw materials, Kiln technology, and firing conditions prevalent in the East Azerbaijan region. In recent years, the structural

characterization of historical tiles has increasingly relied on a combination of non-destructive, microstructural, and chemical methods to obtain precise information on composition, manufacturing technology, raw material provenance, and firing conditions. Among these, Raman Spectroscopy (SEM-EDS), XRD, AND Petrographic analysis provides valuable insights into the body microstructure, crystalline phases, glaze composition, the glaze-body interface, morphology, layer thickness, and the structure and morphology of crystals. To investigate the manufacturing technology, various analytical techniques are employed; inductively ICP-OES is used to measure trace elements for clay provenance; Laser ablation inductively coupled LA-ICP-MS is utilized for spot analysis of the glaze; and XRF is applied to determine the precise elemental composition of both the body and the glaze. Additionally, thermal analysis, including DTA/DSC are performed to understand thermal behavior during firing, while thermogravimetric (TGA) is used to evaluate weight loss and volatile compounds. The finding of this research are highly significant for identifying the manufacturing technologies of different historical periods, reconstructing glaze formulations, estimating historical kiln firing temperatures, and determining the provenance of clay and raw materials.

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P-23. PORTABLE XRF AND OPTICAL MICROSCOPY ANALYSIS OF ISLAMIC CERAMIC FROM SOUTHERN AND WESTERN IBERIA

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The goal of the project GC-CIGA [1] is to explore the diffusion of glaze technology in the western Iberia (Garb al-Andalus during the Islamic period), between the 9th and the 13th centuries, and to understand how Islamic social-cultural expansion, people mobility, exchange of know-how, trades, and raw material access and exploitation might have influenced this process. To this extent, starting from the production and diffusion of first glazed ceramic exemplars, the project goal is to evaluate the dissemination patterns between the heartland (Southern Iberia, Cordoba for example) and the periphery, the social reasons behind the adoption of glaze ceramics, the diffusion of know-how during time, the multiplication of ceramic workshops, and the possible differentiation in raw materials procurement for glaze production in the periphery of the al-Andalus if compared to the heartland of Islamic Iberia. These

data will be used to understand the diffusion of Islamic glazed ceramics in the Garb al-Andalus with a chronological, geographical, technological, and socio-cultural perspective. Almost 500 ceramic samples were selected including common, painted, and different glazed wares (Mono/Di-chromatic, and Green and Brown glazed ceramics) from different Spanish (Malaga, Seville, Cordoba, Pechina), and Portuguese cities (Lisbon, Coimbra, Santarém, Évora, Mértola, Silves).

The paper will present the results obtained by the first stage of the project which includes the not destructive analysis of samples ceramic paste using of portable X-Ray Fluorescence spectrometer (Tracer III SD), and the preliminary results of the application OM microscopy analysis by thin sections analysis to a restricted and selected number of samples.

Overall, the results indicate that the earliest prototypes of glazed ceramics were produced in the major urban centres of southern al-Andalus, during the 9th century AD. These early productions were subsequently distributed to the western territories of Islamic Iberia, demonstrating the existence of well-established exchange networks linking the political and economic heartland with its peripheral regions. During the following decades, glaze technology was progressively adopted in western al-Andalus, leading to the emergence of local ceramic productions that reproduced and adapted the technological and decorative features of the southern prototypes. The archaeometric data reveal both technological continuity and regional variability, suggesting that while the fundamental glazing technology and

manufacturing knowledge originated in southern Iberia, local potters progressively modified raw material selection and production practices according to locally available resources. These findings provide strong evidence for the gradual transmission of technological knowledge from the core regions of al-Andalus to its western periphery through sustained interactions among craftsmen, commercial exchange, and population mobility. The study therefore highlights that the diffusion of glazed ceramics was not merely the circulation of finished products, but also involved the dissemination, adaptation, and assimilation of specialised technological know-how, ultimately contributing to the establishment of new production centres across western Islamic Iberia.

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P-24. EARLY ISLAMIC GLAZED CERAMICS FROM MÁLAGA: ARCHAEOMETRIC EVIDENCE FOR THE INTRODUCTION AND DIFFUSION OF GLAZE TECHNOLOGY IN EMIRAL AL-ANDALUS

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The emergence of glazed ceramics during the Emiral period (8th–10th centuries AD) represents one of the earliest technological innovations introduced into al-Andalus following the Islamic conquest of the Iberian Peninsula. As one of the principal urban centres of southern al-Andalus, Málaga played a fundamental role in the development of glazed ceramic production, becoming an important manufacturing and distribution centre from the earliest stages of glaze technology adoption. Nevertheless, the technological characteristics of these early productions and their relationship with contemporary assemblages from other regions of al-Andalus remain insufficiently understood. This study focuses primarily on a large assemblage

of Emiral glazed ceramics recovered in Málaga, complemented by comparative material from Pechina, Silves, and Mértola. By integrating archaeological evidence with archaeometric analyses, the research investigates ceramic production technologies, raw material selection, and the circulation of glazed wares during the formative centuries of Islamic Iberia. The comparison between southern production centres and sites located in the western territories of al-Andalus provides new insights into the mechanisms through which glaze technology spread across the Iberian Peninsula and into the technological relationships linking production and consumption centres.

A representative assemblage of Emiral glazed ceramics, predominantly recovered from Málaga, was investigated using a preliminary non-destructive analytical protocol on a total of 20 samples. Subsequently, on diagnostic/representative ceramic fragments a partially destructive analysis protocol was developed including optical microscopy (OM), X-ray diffraction (XRD), conventional X-ray fluorescence (XRF), and micro-structural/chemical analysis by SEM-EDS. Results have been interpreted to investigate, by an integration with ceramic typology and chronology, ceramic provenance, technological traditions, and production variability.

The archaeometric results demonstrate the technological complexity of the earliest glazed ceramic productions in Málaga during the Emiral period. The analysed assemblage exhibits a relatively homogeneous compositional signature, consistent with the exploitation of local raw materials and the existence of well-established production practices.

Variations in glaze composition indicate the use of lead-based glazing technology together with different recipes and decorative techniques, reflecting an early stage in the technological development of Islamic glazed ceramics in al-Andalus. Comparison with contemporary assemblages from Pechina, Silves, and Mértola reveals both compositional similarities and significant differences, suggesting that Málaga functioned as a major production centre supplying glazed wares beyond its immediate hinterland, while regional technological adaptations also emerged. The integration of archaeological and compositional data supports the hypothesis that the diffusion of glaze technology towards western al-Andalus was driven by interconnected networks of production, exchange, and technological knowledge. These findings reinforce the central role of Málaga in the introduction and early dissemination of glazed ceramic technology throughout Islamic Iberia and provide new evidence for understanding the origins of one of the most influential ceramic traditions of the medieval western Mediterranean.

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P-25. A THERMO-OXYBAROMETRIC APPROACH TO UNDERSTANDING THE FIRING CONDITIONS OF BIZEN CERAMICS (16TH–17TH CENTURIES CE, JAPAN)

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The present study explores the technological aspects of Japanese ceramics excavated from the Shikata (Okaya-ma, Japan) archaeological site dating from the 16th to 17th centuries CE. The investigated assemblage (Yamamoto et al., 2017) includes sherds from Bizen wares, a stoneware tradition fired in high temperatures for which archaeometric studies remain limited. In particular the investigation of the mineralogy of Fe and Fe-Ti oxides present in the Bizen ceramics is expected to provide temperature constraints, while the Fe redox state preserved in vitrified aluminosilicate matrices could serve as an indicator of local oxygen fugacity.

This study introduces a novel methodological framework by adapting the geological Fe-Ti thermo-oxybarometric approach (Buddington and Lindsley, 1964) to archaeological ceramics. Although traditionally used to estimate equilibration conditions in igneous rocks, the Fe-Ti system can provide a qualitative proxy for investigating the non-equilibrium firing histories of high-fired stoneware. For a detailed investigation of the chemical and mineralogical information both at the micro- and nanoscale, we applied conventional techniques including X-ray Fluorescence (XRF), X-ray Powder Diffraction (XRPD), Scanning Electron Microscopy (SEM), and Raman Spectroscopy, complemented by more advanced techniques like Synchrotron XRF, Synchrotron X-ray Absorption Spectroscopy (XAS) and Transmission Electron Microscopy combined with Precession Electron Diffraction (TEM-PED) and Three-Dimensional Electron Diffraction (3DED).

The mineralogical and microstructural data reveal a strong dependence of

elemental distribution and phase formation on firing temperature. With increasing temperature, atomic diffusion becomes more extensive, promoting the spatial homogenization of Fe and Mn within the ceramic matrix. Ti displays a contrasting behavior, with elevated temperatures favoring localized segregation and the concentration of Ti into distinct high-temperature mineral phases, e.g., anosovite, pseudobrookite. This thermal evolution is also reflected in the size and distribution of Fe-rich black spots, which record localized chemical segregation and mineral nucleation during firing.

