44th International Symposium on Archaeometry

Melbourne, 27th-31st May 2024

Book of abstracts

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Welcome to ISA2024

Dear delegates

We are pleased to welcome you to the 44th International Symposium on Archaeometry, hosted by the Australasian Research Cluster of Archaeological Sciences (ARCAS) at the University of Melbourne. We are grateful to welcome the 175 delegates, coming from over 20 different countries and presenting a total of 136 oral and poster presentations.

We want to acknowledge and pay respect to the Traditional Owners of the unceded lands upon which the Parkville campus is situated, the Wurundjeri Woi-wurrung and Bunurong peoples.

ISA 2024 is located within walking distance of some of Melbourne's major attractions. Including artistic, cultural, and natural history exhibitions, Heritage sites, and guided walks. Melbourne has something to offer for every budget and interest.
Iconic attractions include the Arts Precinct, Museums Victoria (including the Bunjilaka Aboriginal Cultural Centre), State Library Victoria, Federation Square, and sporting and cultural venues.
The ISA 2024 venue is near Melbourne's CBD which offers delegates several dining and entertainment options for all budgets and within easy walking/public transport distance.
From Fitzroy's bohemian reputation to the Southbank waterfront dining, shopping and strolling options, or Lygon Street restaurants, delegates will find much to enjoy in Melbourne's city life.

Venue

Welcome to The University of Melbourne, Parkville Campus

The University of Melbourne is Australia's second oldest university. Its main campus is located in Parkville in the Melbourne CBD. This historic campus is at the heart of three globally recognised innovation precincts. Six specialist campuses across Victoria provide immersive education in life sciences and agriculture.
The campus is situated within walking distance of much of the Melbourne inner city and with the use of public transport has access to much of the city of Melbourne and surrounds.

Venue details

The venue is in the School of Geography, Earth and Atmospheric Sciences.
All the oral and poster presentations will be hosted at Theatre B117 and Foyer B115 in the Glyn Davis Building, B133, Melbourne School of Design.

ISA2024 timetable

Monday		
8.00-9.00	Registration	Session
9.00-9.30	Welcome to Country	
9.30-10.00	Conference opening	
10.00-10.45	Morning tea	
10.45-11.00	N. Babucic	S2
11.00-11.15	S. Fraser	S2
11.15-11.30	A. Güngör	S2
11.30-11.45	I. Moffat	S2
11.45-12.00	Q&A	S2
12.00-13.10	Poster	SA
13.10-14.15	Lunch	
14.15-14.30	I. Reiche	S1
14.30-14.45	R. Popelka-Filcoff	S1
14.45-15.00	S. Mahan	S1
15.00-15.15	B.L. MacDonald	S1
15.15-15.30	M. Crombie	S1 (V)
15.30-15.45	J. Huntley	S1
15.45-16.00	Q&A	S1
16.00-16.30	Afternoon tea	
16.30-17.15	I. Waina, A. Gleadow	KN
18.00-20.00	Welcome reception	

Tuesday		
8.00-9.00	Registration	Session
9.00-9.15	L. Germinario	S8
9.15-9.30	V. Razzante	S8
9.30-9.45	M. Quilici	S8
9.45-10.00	S. Piña Guido	S8 (V)
10.00-10.15	Q&A	S8 (V)
10.15-10.45	Morning tea	
10.45-11.00	P. Pizzo	S8
11.00-11.15	M. Kalofonou	S8
11.15-11.30	Q&A	S8
11.30-12.40	Poster	SA
12.40-13.45	Lunch	
12:50-13:45	IAEA	
13:45-14:00	A. Simon	S8
14.00-14.15	J. McGloin	S5
14.15-14.30	N. Stern	S5
14.30-14.45	C. Longford	S7
14.45-15.00	M. Turnbull	S7
15.00-15.15	J. Mulder	S7
15.15-15.30	M. Belmaker	S7
15.30-15.45	Q&A	S5+S7
15.45-16.15	Afternoon tea	
16.15-16.30	M. Odler	S5
16.30-16.45	B. Chang	S5
16.45-17.00	C. Mather	S5
17.00-17.45	E. Oras	KN
18.00-20.00	ECR event	

Wednesday		
8.00-9.00	Registration	Session
9.00-9.15	Y.L. Wu	S3
9.15-9.30	M.Duval	S3
9.30-9.45	S. Samim	S3
9.45-10.55	MT/posters	SB
10.55-11.10	W. Yu	S3
11.10-11.25	D. Finch	S3
11.25-11.40	I. Dias	S5
11.40-11.55	S. Lin	S5

Thursday		
8.30-9.30	Registration	
9.30-9.45	C. Snoek	S4
9.45-10.00	H. Green	S4
10.00-10.15	J. Russ	S4
10.15-10.45	Morning tea	
10.45-11.55	Posters	SB
12.00-12.15	M. Murillo-Barroso	S4
12.15-12.30	C. Scaggion	S4 (V)
12.30-12.45	S. Samper Carro	S4
12.45-13.00	Q&A	S4
13.00-14.00	Lunch	
14.00-14.15	K. Cooke	S4
14.15-14.30	L. Pospieszny	S4
14.30-14.45	C. Kelepeshi	S6
14.45-15.00	C. Klesner	S6
15.00-15.15	D. Zampierin	S6 (V)
15.15-15.30	Q&A	S4+S6
15.30-17.00	Afternoon tea	
17.00-17.15	S. Liu	S6
17.15-17.30	J. Gao	S6
17.30-17.45	T. Liu	S6

Friday		
8.00-9.00	Registration	
9.00-9.15	M. Gulmini	S6
9.15-9.30	A. Franjic	S6
9.30-9.45	Q.-Q. Lu	S6
9.45-10.00	L. Liu	S6
10.00-10.15	W. Li	S6
10.15-10.30	L. Qin	S6
10.30-10.45	J. Kmosek	S6 (V)
10.45-11.15	Morning tea	
11.15-11.30	J. Meanwell	S6
11.30-11.45	J. Vieri	S6
11.45-12.00	V. Orfanou	S6
12.00-12.15	M. Davis	S6
12.15-13.25	Poster	S6
12.30-13.30	Lunch	
13.30-13.45	F. Rademakers	S6
13.45-14.00	I. Montero-Ruiz	S6
14.00-14.15	Q&A	S6
14.15-14.45	Poster	SB
14.45-15.15	Afternoon tea	
15.15-16.30	Closing ceremony	
19.00-22.00	Conference dinner	

Session 1 (S1): Rock art and pigments
Session 2 (S2): Field methods and remote sensing in archaeological science
Session 3: Dating methods
Session 4: Bioarchaeology and biomolecules
Session 5: Stone, residues, use wear
Session 6: Ceramic, metal, vitreous
Session 7: Human-environment interactions
Session 8: Architectural and cultural heritage archaeology

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Ina Reiche 1, José Tapia Reguera 1, Patrick Paillet 2, Matthias Alfeld 3, Yvan Coquinot 1, Anne Maigret 1, Elena Paillet 4

1- CNRS-C2RMF, France
2- MNHN, France
3- TU Delft, Netherlands
4- MC

Combined hyperspectral imaging with portable spectroscopic investigations of Paleolithic cave art in the Font-de-Gaume cave

We have developed a complementary and completely non-invasive analysis methodology in order to better characterize the materiality of the complex decoration of the Font-de-Gaume cave. During several missions over the past ten years, we have optimized the analysis methods and imaging to acquire a better knowledge of the coloring materials used, with a view to shedding new light on the organization and the sequence of realization of the different prehistoric figures in the main galleries open to the public. These analyses also contribute to a better understanding of the taphonomic processes that affected the parietal works. On site hyperspectral imaging techniques was combined with portable X-ray fluorescence analysis and on site microRaman spectroscopy. Imaging makes it possible to observe coloring materials at the scale of panels and figures, complemented by punctual physico-chemical analyses by Raman spectroscopy and portable X-ray fluorescence. This makes it possible to limit the number of analyses required per figure, to extrapolate the physico-chemical analysis results to the entire figure and to better decipher their narratives. The improved reading can support the discussion of the meaning and the role of the representations at the scale of a figure, a panel or even an entire frieze in the cave.

Rachel Popelka-Filcoff 1, Rafaella Georgiou 2, Illara Bonaduce 3, Jordan Spangler 4, Serge Cogen 2, Roy Lehmann 4, Sylvain Bernand 5, Jean-Pascal Rueff 6

1- University of Melbourne
2- University Paris-Saclay
3- Universita di Pisa
4- Flinders University
5- Sorbonne University
6- Synchrotron Soleil

Using spectroscopy to disentangle the chemistry of Australian plant exudates from a unique historical collection

For thousands of years, the unique physicochemical properties of plant exudates have defined uses in material culture and practical applications. Native Australian plant exudates, including resins, kinos, and gums, have been used and continue to be used by Aboriginal Australians for numerous technical and cultural purposes including pigment binders. A historic collection of well-preserved native Australian plant exudates, assembled a century ago by plant naturalists, gives a rare window into the history and chemical composition of these materials. Here we report the full hierarchical characterization of four genera from this collection, Xanthorrhoea, Callitris, Eucalyptus, and Acacia, from the local elemental speciation, to functional groups and main molecular markers. We use high-resolution X-ray Raman spectroscopy (XRS) to achieve bulk-sensitive chemical speciation of these plant exudates, including insoluble, amorphous, and cross-linked fractions, without the limitation of invasive and/or surface specific methods. Combinatorial testing of the XRS data allows direct classification of these complex natural species as terpenoid, aromatic, phenolic, and polysaccharide materials. Differences in intragenera chemistry was evidenced by detailed interpretation of the XRS spectral features. We complement XRS with Fourier-transform infrared (FT-IR) spectroscopy, gas chromatography– mass spectrometry (GC-MS), and pyrolysis–GC-MS (Py-GC-MS). These techniques provide insight into exudate uses for pigment binders and priming layers. This multimodal approach provides a fundamental understanding of the chemistry of these natural materials long used by Aboriginal Australian peoples.

Session 1 Rock art and pigments
Oral presentations

Samantha Mahan 1, Alexa Kuo 1, David Stalla 2, Gregor D. Bader 3, Brandi MacDonald 1
1- Archaeometry Laboratory, University of Missouri Research Reactor Center
2- Electron Microscopy Core, University of Missouri
3- Senckenberg Center for Human Evolution and Paleoenvironment, Universität Tübingen

Multi-analytical Characterization of Ochre Pigments in Eswatini Rock Art

Ochres, iron oxide rich pigments, are among the most well-known pigments in archaeology and are widely used in rock art. Characterization of these pigments have been used for provenance studies, with implications for resource management or possible trade, and other information about past human behavior. Rock art in southern Africa has been studied in several countries in the region but none yet in Eswatini. Presented here are the results of a multi-analytical analysis of samples from seven rock art sites in northern (Sibebe, Nsangwini, Ntfonjeni, Mkhumbane, Nkambene), southern (Nhlonhleni), and eastern (Muti Muti) Eswatini dating to the Late Stone Age. Scanning electron microscopy energy dispersive spectroscopy (SEM-EDS), Raman spectroscopy, and Fourier-transform infrared spectroscopy (FTIR) were utilized to provide a robust characterization of the ochre samples and show evidence of distinct ochres utilized across the regions.

Brandi L. MacDonald 1
1- Archaeometry Laboratory, University of Missouri Research Reactor Center

Looking Closer: Indigenous Ochre Pigment Materiality and Rock Art Painters at Babine Lake, Canada

Pictographs, and the landscape formations they are featured upon, are culturally significant places among Indigenous communities. I present the results of a recent study on pictographs and the mineral pigments used to produce them at Babine Lake (Canada), in the traditional territory claimed by the Lake Babine Nation, the Tl'azt'en Nation, and the Yekooche Nation. The monochrome motifs were produced with iron oxide mineral pigments (red ochre), and are all painted on prominent, open-air rock faces overlooking deep water. This study also includes collection and analysis of red ochre pigment sources within the area for comparison to the pictographs. Using a series of microanalytical methods applied to the local raw materials and rock art paints, I offer insights into characteristics of pigment materiality, such as artistic selection of minerals with different physicochemical properties and the chaîne opératoire of paint preparation. The results show that rock art painters at Babine Lake chose a diversity of iron oxide types to produce different pigment mixtures with distinctive properties, including the harvesting and thermal enhancement of iron-rich biominerals from colonies of aquatic, iron-oxide-producing bacteria.

Session 1 Rock art and pigments
Oral presentations

Maddison Crombie 1, Agathe Lise-Pronovost 1, Rachel Popelka-Filcoff 1, Marcus Giansiracusa 2, Colette Boskovic 2, Amy Roberts 3, River Murray and Mallee Aboriginal Corporation 4
1- School of Geography, Earth and Atmospheric Sciences, University of Melbourne
2- School of Chemistry, University of Melbourne
3- Archaeology, College of Humanities, Arts and Social Sciences, Flinders University
4- c/o South Australian Native Title Services, Adelaide

A new approach to ochre provenance: Using mineral magnetism to fingerprint cultural ochre sources.

Provenance studies in ochre research are used to characterise the "fingerprint" of different ochre sources, providing the opportunity to trace the cultural movement of ochre in the archaeological past. Ochre pigment composition, and therefore the "fingerprint", often varies between sites leading to source discrimination, but in many cases the composition can also vary within a site, and therefore presents an analytical challenge to develop methods that can differentiate this "fingerprint". This work presents a novel protocol for the analysis of iron- based archaeological ochres from known sources within Australia and Kenya using geological mineral magnetism methods to disentangle complex mineral assemblages1. Magnetic properties have been largely unexplored as a tool for ochre provenance. However, the use of measurements such as room temperature – saturation isothermal remnant magnetisation (RT-SIRM), Hysteresis loops and zero field cooled, field cooled (ZFC-FC) allow for the identification of different magnetic minerals in the ochre samples, which can, in turn, be used to fingerprint ochre sources. This approach works towards understanding (1) the variation within and between sites and how this may differ based on source geologies and (2) the larger goal of tracing the movement of ochre from their sources to archaeological contexts and related ochre cultural exchange.

Jillian Huntley 1, Clarry Nadjamerrek 2, Carolyn Coleman 3, Lynley Wallis 2,4, Brandi L. MacDonald 5, May Nango 2, Djaykuk Djandomerr 2, Helen E.A. Brand 6
1- Griffith Centre for Social and Cultural Research
2- Gundjeihmi Aboriginal Corporation, Jabiru, Northern Territory (The Alligator Rivers region)
3- Bininj Kunwok Regional Language Centre, Jabiru Northern Territory
4- Griffith Centre for Social and Cultural Research, Gold Coast, Queensland
5- Archaeometry Laboratory, University of Missouri Research Reactor
6- Australian Synchrotron, Clayton, Melbourne

Ochre: documenting sources and roasting 'Bininj way' in Mirarr Country, The Alligator Rivers Regions, Northern Australia.

The gathering, preparation, and use of ochres (Earth mineral pigments) is a material trait that has been associated with modern people throughout the world for more than 150,000 years. A preparation for ochres documented from deep antiquity to the present is their roasting – commonly cooking in Earth ovens, something recorded in many cultures including in the lifeways of Indigenous peoples throughout Australia. Here we outline some of the sources of ochres that we have documented in Mirrar Country and present the results of Synchrotron Powder Diffraction analysis from the roasting of a samples of these pigments 'Bininj Way', in Earth ovens using two different heat retainers. We discuss ochre qualities in the Alligator Rivers Regions in the broader context of an ongoing project that explores Mirrar Traditional Owners' rich record of continuous ochre use known to stretch 60,000 years back in time.

Session 1 Rock art and pigments
Poster presentations

Noa Abrahams 1, Rachel Popelka-Filcoff 1
1- University of Melbourne

Shining light on Aboriginal Australian ochre pigment provenance

In developing techniques for investigating the provenance of Aboriginal Australian ochre pigments, non-destructive methods are advantageous in providing characteristic information regarding materials present, without interfering with culturally significant sites.
Reflectance spectroscopy provides a qualitative analysis as an important primary indicator of minerology and chemical composition of such ochre pigments. While this technique has been extensively researched in a non-Australian (primarily European) art context, here it is applied to an indigenous Australian setting, where distinctive site weather conditions, and pigment composition and preparation, require novel method development. Building on knowledge from international contexts, under Australian conditions, develops important methodology of sample identification for otherwise inaccessible sites, and could also enable the creation of a local library of ochre identification data. Standard ochre samples were analysed using the Gorgias Reflectance Spectrometer—in contact and at varying distance to the sample, in artificial, natural light and dark conditions, and with varied light exposure to the probe—to determine ideal conditions for result optimization and reproducibility. By establishing a methodology specifically for pigments used in the indigenous Australian context, characterisation is possible at culturally significant locations, enabling reliable, efficient, and non-destructive site assessment.

Yogambar Singh Farswan 1
1- Department of History, Ancient Indian History, Culture and Archaeology, Hemvati Bahuguna Garhwal University Srinagar Garhwal

Study of Newly Discovered Prehistoric Rock Art Sites in Panna District of Madhya Pradesh, India

The literary data revealed that the Panna district of Madhya Pradesh, India has not been explored extensively in the context of prehistoric archaeology. The present study was considered, keeping in view the same. For this purpose, an extensive exploration of the Panna district was conducted systematically. Panna district is also well known for its cultural heritage, diamond mining and a national tiger reserve. The majority of rock art sites in this area, we have discovered are located around waterfalls such as Badedev Rakseha, Sher Ki Chul, Hatyara-Bedhak Kunda and Panni waterfall etc.
The paintings recovered from these sites are not in good condition therefore, to identify them properly they were analysed by using DStrech techniques. After enhancement, the images of paintings are identified and presented systematically. Results of the DStrech analysis revealed that the themes of paintings are mainly hunting, dancing, battle scenes, food gathering, cattle rearing, figures of animals, decorative motifs, artwork or paintings on the wall of rock, handprints, historical paintings, paintings of humans, flora, zoomorphic figurines, handprints, abstract patterns and geometric as well as non-geometric designs. It is also noticed that the paintings recovered from these rock shelters were made using red or ochre colours.
Geomorphological and geographical estimations also suggested that these prehistoric rock art sites were mainly located near the water source and forest lands. Based on rock art style, colour, composition, technique, theme, subject matter; motifs; such as hunting scenes and the large number of animal groups, it is assumed that this site was inhabited by hunter-gatherer groups of prehistoric people. Finally, we can say that the discovery of these prehistoric sites enhanced our knowledge about the prehistoric culture of the central Indian region.

Ishara Pathirage 1, Janet Hergt 1, Rachel Popelka-Filcoff 1, Jo McDonald 2
1- School of Geography, Earth and Atmospheric Sciences, University of Melbourne
2- Centre for Rock Art Research+ Management University of Western Australia, WA, Australia

Understanding rock art canvas options: whole rock trace element compositions of Rosemary Island and Burrup Peninsula gabbros (Dampier Archipelago, Western Australia)

The Dampier Archipelago (known as Murujuga to its traditional custodians), Western Australia, holds one of the largest collections of Aboriginal rock art in Australia. The ancestors of these cultural landscapes have left behind millions of petroglyphs, which are engraved with skill and detail, revealing the fascinating legacy of beliefs, traditions, and artistic expressions dating back thousands of years. The petroglyphs include symbols, human figures, animals, animal tracks and many other motifs that have been carved, pecked and scratched into the weathered surfaces of the rock substrate. The ancestors have chosen several lithologies for their artwork, and the present study aims to investigate one of these – the Rosemary Island (RI) gabbro. Based on their examination of the motif style and mode of production, McDonald et al. (2022) concluded that the RI gabbro hosts some of the oldest artwork in Murujuga. One of the goals of this study is to examine the mineralogy and geochemical composition of weathering rinds to better understand the age and long-term preservation of the artwork. Before this can begin, it is essential to characterise the whole-rock composition of 'fresh' RI gabbro samples, document any petrographic and geochemical variations within it, and determine how it differs from the gabbros found elsewhere in the archipelago. Inductively coupled plasma mass spectrometry (ICP-MS) has been applied to the determination of 48 elements including the major elements P, Ca, and Ti and the data reveal considerable variation in composition (e.g., a 6-fold variation in Cr concentration). Similar data acquired for gabbros from the Burrup Peninsula confirm the distinct composition of the RI gabbro identified by Fairweather (2019). This work aims to understand the preservation of a deep time style sequence on RI gabbros and aligns with a parallel project being undertaken to explore the production of desert varnish, also found on the oldest art styles on Rosemary Island.

