

ICAS-EMME 2

**Second International Congress on Archaeological Sciences
in the Eastern Mediterranean and the Middle East**

*12-14 November
The Cyprus Institute, Nicosia, Cyprus*



Πανεπιστήμιο Κύπρου
University of Cyprus



ΤΜΗΜΑ ΑΡΧΑΙΟΤΗΤΩΝ ΚΥΠΡΟΥ
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Edited by

Artemios Oikonomou and Thilo Rehren

The Cyprus Institute, Nicosia, Cyprus

2019

From a very early stage of his professional life, **Professor Vassos Karageorghis** has been a staunch supporter of what Archaeological Sciences can do for archaeology, realizing (in his own words) '*that without them we cannot make any real progress in our research*'. However, without the acceptance of what the sciences have to offer, demanding that they address archaeological questions, and providing the intellectual and structural climate to enable their full integration into archaeology, Archaeological Science would be void of purpose. Professor Karageorghis provided all this, and so much more, as part of his life-long work to establish archaeology in all its facets in Cyprus, as a Cypriot endeavor.

We are deeply honoured that he accepted our dedication of ICAS-EMME 2 to mark his recent 90th birthday anniversary.

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Foreword

We are delighted to welcome you to the 2nd International Congress on Archaeological Sciences in the Eastern Mediterranean and Middle East, or ICAS-EMME 2 for short. We are proud to host nearly 100 presentations on a wide range of topics, ranging from Art Characterization to the use of Synchrotrons, from Crops, Foods and Landscapes to Human Osteoarchaeology, and from Archaeological Materials to Digital Archaeology and Computation in Archaeology. Within this, we treat the term 'Archaeology' very broadly - a lot of studies address historical and cultural aspects more than strictly archaeological work. But this is one of the strengths and characteristics of ICAS-EMME: the ability to cross borders, to combine innovation in methods with original research questions, to break out from the strict disciplinary focus and to offer more comprehensive views on the lives and times of people past, regardless of whether the evidence we study and discover emerges from the soil through excavation, or has been kept above ground.

We are thrilled that for each session we were able to attract a senior scholar from outside Cyprus to be the chair, together with one of our own faculty affiliated to the Science and Technology in Archaeology and Culture Research Center (STARC) at the Cyprus Institute. The Chairs have been invited to start their sessions with a Keynote Lecture, and we look forward to a rich range of high-level presentations setting the scene for the subsequent oral presentations in each session. We had hoped to avoid parallel sessions altogether, to facilitate the interaction of speakers and audiences across the thematic sessions; however, the number of presentations received was such that we had to allow some parallel sessions to run on the first day - and to ask numerous colleagues to present their research as posters instead of oral presentations.

For many years, Professor Sturt Manning of Cornell University has been closely associated with STARC, both as a critical friend and Chair of the Scientific Expert Panel regularly evaluating our work, and as a scientific collaborator and leading archaeologist. We are very grateful and deeply honoured that he accepted our invitation to present Tuesday's Public Keynote Lecture on *'Time, History and Climate in Cyprus: the Cyprus Dendrochronology Laboratory and recent progress'*.

The Hellenic Society for Archaeometry (HSA) is the largest and longest-established relevant professional organisation in the Eastern Mediterranean, providing a forum for colleagues not only in Greece to exchange ideas and information, and promoting the application of Science and Technology in Archaeology, History of Art and Cultural Heritage. We are pleased and honoured that the members of their Board accepted our invitation to present a Public Keynote Lecture on the final day of ICAS-EMME, delivered by Dr Vassilis Kilikoglou.

A conference such as this doesn't pop into existence just like that. It took numerous people and organisations to make this happen, and each and every one whom we asked has offered generously of their time, experience, and contacts. We are also proud that this event has come together as a joint effort from across the archaeological community in Cyprus. While the Cyl acted as the nucleus and physical host of the event, our friends and colleagues of the Archaeological Research Unit of the University of Cyprus and the Cyprus American Archaeological Research Institute have enthusiastically accepted our invitation to co-organise ICAS-EMME 2, and the Department of Antiquities not only encouraged us with our combined effort, but also very generously offered the guided tour for our international visitors on Friday morning, and free entrance to the Cyprus Museum for all participants upon presentation of the registration badge.

Special mention should be made of the A.G. Leventis Foundation. Since their inception they have been the leading philanthropic organisation supporting archaeological and cultural heritage work in Cyprus, and Cypriot Archaeology and Heritage worldwide. Their endowment of the A.G. Leventis Chair in Archaeological Sciences

at the Cyprus Institute last year was a key enabler of this conference, and we are most grateful for their enduring support of our common cause. The extraordinary generosity of the Foundation towards all of us cannot be over-emphasized, and is deeply appreciated.

Funding for the conference was provided by the Cyprus Institute as well as by the European Union through the H2020 project **Promised** – *Promoting Archaeological Science in the Eastern Mediterranean*. This Twinning project links the Cyprus Institute with advanced experienced partners at the University of Cambridge and the KU Leuven. Among the activities organised under **Promised** are Short Courses, Summer Schools, mentoring and training visits, and public outreach events in Cyprus, the UK and Belgium - and the organization of ICAS-EMME 2.

Finally, on behalf of the Organising Committee we want to thank all those who made the conference happen on a practical level, particularly Andriani Loui, Giusi Sorrentino, Kyriaki Tsirtsis, Meghna Desai, and Yiannis Trimithiotis, with further support from Cagla Elektrikci, Charis Hephaestou, Evi Margaritis, Nic Jarraud, Pavlos Tsiartas, and many more.

Thilo Rehren, Artemios Oikonomou and Kirsí Lorentz

PROGRAM

Monday 11th of November 2019

18:30-21:30	Welcoming reception at Cyprus American Archaeological Research Institute (CAARI) [11 Andreas Demetriou Street, Nicosia 1066] Pre-registration
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Tuesday 12th of November 2019

08:30-09:00	Registration (NTL Building)
09:00-09:30	Opening ceremony (NTL Building) Prof. Thilo Rehren, A.G. Leventis Professor of Archaeological Sciences Dr Lindy Crewe, Director, CAARI Prof. Vasiliki Kassianidou, ARU Dr Marina Solomidou-Ieronymidou, Director, DoA Mr Theodosios Tsiolas, Permanent Secretary, GDEPCD

Session I Frontiers in Digital Archaeology (NTL Building)

Chairs: Prof. F. Niccolucci, Dr S. Hermon

09:30-10:00	Keynote lecture: <i>Challenges in Digital Archaeology</i>	Prof. Franco Niccolucci
10:00-10:20	FDA1: A LIVING SHIPWRECK: A composite study of scrambling devices: three-dimensional modelling and biological analysis for the understanding of site formation processes in archaeological shipwreck sites	M. Secci, S. Demesticha, C. Jimenez, I. Katsouri, B. Stivarou
10:20-10:40	FDA2: From excavation to the drawing and from drawing to the model. The digital reconstruction of twenty years excavations in the archeological site of Bedriacum	S. Parrinello, F. Galasso
10:40-11:00	FDA3: The identification of cities in archaeology: A case study from central Israel, the seventh-eleventh centuries AD	H. Nol
11:00-11:20	FDA4: Knowledge-based generative adversarial networks for scene understanding in cultural heritage	R. Garozzo, C. Pino, C. Santagati, C. Spampinato, G. Vecchio
11:20-11:40	Coffee break	
11:40-12:00	FDA5: Digital reconstruction and visualization of a New Kingdom palace area from the eastern Nile Delta/Egypt	I. Hein, S. Müller
12:00-12:20	FDA6: HBIM Approach for the knowledge and documentation of the St. John the Theologian Cathedral in Nicosia (Cyprus)	N. Bakirtzis, S. Hermon, C. Laurini, D. Papacharalambous, G. Sanfilippo, C. Santagati
12:20-12:40	FDA7: 3D Geometric descriptors for the study of Cypriot coroplastic production	V. Vassallo, A. Scalas, M. Mortara M., S. Hermon
12:40-14:00	Lunch break	
14:00-14:20	FDA8: SimpleX: Towards an Ontology for Archaeological Pottery	Ch. Paraskeva
14:20-14:40	FDA9: Towards a Phygital Heritage approach for Museum Collection	M. Lo Turco, P. Piumatti, M. Calvano, E.C. Giovannini, N. Mafrici
14:40-15:00	FDA10: Machine Learning approach for monitoring and managing museum collections	F.M. La Russa, C. Santagati
15:00-15:20	Coffee break	

Session II Art Characterization (NTL Building)

Chairs: Dr M. Menu, Dr N. Bakirtzis

15:20-15:50	Keynote lecture: <i>Heritage Science a discipline for the conservation and analysis of works of art.</i>	Dr Michel Menu
15:50-16:10	Art1: Laser applications for the characterization of cultural heritage	V. Detalle, X. Bai, M. Lopez, C. Koch Dandolo, M. Menu
16:10-16:30	Art2: Giovanni Baronzio's 'Crucifixion': Analytical Approaches and Art Historical Considerations	S. Gasanova, N. Bakirtzis, D. Levif-Martos
16:30-16:50	Art3: The Application of Portable XRF on Negev Rock Art: Chronological Trends at the Ramat Matred Petroglyphs as a Test Case	I. Shapira, D. Eisenberg-Degen, L. Schwimer, Y. Goren
16:50-17:10	Art4: Mapping the mineralogical composition of pigments using multispectral imaging in the frigidarium of the Sarno Baths, Pompeii	Y. Asscher, I. Angelini, M. Secco, M. Parisatto, A. Chaban, R. Deiana, G. Artioli
17:10-17:30	Art5: Documentation of paintings restoration through photogrammetry and change detection algorithms	D. Abate

Session III Synchrotrons in Archaeology and CH-SESAME (GOB Building) (parallel session)

Chairs: Dr G. Paolucci, Dr K.O. Lorentz

14:00-14:30	Keynote lecture: <i>Cultural Heritage and Archaeological Research at SESAME Synchrotron</i>	Dr Giorgio Paolucci
14:30-14:50	SSE1: Synchrotron radiation enabled human bioarchaeology in the EMME region: SR-XRF, XANES and EXAFS data in exploring key archaeological questions	K. Lorentz
14:50-15:10	SSE2: SR-FTIR in Archaeological and Cultural Heritage Research at SESAME	G. Kamel
15:10-15:30	SSE3: Advantages and potential of SR phase contrast microCT enabled virtual dental histology in comparison with conventional dental histology	S. Lemmers, K. Lorentz
15:30-15:50	SSE4: Highlights of potential Synchrotron research applications at the University of Jordan: case studies from Cultural Heritage	B.M.Y. Gharaibeh, M. Arimat
15:50-16:10	Coffee break	
16:10-16:30	SSE5: SR-FTIR analyses of ancient hair remains from Anatolia	A. Buyukkarakaya, G. Kamel, S. Lemmers, K. Lorentz
16:30-16:50	SSE6: Comparison of synchrotron CT and laboratory based micro-CT with applications in heritage materials	K. Jakata
16:50-17:10	SSE7: SR microCT in identification of NNL: Distinguishing between stillborn and newborn infants	Y. Miyauchi, S. Lemmers, K. Lorentz
17:10-17:30	SSE8: Synchrotron X-Ray Spectroscopy in archaeology and cultural heritage: Lessons learned	E. Alp

17:30-18:00	Refreshments (NTL Building)	
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18:00-19:00	Public Keynote Lecture: <i>Time, History and Climate in Cyprus: the Cyprus Dendrochronology Laboratory and recent progress</i> (NTL Building)	Prof. Sturt Manning
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19:00-20:00	Reception in Honour of Prof. Vassos Karageorghis (NTL Building)	
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Wednesday 13th of November 2019

08:30-09:00	Registration (NTL Building)
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Session IV Human Osteoarchaeology (NTL Building)

Chairs: Prof. A. Soltysiak, Dr E. Nikita

09:00-09:30	Keynote lecture: <i>Textual sources: A headache and a godsend for Mediterranean and Oriental bioarchaeologists</i>	Prof. Arkadiusz Soltysiak
09:30-09:50	Hum1: Eastern Mediterranean isotopic research within the IsoMemo initiative	R. Fernandes
09:50-10:10	Hum2: Changes to the human diet at Knossos under the Roman Empire and Christianity using stable isotope analysis	A. Moles, H. Reade, A.-L. Jourdan, R. Stevens
10:10-10:30	Hum3: Isotopic reconstruction of the lifeways of ancient Athenians	R. Fernandes, A. Lagia
10:30-10:50	Hum4: Malaria in the Eastern Mediterranean: Preservation, Curation, and Biomolecular Promises	M. Gamble, F. Maixner, A. Loufouma-Mbouaka, A. Zink, M. Binder
10:50-11:10	Coffee break	
11:10-11:30	Hum5: Human remains under the microscope of funerary taphonomy. Investigating the histological biography of the decaying body in the prehistoric Aegean	N. Papakonstantinou, Th. Booth, S. Triantaphyllou
11:30-11:50	Hum6: East of Rome: reexamining impacts of Roman imperialism on Eastern Mediterranean populations through an osteoarchaeological perspective	K.E. Marklein
11:50-12:10	Hum7: Bioarchaeological approaches to human mobility in the EMME and beyond: the People in Motion project in context	E. Nikita
12:10-12:30	Hum8: Inter-personal violence in the Iron Age cemetery at Qareh Tepe, Iran	J. Trębicka
12:30-14:00	Lunch break	POSTER SESSION II

Session V Crops, Food Choices, and Landscapes (NTL Building)

Chairs: Prof. M. Jones, Dr E. Margaritis

14:00-14:30	Keynote lecture: <i>Mobility and selection: some reflections upon domestication</i>	Prof. Martin Jones
14:30-14:50	CFL1: Human diet and landscape as attested by the plant remains of PPNC Atlit-Yam, Carmel Coast, Israel	A. Hartmann-Shenkman, M.E. Kislev, E. Galili, E. Weiss
14:50-15:10	CFL2: Food or fuel? A micro-botanical perspective of plant remains from Neolithic Abu Hureyra, N. Syria	K. Dudgeon
15:10-15:30	CFL3: Between the Desert and the Sown Revisited: crops, food choices and landscapes of the Levant	C. Palmer
15:30-15:50	CFL4: Crop Choice and Socio-Economic Organisation in Bronze Age Western Anatolia	T. Maltas
15:50-16:10	CFL5: Early Bronze Age communities of Western Anatolia: with a special contribution on archaeobotanical research	Ö. Çizer
16:10-16:30	Coffee break	
16:30-16:50	CFL6: The trade distances across the southern Levant during the Early Bronze Age - the botanical evidence	S. Frumin, Y. Melamed, E. Weiss
16:50-17:10	CFL7: Landscapes of production and the nature of urban farming at Tell Brak	Ch. Diffey, M. Charles, A. Bogaard
17:10-17:30	CFL8: Arboriculture and urbanism in the Bronze Age Aegean	E. Margaritis

17:30-17:50	CFL9: Exploring the human-cattle relationship in Bronze Age Cyprus: Archaeozoological, isotopic and ethnographic approaches	A. Spyrou
17:50-18:10	CFL10: The road to the Bronze Age: a diachronic approach to sheep and goat husbandry in prehistoric Cyprus	A. Hadjikoumis
18:10-18:30	CFL11: Isotopic Data ($\delta^{18}\text{O}$, $\delta^{13}\text{C}$) as a Means of Investigating Early Complex Societies: The Case of Animal Management in the Jordan Valley	L. Welton
18:30-18:50	CFL12: A multi-isotope base map for Jordan: a tool for re-examining movement and community in the past	L. Johnson, Kh. Al-Bashaireh, A. Al-Shorman, J. Montgomery, G. Philip
20:30-	Official dinner of ICAS-EMME 2 [Mezostrati tavern, Evagorou 18E, 1065 Nicosia]	

Thursday 14th of November 2019

08:30-09:00	Registration (NTL Building)
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Session VI Computation in Archaeology (NTL Building)

Chairs: Prof. E. Paliou, Dr G. Artopoulos

09:00-09:30	Keynote lecture: Modelling long-term settlement evolution: further insights into the application of spatial interaction entropy maximisation models (SIEMs) in archaeology	Prof. Eleftheria Paliou
09:30-09:50	CA1: ANNFASS: A Neural Network Framework for understanding historical monuments Architectural Structure and Style	M. Igarievna Maslioukova, M. Averkiou, M. Deligiorgi, G. Artopoulos, E. Kalogerakis, G. Patow, Y. Chrysanthou
09:50-10:10	CA2: From Analogue to Digital: 40 years of archaeological documentation and management at the Neolithic UNESCO World Heritage site of Khirokitia	D. Abate, M. Faka, C. Ioannou, N. Bakirtzis, S. Hermon, O.D. Le Brun
10:10-10:30	CA3: Khirokitia: simulating a proto-urban site	G. Artopoulos, I. Romanowska, O.D. Le Brun
10:30-10:50	CA4: When culture meets economy: modelling cultural complexity in an economic setting	I. Romanowska, T. Brughmans, S. Carrignon, A. Lichtenberger, R. Raja
10:50-11:10	Coffee break	
11:10-11:40	Public Keynote lecture: <i>Archaeological materials studies and modern innovation: examples from the study of ceramics and mortars</i>	Dr Vassilis Kilikoglou

Session VII Archaeological Materials (NTL Building)

Chairs: Prof. Kh. Al-Bashaireh, Prof. Th. Rehren

11:40-12:10	Keynote lecture: <i>Ancient marble trade and its provenance determination</i>	Prof. Khaled Al-Bashaireh
12:10-12:30	AM1: A Technological Approach to Iron Age Pottery from the Zagros Region: A Case Study from the Dinka Complex (Iraqi Kurdistan)	S. Amicone, J.-J. Herr
12:30-14:00	Lunch break	POSTER SESSION III
14:00-14:20	AM2: Raw material procurement at Boila Rockshelter, northwestern Greece, as an indicator of hunter-gatherer mobility in Greece during the Late Upper Palaeolithic and Mesolithic	P. Elefanti, G. Marshall, Ch. Stergiou, E. Kotjabopoulou
14:20-14:40	AM3: The contribution of soil micromorphology for understanding the occupation styles in prehistory: Two case-studies from Cyprus and Crete	P. Mylona, M. Pomadère, J.-D. Vigne
14:40-15:00	AM4: Abandonment processes through the microscope lens. Microarchaeological data from Middle Bronze Age Erimi, Cyprus	M. Amadio, L. Bombardieri
15:00-15:20	AM5: Metallic and glazed artefacts from the Cypriot Chalcolithic	V. Kassianidou, A. Charalambous
15:20-15:40	AM6: Preliminary evidences for a Chalcolithic copper workshop in Fasaal, Northern Jordan Valley	Th. Rose, D. Rosenberg, S. Bar, Y. Goren
15:40-16:00	AM7: From desert ores to Middle Kingdom copper: first chemical and lead isotope data from the AHM collection, Belgium	F.W. Rademakers, G. Verly, L. Delvaux, P. Degryse

16:00-16:20	Coffee break	
16:20-16:40	AM8: Using pXRF spectroscopy to identify ancient copper alloys: the case of LBA Enkomi (Cyprus)	A. Charalambous, V. Kassianidou, G. Papasavvas
16:40-17:00	AM9: “Cooking up” pottery recipes: a diachronic technological and provenance analysis of cooking ware ceramics from prehistoric Heraion on Samos, Greece (5th to early 2nd millennia BC)	S. Menelaou, O. Kouka
17:00-17:20	AM10: Indigeneity and innovation of early Islamic glaze technology	C. Ting, I. Taxel
17:20-17:40	AM11: Glass from the Sea: Composition of Raw Glass off the Coast of Israel	Y. Gorin-Rosen, I.C. Freestone, E. Galili
17:40-18:00	AM12: Technology of early Byzantine glass from the glass workshop of Argyroupoli, Rethymno, Crete: Preliminary results using SEM-EDS	A. Oikonomou, A. Fiolitaki
18:00-18:20	AM13: Persian Crucible Steel: Archaeology, Manuscripts and Experiments	R. Alipour, Th. Rehren

Friday 15th of November 2019

10:00-13:00	Visit at the Cyprus Museum (Nicosia)
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LIST OF POSTERS

Poster Session I (Tuesday 12th of November, NTL Building)

Synchrotrons in Archaeology and CH-SESAME

SSE-P1	STARCH: at the origins of starch food diet. SR-FTIR and SEM applied to Palaeolithic Grinding Stones from the Pontic area	G. Biranda, L. Vaccari, N. Cefarin, C. Cagnato, I. Pantushina, N. Skakun, C. Lubritto, G. Sorrentino, L. Longo
SSE-P2	Exploring paleopathology of Hellenistic/Roman Paphos (Cyprus): Potential of high-resolution SR microCT at SESAME	G. Ioannou, S. Lemmers, K. Lorentz
SSE-P3	Charlie 'unwrapped': a scientific investigation of a Mummified Votive offering in the Australian Institute of Archaeology collection	C.A. Raymond, J.J. Bevitt, C.J. Davey
SSE-P4	Hidden Text: Imaging and Reading an Ancient Tablet encased in an Envelope	L.R. Siddall, C.A. Raymond, J.J. Bevitt, C.J. Davey

Poster Session II (Wednesday 13th of November, NTL Building)

Human Osteoarchaeology

Hum-P1	Skeletal evidence of trepanation from ancient Akanthos, Greece	A. Aidonis, Ch. Papageorgopoulou
Hum-P2	Human remains from Bronze and Iron Age sites in Armenia: palaeobiological and paleopathological studies and a new approach to age estimation through the use of Cameriere's dental radiographic method	F. Bertoldi, R. Mkrtchyan, A. Piliposyan, H. Simonyan, R. Cameriere
Hum-P3	The results of the complex study of bone materials obtained in the yard of the Monastery of the Theotokos and the crypt of the Church of Saint Nicholas in Gialia	L. Bitadze, S. Laliashvili, D. Mindorashvili, I. Gagoshidze
Hum-P4	Breastfeeding and weaning patterns in ancient Thessaloniki	E. Ganiatsou, E. Vika, Ch. Papageorgopoulou
Hum-P5	The inhabitants of ancient Kition: Preliminary insights	A. Karligkoti, P. Christofi, K. Helgeson, S. Mavroudas, F. Constantinou, K. Cruz, E. Nikita, N. Herrmann
Hum-P6	Stature estimation in ancient Greek population of Roman times	M. Koukli, F. Siegmund, Ch. Papageorgopoulou
Hum-P7	Burials and human osteological remains from the Bronze Age acropolis of Aghios Ioannis in Boeotia, Greece: preliminary results of the bioarchaeological analysis	E. Kountouri, P. Tritsaroli, Th. Konstantakou
Hum-P8	Social Mobility and Life Quality in Roman Byblos: Comparative Analysis of Cross-Sectional Geometry, Degenerative Joint Disease, Enteseal Changes, Cemetery Clustering, and Tomb Typology	M. Mardini, E. Nikita, G. Doumit, T. Zaven, M. Ghadban
Hum-P9	Evidence of kinship and membership in the Bronze Age collective burials from the Caucasian cemetery of Doghlauri (Shida Kartli region, Georgia)	P.A. Rasia, L. Bitadze, E. Rova, F. Bertoldi
Hum-P10	Investigating oral pathologies and their implications at the Imperial Roman Province of Upper Macedonia	Ch. Vergidou, G. Karamitrou-Mentesidi, S. Voutsaki, E. Nikita
Hum-P11	The assessment of bone deterioration with nuclear magnetic resonance spectroscopy in a multidisciplinary context: The case of the UNESCO world heritage site of Sedlec, Czechia	A. Viani, P. Mácová, D. Machová, T. Čendak