Together, the combined application of the Fe-Ti thermo-oxybarometer, synchrotron-based spectroscopy and advanced nano-crystallographic techniques demonstrates that the mineralogy and elemental distribution of Bizen stoneware preserve signatures of a dynamic, non-equilibrium firing history rather than a single equilibrium state. These signatures record variations in firing temperatures (above 1,050 °C in all samples), kiln atmosphere and localized redox conditions during firing. This study demonstrates the potential of integrating qualitative thermo-oxybarometric concepts with spatial elemental mapping and nanoscale mineralogical characterization to reconstruct otherwise inaccessible technological information in ancient high-fired ceramics.

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P-26. A PURIFICATION- ENHANCED GRAPH NEURAL NETWORK PIPELINE FOR ARCHAEOLOGICAL PROVENANCE OF IBERIAN POTTERY

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The provenance study of ancient pottery faces critical bottlenecks due to homogeneous, overlapping geological catchments and noisy field assemblages confounded by foreign imports, post-depositional leaching, or analytical noise. Traditional classifiers (e.g., LDA, Random Forest) fail in areas like the Tagus River basin because they operate under rigid independent and identically distributed (i.i.d.) assumptions, completely ignoring continuous geographic landscapes. To resolve this, we introduce GraphAT, a decoupled computational pipeline designed to purify geochemical datasets and embed landscape topography directly into geometric deep learning models, bridging bulk geochemistry with macro-geographic pathways.

GraphAT operationalizes composition purification and landscape-aware representation via two successive, decoupled phases:

Phase I Data Purification: To establish high-confidence Local Reference Groups (X_LRG), the 15-dimensional log-transformed pXRF matrix is processed along parallel tracks. Track A uses

HDBSCAN ($m_clust = 6$, $m_samples = 1$) and GLOSH to isolate absolute concentration outliers ($\tau_GLOSH > 0.5$) caused by leaching. Track B deploys a non-linear Hyperspherical MLP Autoencoder projecting inputs onto a $d=4$ unit hypersphere to strip volume scaling and isolate subtle mineral-tempering recipe anomalies based on MSE against an ECDF adaptive threshold ($\gamma_{90} = 0.0193$). A consensus router filters out highly probable foreign imports (X_Exotic).

Phase II Spatial Graph Attention Networks (GAT): The purified cloud is transformed into an Adaptive Purified Multi-Layer Landscape Graph (G_AML). Edge generation integrates intra-site contextual cliques (penalized by GLOSH metrics), latent recipe proximity (via K-NN search on the unit hypersphere), and landscape-constrained corridors (modeling river drainage and maritime pathways). An 8-head GAT is then trained transductively to allow physical terrain to anisotropically govern feature aggregation.

As results, Phase I successfully unmasked diagnostic elements (Sr, $d = 0.88$; Mn, $d = 0.75$). In the supervised tracing phase, the G_AML architecture resolved regional representation confusion, securing an Overall Accuracy of 95.71% and a Macro-F₁ score of 91.97%—a +6.06% predictive lift over node-independent MLP baselines. Low-dimensional UMAP visualizations validate clear cluster isolation (Fig1). Attention coefficients (α_{ij}) extracted for c. 1200 CE revealed prominent flux radiating from Evora to southern coastal centers (Mertola: 0.039; Silves: 0.034) and highlighted Palmela as a critical estuarine gateway. Crucially, the model reverse-provenanced eight cryptic shards

from Muge (Muge_317–328 series) to adjacent Santarem, peaking at 81% confidence for Muge_324.

The pipeline demonstrates that integrating latent technological recipes and physical geographical barriers prevents spatial over-smoothing and suppresses localized post-depositional noise. Anthropologically, the successful reclassification of the Muge assemblages provides robust, quantitative evidence of post-Reconquista artisan mobility. It reveals that migrating Mudejar potters from Santarem strictly preserved their ancestral technological paste preparation traditions while exploiting newly encountered local alluvial clay beds at Muge.

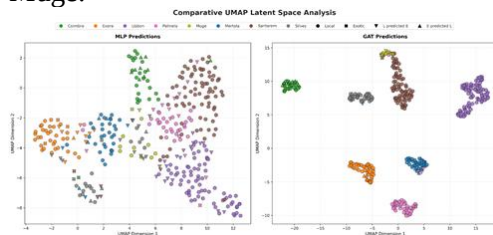


Figure 1. Latent Space Compare (MLP vs GAT)

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P-27. BIOLOGICAL DETERIORATION OF STONE CULTURAL HERITAGE: THE CLEANING POTENTIAL OF PADINA PAVONICA FOR STONE SURFACES

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The biodeterioration of stone cultural heritage by lichens, algae, fungi, and bacterial biofilms presents a major challenge in conservation science (Cirone et al., 2023). Conventional chemical biocides, while effective, can cause environmental hazards, health risks for operators, and long-term physicochemical changes to carbonate substrates (Zuena et al., 2021). In response to the growing demand for sustainable conservation strategies, recent research has focused on natural and low-toxicity alternatives that can remove biological patinas while

preserving the integrity of historical stone materials. Marine macroalgae, especially brown algae rich in phenolic compounds and polysaccharides, have demonstrated promising antimicrobial and antibiofilm properties (Behzadnia, et al., 2024). The present study examines the cleaning potential of *Padina pavonica* extract on Veselje Unito limestone, a carbonate stone quarried near Pučišća on Brač Island and extensively used in Adriatic heritage (Donelli, 2024).

An aqueous extract of *Padina pavonica* was applied to limestone surfaces colonized by lichens. The cleaning performance of the algal extract was compared with that of a conventional chemical biocide (Asepsol Eko). A total of 20 mL of extract was applied to the test area, followed by gentle brushing and a contact time of 15 minutes before rinsing with distilled water. Cleaning effectiveness was assessed through visual evaluation of patina removal and surface preservation.

The algal extract effectively reduced the dark biological patina while preserving the natural color and texture of the stone surface. In contrast, the chemical biocide produced a stronger cleaning effect accompanied by slight tonal inconsistencies, suggesting possible substrate alteration. Toxicological assessment was carried out using the Bioluminescence % Effect assay based on *Vibrio fischeri*. The *P. pavonica* extract produced low inhibition values remaining below the 20% threshold commonly associated with minimal acute toxicity. These findings suggest that *P. pavonica* extract represents a promising environmentally compatible alternative for the biological cleaning of carbonate stone heritage.

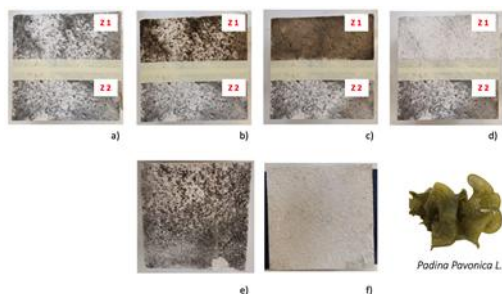


Figure 1. Cleaning procedure and comparison between the algal extract treatment and the chemical biocide treatment on stone samples colonized by lichens. (a) Untreated stone surface showing the original black biological patina; (b) application of 20 mL of algal extract on zone 1 (Z1); (c) gentle brushing of the treated surface and contact time of 15 min to enhance interaction between the extract and the biological layer; (d) rinsing with distilled water and final appearance of the treated area, where Z1 appears white and free of lichens, while the untreated zone (Z2) still shows the black patina; (e) untreated second sample before chemical treatment; (f) final appearance of the second sample after treatment with 20 mL of Asepsol Eko, showing complete removal of lichens.

Acknowledgements

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P-28. SUSTAINABLE SYNTHESIS AND IN SITU APPLICATION OF A NEW NANOLIME FOR THE COMPATIBLE CONSOLIDATION OF HISTORIC PLASTERS. A CASE STUDY IN THE OLD PORT OF GENOA

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The conservation of historic plasters requires consolidation treatments that ensure chemical, physical, and mechanical compatibility, long-term durability, and low environmental impact. In recent years, nanolime-based products have shown promising performance in the consolidation of calcareous substrates (Ambrosi et al., 2001; Otero et al., 2018); however, issues related to the sustainability of synthesis and effectiveness on large surfaces remain open challenges (Monasterio-Guillot et al., 2023). In this context, a new aqueous nanolime, named NANOLAQ, produced by the Spin Off of the University of L'Aquila through a sustainable and patented synthesis route, has been developed and employed for green and compatible consolidation treatments of historic mortars and plasters (Macera et al., 2021; Volpe et al. 2016).