Maedeh Darzi 1
1- School of Geography, Earth and Atmospheric Sciences, University of Melbourne

Colourants in Illuminated Islamic Manuscripts: Qajar Period (1789–1925 C.E.), early modern Iran

Manuscripts, as tangible cultural artefacts, serve as invaluable windows into the past, reflecting the evolution of the alphabet, calligraphy, and artistic techniques, while also offering insights into questions such as traditional colour characteristics, raw material sources, and production methods. The tradition of calligraphy and manuscript illumination in Iran dates to the early third century C.E., to the Manichaean religion (Sassanid Iran), evolving through various cultural and political changes.

Utilising SEM-EDX, micro-Raman spectroscopy, and FTIR, the non-destructive identification and characterisation of elemental compositions and molecular signatures of colourants and substrate in illuminated Islamic manuscripts from the Qajar period were obtained. The analysis of non-ink substrates reveals that cellulose is the primary paper component, with proteinaceous sizing and mineral-based fillers (e.g. aluminosilicate, gypsum, chalk) enhancing quality and reducing the costs of production. Abiotic foxing is a common paper degradation product.

A prevalence of mineral-based pigments has been revealed such as carbon black, ultramarine, Prussian blue, vermillion, and red lead as well as a mixture of vermillion and red lead in the identified colourants. The identification of metallic inks/paints such as brass, pure gold, and gold-silver alloy that contributed to gilding showcases the intricate technology of colour production during this period. The origin of carbon-black has been traced to either soot or charred plant material, and ultramarine was sourced from natural minerals (lazurite from lapis lazuli), whereas vermilion and red lead are found to be artificially manufactured (Darzi et al., 2021). The research highlights challenges associated with Raman spectroscopy posed by fluorescence inherent to some materials.

Session 2 Field methods and remote sensing in archaeological science
Oral presentations

Nikola Babucic 1
1- University of Hamburg

Bridging the Gap: Integrating Non-Invasive Technologies and Traditional Archaeological Methods in the Comprehensive Exploration of Colonia Ulpia Traiana (Xanten)

The paper presents the findings of a comprehensive investigation into Colonia Ulpia Traiana (CUT - Xanten), where only 15% of the 70 ha large site has undergone archaeological exploration. Jointly conducted by the Institute of Classical Archaeology at the University of Hamburg and the LVR Archaeological Park Xanten since 2013, the research utilizes state-of-the-art geophysical surveys, including geomagnetics and georadar. The primary objective has been to classify and standardize geophysical measurement results, incorporating various methods such as magnetics, susceptibility measurements, georadar, aerial archaeology, and the reprocessing of older excavation documentation.

Shaye Fraser 1, Mariela Soto-Berelov 1, Lucas Holden 1, Robert Hewson 2, John Webb 3,
1- STEM College, RMIT University, Melbourne, Australia
2- Department of Applied Earth Sciences, Faculty of Geo-Information Science and Earth Observation (ITC), University of Twente, Enschede, The Netherlands
3- Discipline of Ecology and Environment, La Trobe University, Victoria, Australia

Unearthing the history of the Victorian Volcanic Plain: Mapping stony rise landforms using remotely sensed data and a machine learning approach

Basalt outcrops, locally known as Stony Rises, are prominent Pliocene volcanic landforms found throughout the Victorian Volcanic Plain (VVP), which stretches westwards from Metropolitan Melbourne Victoria towards the Victorian-South Australian boarder in Australia. Stony rises have associated geological and cultural values. Geologically, stony rises and the VVP showcase the rich geological history of Victoria. Culturally, stony rises are important for various First Nations groups throughout Victoria as they provide evidence of Indigenous land use and occupation through the presence of artefact deposits. Additionally, the basalt boulders from stony rises were used by early European settlers in the construction of drystone walls and farm buildings. Stony rises in Metropolitan Melbourne are under threat from rapid urbanisation and land development. Currently, stony rises are mapped on a case study basis performed by traditional field surveys. This presents an opportunity to map stony rises using remotely sensed data such as LiDAR, aerial and satellite imagery, and geophysical data, using machine learning techniques. This study maps stony rises in a case study area in Metropolitan Melbourne utilising remotely sensed and geophysical data with machine learning. Additionally, we assess the destruction of Stony Rises due to development over the last 50 years. It was found that stony rises located within metropolitan Melbourne could be mapped successfully with predictor variables such as slope, local elevation, the concentrations of thorium and uranium, total magnetic intensity, the Normalised Difference Water Index, and the Clay Mineral Ratio. Also, approximately 55 stony rises have been destroyed since the 1970's due to land development. The results highlight the applicability of remotely sensed data and machine learning in detecting stony rise landforms at a landscape level. Such maps created by machine learning techniques have the potential to assist with targeted archaeological surveys to recover cultural material and preserve these landforms.

Session 2 Field methods and remote sensing in archaeological science
Oral presentations

Aylin Güngör 1, Martina Seifert 1, Fabian Schenn 1, Nils Thiele-O'Sullivan 1, Maria Grazia Griffo 2, Mauro LoBrutto 3, Antonella Mandruzzato 3, Anna Occhipinti 2

1- University of Hamburg
2- Parco Archeologico di Lilibeo-Marsala, Italy
3- University of Palermo, Italy

Mapping Ancient Lilybaeum. Strategies for complex multi-dimensional areas and different time phases in a two-dimensional WebGIS

The DFG-funded project "Lilybaeum. Principles of Urban Development" is a collaborative project between the University of Hamburg, the University of Palermo and the Archaeological Park of Marsala, Sicily. Since 2017, the team from both universities work on the archaeological map of ancient Lilibeo/Lilybaeum. A topographic map of all the known archaeological areas in a WebGIS is still a desideratum up to the present date.
The research focus is on the ancient city plan in different time phases, using new survey data as well as already existing data. The long process of data collection and analysis will serve the future qualitative description of Lilybaeum within the supra-regional network of Sicilian cities.
Questions of space and time are essential when creating an archaeological map. One of the main problems is the visualisation of relatively chronological data as well as complex multi-dimensional areas. The project has developed several strategies and solutions that will be discussed in the context of digital strategies. In particular, integration and presentation in geographic information systems through the combination of 2D and 3D methods offers solutions for complex multi-dimensional structures in areas such as necropolises. In addition, "the codified survey" has been developed as a new standardised method which meets the needs of practice by providing a systematic approach to address finds. The paper addresses issues related to dating problems and difficulties, and discusses how to deal with open concepts and temporally vague information.

Ian Moffat 1, Patrick Hesp 2, Amy Roberts 1, Martin Polkinghorne 1, Eddie Banks 2, Graham Heinson 3, Rob Fitzpatrick 4, Xanthé Mallett 5, Philippe De Smedt 6, Petra Schneidhofer 7, Nikos Papadopoulos 8 and Apostolos Sarris 9

1.Archaeology, College of Humanities, Arts and Social Sciences, Flinders University
2.College of Science and Engineering, Flinders University
3.School of Physics, Chemistry and Earth Sciences, The University of Adelaide
4.School of Biological Sciences, The University of Adelaide
5.School of Law and Justice, The University of Newcastle
6.Department of Environment and Department of Archaeology, Ghent University
7.Vestfold County Council
8.Institute for Mediterranean Studies, Foundation for Research and Technology-Hellas
9.Lab of Digital Humanities GeoInformatics, University of Cyprus

A National Facility for the 3D Imaging of the Near Surface

In 2021 we received funding from the Australian Research Council to establish a National Facility for the 3D Imaging of the Near Surface at Flinders University in Adelaide, Australia. This facility has purchased next generation geophysical instruments for high-resolution landscape scale mapping of the shallow subsurface, including a Mala Mira HDR multi-sensor Ground Penetrating Radar and a Sensys MX V3 multi-sensor gradiometer. The expansive size and impressive density of data from these instruments, which are unique in Australia, is fundamentally changing the research questions that can be asked in the fields of archaeology, earth, environmental and forensic science, and providing new opportunities for student education.
These instruments have been used for surveys of high profile archaeological and forensic sites in Australia and Cambodia including historic cemeteries, colonial homesteads, Indigenous sites, a Khmer Rouge prison and Angkorian period temples and industrial sites. This poster presents preliminary results from these projects and provides further information on how researchers from other institutions can access these instruments without cost.

Session 2 Field methods and remote sensing in archaeological science
Poster presentations

Andrew Frost 1
1- Flinders University

Geophysical methods, unmarked graves and the effects of seasonal rainfall on their detection.

The burial of human remains has become an important part of the Archaeological record. Analysis of these remains can disclose much information on social status, diet, age, ancestral lineage, evolutionary development, etc. Locating these graves is important not only for scientific analysis but can also provide information to community and cultural groups, cemetery authorities, and even law enforcement. Geophysical methods have long provided non-invasive and non-destructive ways of locating these burials. Recent longitudinal research has been undertaken in South Australia to assess the effectiveness of two geophysical methods, and their relationship between seasonal changes in soil moisture. Results presented here will show the changes that were experienced in three different soil environments from the dryer parts of South Australia.

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Digital documentation of Ancestral Pueblo rock art from the Canyons of the Ancients National Monument, Mesa Verde region, southwestern Colorado (USA)

This paper focuses on the application of digital methods for documentation, analysis, and subsequent visualization of Ancestral Pueblo rock art (paintings and petroglyphs) dated roughly to the twelfth and thirteenth century AD and located in the three canyons of southwestern Colorado (USA): Sand Canyon, East Fork of Rock Creek Canyon, and Graveyard Canyon. These canyons are part of the legally protected area of the Canyons of the Ancients National Monument, one of the most archaeologically rich and significant places in the entire North America. The project has been conducted since 2011 by the Department of New World Archaeology, Institute of Archaeology, Jagiellonian University in Krakow, Poland.
Several digital methods for documentation, inventory, and spatial analyses were applied: advanced digital photographic techniques including RTI/Reflectance Transformation Imaging and panoramic photography; close-range and UAV/drone photogrammetry and Structure-from-Motion (SfM); as well as terrestrial laser scanning (TLS) and initially LiDAR. The RTI method (including a virtual/VRTI developed by our team) together with the DStretch application was used especially for documentation and interpretation of poorly preserved and faint rock art panels. Other software was applied for visualization, but also integration of various kinds of data, including RealityCapture, Agisoft Metashape, and ArcGIS software. It was also supported by hand tracings of panels in the field and mostly on the basis of collected digital data in the laboratory.
Later interpretations and analysis were carried out with extensive consultations with rock art scholars and members of the Hopi tribe, one of the modern Pueblo groups, direct descendants of the Ancestral Pueblo people that once lived in those canyons. All together serve as a real help for the heritage management, conservation, and future protection of the sites.

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Interdisciplinary research to understand the formation and age of rock varnish at Murujuga, Western Australia

Murujuga's rock art is located across the Dampier Archipelago: petroglyphs pecked into the dark weathering rind to reveal the contrasting lighter-coloured bedrock. Occasionally, rock varnish has formed on these surfaces, including over petroglyphs, therefore the rock varnish is a potential clue to reveal the maximum and minimum dates of production. The Dating Murujuga's Dreaming ARC Linkage Project is investigating the local characteristics of this rock varnish. Research foci include the macroscale of varnish distribution on rocks across the landscape to the microscale observations. Initial analysis of varnish coverage on rock art panels recorded over the last decade by CRAR+M suggests higher proportion of varnish formation on coarser-grained rocks in comparison to finer-grained rocks. Microscopic observations reveal the coarser-grained rocks host rock varnish with more stromatolite-like structures. Differences in varnish micromorphology could be attributed to coarser-grained surfaces as more resourceful habitat for microbiomes, such as protection and moisture retention. Localized environmental variations recorded in varnish are also under investigation, as well as identifying varnish ages by comparing with other sets of chronological data. This presentation will share analytical results achieved so far at the landscape and microscopic scales, concluding with where the research is leading to understand the age of petroglyph production in this important cultural landscape.

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To what extent high resolution mCT-scanning of hominin fossil remains may impact ESR and Radiocarbon dating results ?

In palaeoanthropological research, the study of human fossils is conditioned by the necessity to cause minimum damage to these rare and valuable remains. In this context, micro-computerized tomography (mCT) scanning of fossils is nowadays routinely used to record a high resolution three-dimensional reconstruction of samples, enabling to obtain critical information about the morphology or internal structure of the fossil, and create a digital archive of fossils that may be destructively analysed later. While these destructive analyses may be carried out for a wide range of purposes, including palaeodiet or palaeoenvironment reconstructions, mobility studies, ancient DNA and Geochronology, the potential impact of mCT scanning on the analytical results has been very little investigated so far.
In the present work, we focus our investigations on the Radiocarbon and Electron Spin Resonance (ESR) dating methods, which can both be directly applied to fossils. While Radiocarbon dating is the most widely used for any fossils younger than 50 ka, ESR can take over for older specimens. In particular, the latter has become very popular over the last couple of decades, with the dating of several key human fossils, such as those from Jebel Irhoud, (Morocco), Atapuerca Gran Dolina (Spain), Rising Star (South Africa) or Milsiya (Israel). It is therefore crucial to establish whether mCT scanning has a negative impact on the associated ESR and Radiocarbon analysis, and, if any, to determine how this impact can be reduced. We selected several fossil samples for this purpose and carried out a series of tests with various conventional mCT instruments and using a range of acquisition parameters. Our results show that mCT scanning may not only significantly affect the preservation of the collagen in bones and teeth used for Radiocarbon dating, but also induce a non-negligible radiation dose to the enamel, artificially aging a given fossil sample dated by ESR. Consequently, we recommend caution regarding the systematic and unlimited use of mCT scanning in palaeoanthropology.

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A Turkana Tale: Stratigraphic complexities in interpreting ultra-high resolution 40Ar-39Ar ages of closely spaced tuffs in Nadung'a, West Turkana

The Turkana Basin, Kenya, is renowned for the discoveries of numerous Plio-Pleistocene archaeological sites containing multiple hominin species and their associated cultural technologies. The sedimentary sequences in the Turkana Basin are interbedded with volcanic ash layers (tuffs) that provide age constraints for their enclosed palaeontological and archaeological artefacts. The Nadung'a sites in West Turkana, are particularly valuable as they comprise some of the rarely documented Lower-early Middle Pleistocene sites in East Africa, known for the discovery of a hominin molar and an extensive lithic assemblage that diverges from the conventional Acheulean toolkit prevalent during that time period. The maximum age limit of the Nadung'a sites has been provided by underlying tuffs from the Nariokotome Tuff Complex, comprising the Lower, Middle and Upper Nariokotome tuffs. Unfortunately, the ability to identify which of these tuffs constrains the age of the Nadung'a sites is hampered by a) the inability to distinguish the eruption ages of the three tuff units (because published age constraints overlap) and b) the similar major element compositions of the Middle and Upper Nariokotome tuffs. In addition, fluvial reworking of pumice clasts (the target rock for age determinations) from older volcanic deposits into younger tuff layers can result in erroneous age estimates for a given layer, further inhibiting correct age assignments for a specific site.
Here, we address this problem by combining two tephrochronological tools: single-grain, ultra-high resolution 40Ar-39Ar geochronology of feldspars from pumices enclosed within tuffs, and LA-ICP-MS trace element geochemistry applied to tuff and pumice glass samples. Utilising modern day mass-spectrometers we report the first distinguishable ages for the three Nariokotome tuffs; Lower (1,284.3 ± 2.4 ka; 2σ), Middle (1,263.4 ± 1.9 ka) and Upper (1,228.3 ± 1.2 ka) Nariokotome. In addition, by applying LA-ICP-MS to individual tuff glasses, we obtain unique geochemical fingerprints for these layers and use these to confirm the comagmatic origin of pumice clasts selected for dating. Together, these datasets have succeeded in identifying which of the Nariokotome tuffs is associated with the Nadung'a sites, providing tighter constraints on the maximum age of these important archaeological locations. The combined methodology, therefore, refines the tephrostratigraphy of the region and demonstrates the potential to resolve the stratigraphic complexities associated with assigning ages to archaeological sites.

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Dose assessment of two fossil tooth fragments from Jebel Irhoud (Morocco) and Broken Hill (Zambia) using the SA decomposition CO2- radicals model in ESR dating

This paper presents dose estimations of two fossil tooth fragments from Jebel Irhoud (JI) and Broken Hill (BH). An automated simulated annealing (SA) procedure was applied to the ESR decomposition of two fragments. Both fragments show very different patterns on the natural and irradiated spectra. The SA decompositions of the merged spectra of both BH and IR have shown a very different repartition of AICORs ratios. The Irhoud sample shows an atypical non-CO2- components concentration especially after laboratory irradiation with only one irradiation sensitive lines. At the same time, Wi3 behaves differently in both samples, with saturation occurring sooner in IR than in BH. The influence of irradiation on the AICORs ratio differ from one sample to the other, with 79:21 and 70:30 in IR and BH respectively. The results imply that published ESR dating results will usually be age underestimations. However, the exact AICORs ratios are tooth-dependent and should be calculated for each tooth.

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Chronometric ages for Australian Aboriginal Rock Art

The Kimberley region in north-western Australia is home to one of the world's richest rock art provinces. Extensive fieldwork by earlier researchers, since the 1990's, led to the development of a detailed stylistic sequence thought to date back to the Pleistocene. A key objective of two Australian Research Council Linkage projects, led by the University of Melbourne, was to develop geochronological dating techniques to derive an absolute, robust, time scale for this sequence of Aboriginal rock art.
One of the techniques developed uses radiocarbon dating of mud wasp nests, occasionally found overlying or underlying rock paintings. The ages determined for the wasp nests then serve as maximum and minimum age constraints for the rock art. Initial results, based on a dataset of 75 dated wasp nests, were published in 2020 and 2021. They provided substantial evidence of Pleistocene antiquity for the two oldest phases of painted rock art in the Kimberley stylistic sequence: the Irregular Infill Animal period and the Gwion period.
Since then, a further 360 wasp nests in contact with Kimberley rock art have been dated. Nest samples were collected from 103 rock art shelters up to 100 kilometres apart in Balanggarra country in the far north of Western Australia. These dates are being used to estimate the age span of each of the five main Kimberley rock painting styles that extend back from modern times to the Last Glacial Maximum. Statistical analysis of the dataset explores the reliability of such estimates, given the sample sizes for each stylistic period.
Such a large number of geochronometric ages provides unique insights into the evolution of artistic styles under the influence of major environmental changes in the region.

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Radiocarbon Dating of Mummified Human Remains from the Maranga Archaeological Complex, Peru

The Maranga Archaeological Complex is located in the Rímac River Valley in Lima, on the central coast of Peru. It was an urban center operating from the beginning of the first century AD until the mid-16th century. The origins of the site are related to pre-Hispanic Lima culture, after which the center fell under the rule of the Ichma culture, until it was finally incorporated within the Inca Empire. In 1925, Ecuadorian archaeologist Jacinto Jijón y Caamaño (1890–1950) conducted excavation work in the area of three pyramids (huacas): San Marcos, Concha and Middendorf, discovering numerous human burials and ceramic elements.
The aim of our studies was to record and analyse preserved body decorations, following an interdisciplinary approach. Within the scope of the planned analytical procedure, absolute dating analyses were performed on the mummified human remains, currently held by the Museo Jacinto Jijón y Caamaño (Quito, Ecuador). Radiocarbon analyses successfully determined the chronological and cultural affiliation of the mummies and linked the probable tattoos to a specific archaeological culture that existed in the Central Andes.

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Regional paleomagnetism: towards a new dating tool for Australian Archaeology

The Earth's magnetic field is not uniform at the Earth surface. These regional changes in geomagnetic field intensity and directions through time can be used to date fired artefacts in the archaeological record and natural archives. Regional paleomagnetism is a robust relative dating method that can reach age uncertainties comparable to radiocarbon dating in some parts of Europe, where abundant regional paleomagnetic data is available. However, in Australia, paleomagnetic data is limited and regional paleomagnetic dating impractical. Here I present recent work addressing this issue and report on progress towards providing a new dating tool for Australian Archaeology. I will present paleomagnetic results from lake sediments and cave stalagmites that document the Earth's magnetic field history in south-east Australia over the last 20,000 years. I will discuss challenges and successes, and future applications for regional paleomagnetic dating, including investigating fire technologies and estimating the age of the Budj Bim cultural landscape in western Victoria.