Crops, Food Choices, and Landscapes

CFL-P1	A 3D Tool for Identification of Grapevine Varieties – Sample Preparation, Scanning and Analysis	M. David, E. Drori, A. Karasik, E. Weiss
CFL-P2	Scientific geo-ethnoarchaeology and its archaeological application to investigate farming, settlements and agriculture in the past	S. Elliott
CFL-P3	Crops and food choices at the Late Bronze Age site of Hala Sultan Tekke	D. Kofel, T. Bürge, P.M. Fischer
CFL-P4	The archaeobotany of Pre-Pottery Neolithic Cyprus: a synthesis of current and recent data	M. Rousou, M. Tengberg, O. Kouka
CFL-P5	Marine vertebrate exploitation in the eastern Mediterranean c. 2500 BC - 1300 AD	R. Winter, W. de Kock, C. Çakırlar

Poster Session III (Thursday 14th of November, NTL Building)

Archaeological Materials

AM-P1	Investigating the architectural history of the 14th century AD Al-Attar mosque, Tripoli- Lebanon	R. Baydoun, Z. El Morr, C. Hachem, G. Homsy-Gottwalles
AM-P2	Ancient artisans and ethno-archaeology. From Early Iron Age Naxos and Andros to modern Cyprus: first assessment and perspectives	X. Charalambidou, B. McLoughlin, G. London
AM-P3	Scientific Investigation of Roman-Byzantine Glass Working Remains from 'Aqir, Israel	C. Chen, I. Freestone, Y. Gorin-Rosen
AM-P4	Egyptian Middle Kingdom Copper: Analysis of a Crucible from Buhen	C.J. Davey, B. Santarelli, Th. Rehren
AM-P5	Technology and Provenance of Stamped Documents on Clay: study of Iron Age bullae from Jerusalem	C. Fossé, E. Arie, Y. Goren
AM-P6	"Moving" cooking pots in LBA Chania, Crete: local production and imports	S. Fouriki, E. Kiriati, M. Vlazaki, B. Hallager
AM-P7	Revisiting the question of ceramic provenance in the Northern and North-eastern Peloponnese	C. Gardner, E. Kiriati, N.S. Müller, G. Giannakopoulos, K. Tsirtsis, K. Kissas, S. Muth-Frederiksen, Ch. Hayward, N.M. Kristensen
AM-P8	Bringing life to old MUSEum COllections: The interdisciplinary study of pottery from the Cypriot Iron Age polities of Salamis, Soloi, Lapithos and Chytroi (MuseCo)	A. Georgiadou, M. Dikomitou-Eliadou, G. Papasavvas, P. Waiman-Barak, D. Pilides
AM-P9	Archaeometallurgical analyses of metal finds from the Akko Tower shipwreck	N. Iddan, M. Cohen, D. Ashkenazi, D. Cvikel
AM-P10	Mapping Archaeoseismic Damages across Jordan (MADAJ)	R. Jaradat, Kh. al-Bashaireh, Ad. al-Rawabdeh, A. Gharaibeh, B. Khrisat
AM-P11	Characterization of Historical Materials from Rammed Earth Heritage of Iran	M.Z. Moghaddam
AM-P12	Maritime trade in Early Islamic-period glass: New evidence from the Ma'agan Mikhael B shipwreck	E. Natan, Y. Gorin-Rosen, D. Cvikel
AM-P13	Iron Production Technology in the Neo-Assyrian Sphere: The Iron Workshop at Tel Sera', Western Negev, Israel	Y. Pagelson, E.D. Oren, Y. Golan, Y. Goren
AM-P14	State-of-the-Art TEM coupled with Electron Diffraction for the Study of Silicate Archaeological Materials	N. Zacharias, S. Nikolopoulos, E. Palamara, P.P. Das
AM-P15	Technology of slips and glazes in the post-medieval Balkans: the case of Belgrade in the 16th and 17th centuries	J. Živković

PUBLIC KEYNOTE LECTURES

Time, History and Climate in Cyprus: the Cyprus Dendrochronology Laboratory and recent progress

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Department of Classics, Cornell University

Dendrochronology provides key information for dating, provenance, climate, and environmental reconstruction, and is applicable to a wide range of contexts from the current and past natural landscape to built heritage and archaeological sites both on land and underwater. This paper reviews recent work and progress on the use of dendrochronology in Cyprus, and especially in the context of the recently established Cyprus Dendrochronology Laboratory. The applications of dendrochronology to be discussed will range from forest studies aimed at dendroclimatic reconstruction and environmental and ecological applications to archaeological, architectural and art-historical studies aimed at providing cultural heritage information especially concerning dating and provenance. Examples will include drought history reconstruction for lower elevations on the island over the past few centuries to the dating and provenance of a range of cultural heritage contexts and objects of Ottoman to Medieval date. The application of integrated dendrochronology with radiocarbon to assist in building long chronologies, and to provide close dating for materials of Roman to prehistoric date from Cyprus, will also be illustrated.

Archaeological materials studies and modern innovation: examples from the study of ceramics and mortars

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Materials analysis in archaeology aims to understand the human exploitation of the environment and its resources for the production of artefacts. More specifically, it is concentrated on the study of the large variety of raw materials and the processes involved towards the production of all kinds of composite (ceramics, metals, glass, mortars), stone and organic products, for the wide range of technical and every-day life applications. The most common approach involves the investigation of the life-cycle of the today surviving objects and specimens, which engages production, distribution, use – reuse and discard including the alterations and contamination that might have taken place during burial or exposure to environmental conditions.

Data generated from materials analysis and investigation of the *chaîne opératoire* provides important archaeological information about the organization and technology of production, as well as networks of distribution of raw materials, products and traditions. In addition, aspects regarding the function and use are highlighted and related to social and economic activities of the past societies.

Several studies have shown that there exist technological practices which survived through time and the detailed study of their evolution may offer innovative solutions in modern life applications. Typical examples include the use of clay-based materials and natural pozzolanic mortars in building technology. Furthermore, past technological traditions improving the functionality of ceramic artefacts can now offer eco-friendly solutions and energy efficiency in many applications. Finally, the detailed study of materials behavior during burial or exposure, can instigate the development of nanostructured products to be used for preservation and enhancement of service life of a wide variety of materials and cultural heritage assets.

FRONTIERS IN DIGITAL ARCHAEOLOGY

Chairs: Prof. Franco Niccolucci, Dr. Sorin Hermon

Challenges in Digital Archaeology

Franco Niccolucci

Director, VAST-LAB, PIN, Prato, Italy

The fast advancement of digital technologies proposes new challenges to archaeological research. Grey literature, archaeological heritage management and emergency interventions produce a large amount of information. Data are nowadays widely available on line, thanks to a number of initiatives supporting the deposit of archaeological digital records and making them directly accessible. This created a fragmentation in a myriad of repositories, thus the first necessary activity consisted in integrating them into an overarching catalogue with suitable search functionalities. This has been addressed by the ARIADNE (2013-2017) and its follow-up ARIADNEplus (2019-2022) projects, the former covering a large part of Europe and cataloguing about 2.000.000 archaeological datasets, while the latter extends its coverage to all of Europe, USA, Japan, Latin America and Israel and is expected to double the number of catalogued items. Nevertheless, this is just the first step towards a data-driven approach, which has been so fruitful in other scientific disciplines as biology, medicine, chemistry and so on. The particular nature of archaeological research prevents a straightforward adoption of IT methods used in other fields, what has so far relegated the discipline in the limbo of the “long tail of science”, i.e. those domains in which data science is not applied. Novel IT methods are therefore necessary.

The lecture will address the need of further progress in digital archaeology to manage and effectively use such huge amounts of data. It will outline a roadmap to pursue this objective and be able to address grand archaeological challenges such as the diffusion of technology, migrations, and so on, in order to better understand the past and illuminate phenomena of great importance for our present and future.

A LIVING SHIPWRECK: A composite study of scrambling devices: three dimensional modelling and biological analysis for the understanding of site formation processes in archaeological shipwreck sites

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Since the birth of maritime archaeology in the mid-twentieth century, Shipwreck Archaeology has occupied a predominant role in the research undertaken in the field. Shipwreck sites have enabled further understanding of shipbuilding technologies and traditions, trade routes and traded goods, as well as the life on board ancient vessels. Since its inception by Keith Muckelroy in 1978, the wreck site formation processes (WSFPs) theory has played a relevant role in approaching excavation, documentation and interpretation of archaeological shipwreck sites. Similar to what happens on land, WSFPs allow to better understand the preserved archaeological record and to clarify the course of events which have affected the shipwreck site. The present paper aims to present an innovative procedure to better understand these processes, by employing a multidisciplinary approach using three-dimensional recording and modelling techniques, together with archaeological and biological data, in order to model the amphora cargo mound of the Mazotos shipwreck (IV century B.C., Cyprus). The 3D photogrammetric models of the shipwreck site have been paired with the 3D photogrammetric models of the lifted amphorae bearing the biogenic mark on their walls, in order to model the environment and sedimentation processes at the site. While the combination of the 3D site and amphora reconstructions allow to create a model frozen in time (i.e. the time of excavation and lifting), the biological information adds to the model the fourth-dimension, potentially shedding light on the dynamics which have unrolled at the site. The encrusting communities evident on the amphora surfaces account for dynamic processes of burial/exposure as well as artefacts dislocation, allowing to better characterize the initial model and better interpret the available archaeological record. In conclusion, the approach will allow to better understand the environment of deposition and therefore to better understand the material culture and the events that preceded and followed the sinking of the ship.

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From excavation to the drawing and from drawing to the model. The digital reconstruction of twenty years excavations in the archeological site of Bedriacum

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Within technological progress and the use of interactive systems for the enhancement of Cultural Heritage, the archaeological research is witnessing a growing digitalization of acquired data during the excavation phase. As fundamental medium for the reconstruction of the events that characterize an archaeological area, the development of three-dimensional navigable models for the documentation, conservation and musealization of excavation allows to orient not only the visitor but also the researcher in virtual spaces where the stratigraphy of the excavation operations can be ordered and reconstructed. The creation of virtual 3D environments, aimed not only at dissemination and education, but also at historical and architectural analysis and understanding, is one of the objectives of the research conducted by DAda-LAB laboratory of University of Pavia on the archaeological site of Bedriacum, Roman *vicus* near Calvatone, in the province of Cremona (Italy). The twenty-year excavations, carried out on site by the archaeologists from University of Milan, have discovered a complex system of built areas, villas and structures referable to a period between the II century B.C. and the V century A.D.

The research, co-financed by the Region of Lombardy, has provided the organization of drawings produced during the excavation activities within a three-dimensional system where individual actions conducted by the archaeologists and the corresponding artifacts were included. The three-dimensional system, in which it is possible to appreciate the ruins of the different areas at different depths, was then oriented to a 3D database obtained by laser scanner and photogrammetric survey of the entire archaeological site.

The organization of the actions of a three-dimensional system allowed, in a first phase, to create a database starting from the surveys conducted during the excavation campaigns, developing a cognitive framework of the actions able to describe the history of the documentation process conducted in the last few years. Also, the model highlighted the structures present in the subsoil, at different depths, which are currently not accessible. The production of three-dimensional models will support analyzes and interpretations for the development of reconstructive hypotheses, enabling the creation of information tools and models of Virtual Reality for the promotion of the local archaeological heritage. The central site of Bedriacum, relevant for the two wars fought in 69 AD for supremacy after the death of Nerone, today is not appreciable because it is buried. Thus, it becomes virtually visitable, through an informative system that supports research, guiding the interpretative actions of archaeologists, and, on the other hand, also the enhancement of the site.

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The identification of cities in archaeology: A case study from central Israel, the seventh-eleventh centuries AD

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The terms 'city' and 'village' or 'urban' and 'rural' are frequently cited by archaeologists and historians without a clear definition (Wickham 2005: 592-93). Characteristics such as size, specific site plans or fortifications, together with the identification of sites with textual toponyms, are used randomly to represent an imagined 'city'. Moreover, models such as the Central Place act to detect urban centers. In reality, however, a 'city' is a contextual term, influenced by varied perspectives (e.g. Abrams 1978; Smith 2016) and not only inhabited sites acted as hubs, but also annual fairs (De Ligt 1993: 99-136). Thus, each region should be studied separately and apply its own coherent typology. Secondly, archaeologists must humbly be aware of the etic limitations of their conclusions. This research offers a typology of sites in one region in central Israel, from the 7th to the 11th century AD; and its comparison to contemporary terminology of places. The typology is based on cross-references of varied elements through Big Data, in particular the combination of fire and water instillations, 'industrial' refuse and specific architectural features. It resulted in five site types and in one site (Ramla) which joined several types together. The comparison to settlement terminology ('metropolis', 'city', 'village-town', 'fortress', 'monastery', and 'manor/estate') showed some correlation. Most importantly, it seems that cities set on central routes or the coast, provided a market and all other services but had only little industry. They clearly differ from the metropolis, which was big, industrial and agricultural, and which provided all commodities. The village-town provided similar services as the city but not all, and was placed in less favorable locations.

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Knowledge-based generative adversarial networks for scene understanding in Cultural Heritage

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This work describes a research conducted by an interdisciplinary team for devising artificial intelligence methods to support data understanding in Cultural Heritage. The ultimate objective is to create automated methods for automatically classifying and successively retrieving photographic data and text documents leveraging the current breed of AI methods.

However, AI methods, based on the deep learning paradigm, require significant amount of annotated data that, in the context of cultural heritage (especially in ruins and archeological excavations), it is often impossible to gather. To address this problem, we devise an approach based on Generative Adversarial Networks (GANs) for automatically synthesizing unrealistic photos, which, in turn, can be used for training image classification and retrieval systems.

Nevertheless, GANs ask for also massive amount of images to learn visual features and despite the web is a valuable resource for gathering the needed data, the visual appearance variability of the images complicate the generation of realistic samples.

Under this scenario, in this paper we propose a method to drive the generation of realistic Culture Heritage images by integrating generative GAN approaches with semantic ontology domain representation.

To accomplish this task, we first design a computational ontology for Cultural Heritage domain modelling (shown in Fig. 1), with a specific focus on religious historical buildings. Our ontology is specifically thought to support annotation, automatic indexing, classification and curation of photographic data and text documents. On top of the ontology we build also an annotation tool - CulTo - that allows users to provide concept-level annotations constrained by a specific formal ontology, besides enabling the creation of clusters of collected information (both visual and non) as well as to identify automatically which part of a historical building a specific image belongs to (Fig.2).

Despite CulTO is easy to use, it requires a large intervention of humans as they have to carefully identify several objects and details on the images and their spatial constraints (e.g. an 'arch' is present on the top of image and is composed from several structural objects disposed in specific order). We overcome this problem through the generation of a synthetic dataset starting from a small-annotated dataset by using a GAN model enforced to keep the correct spatial correlation among objects. Our knowledge-driven approach is a two level GAN: the first one that generates or synthesizes isolated objects corresponding to each ontology concept and the second GAN that, instead, combines the generated objects according to the spatial information provided by the ontology in order to generate realistic scenes.

Our approach in this way enables the generation of artificial data for training classification and retrieval methods as well as it represents a powerful design tool for artificially reconstructing the whole archaeological excavation scenario.

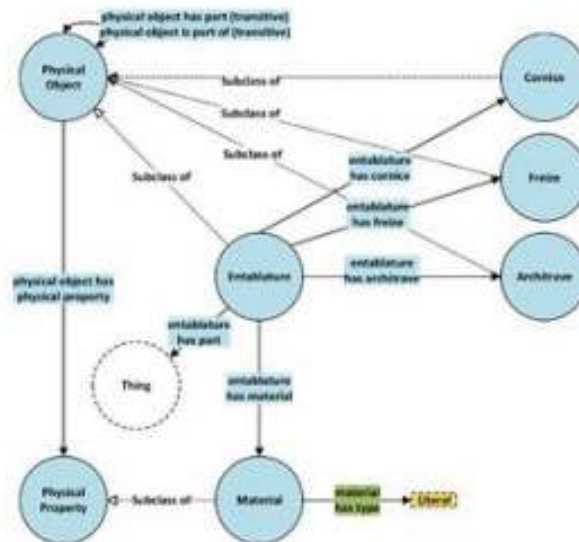


Figure 1. The Visual OWL representation of a subsection of the developed ontology.

Digital reconstruction and visualization of a New Kingdom palace area from the eastern Nile-delta/Egypt

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The excavations of the Austrian Archaeological Institute at Ezbet Helmi (1990-2007) have been dealing with the so called palace platform F from the New Kingdom, and the adjacent habitation and housing areas (field areas H/I, H/IV and H/V). Because of the finds of Minoan frescoes, the areas are often referred to, however a meticulous study of the stratigraphy and find materials is yet missing. The here presented project, that is funded by the Austrian National Bank (ÖNB) since 2018, shall fill the gap, and the goal is the clearance of the stratigraphy of the area and the virtual reconstruction in 3D.

The base of the project is the meticulous analysis and interpretation of the available data from the excavation records, to build up a digital stratigraphy of the area, including the find materials.

In the first stage a GIS related database is created from the available field documentation, including photographs, field records, drawings, as well as the data from the registers, such as ceramic- or object-inventory, data from the sherd collection, the find labels, etc. They are anchored within this database, before transferred into a GEO-database. After the digital acquisition and interpretation of data, the volumetric depiction of features will follow, to create rotatable views of small complex features like ovens, which are resurrected as a brick related 3D visualisation and reconstruction. The sequencing of the features is then possible via the Harris Matrix Composer (developed by the LBI Arch Pro), which results in a Harris matrix.

The maps and 3D models resulting from the spatio-temporal analysis are then the basis for a comprehensive virtual reconstruction of the palace, making the archaeological evidence accessible online and to archive the data in the ACDH (Austrian Center for Digital Humanities).

HBIM Approach for the knowledge and documentation of the St. John the Theologian Cathedral in Nicosia (Cyprus)

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The present study illustrates the results of an interdisciplinary research carried out in collaboration between the Mediterranean Laboratory of Survey and Diagnostics for Architecture (RDA) of the Department of Civil Engineering and Architecture (DICAR) of the University of Catania in Italy and the Andreas Pittas Laboratories for Art Characterisation (APAC) of the Science and Technology in Archaeology Research Center (STARC) of the Cyprus Institute in Cyprus.

The research focused on the application of an H-BIM approach in the study of a Mediterranean iconic heritage asset, the St. John Cathedral of Nicosia. The present church was built on the remains of a monastery which chronologically belonged on the Latin period (1192-1571)/ previous centuries. The adopted methodology has provided the framework for a dynamic investigation, constantly evolving along several dimensions: historical, geometric spatial, architectural-constructive identification and mapping of degrade, interpretation of degenerative causes and design proposals.

Compared to the traditional restoration project workflow, the BIM approach has allowed the creation of an information model in which both the 3D digital survey data (integrated laser scanner and photogrammetry) and the data relating to the cognitive survey (historiographic research, diachronic analysis, classification of the technological system) have been merged to support the diagnostic investigations (decay mapping), the restoration work and the subsequent management of the building.

The convergence of the survey/modeling/mapping phase of degradation into a unique three-dimensional parametric and semantically enriched model, which can always be implemented with new information and/or new phases relating to maintenance and/or restoration projects, has allowed the subsequent export of all those documents (abaci, traditional drawings, etc.) useful for concluding and defining the entire cognitive phase and starting the design phase. In this way, instruments and methods tested, have responded to the needs of process flexibility within a project of complex restoration.

3D Geometric descriptors for the study of Cypriot coroplastic production

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This paper will present a 3D digital methodology developed to support the archaeological research and its application to a Cypriot case-study, the small terracotta figurines of the Ayia Irini sanctuary (Gjerstad et al. 1935). Main aim of the research is to identify production aspects and types based on a 3D digital approach. Particularly, the 3D geometry comparison of the archaeological artefacts and their constituent features addresses aspects of manufacture and production, presence of rules, standards, identification and use of same moulds, possibly detecting specific artisans' hands (Vassallo 2016, Vassallo 2017).

Several Cypriot archaeological collections excavated in the past suffer from being dispersed in various countries and now conserved in different museums, making their holistic study difficult. Besides, these collections belong to old excavations, and therefore, they were studied within an analogic framework.

The revision of the case study material and the above-mentioned issues brought to the identification of the following challenges: 1. How to study and compare artefacts belonging to the same assemblage but physically distant because dispersed in different museums? 2. How to support the traditional typo-technological (and stylistic) study of artefacts on the base of measurable and quantifiable criteria?

The methodology developed for this study and the technological solutions adopted to solve the archaeological questions related to the interpretation of the material production is based on the integration of the geometric and the semantic aspects. Specifically, the geometric investigation is based on the 3D digital reproduction of the artefacts and the comparison of the 3D shapes through computer vision (Scalas et al. 2018). Once geometric descriptors (i.e., measures) based on chaîneopératoire analysis are defined (e.g., symmetry, circularity, straightness), the 3D artefacts are semiautomatically analysed according to those measures. As a result, the material can be typologically classified according to measurable criteria, lowering the uncertainty of human scrutiny. The 3D digital approach can support the archaeological method and help to express the reliability of research, quantifying the uncertainty of assertions and enlarging the frontiers of the traditional archaeology.

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SimpleX: Towards an Ontology for Archaeological Pottery

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Arguably, the accurate and comprehensive documentation of archaeological pottery is one of the most complex tasks in archaeology owing to the polythetic nature of pottery, the overlapping relationships between its attributes, and more practically the lack of institutionalised guidelines for documenting this particular category of material culture. The SimpleX ontology has been recently developed within the broader framework of a postdoctoral research project funded by the University of Cyprus with the aim of conceptually systematizing the methodology of recording archaeological pottery. The ontology extends the CIDOC-CRM (Le Boeuf *et al.* 2015, see also Doerr *et al.* 2016) and CRM-EH (May 2014) and was developed in the Protégé ontology editor (Musen *et al.* 2015). The fundamental noetic construct is the concept of a ceramic object, which is considered to be a physical spatiotemporally existing subclass of the E22 man-made object class under the E92 spacetime volumes and E77 persistent items superclasses in CIDOC-CRM, and is itself a superclass of etically defined sub-entities, such as the concepts of fabric, surface and shape thought to represent different inter-related aspects of the pottery making process and variously informing the archaeologist. All newly defined entities of the ontological model have been associated via extant properties with several entities in the CIDOC-CRM and CRM-EH models, and specifically with entities within the E4 Period, E28 Conceptual Objects and E55 Type superclasses. In the final stage of ontological modelling, the Hermit reasoner was utilized to track orphan entities, identify subsumption relationships between classes, and ensure overall ontological consistency, while the fully annotated ontology was exported in the RDF/XML syntax and is planned to be released online after the postdoctoral project concludes.

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Towards a Phygital Heritage approach for Museum Collection

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The Cultural Heritage field is the community that first faced the issue of digitization processes and tried to introduce the culture of transparency in the knowledge description. Passing from Cultural Heritage (CH) to Digital Heritage (DH) domain, the possibilities of creating, communicating and sharing knowledge are values that must be preserved, documented and made accessible. The CIDOC Conceptual Reference Model (CRM) established guidelines for the information exchange between CH institutions. Starting from the London Charter for the computer-based visualization of CH to the International Principles of Virtual archaeology, the role of paradata documentation became crucial to describe information about human processes of understanding and interpretation of data.