NANOLAQ was synthesized through a low-impact, environmentally friendly process and dispersed in water, avoiding organic solvents. The material was fully characterized in terms of particle size distribution, morphology, phase composition, and carbonation behavior. The consolidating performance was evaluated through an in situ application carried out by airbrush on a deteriorated historic plaster located on the external façade of a building in Via Vico Palla, in the Old Port area of Genoa. The treatment effectiveness was assessed through non-destructive and micro-destructive techniques, including surface cohesion tests (Scotch Tape Test - STT) and microdrilling measurements (DRMS technology).

The synthesized nanolime exhibited nanoscale particle size and effective carbonation under ambient conditions. The in situ application showed a marked enhancement in surface cohesion and a good penetration depth (exceeding 1 cm, with a stable resistance profile up to 20 mm depth). Furthermore, it provided excellent aesthetic compatibility, with no visible chromatic alteration or surface film formation. DRMS results indicated a significant recovery of mechanical performance, increasing the average resistance from 15 N (untreated) to 24 N (treated area), even exceeding the performance of a standard new repair mortar (18 N).

The obtained results highlight the high potential of NANOLAQ as a sustainable and effective consolidant for historic plasters. The combination of green synthesis, aqueous formulation, and high consolidating efficiency makes this product particularly suitable for large-scale and environmentally compatible conservation interventions. The

successful case study in the Old Port of Genoa demonstrates the applicability of NANOLAQ in real conservation scenarios, contributing to the development of innovative and sustainable materials for cultural heritage.

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P-29. NATURAL MATERIALS, CULTURAL IDENTITY, HERITAGE AND HOUSING IN MEXICO: SOME IDEAS FOR CITY PLANNING

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During the Viceroyalty of New Spain, the erection of a city should begin with the layout of the streets, leaving a place in the centre of the settlement for the construction of the church, next to which the central square should be located, and next to the public edifices. The first architectonic constructions in the Viceroyalty were erected using elementary constituents such as stone, clay, wood, and straw. Since much of the Mexican territory has been subjected to volcanic events, volcanic rocks were often found near the cities. Besides, in some cases they were highly prized for construction, as they were relatively soft and could be carved to create artistic designs in stone. Outside of the city grid, in the bordering neighbourhoods, the modest houses were situated. The main constituents used for its construction were customary materials such as adobe (raw earth and straw), rough-hewn stone, thatched roofs, etc. Very few cases of adobe houses erected during the 16th century have survived until today. In any case, only ruins remain. An exceptional case is the Gran Pirámide de Cholula (Pérez et al, 2016), although today, the

pyramid has some problems of stability. The lifespan of adobe material contrast with the lifespan of the quarry stone. The first (covering 3 or 4 generations of humans) is enough to satisfy the identity and diverse needs of a family or small group of persons; while the second, the lifespan becomes longer (hundreds or even thousands of years), desired for an element that has to do with the cultural identity and heritage of a city, a nation, or the entire world.

The difference in lifespan of a building material is related to its composition and then, to its physical and chemical properties. As a result, some zones within human settlements are more susceptible to redevelopment (change), while for others the preservation is preferred. Therefore, the driving force behind studying the natural materials such as those mentioned above is to take advantage of their differences in its lifespan to perform urban planning that promotes desired changes in human settlements. Unlike cement, natural materials offer eco-friendly characteristics suitable to implement changes to remodel a city (e.g. incorporating cycle paths, railways, etc. in places that are reaching the end of their lifespan (Figure 1).

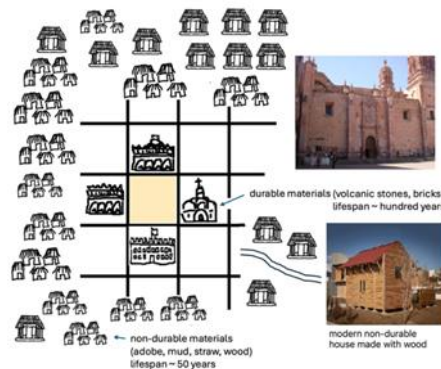


Figure 1. Utopic model for a city: the grid layout appears ideally unchanged because of the highly

durable materials used for its construction. Outside the grid, the dispersed rustic houses change and ideally, allow to remodel the city.

The Materials included in this study were pieces of natural quarries from buildings located in Zacatecas City, Toluca, Oaxaca; and adobes from houses located in Tlalpan Centre (in Mexico City), as an examples of highly and low durable materials. They were characterized by XRD, ATR-FTIR, light microscop-y and compressive strength.

The pink quarries from Zacatecas are composed by rhyolitic ignimbrites (mainly by quartz, 55.8%, and sanidine, 32.5%), while the green quarries from Oaxaca, are characterized mainly by high content of heulandite-Na, 70%, and quartz, 22%. The compressive strength was found to be around 20 MPa for both pink and green quarries, therefore, both are considered soft rocks with a moderate degree of welding. The adobe from houses in Tlalpan, are characterized mainly by a high content 40-50% of amorphous phases, around 27% of andesine, 10-20% of orthopyroxene, and small amounts of quartz, and tridymite.

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P-30. EAST MEETS WEST IN 1933: TECHNICAL STUDY OF FAT TAT TONG (發達堂) IN HONG KONG

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As a typical example of eclectic architecture built by returned overseas Chinese in early 20th-century Hong Kong, Fa Tat Tong (completed 1933) embodies unique Hong Kong-style cultural integration, blending traditional Hakka building heritage with modern Western construction technologies. This declared monument, owned by the influential Hakka Li family of Sha Tau Kok, is still inhabited by Li descendants. It stands as a valuable physical record of Hong Kong's architectural history and cross-cultural exchange. Despite its rich historical and cultural importance, Fa Tat Tong's construction materials and craft techniques have lacked systematic research, leaving a knowledge gap in the study of early Hong Kong Hakka architecture and material culture. This study addresses this gap via comprehensive material analysis, offering scientific support for heritage conservation and a reference for research into Hong Kong's early architectural history.



Figure 1. Fa Tat Tong, built in 1933 in Hong Kong.

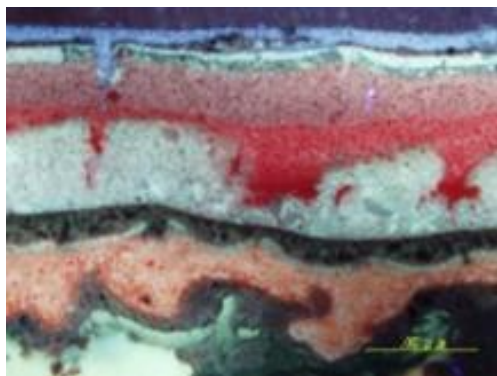


Figure 2. X-section of paint of wooden door.

To meet this objective, a multi-analytical approach was adopted, integrating advanced scientific techniques: reflective visible and UV fluorescence microscopy for cross-section examination; polarized light microscopy for mineral pigment and petrographic identification; SEM/EDX for elemental composition analysis; FTIR spectroscopy for vibrational spectral characterization; and light microscopy for wood species identification. These methods allow systematic analysis of major building materials - including coatings, timber, façade mineral pigments and roofing tiles - revealing the material properties, craft techniques and degradation mechanisms of the monument.

Results reveal distinct material characteristics that reflect early 20th-century Hong Kong's cultural fusion

and technological transition. FTIR confirmed all coatings are alkyd-based, a modern Western finish widely adopted locally in that era. The painting process displays unique cultural adaptation: original green layers with high-purity aluminium powder for metallic sheen were later repainted brown to harmonise with wooden doors and handrails. This selective repainting merges Western alkyd technology with traditional Chinese aesthetics, creating colour coherence between metal and timber components.

Interior ceiling and wall coatings in white, yellow and red share the same application procedure and material composition. The lime base is tinted with gypsum, with colour differences derived from inorganic impurities and natural mineral inclusions in raw materials. This practice carries on traditional Chinese lime plastering, combining classic Guangdong-Hakka building heritage with modern material applications.

Hakka roof tiles come in red and green variants. Both are clay-iron ochre based, differing in iron content, quartz ratio (3% for red tiles, 5–10% for green tiles) and structural arrangement. Variations arise from clay origins and firing conditions; red tiles gain iron oxide colouration in oxygen-rich kiln environments. These tile types embody traditional Hakka roofing aesthetics and locally sourced materials suited to Hong Kong's subtropical climate.

Timber analysis confirms careful material selection: China fir (*C. lanceolata*), a durable local softwood commonly used for Hakka roof battens, complies with the lightweight, breathable framing principles of classical Chinese timber architecture. By comparison, *Shorea* spp. - premium Southeast Asian

imported hardwood - was utilised for doors and handrails for its durability and wear resistance. This dual timber approach blends Eastern and Western construction practices, demonstrates Hong Kong's mixed architectural culture in the early 20th century, and highlights its status as a regional trade hub.