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Luminescence dating of Middle Palaeolithic site of Cova del Puntal del Gat (Benirredrà, València, Spain) – The challenge of calcite-rich contexts

The Mediterranean basin constitutes one of the best areas to analyse Neanderthal populations and lifestyles in SW Europe. In this context, new excavations conducted in the Middle Palaeolithic site of Cova del Puntal del Gat aim to expand the information available regarding this rich region. As a part of a broader project, which includes detailed studies on stratigraphy, lithic technology, anthracology, carpology, zooarchaeology and taphonomy mammals, in this work dosimetric and compositional studies, as well as, absolute dating were performed. Luminescence dating protocols were applied to improve the knowledge of the archaeological sequence, collected from the geological background (Limestone) towards the topsoil. The variations of the absorbed dose (De), determined by OSL, along the profile, had been interpreted as distinct deposition rates. The deposition rate of the material in each context gives a clear idea of the deposition event rate. Along the context associated with human occupation level, the apparent De decreases upwards and reflects a more rapid event of deposition than after human abandonment. Low contents of radionuclides and the consequent low dose rate (DR) obtained are in accordance with similar carbonate-rich materials and are related to high carbonate contents in the matrix of the samples, which promote the "dilution effect" of radionuclides content and a high-water retention. In this case, an overestimation of the luminescence age can be considered – that is, the obtained luminescence age indicates a sample older than it is. This effect in the studied samples can be discussed using the approach of "radionuclide weighed" protocol, developed in previous works by some of the authors, which intends to minimize the carbonate content effect on DR. By employing this approach, the ages are lower and – particularly for samples from human occupation context - are in agreement with the archaeological information (110-130 ka).

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Application 40Ar/39Ar radiometric dating to archaeology: Case studies from Budj Bim, SE Australia and Turkana, Kenya

The 40Ar/39Ar technique is one of the most widely applied radiometric dating methods. It is particularly important for constraining the ages of young (<5 Ma) volcanic rocks. Here, we present two case studies to illustrate application of the method to archaeology.
The first case study documents 40Ar/39Ar age results obtained for basalt lavas from Budj Bim and Tower Hill in southeast Australia. Budj Bim and surrounding lava landforms are of significant cultural importance, as recorded in oral traditions of the Gunditjmara people. Tower Hill tephra overlies an important stone tool. 40Ar/39Ar analyses yield high precision ages of ca.37 ka for both, providing a minimum age for human migration in Victoria and hinting at the persistence of oral traditions for >35 ka.
The second case study reports ultra-high precision ages from the Turkana Basin in Kenya and Ethiopia. This region contains remarkable fossil-rich Plio-Pleistocene sediments that provide a record of hominin evolution over the past ~4.3 Ma. Time constraints for hominin fossils derive from interbedded silicic tuffs dated by the 40Ar/39Ar method. However, most existing ages are limited by large uncertainties (~20-60 ka), inhibiting precise temporal constraints on the ages of key fossiliferous sequences. Multi-collector 40Ar/39Ar mass spectrometry is now capable of ultra-precise (2-3 ka) ages for Pleistocene tuffs, providing high resolution age constraints on individual fossil occurrences and permitting distinction of previously indistinguishable time markers.

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The power of strontium – Exploring the full potential of strontium concentrations and isotope ratios in bioarchaeology

Strontium isotope analyses have traditionally been limited to the measurement of 87Sr/86Sr in a wide range of archaeological materials. In bioarchaeology, the targeted samples are either tooth enamel or fully calcined bone, as other forms of bioapatite are likely to have been contaminated with environmental strontium. While the use of 87Sr/86Sr alone provides crucial information about mobility, landscape use, and migration of individuals and communities, additional information can be extracted from strontium concentrations ([Sr]) as well as the novel δ88Sr proxy. These proxies are linked not only to the geographical origin of the foods consumed by humans and animals, but also to the type of food as animal products have different δ88Sr values compared to plants, and condiments, such as salt, also have clear δ88Sr signatures. As such, the combined use of 87Sr/86Sr, δ88Sr, and [Sr], which can be measured simultaneously by MC-ICP-MS, provides a powerful tool for obtaining both palaeodietary and palaeomobility information from animals and humans. This is particularly interesting in cases where traditional C and N isotope analyses are not possible such as in arid areas with poor collagen preservation and places where cremation was practiced.

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Evidence for a microbial source of oxalate in rock coatings based on trace organic analysis

Oxalate-rich, layered, glaze like deposits are often found coating surfaces in Australian rock art shelters. The synchronous growth of individual layers, on a regional scale, suggests a formation mechanism linked to environmental conditions, however, this link remains unclear.
A connection to microbial activity could establish these deposits as paleoenvironmental proxies, with age constrained layers forming only under certain conditions. Biomineralization of the oxalate minerals is supported by circumstantial evidence such as the niche environments in which the deposits are found and micro-stromatolitic structures observed within the internal layering. However, the organic content of these deposits has not previously been explored. We collected 16 glaze deposits and various control samples from sites across the north-east Kimberley region of Western Australia. Using gas chromatography mass spectrometry, we analysed the trace organic composition of the mineral system, to identify glaze-specific biomarkers, distinct from the control samples. These biomarkers reflect potential source inputs and provide links to organisms potentially involved in the biomineralization of oxalate minerals, opening the possibility for their use as new paleoenvironmental proxies.

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Identifying Elephant Species on Archaeological Ivory (…or not)

Long distance exchange networks are a hot topic on archaeological research, and latest advances on archaeometric techniques of materials characterization allow sourcing raw materials with increasing precision.
For ivory trade in Mediterranean Prehistory, exchange routes are based on the aims of identification of African (Loxodonta) or Asian (Elephas maximus) elephants as the sources of ivory found on archaeological contexts. Both species are claimed to have reached the Iberian Peninsula since the Copper Age (3100-2200 cal BC) thus demonstrating long distant exchanges with the Near East (e.g. Schuhmacher 2017).
This provenance analyses are usually based on spectral differences on L. and E. maximus samples analysed by Fourier Transformed Infrared Spectroscopy (FTIR) and compared with the reference collection materials database of INCENTIVS (Banerjee et al. 2008; Banerjee and Huth 2012; Chamón et al. 2008; García Sanjuán et al. 2013; Liseau and Moreno, 2012; Morillo et al. 2018; Schuhmacher et al. 2009; Schuhmacher 2017).
In this paper we present a systematic study of an ivory assemblage with more than 120 pieces from the Neolithic site of La Beleña (Córdoba, Spain). Samples were systematically observed by Optical Microscopy and analysed by FTIR, and a batch of samples were further selected for ZooMS and aDNA identification. Results cast doubts on the reliability of FTIR analyses for elephant species identification and show the limitations and difficulties of ZooMS and DNA for the same purposes. We propose therefore that narratives on long trade exchanges of Western and Eastern Mediterranean during Prehistory should be nuanced at least until more and solid scientific-based data can be achieved.

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A fresh perspective on infrared spectroscopy as a prescreening method for molecular and stable isotopes analyses on ancient human bones

The investigation of osteological finds of museum interest is increasingly utilized and popular, thanks to the constant development of modern molecular sequencing technologies. Employing viable protocols to assess bone quality would help preserve these valuable collections from overly invasive analysis, while also allowing greater access to specimens for scientific research. This has resulted in a growing demand for osteoarchaeological finds, which serve as truly precious biological archives, useful in various research fields, including archaeology, geology, as well as forensic and molecular anthropology.
The primary objective of this study is to examine a substantial collection of skeletal tissues characterized by their origin, chronology, and state of preservation, with a particular focus on petrous bones and tooth roots. Infrared spectroscopy is employed as a prescreening method to evaluate bone quality for molecular analyses.
Structural and compositional changes in the extracted collagen and bone tissue were analyzed using Fourier transform spectroscopy (FTIR spectroscopy), linking infrared spectral data to genetic and isotopic information. Through spectral analysis, sensitive and precise infrared parameters were identified to effectively describe bone preservation. The study supported the hypothesis that genetic fragments are preferentially associated with the mineral component of the bone. Additionally, the predictive model identified a spectral parameter capable of determining the presence of ancient DNA, although the quality/quantity of the genetic molecules preserved in the bone finds cannot be determined due to the influence of environmental and local factors undergone by bones during the burial period.
This methodological approach could potentially overcome the challenge of identifying genetic material in osteoarchaeological collections in an easy, time-efficient, and economical manner. Beyond genetic analysis, this selection method has shown promise for profitable use in stable isotope analysis of C and N, examining both the bone material (comprising organic and inorganic components) and its extracted and lyophilized bone collagen.

Session 4 Bioarchaeology and Biomolecules Oral presentations

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Collagen preservation in animal bones from tropical environments. Developing a baseline for palaeoproteomic analysis in Indo-Pacific archaeological sites

The analysis of bone proteins has emerged as a resolutive approach for the study of human evolution, past biodiversity and human behaviour. Advances in mass spectrometry techniques and instruments now allow us to analyse palaeontological and zooarchaeological material hundreds of thousands of years old. Nevertheless, research has predominantly focused on material from temperate and cold environments, conditions that favoured the preservation of organic material, such as collagen. Comprising over 90% of the proteins present in bone, collagen preservation has a long history of study in archaeology, due its relevance to radiocarbon dating. Pre-screening techniques for C14 dating include the calculation of nitrogen content (%N) and the carbon/nitrogen (C/N) ratio, with established threshold values. More recently, the application of attenuated total reflection Fourier transform infrared (ATR-FTIR) provides a fast alternative to other methods, with promising results for vertebrate remains.

Here we propose the development of a threshold for collagen preservation in zooarchaeological assemblages from tropical environments. To that end, we present the data obtained from archaeological sites in Kimberley (Australia), East Timor, Indonesia, Vanuatu, PNG and French Polynesia with a controlled experimental assemblage comprising modern bones buried in guano deposits. These samples were tested for %N, C/N and ATR-FTIR. Values from the controlled experiment match the expected collagen degradation, with large values anticipating successful palaeoprotemic results. In the archaeological material, our analysis highlights the importance of extensive sampling in archaeological assemblages prior to palaeoproteomic analysis, as successful palaeoproteomic results occur randomly within the same excavation unit, presumably due to inter-site differences in similar environmental conditions. Our results support the application of ATR-FTIR as a fast and precise alternative for pre-screening before long and convoluted palaeoproteomic analysis.

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5- BioArch South, Waitati, New Zealand
6- Solomon Islands National Museum, Honiara, Solomon Islands

Palaeohistopathology of Treponematosis: the value of histomorphometric analyses in infectious disease investigations

Palaeohistopathology of infectious disease has previously focused on histomorphological changes, utilised often unsuccessfully in the diagnosis of disease in skeletal remains. Treponematosis, an infectious disease with a contentious human history, is no exception with published histological studies only reporting morphological observations, without empirical or statistical analyses. This study sought to expand on this research through palaeohistopathological examination of human bone affected by treponematosis, with both histomorphological and histomorphometric analyses. The inclusion of empirical methods aimed to improve understanding of bone pathophysiology and assist in the histological diagnosis of disease in skeletal remains.
Thin sections were prepared from the mid-anterior tibia in individuals from the Taumako collection, Solomon Islands (1510-1800CE). This collection included individuals with no visible pathology (n=39) and those with macroscopic indicators of treponematosis infection (n = 25). In morphological assessments of the thin sections, porosity significantly increased in those diagnosed with treponematosis ($p=<0.001$). However, it was histomorphometric analyses which found this porosity was due to trabecularisation of cortical bone, as vascularity significantly decreased in those with treponematosis ($p=<0.001$), and no statistically significant changes in vascular canal size or osteoclastic activity were identified. Furthermore, no significant changes were observed in osteon histomorphometry, indicating cortical bone was replaced by trabecular bone, bypassing stages of poor remodelling or gradual increases in porosity.
This study demonstrated the value of empirical analyses in palaeohistopathology, with histomorphometry providing greater insight into bone health and remodelling in response to treponematosis infection than could be ascertained through morphological observations alone. While underutilised in palaeohistopathology, the success of histomorphometry within this study indicate the need for histomorphometry to become standard of palaeohistopathology, particularly in analyses of infectious diseases. Furthermore, the understanding of bone pathophysiology gained through histomorphometric analyses may be key in the histological diagnosis and differentiation of infectious diseases in skeletal remains.

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Waves of change: Exploring socio-economic transformations in Western Eurasia through biomolecular and geochemical approaches

In the 3rd millennium BC, human migrations from the Western Eurasian steppes left discernible imprints in burial practices and portable material culture of various European societies. Plausibly, the steppes served also as the main pathway for the introduction of common millet to Central Europe in the mid-2nd millennium BC.
Owing to the highly mobile lifestyle and elusive settlements of the descendants of the steppe people, our understanding of their subsistence strategies remains limited. To address this gap, we employed various methods to reconstruct human diets and identify biomarkers of foodstuffs at selected sites in Germany and Poland.
Carbon and nitrogen stable isotope analyses of bulk collagen, in conjunction with AMS radiocarbon dating, have enabled the unravelling of dietary patterns and their evolution in a long-term perspective, spanning from the later Neolithic to the Middle Bronze Age.
Strontium and oxygen isotope analyses in tooth enamel, provided direct evidence of low levels of human mobility. However, a correlation was discovered between changes in burial customs in the mid-2nd millennium BC, specifically the resurgence of burial mounds (tumuli), and a rapid increase in the consumption of C4 diets.
Preliminary analyses of lipid residues in pottery, originating from both burials and settlements, offer complementary evidence to human diet reconstructions. They suggest a gradual shift towards an economy heavily reliant on livestock herding in open landscapes.

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Imaging Diagnostics of Funeral Urns from Chazuta – Introductory Remarks

Chazuta is an archaeological site located in the province and department of San Martín in northern Peru. In 2002, Peruvian archaeologist Anselmo Lozano Caledrón conducted some rescue archaeological research during which 25 funeral urns with numerous grave goods were discovered, including various stone tools. So far, stylistic analyses of ceramic items – including bowls, plates and the above-mentioned urns – have been researched, although local burials remains an unexplored area.
In 2023, in cooperation with the Decentralised Directorate of Culture of San Martin, a research project was launched entitled 'Funeral urns from Chazuta from an interdisciplinary perspective' with the aim of learning about funeral customs based on comprehensive and multi-faceted expertise and research. The planned analytical methods include non-invasive diagnostic imaging techniques: computed tomography and X-ray. As a result, the contents of ceramic funeral urns were identified and subsequently analysed. The aim of this presentation is to show the results of the radiological examination together with an anthropological assessment of a funeral urn of the cylindrical subtype, currently held by the Museo Departmental de San Martín in Moyobamba.

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Bucktooth and Dogtooth: Insights from Stable Isotopes on Diet, Territoriality, and Human-Animal Interaction in the Kentucky Bluegrass

Our study aims to investigate the movement and territorial behaviors of white-tailed deer (Odocoileus virginianus Zimmermann) and dogs (Canis familiaris Linneaus) over time, utilizing carbon, nitrogen, and oxygen isotope values derived from archaeological remains. An analysis of these isotope values extracted from tooth collagen and enamel was conducted for 20 deer teeth from 13 archaeological sites in Kentucky, spanning a period of approximately 1,500 years of human occupation. The "canopy effect" (grazing in deeply forested areas) in deer stable carbon isotope values was identified in the remains covering the Middle Woodland (200 BCE - CE 500) to Late Fort Ancient (CE 1400 - 1680). Additionally, tooth samples from nine dogs and one wolf (Canis lupus Linneaus) were analyzed which revealed significant maize consumption in seven of the dog samples. These samples came from seven of the sites spanning the Early through Late Fort Ancient (CE 1400 - 1680) periods. Furthermore, we present carbon and nitrogen isotope values derived from deer bone collagen, analyzing nine samples from three of these sites dating to the Middle to Early Late Woodland (200 BCE - CE 800) periods. Hence, our study contributes to the growing database of isotope studies in the Eastern Woodlands.

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Historical visits to northern Australia by island Southeast Asian mariners: Assessing their regions of origin, the forest and marine commodities they exported, and chronology, through archival research and residue analysis of their discarded earthenware

Earthenware pottery has been found discarded in the Kimberley, Arnhem Land and the Groote Eylandt Archipelago (GIA), if not Torres Straits. Compositional analyses have provenanced 'Group 2' earthenware to the Makassar, South Sulawesi, region but the origins of 'Group 1' pottery are unresolved and the proposed functions of earthenware forms remain untested. Up to 19 additional commodities were probably exported by Makassans besides trepang (Clayton 2023). Earthenware was probably used to process these commodities, or their by-products for food. Mariners from different regions may have brought different staple carbohydrates (e.g. maize or sago vice rice). Lipids absorbed by the fabric of excavated earthenware from existing collections (e.g. from Lyäba, GIA, which yielded the oldest coin, minted AD 1742) have been analysed using established GC-MS and GC-c-IRMS techniques. I will present the preliminary results of residue analyses to identify the commodities and staple carbohydrates processed using the discarded earthenware. Data interpretation is informed by analysis of comparative controls and review of ethnographic literature and historical observations. This research is important because evidence for the extraction of particular commodities might be a proxy for age estimation of Makassan sites (Clayton 2023). Also, identification of staple carbohydrates may assist in identifying the regional origins of the visiting mariners and 'Group 1' earthenware.

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"Betel juice, betel juice, betel juice": experimenting with stimulant narcotic Areca catechu L., Arecaceae

Throughout South Asia, Southeast Asia, and the Pacific Islands the stimulant narcotic Areca catechu L., Arecaceae (betel nut) is chewed for a wide variety of social, ceremonial, and medicinal purposes. The betel quid generally involves the combination of A. catechu seeds, the leaf of Piper betle L., Piperaceae (betel leaf), and slaked lime (calcium hydroxide). As widespread as its use and distribution is today, use of A. catechu in the past is not well understood. Archaeobotanical remains of A. catechu are limited and those recovered have been plagued with issues around taxonomic identification and antiquity. Another line of enquiry examines the reddish-brown-black staining produced by 'betel juice' that can be identified in archaeological dental remains. To gain a deeper understanding of the process of teeth staining and our ability to identify betel chewing in the archaeological record, we conducted a series of experiments using different betel quid preparations and traditional methods to create slaked lime. Samples were analysed through liquid chromatography/tandem mass spectrometry (LC MS/MS) to examine molecular mass differences between compounds. Our results propose new methods and parameters to assist on the identification of betel nut consumption in prehistoric contexts, proposing an analytical framework that could be applied to the study of narcotic use in past communities.

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Do bivalve shells have uniform trace element distributions in contemporaneous growth increments? Investigating Tridacna shells through LIBS

Ultra-high resolution palaeo-environmental proxies from archaeological archives provide us with a window into ancient times. As one of the most common and well-developed archives, bivalve shells play a very important role in connecting palaeo-environment with ancient human behaviours. Sr/Ca and Mg/Ca ratios are often employed proxies for reconstructing palaeoenvironmental parameters such as sea surface temperature from bivalve shells. However, we still lack a basic understanding of whether bivalve shells have evenly distributed trace element concentrations in contemporaneous growth increments.
In this study, we applied Laser Induced Breakdown Spectroscopy (LIBS) on Tridacna shells. LIBS employs a fast laser and low energy pulse (1–2 mJ) which enables rapid analysis that is less destructive than other geochemical techniques. This makes LIBS well-suited for scanning large areas in a rapid pre-scanning step prior to further geochemical analyses. It is also less destructive to archaeological samples. As one of the biggest and fastest-growing bivalves, Tridacna can provide wide and clear contemporaneous daily increments for analysis.
Our scanning results show that Sr/Ca distribution in the contemporaneous increments is unified in both the inner and the outer shell layers. However, the Mg/Ca distribution shows uneven patterns in the outer shell layer, which indicates the need for caution in analysing the outer shell when undertaking quantitative Mg/Ca analyses.

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2- Canada Research Chair in Biomolecular Archaeology
3- University of York

Shifting foodways: biomolecular archaeology in Vanuatu

In Oceania, pottery dates to at least 3,000 years as it was introduced into the region by the founding colonists known as Lapita people who settled on large island groups from New Guinea to Tonga and Samoa. Despite being the most frequent artefact left by the past societies who inhabited the 4,000 km chain of Oceanic islands, little is known about how the pottery vessels were used, particularly the foods and products that were cooked and stored in them. The consensus is that the dentate-stamped Lapita vessels were probably used in special contexts (ceremonial, non-secular) rather than being a domestic cookware implement, but this idea is based exclusively on indirect contextual evidence from a number of Lapita sites. I will detail in this presentation some results from the first comprehensive organic residue analysis undertaken on Lapita and immediate post-Lapita pottery combining gas chromatography mass spectrometry (GCMS) and gas chromatography–combustion–isotope ratio mass spectrometry (GC-c-IRMS) analysis of lipids. The biomolecular and isotopic analyses shed light on the range of food sources (or mixture of food) that was placed in the vessels at several archaeological sites in Vanuatu. Preliminary results enhance our understanding of past subsistence practices and document the evolution and adaptation of past diet and culinary practices through time.