The BACK TO THE FUTURE research (Politecnico di Torino - Museo Egizio of Turin collaboration), proposes a graph about reproducible science in DH, documenting historical research: not just working about non-linear spatial narratives for 3D models platforms, but a rethinking of data structure using the advanced data modeling approach of an event-centric documentation model, according with the CIDOC CRM and its extensions.

This research offered interesting aims for working on the crucial relationship between content (collection) and container (museum) through shared and interoperable digital workflows. The artworks are characterized by intangible values including historical, artistic, social and media attributes and their weighted relationship helps to create an attractive weight of the artwork within the exhibition project. Therefore, it is an interesting subject for a correct foreshadowing of visitor flows. The recent launched SMART MUSEUM research works on automated procedures to show, through graphics, the complex phenomena triggered by the attractive weight of the collections. The involved elements are the exhibition area (the graphic field), the collection (the attractive elements) and the users. The conceived procedure, once automated, becomes a prototype to support the curators to control and improve the efficiency of the exhibition layout.

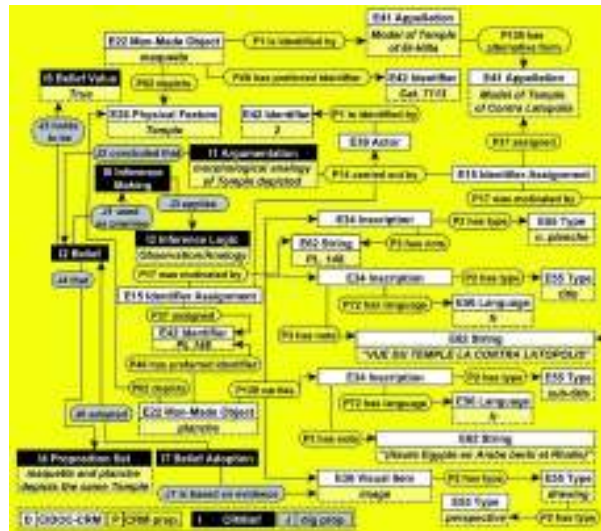


Fig. 1. Data modelling to argument morphological analogy between different representation of the same object, based on archival documentation

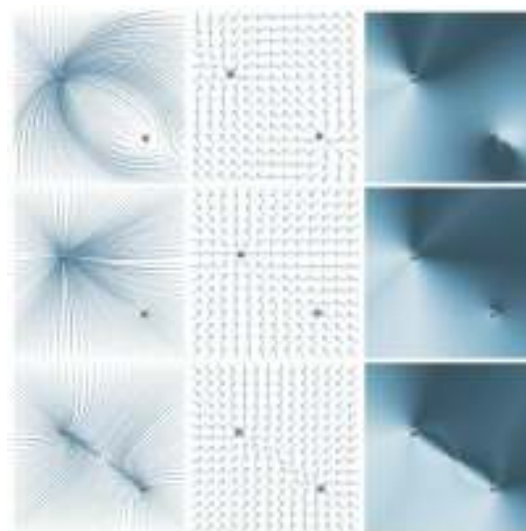


Fig. 2. Automated algorithms to visualize complex phenomena triggered by the attractive weight of the collections

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Machine Learning approach for monitoring and managing museum collections

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The study is focused on the experimentation of innovative methodologies that allow an advanced management of museum collections through the development of a system that uses the tools of Machine Learning to implement effective conservation strategies. The experimentation aims at creating an autonomous decisional system of the management model that, on the basis of machine learning processes, suggests to the professional who cares about the museum how to manage the collection, the best position of some elements of the collection, the operating modes of the air conditioning systems, the opening and closing of the windows and doors for the exact amount of ventilation to be provided to maintain certain thermo-physical conditions, the number of people who can access the rooms at each shift, etc.

In order to find the amount of data needed to train the system, it is necessary to have a copious starting database from which to use the data, but to do this it would take months if not years of data collection. In order to boost the time required to gather the needed dataset a possibility is to train the decision-making model based on machine learning through the use of plugins connected to VPL (Visual Programming Languages) that allow the simulation of different scenarios starting from open source data. We could then make a dynamic analysis of the thermo-technical behavior of the building starting from the data of the .epw open source files (weighed against the heat island thanks to Urban Weather Generator) that allow me to understand the response of the building on the basis of simulations of configurations day by day for the duration of one year. This process of training the machine learning mechanism will be supervised (they are scenarios controlled by the designer) and each solution will be "an experience" for the building from which to learn. This process allows the system to give answers and suggestions right from the start of its installation. In the future its outputs will be based on the real experience data gathered from the installed sensors and feedback from users. Along the time thanks to experience and background data the decision-making system will improve the quality of his work.

ART CHARACTERIZATION

Chairs: Dr. Michel Menu, Dr. Nikolas Bakirtzis

Heritage Science a discipline for the conservation and analysis of works of art

Michel Menu

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The C2RMF is a National laboratory in charge of the conservation and study of the artefacts kept inside the 1200 French museums. The laboratory inside gives service to the museums in terms of expertise and of assistance to conservation. It develops also research in these areas and more generally the research merging Natural Sciences and Art History on museum artefacts.

To this goal, the laboratory has an active research activity devoted to new developments and implementation of analytical methodologies taking into account the specificity of the works of art: preciousness, sensitivity etc. For this purpose and with the support of National Research institutions (CNRS, CEA, Universities, etc.), the C2RMF laboratory maintains and develops a unique Ion Beam accelerator fully dedicated to the characterization of cultural heritage materials in a non-destructive way. On the other hand, during the 10 passing years, the laboratory was involved in the implementation of mobile instrumentations among them lasers sources are an indispensable part.

I will present several applications of experiments achieved inside the laboratory such as OCT, MA-XRF or UV Fluorescence imaging on several paintings and sets of archaeological objects.

Laser applications for the characterization of cultural heritage

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C2RMF is involved for years now in the development of laser based techniques dedicated to cultural heritage characterization.

These techniques could play a key role for the different area of the conservation works: preventive conservation (OCT, DHSPi), archaeometry (LIBS, Raman) and restoration (laser cleaning).

In addition, and in order to feed the European MOLAB (access to mobile examination and analytical methods to study the works in situ) with new instrumentations, IPERION-CH European program supports the creation of new mobile analytical technique and the C2RMF lead to develop one hyphenated LIBS/LIBS/RAMAN portable instrumentation.

All these new instrumentations will address the experimental problems of knowledge and conservation of heritage materials (collections of art and natural museums, monuments, archaeological sites, archives, libraries, etc.).

We will present through different examples the possibilities and contributions of laser techniques to the heritage science.

Giovanni Baronzio's 'Crucifixion': Analytical Approaches and Art Historical Considerations

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The small panel of the 'Crucifixion' attributed to Giovanni (da Rimini) Baronzio is a perfect example of the artistic achievements of the so-called School of Rimini. Baronzio, active between 1320 and 1350, was one of the most important painters of a group of artists working in Rimini during the first half of the 14th-century whose work was heavily influenced by the work of Giotto di Bondone (1267-1337), characterized by Gothic and Byzantine influences. The panel, with an estimated date in the end of the 1320s, represents a popular iconographic theme during this period and was painted in tempera and gold on wood. Non-invasive analytical approaches have revealed a rich history of interventions, re-touching and restorations, which allows for some interesting observations and considerations in regard to the work's history. The applied analytical methods and the related art historical observations and interpretations, performed at the Andreas Pittas Art Characterization Laboratories (APAC Labs) of STARC at the Cyprus Institute will be the focus of the present paper.

In order to avoid micro-sampling, a non-invasive methodological approach integrating spectroscopic (μ X-Ray Fluorescence spectroscopy, Fiber Optic Reflectance Spectroscopy, Fourier Transform Infrared spectroscopy), imaging (UV, X-Ray Radiography, Infrared Reflectography) and digital microscopy techniques was applied. This study aimed at the identification of the work's original materials and techniques, its conservation state and the complex history of interventions and restorations. Results showed that while original materials of the painting conform with those used by artists in 14th century Renaissance Italy there are multiple later interventions both as small-scale inpainting as well as extensive overpainting of various parts of the original Crucifixion composition. Careful consideration of these interventions can shed light to aspects of the panel's history of preservation as well as on issues of stylistic or compositional 'corrections'- always an interesting dimension of the changing perceptions of works of art through time.

The application of portable XRF on Negev Rock Art: Chronological trends at the Ramat Matred Petroglyphs as a test case

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Negev rock art comprises a large and diverse corpus of motifs and compositions developed over the course of several millennia, usually in the form of petroglyph engraved on the rock coatings. As dating of specific elements has been until now not possible, research has focused on stylistic and statistical aspects, as well as the distribution, superposition and the study of individual panels where internal sequences of engraving could be discerned (Eisenberg-Degen and Rosen, 2013). At the same time, much effort was put on the investigation of the formation processes of rock coatings (also referred to as desert varnish) in terms of the identification of the microbiota and mineralogy involved in the formation processes (Goldsmith et al., 2014). In the present study, an attempt was made to involve the new methodology of surface analyzing by portable X-ray fluorescence (pXRF) as means for relative and in some cases also absolute dating of petroglyphs in the Central Negev highlands (Goren et al., 2011). As a study case, several composite panels including dated and undated motifs were studied, together with a few simpler panels comprising of one or more motifs of specific types. The results provide encouraging outcomes for chronological sorting of individual elements within the composite panels in particular, and rock art in this region in general. The great contribution of direct pXRF dating will be in securing the relative and absolute chronology of the entire rock art phenomena in the Central Negev and beyond.

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Mapping the mineralogical composition of pigments using multispectral imaging in the frigidarium of the Sarno Baths, Pompeii

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Documenting pigments in wall paintings on-site and assessing their state of degradation requires large-scale chemical and mineralogical characterization techniques. In the site of Pompeii, which encapsulates invaluable archives of pigments, techniques, and artistic expressions Roman art from mid-first century AD, non-invasive approaches are in need. In this research, the goal was to develop a new methodology for mapping mineralogical composition of wall paintings in the archaeological site, based on combining point analysis of portable X-ray fluorescence and fiber optic reflectance spectroscopy with multi-spectral imaging. Stacked photos from a portable modified digital camera that can register the ultraviolet, visible, and infrared spectral regions were normalized to represent a relative reflected intensity at different band widths, and based on mineral-specific band ratios, mineralogical maps were constructed. The minerals hematite, goethite and cuprorivaite were documented in the pictorial layers of large-scale frescoes in the frigidarium of the Sarno Baths complex of Pompeii, complementary to high-resolution mineralogical and structural information from X-ray diffraction and Raman analyses of fragments found below the wall paintings. Results confirm that the wall paintings in the frigidarium were painted with a limited artist's palette, documenting iconographic figurines of plants, pygmy people, and animals from a degraded depiction of a river scene, which refines previous restoration suggestions that are based only on visual observations.

Documentation of paintings restoration through photogrammetry and change detection algorithms

Dante Abate

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The philosophical and theoretical foundations of the Theory of Restoration, envisioned by Cesare Brandi in 1975, are established around clear and straightforward guidelines on what is ethically acceptable, and unacceptable, in conservation. Specifically, the Italian scholar advocates for the complete reversibility of restoration work and respect for the history of an artwork. Indeed, according to these concepts, all interventions should be fully reversible so to return the object to its initial conditions without any damage. Bearing in mind these assumptions, a detailed documentation of all the steps of the conservation process, and the possibility to retrieve them a-posteriori, must be considered essential. This concept especially applies when dealing with paintings restoration characterized by fine and small details. In recent years, the tendency is to favor minimal invasive interventions ranging from consolidation actions, cleaning samples, and colors retouching. Materials change more or less conspicuously over time according to their consistency and the intensity of the changing factors. Icons do not make an exception to this rule. This process affects the icon's whole structure: the support, the painting itself and the varnish coating. This paper investigates the performance of change detection algorithms, developed in the remote sensing domain, and, in the framework of this research applied at a microscale (paintings). Each phase of the restoration process is documented exploiting a multi-epoch image acquisition. A monitoring methodology coupled with photogrammetry and 3D shape analysis is tested and described. It is anticipated that the proposed innovative use of change detection techniques can be applied to different kinds of painted surfaces. An icon, today preserved at the Byzantine Museum Makarios III Foundation in Nicosia and restored by the Department of Antiquities of Cyprus labs, has been used as a case study.

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SYNCHROTRONS IN ARCHAEOLOGY AND CULTURAL HERITAGE-SESAME

Chairs: Dr. Giorgio Paolucci, Dr. Kirsi Lorentz

Synchrotron radiation enabled human bioarchaeology in the EMME region: SR-XRF, XANES and EXAFS data in exploring key archaeological questions

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This paper takes stock of the current state-of-the-art in synchrotron radiation enabled human bioarchaeology, and focuses on how these approaches can be used in resolving key questions for the archaeology of the EMME region. As a case study, the presentation will focus on the use of SR-XRF, XANES and EXAFS data in exploring heavy metal exposure in the past metal working cities of the EMME region. In specific, this paper shows how synchrotron radiation X-Ray Fluorescence (SR-XRF) can be used to explore biogenic versus diagenetic/environmental uptake of metals, and copper in particular, in ancient human hair and bone, providing data relevant to exploring key archaeological questions, such as effects of intensive metal and craft work on human health. The scanning X-ray microscope optimized for 2D μ XRF (elemental maps) was used at ESRF (European Synchrotron Radiation Facility) beamline ID21 to obtain detailed maps of the localisation of metal elements, including Cu, in ancient hair sections (10 μ m) of eight individuals (n=8), as well as modern hair controls (n=2). Only a handful of studies using synchrotron radiation enabled approaches to ancient human hair have been undertaken to date, few studies explore metal element distribution within ancient hair, and none Cu in specific. Further work using SR-XRF, XANES and EXAFS at SESAME (XAFS/XRF beamline), as well as microXRF mapping at the Swiss Light Source (microXAS beamline) on human bone was conducted. Within this study, significant differentiation in the levels of Cu were discovered between different skeletal individuals from the site of Shahr-i Sokhta, a 3rd millennium large urban site with intensive metalwork and other craft work activities from ancient Iran.

SR-FTIR in Archaeological and Culture Heritage Research at SESAME

Gihan Kamel

SESAME - Synchrotron light for Experimental Science and Applications in the Middle East

SESAME is the only synchrotron light facility in the Middle East. It aims at promoting advanced research capabilities and technology within its Members, and considered as the region's bridge to peace and mutual understanding. Current Members are Cyprus, Egypt, Iran, Israel, Jordan, Pakistan, the Palestinian Authority and Turkey. Whereas, Brazil, Canada, China, the European Union, France, Germany, Greece, Italy, Japan, Kuwait, Portugal, the Russian Federation, Spain, Sweden, Switzerland, the United Kingdom and the United States are the Observers. SESAME is currently in full operation and the installation of the beamlines is significantly progressing, covering a range of full operation, installation, and design phases.

With an equivalent success to Synchrotron facilities all over the world, the Infrared Microspectroscopy technique proved a distinct competence. IR Microspectroscopy is a vibrational technique that is non-destructive and which is exhibiting a strong interest at synchrotron facilities and is preferred by scientists working in the fields of archaeology and cultural heritage compared to laboratory-based sources. In the context of beamlines selection of the potential end stations at SESAME, infrared Microspectroscopy was identified as one of the most demanded techniques, as shown by various scientific communities. It is the first newly designed beamline at SESAME realized in collaboration with the French Synchrotron, SOLEIL. The SESAME IR Beamline was completed and opened to serve users in November 2018. This talk highlights a few examples of SESAME Users' first experiments on archaeological remains, historical parchments, and on a collection of preserved wall paintings, together with the future opportunities in the field of cultural heritage at SESAME.

Advantages and potential of SR phase contrast microCT enabled virtual dental histology in comparison with conventional dental histology

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Dental histology enables highly accurate estimation of crown formation time, age at death in developing dentitions and timing of the occurrence of stressful events in an individuals' life through the identification of accentuated lines in enamel and dentine. Dental histology is therefore a vital tool for bioarchaeologists in reconstructing aspects of growth, development and physiology. The conventional approach to dental histology involves manually sectioning a specimen and polishing it to a specific thickness, after which sections can be examined using transmitted light microscopy, with neutral density and polarization filters to enhance the visibility of microstructures. This technique offers an affordable approach which allows for highly accurate visualization and analysis of the internal microstructures of dental tissues. However, there are multiple drawbacks to this technique. Conventional histology is time-consuming, invasive, and/or destructive. Furthermore, plane of sectioning and section thickness cannot be altered once sectioning is completed, limiting analysis possibilities. In the last decades, the application of synchrotron radiation phase contrast micro computed tomography (SR phase contrast μ CT) has been used to study dental microstructure of paleontological samples. With SR phase contrast μ CT, a computerized reconstruction of cross-sectional slices of teeth are made and stacks of these virtual slices can be used to create three-dimensional representations of a tooth specimen. This allows us to explore the internal microstructures and enables the study of three-dimensional properties within a specimen. Specifically, phase contrast enhances the visibility of microstructures that are not visible with standard microtomographic absorption techniques. From comparative studies, we know that submicron-resolution phase contrast SR- μ CT yields accurate representations of dental microstructure, comparable to the quality of images obtained using the conventional approach. Additionally, the SR- μ CT images can be manipulated, adapting slice thickness, contrast and orientation. The use of this technique therefore brings many advantages for the study of archaeological dental remains, particularly as it is non-invasive and non-destructive, and can be applied to extremely fragile and unique specimens. Although this field is developing rapidly with many application possibilities for bioarchaeologists, the conventional approach to histology still has an important role. In this paper, we discuss our perspectives on the advantages of using Virtual Dental Histology for bioarchaeologists, while acknowledging aspects of conventional histology still of use. We discuss this using examples of our own experience on applying both techniques on material from various prehistoric sites of the EMME region.

Highlights of Potential Synchrotron Research Applications at the University of Jordan: case studies from cultural heritage

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The partnership between the University of Jordan and SESAME led to establishing a dedicated center for synchrotron applications. The center serves all Jordanian users to prepare, test, analyze results and work together at on location prior and after their beam time experiments at SESAME in a broad spectrum of science fields including cultural heritage. In this presentation; a description of the center's functions and structure is presented as well as the resulted users work groups activities from science, and cultural heritage applications. Over the last year, there has been an increasing demand for the use of synchrotron radiation technique (SR) and its application to study archaeological materials and cultural heritage.

The specific characteristic of the archaeological materials is that they often heterogeneous and complex in shape and composition (pottery, glass, stones, metals, wood)

The use of synchrotron radiation is particularly suited to study such materials. The main areas of investigation are: composition, provenance of the raw materials, techniques used, age dating, and the conservation (how to avoid its deterioration). In this presentation, the conservation of mosaic for a Jordanian cultural heritage sight is presented. Several investigation and analysis methods are presented, and the SR can play a central role and it is a powerful tool to study this type of archaeological materials.

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SSE4 - Oral presentation

Arinat, M., Shiyyab, A., and Abd-Allah, R., 2014. Byzantine Glass Mosaics Excavated From The “Cross Church”, Jerash, Jordan: An Archaeometrical Investigation, *Mediterranean Archaeology and Archaeometry*, 14(2), pp. 43-53.

SR-FTIR analyses of ancient hair remains from Anatolia

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(3) The Cyprus Institute

The aim of this research was to explore the preservation status of Roman period archaeologically recovered human hair through SR-FTIR mapping of organic compounds, for the purposes of assessing feasibility of destructive analyses, such as stable isotope analyses for diet, which rely on the sufficient preservation of the organic components of the ancient human hair. This aim was achieved through the following objectives: (1) mapping of organic compounds in cross sections (5 micrometers thick) and longitudinal sections of ancient human hair; (2) mapping of organic compounds in cross sections (5 micrometers thick) and longitudinal sections of modern human hair; (3) comparative analyses. Strands of human hair were discovered within a Roman period burial in central Anatolia. The archaeological finds from the graves in this necropolis (near the ancient Skopas River (Aladağ Creek) near Sarılar Village, on the border ancient Bthynia and Galatia regions), and the studies on the coins revealed that this burial site is the necropolis of the ancient city of Juliopolis. It is reported that there are rich and elaborate grave goods in the tombs in the Necropolis of Juliopolis. Among the grave goods found at the site there are various types of jewellery, metal containers, strigils, mirrors, medical instruments, oil scent bottles, coins, glass artefacts, oil lamps, ceramic pots and artefacts made of animal bone. The hair strands recovered can give us invaluable insights to the life of an individual in central Anatolia in Roman times, allowing data on diet, potential exposure to environmental contaminants, hair colour, and ancient DNA to be recovered, provided that the preservation status of the hair is suitable. Before subjecting such rare finds of hair to destructive analyses, it is crucial to explore the preservation status of the hair in detail.

Comparison of synchrotron CT and laboratory based micro-CT with applications in heritage materials

Kudakwashe Jakata

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Computed tomography (CT) has become an integral part of research in the fields of Archaeology and Palaeontology. It is a technique that makes use of X-rays to non-invasively obtain 3D images of a specimen and allows researchers to obtain information on the internal and external structure reducing the need for handling.

Laboratory based micro CT systems generate a polychromatic beam of X-rays which are transmitted through a specimen on a rotating stage and then collected by a detector. A synchrotron can produce a beam with a broad range of frequencies but however, allows the use of a monochromatic beam depending on the experiment. Synchrotron radiation sources also have a much higher brilliance and phase contrast can be obtained from typical CT experimental arrangements.

We will give an overview of laboratory-based micro-CT scanning compared with synchrotron CT. We will also present highlights on heritage specimens from Archaeology and Palaeontology carried out at the Evolutionary Studies Institute. We will present images from specimens such as dinosaur eggs of *Massospondylus*, and a fossil burrow in which two fossils have been discovered. Our current understanding of the evolution of human beings has also been aided by discoveries of fossils such as the *Australopithecus sediba* and the “Taung Child” and determination of their mobility and cognitive abilities or the environments in which they existed have been aided by computed tomography. Highlights of CT work that has been done on hominids will also be presented together with work on some archaeological specimens discovered in South Africa.

SR microCT in identification of NNL: Distinguishing between stillborn and newborn infants

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SR phase contrast microCT has high potential for studying archaeological human remains due to its high resolution and non-destructive or non-invasive characteristics. Microstructure of human teeth holds information on an individual's past health condition. Physiological stress experienced while teeth are forming can result in the formation of distinctive markings in the enamel and dentine. These lines are commonly referred to as accentuated lines (ALs). The neonatal line (NNL), representing the event of birth, is present in deciduous teeth and the lower permanent first molar. Medical studies indicated the NNL is absent in stillborn. Hence, the presence or absence of the NNL in perinates could give valuable information on an individual's survival time. The conventional approach of observing the NNL is by making histological thin sections of teeth and observing their microstructure with light transmitted microscopy. This method is however destructive. SR-micro CT is the only non-destructive method that allows us to study accentuated lines in full detail. Combining the identification of the NNL with archaeological context on burial customs can give us valuable insight in past societies approach to life and death. Ancient texts as well as archaeological and ethnographical evidence shows that people had different attitudes towards stillborn and newborn infants which died shortly after birth. Correlating age and burial practice enables us to explore social identity of specific age groups, and how people conceptualized age. SR-microCT is a highly valuable means of solving such key questions without damaging valuable archaeological remains. SR phase contrast microCT also enables distinguishing between stillborn and newborn individuals in forensic contexts. However, not all SR-microCT facilities enable virtual dental histology as above, as technical specifications suited for virtual dental histology are required. Designing a beamline enabling virtual dental histology has high potential for future use of SESAME.