This study systematically analyses the construction methods and materials of Fa Tat Tong. While limited published research addresses traditional and contemporary Hakka building techniques from this era in Hong Kong, this work identifies shared construction practices between historic Guangdong-Hakka dwellings and modern building approaches, which together embody Hong Kong's cross-cultural identity.

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P-31. AN ASSESSMENT OF REPEATEDLY REPLASTERED AND RED-PAINTED FLOOR OF A NEWLY IDENTIFIED PUBLIC BUILDING AT ÇAYÖNÜ TEPEŞİ

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Çayönü Tepesi in southeastern Türkiye is one of the most important Neolithic settlements of Upper Mesopotamia, renowned for its communal architecture and long sequence of occupation. Excavations conducted during the 2025 field season revealed a newly identified public building located at one of the highest topographic points of the settlement and forming the easternmost component of the communal precinct. Constructed with stone foundations and mudbrick superstructures, the building occupies a transitional position between residential areas to the west and communal spaces to the east.

Architectural and stratigraphic evidence demonstrates that the structure remained in use for a prolonged period and

underwent at least four major renovation episodes. Each phase involved the application of thin lime-plaster coatings, generally 1–2 mm thick, followed by repeated repainting of floor surfaces. Multiple superimposed pigment layers, including red, reddish-brown, and reddish-orange colours, were documented. These recurrent practices indicate deliberate programmes of maintenance and visual renewal rather than occasional repair activities, suggesting that the building possessed social and symbolic significance beyond everyday domestic functions.

The structure was documented through high-resolution photogrammetry, three-dimensional modelling, digital architectural recording, and GIS-based spatial analyses. In parallel, an archaeometric research programme has been initiated to investigate the composition, production technologies, and renewal practices of the lime plasters and pigments. Multi-layered sampling strategies were employed, and analyses using Raman spectroscopy, X-ray diffraction (XRD), scanning electron microscopy with energy-dispersive X-ray spectroscopy (SEM-EDS), and Fourier-transform infrared spectroscopy (FTIR) are currently underway. These studies aim to characterise the mineralogical and chemical composition of the pigments and plasters, reconstruct technological choices related to their production and application, and evaluate the cultural significance of repeated replastering and repainting practices.

The integration of architectural, spatial, and archaeometric datasets provides new insights into technological knowledge, symbolic behaviour, and the maintenance of communal institutions in Neolithic Upper Mesopotamia.

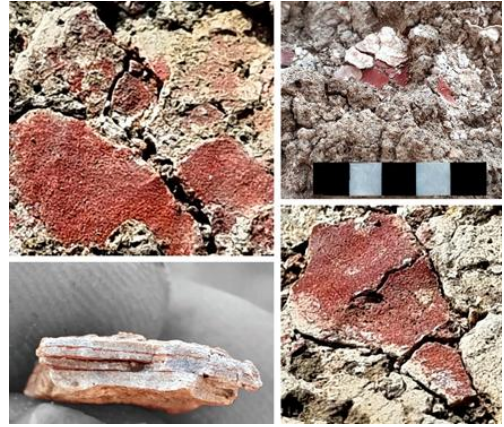


Figure 1. Red paint residues identified on the lime-plastered floor surface of the Red-Painted Building at Çayönü Tepesi.

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**P-32. MULTI-ANALYTICAL
STUDY OF GREEN PASTE
MUD FROM THE
WUWANGDUN NO. 1
TOMB, CHINA: A
COMPARISON WITH
ORDINARY RAMMED
EARTH**

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Green paste mud is a distinctive earthen material found in high-status tombs of ancient China and is commonly regarded as an important component of tomb sealing systems (Song, 1991; Wu, 2015). However, its material characteristics and the basis of its potential sealing function remain insufficiently understood, particularly because systematic comparisons with ordinary rammed earth within the same tomb construction system are scarce (Wei et al., 2021). The Wuwangdun No. 1 Tomb in Huainan, Anhui Province, is a high-status Chu tomb dating to the late Warring States period and provides a key context for addressing this issue. This study

compares Green paste mud and ordinary rammed earth from the tomb to clarify their material differences and provide evidence for subsequent research into source materials, formation processes, engineering performance and conservation.

Four categories of earthen material were selected according to macroscopic appearance, spatial position and structural relationship: two Green paste mud materials from the top of the tomb pit and the enclosing wall of the burial chamber, and two ordinary rammed-earth materials adjacent to the upper Green paste mud layer. Analyses included macro- and microscopic observation, physical and geotechnical tests, CIELAB colour measurement, laser particle-size analysis, X-ray diffraction (XRD), X-ray fluorescence spectrometry (XRF), major-oxide multivariate statistics and soil micromorphology.

The results reveal systematic differences between Green paste mud and ordinary rammed earth. Colour measurement confirms that Green paste mud changes during drying from darker greyish-green to lighter greyish-white and has lower chroma than ordinary rammed earth. It also exhibits lower plasticity indices, indicating that strongly plastic clay behaviour is not its principal characteristic. All samples are silt loams dominated by silt-sized fractions. XRD shows that both materials are mainly composed of quartz, feldspar and the same clay-mineral types, without fundamental differences in mineral assemblage; however, Green paste mud is relatively enriched in quartz and contains lower total proportions of clay minerals. XRF and major-oxide multivariate analysis are consistent with the mineralogical evidence: although the

two materials can be compositionally distinguished, their differences do not indicate entirely separate raw-material systems, but more likely reflect variations in siliceous versus aluminosilicate/clay-rich components within a broadly comparable raw-material background. Micromorphology further shows a better-sorted, more homogeneous and continuous silty groundmass in Green paste mud, compared with the heterogeneous silty-clayey matrix of ordinary rammed earth. In addition, abundant plant remains observed in the Green paste mud from the enclosing wall of the burial chamber suggest that this material may represent a composite construction material produced through further processing involving the incorporation of plant-derived components.

In summary, the differences between Green paste mud and ordinary rammed earth lie primarily in mineral proportions, plasticity, particle sorting and microfabric, rather than in fundamentally different mineral species. Green paste mud may represent a silty earthen sealing material formed through selective use or some degree of intentional processing of source materials broadly similar to those of ordinary rammed earth. Its relatively low clay-mineral content and weak plasticity challenge explanations that attribute its potential impermeability or sealing performance chiefly to high clay content. Better particle sorting, a continuous silty groundmass, lower clay-rich components and local plant-derived constituents may together influence shrinkage cracking and potential sealing performance, although direct engineering tests are required to verify this interpretation.

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P-33. CHALLENGES, LIMITATIONS AND RESEARCH DESIGN OF LUMINESCENCE DATING FOR CLAY HISTORIC BUILDING MATERIALS IN THE CZECH REPUBLIC

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Luminescence dating methods, particularly thermo-luminescence (TL) and optically stimulated luminescence (OSL), have become valuable tools for establishing absolute chronologies of archaeological materials and structures. Although luminescence dating has been successfully applied to architectural materials and historic structures in numerous international case studies, its use within Czech archaeological and architectural-historical research remains limited. As a result, the methodological potential and practical limitations of luminescence dating for historic building materials have not yet been systematically assessed in the Czech context. The absence of a standardized methodological framework is one of the factors contributing to the very limited use of luminescence dating in the study of historic architecture in the Czech Republic.

This paper presents an ongoing PhD research project focused on evaluating the applicability of TL and OSL dating to medieval building ceramics and architectural structures. The study

combines archaeological, archaeometric, and art-historical approaches and is being developed in collaboration with the luminescence laboratory Archéosciences-Bordeaux.

Particular attention is devoted to sampling strategies, environmental dose-rate assessment, field documentation, and the selection of suitable reference sites with secure chronological frameworks.

The selected case studies range from prehistoric contexts to securely dated medieval monuments, providing comparative reference points for evaluating sampling procedures under different archaeological and architectural conditions. Preliminary fieldwork suggests that sampling strategy and contextual documentation are among the most critical factors influencing the applicability of luminescence dating to architectural materials. Initial observations further indicate that major challenges arise not only from laboratory procedures but also from sample accessibility, environmental conditions, and the integration of archaeological and scientific datasets. The paper also revisits earlier applications of luminescence dating in Czech archaeology during the 1990s and discusses their methodological context.

These initial findings suggest that the successful application of TL and OSL dating to historic building materials requires a standardized methodological framework that integrates fieldwork, laboratory analysis, and archaeological interpretation. The project aims to contribute to the development of such a framework and to assess the broader potential of luminescence dating for the study of medieval architecture and built heritage in the Czech Republic.