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Life on a troubled border: Preliminary results from stable isotope investigations at a late medieval site in Dalmatia, Croatia

Territorial borders and the processes of establishing, negotiating, and defending them have complex cultural and physical implications for those living there. The late Medieval (15th-16th century AD) populations of Pakoštane near Lake Vrana in Dalmatia, Croatia, provide an excellent case study for examining how these phenomena manifested at the border between the Venetian Republic and the Ottoman Empire. High levels of skeletal trauma indicative of interpersonal violence and physiological stress markers in individuals suggest that these communities often faced dangerous and difficult times. Here we report the first results of stable carbon (δ13C) and nitrogen (δ15N) analyses of bone collagen and serial tooth dentine to investigate potential impact on diet and subsistence over the life course of these individuals. Preliminary data suggest individuals consumed a primarily terrestrial C3 diet with high trophic level protein, most likely freshwater fish, regardless of sex or life stage. These results suggest that dietary inputs remained consistent over time, in spite of historic political instability. Future integration of ongoing bioapatite analyses (O, Sr, Pb) will provide further insight into lifeways on the border at Pakoštane. More broadly this research provides bioarchaeological insights into life on the border of two historically powerful states and how this affected the individuals caught in between.

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2- Instituto Geológico y Minero de España (IGME-CSIC)
3- University of Barcelona

Characterisation of Iberian Cretaceous Amber for Provenance Studies

Amber trade studies have drawn the attention of scholars since the Antiquity. Pliny the elder already wrote on the amber rout and distribution on the Roman Empire, and this interest has lasted until today. Most studies have been traditionally focused on the distribution of Baltic amber, as it has been the most extensively exploited amber type in History and in present times. Nonetheless, other less abundant fossil resins such as the Sicilian simetite or the Spanish Cretaceous amber were also exploited during Prehistory (Murillo-Barroso et al. 2018).
Provenance studies on amber archaeological objects are usually based on Fourier Transformed Infrared Spectroscopy (FTIR), a useful technique for the identification of organic materials which requires minimum sample extraction and therefore secure archaeological objects preservation. However, in order to be able to match objects and amber outcrops, a geological database with reference spectra of the different amber deposits is needed.
More than 150 amber outcrops are known In Iberia. They are mostly dispersed on the North and East coast of the Iberian Peninsula with an Early Cretaceous origin. Some Late Cretaceous outcrops are also documented mostly concentrated on the Northeast. In order to have a good characterization of the Iberian outcrops, 176 samples representative of the different localities and ages have been analysed by FTIR with the aim to evaluate possible spectral differences between Early and Late Cretaceous amber which allow us having a more detailed information on amber exploitation and networks. Additionally in a selected batch of samples, analysis on both the amber core and the weathered surface have been conducted for the evaluation of spectral variations due to pots-depositional weathering, something that usually affects archaeological materials. Results are also compared with other amber types (Baltic and Simetite) and with archaeological materials to better define amber exchange networks.

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Examining Mobility at Sultana, Romania during the Eneolithic through Strontium Isotopic Analyses of Plants and Human Tooth Enamel

Material evidence indicates that the Eneolithic communities inhabiting the tell settlement of Sultana, Romania were fully integrated into a vivid trade network that encompassed most of southern Romania and Bulgaria. However, the question of whether this phenomenon consisted solely of an exchange of goods and ideas or if it also corresponded to an increase in mobility of individuals among the different social groups is still debated. Strontium isotopic analysis of human tooth enamel provides us with direct evidence regarding the extent of mobility during the period. The interpretation of the results obtained on the human material is enhanced by the analysis of contemporary plants at several locations, which constitutes a baseline for the bioavailable strontium (BASr) at a regional level. Samples from forty-four individuals from Sultana-Malu Roşu, two from Sultana-Gheţărie, and three from Sultana-Şcoala Veche were selected for this study. Fifteen plant samples from five different locations were collected to constitute the BASr baseline, and another forty-five from fifteen different locations were used to assess variations at a regional level. The samples were analyzed on a MC-ICP-MS at the Brussels Bioarchaeology Lab (BB-LAB) of the Vrije Universiteit Brussels (VUB), Belgium. Seven outliers were identified and represent individuals who must have moved into the area after their childhood. These results offer us a precious insight on the mobility of ancient communities in the Northern Balkans during the fifth millennium BC.

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Gas-Chromatography Mass Spectrometry and Proteomics Profiling of Organic Residues from Sicilian Early Bronze Age Pottery: First Evidence for Consumption of Horse Meat

The reconstruction of the dietary regimen of prehistoric communities is intertwined with the study of those productive and economic activities guaranteeing food supply, such as agriculture, husbandry and hunting. However, those activities leave a fading trace in the archaeological record, especially in contexts several thousands of years ago. In that case, a multi-technique analytical approach centered on organic residues extracted from pottery remains the best methodology.
This contribution focuses on the Early Bronze Age (2500-1650 BCE) assemblage of table ware and cooking from the site of Polizzello Mountain (Caltanissetta), in the uplands of central Sicily. The excavation of Hut 1, with a circular plan of about 6 meters and foundations in rubble stones and elevation in wattle and daub, showed that it was suddenly abandoned and that the occupants left a good number of ceramic artifacts in situ on the floor level. Subsequently the walls and the roof collapsed but without any trace of fire or of subsequent reoccupation later in time. The area immediately around Hut 1 offered evidence of two small fireplaces surrounded by further examples of cooking ware and animal bones.
To better understand the function of the different pottery types and infer information about the dietary regimen of the occupants of Hut 1, 54 samples were taken from all the vessels retrieved and submitted to Gas-Chromatography Mass Spectrometry and Proteomics profiling. Among the results obtained, that we'll argue in detail, it emerged that 23 samples contained a high level of horse albumin (Equus) offering the earliest evidence in Sicily for consumption of horse meat. Considering that, from zooarchaeological studies the domesticated horse does not appear in Sicily until the Late Bronze Age (1250-1050 BCE), this discovery from Polizzello Mountain informs us about a previously unknown practice of hunting and consuming wild horses.

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1- University of South Florida
2- Washington University in St. Louis
3- National Museum of Kenya

Social Status and Dietary Variation in Medieval Coastal Kenya

Dietary practices at two historic sites in coastal Kenya are compared. Mtwapa (ca. 800-1750 CE) is a site of the early Swahili coastal people of elite status, with burial arrangements similar throughout the Islamic world. Msumarini Beach (ca. 1300-1850 CE), is the first study of the burials of non-elites at Swahili sites. In both cases, burial practices follow traditions with no grave offerings or treatment related to sex, age, or status, while this study assesses whether dietary practices were similar (or not) for these two status groups. Twenty-five individuals from each of these two sites were selected for stable isotope analysis. Following standardized sample preparation methods, bone collagen (C & N) and bone apatite (C & O) data were obtained.
For Mtwapa, the isotope results vary significantly (δ13Cco -14.3 to -9.3‰; δ15N 8.5 to 13‰), while in general indicating a mix of seafood and C4 plants such as millet and sorghum in the diet. For Msumarini Beach, there was even greater variation (δ13Cco -13.5 to -6.3‰; δ15N 7.7 to 14.1‰), with 20 individuals having a similar collagen carbon isotope range as at Mtwapa (δ13Cco -13 to -8.5‰) and four individuals having very positive carbon isotope values (δ13Cco -6.7 to -6.3‰), perhaps originating elsewhere. Other than for one outlier, δ18O isotope values however are very similar (range of just 2.5‰) for both Mtwapa and Msumarini Beach individuals at these coastal sites. The range for each site in apatite δ13C values is quite similar (~5‰), but the values for individuals vary tremendously. A detailed interpretation of dietary practices by individuals at these two sites provides an understanding of human lifeways during this period.

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2- University of Kentucky
3- University of Missouri

The Early Medieval Transition in Northeastern Italy: Data on Diet and Mobility

The Late Antique migrations from Central Europe and beyond into the areas previously controlled by the Roman Empire represent the most seismic reshuffle of European societies, and modern nations were formed on the resulting groups following those migrations. The later periods with substantial immigration, such as the Franks and Longobards (Lombards) are generally better known, but to this day very little is known of the earliest immigrants, dating to the 4th-7th centuries CE, and how they integrated or disrupted the Roman society at its core (Ravenna was then capital). Bone and tooth samples from over 100 individuals excavated at Chiunsano, Ficarolo and some other sites in the regions of Veneto and Emilia Romagna in northeastern Italy were selected, while results to determine their diet and possible origin have been obtained for 43 individuals from their carbon, nitrogen, and oxygen isotope ratios, and 54 individuals for Sr isotopes of both bone and tooth samples.
The material culture associated with all burials suggest some change and disruption from previous Roman traditions. Using only typological indicators, it is impossible to discriminate between immigrants and people that embraced new ideas. Our results from strontium analyses suggest a high homogeneity of the people investigated, while the dietary data suggested a more marked shift in diet. It seems that physical immigration was relatively low before the larger migrations but was culturally and socially very disruptive of the existing systems. It opened local people to different traditions and explored possible areas of co-existence. In short, it appears that early migratory flows prepared local populations to change and informed migrating people of regions where coexistence might have been possible, but most changes were due primarily to dissatisfaction with the prior system. Our results add an important contribution to understanding some of the most consequential migratory flows in Europe.

Session 4 Bioarchaeology and Biomolecules Poster presentations

Chong Yu 1, Yue You 2, Qiurong Rian 3, Minoru Yoneda 4, He Yu 5
1- Sun Yat-sen University
2- Capital Normal University
3- Institute of Cultural Relics and Archaeology Xinjiang Uygur Autonomous Region
4-The University of Tokyo
5- Peking University

Sophisticated cattle husbandry strategies at Halehaxite in the Tianshan Mountains: evidence from stable isotope and aDNA analysis

Cattle was imported into China from West Asia through Central Asia around 4500 years ago and then soon integrated into the indigenous farming system of ancient China. However, issues about cattle husbandry strategies in China is poorly studied. This poster focuses on cattle excavated from Halehaxite site, Xinjiang Uyghur Autonomous Region of China, dating back to 3300 – 3000 years ago (Late Bronze Age). These cattle were the westernmost discovery in China up to date. The aim of this poster is to explore the birth seasonality and slathering preference of northwest China during Late Bronze Age by using sequential oxygen isotope analysis and aDNA analysis.

Session 5 Stone, residues, use wear Oral presentations

Jemma McGloin 1
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An experimental approach for a microwear study on Pinctada margaritifera from French Polynesia

In Central-East Polynesia, objects made from Pinctada margaritifera, commonly known as the black-lip pearl oyster, have been widely found in the archaeological record. These pearl shell artefacts have come in a variety of forms, from shell tools such as fishhooks and tattooing combs to ornaments such as discs or plates on ceremonial clothing, for example those on mourner's costumes. Whilst many studies have documented these items and examined their typologies, no known studies have incorporated an experimental framework to test the feasibility of the hypothesised crafting technology and techniques on pearl shell. This presentation will focus on the preliminary results of the experimental methodology and the creation of a reference collection for microwear traces on Pinctada margaritifera. Building and expanding on ethnographic literature, experiments covered a series of technical actions: abrasion; sawing; percussion; filing; grooving; drilling; and polishing, with various types of materials including: coral; sand; water; seawater; vesicular basalt; sea urchin spine; other pearl shells; lithic blades; Perna Canaliculus shell; rats teeth; Terebra shell; and black tip reef shark teeth. The experiments have highlighted that Pinctada margaritifera is a hard and time-consuming natural material to work with, further indicating the value and crafting choices placed on items made from this material. Further analysis of these results will provide significant insight on the development of traces on crafting with mother of pearl and will be useful in shedding further light on the chaine opératoire of pearl shell archaeological artefacts.

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2- In the Groove Analysis

Residues and use wear traces on chipped stone artefacts from the Lake Mungo lunette in the Willandra Lakes Region World Heritage Area in south-eastern Australia.

Lake Mungo, which was once part of an active overflow system fed by water from the Australian Alps, preserves a remarkable archaeological record in the dune and lake margin sediments that built up along its eastern shoreline. This record spans the last 54,000 years and consists of individual activity traces, like the remains of a fire lit to cook a single meal, a cluster of tool-making debris or a grindstone stashed for future use, and each of these is embedded in sediment that records the conditions that prevailed in the adjacent lake. Activity traces are exposed on the surface of the dune through ongoing erosion by wind and water and small-scale, shallow excavations have been undertaken to recover what remains of selected features. Some of the chipped stone artefacts recovered from the excavated hearth features exhibit well-preserved residues and use wear traces, despite shallow burial or exposure on the dune surface. The methods employed to study the residues and wear traces are described, including the experimental work needed to understand the development of wear traces on silcrete and quartzite tools. Different categories of information are generated from the residue and use wear studies, but together they provide insights into the way the tools were used. In some cases, the inferences drawn from the study of the residues and wear traces are consistent with those drawn from the analysis of the associated faunal remains and in other cases, they provide insights into activities that have left no other material trace.

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2- Institute of Science and Technology in Art, Academy of Fine Arts Vienna; Nuclear Physics Institute, Academy of Sciences of the Czech Republic, Řež

Axes of power, axes of toil: the production and use wear of the ancient Egyptian and Nubian copper alloy axe blades within their contexts of use

In 1987, Egyptologist Vivian Davies published a catalogue of the ancient Egyptian and Nubian axe blades within the collection of the British Museum, London. Their standard typological research was aided by a broad archaeometallurgical dataset, encompassing all discussed specimens. Not only that, a corpus list of all known Chalcolithic and Bronze Age axes known from Egypt and Nubia, provenanced and unprovenanced, was included. With the addition of material published after this date, it totals altogether more than 1,900 known specimens of full-size and model axe blades from the entire periods and regions mentioned. The present paper is focused on the macro- and micro-evaluation of this dataset, as the recent upsurge in online publication of museum collections enables to gather more information on the artefacts than ever before. This is aided by the meticulous study of the production and use wear of the tens of artefacts, which were available for direct inspection, and compared with rich Egyptian iconographic and textual sources. And by the addition of the elemental composition data, not only from the literature (more than 300 analysed artefacts), but also newly gathered by the portable XRF and more precise techniques, such as e.g. NAA and metallography. The dataset enables us to address anew the questions of the distinction between the battle axes and artisan ones (used for woodwork and stonework), as well as identifying the unclear category in between both of these. Further dimension is the connection to the frequent and wide use of stone axe blades, initially, in Chalcolithic, inspired by stone forms, in the Bronze Age often reverted as skeuomporhs of metal shapes. The paper is an interim report on a post-doctoral project EgypToolWear – Metalwork Wear Analysis of Ancient Egyptian Tools, supervised by Prof. Andrea Dolfini.

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2- National Museum of Korea

Unveiling geoarchaeological origins of stone arhat statuettes in Naju, Korea

This study focuses on the geoarchaeological importance of arhat statuette stones unearthed in Naju, Korea, utilizing precise data on their chemical compositions and mineral phases. The analysis involved quantitative assessments through calibration curves and Rietveld-based methods. Complementary insights were gained using light and electron probe microscopy, along with colorimetric analyses. The stones were identified as ash tuffs with a rhyolitic composition, and the discovery of an amorphous iron-oxide phase in voids within reddish layers proved crucial in understanding the formation of the characteristic layered texture. Furthermore, distinct pairs of illite–feldspars and kaolinite–micas in a hydrothermal system indicated divergent pathways in the weathering processes of volcanic ashes concerning temperature and fluid pH. The interplay of iron content and mineral pairs, evident in the color of powder samples, facilitated the integration of textures and hydrothermal environments into a unified system. Ultimately, a comprehensive geological model, drawing from multifaceted scientific analyses, was established. This model contributes significantly to conservation science by emphasizing the importance of revealing the source rock provenance for the arhat statuettes. The holistic approach enhances our comprehension of rock-forming processes and the surrounding environments, providing valuable insights for the preservation and significance of these archaeological artifacts.

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2- School of Social Sciences, The University of Western Australia
3- Centre for Data Driven Geosciences, School of Earth Sciences, The University of Western Australia

Quantifying the influence of argilliturbation on lithic artefacts in clay-rich soils: a case study from Middle Gidley Island, Murujuga, northwest Western Australia

Natural soil processes have the potential to change archaeological contexts, altering artefact distributions and compromising the interpretation of archaeological deposits. One such process is argilliturbation: the movement or mixing within a soil profile due to expansion and contraction of the soil during wetting and drying cycles. Argilliturbation occurs in soils containing high proportions of clay minerals that exhibit shrink and swell characteristics (e.g., smectite minerals). Middle Gidley Island, located in the archaeologically significant Murujuga rock art province in northwest Australia, contains a clay-rich sediment basin and archaeological site that provides an opportunity to investigate the potential impact of argilliturbation on artefacts. Here we present a pilot experimental study to quantify the movement of artefacts, specifically lithic artefacts that are common at the site, from argilliturbation following wetting and drying treatments using the local soil and other contrasting soil textures. The soils used were the Middle Gidley Island sediment basin soil (MG-Soil), a pure sand of >99% quartz (S-Soil), and a mixed soil (X-Soil) comprised of 25% MG and 75% S soil by weight. We undertook six weekly wetting and drying cycles under controlled laboratory conditions on 30 soil experiment tubs. Each tub (23 cm (H) x 18.5 cm (W) x 18.5 cm (D)) contained one of the three soil types and included small, medium or large lithic artefacts, with size categories determined by the size distribution surveyed at the Middle Gidley site. The experiment tubs were imaged in 3D using CT-scanning before and after the experiment, and the movement of artefacts in mm was accurately determined using 3D image correlation methods. Our results showed that all artefacts within the clay-rich MG-Soil moved upwards (average = 3.8 mm), whereas artefacts within the sand S-Soil moved downwards (average = -1.7 mm) and minimal vertical movement (average = 0.5 mm) occurred within the X-Soil. By providing quantitative information on the movement of artefacts in the experiments it may be possible to assess the degree of movement and mixing from argilliturbation at Middle Gidley sediment basin and more accurately interpret the archaeological assemblage as found today. The outcomes of this study provide a baseline that can be used to explore more sites that are affected by expansive clay-rich soils.

Session 5 Stone, residues, use wear
Oral presentations

M. Isabel Dias 1, M.I. Prudêncio 2, J. Mihaly 3, G. Káli 4, A.C. Valera 5, Zs. Kasztovszky 6, I. Harsányi 6, I. Kovács 7, Z. Szőkefalvi-Nagy 7

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2- Centro de Ciências e Tecnologias Nucleares – C2TN. Campus Tecnológico e Nuclear, Loures, Portugal.
3- Research Centre for Natural Sciences, Hungarian Academy of Sciences. Budapest
4- Institute for Solid State Physics and Optics, Wigner Research Centre for Physics, HAS, Budapest, Hungary
5- Interdisciplinary Center for Archaeology and Evolution of Human Behavior (ICArHEB, Universidade do Algarve, Portugal.
6- Centre for Energy Research, Hungarian Academy of Sciences, Budapest, Hungary.
7- Institute for Particle and Nuclear Physics, Wigner Research Centre for Physics, HAS, Budapest, Hungary.

Long and local trade in the Chalcolithic of the southern Iberia: The case of funerary votive assemblages from Perdigões, Portugal

Perdigões is one of the largest known Portuguese Chalcolithic ditched enclosures with a high variety of burial remains comprising pottery, lithic artefacts, stone and bone idols, beads, etc.
This study aims to contribute to provenance issues and raw materials identification of funerary votive assemblages from Perdigões, Portugal, also supporting the discussion around long and local trade in the Chalcolithic of the southern Iberia. Non-invasive nuclear techniques were used at the Budapest Neutron Center: Prompt Gamma Activation Analysis (PGAA), External Beam PIXE (particle induced X-ray emission) and neutron radiography (NR); complemented in selected artefacts with high-resolution time-of-flight diffractometer (ToF-ND), Infrared spectroscopic measurements (FTIR) and Scanning Electron Microscopy (SEM/EDX).
Results enable successfully define the nature of the votive artefacts: beads are shell made, and the stone vases and idols are mostly marble, but also some consist of limestone. Shell beads were found in funerary contexts and burnt together with bones during funerary practices in Perdigões site.
The results show signs of both nearby and long distance procurement, as well as of unknown attribution; different raw material provenances seem to be associated with different contexts and rituals, deepening the contrasts that we can see between these funerary features in Perdigões.