STARCH: at the origins of starch food diet. SR-FTIR and SEM applied to Palaeolithic Grinding Stones from the Pontic area

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The advent of dietary carbohydrates as human staple food was a breakthrough. However, perishable plant-food remains (e.g. starch) are poorly represented in the archaeological record, and the role played by vegetable food processing has only recently been reconsidered. Evidences from our research on grinding stones retrieved in MIS 3 sites are challenging the mainstream model of the so-called Neolithic Revolution. Plants rich in starch, like roots and tubers, were processed into flour by means of grinding and pounding stone tools. Preliminary results are showing that use-related biogenic residues such as starch granules can be extracted and characterized with cutting-edge analytical protocols combining optical and FE-SEM microscopy (low vacuum) coupled with micro and nano-FTIR spectroscopy coupled with the high brightness of synchrotron radiation (SR).

Use-related starch granules, extracted from grinding stones retrieved from Pontic Steppe Early Upper Palaeolithic sites, have been morphologically identified and SEM micrographs show the lamellar structure (amylose and amylopectin). Those features were targeted by FTIR analysis and the spectral feature of amylopectin was detected, even though possibly degraded (Figure 1). The spectra of archaeological starches were compared with those obtained from modern starches (red potato).

New data from the on-going beamtime, strengthening the putative hypothesis, will be presented during the workshop. The research reveals twofold outcomes: (i) it demonstrates the suitability of high-hand large infrastructure to be applied to archaeological materials; (ii) it sheds light on the introduction of dietary carbohydrates in Homo sapiens nutritional strategies, occurring at least around 40,000 ka around the Black Sea area. Finally, it proves that STEMs and Humanities can be positively merged to solve relevant issues in humans' dietary adaptation according to the colonized niches. Moreover, investigating the "Starch Food Niche" in an evolutionary perspective brings revelatory keys on the origins of contemporary mismatch which is at the base of diseases related to starchy food (metabolic syndrome) highlighting the relevance of investigating our past to understand our present and to plan future sustainable strategies.

SSE-P1 - Poster presentation

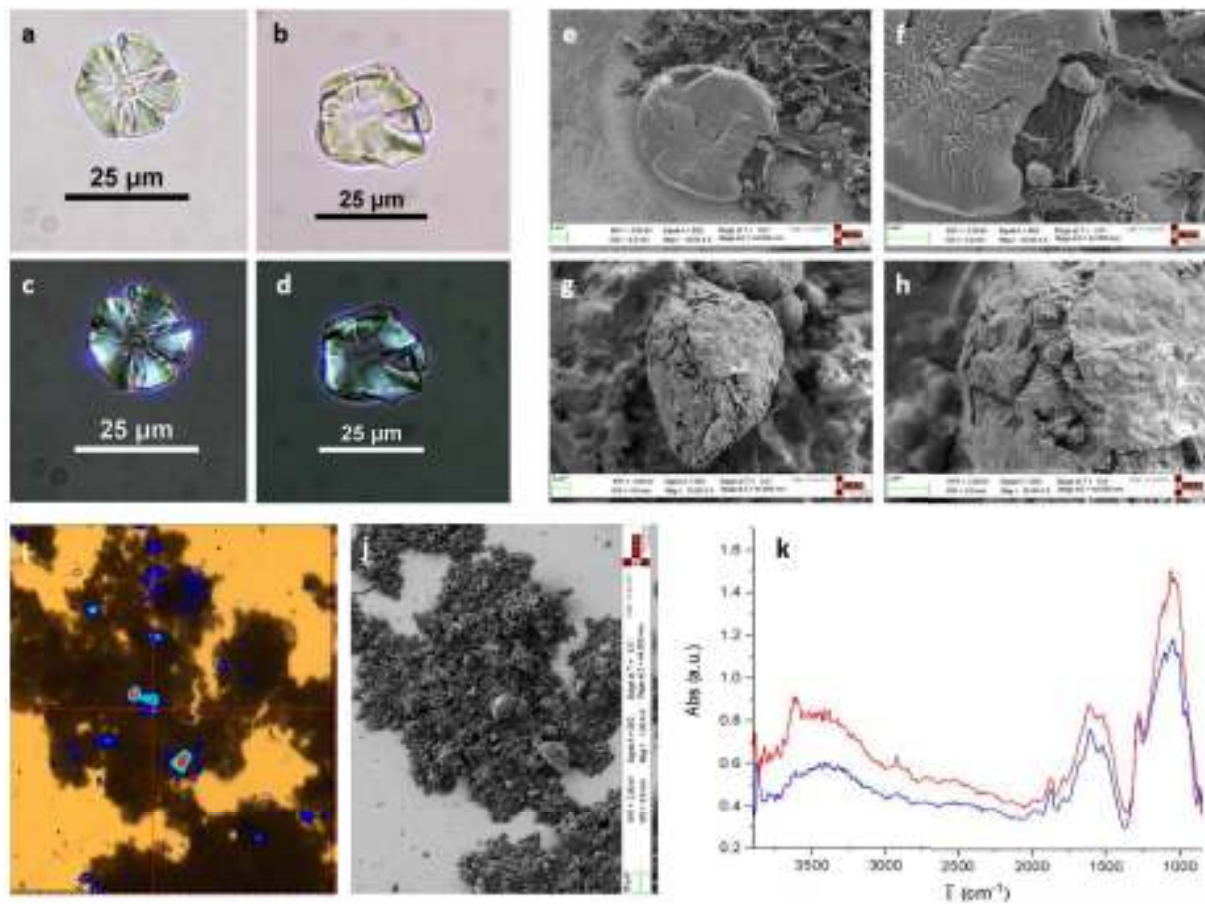


Figure 1. a-b: Optical image of an isolated ancient starch; c-d: Image of the same starches obtained with polarized light; e-h: Image of starches obtained with SEM; i: microFTIR image obtained from the sample in panel j (SEM image) and relative FTIR spectra by comparison.

Exploring paleopathology of Hellenistic/Roman Paphos (Cyprus): Potential of high-resolution SR microCT at SESAME

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SR microCT is instrumental to exploring bioarchaeological questions requiring detailed understanding of 3D internal microstructures, non-invasively, with non-or minimally destructive approach. Human remains derived from archaeological contexts are valuable as they are the most direct route to an individual's life and health. Therefore, destructive analysis should be limited. With the development of synchrotron radiation (SR) enabled bioarchaeology and particularly with the application of SR microCT, archaeological and biological questions can be explored with a non-destructive approach. Bone and dental histology has long been of interest to bioarchaeologist, however, the conventional way of histological analysis is thin sections/transmitted light microscopy. The last decades, advanced developments in high-resolution X-ray imaging through the use of SR, enables a 3D visualization to high resolution examination of micro structures, with non-invasive and non-destructive procedures. In addition, it offers greater image quality, resolution and visualization. Here, we present how SR MicroCT can be employed to analyse the osteological collection from Ktima-Upper City, in order to answer questions related to bone pathology, stress, diet and bone remodelling which cannot be approached with conventional methodologies. These questions are related to the health and lifeways of this specific population and how the blasting urbanism of the Hellenistic/Roman period has affected them. For instance, stress and time of occurrence in individuals can be explored and understood through the application of SR microCT. Furthermore, diet can be studied through the micro-analysis of dental calculus, which is mineralized dental plaque acting as a reservoir of dietary biomolecules and microfossils. A SR tomography beamline in our region, with technical specifications enabling the exploration of above mentioned range of bioarchaeological questions, would allow advancing human bioarchaeology in Cyprus, the Eastern Mediterranean and the Middle East – the cradle of civilisation.

Charlie ‘unwrapped’: a scientific investigation of a Mummified Votive offering in the Australian Institute of Archaeology collection

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The research undertaken on the mummified cat (IA1.2402) to establish its authenticity, age and provenance is described. Using a combination of established and novel non-destructive imaging techniques including X-ray computed tomography (CT) and neutron computed tomography (NCT) enabled a detailed study of the mummy's contents, which was found to be a partial skeleton of a small, juvenile cat. Use of both techniques allowed for dual contrast and complementary study of bones, soft tissue, and textile components. NCT provided valuable insights into wrapping techniques used in the mummification process. Acquisition of radiocarbon dates provided quantitative results to compare with morphological observations and conclusions based on partiality of the contents. All techniques were employed to better define and profile the specimen within its historical, social and religious contexts, while causing as little physical disruption as possible

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Hidden Text: Imaging and Reading an Ancient Tablet encased in an Envelope

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A tablet from Nimrud, which is encased in an inscribed clay envelope IA5.074 (ND 3430), was imaged at the Australian Synchrotron Imaging Medical Beamline (Postgate 1976). This confirmed that there was a cuneiform tablet inside the envelope, the text of which could be read. The poster provides the details of the imaging, describes the tomography, offers a reading of the enclosed tablet and comments on the variation between the text on the envelope and tablet and the significance of this for Assyrian contract law.

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HUMAN OSTEOARCHAEOLOGY

Chairs: Prof. Arkadiusz Sołtysiak, Dr Efthymia Nikita

Textual sources: A headache and a godsend for Mediterranean and Oriental bioarchaeologists

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The Near East and Eastern Mediterranean are the regions where history (defined by presence of textual sources) begins much earlier than in other parts of the world. This allows for more specific contextualisation of research on human remains, although in many cases use of textual sources is quite superficial and limited to general introduction to the period / place in question. However, there are at least two lines of research that use textual sources more extensively: the first is osteobiography of people known by name and the second is research on mass graves that may be attributed to historical events. Quite often, however, use of textual sources leads in both cases to wishful thinking and controversies in interpretation of bioarchaeological evidence, with the Tomb II at Vergina and scatter of human skeletons in Nineveh as examples. Another way to use textual sources, less spectacular and more difficult, but also potentially more fruitful is to construct testable models based on economy-related textual sources and to test these models on bioarchaeological data. Finally, short-term changes in human behaviour may be approached using age-at-death cohorts from mass graves of date corroborated by historical sources.

Eastern Mediterranean isotopic research within the IsoMemo initiative

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Stable and radioactive isotopic proxies are rich sources of information for archaeological research. These have been employed, among others, to study the trade and source of raw material (e.g. copper, marble), reconstruct spatial and temporal variability of human diets, assess human-driven environmental impacts resulting from agricultural or industrial activities, reconstruct large-scale movements of humans and other species, and to investigate links between human activities and climatic phenomena. However, until recently there was no coordinated global effort to explore the research potential of a Big Data approach to the large amounts of available isotopic data. This was the motivation for the establishment of IsoMemo, a Big Data initiative that brings together a consortium of autonomous repositories of isotopic data within the fields of archaeology, ecology, and environmental and life sciences. One of the goals of the IsoMemo initiative is to develop large-scale interdisciplinary projects employing purposely-built Bayesian statistical tools to map human and environmental histories at wide spatial and temporal scales. This presentation will provide an update on ongoing IsoMemo projects with particular relevance for archaeological research in the Eastern Mediterranean.

Changes to the human diet at Knossos under the Roman Empire and Christianity using stable isotope analysis

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Stable carbon and nitrogen isotope analysis was conducted on human bone samples from Hellenistic, Roman and Late Antique Knossos to determine aspects of diet and assess whether the large-scale socio-political changes across this time frame impacted on what foods were being consumed at the site. A large enough sample size was used to compare different cemeteries surrounding the settlement and different types of tomb for the comparison of individuals of different social status. While changes in diet were detected over time, there was no significant difference detected by tomb type or cemetery group. In the Hellenistic period, the sample shows a C3 terrestrial diet with most individuals consuming some animal protein. The higher carbon isotope ratio values in the Roman period without any elevation in the nitrogen isotope values can be attributed to an increase in millet, a small amount of marine protein or low trophic level fish in the diet. The Late Antique isotope signatures indicate a greater number of individuals were consuming significant amounts of fish in this time period, which may be attributable to the Christian dietary regimen. This adds significantly to the isotopic information on diet for these time periods in Greece and the Eastern Mediterranean as isotopic analyses have been an under-utilised technique for the investigation of diet and can be combined with other historical and archaeological (i.e. residue analyses, archaeobotany, zooarchaeology and human osteology) evidence to create a more complete picture of past human diets.

Isotopic reconstruction of the lifeways of ancient Athenians

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The study of diet in classical antiquity has the advantage of relying on a multitude of sources including written, osteological, isotopic, zooarchaeological and paleobotanical among other. In terms of the study of human skeletal remains several studies investigating carbon and nitrogen stable isotopes from diverse sites of the Greco-Roman world suggest that protein intakes were adequate, while in most cases they express a rather narrow dietary range in relation to respective sites from other geographical regions. Written sources on the other hand describe an unusually broad dietary range and together with other lines of evidence support the view of a high standard of living surpassing other periods in antiquity and in more recent times. Who did this living standard however concern and how did it vary temporally?

In the present study, we address these questions by applying a multiproxy isotopic approach to samples from Classical, Hellenistic, Roman Athens, and Classical Laurion that were previously investigated for their bulk collagen carbon and nitrogen isotopic composition (Lagia 2015). That study showed a temporal decrease protein intake and differentiation according to sex and social status. In the current study, we delve deeper into the understanding of dietary diversity and nutritional status by adding carbon and oxygen isotopic analyses of bone carbonate plus carbon and nitrogen isotopic analyses of single amino acids isolated from bone collagen. Compared to a traditional bi-isotopic approach this multi-proxy approach expands the variety of information that can be obtained on past human lifeways and allows for higher resolution estimates of dietary intakes. Bayesian modelling of multi-isotopic data is employed to reconstruct the caloric and nutrient contributions from different food groups (Fernandes et al. 2014). We present preliminary results and discuss the new insights provided by our analyses.

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Malaria in the Eastern Mediterranean: Preservation, Curation, and Biomolecular Promises

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Malaria is suspected to be one of the most prolific and lethal diseases in human history. However, currently there is no definitive way to identify malaria in the past. Today, malaria is a plague of Southeast Asia and Sub-Saharan Africa, but in the past, genetic evidence suggests that malaria must have had a long history in the Eastern Mediterranean. This paper will present the most recent results of the biomolecular analysis of human remains from Lebanon, Cyprus and Egypt searching for malaria. While a large number of samples were taken and tested, challenges with preservation have given limited results. These challenges will be discussed and the results will be framed within the current state of the biomolecular methods, in particular immunological/protein assays and aDNA. These methods are a key part of the arsenal available to palaeopathologists and archaeologists for identifying malaria in the past and have been adopted and adapted for this project to attempt to push this topic forward. Overall, they are still in the early stages of development, but have returned some promising results in regards to improving the process of analysing samples. Of the 53 samples tested, only five have proven positive for Plasmodia aDNA; with results differing for the immunological assays (four of 61 samples showing positive results). This difference can only be explained by the difference in preservation of proteins compared to aDNA. Further work on this topic is needed to explore the differences in protein versus aDNA survival in the Eastern Mediterranean.

Human remains under the microscope of funerary taphonomy. Investigating the histological biography of the decaying body in the prehistoric Aegean

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Funerary practices and especially the manipulation of the dead body have in the last decades become a central focus in prehistoric Aegean mortuary studies. The management of the body is part of an ongoing and complex process, that often involves multi-staged rituals, tomb reuse, multiple interments and visits by the living, as well as secondary treatment and manipulation of the deceased. During the last decades, taphonomic analysis of skeletal remains has been more frequently employed by bioarchaeological research in the prehistoric Aegean region with a view to understanding modes of pre- and post-burial treatment and reconstructing funerary activities (e.g. Crevecoeur *et al.* 2015; Lagia *et al.* 2016; Moutafi 2015; Papakonstantinou in preparation; Papathanasiou 2009; Triantaphyllou 2016; 2017). Several histological studies of archaeological and forensic skeletal remains from Europe have shown that the extent of bacterial bioerosion in bones broadly correlates with early taphonomic processes and pre-depositional treatment (e.g. Booth 2016; 2017; Jans *et al.* 2004; Nielsen-Marsh *et al.* 2007; White and Booth 2014). In this connection, this paper aims to present and discuss the results derived from the histotaphonomic analysis applied for the first time on archaeological skeletal assemblages of the prehistoric Aegean, in order to unfold the histological biography of the decaying body and obtain insights into the post-mortem histories and the taphonomic processes affecting the human remains in their burial environment. A total of 108 human bones from eleven prehistoric sites of the Aegean region dating from the Neolithic to the Late Bronze Age period was examined and assessed using thin section light microscopy. The samples were recovered from variable disposal areas (chamber, tholos and house tombs, pits, ossuary pits and burial rockshelters) and in various states of articulation.

The results of the study provide evidence for intra- and inter-site variation in diagenetic alterations. Samples display either no or extensive bioerosion, or in some cases, arrested bioerosion. Thin sections also exhibited a variety of diagenetic alterations such as different types of staining, inclusions, microfissures and overall destruction. Each section varied with regards to the diagenetic alterations present, with some sections displaying more combined alterations than others. Different combinations of these patterns are apparent in different burial environments or in the same disposal area. These results suggest variation in early taphonomic processes that affect the degree of early bacterial soft tissue decomposition and different modes of depositional treatment. Alongside the microscopic analysis, certain parameters of the macroscopic study will be discussed and combined to discriminate between different formation mechanisms of skeletal assemblages and make inferences for the funerary treatment and manipulation of the deceased.

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East of Rome: reexamining impacts of Roman imperialism on Eastern Mediterranean populations through an osteoarchaeological perspective

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The sociopolitical and biocultural impacts of Roman imperialism within western provinces (e.g., Britain, Gaul) have been championed by researchers, while overlooking the politically, economically, and culturally vital eastern expanses of the Empire. In contrast to the western provinces, in which many local infrastructures were dissolved for reinstated Roman governance, eastern provinces were incorporated into the Empire with some modifications to, but general continuation of, political and societal organization. However, governance of eastern provinces and populations varied across the Eastern Mediterranean, with regions falling under senatorial or imperial jurisdiction, the latter of which required more direct interference in daily life. Drawing from published bioarchaeological data in Anatolia, Cyprus, and Greece (N=18), this study examines skeletal and dental proxies of stress, diet, and disease in light of a community's political (senatorial or imperial province) and geographical (coastal or inland) position to evaluate impacts of direct and indirect Roman rule. Gross prevalence data from childhood (linear enamel defects) and adult (antemortem fractures and degenerative joint disease) stress markers, dietary proxies (cariou lesions, calculus, and tooth loss), and specific (periodontal disease, PD) and non-specific (periosteal new bone) bone lesions were compared within political (senatorial/imperial) and geographical (inland/coastal) groups. Despite the observation of higher frequencies of adulthood stress in imperial and inland communities, non-parametric Kruskal-Wallis tests indicated no significant differences ($P < 0.05$) between groups for the majority of conditions, although the difference in percentage of individuals with PD in inland (60.7%) versus coastal (17.8%) communities was approaching significance ($P = 0.059$). Although populations in the eastern provinces may have experienced theoretically similar political oversight, results suggest that communities in senatorial and imperial provinces did not experience prescriptive levels of stress based on their provincial status. Rather, the heterogeneity in stress, diet, and disease proxies demonstrates how communities locally and differentially buffered and negotiated the impacts of Roman imperialism.

Bioarchaeological approaches to human mobility in the EMME and beyond: The People in Motion project in context

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This presentation will initially provide a brief overview of human mobility studies in the Eastern Mediterranean and Middle East region, with an emphasis on diachronic patterns in the nature of relevant studies. Subsequently, the *People in Motion* project will be presented. This is an ongoing project, funded by the Cypriot Research and Innovation Foundation, which aims at exploring human mobility across the Mediterranean during the Byzantine period. Human mobility played a key role in the formation of the multi-ethnic Byzantine state and *People in Motion* is the first project to systematically examine the scale, nature, and impact that migration had on those who relocated and on the local communities in the lands they inhabited based on the most direct evidence of these individuals, skeletal remains. Encompassing material from Tunisia, Italy, Greece and Cyprus, temporally spanning the 5th-15th centuries, this project is one of the first initiatives in the region to develop a bigger synthesis on the topic of mobility. In addition, human mobility is explored for the first time using a three-step approach: The first step involves the analysis of dental nonmetric traits to examine the extent of gene flow between different Mediterranean groups. The second step includes the microscopic study of dental calculus to identify nonlocal dietary and occupational microdebris, pointing to individuals who either arrived from a different region or local people who consumed imported goods. Finally, the third step will adopt strontium isotope analysis to identify whether the aforementioned individuals were indeed of a local or nonlocal origin. Given the worldwide trend towards closing borders, this project is expected to increase public awareness regarding the antiquity of migration and its role in shaping modern identities.

Inter-personal violence in the Iron Age cemetery at Qareh Tepe, Iran

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Qareh Tepe is a vast, multilayer cemetery located in the Qazvin Plain, in north-western Iranian Central Plateau. Based on the local pottery sequence the site is dated to the Iron Age II and III (c. 1200-600 BC). During the 2018 excavation season archaeological works were conducted in the eastern part of the cemetery (Trench 12). Human remains of at least 41 individuals were found in 16 mudbrick burials, furnished with pottery, metal and stone objects, and animal offerings. Exceptionally good state of preservation of bones enabled analysis of several pathological conditions and offered some insight into the life of buried individuals. While the frequency of caries, cribra orbitalia and porotic hyperostosis in the Qareh Tepe population was relatively low, traumatic lesions, such as ankylosis, long bone shaft fractures, as well as blunt and sharp force trauma to the skull, were observed in remains of many individuals. These results suggest that the quality of life of individuals from Qareh Tepe was relatively good, however, the scope of inter-personal violence could have been high in time of early state formation in Iran.

Skeletal evidence of trepanation from ancient Akanthos, Greece

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Trepanation or thephination, considered the oldest surgical operation identified in archaeological context, is the surgical perforation of the human skull by drilling or removing a piece of bone. It is well documented all over the world and its antiquity dates back to the Mesolithic. In Greece, trephined skulls are dated since the Middle Minoan period. Despite the detailed textual description of trepanation in the Hippocratic Corpus, there weren't skeletal findings to verify its implementation in classical times in Greece. We report four skulls from the Classical-Hellenistic period, excavated at the necropolis of ancient Akanthos, on the Athos peninsula, North Greece. The aim of the study was to analyze the techniques used and the motives behind the operation. We used macroscopic and stereoscopic observations as well as CT scanning to investigate traces of surgical tools, associated pathology and survival. In the skeletal sample from Akanthos, two different trepanation methods identified, scraping and drilling. We also reviewed the already published cases from Greece in order to understand other aspects of the operation, regarding demographic parameters, side and location of the lesions and survival rates.

Human remains from Bronze and Iron age sites in Armenia: palaeobiological and paleopathological studies and a new approach to age estimation through the use of Cameriere's dental radiographic method

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As part of an exchange programme of one of the authors we had the chance to analyse the human remains from the collective burial of Hatsarat (Early Iron age). For these human samples we managed to calculate the MNI and study anthropological and paleopathological evidence. The presence of several discontinuous traits of the skull led us to suppose close genetic relationships among the subjects, as peculiar markers of occupational stress, pathologies and nutritional stress indicators allowed us to reconstruct their lifestyle patterns.