P-34. CHRONOLOGY AND FIRING TECHNOLOGY OF LATE NEOLITHIC CERAMICS FROM NORTHERN GREECE

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Dating and technological characterization of archaeological ceramics are essential for understanding ancient production practices. This study presents an integrated archaeomagnetic, mineralogical and thermoluminescence investigation of Late Neolithic ceramics from three archaeological sites in the broader Thessaloniki region, northern Greece.

Nineteen pottery fragments (45 specimens) and samples from one furnace were analyzed using Thellier–Thellier palaeointensity experiments, complemented by rock magnetic measurements XRD, TL and magnetic susceptibility analyses to determine both firing conditions and archaeointensity. The combined mineralogical, magnetic susceptibility and TL approaches indicate firing temperatures ranging from 640 to 820 °C, suggesting adequate firing conditions and consistent production

techniques among the investigated sites. The agreement between these independent methods supports the reliability of the estimated firing temperatures.

The combined mineralogical, magnetic susceptibility and TL results indicate firing temperatures between 640 and 820°C, suggesting well-controlled firing conditions and similar production techniques across the studied sites. Archaeomagnetic experiments achieved a 75% success rate under strict acceptance criteria, yielding palaeointensity values ranging from 23 to 50 µT with good internal consistency. TL dating, supported by archaeological evidence, indicates ages between 5500 and 4500 BCE.

The agreement between the independent methods demonstrates the reliability of the estimated firing temperatures and chronological framework. These results provide new archaeointensity data for northern Greece and contribute to improving the regional secular variation record for the Neolithic period.

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P-35. THE SEASONALITY OF FESTIVALS AT HELLENIC TEMPLES WITH SKYSCAPE ARCHAEOLOGY: METHOD, DATABASE AND INDUCTIVE MODEL

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In Greek religion, festivals are recurrent and periodic ritual occurrences characterised by precise aetiological myths, wearing features, processions with specific objects, the preparation of food or fasting, performative actions, choreatic dance, agonistics games, markets, to-gether with sacrifices followed by banquets (Chaniotis, 2011, p. 15). Festivals were holiday time, where legal, administrative, working, educative, military, political activities were not permitted as prescribed by cult regulations. Their celebration was fundamental for the social cohesion of the communities. However, for many sanctuaries it is mostly unknown when their main celebration happened during the year. The application of skyscape archaeology to the spatiality of temples aims to provide an indicator of this festive seasonality to try filling this gap of knowledge.

The project FEAST investigates the timing of festivals combining archaeology, topography, and astronomy. The approach of archaeoastronomy or skyscape archaeology has been

previously applied to Greek temples (Liritzis and Vassiliou, 2002; Pantazis, 2014; Pantazis and Lambrou, 2018; Boutsikas, 2020). Results still remains elusive and, apart few case studies, it is still unclear the rationale behind the placing and orientation of Greek temples. This research aims to elaborate on this issue by compiling a database of orientations of sacred structures from the Archaic to the Hellenistic period, focusing on Attica on the comparison with festivals timing after inscriptions and literary sources. Indeed, the astronomical movements of the sky included both a datum from a spatial level (apparent position of the rising and setting of astral bodies on the local horizon) and on a temporal level (annual time when that event happens on that position). Given this double connotation of a single astronomical event, it is possible to convert the spatiality of architectural structures to a seasonal time in the solar–lunar year. The hypothesis of the research is that this seasonal time may corresponds to the acme of the rituality of a sanctuary, that is the celebration of its festival. Two datasets – a) skyscape event after orientation and b) festival time from written sources – are converted in number of days from the local summer solstice, which was the main reference for the new year in the Attic calendar. Given the wandering character of the solar–lunar calendar, it is necessary to consider an interval of about 28 days as range to set the interval between summer solstice and the new crescent moon, which defined the start of the month. The Attic months are then calculated as alternation of 29 and 30 days each. This database gathers all the information necessary to build a model, in order to scientifically validate the

starting hypothesis by comparing the two datasets with a statistical test.

Preliminary results show a correlation between the orientation of temples, the movement of the sun, moon, stars, and the season of festival. Uncertainties given by the identification of the festival with a given sanctuary introduce ambiguity to the direct comparability of datasets. Nevertheless, a deeper investigation into the wider cultic and mythical spheres of the festivals will help to identify the correct seasonality and to refine the model (Parker and Sourvinou-Inwood, 2011). Further work will be necessary to better under-stand the rationale behind orientation of the Greek temples and their placing within the wider cosmos.

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P-36. DIET AND MOBILITY: PRELIMINARY STABLE ISOTOPE RESULTS FROM THE BRONZE AGE SITE OF LINOU, CYPRUS

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Isotope analysis has been an essential tool in archaeological sciences for several decades, enabling investigations of paleodiet and mobility (e.g. Evans et al. 2006; Lee-Thorp 2008; Nafplioti et al. 2021). However, in Cyprus, isotopic datasets for past human remains are currently limited (Goude et al. 2018; Calabrisotto 2019). This paper presents part of the results from an ongoing PhD dissertation; it examines mobility and dietary practices through isotope analysis of 49 human skeletons from the Bronze Age site of Linou, Nicosia district, Cyprus.

Isotopic analysis, as a branch of chemical bioarchaeology (Ambrose & Krigbaum, 2003) provides documented data that complements and expands archaeological interpretations.

The data include carbon ($\delta^{13}\text{C}$), oxygen ($\delta^{18}\text{O}$), and strontium ($^{87}\text{Sr}/^{86}\text{Sr}$) isotope ratios measured in human enamel.

Carbon isotope values strongly support a C3 dominated diet, irrespective of the individual's sex, while oxygen and strontium isotopes reveal interesting

patterns of human mobility within the island.

Importantly, isotopic values are discussed in association with macroscopic evidence of health and disease in this assemblage, stressing the complementarity of different lines of evidence.

The results contribute to the growing body of isotopic research in ancient Cyprus and promote a better understanding of how inland communities engaged with the dynamic world of the Bronze Age.

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P-37. ISOTOPIC AND MACHINE LEARNING APPROACHES REVEAL INCREASING DIVERSITY IN INFANT WEANING PRACTICES IN BYZANTINE THESSALONIKI

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The period between 300 and 600 CE was characterized by extensive population mobility and demographic restructuring across Europe. These large-scale migration processes reshaped urban communities, altering their demographic composition, health profiles, and subsistence strategies. Because infant feeding practices are closely linked to maternal behavior, cultural traditions, and environmental conditions, they provide a sensitive indicator of social change during periods of population transition.

In this study, we investigate changes in infant feeding practices across the transition from the Roman to the Byzantine periods using individuals from Thessaloniki, the capital of the Roman province of Macedonia. As one of the most important urban centers in the Balkans, Thessaloniki retained its

political, administrative, and economic significance throughout the Byzantine period, providing a unique opportunity to examine the long-term effects of demographic and cultural transformation on childhood dietary practices.

A total of 96 individuals were analyzed, including 41 Early Byzantine, 8 Middle Byzantine, and 47 Late Byzantine individuals. These data were combined with isotopic data from 68 previously published Hellenistic, Roman, and Post-Byzantine individuals from Thessaloniki, yielding a dataset of 164 individuals spanning more than two millennia. Incremental dentine $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ sequences obtained from first permanent molars were analyzed using a long short-term memory (LSTM) machine learning framework to estimate the age at weaning completion.

Preliminary results indicate that weaning practices remained relatively stable during the Hellenistic and Roman periods, with a mean weaning age of approximately 1.8 ± 0.6 years. In contrast, substantially greater variability emerged from the Early Byzantine period onward. Estimated weaning completion ranged from approximately 1.0 to 4.3 years in the Early Byzantine period, 1.5 to 2.5 years in the Middle Byzantine period, and 0.6 to 5.0 years in the Late Byzantine period, reflecting both earlier cessation of breastfeeding and markedly prolonged breastfeeding in some individuals.

The increased variability in weaning practices during the Byzantine period likely reflects the combined influence of demographic change, shifting social and cultural norms, and environmental pressures associated with periods of political and economic transformation. These findings provide new insights into

childhood dietary practices and establish a foundation for investigating how major societal changes influenced infant health and early-life experiences in one of the Eastern Mediterranean's longest continuously occupied urban centers.

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P-38. ELEMENTAL MAPPING OF ARCHAEOLOGICAL TATTOOED SKIN: A PILOT LA-ICP-MS STUDY OF PRE-COLUMBIAN PERUVIAN MUMMIFIED REMAINS

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Archaeological tattooed skin provides rare direct evidence for past practices of body modification, but its chemical composition remains difficult to investigate because pigment particles are embedded within altered and often fragile preserved tissue. Tattoos preserved on mummified remains are usually documented through macroscopic observation and non-invasive imaging, whereas chemically analysis of pigment distribution within the skin is less frequently undertaken. This paper presents a pilot application of Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS) to tattooed mummified human skin from pre-Columbian Peru. To the best of our current knowledge, it is one of the first applications of LA-ICP-MS focused directly on archaeological tattooed skin and the first such approach applied to material from pre-Columbian Peru.