Sam Lin 1, Chris Clarkson 2, I Made Agus Julianto 3, Anton Ferdianto 1, Jatmiko 4, Thomas Sutikna 4

1- University of Wollongong
2- University of Queensland
3- Udayana University
4- National Research and Innovation Agency

A new method for quantifying flake scar organisation on cores using orientation statistics

In stone artefact studies, researchers often rely on qualitative classifications to describe flake scar arrangements on cores. While this approach provides a broad overview of core reduction patterns, its application can be ambiguous due to the three-dimensional complexities of core geometry and the subjective nature of qualitative classifications. We propose a new approach to quantify one aspect of flake scar arrangement on cores: the three-dimensional orientation of core scar negatives. Using experimental cores, we demonstrate that statistical techniques from fabric analysis can quantitatively differentiate scar orientations among major core types. This method is also able to reveal variations in the flake scar arrangements of informal cores, such as multiplatform cores. When applied to a sample of multiplatform cores from the Homo floresiensis type-site of Liang Bua in Indonesia, we identify differences in flake scar orientation between cores made by Homo floresiensis and those manufactured by the modern humans who utilised the site after the disappearance of the extinct hominin. This finding suggests a possible divergence in stone knapping practices between the two hominin taxa at Liang Bua. In summary, our research provides a new quantitative approach to gain new insights into hominin technological behaviour through stone artefact analysis. It also highlights the potential of 3D analysis for advancing the field of archaeological lithic research.

Session 5 Stone, residues, use wear
Poster presentations

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2- Department of Geosciences, University of Padova

A multi-analitycal approach for tracking the provenance of stone materials used in the Roman towns of the Veneto region (North-Eastern Italy)

This presentation aims to define types and provenance of stone building materials employed in Roman times in the main towns of the Veneto region (North-Eastern Italy), encompassing the ancient Adria, Vicenza, Padova, Verona and Oderzo. The study is based on the analysis of around 250 stone samples, mainly constituted by fossiliferous limestones coming from various outcrops of the Veneto and Friulan pre-Alpine arc and, subordinately, by the local effusive volcanic-rocks of the Euganean Hills magmatic district. The attribution to geological formations for limestone samples was established through the recognition of index fossil assemblages by Polarized Light Optical Microscopy (PLM). For volcanic-rocks, a comprehensive multi-analytical characterization allowed for a more in-depth identification of the quarry sites. Provenancing was primarily based on the comparison between the bulk-rock geochemical composition of the archaeological samples, analyzed via X-Ray Fluorescence, with that of a reference baseline of geological volcanic-rock samples collected from known quarries of the Euganean district. Moreover, the bulk-rock geochemical data were treated through discriminant analysis (DA), to identify the best matches between the archaeological samples and the quarry ones in probabilistic terms. Provenance determination was eventually supported by PLM and Quantitative Phase Analysis-X-Ray Powder Diffraction, that allowed to discriminate the samples according to peculiar petrofabrics and mineralogical profiles too. Selected case studies will be presented, where the different forms of exploitation of the stone materials in the towns is highlighted as well as the dynamics of stone trade from quarries to sites.

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Marble Source Identification in the Provincial Roman City of Cuicul (Djemila, Algeria)

Djemila is a world heritage site in the northern mountains of Algeria, with a complete Roman urban layout of the 2nd-6th centuries: colonnaded architecture, grand temples, public squares, baths, churches, and statues. The city is mostly built of local stones, but has a significant presence of white and colored marble, which stands out as a refined, elite material. Source identification of the marble can give information on trade, workshops, and sources of artistic influence. A previous study by an Italian team has identified stones "imported" from the Aegean area, as well as from local sources, especially Mt. Filfila on the Algerian coast. The Italian study made use of optical analysis, petrography, and carbon and oxygen isotopes. Our study, which combined isotopic data and elemental analysis using a portable X-ray fluorescence spectrometer, complements this previous work, but in some cases leads to different results,. When two or three results are possible petrographically and/or isotopically, however, macroscopic evidence can at times establish the most probable option.
A persistent problem at Djemila is what might be called the "Mt. Pentelicum/Mt. Filfila entanglement." The two marble sources overlap isotopically, but macroscopic examination of the artifact can at times determine a preference. In third-century Djemila, both the sculptures in Filfila and those in Pentelic marble present an exuberant provincial version of central Italian types. Artistic influence from central Italy, however, does not translate into the use of marble from the main Italian quarry of Carrara. A few sophisticated sculptures at Djemila are marble from the Greek island of Thasos. A portrait head of the emperor Geta is likely to be from the Göktepe quarries near the sculptural center of Aphrodisias in Turkey. These works were probably made by expert workshops based in Rome or elsewhere in North Africa rather than in Djemila, Aphrodisias, or Thasos.

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Update of the Hispanic marble analytical database. Application to the archaeometry of Roman and Medieval pieces

It has been over twenty years since the inaugural comprehensive publication that addressed the characterization of white Hispanic marbles sourced from historically significant quarries, pivotal to the understanding of marble origins throughout the Roman period and the Middle Ages. The originality of this work stemmed from the combined application of petrographic, cathodoluminescence, and stable C and O isotope techniques. This versatile analytical protocol has proven successful in investigating the origins of numerous statuary pieces of various sizes, architectural embellishments, and epigraphy.
The primary focus of this methodology has been on identifying distinctive analytical criteria within the domain of white classical marbles, deliberately excluding grey marbles. However, the need to integrate greyish marbles into the analytical database has become evident, especially when examining specific elements, notably those of a funerary nature and architectural ornamentation.
Supplementary circumstances, linked to the revelation of ancient quarries producing imperial white and grey marbles in ancient Caria, have also impacted the archaeometric investigations into marble provenance. Consequently, the present state of the analytical UNIZAR/ICAC marble database, pertaining to the most paramount classical marbles, is herein delineated, along with its archaeometric application to some recent Iberian examples.

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New Results from the Australasian pXRF Archaeological Researchers Collective

New results are presented from the establishment of an 'Australasian Portable x-ray fluorescence (pXRF) Archaeological Research Collective' that seeks to address common issues faced by archaeological and First Nations researchers wanting to use pXRF. This is a preferred technique for chemical characterisations of artefacts because it is non-destructive and pXRF instruments are often marketed as 'out-of-the-box-ready-to-go', however the practical realities for research are not always so straight forward. This extends to training communities on these instruments for use in the field and in collections. Key issues include custom calibrations, radiation safety (state legislation), realistic field applications and data quality. The solution requires much more collaboration between researchers and institutions in Australasia. Importantly, our current research must now confront how archaeologists curate databases for Open Science to meet the UNESCO "Findable, Accessible, Interoperable, Reusable" and "Collective Benefit, Authority to Control, Responsibility, Ethics" (FAIR and CARE) principles especially when working with First Nations communities. Work towards solutions is being achieved through this project by connecting multiple archaeology departments in different institutions across Australia and New Zealand to establish a network of accessible research-ready instruments across Australasia.

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Damage and restoration of stone cultural pagoda composed of carbonate rock

Most stone cultural properties in Korea used granite, but some stone cultural properties used single or composite materials such as igneous rock, metamorphic rock, and sedimentary rock. The subjects of study are three stone cultural pagodas owned by the National Museum of Korea: 1) Stele of State Preceptor Hongbeop and 2) Stupa of State Preceptor Hongbeop at Jeongtosa Temple Site, Chungju, and 3) Stele for Master Wollang at Wolgwangsa Temple Site, Jecheon. There are composed of a monolith of carbonate rock or a composite of carbonate rock and granite. Because granite is widely distributed nationwide and has similar chemical composition, it is difficult to estimate its origin based on simple analysis values. Therefore, the origin of rocks requires a comprehensive review of data on occurrence, mineral phases, physical properties, and chemical composition. However, since the rock cultural properties under study are designated as national treasures and sample collection is not possible, classification and mineral identification were conducted through non-destructive methods such as visual observation, magnetic susceptibility (MS), portable XRF, and short-wave infrared spectroscopy (VNIR-SWIR). In conclusion, it is presumed that the stone cultural Stele of Jeongtosa Temple in Chungju and Wolgwangsa Temple in Jecheon are suggest of the same origin. The granites of stone cultural properties are separated into fine thin films or develop into micro-cracks due to physical and chemical weathering, and plagioclase was partly altered to kaolinite. Chemical weathering confirmed gypsum and clay minerals as secondary minerals through SWIR spectroscopic analysis.

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Digital conservation of the megalithic landscape of Laos

The megalithic landscape of north-central Laos, often referred to as the Plain of Jars has long been an enigma. Megalithic sites are found both on the Plain around Phonsavan, Xieng Khouang and in the surrounding mountains, and comprise more than 2,500 hollowed stone jars, discs, and boulder burial markers. These are spread over more than 120 documented sites, 11 of which were inscribed as UNESCO World Heritage in 2019. Research on these sites, however, has been hindered due to the extensive unexploded ordnance (UXO) contamination of Laos. A joint Australian-Lao initiative commenced research in 2016 in an effort to fill the lacuna in archaeological investigation.
Throughout the project, a vast archive of digital data has been collated from excavation, landscape survey, and documentation of material cultural heritage and stored in an open-access website repository. In an effort to aid conservation endeavours at five sites, every megalithic jar at the investigated sites (more than 1100), disc, and boulder were photographed and geolocated, with morphological attributes recorded. At the most visited and accessible site, Site 1, a high-resolution 3D map was created through extensive UAV mapping, with the precise position of each of the 316 individually numbered jars and discs recorded. This map will be used by heritage personnel to monitor 'megalith health' and site integrity as part of the requirements of World Heritage Listing. Further research will commence on the Megalithic Jars of Laos in February, 2023 with the support of the Australian Research Council. This will see not only the jar sites further explored but also the standing stones (menhir) of Laos and strikingly similar jar and menhir sites in Northeast India.

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Quantitative use-wear analysis by optical profilometry of percussive stone tools from Kenya (Nyayanga, Early Stone Age)

Quantitative use-wear analysis of archaeological materials has increasingly gained popularity recently, supporting qualitative functional studies for further insights into past human behavior. Despite the technological advances, the quantitative approach still suffers from methodological limits and has mostly addressed only experimental materials. In this contribution, 3D optical profilometry is applied to the quantitative use-wear analysis of percussive stone tools (made of quartzite, rhyolite, and granite) from Nyayanga (3.032–2.581 Ma), an Early Stone Age archaeological site in Kenya. The surface topography of the tool replicas was computed from 3D models acquired by profilometry; their morphometric parameters (roughness, peak height, valley depth, etc.) were then treated by multivariate statistical analysis. Based on the indications from qualitative microscopic observations disclosing the use-wear patterns, the different functions of the stone tools for processing animal tissues (bones and soft tissues) and plants (underground storage organs) were discriminated. These are consistent with the archaeological context, characterized by remains of hominins and animal fossils with cutmarks. The findings provide indications on early hominin technological evolution and dietary strategies. Moreover, the potentialities of quantification by profilometry are shown, while stressing the urge for standardization of the measurements and data processing methods.

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1- University of South Florida

Late Bronze/Early Iron Age Obsidian Use at Santa Barbara di Bauladu in Sardinia (Italy)

Archaeological excavations at the Late Bronze-Early Iron Age site of Nuraghe Santa Barbara di Bauladu in Sardinia produced more than 1000 obsidian artifacts. Analyses were conducted in 2023 on 617 of the artifacts, identifying the specific geological sources that were used and allowing the reconstruction of prehistoric trade and exchange patterns. This study, on the largest number of obsidian artifacts ever done in Sardinia, provides statistically significant data that may be compared with results from both contemporary LBA/EIA sites as well as earlier Neolithic/Chalcolithic sites.
Santa Barbara di Bauladu is a complex Nuragic site with multiple external towers, constructed in the Middle Bronze Age about 1500 BCE. The village on the west side of the Nuraghe (1200-800 BCE) has evidence for bronze, copper, and lead metal casting used for tools and bronze figurines. Obsidian continued to be used throughout the Bronze Age, however, with the material obtained from different subsources at Monte Arci.
A Bruker Tracer 5e X-ray fluorescence spectrometer was used to conduct non-destructive analyses on an extensive number of geological samples from each subsource, and the obsidian artifacts from Nuraghe Santa Barbara. Trace elements Rb, Sr, Y, Zr, and Nb were used to assign each artifact to a specific Monte Arci subsource (SA: 90, SB1: 9, SB2: 99, SC: 419), as well as identifying several artifacts which were not obsidian. The results are compared for different contexts of the site, and with other Nuragic sites with at least 25 artifacts tested: Ortu Comidu (147), Duos Nuraghes (244), Serbine (35), Urpes (45), and Mitza Pidighi (142). The patterns for these Nuragic sites are then compared with those from the Neolithic and Copper Ages, and changes over time in socioeconomic complexity discussed. While the SA and SB subsources dominated many Early Neolithic sites, SC was ≥66% for these six sites.

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Sourcing of Obsidian Artifacts from Corbeddu Cave (Sardinia, Italy)

Best known for pre-Holocene discoveries at the site, excavations of Corbeddu Cave in Oliena (Nuoro, Sardinia, Italy) discovered obsidian and other lithics, ceramics, and domesticated animal remains from more recent contexts starting in the Early Neolithic. There is no evidence of continuous occupation from the Mesolithic to Early Neolithic, when there is the appearance of the neolithic "package" at many sites in Sardinia. At the Corbeddu Cave site, most of the obsidian finds date to the Early and Middle Neolithic, but continue to the Early Bronze Age. The obsidian artifacts excavated in the cave include blades, scrapers, gravers and trapezes, and were analyzed non-destructively using a Bruker Tracer 5e X-ray fluorescence spectrometer. This instrument was used on an extensive number of geological samples from each subsource of the Italian island sources (Lipari, Palmarola, Pantelleria, Sardinia). Trace elements Rb, Sr, Y, Zr, and Nb were chosen to assign each artifact to a specific Monte Arci subsource.
Thirty-six obsidian artifacts were analyzed and assigned to the Monte Arci SA, SB2, or SC subsources. None matched with any of the SB1 subsources, which were rarely used. Two other artifacts in the assemblage turned out not to be obsidian, but likely a dark-colored chert or flint. More than 80% are from the SC subsource, clearly a selection when compared with other sites in Sardinia. Other studies have shown that SA and SB2 were widely used in the Early-to-Middle Neolithic, as far as mainland Italy and southern France, with SB2 almost disappearing and SC dominating virtually all sites by the Late Neolithic/Chalcolithic. Few previous studies have dealt with sites to the east of Monte Arci, however, and this study addresses potential routes from the SC subsource to the mountainous regions of the Barbagia.

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Ceramic technologies in transition, or continuation? A petrographic and geochemical study of Hellenistic to Roman Imperial tableware from Sagalassos (SW Anatolia)

Located on the slopes of the Western Taurus Mountain range, the ancient town of Sagalassos underwent extensive urban development from the 2nd c. BCE onwards and gradually became one of the main ceramic production centres in the historical region of Pisidia. From the second half of the 1st c. BCE, the so-called Sagalassos Red Slip Ware (SRSW), a regional variety of the style and tradition of eastern sigillata, started being produced at the site and gradually replaced its Hellenistic predecessors. This study investigates how SRSW emerged and how it relates to the pre-existing tradition in Hellenistic slipped pottery at the site in terms of the technology of production and raw materials used. For that purpose, 92 samples from the site dating from the Hellenistic to Middle Roman Imperial periods have been analysed using thin-section ceramic petrography and geochemical analysis (ICP-OES & -MS). A subset of representative samples was further investigated using SEM-EDS to characterise the microstructure and chemical composition of slips over time. The results reveal the continuous use of the same raw materials, namely the clays from the northwestern part of the Çanaklı valley, despite the fact that the society was different in each period. Tableware production at Sagalassos shows a high degree of conservatism and continuity in terms of the raw materials used, indicating the quality and preference for these mineral resources. Focusing on the site of Sagalassos, the study demonstrates the importance of examining Hellenistic slipped wares alongside the subsequent Roman sigillata production in order to better understand this transition in ceramic styles and reconstruct ceramic traditions in the longue durée.

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Variability in chaînes opératoires for negative painted pottery from Nariño, Colombia

Negative painted pottery represents a complex, multi-step production process that was employed across the Americas. The negative decoration was achieved through resist painting, where the design was first painted with a temporary protective material such as wax, after which the ceramic was covered all over with a material imparting a dark colour, and subsequently the protective material was removed to expose the underlying design in a light colour against a dark background. Prime examples of this are seen in the Nariño region of Colombia, where three overlapping pottery styles, Tuza, Piartal and Capulí, were produced in the pre-Hispanic period (~5th-16th c. CE). Two of these, Piartal and Capulí, employ negative decoration on a wide range of vessels and figurines, contemporaneously with negative decoration in metals and textiles.
We present the results of the first reconstruction of the chaînes opératoires of Tuza, Piartal and Capulí ceramic vessels with the aim to better understand craft organisation in pre-Hispanic Colombia. Leveraging in-situ, non-invasive analysis of complete vessels (n=114), and minimally invasive analysis of sherds (n=93), we characterised vessel morphology (3D GMM), ceramic paste and surface decoration composition (pXRF, Raman spectroscopy), and technology (SEM-EDS), thus reconstructing production pathways for these ceramic styles. While similar raw materials were exploited to produce the red (Ti-enriched hematite) and black (carbon) designs, they were used through distinct production pathways and achieved different stylistic results. The results suggest that production of these wares was not controlled or constrained to discrete workshops or individuals, instead the evidence points to widespread production. The comparative study reveals a complex picture of craft production in the region, including issues of heterarchy and cross-craft interaction.

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A multi-analytical approach applied to pottery from Oman as a key to understanding ancient Indian Ocean maritime trade.

The populations in Sumhuram (3rd/2nd century BCE - 5th century CE) and Hamr al-Sharqiya 1 (HAS1) (1st millennium BCE - 1st/2nd century CE) were involved in one of the most important examples of large-scale trade systems in antiquity: the maritime network connecting the coasts of the Indian Ocean. This research focuses on a total of 35 southwestern Arabian and Indian pottery sherds from both the settlements of Sumhuram and Hamr al-Sharqiya 1, analysed through a multi-analytical complementary approach. This study intends to test the input potential of this type of approach applied to ceramics in the context of the Indian Ocean trade network. The techniques adopted are Powder X-Ray Diffraction (PXRD), Optical Microscopy (OM), Inductively Coupled Plasma-Mass Spectrometry (ICP-MS) and Scanning Electron Microscopy coupled with Energy Dispersive X-ray Spectroscopy (SEM-EDS). The results obtained allow the identification of 8 distinct groups, each characterized by unique (textural, mineralogical, geochemical) signatures, providing specific clues for determining their provenance, specifically from the Indian subcontinent and southwestern Arabia. This paper shows the importance of this type of archaeometric studies that must be integrated into a transdisciplinary approach.

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The copper provenance in the Shang period China

The provenance of copper is a key issue for the study of Shang period (16th-11th century BC) China. However, as most Shang bronze artefacts were heavily leaded, lead isotope analysis provides little information regarding the origin of copper and left a significant research lacuna in the reconstruction of metal flow network in Bronze Age China. More than 300 pieces of copper ore fragments recently identified in the Early Shang capital at Zhengzhou shed new light on this issue. We developed a innovative copper provenancing approach focusing on mineralogical, chemical and isotopic analyses for copper bearing minerals and garnet in these ore fragments. In-situ U-Pb dating of garnet with LA-ICP-MS reveals an ore forming age of 143-145 Ma, corresponding well with the middle Yangtze copper belt and significantly varied from ore sources in north China. EMPA analysis of garnet and LIA of chalcopyrite help to differentiate these samples from ore deposits in Qinling, Eastern Hubei and Southern Anhui, pinpointing their source to the Skarn deposit in Jiurui orogenic belt. We further analyzed un-reacted garnet inclusions in Shang period copper smelting slag identified in this region and obtained quite similar U-Pb dating result. This research demonstrates a long-distance transportation of the copper resources from the Middle Yangtze River valley to the Central Plain during the Shang period and revealed the significance of southern copper resources in the Shang massive bronze production. Additionally, this research showcased the importance of analyzing ore fragments revealed from settlement sites and established a new route for provenancing copper in the Bronze Age China.