In order to refine age at death diagnosis of Hatsarat and other Armenian samples, we collected and analysed teeth (27 canines and 18 premolars) to be included in our AgEstimation project and to be evaluated through the R. Cameriere's radiographic method, measuring the reduction in size of the pulpar chamber, as age increases and secondary dentin develops. We compare here their age diagnosis obtained through traditional and experimental anthropological methods to test the utility of this method when applied to both forensic and archaeological samples.

The results of the complex study of bone materials obtained in the yard of the Monastery of the Theotokos and the crypt of the Church of Saint Nicholas in Gialia

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The Georgian Monastery of the Theotokos founded on Cyprus in the X century had been functioning until the island was conquered by Ottomans in the XVI century. Several complex archaeological expeditions were conducted in 2006-2010 in order to study the site, in which anthropologists participated as well.

28 burials were excavated in all four sides of the church yard. Most of the burial set are glazed bowls. The date of burials was determined according to the shape and decor of the vessels: the early XIV c., XV c., the second half of the XV c. - the first half of XVI c., XVIII c.

Eighty two males had been buried in the crypt, and it was managed to define age of thirty nine of them.

As a result of anthropological research, it was established that metopic suture, hyperostosis on the brows, arch and in orbit, caries, tooth stone are observed in the dead persons entombed in the burials and the crypt. There are frequent cases of tooth loss during life, that is connected to numerous negative factors: unbalanced diet, infectious diseases, lack of microelements (trace elements) and ecologically clean drinking water.

The Mediterranean region is known as the area of widespread malaria. The hyperostosis of the orbit observed on the bones of some of the dead might have been caused by malaria. Based on craniological and osteological studies, it was found that persons buried around the church are not monks. The skeletons of two women and four children were discovered in the burials, that excludes their belonging to the monks. It seems that the burials around the church belonged to the population of a nearby village. The men entombed in the crypt were monks.

Breastfeeding and weaning patterns in ancient Thessaloniki

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Breastfeeding and weaning are perhaps the most important biological processes for the physical and mental development of man. By acting as catalysts, they have a significant impact on the shaping of social roles while at the same time their practices are modified on the basis of perceptions, religious beliefs and socio-economic conditions. At the same time, they play an important role on the demographic aspects of a population, affecting its fertility, morbidity and mortality. It is therefore paradoxical that while breastfeeding is probably one of the most important processes for the physical and mental development of humans, it has not been adequately studied in prehistoric and historical populations.

Novel applications of paleodiet reconstruction allow nowadays the study of breastfeeding and weaning as part of past human activity. Our project studies breastfeeding and weaning patterns in ancient Thessaloniki by applying the novel technique of incremental dentine analysis. We aim to account on the duration of breastfeeding and weaning and report on possible diachronic changes especially through the change to Christianity. This method tracks the isotopic shifts of carbon ($\delta^{13}\text{C}$) and nitrogen ($\delta^{15}\text{N}$) on the sequential layers of dentine for every year of age since birth. Dentine, in contrast to bone does not remodel and is developed following a standard pattern. This characteristic enables researchers to study infant diet with great precision. Ultimately, we will be able to delve deeper into the biological effects of breastfeeding for mothers and children as well as describe cultural and social differences as seen on burial context, parental investment and the transition to adulthood from the Roman to the Byzantine Period in Thessaloniki.

The inhabitants of ancient Kition: Preliminary insights

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Recent excavations by the Department of Antiquities as part of mitigation efforts related to the waste water and sewer modification project in Larnaka have brought to light the cemetery of ancient Kition. This cemetery extends across the modern city of Larnaka and has a temporal span from the prehistoric to the early Byzantine era. The skeletal analysis of the material retrieved in the cemetery is a collaborative effort between the Department of Antiquities, Texas State University, and the Cyprus Institute. The first data collection season (July-August 2019) focused on the remains from two tombs: Agiou Georgiou Kontou street T1 ΣΜ1-Y259 (hereafter T1) and Anagenniseos street T2-D900-D221.3 (hereafter T2). T1 is dated to the Classical/Hellenistic era, while T2 possibly belongs to the Hellenistic/ Roman times. Most burials represented primary inhumations (with some post-depositional disturbance) but scattered skeletal elements were also found. This presentation will focus on the primary inhumations as these represent the majority of the assemblage. The osteological analysis to date has identified 14 individuals in T1 and 20 in T2. While our study is still at a very early stage, the demographic characteristics, pathological lesions, metric traits, and activity markers identified on these individuals provide interesting first insights into life and death in ancient Kition and highlight the need for more extensive research in this direction.

Stature estimation in an ancient Greek population of Roman times

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Stature is one of the key concepts when it comes to human past lives. This study aims to apply for the first time the anatomical method to an ancient Greek population, to evaluate the effectiveness of mathematical methods and to re-evaluate factors related to their accuracy such as body proportions and reference series. The study was conducted on 217 individuals, originating from a Roman-era necropolis in Northern Greece. We applied both anatomical and mathematical methods in 68 individuals (35 males and 33 females), evaluating the accuracy of regression equations. We calculated the percent prediction error (%PE) produced by each method. We introduced the total %PE for males and females to check the equations' effectiveness on both sexes. To examine body proportions we calculated long bone ratios and the Euclidean distance between reference series. Mean stature values for the anatomical sample is 178.0 cm \pm 5.38 for males and 156.9 cm \pm 5.27. The range of estimations from the use of mathematical methods is similar for both least square (LSR) and reduced major axis (RMA) equations. Both mathematical approaches can produce reliable results to our population. Body proportions in terms of Euclidean distances presented low values in both modern and pre-modern reference series. For the Greek population of Roman times, Vercellotti et al. 2009 (LSR), followed by Maijanen & Niskanen's 2010 (RMA) formulae seem to serve well for both sexes in our sample. The similarity of body proportions between the reference series and the target population was not the decisive factor for the accuracy of the estimates. The same characteristic can be observed in the case of the chronological origin of reference series.

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Burials and human osteological remains from the Bronze Age acropolis of Aghios Ioannis in Boeotia, Greece: preliminary results of the bioarchaeological analysis

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Aghios Ioannis, located in the northeastern Basin of Kopais, was explored within the frame of the Mycenaean Northeastern Kopais (MYNEKO, 2016-2018) project, directed by the first author. It consists of a small rocky elevation with a total surface of approximately 35 acres. Three spacious natural plateaus are traced atop the hill, at the north, the middle and the southwest edge. Archaeological evidence (architectural remains and pottery) from the north and middle plateau reveals two phases of occupation. The earlier phase is dated to the MHII/III. Part of rectangular edifices that were revealed, appear to represent the earliest permanent habitation of the site. A group of cist graves occupied the north plateau. These were of rectangular shape, cut into the bedrock; they were made of limestone slabs and were covered by a low tumulus. The next occupation phase dates to the MHIII/LHI period. The settlement is moved or expanded southwards and the burial space is relocated at the middle plateau, over the MH architectural remnants.

Human osteological remains were unearthed from ten cist graves and few deposits of bones found outside graves in both plateaus. The aim of the bioarchaeological analysis is first to reconstruct the biological profile of the individuals and second to understand mortuary practices and the formation process of each funerary context. To achieve this aim we conduct an integrated osteological and taphonomic examination. Preliminary results allow addressing issues regarding the inclusion of subadults in the formal burial space, secondary treatment of the deceased as well as variations in the use of the burial ground at the transition from the MH to the LH period in Boeotia.

Social Mobility and Life Quality in Roman Byblos: Comparative Analysis of Cross-Sectional Geometry, Degenerative Joint Disease, Enthesal Changes, Cemetery Clustering, and Tomb Typology.

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A bioarchaeological analysis has been conducted on 62 skeletons from a Roman Necropolis (1st – 4th century AD) situated in the eastern outskirts of the ancient city of Byblos. The purpose of this study is to evaluate the impact of activity patterns on the social mobility of the population from Byblos. The study explores the activity patterns of both males and females by means of cross-sectional geometry, degenerative disease, and enthesal changes, and the correlation of these patterns with cemetery clusters and tomb typology to test for a possible social hierarchy in the Necropolis. Activity in the form of profession is difficult to identify given the lack of contextual data and a gap in the bioarchaeological record of Lebanon is evident. Intra-population comparisons of cross-sectional geometric properties showed that male upper limbs are involved in more strenuous load-bearing activities, however, diaphyseal shape indices in females show higher and more consistent upper limb rotational

movements. “Stress” markers associated with degenerative disease and enthesal changes show age as a primary factor determining activity-related distribution patterns with the exception of Schmorl’s nodes. Despite age being a primary factor for the manifestation of “stress” markers, intra-population comparisons showed that males on average have a higher expression of degenerative disease and enthesal changes. Patterns of possible preferential treatment based on the age of the deceased was identified when examining cemetery clusters and tomb typology. These results present one of the few bioarchaeological attempts at reconstructing life quality and social mobility from Lebanon; however, it is only with the integration of more data from different sites across Beirut, Tyre, and Byblos, that it will be possible to formulate a clear biocultural narrative in the eastern Mediterranean and Near East.

Evidence of kinship and membership in the Bronze Age collective burials from the Caucasian cemetery of Doghlauri (Shida Kartli region, Georgia)

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The emergency investigation to save the Doghlauri archaeological site led by I. Gagoshidze of the Georgian National Museum allowed the partial excavation of the wide burial area in which more than 450 burial structures have been brought to light (even if not all of them contained human skeletal remains) and dated back to two distinct chronological phases, the Early Bronze Age (Kura- Araxes period) and the Late Bronze Age. The human remains preserved in 75 of these burials have been analysed in the framework of the joint "Georgian-Italian Shida Kartli Archaeological project", managed by I. Gagoshidze (Georgian National Museum) and E. Roa (Ca' Foscari University, Venice). Although almost all the skeletons are incomplete, we could nevertheless diagnose sex and age at death (Fig. 1 and Fig. 2) for most of them and record other extremely useful paleobiological data to compare these two population samples (Bertoldi *et al.*, 2016). Many tombs contained the bones of more than one subject, usually commingled and placed on or set aside the last individual buried in them, attesting their use for consecutive and collective burials during a long span of time. Thirteen Kura-Araxes tombs (on a total number of 23) contained the remains of several subjects: half of these graves had a MNI of more than three and up to six subjects. On the contrary in Late Bronze age only four occurrences (on a total number of 52) contained just 2 individuals (double burials), and in them we found only females and juveniles in 3 cases out of 4 (in the fourth grave we could not determine sex and age at death). In conclusion, we can say that in Doghlauri cemetery collective burial practice is common and reasonably linked to a familiar use with strong evidence of membership to the same group, while in the Late Bronze we face a different burial custom (see Table below).

Fig. 1 Sample Compositions
(Early Bronze Age on the left)

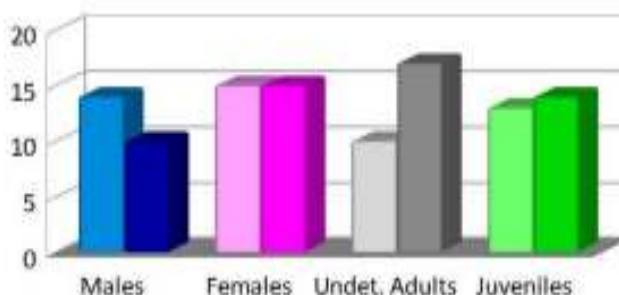
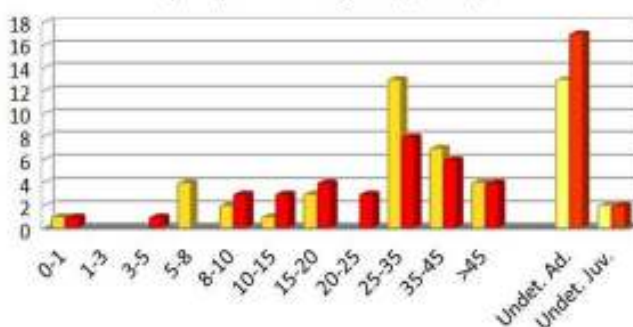


Fig. 2 Age at death in the two samples
(Early Bronze Age in yellow)



COLLECTIVE BURIALS COMPOSITION				
EARLY BRONZE AGE				
10	J	U		
20 (double)	M	J		
25	F	J	U	U
51	M	M	F	J J J
52	M	M	J	
54	F	J	U	
94	M	J		
97	M	F	J J J	U
102	M	F	F	
111	J	U		
113	F	F	U	
145	M	U	U	
2 (2015)	M	F	F	
LATE BRONZE				
49	F	F		
76	U	U		
78	J	U		
93	F	J		

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Investigating oral pathologies and their implications at the Imperial Roman Province of Upper Macedonia

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Studies aiming to investigate the social aspects of past dietary habits have largely focused on dental diseases. This study explores the relationship between oral pathologies, dental wear patterns and demographic factors among adult and non-adult individuals interred at the *Pontokomi* cemetery of the Imperial Roman Province of Upper Macedonia (modern Western Macedonia, Greece) with the aim to understand the consumption profile of this group. Dental caries, enamel hypoplasia, ante-mortem tooth loss, dental calculus, periapical abscesses and dental wear data were compared among the different age and sex groups of the assemblage. The results of this investigation show differentiation in the prevalence of dental pathologies between different demographic groups, thus pointing to possible different consumption preferences. These findings have significant implications for the understanding of how food acquisition strategies and preferences help redefine social and cultural affiliations within past communities. They also lay the groundwork for future microscopic and bio-chemical research, which are already being planned and will be carried out within 2020-2021. These analyses will not only fill a gap in palaeo-dietary research in the Greek world but also enhance our understanding of the re-negotiation of social and cultural identities in Macedonia after its incorporation into the Roman Empire.

The assessment of bone deterioration with nuclear magnetic resonance spectroscopy in a multidisciplinary context: The case of the UNESCO world heritage site of Sedlec, Czechia

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Human remains from the skeletal collection of the UNESCO world heritage site of Sedlec (Czechia) have been investigated with ¹H, ³¹P and ¹³C magic-angle-spinning nuclear magnetic resonance spectroscopy. The quantitative description of the component of the phosphorus signal attributed to the external amorphous hydrated layer of the mineral apatite particles is considered a sensitive index of the bone integrity, in general agreement with indicators of decay derived from other analytical techniques. Differences in proton and phosphorus resonances were related to deterioration effects, allowing for the identification of local conditions posing a threat to bone preservation. The results have been compared with those obtained from other well established analytical techniques: X-ray powder diffraction (XRPD), Fourier transform infrared spectroscopy (FTIR), and optical and scanning electron microscopy (SEM).

CROPS, FOOD CHOICES, AND LANDSCAPES

Chairs: Prof. Martin Jones, Dr. Evi Margaritis

Keynote lecture

Mobility and selection: some reflections upon domestication

Martin Jones

Department of Archaeology, University of Cambridge, UK

A triple toolkit of bioarchaeology has emerged - bringing together genetic, morphological and isotopic studies, the latter two of which are well represented in this session. I shall reflect upon how this triple toolkit has reconfigured our understanding of 'domestication', considering both the East/Mediterranean/ SW Asia, as the main focus of this meeting, but also compare with some recent East Asian findings.

Human diet and landscape as attested by the plant remains of PPNC Atlit-Yam, Carmel Coast, Israel

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The Pre Pottery Neolithic C submerged village of Atlit-Yam (9,200-8,500 cal. BP) is located in the north bay of Atlit, 200-400 m west of present Mediterranean coastline, 8-12 m below current sea level (Galili et al 1993). The plant material – waterlogged and charred seeds and fruits remains belonging to ca. 90 species, was derived from a single well, which is one of the most ancient well fill hitherto studied. This assemblage providing an almost complete record of the site inhabitants' diet, and their relations with varied habitats around them.

It appears that the people of Atlit-Yam based their sustenance on domesticated cereals (emmer wheat, small-grained wheat, and barley), as well as of pulses (lentil and chickpea), fruits (figs, grapes, almonds and pistachio) and vegetables (small-flowered mallow, coriander, sorrel). This, in addition to animals and fish, which provided a well-balanced diet.

These plants came from various habitats: local fields, kurkar (calcareous sandstone) ridges and the basins between them, nearby forests, and wet habitats, such as marshes and river shores. Surprisingly, we have not found plants of saline and sandy soils that located today in the sites' area. Finally, we will show how the sea-level changes had affected the local ecology.

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Food or fuel? A micro-botanical perspective of plant remains from Neolithic Abu Hureyra, N. Syria

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Archaeobotany contributes crucial evidence for shifts in human economy from foraging to farming, understanding early village life and for understanding the strategies employed by people in the past to cope with changing environmental conditions. However, differential preservation of plant proxies leads to the over or under representation of some plant types. This research adopts a multi-proxy approach, including the analysis of phytoliths, charcoal and faecal spherulites to provide new perspectives on human economy at the Neolithic site of Abu Hureyra, N. Syria (~11,150-6000BC), where the charred plant macro-fossils have been extensively analysed. This site is of especial importance as one of the earliest and largest PPNB farming settlements in the world, however, it was flooded following the construction of the Taqba dam in the 70s. This research therefore presents a case study for the multitude of methods which can be applied to archived material to continue research in areas of high archaeological significance that are no longer accessible. This paper presents the results of new phytolith analyses which show a diverse range of vegetation types exploited throughout the lifespan of the site whilst the presence of faecal spherulites highlights dung as a potential fuel source and depositional pathway for plant remains.

Between the Desert and the Sown Revisited: crops, food choices and landscapes of the Levant

Carol Palmer

CBRL, British Institute in Amman

This presentation provides an overview of the ecological variation of Levantine landscapes and the agro-pastoral strategies employed in the recent past by Bedouin and Fellaheen (farmers or cultivators) that aided in their exploitation. The Levant has a remarkably diverse flora that reflects its transitional position between semi-arid and arid climatological zones. There are four principal biogeographical regions: the Mediterranean, Irano-Turanian, Saharo-Arabian and Sudanian (representing tropical penetration). All traditional lifeways encompass a degree of mobility linked to pastoralism and seasonality.

The traditional components of the cuisine are chiefly based on cereals, pulses and milk products in a remarkable number of combinations. Field, orchard and garden crops provide a wide array of food choices, with wild plant resources continuing to be an important component today as they were in the past (sometimes also brought into cultivation today), both as foods and as flavourings that also provide benefits for health and well-being. Fruits and vegetables are more closely associated with more settled lifeways, while the search for grazing among pastoralists still permits them greater access to wild plant food choices. Both plant and animal-derived fats enrich the diet as well as provide relished tastes. Both Bedouin and Fellaheen lifeways prided themselves on hospitality and reciprocity embedded in food sharing. These are the focus of all social relations and are part of all social gatherings which also involve oratory and storytelling. Through globalisation and modernisation both lifeways faced rapid change that tended to decrease the diversity and content of food identities, but which today are increasingly highly prized. Far from having only nostalgic importance, these food cultures have demonstrable benefits for modern people within the region and beyond.

Crop Choice and Socio-Economic Organisation in Bronze Age Western Anatolia

Tom Maltas

Institute of Archaeology, University of Oxford

This paper investigates the relationship between choices in the cultivation of staple crops and socio-economic organisation in Late Chalcolithic and Bronze Age western Anatolia. A hypothesis is presented that population pressure during the Bronze Age forced arable land further from settlements and led to the adoption of labour saving (but land intensive) agricultural strategies. This may have been associated with a reduction in crop diversity as a means of maximising arable production. It is also suggested that this 'extensification' of agriculture provided a source of wealth (arable land) that could be accrued in a way not possible within agricultural systems limited exclusively by labour. This may have contributed to the formation of the marked socio-economic inequalities visible during this period.

These hypotheses are addressed through an analysis of archaeobotanical remains from four sites near modern Izmir, Turkey: Çeşme-Bağlararası, Liman Tepe, Bakla Tepe and Kocabaş Tepe. Spanning the Late Chalcolithic to Late Bronze Age, the sites present an overlapping sequence of occupations encompassing marked shifts in settlement organisation and socio-economic inequality. The results from this analysis are compared to contemporary sites with archaeobotanical remains elsewhere in western Anatolia and the eastern Aegean.

Early Bronze Age communities of Western Anatolia: with a special contribution on archaeobotanical research.

Özgür Çizer

Science and Technology in Archaeology and Culture (STARC), The Cyprus Institute

EBA is considered in Western Anatolia as a period of the development for the pre- and proto-urban societies. There are numerous Bronze Age sites in Western Anatolia where the occupation sequences enable the archaeological correlation and understanding the relationships with the Aegean and Cyprus in the same time period.

Environmental archaeologist, especially the archaeobotanists try to disentangle these environmental effects from the anthropogenic ones in order to understand the settlement development and the emergence of early farming communities. Archaeobotanical research in particular aims to contribute to this through the investigation of botanical macro and micro remains analysis.

The contribution of the archaeobotanical research to Western Anatolian archaeology needs to be supplemented with such high-resolution on-site archaeobotanical data, which enables clarification of the environmental, economic, and social processes that consequently had an effect on the agricultural decision-making of these early farming societies. Current archaeobotanical research from different Turkish Bronze Age sites sheds light on the archaeological interpretations of the settlement development and urbanisation process of the western Anatolia in its supra-regional context.

The trade distances across the southern Levant during the Early Bronze Age – the botanical evidence

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(1) Martin (Szusz) Department of Land of Israel Studies and Archaeology, Bar-Ilan University, Israel

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The lecture will present a southern Levantine regional analysis of the level of agriculture during the Early Bronze Age, based on the archaeobotanical finds from Tel es-Safi/ Gath. Here, more than 60 plants were identified, to species level and even sub-species when possible. Following the ecology of these taxa, we were able to reconstruct habitats and regions of Israel that were used by the site inhabitants, both for agriculture and for pastures. We compared Tel es-Safi's plant assemblage with that of contemporaneous sites, such as Beit She'an, Jericho and Arad, as well as with agricultural traditions described in coexistent sites in Jordan, Turkey and Egypt.

Our results reveal, for the first time, the uniqueness of agriculture, plant use (for food and fuel), land use and trade in Early Bronze Age Levant. The local agriculture was based on cultivation of food plants in the vicinity of the settlement but included also connections with neighbouring regions as well as with remote areas. Wheat and olive, apparently, have been the basic components of the local agriculture, while barley, legumes, and grapes were less important. In addition, it turns out that local Early Bronze Age was characterized by the presence of crops varieties that were different from those identified in neighbouring countries. Nevertheless, these plant assemblages revealed that long-distance trade existed, through the arrival of goods, or perhaps the merchants themselves.

Landscapes of production and the nature of urban farming at Tell Brak

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Urban development and the subsequent increase of city-dwellers during the Bronze Age in the Near East (c. 2500 BC) necessitated fundamental changes to the pre-existing forms of agricultural production. One of these primary changes appears to have been the shift from labour-focused agricultural systems to land-focused systems; with arable land itself becoming the most important and quantifiable resource within the agricultural economy. Divisions between the land-rich and land-poor may have led to the creation of different spheres of production; the state/temple land-rich sphere able to control large-scale production systems and the domestic land-poor sphere which produced food purely for household consumption.

At the site of Tell Brak in north-eastern Syria, the archaeobotanical analysis of material from Bronze Age levels has provided a wealth of information regarding issues such as: crop choice, agricultural landscape management and the control of the wider farming economy. Furthermore, the use of innovative methods such as crop stable isotope analysis and functional weed ecology has allowed the inference of specific crop husbandry conditions and farming regimes. This paper will seek to discuss these results in relation to the rise of lasting social inequality and the formation of separate spheres of production both at Tell Brak and within other urban societies of Western Asia.