In this study, LA-ICP-MS was employed to obtain elemental maps of selected regions of mummified skin. Small skin samples containing dark tattoo marks were analysed to characterize the elemental composition of the skin,

identify potential elemental markers associated with tattoo pigments, compare the elemental distributions in tattooed and non-modified skin, and assess whether the observed elemental signatures are consistent with the use of inorganic rather than organic tattoo pigments.

Preliminary results indicate that LA-ICP-MS is well suited for documenting elemental variability at a spatial scale relevant to archaeological tattooing while requiring only minimal tissue samples, unlike conventional ICP-MS. In addition to providing bulk elemental data, LA-ICP-MS preserves spatial information, enabling elemental signatures to be linked to specific regions of the sample. This is essential for distinguishing signals associated with tattoo pigments from those of the surrounding skin tissue. The study demonstrates the potential of LA-ICP-MS as a complementary archaeometric method for the study of modified human skin. It does not replace non-invasive documentation, but extends it by adding high-sensitivity, spatially controlled chemical information. The pilot data contribute to broader discussions of ancient tattoo pigment and skin composition.

P-39. A MYCENAEAN BOAR'S TUSK HELMET FROM MESSENIA: AN ARCHAEOMETRICAL INVESTIGATION

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Fragments of boar tusk, interpreted as parts of a ceremonial boar's tusk helmet, were recovered from Tholos Tomb 2 at the fortified hill of Metsiki, near Psari in northern Messenia, excavated over three seasons (2018–2020) under the auspices of the Ephorate of Antiquities of Messenia. The tomb, one of the largest and most complex in the region, dates to the Late Helladic IIA period (ca. 1520/10–1450/40 BCE). Its assemblage - bronze swords, flint arrowheads, daggers, ceramic vessels, gold-decorated appliques, beads, seals and bone objects - indicates the burial of a high-ranking warrior, in accordance with the Homeric description of the helmet. Thirty-six conserved fragments were integrated into an interpretative reconstruction, followed by seven non-conserved fragments and three referential modern *Sus scrofa* tusks selected for analyses. A lack of comparable archaeometric methodologies

applied to similar artefacts provided a rare opportunity for their in-depth scientific investigation.

The study aimed to establish the taxonomic attribution of the fragments, to detect residual materials, to record traces of surface treatment, and to characterise post-depositional alteration within the burial microenvironment. The non-destructive techniques employed were optical microscopy, portable Raman spectroscopy (Bruker BRAVO), SEM/EDS (JEOL JSM-6510LV) and reflection FTIR (Perkin-Elmer Spectrum GX I), with the Kramers–Kronig transformation applied to the reflection spectra.

Raman and FTIR consistently showed the characteristic bands of carbonated hydroxyapatite, with a strong $\nu_1(\text{PO}_4^{3-})$ peak near 960 cm^{-1} , matching modern reference tusk spectra and confirming the material as *Sus scrofa*. The detected pseudomalachite indicates contact with copper-bearing materials, most plausibly the bronze objects deposited alongside, while calcite, quartz, iron oxides and carbon bands record a carbonate- and metal-rich burial microenvironment and possible partial thermal exposure. SEM/EDS demonstrated that preservation varies sharply within a single tomb: in DK 10 the biogenic Ca–P signal is largely masked by soil-derived aluminosilicates and iron oxides, whereas DK 50 and DK 62 retain calcium and phosphorus in proportions characteristic of hydroxyapatite. FTIR indicated partially surviving collagen (amide I and II), a low collagen index (~ 0.21) and a high crystallinity index ($\text{IRSF} > 2.8$), pointing to advanced diagenetic recrystallisation. Optical microscopy documented obliquely cut plates, through and blind perforations, polished surfaces,

and traces of gold leaf and pigment. Together the results reveal a sophisticated combination of biological material selection, technological craftsmanship and symbolic significance, and provide a rare physicochemical window onto Mycenaean elite identity during the Late Helladic IIA period.

Table 1. Studied items and basic morphological features.

Object	L (cm)	W (cm)	Th (cm)	Analyses
DK 74	3.34	1.57	0.54	Raman, FTIR
DK 85	3.41	1.51	0.43	Raman
DK 50	2.77	0.97	0.36	Raman, SEM/EDS
DK 62	3.83	1.45	0.53	Raman, SEM/EDS
DK 12	1.67	0.97	0.48	Raman, FTIR
DK 71	3.91	1.61	0.47	Raman, FTIR
DK 10	2.07	1.66	0.69	Raman, SEM/EDS, FTIR

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P-40. ANCIENT ROAD NETWORK IN THE TERRITORY OF MONTEPULCIANO (SIENA, ITALY): GIS MODELLING AND GROUND-PENETRATING RADAR INVESTIGATIONS

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The research presented here forms part of the wider Carta Archeologica di Montepulciano project, which aims to reconstruct the long-term settlement history and archaeological landscape of the Montepulciano area, in southern Tuscany. Within this framework, ancient mobility represents a key research issue, since the territory lay at the intersection of routes connecting Chiusi, Arezzo, Siena and Florence.

Literary, cartographic and epigraphic sources attest the importance of this road network, but the precise course of the routes, the identification of the ancient stationes and the diachronic development of the road system remain difficult to reconstruct. The relationship between major Roman itineraries, local paths and successive interventions in the landscape is still debated, while direct archaeological evidence for ancient road surfaces is scarce or absent in situ, making field verification particularly challenging.

This research presents an integrated methodological approach combining GIS-based least-cost path analysis and non-invasive geophysical survey to evaluate the spatial plausibility of proposed ancient road courses and to guide targeted field investigation.

The GIS workflow was based on the construction of movement-cost models derived from a 10 × 10 m DTM. Travel times were calculated for different mobility scenarios, including pedestrian movement and transport by cart, in order to compare how alternative modes of movement affected route choice across the landscape. Slope was treated as a primary constraint on pre-modern mobility and modelled through slope-dependent cost functions, while additional cost factors were introduced along the hydrographic network to discourage unrealistic paths along minor streambeds while still allowing plausible crossings. Least-cost paths were then calculated between the main nodes identified from ancient sources and modern scholarship, including the presumed position of the statio Ad Novas at Acquaviva, possible routes toward Chiusi, Arezzo, Siena and the Val di Chiana and intermediate archaeological or topographical markers where relevant. The model was not intended to produce a single definitive reconstruction but rather to identify areas where several independent route hypotheses converged and where the morphology of the landscape made ancient transit more probable.

A high-potential sector, where least-cost modelling converged with historical and topographical evidence, was selected for ground-truthing through ground-penetrating radar. The survey was designed to assess whether the predicted

route corresponded to subsurface anomalies compatible with buried linear features, road preparation layers or associated roadside structures.

Preliminary results suggest that least-cost modelling can provide a useful framework for prioritizing field investigation in landscapes where ancient road traces are poorly preserved. The comparison between modelled routes, calculated travel times and GPR evidence offers a first empirical assessment of selected route segments and highlights the potential of combining spatial modelling with targeted, low-impact geophysical survey in contexts where textual evidence is present but materially uncertain.

P-41. PHOTOGRAMMETRIC APPROACH ON THE DOCUMENTATION OF UNIVERSITY ARCHAEOLOGY COLLECTION: EARLY BRONZE I (EBI) HIGH-LOOP HANDLE JUGLET

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Archaeological expeditions directed by various universities since the last century have yielded different types of artifacts that have continuously helped generations of archaeology students to understand the past society through the technologies used in making these artifacts. Whilst the presence of the artifacts is accessible for in-class learning, digital documentation will also provide great study value as some details on the objects may not be noticed by human eyes and the objects become more accessible outside of the classroom setting. Photogrammetry on small objects provided details that are unable to show through photography. Compared to large objects such as architectures and sculptures where allow audience to have some degrees of close-up interactions, small objects in museum display have restricted views. Therefore, photogrammetry provides invaluable opportunity for education as it not only allows interactive museum object display, but it also trains students to learn how to operate a camera and develop their skills with Metashape and Meshlab. The aim of this research was to compare the differences between traditional

documentation and 3D modeling of small objects. Moreover, this research explored the potential of using photogrammetry in a pedagogical setting to assist in building a digital database for the university archaeology collections. A Early Bronze I (EBI) high-loop handle juglet from Jericho from the Near Eastern Archaeology collection from the University of Toronto was selected for a photogrammetric recording in comparison to traditional recording on paper. The examined object was first recorded in a traditional pottery drawing. Then, a turn-table was used for photographing all sides of the object. Photos were processed in Agisoft Metashape and the details of the final products can be highlighted by switching the light settings in Meshlab. The different case studies were used to understand how photogrammetry has gradually become an integral part of understanding the contexts of pottery, which aligned with the objectives of this study. Through the different light settings in Meshlab, the “finger scrape” on the globular body of the juglet and the conservation mending on the handle are more visible. These details may provide insights into the object’s past life and “present” life after the discovery.