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Technical and economic history of Western Han dynasty revealed by mirrors from Zonglvcheng cemetery, Linzi, China

In this study bronze mirrors from the Zonglvcheng cemetery in Linzi city, the unique bronze mirror production centre of the Western Han dynasty (WHD, 202 BC - 8 AD), were subjected to scientific examinations. Compositional and lead isotope ratio analyses on 41 bronze mirrors from different periods of WHD were conducted. For the first time, a mirror made of pure lead and another one made with highly-radiogenic-lead were identified. The compositional analysis revealed a roughly stable copper-tin-lead ratio of 14:5:1 for mirrors, providing insights into a standardized mirror production. The interpretation of isotope ratios was by combining characteristic parameter and kernel density estimate methods, compiling a wide range of published for comparison to mitigate the detrimental effects of overlap effect. The results indicate that the majority of mirrors were produced within Linzi city, but their lead sources were likely from the Xiaoqinling metallogenic belt controlled by the Han Empire rather than local to Shandong province. This study demonstrates that changes in the alloy compositions and ore sources for bronze mirrors and other objects with time were influenced by state-intervention economic policies, providing a new perspective for the study of technical and economic history during the WHD.

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The Empire of Silver: An insight of the Ming Dynasty silver-based monetary system from stylistic and scientific investigation of Ming silver Bullions

The exploration of silver deposits in America and Japan since the 16th century had given a great impetus to the early globalization process and caused a large amount of silver flowing into China. In the middle of the Ming dynasty, silver finally achieved the status of standard currency, and was widely used for national affairs such as taxation and military expenses, as well as domestic trade and labor pricing. Previous studies of Ming silver currency system were mainly based on documentary evidence, while much less attention was paid to physical evidences e.g. silver bullions. Indeed, standardized silver bullions carried a great amount of information about the Ming silver currency system and can greatly enhance our understanding about this period.
Based on the examination of shape, weight, production technology, and chemical composition, this research is devoted to understand the evolution of the Ming silver-based economy and influence of imported silver on this system. More than 500 bullions have been subjected to stylistic analysis, while 200 of them were analyzed for their chemical composition. The shape and weight of ingots show a clear diachronic change and might be related to the development of purity testing techniques . The varied chemical compositions of ingots from different provinces suggest quality-control measures might be region-based and highly diverse. The on-going isotopic and trace element analyses will potentially reveal the flow of imported silver in Ming domestic market and explain how a civilian-based activity (oversea silver trade) finally altered the political and economic structure in the Royal Court.

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A comprehensive archaeometric study of the first half of the 1st millennium BCE glass from South Etruria and Latium

After presenting some preliminary results at ISA 2022, the INGOT-EL project (INvestigation of Glass Origin and Technology in the Etruscan Lands) has now been completed and is reported in this presentation. It provided compositional data for about 290 glass objects (mostly beads) from 14 archaeological sites in southern Etruria and Latium, dating from the Early Iron Age to the Archaic period. The first step was to define a typological framework in order to group the objects according to their shape, dimensions and decoration. We then carried out a non-invasive chemical characterisation in the museums using portable instruments for X-ray fluorescence spectrometry and fibre optic diffuse reflectance spectroscopy. Finally, a subset of samples was analysed in the laboratory, mainly using laser ablation inductively coupled plasma mass spectrometry. Overall, the approach provided information on the base glass, colourants and opacifiers, showing a complex picture of glass production by the use of different raw materials. Trace element profiles revealed several sources of silica, suggesting many origins for the glass that reached the Italian peninsula. In some cases, the chemical composition allowed us to indicate a possible region of origin, and glass produced in Egypt, the Levant and the Italian peninsula was identified by comparison with data from the literature and archaeological evidence. The data show that the Iron Age glass industry in the Mediterranean was a constantly evolving one as the change in the use of certain materials over time was documented by the chronological distribution of the objects. Although conclusions about provenance should be drawn with caution in the absence of actual evidence of glassmaking and large-scale provenance testing, the reconciliation of chemical data with typological information allowed a contribution to the discussion of glass supply and circulation in the area during the first half of the first millennium BCE.

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Piecing the shattered past: discovering the stained glass of late medieval Dubrovnik

One of the most striking architectural features of the medieval and post-medieval periods in Europe, stained-glass windows are at present a very rare find in the wider Balkans region, and chemical analyses of these are even scarcer. In this paper, we present the first compositional analysis of late medieval stained glass from the Cathedral of the Assumption of the Blessed Virgin Mary in Dubrovnik, Croatia.
The Romanesque Cathedral was built in the twelfth century and the glass from this study is presumed to date from fourteenth to fifteenth centuries. The 35 samples were analysed using LA-ICP-MS to investigate the variety of compositional types present in the assemblage, and to assess the prospect of local production of red flashed glass during the Gothic-Renaissance period, mentioned in manuscript sources from the Dubrovnik archives.
The analysis has shown the assemblage mostly comprises Central European forest glass, with notable examples of red and purple flashed glass. Use of the same base glass in preparation of the white and red layers of flashed glass could suggest they were prepared (coloured) by a local glassmaker. The results build on current insights into the extent of glass trade in South East Europe during the late Middle Ages, and shed light on the connections of the Dubrovnik Republic with the various glass production zones active in the period.

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Using Sr and Nd isotopes to provenance plant-ash glass from the Silk Roads

Research on plant-ash glass has largely focused on evidence from the Near East, while the production and trade of various plant-ash glasses from the eastern Silk Road regions, including Iran, Central Asia, and Xinjiang (China), are not well understood. Here, we present research on plant-ash glass provenance in these understudied regions through the novel application of Sr and Nd isotopes, which are respectively used to trace the major glassmaking materials – plant ash and silica. We employ an integrative approach for plant-ash glass provenance that incorporates chemical composition, Sr and Nd isotopes, Nd isotope mixing lines, and Sr-Nd isotope baselines. Chemical composition and Sr-Nd isotopes reveal potential sample connections through compositional signatures, while the Nd isotopic-chemical relationship (mixing line) captures the dynamics of the mixing process. We compare the glass isotopic signatures to those of bioavailable Sr and detrital Nd isotopes for demarcated zones in the Tigris-Euphrates River Basin, Iran, and Central Asia, serving as the geochemical benchmark for raw material provenancing. Applying this approach to study the organisation of glass production, we find that the decentralised glass industry in Islamic-period West and Central Asia likely thrived by exploiting and sharing diverse, regionally characteristic raw material sources. We also present a pilot study on an 11th–12th century assemblage unearthed in Shadyakh, Nishapur, Iran, and find diverse origins for these artefacts. Our research demonstrates the utility of Sr-Nd isotopes in characterising diverse plant-ash glasses from the eastern Silk Road regions and shows that the integrative approach may help refine the provenance of plant-ash glass.

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Characterization and new insights of the Warring States period faience beads from Gansu, China

First appearing in the Near East and Egypt toward the end of the 5th century BCE, faience is thought to have spread to Europe and suddenly appeared in the Central Plains of China with the rise of the Western Zhou Dynasty, about 3000 years later compared with the western countries. The faience production in China was developed during the Han Dynasty (202 BCE to 220 CE). With the development of technology, glass production thrived and gradually replaced the faience production. During the Warring States period. The adoption of lead and barium as flux in glass/faience production was found exclusively in China since the same period.
16 beads with the full structure were carefully selected from grave M52, Majiayuan Cemetery of the Warring States. Methods such as OM, SEM-EDS, Raman, XRD and EPMA were adopted, for the characterization of the materials and crafts. This study revealed that the beads were produced using the “core forming” technique. The beads were porous, with the surface layer partially visible. Continuous interparticle glass or interaction layer were not formed. The severe weathering, leading to the partially visible glaze layer and concentrated Pb on the edge of rims. Moreover, it’s quite interesting to find the Fe-rich mineral next to the inner rim of the bead. Han Blue and Han Purple, the earliest ancient Chinese synthesis pigment, were identified as colorants, and the Ba source was assumed to have originated from BaCO3. The ratio of Pb-Ba-Si was kept within a specific range for stable Han Purple and Han Blue. Unlike other tested samples, faience in M52 has a constant low concentration of Na2O-K2O-CaO and a lower fluctuation of PbO-BaO. Nevertheless, the PbO-BaO content of faience beads has a relatively concentrated range instead of a random recipe.

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Microstructure Analysis and Coloring Mechanism of the Jian Bowls

The Jian kiln in Jianyang, Fujian began producing renowned black-glazed bowls during the Song dynasty (960~1279 A.D.), influenced by the refined tastes of an cultivated scholar class. These bowls were ideal for tea tasting, emphasizing the rich white tea decoction.
Jian bowls have a thick and lustrous black glaze with patterns called "hare's fur (HF)" or "oil spot (OS)". Most are brown HF, while rare ones show silvery HF or OS patterns. On a very small number of excavated Jian bowls, some surface areas exhibit color changes based on the viewing angles.
This study focuses on the excavated Jian bowl shards with different visual appearances, using various characterization techniques, such as OM, EDXRF, angle-resolved reflectance spectra, XRD, micro-Raman, SEM-EDS-EBSD, and AFM. Macroscopic optical properties of the feature areas were characterized, and the relationship between chemical composition, microstructure, corrosion characteristics, firing process, burial environment, and coloring mechanism was systematically investigated.
For the first time, the physical colors of the Jian bowls are categorized into two types: First, the Blue HFs are due to coherent light scattering by a structure formed by iron oxide crystals, while silvery HFs result from light reflection by dendritic crystals, inhibiting iron oxide coloration. Second, the bowl's iridescent color is from surface corrosion, displaying rich color and obvious angle dependence, attributed to thin-film interference.

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Transformation and Adoption: 8th-13th Century Technical Innovations in Pottery in Raqqa Syri a within a Comparative Study between it and Chinese Turquoise-Glazed Ware

Raqqa/Rafiqa, Syria, was one of the production centers for turquoise-glazed ware with a longstanding tradition in West Asia. The term Raqqa ware is broadly referred to as turquoise glaze ware. However, pottery production in Raqqa extends beyond the connotation of "Raqqa ware".
In recent decades, archaeological excavations at the sites of Tell Asward, Tell Zujaj, Tell Fukhkhar, Tell Abu Ali and the eastern city wall have uncovered key pottery and glass workshops. Scientific archaeological analysis of petrography, strontium isotopes, and scanning electron microscopy, pottery techniques in Raqqa underwent a shift from lead-alkali glazes to alkali glazes and existed various experimental glazed pottery. Simultaneously, glass technology experienced a transition from soda-lime glass to ash plant glass, with a certain degree of technological overlap between glass and glazes.
Through maritime trade in the Indian Ocean and the expansion of the Mongol Empire, turquoise glazed ware served as one of the material cultural carriers reflecting the interaction between China and West Asia. During the 8th-10th centuries, West Asia turquoise glazed wares were unearthed in several sites with different archaeological contexts in China, and Raqqa may be one of the production areas. However, it wasn't until the 12th-13th century that kiln evidence of domestic production of turquoise glaze appeared in China. Combining Chinese glaze pottery tradition, three turquoise glaze systems—lead-alkali glaze, high-calcium glaze, and high-alkali glaze—were developed, and it is also associated with glass and alchemy. Chinese turquoise glaze ware, Fahua ware, and Cizhou ware have similar decoration styles to West Asian Laqabi, Sgraffito, and black painting under turquoise glaze ware. Apart from technological choice, as a foreign color '胡色', the shift from neglect to acceptance of turquoise glaze in China should be understood within the context of the Chinese color system.

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Production of arsenical bronze using speiss on the Elephantine Island (Aswan, Egypt) during the Middle Kingdom (Middle Bronze Age)

We would like to present in this paper the first direct evidence of the copper alloying by arsenic in Ancient Egypt, i.e. the evidence for the production of arsenical bronze. The material in question comes from a well-stratified and well-dated context of the Middle Kingdom settlement on the Elephantine Island, located in the Nile in contemporary city of Aswan. Several excavation seasons of the Realities of Life project, led by Johanna Sigl, focused on a small part of the Middle Kingdom settlement on this island. The main deposits are datable from the Eleventh to Thirteenth Dynasty. Almost 500 stratified metallurgical remains (slags, fragments of crucibles, casting prills), minerals and finished produced artefacts were documented and analysed using the pXRF in the site magazines. Selected 48 metallurgical by-products were studied in more detail using metallographic methods (at the laboratory of the Institut français d'archéologie orientale du Caire, pôle Archéométrie) and the SEM/EDX (Desert Research Center), with the research supported overall by the Ministry of Tourism and Antiquities. Secondary metallurgical operations (including melting, casting, alloying and possible recycling), processing unalloyed copper, mostly arsenical copper, and also ternary alloy of copper, arsenic and tin were recorded within this extensive analytical research. Evidence of the copper alloying by arsenic and intentional production of arsenical bronze at the site is supported by the finding of speiss fragment, coming from the remains of House 175, datable to the advanced Twelfth Dynasty (18th Century BC). This artificially produced iron-arsenic alloy is relatively well-known from several EBA and LBA copper workshops, especially located in Iran, suggesting that speiss was widely used and traded (Thornton et al. 2009, Rehren et al. 2012). This newly studied material makes the corpus from the Elephantine Island a crucial contribution to the understanding of the processes of Middle Kingdom copper metallurgy in Egypt.

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Inferring Metallurgical Practices from Metallurgical Ceramic Fragments at Mayapan, Mexico

Metal workers at the site of Mayapan, Mexico produced a variety of metal artifacts, including bells, tweezers, rings, fishhooks, and other decorative items from copper and copper alloys during the Postclassic period (AD 1150-1450), despite living in a karstic environment hundreds of kilometers from metal ores. These specialized craftspeople focused on remelting and casting copper into the objects used at Mayapan. Our initial investigations of the metallurgical ceramics they used, including molds and tuyeres (blowpipe tips), confirmed the local production of metal objects at the site. In this study, we expand the corpus of metallurgical ceramics studied to reconstruct additional details of the metallurgical techniques used at Mayapan. Here we present evidence from the study of 55 metallurgical ceramic fragments to better understand the melting and casting processes, such as the direction of heat flow and the volumes of material processed in each batch. Using data from a variety of analytical techniques, including scanning electron microscopy (SEM), mass spectroscopy (ICP-MS), and reflected and transmitted light microscopy, we suggest that Mayapan metallurgists worked with small volumes of metal at a time and likely used a variety of heating techniques to melt the copper for casting.

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Reintegrating the local into the global: intra-regional movements and the symbolic values of imported Muisca gold (Colombia, AD 600-1600)

Provenance studies often elicit discussions of how people in the past ascribed special value to materials due to the perceived difficulty of obtaining them across long distances. For instance, the Muisca of the Eastern Cordillera of Colombia are known for relying extensively on gold to manufacture both votive offerings and body ornamentation, even while lacking direct access to geological deposits of the metal.
In this work, we use compositional evidence to show that the symbolic value of Muisca gold did not arise exclusively from its status as a foreign luxury. We first present the results of new computational models on the region's goldwork. We propose that the chemical signatures of the votive offerings reflect contributions of gold from people converging into specific locations for festivities, highlighting the importance of communal activities involving intra-regional movements of the metal. In contrast, the chemical signatures for body adornments indicate more restricted practices of metal procurement and processing. Secondly, we present new LA-ICP-MS data of ornamental Muisca goldwork from the site of Nueva Esperanza for a more detailed case study of how gold changed hands across the region and moved into a single settlement. We conclude by calling for a more widespread re-assessment of archaeometric models that place excess emphasis on long-distance processes, at the expense of both the intra-regional and the local.

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Metals meet culture: Management and hoarding of metals in prehistoric southeastern Europe

The burial of metals in hoards is a trademark phenomenon of prehistoric Europe that may be counterintuitive to perceptions of value nowadays. Much of existing research on prehistoric hoarding has focussed on hoard composition and patterning or on specific technological and provenance indications. For the first time during this study, we establish detailed biographies of a large corpus of hoarded metal objects that reveal how Late Bronze Age societies engaged with their material wealth. We combine quantitative and qualitative data from ca. 200 metal tools and weapons and use data reduction methods to define technological pathways in the sourcing of materials, production, use, decommissioning, and deposition from a cross-cultural transect in the southern Pannonian Plain. Bulk elemental compositions are combined with detailed metallographic observations registered over ca. 40 scale and ordinal variables from axes, sickles, spears, and swords. This comprehensive metallographic database turns descriptive metallographic observations to quantifiable variables that can be then processed statistically for uncovering patterns of technological choices within the sample. Our results show how the differential treatment of materials and objects was strongly biased by social decisions across the artefact types. We identify signature treatments manifested through communities of practice extending beyond social-spatial boundaries. Consumer dynamics and perceptions about the social lives of metal tools and weapons shape as they are being shaped by community relations in later 2nd millennium BC southeastern Europe. Our findings bring new insights on the interface between communal and elite wealth management at the intersection of technological reasoning and symbolic beliefs in prehistoric communities.

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Searching for the origins of early Islamic brass-making in the Middle East and Western Asia

In the early part of the second millennium CE, brass emerged as a major form of Islamic metalworking, with beautiful objects inlaid with intricate copper and silver designs. However, we know comparatively little about the background to this development, and particularly its association with earlier brass-making in Europe and Asia. Securely dated archaeological finds from sites across the Middle East and Western Asia provide new evidence and a new opportunity to trace the development of these traditions.
We present analyses of hundreds of excavated artefacts from regional sites dating from Late Antiquity to the early Islamic period, including the Persian Gulf port of Siraf and the central Asian city of Merv. Using XRF and SEM-EDS, we trace the different metals and alloys in circulation at different times and places, as well as the various manufacturing processes associated with their use. We also integrate these new analyses with a range of legacy scientific data from the eastern Mediterranean and Asia. This provides context and insights into the choices of metalworkers and consumers in this period, as well as changes in the nature and role of brass within these communities in the lead up to its adoption as a popular and prestige material.

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2- Sorbonne University
3- KU Leuven

Active arsenical copper alloying in the ancient Nile Valley

Arsenical copper was the first widespread copper alloy employed in the Nile Valley, remaining dominant from the Naqada II through the Middle Kingdom period (ca. 3500-1650 BCE). Despite its gradual replacement by tin bronze from the Middle Kingdom onwards, evidence for continued arsenical copper use in Egypt and Nubia exists in later periods. Yet the metallurgical processes underlying arsenical copper production remain poorly understood.
Recent research into primary copper production evidence has illustrated the high purity of exploited copper ore and raw copper smelted during the Old and Middle Kingdom, for example in Southern Sinai and at Ayn Soukhna. This stands in contrast to the abundance of arsenical copper alloys, indirectly suggesting a secondary alloying procedure (cf. Rademakers et al. 2018 (JAS) and 2021 (AAS)). However, direct evidence for such active alloying processes has remained undocumented until now.
In this paper, we present new results proving the hypothesis for intentional secondary arsenic alloying, drawing together studies of production waste from Ayn Soukhna and Amarna (Egypt), as well as Kerma (Sudan). New data is presented from fieldwork and in-situ analysis of archaeological remains in Egypt and Sudan, as well as the study of objects from the British Museum collection.
Comprehensive typological, elemental, mineralogical and lead isotopic analysis of these materials is combined to characterise the rare indicators for this unique technology and outline its impact for our understanding of copper alloys and their underlying production chains in the Nile Valley. More widely, evidence for the use of arsenic-rich minerals and/or speiss in the eastern Mediterranean Bronze Age is evaluated in light of these new discoveries.

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2- University of Granada
3- Queen's University Belfast

Copper-based metals from El Argar (Antas, Spain). A first detailed case study about Bronze Age metallurgy in Iberia

El Argar is one of the most outstanding sites in Bronze Age Europe. Excavations at the end of the 19th century by Henri and Louis Siret unearthed more than one thousand burials, many of which contained metalwork objects among the grave goods. The burials were located under the floors of the dwellings, with assemblages showing the social diversity of the interred. The materials from this site were dispersed across numerous museums, hindering a comprehensive study after the partial publication of the findings in 1887, which only covered the first 780 tombs. Thanks to the documentation from the Siret Archive, a digital open-access resource, and to several recent research projects we can now describe the metalwork assemblage recovered and the spatial distribution of objects with better detail. The Siret brothers found nearly 1250 copper-base objects, and a few more have been discovered later. Only 77 elemental analyses were published in previous studies, but in the last ten years, a substantial number of new elemental and lead isotopes analyses from objects held in different museums (Madrid, Ghent, Brussel, Rome and London) and a fresh survey of the site of El Argar have significantly increased the available information. At present, 209 elemental and 91 lead isotope analyses are available to describe the process of the adoption of tin bronze, to help us understand the provenance of the metal and to discover socioeconomic patterns in metalwork production and consumption.
The metalwork assemblage from El Argar can be classified in three main groups: tools, weapons and ornaments. There is a clear trend towards sampling larger and more massive metal objects (easier to sample), with ornaments being the numerically largest but the least analysed group. Each object is classified according to the alloy (copper, arsenical copper or tin bronze) and assigned to a copper group following the Oxford model, based on the presence/absence of As, Sb, Ag and Ni. This model lets us use legacy data and chemical data obtained through different analytical techniques with varying quality. Provenance research offers the opportunity to discuss opposing models previously proposed (centralised or decentralised supply). Finally, the combination of age, gender and spatial location of the burials with chronological data derived from new radiocarbon determinations allows us to paint a more complete picture of the use and consumption of metals at this emblematic site from the Iberian Bronze Age (2200–1550 cal. BC).