Arboriculture and urbanism in the Bronze Age Aegean

Evi Margaritis

Science and Technology in Archaeology and Culture Research Center, (STARC), The Cyprus Institute

This paper will focus on the role of fruit trees, mainly the vine and the olive, in the shaping of agricultural practices and economic choices during the Aegean Bronze Age and their connection to the creation of complex societies and the transition to urbanism. This paper will examine the use of grape and olive in urbanisation in the Aegean using the occurrence of archaeobotanical remains, indicative of cultivation and production of secondary products, alongside evidence from material culture, such as installations and pottery. The intensive cultivation of fruit trees in the Aegean began in the Early Bronze Age, placing this as a transition between Neolithic agriculture where staple crops prevail and the later rise of urbanism. The cultivation of grape and olive initiated a new era for the agricultural systems of Bronze Age Aegean, which was marked by a change in land use, long term investment in the cultivation of fruit trees and the re-organization of the labour needed for the maintenance of vineyards and olive groves and the production of secondary products. Arboriculture created not only a new agricultural landscape but also a social one with a new ideology in the centre of the ritual and social sphere of the Aegean Bronze Age.

Exploring the human-cattle relationship in Bronze Age Cyprus: Archaeozoological, isotopic and ethnographic approaches.

Anna Spyrou

Science and Technology in Archaeology and Culture Research Center, (STARC), The Cyprus Institute

Since Neolithic times, domestic cattle have been our most important livestock, supplying human societies with milk, meat, hides, manure and traction. However, there is also evidence to suggest that cattle have meant more to people than just an economic resource, that they played a socio-ideological role and were integral components in mortuary rituals, social networks and large-scale feasting events.

Cattle has a fascinating story on the island of Cyprus. Domesticated cattle are now known to have been present on the island in the early Aceramic Neolithic, however, the species did not survive into later phases of the Neolithic. Cattle re-appears during the Philia Early Cypriot Bronze Age (c.2400-2200 BC) along with other innovations, including changes in domestic architecture, new heating and manufacturing technologies, new agricultural practices and new rules in commensality and ritualized consumption. While the timing of cattle's introduction, disappearance and reappearance in the archaeological record of prehistoric Cyprus has been traced, the longer-term economic and social impact of the introduction as well as the human-cattle relationship is still poorly understood. This paper will explore the role of the newly-introduced cattle in Bronze Age economy and society through a multi-disciplinary approach that combines archaeozoological, isotopic and ethnographic approaches, aiming to provide a better understanding of the human-cattle relationship and, in a wider scope, of the dynamics of economic and cultural transformations that occurred on the island during this significant period.

The road to the Bronze Age: a diachronic approach to sheep and goat husbandry in prehistoric Cyprus

Angelos Hadjikoumis

The University of Sheffield

Diachronic studies on animal husbandry and economic change in general are scarce in Cypriot archaeology, resulting in significant knowledge gaps. Through the lens of sheep and goat husbandry, this study addresses one of these gaps by contributing new insights into Cyprus's unique trajectory towards social and economic complexity. The economic and dietary contribution of sheep and goat fluctuated significantly through Cypriot prehistory, from a complementary component in the early Neolithic to a paramount importance in the Bronze Age. This study employs a zooarchaeological approach to provide a diachronic perspective on sheep and goat husbandry and its effects on Cypriot societies from the colonisation of the island to the emergence of socioeconomic complexity. Economic and dietary importance is illustrated through biometric analyses, mortality profiles and butchery patterns, with all lines of evidence being integrated in the wider social and environmental background of each period.

On the large scale, these patterns suggest at least two long-term cycles of intensification, one within the long Cypriot Neolithic and a second in the Bronze Age. When these cycles are broken down into smaller chronological and geographical units an underlying diversity is revealed, reflecting local adaptations of sheep and goat husbandry systems. The interplay between these different scales of analysis provides further opportunities to follow some of the processes that eventually lead to the emergence of socioeconomic complexity. This line of investigation aspires to complement its findings up-to-date with further analyses in the near future, involving the integration of stable isotope analyses and ethnographic data to address questions revolving around the seasonality of the agropastoral cycle and the scale of caprine husbandry.

Isotopic Data ($\delta^{18}\text{O}$, $\delta^{13}\text{C}$) as a Means of Investigating Early Complex Societies: The Case of Animal Management in the Jordan Valley.

Lynn Welton

Durham University

Despite the sustained scholarly attention that the dynamics of relationships between mobile and sedentary communities in the ancient Near East has received, isotopic studies in this region have not traditionally focused on changes in animal management strategies that occurred with the development of towns and urban centers in the Levantine world. Instead, isotopic investigations of animal management in the Levant have generally focused on the process of domestication and the shift from hunting to the early adoption of pastoralist practices in the Neolithic period. This talk will discuss the implications of developments that occur in the Levant during the 4th-3rd millennia BCE for isotopic analysis of animal remains, and will present preliminary data from sequential isotope analysis ($\delta^{18}\text{O}$, $\delta^{13}\text{C}$) of dental enamel from ovicaprines dating to the Chalcolithic-Early Bronze Ages from the sites of Tell esh-Shuna and Pella, located in the Jordan Valley. Discussions will focus on the patterns of animal movement that can be reconstructed from isotopic analysis of their skeletal remains, and on inferring the scale of this movement. Were herding movements at this time confined to the local level, or did they expand to the regional or supra-regional levels? These interpretations will be informed by preliminary data from ongoing efforts at Durham and Yarmouk Universities to construct a multi-isotope base map for Jordan. The multi-period sample provided by the sites of Shuna and Pella permits an examination of long-term changes in animal management practices, which will be interpreted in light of how these might be related to concomitant changes in socio-political organization. Ultimately, these questions can provide vital new perspectives on the organization of ancient agro-pastoral economies and the ways in which pastoralism contributed to the development of early social complexity.

A multi-isotope base map for Jordan: a tool for re-examining movement and community in the past

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This research project aims to use a strategy of systematic sampling of plant, water and invertebrate samples taken from targeted locations across Jordan to characterize geographical isotopic variation and create the first multi-isotope map for Jordan ($^{87}\text{Sr}/^{86}\text{Sr}$, $\delta^{18}\text{O}$, $\delta^{34}\text{S}$, $\delta^{13}\text{C}$). This map, which is similar to the multi-isotope map produced for Britain (Evans *et al.*, 2018), will be the first of its kind in the Middle East, and thus its creation will position Jordan at the forefront of developments in isotope research. The resulting multi-isotope map will also have widespread impact outside of the field of archaeology, as understanding geographical isotopic variation has a wide range of applications in areas of commercial and governmental activity.

The project is funded through the Arts & Humanities Research Council Newton-Khalidi programme '*Cultural Heritage and Sustainable Development in Jordan*', and is a collaboration between Durham University (U.K) and Yarmouk University (Jordan), designed to enhance research capacity within Jordan in isotopic analysis and to address issues for movement and identity within past communities.

The first period of field data collection was successfully undertaken in June 2019. A total of 48 locations were visited across northern Jordan in the governorates of Irbid, Ajloun and Jerash, east into Az Zarqa and Al Mafrq and along the King's Highway towards the famous archaeological site of Petra. We will provide an introduction to the project, present our initial results and discuss our overall aims and future ambitions.

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A 3D Tool for Identification of Grapevine Varieties – Samples Preparation, Scanning and Analysis

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Grapevine (*Vitis vinifera*) is one of the classical fruits of the Old World. Among the thousands of domesticated grapevine varieties and variable wild *sylvestris* populations, the range of variation in pip morphology is very wide. In this study we scanned representative samples of grape pip populations, in order to probe the possibility of using the 3D tool for grape variety identification.

Structured-light 3D scanner has several requirements as color and shine of the scanned object. Scanning of grape pips present another unique challenge – residual fruit tissue that coats the crevices and limits the identification. For that reason, we used mechanical, biochemical and chemical methods to prepare the pips for scanning. We created protocols for cleaning recent seeds, as well as archaeological seeds which were preserved via natural desiccation. After the preparation the pips were scanned to produce 3D models, followed by mathematical and statistical analysis using innovative algorithms from the field of computer sciences. Using selected Fourier coefficients, a very clear separation was obtained between most of the varieties, with only very few overlaps. These results show that this method enables the separation between different *Vitis vinifera* varieties.

In the future we will classify the archaeological pips, based on the 3D models of the modern pips in the reference collection, in hope to revile which ancient grape varieties were used in the past.

Scientific geo-ethnoarchaeology and its archaeological application to investigate farming, settlements and agriculture in the past

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Common methods to investigate the development of archaeological farming villages rely on the interpretation of archaeological contexts and their associated material culture. However, new approaches are being developed to examine past human activities, for example the analysis of sediments and their microscopic remains. We can go one step further and incorporate scientific microscopic techniques in combination with modern ethnoarchaeology to gain further insights. This paper presents the application of multi-methodologies which combine a range of scientific geo-ethnoarchaeological approaches to answer questions about farming, settlements and agriculture in the past specifically focusing on Neolithic case studies in the Middle East.

Typical archaeological proxies such as macrobotanical remains and animal bones are subject to decay, and the morphological traits associated with domestication are not observed until hundreds of years after plant cultivation and animal management started. I aim to better interpret the ephemeral archaeological signatures of the Middle East by developing a multidisciplinary approach that examines microscopic inorganic remains which are not subject to the same preservation issues as artefactual evidence. My method involves the analysis of sediment samples from known activity areas in modern villages and dung samples from targeted animal species, which will then act as a comparative dataset to interpret samples from Neolithic sites. This enables key concepts such as sedentarisation, domestication, and the use of space to be investigated. The remains which are targeted include sediments, phytoliths, and animal dung. Documenting penning deposits, through identification of compacted animal dung (using micromorphology) enables the identification of early animal management 500-1000 years before it is evident from bone morphological changes. Animal dung has provided an independent marker for animal management (Matthews et al. 2013). Signatures of human activity and construction practices can be discerned through combined analysis of geochemistry and phytolith analysis (Jenkins et al 2017, Allcock et al forthcoming).

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Crops and food choices at the Late Bronze Age site of Hala Sultan Tekke

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The archaeological site of Hala Sultan Tekke (HST) is located on the south-eastern coast of Cyprus, c. 7 km from modern-day Larnaca. The excavations started in the early 1970s and continued intermittently for almost four decades (Fischer 2012: 73). The most recent excavations by the 'New Swedish Cyprus Expedition' revealed four new city quarters (CQ1–4), where domestic and industrial activities could be attested. Although the earliest occupation of the city can be dated to around 1500 BC, the best attested period of occupation is from the 13th c. BC to roughly 1150 BC. Around the mid-12th c. BC, the town was destroyed and abandoned, never to be occupied again (Fischer and Bürge 2018: 603–617).

Uncovered structures together with artefacts and other materials indicate that in the 13th c. BC, HST was a developing town going through a period of intensification of industrial and commercial activities. The growth was possible due to the location of the town on the shore of the Mediterranean Sea. The surrounding area has been referred to as the 'fertile crescent of Cyprus' on the account of its productive agricultural land and density of its population (Åström 1965: 119, note 19; Fischer and Bürge 2018: 603–617).

The archaeobotanical research that has been conducted since 2013 revealed interesting results regarding plants cultivation and processing. During the presentation the matters of various uses of plants at the site of HST, such as food, ornament, dyes and pigments will be discussed.

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The archaeobotany of Pre-Pottery Neolithic Cyprus: a synthesis of current and recent data

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The recent discoveries of early Neolithic sites dating to the late 10th and early 9th mill. BC in Cyprus have shed light on the earliest prehistory of human settlement on the island and show the presence of sedentary populations as early as the Cypriot-PPNA. One main aspect of the archaeological research concerns the interactions of these prehistoric communities with the plant world as this can be reconstructed by the analytical study of archaeobotanical remains in archaeological contexts. Such studies consist mainly of site-based reports, while more synthetic studies are still rare, resulting a gap in our knowledge on the human-plant interaction in prehistoric Cyprus, if compared to neighbouring relevant prehistoric landscapes in Anatolia and the Levant.

The present paper will focus on data available on the nature of the vegetation cover, the use of wild and cultivated plant resources, as well as possible changes of the environment due to the interaction with human activities. Questions of particular interest for understanding the emergence of the earliest agricultural economies on the island will also be raised, such as the introduction and the role of cereal crops from the Near East. The aforementioned questions display part of an on-going PhD thesis, that deals with the analysis of botanical remains (fruit, seed and charcoal) and will be discussed based on relevant remains from the sites of Ayios Tychonas-Klimonas (ca. 9500 cal. BC), Parekklishia-Shillourokambos (ca. 8400-7000 cal. BC) and Khirokitia-Vounoi (ca. 7000-5500 cal. BC).

Marine vertebrate exploitation in the eastern Mediterranean c. 2500 BC - 1300 AD

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This poster introduces two of the fifteen projects that are a part of the SeaChanges international training network which commenced this past October. The zooarchaeological assemblages studied come from Kinet Höyük on the Anatolian coast, Tell Fadous, and Tell el-Burak both on the Lebanese coast and date between approximately 2500 BC and 1300 AD. The first project is focusing on groupers (*Epinephelus*) utilizing zooarchaeological techniques, stable isotope analysis, and zooarchaeology by mass spectrometry (ZooMS). There has been an observed bias of ichthyarchaeological studies focusing on the western Mediterranean (Mylona 2018, Trentacoste et al. 2018) and a sparse number of fish studies which combine traditional zooarchaeological techniques with biomolecular analysis (Harvey et al. 2018). It is hoped that the application of ZooMS may enable the identification of grouper and turtle remains to species level (Richter et al. 2011, Buckley 2017). The second project will study the Mediterranean green sea turtle (*Chelonia mydas*) using aDNA and stable isotope analyses with the aim of discovering past population dynamics and diet. Periodic increases in abundance of green turtle bones in the eastern-Mediterranean raise interesting archaeological questions. This project aims to combine molecular analysis with archaeological research to discover connections between human exploitation and changes in populations or foraging behaviour. Correlating isotope and genomic data with known cultural and historical phenomena will provide insight into the impact anthropogenic factors had on foraging ecology of past grouper and turtle populations. By studying past marine populations a better understanding of their ecology, population changes, and adaptations to past anthropogenic factors will be gained to aid in better managing the conservation of modern marine environments (Sala 2004).

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COMPUTATIONAL ARCHAEOLOGY

Chairs: Prof. Eleftheria Paliou, Dr. George Artopoulos

Modelling long-term settlement evolution: further insights into the application of spatial interaction entropy maximisation models (SIEMs) in archaeology

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Institute of Archaeology, Faculty of Arts and Humanities, University of Cologne

Spatial interaction models that draw from entropy-maximising methods have been increasingly used in archaeology in recent years to explore long term settlement evolution, and in particular, the emergence of regional central places. The application of such models to archaeological datasets has so far suggested that they can capture some essential properties of evolving settlement structure, despite the challenges presented by incomplete and fragmented archaeological datasets. Still, the validation of these models has so far mainly relied on sparse evidence on the sizes of often poorly preserved settlements and limited proxy data (artefact distributions, textual sources) suggesting central place functions. This talk aims to tackle some aspects of the application of SIEMs in archaeology that have been little investigated to date, namely the degree to which such models could be successful in identifying (1) central settlements in changing socio-political and economic conditions over time, and (2) the emergence of minor centres, namely secondary agglomerations that are typically less well represented in archaeological literature. To this aim, the application of SIEMs is discussed with respect to an unusually well-contextualised and rich (yet still patchy) archaeological record from the Pontine region (Italy) which offers a great range of indicators for central place functions for three subsequent periods (Archaic / 600-350 BC, Republican/350-50BC and Imperial/50BC - AD 250).

ANNFASS: A Neural Network Framework for understanding historical monuments Architectural Structure and Style

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ANNFASS brings together scientists from different disciplines, ranging from computer graphics, geometry processing, machine learning and architecture, for the development of an online framework focused on assisting Cypriot cultural heritage experts in their documentation workflow. The framework consists of a monument digital database and a neural network for learning a monument's structure and style. Cyprus, due to its geographical position, has been a target for crusaders, each influencing the local architecture. Several indicative buildings of each time period have been collected and digitized (3D models), to create a publicly available online database. The database will allow users to organise, examine and further understand Cypriot monuments and their architectural style. The collected dataset will be annotated by a group of Cypriot cultural heritage experts and will then be used for training and testing the neural network. The neural network will be able to segment monuments into architectural components (windows, doors etc.) and highlight its main stylistic influences. ANNFASS is an early effort in developing a framework with a unified, shared, online accessible database with Cypriot monuments and machine learning processing techniques.

From Analogue to Digital: 40 years of archaeological documentation and management at the Neolithic UNESCO World Heritage site of Choirokitia (Cyprus)

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(2) French Archaeological Mission at Khirakitia, (CNRS/Ministry of Foreign Affairs).

The presentation introduces research challenges of a collaborative project aiming at integrating recent 3D documentation of architectural remains at the prehistoric site of Choirokitia (Cyprus) with earlier, analogue and digital data obtained during the site's more than 40 years history of excavations and multi-disciplinary research (archaeology, bioarchaeology, geology). The project, led by The Cyprus Institute in collaboration with the CNRS archaeological team, the Department of Antiquities of Cyprus and the National Center for Supercomputing Applications of the University of Illinois, aims at creating a virtual environment for the visual representation of diachronic and temporal events at Choirokitia, based on the huge amount of multi-disciplinary data collected at the site, to be proposed for integration within the site's management masterplan.

Beyond the complexity of 3D data acquisition, due to extension of excavated areas and intricate remains (buildings overlaps, collapses, fragments of walls, features), another challenge is posed by the digital data fusion process, constantly corroborating digital with analogue material, crucial for the presentation of the development of excavations and the gradual exposure of remains. The final 3D model will be subdivided in blocks according to types of processed data, details of geometric and geodetic information and richness of metadata.

The site has been first investigated between 1936 - 1946 by P. Dikaios (Curator of the Cyprus Museum) and later between 1976 - 2009 by the French Archaeological Mission at Choirokitia (Centre National de la Recherche Scientifique - Ministry of Foreign Affairs). Its extensive excavations and consequent multi-disciplinary research revealed a complex and dynamic history. Due to its exceptional preservation and contribution to the knowledge on the Neolithic period, its culture and people, the site was included to the UNESCO World Heritage Sites List in 1998; a comprehensive management masterplan was submitted to the relevant authorities.

Khirkitia: simulating a proto-urban site

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A UNESCO heritage site, Khirkitia is an important Neolithic settlement in Cyprus occupied between 7th and 5th millennium BC. The settlement consisted of mudbrick and stone circular houses enclosed by a sequence of defensive walls. The organisation of private and communal spaces indicate a high level of social organisation and planning (Daune-Le Brun and Le Brun 2016). The rich data from thirty years of excavation can now be integrated into a comprehensive framework. The aim of the Khirkitia 3D project is to apply multiple computational modelling techniques to develop a better understanding of spatial relations and their evolution at the site. Modelling and simulation of individual and group interaction can reveal hidden or overlooked hierarchies of spaces and spatial structures in the settlement and their transformations through time. The project aims to identify topological relations and configurations of specific functional areas in the settlement's plan as these were transformed chronologically, e.g., central and peripheral zones, main movement arteries, important buildings or spaces. By applying multiple computational modelling methods including space syntax and agent-based modelling we can compare and contrast their outputs and provide indications for further studies in the future regarding their robustness and specific sensitivities. Overall objective of the research is to visualise the transformation of the settlement throughout its two millennia of development to enable quantitative testing of existing hypotheses regarding the evolution of the settlement and the social structure of its inhabitants. In addition, this research will contribute to the creation of a Virtual Tour that will visualize and effectively integrate the rich archaeological and environmental data to provide the visitors with the most complete picture of life in Khirkitia yet.

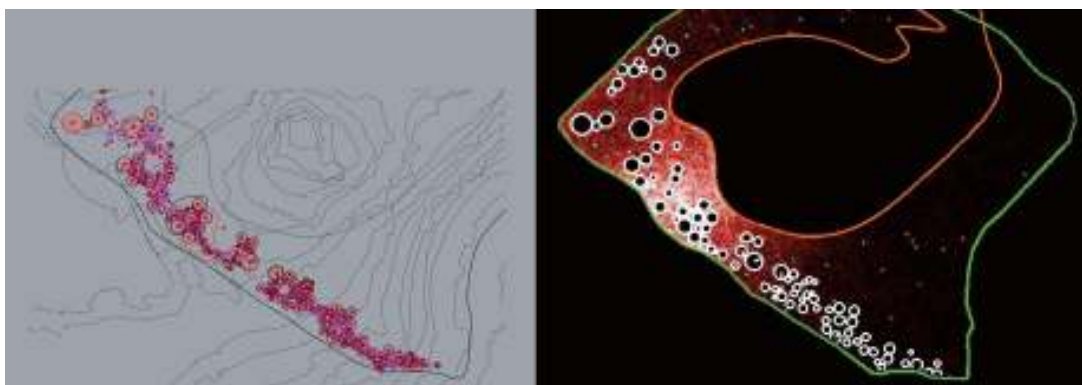


Figure 1. A representation of the “Eastern sector B5” units according to Daune-Le Brun, Hourani and Le Brun (2017), populated with additional units, was used as base model for the application of the two methods of spatial analysis and simulation under study, i.e., a network centrality analysis (space syntax), and an agent based modeling simulation for correlated random walk in the settlement.

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When culture meets economy: modelling cultural complexity in an economic setting

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Imagine going to a market to buy a new plate. The seller offers you a wide selection of locally made or imported ceramics, some cheaper, some more expensive. However, which one to choose?

Here we present a model of economic preference designed to investigate how simple customer preferences can shape centuries long term economic and cultural trends. By applying several standard cultural evolution algorithms (conformity bias, prestige bias, neutral etc.) to a baseline economic model (utility maximisation or 'sell high, buy low') we investigate how cultural behavioural scenarios can lead to different patterns in economic data. Does a complete dominance of one type of good signify a strong preference of the buyers or can this pattern arise from other types of cultural bias? Can a high level of variability in terms of products be equated with more complex behavioural patterns? Our goal is to provide a benchmark for a more informed interpretation of cultural assemblages, such as pottery found at archaeological sites, and to understand what kind of processes might have driven the apparent changes in cultural complexity over centuries-long periods.

To showcase the utility of these abstract cultural/economic models we provide a case study centred on Jerash, a medium-sized Roman town in present-day Jordan, where recent excavations revealed that the local pottery dominates the archaeological record for six centuries. The results of our agent-based model indicate that this pattern could have arisen only within a narrow band of conditions giving us an unprecedented window into the lives and decisions of ancient inhabitants of Jerash.