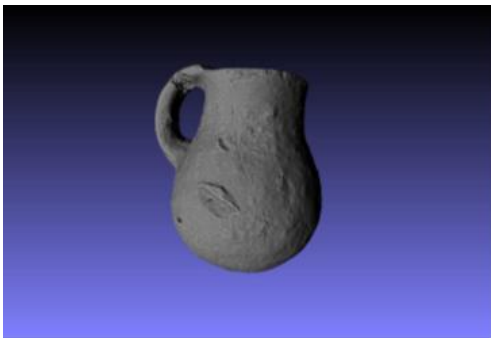


Figure 4. Lambertian shading on Meshlab showcasing the ‘finger scrape’ and conservation joint on the object.

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P-42. BEYOND THE PHOTOGRAPH: PHOTOGRAMMETRIC DOCUMENTATION AND PRELIMINARY ANALYSIS OF TWO IVORY PLAQUES FROM CRETE

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Ivory is not a locally available raw material in Bronze Age Crete, and archaeologically speaking, its presence on the island (as worked objects, blanks, or raw tusk) is generally considered as direct evidence of long-distance trade connections across the Mediterranean, within which Crete was an active participant. Ivory finds from Cretan contexts therefore serve as material evidence for connectivity and exchange. Photography and photogrammetry are among the most widely used methods in archaeological publication for efficiently and objectively communicating the morphological, technological, and aesthetic characteristics of an object. This poster presents the preliminary study and 3D documentation of two small ivory plaques recovered (approximately 12 x 9 x 1 cm in size) in 2005 from the [LM IIIA1] tholos tomb at Kaminaki-Magoulas, in the Lasithi Plateau area of eastern Crete, a site whose unpublished status makes systematic visual documentation especially valuable ahead of formal publication. While

photogrammetry is increasingly used in cultural heritage field to produce standardized, reproducible, and objective visual records, its application as an analytical (rather than purely representational) tool remains underdeveloped. This study therefore pursues two related aims: first, to test whether a minimal-equipment, fixed-camera photogrammetric setup can produce a model of sufficient resolution to support technical analysis, not just visualization, of a small and fragile ivory object; and second, to use this model (together with UV-fluorescence imaging and pXRF analysis) for the preliminary documentation and study of the plaques itself, focusing on the visualization and mapping of surface tool marks, the separation of original ivory from restoration material, and the identification of possible surface decoration.

The plaques were documented using a fixed-camera turntable setup: a Sony NEX-6 (16.1 MP APS-C sensor, 16–50mm f/3.5–5.6 kit lens) for the main photogrammetric sequence, and a Nikon D60 (10.2 MP APS-C sensor) with a third-party 135mm f/2.8 lens (≈202mm equivalent) for close-up documentation of tool marks and restoration areas. A calibrated sample holder incorporating scale, colour, and greyscale reference targets was used throughout. Images were captured at 8–10° rotation increments across multiple camera heights, in both the object's original and inverted orientation, achieving complete angular coverage of surfaces otherwise obscured by the sample holder in a single pass. The merged image sets were processed in Agisoft Metashape (2.3.1) to generate sparse cloud, dense cloud, mesh, and texture outputs. The mesh was

further imported into Blender to produce virtual raking-light renders highlighting surface topography.

Surface features were additionally examined with a Leica M60 stereo zoom microscope (0.6–4× magnification), and UV-induced fluorescence imaging (UVF) (365 nm, ZWB2 filter), to identify restoration-related organic compounds such as glue, as well as pigment related binders. Elemental analysis via portable XRF (Bruker Tracer III SD; 40 kV, 12 µA, 120s acquisition) was carried out on light and dark surface areas to investigate possible painted decoration.

This preliminary study demonstrates that a low-cost, fixed-camera photogrammetric workflow can generate a complete, high-resolution 3D record of small and fragile ivory artefacts, supporting both their preservation and integration with complementary analytical techniques. The model allowed original ivory to be visually distinguished from restoration material, and its high-density mesh enabled the study and mapping of possible tool marks relevant to manufacturing technique. pXRF spectra showed calcium peaks in lighter areas and combined calcium and iron peaks in darker areas, suggesting the possible use of an iron-oxide-based pigment, while UV-fluorescence imaging indicated areas of glue, though confirmation of the organic binder used requires further analysis.

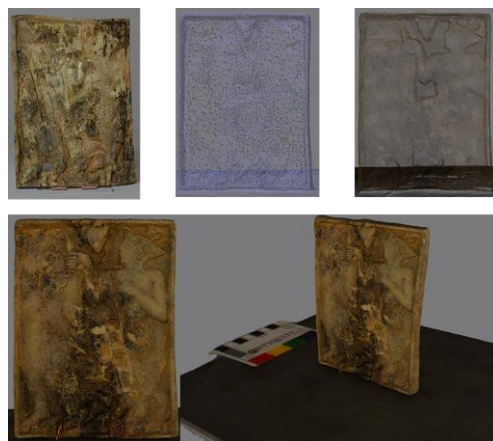


Figure 1. Top left: Visible light image of Plaque A, frontal view. Middle: Plaque B, 3D structure of the model in low density “mesh” view. Right: Plaque B, Model in the “point cloud” view. Bottom left: textured final view of the Plaque B. Bottom right: Textured view of the model in Agiosoft Metashape software and the image acquisition set-up, illustrating the reference elements.

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P-43. TESTING THE CAPABILITIES OF ARTEC SPIDER VIA CREATING 3D MESH OF A FISHBOWL REPLICA

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Structured light scanning technologies have proven to provide the precision required for detailed digital reconstruction of complex 3D objects with authentic textures (Storeide et al. 2023). Using laser sources for acquiring 3D offers high geometric accuracy, as bright, tightly focused laser light remains stable over long distances and consistently targets the surface (Pavlidis et al. 2007). An optical detector identifies the emitted laser on the objects and by applying the triangulation principle the system can obtain the geometry of the object. Through this triangulation, the determination of 3D point coordinates becomes possible, producing a dense point cloud that represents the object's geometry (Soile et al. 2013). After acquiring the 3D data, post-processing is essential for converting the set points into a reality-based digital 3D model (Guidi et al. 2020).

The goal of the current research is to reproduce a digital mesh of a Fishbowl replica object using the Structured Light Scanning technology, employed by the Artec Spider Handheld Scanner that is available in the Laboratory of Archaeometry in the University of the Peloponnese in Kalamata. After the digitization process through the scanning,

the necessary work of processing the data is followed to achieve the outcome of the complete digital model of the object.

The digital reproduction of the object was achieved with the use of the Artec Spider 3D Scanner, a high-resolution handheld 3D laser scanner, that was also chosen due to the small size of the artefact (Diara, 2023). For the scanning process, the Artec Spider Scanner has been placed stable on a tripod and the object positioned at an appropriate distance ideally on a turntable for full surface capture. Due to non-availability of the appropriate support at the time, an improvised setup was employed, where the object was rotated manually. Multiple scans from different angles were performed to ensure complete coverage.

The processing of the 3D data was carried out in the software Artec Studio 18 Professional, making it possible to collect the geometric data, generate the surface, filter noise, merge the individual surfaces, apply the texture and perform the final processing of the three-dimensional textured object. Further processing like gap filling was necessary. The result of the processing stages is a polygonal mesh capable of accurately representing the object's geometric characteristics. Moreover, to achieve photorealistic visualization, texture mapping applies high-resolution images to the mesh, ensuring that the reconstructed model reflects both its form and surface appearance. Through this work, the processed model was imported into Agisoft Metashape Professional, where it was exported as a 3D image file together with its associated texture data, enabling the object to be visualized as a three-dimensional digital visualization.

This study demonstrates the effectiveness of structured light-based 3D scanning, as the practical application of Artec Spider Scanner produced high-resolution data capturing both geometric detail and surface texture, suitable for digital reconstruction and further analytical work. Although challenges arose, such as object positioning, incomplete surface coverage and need for post-processing interventions, the workflow proved capable of generating a reliable and visually accurate 3D digital model.



Figure 1. The scanning set up – the Artec Spider Scanner in operation.



Figure 2. After data processing, view of the digital point cloud.