Session 6 Ceramic, metal and vitreous Poster presentations

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Preindustrial Copper Smelting in Western Mexico: A Technological Reconstruction

The earliest evidence for copper metallurgy in Mesoamerica, comes from West Mexico and dates to ca. A.D. 800. Over a period of approximately 700 years, a wide variety of artifacts, typically decorations and other valuable non-utilitarian in a number of contexts. After the Spanish Conquest, the colonizers assumed control of the local copper industry, but they employed native miners and smelters, who for decades carried on the metallurgical techniques that they knew. While metal was used for an array of goods, little is known about the châine operatoire of this craft. Archaeological research at the site of Jicalán Viejo (ca. 1400-1609), in Central Michoacan, has recently located potential production areas where concentrations of manufacturing slag and other smelting byproducts were recorded.
The smelting of ores is almost invariably related to the formation of slags, because these byproducts act as collectors for impurities introduced into the smelting process. Slag analysis, thus, has the potential for revealing important information about metallurgical technology. Copper smelting slag recovered from Jicalán Viejo, have been analyzed for microstructure and compositional properties using optical microscopy, X-ray fluorescence spectroscopy (XRF), and scanning electron microscopy with energy-dispersive X-ray spectroscopy (SEM/EDS). Preliminary results indicate a smelting technology that used sulphidic and arsenical ores, and efficient furnaces. Further investigations are currently in progress to precisely date these activities. This technological information is important for establishing the context and scale of production of metal goods in ancient Mesoamerica.

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Let the sherds speak: Petrographic analysis of new ceramic finds from Ormi, Eastern Torres Strait

Despite representing one of Australia's only known ceramic traditions, limited provenance work has been done on pottery from the Torres Strait. This is partly due to the small number of sherds recovered from the region, with over 20 years of excavations yielding less than 50 sherds. This poster presents petrographic results from three sherds and a locally fired object recovered in 2022 from excavations at the Ormi site, in the Eastern Torres Strait. Two of the sherds were red-slipped surface finds that exhibited striking similarities in their petrography, suggesting a common origin. The third sherd was from an excavated context of ~2,600 BP. It was petrographically different from the other sherds and distinct from anything previously noted in the literature. Fired loam from a sediment block was also examined to provide a baseline for recognising local ceramic tempers in the ETS.

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Crafting Neolithic Narratives: A Comprehensive Study of Pottery and Plaster Technologies in Makri, Northern Greece

This doctoral research project, conducted within the Marie Sklodowska-Curie Innovative Training Network (PlaCe), investigates Neolithic pottery and plaster technologies at the systematically excavated site of Makri in Northern Greece. By studying the site's well-preserved assemblage of black-burnished pottery, clay figurines, clay architecture, and lime-plastered floors, this study looks beyond the traditional focus on pottery technology to explore various facets of ceramic craftsmanship. It integrates macroscopic and microscopic analyses, mineralogical examinations, chemical analyses, and experimental data to reconstruct complete production sequences for ceramics, plaster, and earthen constructions at Makri. Key objectives include understanding raw material procurement and manipulation, reconstructing ancient pyrotechnological practices, tracing the evolution of manufacturing traditions, and identifying potential cross-craft interactions within the same site. It is hoped that this will shed light on economic and social aspects of material culture production, cultural connections, and shared craft practices. Due to its location between western Anatolia and the Balkans, Makri is key to understanding the cultural development of the earliest Neolithic communities in southeastern Europe. The present paper introduces the research project, shares preliminary findings, and anticipates the broader impact on our understanding of Neolithic craftsmanship, intercultural interactions, and socio-economic dynamics in early European communities of the Northern and Central Balkans, and Western Anatolia.

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Beneath the Surface: An Investigation of the Final Neolithic Banded Pottery in Taiwan through SEM-EDS and Petrography

The Final Neolithic Botanical Garden Culture in Northern Taiwan, dating approximately 2500-2000 BP. It is a critical period between the Late Neolithic and the Iron Age in Taiwan and has been considered as a phase with a significant development in pyrotechnology, in particular, pottery technology.
The Final Neolithic Botanical Garden Culture is distinguished by the characteristic ware type known as the "banded pottery", a nomenclature derives from the geological terminology "banded iron formation", referring to the banded iron deposits. The banded pottery present red layers on the surfaces featuring light pink to orange clay with fine sandy texture. Notably, in some cases, the opaque minerals can be identified visually on pottery surfaces. Such banded texture can be observed in the cross section of potsherds, possibly suggesting specific choices of raw materials. However, it is not clear whether such banded texture is the result of specific choices of iron-rich clays or intentional mixing of iron-rich raw materials.
The research materials come from two sites, Xiyunyan and Tzufakung, currently stored at the Museum of Anthropology of National Taiwan University. The assemblage comprises abundant pottery sherds that can be characterized as Final Neolithic banded pottery.
In addition, the investigation of pottery firing remains uncommon in Taiwan, especially in the use of the scanning electron microscope (SEM). Therefore, this study also explores the viability of SEM to examine the firing technology in prehistoric pottery in Taiwan.
Here we present a preliminary result, integrating thin section petrography and the scanning electron microscope coupled with energy dispersive X-ray spectroscopy (SEM-EDS) to investigate the mineralogical and chemical composition and vitrification of clay pastes to understand the choices and manipulation of raw materials and firing conditions of the banded pottery. The analytical results can improve our understanding of the hypothesis of technological development in the Final Neolithic Taiwan.

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2-Independent scholar
3- Unión del Sur
4- Universidad de Antioquia
5- Universidad de Caldas

Intra vessel variation: 3D geometric morphometrics of pre-Hispanic ceramics from the Nariño region of Colombia

Geometric morphometrics (GMM) are becoming increasingly central to studies of artefact shape, as the technique poses the ability to quantify and statistically assess temporal, spatial, technological, and post-depositional variability in archaeological materials. In ceramic studies, both 2D and 3D approaches to GMM have been employed to explore inter and intra-vessel variation, and to identify different hands involved in the production process. Nonetheless, use of 3D GMM in the analyses of non-wheel thrown ceramics has been limited, in spite of its great potential to assess variability within a single vessel, potentially revealing different skill levels or idiosyncratic maker traits.
This study explores the application of geometric morphometrics (GMM) in a large corpus of hand-built ceramic vessels from the Nariño region of southern Colombia (ca. 400-1600 CE). All vessels are open, complete or near complete, and come from six archaeological sites or collections. Following a sliced segmental extraction approach from 3D models, we can assess rotational symmetry for each vessel, identify vessels (and vessel parts) where variation is higher, and quantify this variation. Thus, providing the basis for comparisons within and between archaeologically contextualised assemblages.
We present a workflow utilising freely available, open-source software, for the assessment of intra-vessel variability from 3D surface scans, which can be applicable to all ceramic vessels.

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Using petrography, laser ablation inductively coupled plasma mass spectrometry (LA-ICPMS) and portable X-ray fluorescence (p-XRF) to distinguish between sherds made in the Markham Valley and Eastern Highlands of Papua New Guinea.

Oral accounts tell of community movements near Yonki Dome in the Eastern Highlands of Papua New Guinea (PNG). Ethnographic evidence suggests that community settlement may be distinguished by the differential use of pottery made from local Eastern Highlands materials and ceramics imported from the nearby Markham Valley. Collections from sites on Yonki Dome and its surrounds contain both decorated and non-decorated sherds. Decorated sherds were used to determine how well: macroscopic fabric inspection; petrographic thin-sectioning; laster ablation inductively coupled plasma mass spectrometry (LA-ICPMS); and portable X-ray fluorescence (p-XRF); distinguished the different ceramic industries.
The most destructive and resource intensive techniques; petrography and LA-ICPMS were able to clearly distinguish the quartz-feldspathic Eastern Highlands fabrics from the more sericitic-feldspathic Markham Valley ones. Despite the heterogenous nature of the inclusions, and less accuracy when detecting low levels of some elements, p-XRF on cut sherds was able to distinguish between the sources. Macroscopic fabric inspection, was less accurate at distinguishing the ceramics, but with more minor contributions from sherd colour and finishing, it could predict the proportions of Markham Valley pottery in an assemblage with a less than 10% error rate. A combination of these techniques were used to support the local oral histories of past settlement movements on Yonki Dome.

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Preliminary study on the material of the bianqing excavated from the Tomb of the Marquis of Haihun in Nanchang, China

Bianqing (编磬) was an important stone musical instrument from the Pre-Qin to the Western Han Dynasty in ancient China. A set of bianqing was unearthed from the Tomb of Marquis of Haihun in Nanchang during the Western Han Dynasty, and constitutes a complete set of hanging instruments with other two sets of bronze chime bells. The bianqing were moved out of the excavation site using wooden box and transported back to the laboratory for detailed excavation. The unearthed bianqings have the shape of an empty shell and look like rusty iron, and some have a lot of gray powder filling inside. The compositions of the "shell" and the powder are analyzed using XRD, SEM-EDS, Raman spectroscopy, TEM, etc. The results show that the shells are not made by iron. The powder inside the bianqing was mainly composed of calcite, small spherical iron oxides, and some fluorite and quartz. The fracture surface of the four Bianqing shell samples are loose and porous, like sponge, with strips of different colors caused by different crystallization states of the iron minerals. The compositions of shells are mainly goethite and siderite, and sample no.1 also contains a large amount of calcite while sample no.5 mainly contains siderite only. TEM shows that the calcite particles embedded in the shell of sample no.1 are single crystals, and the iron(III) oxide minerals are polycrystals composed of fine grains. The current research results show that the fragment of bianqing shell is compositionally heterogeneous. Although the component types of different shells are similar, the proportions and matrix structure can be very different. The bianqing powder may be related to limestone (chime stone). The current condition of the bianqing may be deeply affected by the burial environment, and their causes of formation will be further explored.

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Provenance of Greco-Italic amphorae in the Pontine region, southern Lazio, during the Middle Republic

This poster presents the current state of knowledge on Greco-Italic amphorae – the first mass-produced wine container produced on Italian soil, which has historically been linked to a phase of increasing agricultural specialisation in Central Italy during the Mid Republican period, including the Pontine Region.
A total 39 Greco-Italic amphorae were selected from two roadside settlements along the Via appia, Forum Appii and Ad Medias, and from small rural sites in their immediate surroundings. The amphorae were found during surveys carried out in the framework of the Pontine Region Project. To examine their composition and reconstruct their technology and provenance, all (39) amphorae were analysed, combining thin section petrography and geochemistry (e.g., WD-XRF).
Using these techniques, several fabrics, originating from different workshops on the Tyrrhenian coast, were identified. More specifically, most amphorae were produced in southern Lazio or Campania, while very few were imported from Etruria. These results suggest that both roadside settlements were firmly embedded in regional trade networks prevailing during the Middle Republican era.

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Sourcing Pottery from the Site of Ch'uxuqullu on the Island of the Sun (Lake Titicaca, Bolivia)

Ceramic artifacts from the site of Ch'uxuqullu on the Island of the Sun in Lake Titicaca were tested to address mobility and trade during the Early Formative period (1200-200 BCE). This island is the largest in Lake Titicaca (ca. 21 km sq), while the site is relatively small, about .25 ha. Paste analysis of the sixty-seven pottery sherds, which were recovered from surface contexts, indicates multiple paste types but mostly of paste type I. Most of the pottery vessels were utilitarian wares made locally.
Elemental analyses were determined by non-destructive analysis using a Bruker Tracer 5e X-ray fluorescence spectrometer. The analyses were conducted using settings of 50 kV and 35 □A for 30 seconds, and with a filter to reduce the mid-range background and enhance the results for trace elements Rb, Sr, Y, Zr, Nb, and Ba. Both sides of the ceramic sherds were analyzed to check for heterogeneity within each object, while major elements such as Fe and Ca were tested to determine the use of different types of clay. The results obtained were calibrated using established software and the results reported on percent or parts per million.
The trace element data for most of the artifacts cluster together, but about 25% fall in a broader range of values, perhaps representing different sites/sources to the south of Lake Titicaca. There are two artifacts with values that fall by themselves. Also found at Ch'uxuqullu are a number of pieces of obsidian, which have been assigned to the geological source of Chivay some 275 km to the west of Lake Titicaca. The appearance of both ceramics and obsidian on this island demonstrates travel by watercraft, in this case balsa rafts, likely on a frequent basis.

Theodore Vasileiou 1

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“Twinkling” needles in the hay: An analytical exploration of early mediaeval glazed pottery (7th-9th/10th CE) in the Eastern Mediterranean. A preliminary report.

Glazed ceramics are perhaps the most known, recognisable and studied pottery of the Byzantine times. Overall established during the middle-byzantine period, many studies have explored its technological, stylistic, and economic aspects. In comparison, fewer projects have been involved in the analytical exploration of early byzantine red and white-bodied glazed productions (7th-9th/10th CE), primarily due to the scarcity of the material under discussion.This study presents preliminary results on early mediaeval glazed wares from the Eastern Mediterranean (mainland Greece, Crete, Cyprus). The goal is trifold: a)to contribute to the documentation of early-glaze technological practices, b)discern technological differences/choices within the sample set, and c)explore its provenance at an intra/inter-regional level. This study incorporates data regarding the composition and texture of the ceramics through ceramic petrography (TL/RL-OM), their mineralogy through the application of XRD, and imaging and chemical data regarding the body and its glaze layer through SEM-EDS. By integrating samples from a broad geographical region, this study aspires to bridge the gap between Late Antique and Middle-Byzantine glaze traditions and to contribute to the ongoing effort of better understanding early Byzantine lead-glazed ware technology, production and distribution in the “Byzantine world” of the Early Middle Ages.

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Research on the Application of Intelligent Technology in the Dissemination of Ceramic Culture

With the rapid penetration of intelligent technology into various fields, digital technologies such as machine learning, Artificial Intelligence Generated Content (AIGC) and virtual reality have begun to empower the physical and cultural forms of Chinese ceramics. This paper mainly sorts out the research directions and hotspots of intelligent technology in ceramic culture in recent years from the perspective of technical means, in order to inherit the technical civilisation, cultural connotation and artistic aesthetics of ceramic cultural relics. By analysing the broad application scenarios of digital humanities, it further explores how to promote the intelligent protection and active dissemination of Chinese traditional cultural heritage, and contemplates the future of digital civilization under the intelligent ethics.

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Non - destructive analyses of Early Iron Age ceramics from Obobogo (Centre- Cameroon, west central Africa)

The appearance of ceramics in Sub-Saharan-Africa is associated with a linguistic based migration model of a new way of life with (semi-) permanent settlements, agriculture, herding, metalworking from central to southern Africa within 2.000 years. The homeland of this Bantu expansion is expected to be in the border area between todays Cameroon and Nigeria. Although Shum Laka (9.000 - 900 BP) and Obobogo (3.000 BP) are the most famous sites in this region, their material was only examined through a stylistic morphological approach (Claes 1985, Lavachery 1998). The presented research is an archaeometric pilot study of ceramic samples from Obobogo, showing stick, spatula and comb impressions. Non-destructive techniques are used to determine the manufacturing techniques and the nature of the raw materials within this site and will be contrasted with the stylistic typology. The samples have been selected according to their colour, thickness and decoration and were documented and analysed by a 3D profilometer, portable X-ray fluorescence (pXRF) and Fourier Transform Infrared Spectroscopy (FTIR). Two macroscopic groups of ceramics were identified: Group 1 is characterized by a reddish to brownish colour whereas group 2 shows light grey to dark grey colours on their surfaces. This differentiation is confirmed by pXRF. Ceramics from Group1 present a content (av.) of 17.6% of silicium and 7.5% of aluminiun whereas the ceramics from Group 2 have a content (av.) of 12.6% of silicium and 15.04% of aluminium. The high content of aluminium in the ceramics from Group 2 suggests a high content of phyllosilicates and feldspars in this group but lower in Group 1. The FTIR-spectra indicate the presence of quartz, feldspars and phyllosilicates, suggesting firing with low temperature. The correlation between the geology of the region and the mineralogical and chemical results of the ceramics suggested a production with different local clays.

Session 6 Ceramic, metal and vitreous
Poster presentations

Sarah De Ceuster 1, Patrick Degryse 1
1- KU Leuven

Lead isotope analysis for provenancing ancient materials: is overlap the end of the story?

Lead isotope analysis has been used to provenance metals such as lead, silver and bronze for many decades. Different approaches to interpret lead isotope ratios were proposed, and various limitations of the method have been discussed and addressed. Overlap in composition between different possible ore sources is always mentioned as a major limitation in lead isotope studies, but has never been thoroughly studied in itself.
In this paper, the kernel density estimation (KDE) approach proposed by De Ceuster and Degryse (2020) is applied to calculate overlap between possible ore source regions. Firstly, the copper and lead ores of the same regions are compared, to assess if they are identical and thus can be combined to increase sample size for provenance studies. Secondly, the overlap between all the mining regions per pair is calculated to determine if the distinction can actually be made between those ore fields.
The use of one-dimensional KDEs is very effective for calculation and assessment of the overlap between ore sources. This study argues that merging the lead and copper ore data might increase the reliability of a region's KDEs in most cases, but the overlap should be assessed beforehand. Furthermore, the study provides a useful tool to verify for every pair of possible ore sources if it is theoretically possible to discriminate between them, and to what extent.

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Mass production of iron in Han Period China: evidence from the Xiahewan site

The Han Dynasty was a period of large-scale iron production in China. Both historical records and archaeological discoveries indicate that Henan was the core region of iron production in the Han Dynasty. This article conducted field surveys on an iron smelting site in Xiahewan, Miyang, Henan Provence, which was from the late Warring States period to the late Eastern Han Dynasty. Metallurgical relics such as furnace slag, furnace wall, and tuyere were collected. Research in metallurgical archaeology shows that there were relatively complete iron and steel production processes such as pig iron smelting, ceramic mould casting, and decarburization of ironware in the Xiahewan site, which presented the typical functions of iron smelting workshops in the central plains of the Han Dynasty. In addition to the ore-based smelting and casting production system, there may also be a situation of recycling discarded iron products. At the same time, the existence of iron-silicon slag implies that production technologies such as stainless steel smelting may also be applied. This study is helpful to enrich and improve the understanding of the iron and steel technology system in the central plains of the Han Dynasty.

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Highly varied copper trace elements pattern from one smelting site revealed by LA-ICP-MS analysis

Trace element is one of the most important provenance indicator of archaeological copper-based materials. However, there has been little understanding about the variation range of copper trace elements concentration generated from one single smelting site. Current research developed a method to analyze copper prills trapped in smelting slag based on LA-ICP-MS calibrated with a spot size of 64 um. The result shows copper prills smelted from different type ores at the same mine have different trace element characteristics and the ranges of copper products smelted from the same ores at the same site are large. The differences in trace element of bronzes may indicate not only the differences in the sources of copper materials, but may also be the result of fluctuations in trace elements caused by different mineral types or smelting techniques from the same provenance. This result suggests that copper provenance should pay more attention to the information on copper materials.