ARCHAEOLOGICAL MATERIALS

Chairs: Prof. Khaled Al-Bashaireh, Prof. Thilo Rehren

Ancient Marble Trade and Its Provenance Determination

Prof. Khaled Al-Bashaireh

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Marble is a metamorphic rock that needs certain conditions for its formation. It has been widely traded since antiquity from high to poor marble regions. Many ancient marble quarries of Greece (Thassos, Paros, ...), Asia Minor (Marmara, Docimium, ...) and Italy (Carrara) were the primary sources that produced huge amounts of the material. White and colored marbles were used for many purposes, but mainly for carving statues and architectural elements. The similarities of some marbles from different quarries in their physical features, especially of polished or small size samples, prevent their accurate identification, consequently the determination of their source. During the past decades, archaeologists and material scientists established databanks for the results of geochemical, mineralogical, microscopic analyses of the main ancient quarries exploited in antiquity. They used several techniques to characterize marble samples uncovered from archaeological sites and compared the results to the databanks to determine the provenance of the samples. It is widely accepted now that multidisciplinary scientific approach is necessary for an accurate determination of the provenance of marble samples. However, exhausted marble quarries, discoveries of new ones and lack of complete databanks, makes it difficult to assign the source of some marbles. This presentation will discuss these issues and give a case study of marble provenancing.

A Technological Approach to Iron Age Pottery from the Zagros Region: A Case Study from the Dinka Complex (Iraqi Kurdistan)

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The expansion of the Neo-Assyrian Empire (c. 900 – 600 BC) into the Zagros area has been known mainly through Neo-Assyrian texts dealing with the conquest and administration of this region. However, little was known archaeologically about this process until, recently, a wealth of new data has become available from Iraqi Kurdistan, through both surveys and excavations.

In this paper, we want to focus on the technological study of a pottery assemblage from the Dinka Settlement Complex, located in the Peshdar Plain (Sulaymaniyah region), excavated since 2015 by the Peshdar Plain Project (Radner *et al.* 2018). The Dinka Settlement Complex has yielded a pottery repertoire coming from stratigraphic contexts that can be safely dated through radiocarbon analysis to before and after the Assyrian conquests. This repertoire appears to be different from the proper Assyrian pottery culture of northern Mesopotamia. Rather, it has links to other sites of Iraqi Kurdistan located close the Zagros mountain range, as well as sites located beyond it in western Iran and in the mountainous regions of south-eastern Anatolia. An integrated analytical approach using petrography, SEM and XRF analysis has been applied to several samples representing the main macroscopic types and fabrics that were in use at the site.

Combining macro technological studies with results of archaeometric analyses allowed painting a detailed picture of pottery production and consumption at the Dinka Complex over the studied period. Beyond tracing local manufacture over time, it enabled us to assess the presence of imported vessels. It also showcases that the traditional picture of pottery production and consumption based solely on morphological types is incomplete. With our study, we contribute to the wider understanding of the social dimension of production of these commodities in the Zagros region and hope to provide new impetus for the study of Neo-Assyrian pottery.

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Raw material procurement at Boila Rockshelter, northwestern Greece, as an indicator of hunter-gatherer mobility in Greece during the Late Upper Palaeolithic and Mesolithic

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Mobility represents one of the most important behavioural strategies of the Palaeolithic and Mesolithic, allowing hunter-gatherers to organise their use of landscape by positioning themselves close to critical and seasonal resources, as well as allowing them to regulate group sizes and social networks. One way of measuring the scale and nature of mobility systems is through the transport of objects and in particular stone tools. The distances over which these were carried provide an index for the scale and direction of human movement. The aim of this paper is to discuss original research into the organisation of hunter-gatherer mobility in Greece during the transition from the Late Upper Palaeolithic to the Mesolithic. We take as a case study the Boila Rockshelter, located in the Voidomatis basin in the rugged uplands of the Tymphi Mountains in northwestern Greece. The study sets out to assess whether there is any evidence for a shift towards a more extensive system of hunting and gathering during the transition, as expressed in the movement of lithic raw materials over longer distances.

To do this, an interdisciplinary analysis of the chipped stone assemblage from the site is being carried out, combining typo-technological observations with field survey, mineralogical observations and preliminary results from geochemical trace element analysis. The aim is twofold, to present the complicated geological history of the area and the role this played in the presence of the local Voidomatis flint which was widely used at the Palaeolithic sites within the Voidomatis gorge. Secondly, to assess the provenance of potential non-local raw materials such as the red and brown cherts which are present at low density at Boila.

Research on the Boila Rockshelter is part of a larger interdisciplinary project entitled 'From hunter-gatherers to early farmers in Greece', which sets out to investigate settlement, subsistence and material culture during the final phases of the hunter-gatherer way of life in Greece.

The contribution of the soil micromorphology for understanding the occupation styles in prehistory: Two case-studies from Cyprus and Crete

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The major objective of geoarchaeology is to define the relation between human, soil and environment. The soil micromorphology constitutes an important tool to approach this research question. It contributes to characterize the earthen material and describes the construction techniques. It can also define the use of space in archaeological sites. Here, we present two examples on how the soil micromorphology can help better understanding of the social organization of ancient societies. The examples come from Cyprus and Crete from two sites with different culture and social background: the communal building of the Neolithic village of Klimonas in Cyprus and the domestic area of area Pi in Minoan Malia in Crete. The aim of the geoarchaeological study applied in both sites is to characterize the floor construction techniques and the use of space. Taking into account that the human behavior is recorded in the sediments, this study seeks to understand the development and the establishment of the earthen construction know-how from Neolithic period to the Middle Bronze Age in Mediterranean environment. The characterization of the use of space showed the spatial organization of each site and contributed to define the function of the structures. Finally, the study allowed us developing a first pedo-sedimentary model on how the earthen construction can record both natural and human factors directly related to the spatial and social organization.

Abandonment processes through the microscope lens. Microarchaeological data from Middle Bronze Age Erimi, Cyprus.

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The study of abandonment processes in archaeological contexts is key to reconstruct the life-history of buildings and settlements and the biographies of individuals, households and communities associated with them (Cameron 1993). Unlike floors that have been given a lot of attention in archaeological research, the study of abandonment sequences remains still little explored. However, abandonment processes have a key role in the formation of the archaeological record (Schiffer 1987; Tomka and Stevenson 1993). Exploration of the complex interaction between abandonment processes and resulting archaeological evidence requires research designs which raise questions during excavation, recording, and sampling, and which enable integration of a range of field and laboratory characterisation.

In this paper, abandonment sequences from the Middle Bronze Age Cypriot site of Erimi-Laonin tou Porakou (c. 1950-1650 BCE; Bombardieri 2017) have been analysed through a multi-scalar interdisciplinary approach based on the integration of stratigraphic analysis and high-resolution microarchaeological techniques, including micromorphology, infrared spectroscopy (FTIR) and phytoliths analysis. The aim is to shed new light into the socio-cultural practices and environmental processes that impacted on the abandonment of buildings at Erimi by providing richly networked data in the examination of destruction deposits and materials. Resulting data revealed the occurrence of two distinct abandonment processes: the gradual structural degradation of buildings which caused the slow burial of the structures and impacted on the preservation of the underlying deposits, which were poorly preserved; and the fast destruction of buildings, caused by a fire event, which sealed completely the occupation surfaces and deposits and preserved intact artefacts and micro remains. Destruction deposits within fired buildings were further examined in order to identify the temperatures sediments and materials were exposed to and to reconstruct the conflagration event. We hypothesise a first stage of slow-burning fire, which started from the roof, followed by second stage of well-vented fire, which caused the destruction of the structures. We finally assume that the fire was presumably deliberate and not accidental.

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Metallic and glazed artefacts from the Cypriot Chalcolithic

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Fire was used to transform materials, for example gypsum or limestone into plaster and clay into ceramic, already since the Neolithic period on Cyprus. Both of these pyrotechnological processes require temperatures below one thousand degrees Celsius. By the Middle Chalcolithic the first metal artefacts on the island appear (Gale 1991; Peltenburg 2011). The earliest are personal ornaments, most likely produced through mechanical treatment of native copper, a process which also does not require very high temperatures. But by the Late Chalcolithic copper tools, such as chisels, were clearly being cast. They indicate a development in pyrotechnological skill, since such processes require temperatures of over 1000 degrees. At the same time the first glazed artefacts are found on the island - small faience beads coloured with copper minerals. The discovery of new metal artefacts and faience beads, from secure archaeological contexts at the cemetery of Souskiou – Laona was the incentive that led to the study of these two distinct, and yet related assemblages which provide important insights regarding the level of pyrotechnology available at the time on Cyprus (Peltenburg et al. 2019). The fact that both are composed of rare artefacts that could not be sampled dictated the method of analysis that could be used for their characterization. Namely, they were analyzed using a handheld portable XRF. The disadvantages and limitations of the technique are well known. Nevertheless, the fact that the handheld portable XRF can provide a non-destructive means of acquiring a chemical profile is one of the main reasons it was used in this project, as indeed in many other projects the authors have undertaken with success over the last few years. Here we report on the results of the analysis of the metal and faience objects from Souskiou Laona and other Chalcolithic metal and glazed artefacts.

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Preliminary evidences for a Chalcolithic copper workshop in Fasaal, Northern Jordan Valley

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Recent excavations in the Chalcolithic site of Fasaal (Northern Jordan valley) revealed metal mace heads and slagged ceramic sherds with green remains of metal corrosion. For the first time, the presence of the famous Chalcolithic metal mace heads of the Southern Levant is evidenced in the Northern Jordan valley, making them the most Northern southern-levantine Chalcolithic metal mace heads found so far. At the same time, the typical green stains of corroded copper and the slagged surfaces on the ceramic sherds indicate the use of these vessels as crucibles in copper metallurgy. This would evidence the presence of a copper workshop far away from the established metallurgical centres in the Nahal Beer Sheva. And of course, the combination of metal mace heads and remains of technical ceramics used in copper metallurgy in the same site raises the hope to finally have found a production site of the metal mace heads or at least a workshop dealing with the typical antimony-arsenic copper alloys and/or arsenic-nickel copper alloys used for the so-called prestige items.

To shed light on all these different aspects, the finds were thoroughly analysed in a multi-method approach, including petrography, metallography, and chemical analyses. The results will allow us to reconstruct the provenance of the ceramic material and compare it to e. g. the provenance of mould remains from other Chalcolithic prestige items of the Southern Levant. Based on these first results, the metallurgical process on the site will be reconstructed. The results will be compared to the present knowledge about copper metallurgy in the Chalcolithic Southern Levant. This finally will allow us to draw first inferences about the Chalcolithic copper metallurgy in the Southern Levant and whether the site has the potential to rewrite it.

From desert ores to Middle Kingdom copper: first chemical and lead isotope data from the AHM collection, Belgium

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Copper has played a central role in Pharaonic Egyptian material culture throughout history and its consumption is widely attested in ancient funerary and urban contexts. The underlying production and supply systems have remained, however, relatively obscure as a result of limited interest or specialised study of the subject. It is likely, however, that the technological and economic framework of copper production and consumption in Egypt changed significantly throughout these millennia.

Indeed, recent studies have shed light on the earliest occurrence of copper in Pre-Dynastic up to Old Kingdom times (e.g., Abdel-Motelib et al. 2012, Kmošek et al. 2018, Rademakers et al. 2018, Rehren and Pernicka 2014), suggesting a highly different provisioning system compared to the New Kingdom (cfr. Rademakers et al. 2017 and Stos-Gale et al. 1995). However, these studies necessarily cover only a relatively small window of time and space, fragmentarily illuminating an ancient economy wherein millions of copper objects circulated.

In this study, we present the latest analytical results from chemical (ICP-OES) and lead isotope (MC-ICP-MS) analysis conducted on forty artefacts from the Art and History Museum Brussels, dating to the Middle Kingdom period. Great efforts have been made to reconstruct the archaeological contexts for these artefacts, mostly excavated in the late 19th to early 20th century, enabling meaningful discussion of their provenance. Furthermore, the production technology of Middle Kingdom copper in Egypt is currently being studied by the same team at Ayn Soukhna (Verly 2017, in preparation), providing an interpretational framework rooted in ongoing excavation and experimental archaeology. These new data provide the first insight into Middle Kingdom copper provenance so far.

The discussion of these results delivers insight into the importance of “domestic” copper and Egypt’s participation in Eastern Mediterranean copper trade through time, and integrates a broad perspective on the underlying techniques for raw and alloyed copper production in Middle Kingdom Egypt.

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Using pXRF spectroscopy to identify ancient copper alloys: the case of LBA Enkomi (Cyprus)

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The present analytical study concerns the interdisciplinary investigation of more than 200 copper alloy artefacts, coming from the very important Late Bronze Age settlement of Enkomi (Dikaïos, 1969), located on the east coast of Cyprus, dating to the 16th-11th centuries BC (Kassianidou, 2012, 2016). The assemblage consists of various categories of objects, such as weapons, tools, ornaments and scrap metals. The material was non-destructively analysed using a handheld pXRF instrument. The basic aims of the present work are the determination of the alloy type of the artefacts and the comparative study of the copper alloys used in the different chronological phases of Enkomi's settlement. The results show that the large majority of the analysed artefacts, in all chronological phases, are made of a copper-tin binary alloy (bronze) with a tin concentration lower than 10wt%, while some artefacts were made of unalloyed copper. Among the bronze artefacts, there is a group of objects which was found to have a significantly higher tin concentration (>13wt% Sn). Regarding the other elements, there is a limited number of copper-arsenic and copper-zinc (brass) alloys and an extensive presence of lead, but in most of the artefacts is detected in concentrations lower than 1wt%. Because lead concentration in local Cypriot ores is unusually low (Constantinou, 1982), its presence is interpreted as a deliberate/accidental addition even at these low concentrations. In addition, the presence of a noteworthy number of scrap metals and the detection of low concentrations of arsenic and lead in most of the copper-tin alloy artefacts may suggest the possible use of recycled metal deriving from artefacts dating to the Early and Middle Bronze Age, with originally much higher concentrations of arsenic.

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“Cooking up” pottery recipes: a diachronic technological and provenance analysis of cooking ware ceramics from prehistoric Heraion on Samos, Greece (5th to early 2nd millennia BC)

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Cooking vessels have usually been interpreted as indicators of consumption practices or markers of ethnicity and cultural affinities, based on popular views that consider this ceramic category as reflecting local products and thus being resistant to change. This has attracted the initiation of projects that deal with the study of ceramics related to the preparation of food, in order to test the static and conservative nature of these vessels especially in prehistory. Moreover, new advances in archaeological science and theoretical approaches have shown the importance of cooking vessels also for identifying connections and exchanges between different sites.

This paper, drawing from a broader ceramic analytical project from the Chalcolithic (Ch) through the Early Bronze Age (EBA), as well as from preliminary remarks on Middle Bronze Age (MBA) pottery from Heraion on Samos, will focus on the diachronic study of cooking ware vessels. Using an integrated typological, fabric (macroscopic and petrographic), microstructural, and chemical programme of analyses this paper aims to explore local technological developments, as well as the determination of provenance of suspected imports.

The programme of analysis, mainly based on fabric and clay composition data, has produced significant patterns of production at a micro-scale level and has shed light into the connections of Heraion diachronically. The preliminary results suggest the existence of distinct production centres specifically for the manufacture of cooking vessels in different fabrics, corresponding to period-specific choices. While some clay recipes show chronological consistency, the majority of cooking vessels made into the metamorphic fabric(s) have a continuing local tradition from the Ch to the MBA. However, the remarkable conservatism seen in types and manufacturing techniques for the Ch and early EBA is rather challenged in the late EBA and MBA with the adoption of regional cooking vessel types and the experimentation of local fabrics with foreign forms (e.g. Minoanizing), or even the importation of Minoan cooking pots during the early second millennium BC.

Technology of early Byzantine glass from the glass workshop of Argyroupoli, Rethymno, Crete: Preliminary results using SEM-EDS

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Archaeometrical studies on early Byzantine glass excavated in Greece are extremely scarce in the literature and limited to a small group of samples, mainly glass tesserae. This paper presents early Byzantine glass excavated in ancient Lappa, modern town of Argyroupolis, SW of Rethymno in Crete.

Salvage excavations discovered a complex of 5 rooms identified as a secondary glass workshop, yielding more than 1500 glass fragments including fragments of glass objects (mainly vessels) and glass working debris (mainly test drops, chunks etc.). The glass and the architectural remains date to the 6th-7th c. AD.

The project investigates the technology of the glass assemblage from Argyroupolis using macroscopic investigation and SEM-EDS analysis. The analysed assemblage covers both categories, namely objects and glass working debris. The objects consist mainly of rims and stems of glass goblets (55 fragments of different objects), a typical vessel found in Late Antique contexts, while the glass working debris consist of semi-fused glass, chunks and test drops (21 fragments in total) (Fig. 1).

The glass of both categories is a typical soda lime silica glass made by fusing sand and natron. As expected, there are similarities between the chemical composition of the glass working debris and the objects found in the complex. The glass working debris can be divided in 4 compositional groups based on differences in major and minor elements associated with the sand raw material, namely silica, lime, alumina and iron, indicating possible different sources of sand. This differentiation can be also broadly linked to the objects (Fig. 2), while the types of the glass working debris are mixed in these corresponding groups. Further investigation using trace element analysis and isotopic analysis will test the idea of different sand sources in the assemblage and link the objects to the typical compositional groups (Levantine 1, 2, Foy 2.1, Foy 3.2, HIMT etc.) circulated widely in the Mediterranean during Late Antiquity.

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Fig. 1. Characteristic photo of the a. objects (stems and rims) and b. the glass working debris (semi fused glass, chunks and test drops) under study (the separate images are not in scale).

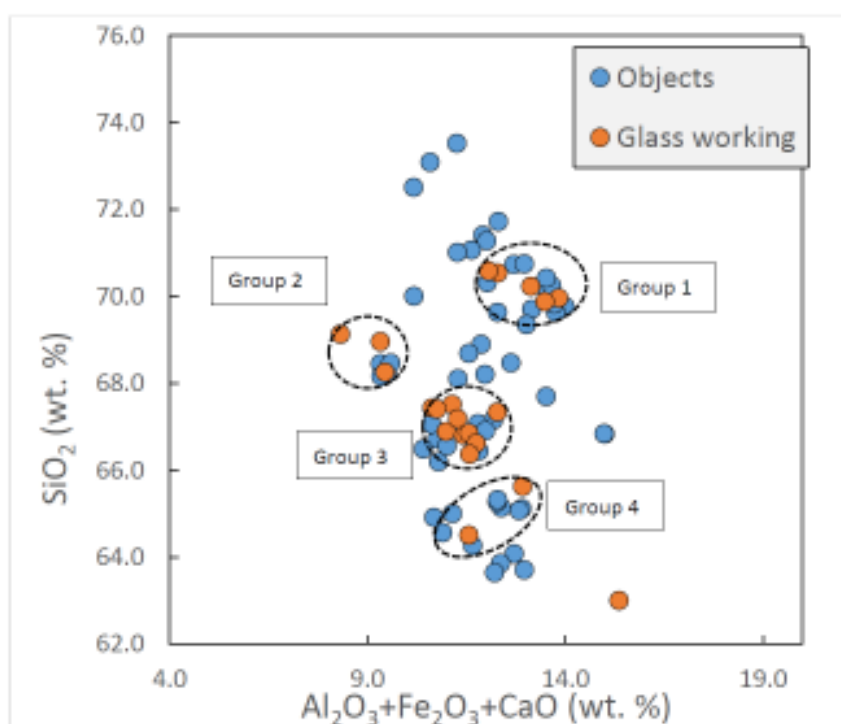


Fig. 2. Correlation between silica (SiO_2) and the sum of alumina (Al_2O_3), iron (Fe_2O_3) and lime (CaO). The glass working debris cluster in four different groups in which few objects can be linked broadly.

Glass from the Sea: Composition of Raw Glass off the Coast of Israel

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Large glassmaking installations located in the coastal strip of Israel are thought to have supplied much of the glass used across the old world in the first millennium CE. In underwater surveys conducted during the last fifty years along the coast of Israel, large chunks of raw glass were recovered. Some of these chunks are concentrated in or near ancient ports and some are scattered near remains of shipwrecks, which could be the vessels in which they were traded.

These apparently represent items of trade en route for glass workshops across the Mediterranean and beyond. Here we describe the character and distribution of the finds and report a compositional study of twenty-two representative chunks by electron microprobe analysis. Current understanding of compositional variations between production sites allows the chunks to be related to their likely places of origin and to assign probable date ranges. Most of the glass chunks represent the products of the primary production sites excavated previously in Israel, while a number of the finds are assigned to groups which have been considered to be characteristic of Egyptian production. The implications of these findings are discussed.

Indigeneity and innovation of early Islamic glaze technology

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Dated to the early eighth century AD, the Coptic Glazed Ware (CGW) has recently been established as the predecessor of the Islamic opaque glaze (Matin et al. 2018; Watson 2014), which is widely recognised as a revolution in ceramic technology. In order to have a better understanding of the mechanisms that fuelled such technological change, this study seeks to reconstruct the CGW technology in relation to the contemporaneous unglazed fineware and glaze traditions in the eastern Mediterranean. For this purpose, we examined the CGW assemblages recovered from various sites in early Islamic Palestine using scanning electron microscopy energy dispersive spectrometry.

The results show that the CGW samples were originated from Egypt, which is known to have involved in the production of Late Roman fineware such as the Aswan Red and White Slip Ware and Coptic Painted Ware. Continuity of these local fineware traditions is reflected in the preference for slipping and painting as the principal decorative techniques to adorn the CGW, whereas the use of lead glaze was likely adopted from the Byzantine technology. At the same time, the potters experimented with how to colour glaze and use glaze as a decorative medium, which is evidenced in the diversity in glaze composition and microstructure (Fig. 1). Based on these findings, we argue that the change in ceramic technology was a gradual process. The rich local tradition in fineware production might have paved the way for change by nurturing a high level of craftsmanship among the potters. The catalyst that set this change in motion was the transfer of rulership in Egypt from the Umayyad to Abbasid during the eighth century, resulting in the appearance of new settlers, new political agenda and possibly new demand for material representations.

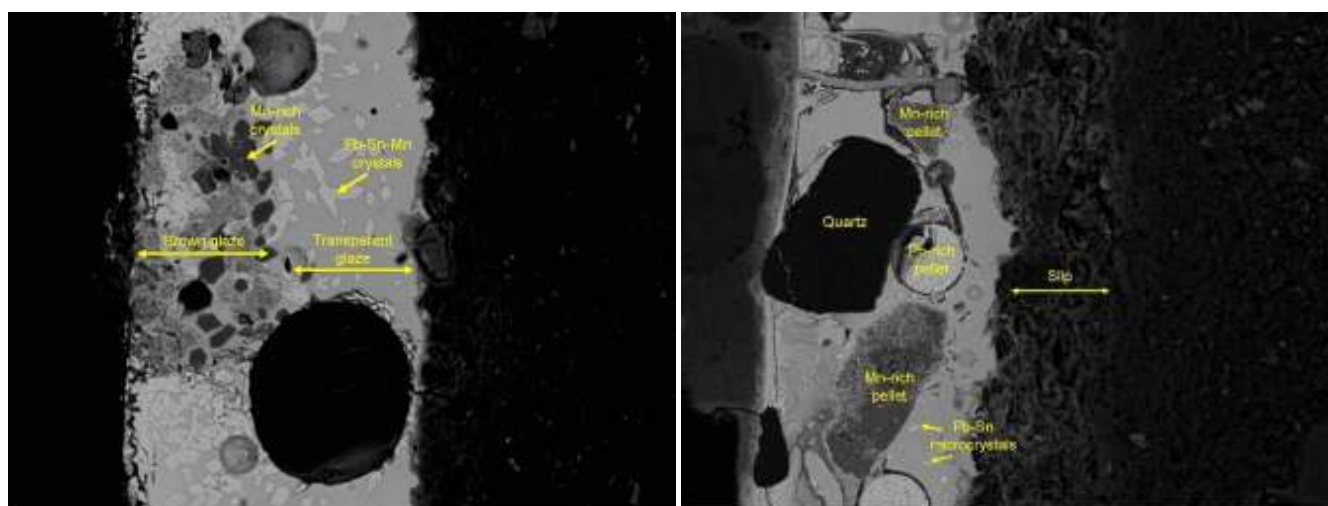


Figure 1. Backscattered electron images showing different ways of colouring and applying the brown glaze.