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P-44. 3D DOCUMENTATION AND CONDITION ASSESSMENT OF THE CHURCH OF AGIOI APOSTOLOI IN KALAMATA USING PHOTOGRAMMETRY

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In 1986, a devastating earthquake of magnitude 6.0 struck the city of Kalamata, causing extensive damage to its built environment. Among the affected structures was the Church of Agioi Apostoloi (the Holy Apostles), located in the historic centre of the city. This significant monument, constructed between the 12th and 17th centuries, suffered near-total collapse and therefore underwent extensive restoration and reconstruction works. Since then, the monument has exhibited various forms of deterioration affecting its current state of conservation.

In this context, photogrammetry is used for the creation of a detailed three-dimensional (3D) model that supports both the accurate geometric documentation of the monument and the high-resolution recording of conservation-related information. Additionally, in-situ spot tests for salt identification are conducted to provide preliminary indications regarding the origin of soluble salts.

The 3D model of the Church of Agioi Apostoloi is developed through the combination of UAV and close-range photogrammetry in order to capture its exterior and interior surfaces,

respectively. The acquired imagery is processed using photogrammetric software to generate a detailed 3D model from the resulting point cloud, which is subsequently imported into a 3D environment for the organisation and visualisation of conservation-related information. The developed model incorporates the recording and mapping of construction phases, restoration interventions, visible deterioration features and salt distribution patterns.

The resulting model provides an integrated visual representation of the monument's current state of conservation, enabling the spatial correlation of architectural, historical and conservation-related information. Through the organisation of these data within a unified 3D environment, the framework facilitates a holistic assessment of the monument's current state of conservation and supports future conservation planning and decision-making.

Furthermore, the developed framework is designed to support the future integration of additional documentation, analytical and diagnostic data, contributing to the long-term monitoring, study and conservation management of the monument.

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P-45. THE THREE STATES OF MATTER. MODELLING A BYZANTINE COLUMN FROM THE CHURCH OF HODEGETRIA, MYSTRAS, LAKONIA

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We are presenting here the results of our digital work on the last original column of the church of Hodegetria in Mystras, Lakonia. Two models will be presented on the poster: one digital model made in Blender®, and one 3D printed model.

Recently, the palace of Mystras was opened again to the public, with a special focus on digital exhibitions inside of its space, regarding life in Mystras, political and domestic aspects of the medieval city. Therefore, this work follows this project of digital enhancements for the visitors, by proposing digital and physical models of an element of one of the churches of Mystras, that could be included in a presentation about art and architecture in the city.

This work could be an entry to new approaches towards figuring and understanding ancient architecture, enhancing traditional approaches like drawings or 2D plans. In Blender®, one can also build evolutive 3D models to record for example restoration processes.

As capitals and columns are non-movable elements, building digital and printed 3D-models of them can help studying them and understand the evolution of stylistic phases of ornaments for capitals, especially for a site like Mystras which underwent several

successive phases and influences from a lot of regions in the world. As the capital presented is the last one of the church, it can also help visualise how the church was with complete art and architectural element.

The printed 3D capital could also be presented to disabled people who could touch it without fear of degradation. It can be presented to a large public, who does not necessarily have access to the original artwork. The digital model is equally important for this reason, as it can be seen as a first step to recreating architectural elements with elaborate ornaments in their context for precise (and interactive) 3D models available online.

The digital model was created using photographs as references. Basic geometry was first modelled, then the ornaments were created, starting from a flat sheet to give the general shape to the elements of the décor and then giving it a 3D dimension and creating relief. The 3D model was printed in 8 parts to achieve a satisfactory size which allowed to see all the details.

Even though it allowed the creation of a very accurate to-reality elements, the many details involved in the model made the file way too heavy for the software, and it was complicated to work on it for the 3D impression. Therefore, modelling process can still be improved to build lighter digital replicas, especially if the final goal is to make them available online.



Figure 1. Digital 3D Model in the Blender viewport.



Figure 2. Printed Model with FlashForge Adventurer 5MPro and HS-PLA Ruby Red 1,7mm filament.

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P-46. FROM THE MONUMENT TO THE DIGITAL TWIN: THREE-DIMENSIONAL DOCUMENTATION AND VIRTUAL EXPLORATION OF PHILOPAPPOU HILL

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The rapid advancement of digital technologies has created new opportunities for the documentation, preservation, and promotion of cultural heritage. Within this context, the present study investigates the contribution of photogrammetry and interactive digital applications to the digital representation and dissemination of archaeological monuments, using Philopappou Hill in Athens as a case study.

The aim of this research was to produce three-dimensional digital models of selected monuments on Philopappou Hill, develop their corresponding digital twins, and integrate them into an interactive virtual exploration environment designed for educational purposes.

The project was implemented using a photogrammetric workflow based on low-cost, consumer-grade equipment under real field conditions. The acquired photographs were processed in Agisoft Metashape to generate point clouds, polygonal meshes, and photorealistic three-dimensional models, which were subsequently optimized using MeshLab. The finalized models were then integrated into an interactive virtual

exploration environment, developed with Unity 3D. The application was enriched with points of interest, historical information, multimedia content, and interactive navigation features to enhance the overall user experience.

Through the virtual exploration environment, users can explore the archaeological site regardless of geographical or physical constraints, gaining access to well-documented information and cultural content. Furthermore, this approach contributes to the preservation of cultural memory and promotes the wider dissemination of knowledge about monuments that remain relatively unknown to the general public. The results demonstrated that photogrammetry can accurately reconstruct the geometry of monuments of different typologies while maintaining a high level of visual fidelity, even when using low-cost equipment. Furthermore, the user evaluation of the application revealed positive feedback regarding its usability, level of immersion, and educational value. The findings also confirmed the potential of virtual exploration environments to serve as effective tools for the dissemination of cultural heritage information and the enhancement of learning experiences. This research highlights the significant potential of three-dimensional digitization technologies and interactive virtual environments for the documentation, preservation, interpretation, and promotion of cultural heritage.



Figure 1. S.S.-C., 2025. Northeastern (front) view of the optimized 3D model of the Philopappou Monument, generated following post-processing in MeshLab [Author's own image].

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P-47. EXPERIENCING ARCHAEOLOGICAL HERITAGE THROUGH VIRTUAL RECONSTRUCTION AND AUGMENTED REALITY

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Archaeological heritage management currently faces significant challenges regarding the preservation, interpretation, and public engagement of archaeological sites. The vulnerability of these spaces results from their continuous exposure to deterioration agents, their large physical scale, and the frequent adoption of minimal intervention principles, which are not always sufficient to ensure visitors' understanding and interpretation of the archaeological environment. At the same time, the rapid development of digital technologies has enabled the creation of tools capable of supporting the documentation, preservation, and dissemination of cultural heritage. Among these, photogrammetry, three-dimensional (3D) modelling, virtual reconstruction, and Augmented Reality (AR) applications have emerged as

valuable resources for promoting more immersive and informative experiences. Within this context, the present project focuses on the Ruínas Romanas de Milreu (RRM), one of the most important Roman archaeological sites in Portugal and classified as a National Monument since 1910. The main objective is the development of 3D reconstructive hypotheses for different areas of the archaeological complex and their integration into an AR platform capable of superimposing digital content onto the physical environment while providing access to historical and archaeological information in situ.

The methodology combined aerial photogrammetry and terrestrial LiDAR scanning for point cloud generation and 3D modelling of the archaeological site, processed in Agisoft Metashape. Smaller objects were documented using structured-light 3D scanning with the Artec Leo scanner and processed in Artec Studio. The hypothetical reconstruction was developed in Blender based on historical and archaeological sources, including plans, architectural elevation drawings and 2D illustrations.

The validation of the reconstructive hypotheses was supported by continuous collaboration with the archaeological team responsible for the archaeological site, as well as by the application of historical-archaeological evidence scales to ensure greater scientific transparency throughout the reconstruction process. The AR application was implemented using Vuforia Engine integrated within Unity and supported by image-recognition systems.

The present work delivers a set of 3D models for the interpretative virtual reconstruction of the RRM, together with the use of a historical and archaeological

evidence scale. Both materials were integrated into an AR application aimed at improving visitors' understanding of the archaeological site. To facilitate accessibility, the digital content can be accessed through the existing signage distributed throughout the site, corresponding to each reconstructed space, allowing any visitor with a mobile device to access the material.

The implementation of the project demonstrated potential for improving the visitor experience by promoting a clearer understanding of the archaeological site. This was achieved through an immersive sensory experience based on the visualization of virtual reconstructions superimposed onto the existing ruins, combined with access to relevant historical and archaeological information, fostering a more informed and engaging interaction between visitors and the site. Overall, the integration of digital technologies into archaeological heritage management demonstrated strong potential for improving the preservation

and dissemination of the RRM. By providing visitors with enhanced access to historical and archaeological information, these technologies foster greater public interest in the discovery of the site and reinforce the continuing relevance of history, culture and technology in contemporary society.

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