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AM12 - Oral presentation

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Persian Crucible Steel: Archaeology, Manuscripts and Experiments

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This paper explores the potential of historical data and experimental archaeology in combination with material analysis of archaeological samples, to reconstruct and understand historical pyro-technologies, particularly Persian crucible steel.

Building upon the material analyses of archaeological samples from crucible steel making site of Chahak (Alipour 2017) (11th CE) by Optical Microscopy (OM) and Scanning Electron Microscopy-Energy Dispersive Spectrometry (SEM-EDS), the slag composition reveals, for the first time, a peculiar presence of chromium (about 1%), which marks the earliest deliberate addition of this element to steel manufacture. This is exclusive to Chahak tradition as this element has not been reported in former analyses of the Central Asian and Indian crucible steel slags. The historical recipe of crucible steel making by Biruni (10th CE), includes a peculiar component *rusakhtaj* which means the burnt in Persian, and is most probably representative of black chromite sand. Additionally, the choices of organic material reported in the historical recipes reveal an extraordinary fusion of the local ritual and mystical practices in the production of crucible steel.

The slag composition of Chahak samples and the historical data were combined to produce crucible with the purpose of understanding whether a simple carbonization technique by only some organic matter and without sophisticated furnaces would result in the reduction of chromite to chromium in the ingot. The resulting crucible steel ingot, is very similar microstructure and chemical composition of metallic prills trapped in Chahak crucible slag (tentatively Chahak ingots).

This paper combines the historical, archaeological and experimental disciplines to develop a better understanding of Persian Crucible Steel and potentially making it possible to linking crucible steel museum objects with Chahak or Chahak tradition.

Investigating the architectural history of the 14th century AD Al-Attar mosque, Tripoli- Lebanon

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Al Attar mosque in Tripoli, Lebanon, was built in the 14th century AD by a merchant holding the same name. Based on an account by Abd Al-Ghani Al-Nabulsi who traveled to Lebanon by the end of the 17th century AD, archaeologists suspected that the mosque was built over an older church.

This was confirmed recently during the restoration work of the building where several archaeological soundings revealed an apse and several overlapping floors showing that the church itself underwent several modifications.

In this paper, we present an interdisciplinary investigation using radiocarbon dating, characterization of lime floors and stratigraphy in order to reconstruct the architectural and occupational history of this site.

Ancient artisans and ethno-archaeology. From Early Iron Age Naxos and Andros to modern Cyprus: first assessment and perspectives

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Early Iron Age Naxos and Andros in the Cyclades had a key role in Aegean trade networks and cultural transmission between the islands and the mainland. Both islands also had robust handmade/hand building potting traditions in the Early Iron Age to satisfy local consumption in various contexts: settlements, cemeteries, sanctuaries. Through interdisciplinary researches, from macrotrace documentation of manufacture and finishing techniques to petrographic analysis which provides information both on provenance and technology, our aim is to infer the chaînes opératoires of hand building Early Iron Age wares from Naxos and Andros, with emphasis on two important sites which have yielded significant corpuses of this hand building potting tradition. These are the Iron Age cemetery of Tsikalario in inland Naxos and the Early Iron Age settlement of Zagora on Andros.

Ethnoarchaeology can be an important tool to reconstruct these chaînes opératoires and it now becomes evident that the traditional potting culture of Cyprus can provide us with detailed ethnoarchaeological parallels to understand the life cycles of Early Iron Age hand built wares, and the potters who made them. The original ethnographic field work by the ethno-archaeologist Gloria London between 1986 and 2000, and her current work for the Agios Demetrios and Kornos communities, cataloguing and curating heritage collections of pots made by the Kornos and Troodos Mountain women potters, can serve as a valuable reference to understand better the above mentioned Early Iron Age archaeological ceramic datasets and the roles of the women who could have potentially made them. The hand building women's potters tradition of Cyprus is one of very few continuous traditions in the Mediterranean maintained through the 20th century. And it is also the only well documented female potting tradition in the Mediterranean largely thanks to the systematic work of Gloria London.

This presentation will highlight the archaeological methods used in our researches to trace the chaînes opératoires of hand building Early Iron Age pottery from Naxos and Andros, how the archaeological corpus of Naxos and Andros can be linked with the women's potting tradition of Cyprus as well as the potentials of Gloria London's systematic ethno-archaeological work to provide an ethnographic reference dataset of this hand building dynamic pottery culture for archaeological research. The inference linkages between the Naxian and Andriot corpuses and the Cypriot tradition will serve as an example for other researchers working with similar material to take advantage of this ethnographic data and to showcase the importance of this unique Cypriot tradition as a vital part of the cultural heritage of Cyprus.

Scientific Investigation of Roman-Byzantine Glass Working Remains from 'Aqir, Israel

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The Levant was arguably the most important glass production region in the first millennium CE. Levantine glass, identified by its chemical and isotopic composition, is found across the world. However, in spite of significant research into glass in the past two decades and the excavation of both primary (glass-making) and secondary (glass-working) production sites, the investigation of the production technology is limited.

Finds from a secondary workshop in 'Aqir, central Israel, including pieces of glassworking remains as well as glass products, have been analysed by Scanning Electron Microscopy with Energy Dispersive Xray analysis (SEM-EDS) and thin-section petrography.

The results suggest that the workshop melted raw glass chunks of the same composition as the glass made at Apollonia, modern Israel, to produce secondary glass products. Glass products of different origins were also recognised among the debris, providing evidence of communication between the Levant and North Africa in the Roman to early Islamic periods. The furnace discovered in the excavation was built with refractory mudbricks specially made by tempering with quartz sand and it was fired by potash-rich fuel to approximately 1100°C. Mortar was either used to cement the gaps between mudbricks or applied to the floor and walls of the furnace, and this introduced a previously unrecognised type of contamination, mainly of CaO and FeO, into the glass.

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Egyptian Middle Kingdom Copper: Analysis of a Crucible from Buhen

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Buhen was located immediately below the second cataract on the west bank of the Nile in the Sudan and near the border with Egypt. Prior to its inundation in 1964, it was excavated by the University of Pennsylvania's Eckley B Coxe Expedition in 1909-10 under the direction of David Randall-Maclver (1873-1945) and Charles Leonard Woolley (Randall-Maclver and Woolley 1911) and by Walter Emery of the Egyptian Exploration Society after 1957 (Emery et al 1979). Emery found what he claimed was a copper 'factory' making the site important to Egyptologists researching metal working (El Gayar and Jones 1989).

While some of Emery's metallurgical features are questionable, the site yielded numerous crucibles and other metal working equipment and debris. The crucible styles are typical of other Egyptian crucibles of the period, few of which are fragmentary and available for analytical study (Claes et al 2019). A sample of the fabric from one crucible fragment in the Petrie Museum (UC 21748) has been investigated at the Cyprus Institute using optical microscopic techniques and SEM analysis.

The paper describes the results of the analyses and explains the implications for the crucible ceramic, the processes it was used for and the metals with which it was concerned.

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Technology and Provenance of Stamped Documents on Clay: study of Iron Age bullae from Jerusalem

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During the third and second millennia, writing on clay tablets has played a role in the ancient Near East such as administrative and legal uses, literature and religion, communication, education, diplomacy and politics, to support religious beliefs (funerary, votive and protective) and to mark ethnic identity. With the beginning of the Iron Age, we witness a gradual loss of the visibility and the use of all the scripts previously found in the Southern Levant (Sparks 2013). Bullae, or seal impressions on clay shaped as flat disks, are remnants of documents and commodities that were once attached to them, usually affixed by a cord, or pressed against wood, fabric, etc. This study presents 51 items in a very good state of preservation that surfaced in the antiquities market and published by the late Prof. Nahman Avigad of the Hebrew University of Jerusalem. The collection belongs now to the Israel Museum in Jerusalem (Goren et al. 2014). The bullae were subjected to a set of analyses including pXRF and Raman followed by delicate sampling petrography, VP-SEM/EDS, TGA/DTA and LA-ICP-MS (Goren 2018). The purpose of those analysis was to characterize the forming technology, the mineral composition, the element concentration, the firing processes, the post-depositional processes and to determine the provenance. The aim of this presentation is to show the methodology adopted for this research and its potential, introduce the first results, pin-point the geographic origin and the possible source of composition.

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“Moving” cooking pots in LBA Chania, Crete: local production and imports

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Cooking pots often receive less attention for their implications about interconnections between different sites in contrast with other pottery classes, such as transport jars or fine tableware. The research presented here, however, stresses the significance of Cooking Ware in establishing relations and connectivity between sites of the LBA Aegean. This is especially crucial for the period under study, namely the transition from the Neopalatial to the Post-Palatial, which is characterised by socio-political upheavals.

The present project, through the petrographic analysis of 39 samples explores the technological tradition of the Cooking Ware of Chania, west Crete, from the Neopalatial (LMI) to the Post-Palatial (LMIIIB2) period. The primary aim of this study is the characterisation of the local production of cooking pots, from raw material selection to firing and, subsequently, the investigation of imports and their provenance.

The petrographic analysis of the Cooking Ware provides valuable information on the cooking pots' production and consumption in Chania. It is evident that there is a very strong local tradition that reaches back to the EBA and remains almost unchanged throughout the centuries. In addition, it appears that there are imported cooking pots from at least two different areas: the islands of Kythera and Aegina. These sites are renowned for their Bronze Age ceramic workshops and their products are widely distributed in the southern Aegean. Aeginitan tripod cooking pots are found as far away as Dimini in Thessaly, the northeast Peloponnese and the north Cyclades, but there is no evidence so far of their presence on Crete.

Revisiting the question of ceramic provenance in the Northern and North-eastern Peloponnese

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Throughout its existence, Corinth has been a well-known centre for the production of ceramic products. There are a number of studies which have aimed to characterise the products of Corinth, spanning multiple periods at the site. Questions of technology have been explored but the problem of defining provenance still persists, especially in terms of distinguishing between different potting centres across the Northern and North-eastern Peloponnese. The problems stem from the homogenous geology of the region. Large beds of marly clays, topped with terra rossa, extend from east to west. There is added complexity due to there being, at all periods, a number of potential production sites across this zone, contemporary with Corinth, for example Sikyon, which has more recently been receiving comparable attention. Will it ever be possible to differentiate the products of these centres, including Corinth, on the basis of fabric composition or clay paste preparation technology?

Since the 70s, efforts have been made to locate the source of the clays used around Corinth, and more recently other centres in the region, but problems caused by the geology and the apparent lack of suitability of the clays for pottery production has led to little conclusive evidence. Whilst the exact location of the clay beds exploited for pottery production may never be found, this project aims to systematically investigate the question of compositional variation within and across the main sediment units of the region whilst also looking at the question of clay suitability within a broader light. An extended sampling programme was undertaken aiming to assess the physical, chemical, and mineralogical nature of the clayey raw materials from 33 locations around Corinth and Sikyon. By experimenting with different preparation and treatments of the clay, this project aims to shed new light both on the clays and the technology employed for their processing and contribute valuable information to the analysis of ceramic products of this region of the Peloponnese. This paper presents preliminary results.

Bringing life to old MUSEum COllections: The interdisciplinary study of pottery from the Cypriot Iron Age polities of Salamis, Soloi, Lapithos and Chytroi (MuseCo)

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This poster will present the ongoing research project MuseCo, which is a large-scale interdisciplinary study of fine and coarse pottery from various archaeological sites pertaining to the Cypriot Iron Age polities of Salamis, Soloi, Lapithos and Chytroi. The ceramic artefacts under study constitute an important corpus of the Cyprus Museum pottery collections that were formed before 1974, but they still remain unknown to scholarly literature. The principal objectives of MuseCo involve the morphological, technological and compositional characterisation of regional pottery production dated between the 11th to 4th centuries BC, combining a detailed ceramological study of pottery assemblages with ceramic petrography and wavelength-dispersive X-ray fluorescence. This research project addresses a series of interlinked issues, including the designation of regional cultural identities and social and cultural interactions, as these can be comprehended from the study of the pottery craft of the Iron Age polities under examination. In a wider perspective, the project aims at facilitating an enhanced understanding of the distinct politico-economic peripheries and the socio-cultural phenomena that characterised the respective city-kingdoms, as well as their commercial and cultural networks of exchange. This final task will be implemented with a comparative study of the project's final results with those of other contemporary projects in other regions of the eastern Mediterranean. MuseCo (EXCELLENCE/1216/0093) is funded by the RESTART 2016-2020 Work Programme for Research, Technological Development and Innovation for the period 2019-2021.

Archaeometallurgical analyses of metal finds from the Akko Tower shipwreck

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The Akko Tower shipwreck is the remains of a ship, apparently a 25-m-long merchant brig of 200 tons, built in the French shipbuilding tradition and dated to the first half of the 19th century. The shipwreck was excavated for four seasons, and various metal finds, such as brass nails and sheathing, iron rigging elements and anchor chain, were retrieved for further study.

The metal finds were examined using archaeometallurgical methods, which presented distinct advantages and disadvantages with regard to the specific characteristics of each item. Most finds were cross-sectioned and underwent a complete suite of examinations: metallographic micro-structural characterization, OES bulk compositional analysis, SEM-EDS analysis, lead isotope analysis (for copper alloys), and microhardness testing. Naturally, some finds were not destructively examined, due to conservation concerns and other limiting circumstances. For these items, surface-based examination, such as XRF compositional analysis, multifocal 3D light microscopy and surface SEM, were used in conjunction with X-ray radiography.

The analysis results contributed valuable information for reconstructing the manufacturing processes, and consequently the origin and date of manufacture of the items. These details usually included distinct micro-structural features, such as casting defects, dendrites, slag inclusions, twinning, strain-induced grain morphologies, and significant compositions, such as zinc content in brass and slag composition in iron.

Analysing the metal finds from the Akko Tower shipwreck supported setting an upper limit of dating based on the use of wrought iron, and a lower limit of dating based on the high zinc and low lead content of the brass items. More information, such as possible provenance of the brass items and the forge-welding features of the ferrous items, also contributed to localizing the possible origin and dating of the ship.

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Mapping Archaeoseismic Damages across Jordan (MADAJ)

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Most of the archaeological sites in Jordan were built in areas of high earthquake risk due to its location in close proximity to the Dead Sea Transform fault system. Several earthquakes reoccurred during the past millennia, which left significant damage traces on existing structures and features (Anastasio et al., 2016). Although scientists noticed several damage traces on different parts of archaeological structures, many remain unexcavated. This research project (MADAJ) is designed to study and document various forms of seismic destruction within selected archaeological sites across Jordan. Previous research on the area attributed most of the former archaeological damages to the earthquake of 18 January 749 AD, while it is expected that examining earthquake damage indicators of spatially distributed archaeological sites; yet largely devastated, can reveal other potential causative events.

The general aim of MADAJ is to build an Atlas for Archaeoseismic Damages of Jordan. The expected results of MADAJ will provide the means to correlate observed forms of damages against written records of ancient earthquakes and existing earthquake catalogues in order to enhance the accuracy of historical seismic records of the region. The data might provide strong evidences to determine ancient earthquake epicenters that most likely affected these sites. Additionally, the collected data will support the efforts needed to mitigate seismic risk and to protect and preserve these sites against future earthquake damages.

The project acts under the official approval of the Department of Antiquities of Jordan, where a team of scholars of various scientific disciplines is involved. Accordingly, a systematic and multi-method approach is proposed that includes: compiling and reviewing ancient archives of photographs and written records (i.e. historical textual resources, published scientific and unpublished excavation reports, etc); documenting existing field observations using different photogrammetry methods (i.e. 3D photogrammetry, drone stereo-imagery and terrestrial LiDAR); and collecting in-situ measurements of earthquake related damage indicators (such as collapsed structures, arch stone sliding, etc), using compass, tiltmeter, range finder, camera; documenting in-situ features (damage layers, architectural stratigraphy, rebuilding or restoration activities, etc) and examining local specific site conditions that may attribute damage to natural causes of destruction at a site using geophysical surveys.

Subsequently, observed earthquake damage features shall be classified based on the Earthquake Archaeological Effects (EAEs) scheme proposed by Rodríguez-Pascua et al. (2011). Finally, the collected information will be analyzed, in view of available historical records/catalogues of seismic activity within the region, to validate or to determine potential causative events.

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The MADAJ is in its first (3 years) phase that focuses on north Jordan which is dominated by a vast number of archaeological sites. Based on available funding, the next phase will cover the central and southern parts of Jordan.

The presentation will discuss the project's aims and methodologies, shed light on the preliminary results or findings and their interpretation, and discuss future ambitions.

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Characterization of Historical Materials from Rammed Earth Heritage of Iran

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Earthen structures are important elements of world heritage. Among the most widely documented structural types rammed earth is widely spread: this is a traditional building technique consisting of compacting moist earth by layers inside a formwork. Although, to my knowledge, rammed earth is one of the most popular ancient techniques in rural areas, little investigation was devoted to the better comprehension of the characteristics of this material, a necessity for preservation purposes. The poor conservation of these structures menaces their integrity and the life of their inhabitants. This study, conducted in the frame of the T4C PhD Programme at the University of Torino discusses the applicability of various computational methods for investigating material characteristics of earthen heritage in Iran. Basing on an interdisciplinary approach, this research utilizes various technologies, including X-ray diffraction, scanning electron microscopy and imaging technologies, to provide in-depth information on the characteristics of historic rammed earth, which in turn will contribute to expand our understanding and knowledge from purely architectural to more detailed scientific facts. To this aim, earthen materials collected from rammed earth heritage of Iran are investigated to characterize archaeological, mineralogical, chemical and mechanical properties of earthen heritage in Iran. In the end, this research should give insight on scientific and technological aspects of characterization of rammed earth cultural heritage. Specifically, it provides valuable information about historical rammed earth material, which is an essential requirement for decision making in conservation of earthen heritage.

Maritime trade in Early Islamic-period glass: New evidence from the Ma'agan Mikhael B shipwreck

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The Ma'agan Mikhael B shipwreck is the remains of a 25-m-long merchant ship which plied the eastern Mediterranean in the 7th–8th century CE – the late Byzantine–early Islamic period in the region. A significant portion of the wooden hull survived in a good state of preservation, containing various finds, such as rigging elements, food remains, coins, and complete amphoras (Cohen and Cvikel, 2019).

More than 500 glass fragments were found inside the ship. They included lumps of raw glass and small fragments of glass artifacts: bowls, beakers, wine glasses, oil lamps, bottles, tesserae and a bracelet. There were also a seal attached to the rim of a glass vessel – a typical early Islamic tradition, and an almost complete bottle. Except for a few finds dated to the Late Roman period, most of the glass items recovered from the shipwreck dated to the Late Byzantine and Umayyad periods.

Geological and geographical conditions led to Palestine becoming a major producer of raw glass and glassware during the 1st millennium CE (Gorin-Rosen, 2015). Raw glass chunks were exported as part of maritime trade, and broken glassware was usually traded as cullet for recycling. Finds of small numbers of complete vessels are usually explained as sailors' belongings.

Although it is small, the Ma'agan Mikhael B glass assemblage is a very important discovery. To date, no ancient glass remains found in the Southern Levant, have been found in situ in a shipwreck (Galili et al., 2015). This is the first study conducted on a glass cargo discovered in context in a shipwreck from the late Byzantine and Early Islamic period, using typological methods and chemical analysis. The results indicate that maritime trade existed between glass workshops in Palestine and the West.

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Iron Production Technology in the Neo-Assyrian Sphere: The Iron Workshop at Tel Sera', Western Negev, Israel

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In the ancient world, iron was produced in a process called bloomery production. The chaîne opératoire of this industry is known from archaeological and ethnological sources. Yet despite recent discoveries and the introduction of analytical methods from the life and material sciences, very little is known about the industry during the Iron Age in the southern Levant (Eliyahu-Behar et al., 2013; Veldhuijzen and Rehren, 2007). As few in-situ remains of the industry have been found to date, recent studies are often predicated on waste products found in secondary context. However, such in-situ remains have been found at Tel Sera'. Amongst the finds at the site, excavated during the 1970's, is a plethora of metallurgical remains found at the Neo-Assyrian fortress' courtyard (Oren, 1982). The purpose of this study is, by identifying the iron production remains at the site, to better understand the practice in the southern Levantine Iron Age in general, and in the Neo-Assyrian empire in particular. Although previously briefly published (Rothenberg and Tylecote, 1991), we have undertaken a renewed study of the metallurgical remains. Established methods such as SEM-EDS, metallography and optical microscopy are used, but we also show a renewed application of these methods in archaeometallurgy, particularly in the study of the technical ceramics. In addition, thermo-gravimetric analysis (TGA), previously unused in such a study, is applied. Our research indicates that repeated production of bloomery iron took place at Tel Sera' under institutional control. Iron ores were likely transported from the Makhteshim of Negev highlands. The technical ceramics, i.e. the furnace walls and tuyères, were made locally, and were designed to withstand the thermal stress. In addition, we present a hitherto unknown element in Levantine iron smelting, the pre-smelt roasting of ores.

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State-of-the-Art TEM coupled with Electron Diffraction for the Study of Silicate Archaeological Materials

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Transmission Electron Microscopy (TEM) till recently, has shown limited use in Archaeological Science and Cultural Heritage Studies (Sciau, 2016) despite the unique information it allows for unit-cell characterisation, crystalline phase and orientation characterisation, the later in combination with Electron Diffraction (ED) measurements.

The present work reviews on recent advances in TEM/ED studies for silicate material and especially on pottery, glass amphorisks and glass tesserae and Maya blue pigments (Zacharias et al., 2018; Nikolopoulos et al., 2018, Nikolopoulos et al., 2019).

Such TEM-based laboratory protocols can be an alternative to synchrotron techniques and can allow distinguishing accurately different crystalline phases, even in cases of identical or very close chemical compositions, since it operates in the nanometric scale; thus it provides an additional to the chemical analysis of the material that of the mineralogical ‘nano-fingerprinting’ characterisation.

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Technology of slips and glazes in the post-medieval Balkans: a case of Belgrade in the 16th and the 17th centuries

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This paper presents scientific data concerning the production technology of post-medieval slips and glazes in Ottoman Belgrade (the 16th-17th centuries), obtained in the first systematic research conducted on this topic in the Balkans. Slips and monochrome glazes are among the most common types of decorations found on post-medieval wares. Despite their ubiquity at archaeological sites, not much is known about compositions and methods of applications. In order to explore these two topics important for the reconstruction of production technology, 30 samples of slipped glazeware, selected from well-contextualised archaeological sites in Belgrade, were examined with SEM-EDS. The results show that four compositional groups of slips can be distinguished, made of non-calcareous clays compositionally different to those used for ceramic bodies. All monochrome glazes are of a high-lead type, but several methods of preparation and application are singled out. The plurality of technological choices sheds a new light on the technological complexity of common wares in the post-medieval Balkans and presents an important contribution to archaeological studies of production.

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