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X-ray fluorescence studies of 3rd Millennium BC copper-based metallic objects from the Alto Guadiato valley (Córdoba). Technological choices. Different metallurgical traditions in Southern Iberia. The Alto Guadiato valley (Córdoba) as a case study

Inferring 'metallurgical recipes' developed by different communities when manufacturing metal object is a challenging target in archaeometallurgy studies. In Iberia, two metallurgical focuses have been identified during the Copper Age (3200-2250 cal BC): the Iberian Southeast, with significant metallurgical sites such as Los Millares, Almizaraque, Las Pilas or Santa Bárbara, and the Iberian Southwest with sites such as Valencina de la Concepción (Seville) or Cabezo Juré (Huelva). Nonetheless, littles is known on the metallurgical activities of the communities living between these two main focuses.
In this paper we present an archaeometallurgical study of on a set of 33 copper-based objects from Copper Age contexts from the Alto Guadiato valley, a valley located in the northwestern part of the province of Córdoba, between the Southeastern and Southwestern metallurgical cores.
All items were analysed using portable X-ray fluorescence (pXRF) equipment. Results were compared with main data from southern Chalcolithic sites such as Valencina de la Concepción (Seville), Cabezo Juré (Huelva), Cerro Jesús (Baena, (Córdoba), Los Millares (Almería) and Almizaraque (Almería), applying the Oxford method for the classification of alloys.
This study allowed us to better characterise metallurgical traditions of both Southeas and Southwest evaluating different patterns of elemental composition, and connecting them with the different mineralization known in each area, as well as the possible technological choices preferred in each region and the influences by southeastern or southwestern metallurgies on the in-between communities.

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Archaeometallurgy in inland Iberia: Mineralogical and chemical study of slags to investigate iron manufacture in the Celtiberian during the early Roman period

The iron industry in inland Iberia are less studied than other metallurgical activities, but its research can lead to a better knowledge of materials exploitation, exchanges and technology evolution. For this purpose, La Caridad (Caminreal, Teruel, Spain), an archaeological settlement with a very precise chronology and a very short period of occupation (the end of the 2nd c. – around 74 BCE), is a good example where focusing the study. It was a formally Roman settlement, but mostly occupied by indigenous population, mainly Celtiberian. One of the best-documented activities was the mining and, then, the processing of iron ores for the manufacture of tools; several ore-reduction structures were found in some excavated rooms, in addition to many iron objects. The nearby iron sources, moreover, largely justify the choice of this place for the construction of the city. More than 30 slags were selected, including some materials found in chronologically similar sites. The bulk chemical compositions were obtained by ICP-OES and their trace elements determined by ICP-MS. Microstructures were studied by Optical Microscopy and SEM, with EDX microanalysis. The results showed the different slag types related to the processing of iron ores and the refining, and improving the understanding of the activities distribution in the city. In addition, the data highlighted the manipulation of some raw materials during the reduction treatment, and the probable use of only one iron mineral source.

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X-ray imaging for Heritage Science: results and perspectives at UniTO/INFN/CCR

X-ray imaging is a powerful tool to "see" the inner and hidden parts of archaeological materials in a non-invasive way. Radiography is often enough to understand the distribution of different materials or to have some hints about the state of preservation. This is especially true for thin objects, while for more complex archaeological findings or when the radiographic projection is not clear enough, computed tomography (CT) is required to visualise the entire 3D volume. In fact, even if it is more time-consuming than radiography, CT allows revealing and precisely localising hidden features, measuring the dimensions of inaccessible parts, evaluating the state of preservation, identifying and monitoring an eventual decay of the constitutive material, discovering previous restoration interventions.
Since 2008, a collaboration among the University of Torino (UniTO), the Italian National Institute for Nuclear Physics (INFN) and the Centro Conservazione e Restauro "La Venaria Reale" (CCR), led to the design, development, and installation of different instruments to perform both radiography and tomography. Using different setups, it is possible to have a high flexibility in terms of both materials and dimensions of the analysable objects: voluminous objects up to 2.5 meters can be analysed with sub-millimetric resolution, while on small objects a resolution of few microns can be reached. During these years, many archaeological findings have been analysed by means of CT using these apparatuses: a review of some of the most interesting results will be presented, highlighting the versatility in analysing wooden, ceramic, glass, shell-made and metal artefacts, ranging from few centimetres to some metres, showing also the last developments and upgrades.

Ravindra Nath Singh 1, Cameron A. Petrie 2
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2- University of Cambridge

Analyses of Metallic Slag from Khanak: An Indus Civilization Site in North West Indiaus Civilization Siteus Civization

The populations of South Asia's Indus Civilisation occupied a diverse range of environments across large parts of modern Pakistan and India. Indus populations made use of a wide range of raw material resources, and although there is much known about the sourcing and exploitation of stone (Law 2011), there are outstanding questions about the sources of Indus metals. The Aravalli hills, which lie in the desert margins of southern Haryana and northern Rajasthan in west India contain a wide variety of ores and minerals, but the degree to which Indus populations exploited this material has not been clear.
Recent discoveries of Bronze Age artefacts, tin slag, fragments of furnaces and crucibles, together with new geological evidence on tin deposits in Tosham area of Bhiwani district in Haryana provide the opportunity to survey the evidence for possible sources of tin and the use of bronze in the Harappan sites of north western India. The Harappan settlement of Khanak is located in Bhiwani, Haryana, India. Khanak has been excavated by first author in collaboration with Prof. Cameron Petrie, University of Cambridge. From amongst the cultural materials recovered from two seasons of fieldwork at Khanak several samples related to metal production were selected for scientific studies. This included five fragments of crucible, four slag, two samples of copper celt and one sample of melt adhering to a potsherd. These were examined using SEM-EDS, EDAX &; Petrological techniques. Thin-section petrography technique has played a crucial role in the provenance studies of the ancient ceramics and slag. First, when the non-plastic inclusions derive from distinctive igneous and metamorphic rocks, thin-section petrography of slag provides a predictive method for identifying the source of the raw materials used in metallurgy. Very occasionally, a particular 'key' inclusion allows one to identify the precise source of the raw materials, ores and minerals. Electron microscopy was used to study the surface and internal structure of the slag samples. The information acquired provides more detailed information than that obtained from the petrological analysis. The data that has emerged so far from the present and earlier analysis will be presented.

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X-ray imaging for Heritage Science: results and perspectives at UniTO/INFN/CCR

Provenance of metals is a major theme in Bronze Age archaeology since it can help to reveal complex cultural and economic entanglements in ancient times. However, where complex societies with diversified trading relation ships are concerned, identifying metal provenance has often proved to be challenging due to the frequent mixing of metals from different sources in antiquity. This research addresses this question by developing an innovative method for interpreting lead isotope data of bronze artefacts. Manifold learning and a Bayesian mixing model are combined to reconstruct quantitatively the contribution of metal sources to ancient bronzes. The methodology is employed to resolve the complex metal circulation system in the Zhou period (11th–3rd century BC) of China, and reveals a significant diachronic change of metal resources from North, Central, and South China. The North China metal sources were mainly employed in the Early Western Zhou period (1046–950 BC). In the following ages, the Yangtze River Valley and Qinling Mountains became the major metal sources for Zhou people. The Middle Spring and Autumn period (660 BC–560 BC) witnessed a major shift of dependence between these two sources, demonstrating a fundamental transformation in the metal circulation system. The South China metal sources were exploited throughout the entire Zhou period and probably associated with polymetallic deposits in the Nanling area. This research reveals the long-term patterns of metal exploration and mixing in the Zhou period of China, and also demonstrates the great potential this new methodology promises in addressing the complex metal mixing history in other cultural contexts.

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New Insights into Chalcolithic Metallurgy in Europe: pXRF Analyses Performed on the Copper-Based Artifacts from the Gumelnița and Vidra Sites (Southeastern Romania)

This poster focuses on the study of some copper-based artifacts from the area of Kodžadermen-Gumelniţa-Karanovo VI civilization (KGK VI) defined by the Carpathian Mountains to the north and the Balkan Mountains to the south, dating to the second half of the 5th millennium BCE. The investigated items were discovered at the Vidra and Gumelnița tell settlements in domestic contexts and belong to the Archaeology Collection of the Bucharest Municipality Museum (Romania). These copper-based metal artifacts' morphological and typological features are typical for KGK VI communities from the Danube's north and south. The copper items consist of awls (14), four still with their bone handles, chisels (4), pins with double volute (2) and a fragment.
Given the geographical background of the southeastern Romanian plain and the absence of metal ores, we focused on identifying the elements and alloys (with tin, lead) that can be linked to raw material sources that were exploited in the Chalcolithic, using the pXRF method. Previous research demonstrated that several copper mines operated in the Chalcolithic (e.g., Ai Bunar in northern Bulgaria and Majdanpek in eastern Serbia). The emergence of new raw materials (copper, gold) reflects the intensification of exchange networks in southeastern Europe, demonstrated by the broader distribution of similar morphological copper-based metal forms in the KGK VI area.

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Egyptian coffin "pastes": application of a new analytical protocol to the coffin set of Nespawershefyt (21st Dynasty, Thebes)

Ancient Egyptian mummies and coffin sets have been the focus of multiple science-based studies, which are informative of aspects ranging from the funerary ritual to the polychrome decoration of the coffin surfaces. Beneath the painted surfaces, however, coffin sets have a variety of material substrates that typically receive less attention. Generally called "pastes", these may include gypsum, plaster, or crushed limestone, mixed with a variety of organic binding media and potentially including minerals and vegetable fibres. These pastes were used for gap-filling, to create background layers for funerary masks and complete objects, as substrates for painted and gilded decorations and as key components for cartonnage.
Pioneering work by a team at the Fitzwilliam Museum has begun to demonstrate the potential of coffin paste analyses to reveal variability in the selection and processing of materials. This can, in turn, reflect patterns in craft organization, trade, and technological development. We have now developed a minimally invasive methodology to characterize both the inorganic and the organic components of these pastes, and their underlying technology. Our approach includes optical microscopy, SEM-EDS, FTIR and palaeoproteomic analyses.
Here we present an example of the application of this new protocol to three different kinds of pastes present in the nested coffin set of Nespawershefyt, made in Thebes in the 21st Dynasty of the Third Intermediate Period (ca. 1000BC). This is a wooden anthropoid coffin set comprising a mummy board, inner coffin and outer coffin complete with lids and boxes, on which different pastes were applied, serving different purposes. Our results reveal a variety in materials and recipes for the creation of these pastes, including geological materials from different sources and binders of animal origin, allowing systematic comparisons with other coffin sets and funerary artefacts from Thebes.

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Research progress of the manufacturing place of the bronzes unearthed from the Sanxingdui site

In 1986, archaeologists found two pits in Sanxingdui site. Numerous Shang-dynasty bronzes have been excavated in these two pits with a huge quantity and a rich range of forms and decorations. The scholars in a wide range of disciplines are interested in the preservation and the scientific research to create the bronze objects unearthed from the two pits of the Sanxingdui site. Although researchers have carried out a number of studies on this topic, the casting sites of the different types of the Sanxingdui bronzes remain unclear. This research for the first time use petrographic analyses, major elements analyses and trace elements analyses to conduct the material characterization of casting cores from this site. All of the samples are from the bronzes unearthed from the two pits of the Sanxingdui site. The petrographic analyses show that the casting cores can be divided into two groups on the basis of varied mineralogical, corresponding to vessels and non-vessels bronzes. And the river sand was found as the main raw material for the casting cores manufacturing. The two groups differ in mineral composition, sorting, roundness and the content of clay. Several biotite, muscovite and amorphous calcium carbonate could be found in the casting cores of the non-vessel group. And casting cores of the vessel group had higher content of the clay. And the two group differ in chemical composition. The non-vessel group had high Ca and Mg content. By comparison with geological samples from the Sanxingdui site, the casting cores of the non-vessel group were not consistent with the local soil and sand geological characteristics. And the casting cores of the vessel group were largely different from the local soil. It can be further speculated that the Sanxingdui bronzes would have several casting sites.

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4- Dipartimento di Scienze della Terra e dell'Ambiente and Arvedi Laboratorio, Università degli Studi di Pavia, Italy
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Looking at the manufacturing technique of a tiny golden filigree from the Chiaravalle Cross

A very small portion of filigree, from a jewelry masterpiece (the Chiaravalle Cross) has been made available for analyses, after a restoration [1,2]. The filigree has a multi-component structure, made of rolled and twisted silver wires, soldered and finally gilded. The complex structure of this ancient golden filigree has been disclosed in a non destructive way by a neutron tomographic experiment and this information will be compared to a SEM investigation made on another portion of the same filigree, in order to derive details on the manufacturing technique.

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Agriculture in the Highlands: perspectives from 3rd millennium BC Sos Höyük and Rabati.

The highlands of Northeast Anatolia and the Southern Caucasus are characterised by harsh snowy winters and short summers. Transhumant pastoralism is often seen as an economic adaption to life in mountain environments. This paper integrates archaeobotanical and stable isotope data from Sos Höyük, Türkiye and Rabati in Georgia to explore crop choices and agricultural strategies in highland environments throughout the 3rd millennium BC. Sos Höyük is located at 1700m asl in the Pasinler Valley between the Karapazari and Palandoken Mountains and Rabati at 1480m asl on a plateau overlooking the deep gorge of the Kura River. During the 3rd Millennium BC these regions were part of the Kura-Araxes cultural complex (ca. 3500-2500BC) known for its distinctive red-black burnished pottery. Although initially interpreted as transhuman pastoralists, recent research has indicated that Kura-Araxes communities lived in stable, agro-pastoral villages. Around the mid third millennium, Kura-Araxes traditions rapidly disappeared and were replaced by communities with new material culture and lifeways. The Early Kurgan cultures (Martkopi, Bedeni c.2500-2000BC) are noted for their ostentatious barrow burials under large funerary mounds, however, as associated settlements are virtually unknown, these populations are often interpreted as embracing a mainly mobile lifestyle. Both Sos Höyük and Rabati enable comparison Kura-Araxes and Early Kurgan period agriculture and crop choices at each location throughout the 3rd millennium BC. Moreover, these sites offer a valuable opportunity to investigate subsistence in the Early Kurgan period through archaeobotanical analysis of rarely found settlement sites. At both sites, archaeobotanical evidence indicates continuity of agricultural practice, implying that some elements of these communities were present year-round to manage the fields. The suggestion of permanent settlement throughout the 3rd millennium BC at Sos Höyük and Rabati potentially alters our interpretation of Early Kurgan societies and how people adapted to life in highland environments.

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New phytolith reference collections for reconstructing human-environment interactions in Sahul: standards moving forward

Phytoliths are robust microfossils of great significance for investigating human-environment interactions. In Australia, however, phytolith research has been marginalised from mainstream archaeological research practices and has experienced a downward trend in the number of analysts and routine studies. Many plants produce distinct phytolith morphologies that are genetically and physiologically controlled, thereby making them highly useful proxies for understanding vegetation change and human plant-use across Sahul. However, before phytoliths from ancient deposits can be studied, their taxonomic significance for extant Australian plants needs to be established. This means that assembling modern reference collections for different biogeographic zones in Sahul is of paramount importance.
In this paper, we outline the methods and some early results of new collaborative reference collection work being conducted across humid and semi-arid regions of Southeast Sahul by teams from La Trobe University, the University of Wollongong, and the University of Queensland. We present an approach for the development of modern reference collections in Australia that not only employs high-quality laboratory protocols and scientific analyses, but is also based on partnerships with First Nations communities to integrate this with Traditional Ecological Knowledge. Our studies of modern plant material have revealed phytolith production and morphological patterns in several plant families described previously as non-producers of phytoliths. Some preliminary applications are discussed, including the results of new research from the Willandra Lakes World Heritage Area that provide initial insights into past changes in vegetation and plant resources. The development of these modern reference collections is changing previously held views about the production of phytoliths by Australian plants, which has enhanced our global understanding of phytolith production and their taxonomic significance.

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Trace element geochemistry in tufas suggests a much wetter early Holocene in the Darling Downs, Queensland

Climate models are necessary to aid prediction of, and adaptation to, environmental change. However, climate models developed overseas have proven unreliable in the southern hemisphere. Australian climate models are hampered by the continent's large size and sparse distribution of recent palaeoclimate data. Well studied climate proxies are rare in Australia relative to geographic scale and the continent's central aridity biases most existing paleoclimate records to coastal regions. More inland regional palaeoclimates are poorly known. This lack of data is of particular concern to Australian archaeology due to the importance of past climate change for hypotheses of human-environment interactions, including megafaunal extinction and intensification debates.
Tufa, a terrestrial carbonate precipitated from natural alkaline surface waters records many aspects of its local environment, thus potentially providing a high-resolution climate and environmental proxy. This project analysed early- to mid-Holocene tufa samples from Neds Gully, inland Southeast Queensland, a region where tufas do not form today. Morphological analysis of tufas samples indicates that they formed on a range of aquatic vegetation in both flowing and standing bodies of water. Geochemical analysis (rare earth elements — REEs) of the samples supported the interpretation of both boggy, standing water bodies and well oxygenated, free flowing water. Tufa REE distributions with those in older Pleistocene-aged bone (phosphate) samples are extremely similar, suggesting that the water chemistry and source did not change dramatically over that timeframe. Combined, our data suggest a much more humid local environment in the early-mid-Holocene and a dramatic reduction in water availability during the latter part of the Holocene. As only the second geochemical trace analysis of tufas conducted in Australia this project broke new ground in understanding the complexities of recent palaeoclimate in south east Queensland while further demonstrating the utility of trace element geochemistry in bone beds and tufas.

Miriam Belmaker 1
1-The University of Tulsa

Inter and intra-species variability in herbivore dental tribology patterns as paleoenvironmental indicators: Paleoecological implications for the Pleistocene of the Levant

Herbivores are adapted to process the vegetation available in their habitats. Thus, morphological features of teeth reflect the properties of available foods. Therefore, the morphological traits of animal communities (ecometrics and ecomorphology) can be used to characterize their habitats and climatic conditions. Many ecometric studies have focused on inter-species dental tribology (mesowear and microwear) to identify paleoecology and paleoclimates. However, this method does not apply to regions with high stability in species presence, such as the southern Levant, where the mammalian community is nearly identical throughout the Middle and late Pleistocene.
Here, we compare the predictive power of interspecies vs. intraspecies herbivore dental tribology of herbivores to a suite of climatic and environmental variables. As case study, we focus on mesowear and microwear of mountain gazelles (Gazella gazella) and Gunther's vole (Microtus guentheri) across the southern Levant.
We measured mesowear on georeferenced specimens of gazelles and voles from the Steinhardt Museum of Natural History and the National Natural History Collection of the Hebrew University of Jerusalem. We measured mesowear following published procedures and microwear using an S-Neox white light confocal microscope. Climatic and environmental variables were retrieved for each location from open-access sources and analyzed using ArcGIS.
Results indicate that mesowear and microwear values differ predictably within a single species across mean annual precipitation (MAP), the mean temperature of the coldest and warmest months, and the percent woody vegetation.
We tested mesowear and microwear in paleontological samples from Israel's early and middle Pleistocene sites ('Ubeidiya 1.2 – 1.6 Ma; Hayonim E 160 Ka, Rantis 160 Ka). Results suggest all sites are more humid and cooler than today; however, Hayonim in North Israel is more humid and cooler than Rantis in central Israel.
We propose that intraspecies dental tribology and ecometrics may be used as a novel paleoecological proxy.

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What can Conomurex luhuanus tell us about the shellfishing behaviours of First Nations communities on the Great Barrier Reef?

The aim of this research is to investigate long-term Indigenous shellfishing patterns at Jiigurru (Lizard Island) on the Great Barrier Reef to determine whether the islands were occupied seasonally or year-round across the mid-to-late Holocene. In this ongoing research, seasonality is investigated using a marine gastropod species (Conomurex luhunaus) as a new palaeoclimate archive. The measured oxygen isotope composition obtained from the last deposited layer of shells provides information about the season in which shells were collected. We apply sclerochronology techniques – analogous to dendrochronology, but focusing on growth increments in shells – to obtain such information. However, as the use of C. luhunaus as a palaeoclimate archive has not yet been tested, we employ sclerochronology techniques to analyse oxygen isotopes in modern shells to test the efficacy of the species in recording environmental factors. Measured δ18Oshell ranged between -0.4 and -1.5 ‰ (VPDB) in modern samples. Our results show that this species can reliably record SST in equilibrium with the surrounding environment at daily resolution. After establishing modern calibration, we will use the same technique on archaeological shells to determine the seasonal variability of shellfishing behaviour of the Traditional Owners at Jiigurru. This research will provide the first scientific evidence of seasonal-resolution human landscape use at Jiigurru. Considering the deep time archaeology and continuing connection to Country of the Traditional Owners at Jiigurru, such information helps to inform future sustainable management practices of the fragile GBR system that foregrounds traditional Indigenous shellfish management.

Sheahan Bestel 1
1- Independent researcher

Human-Environment Interactions at Zhaoguo Cave, southwestern China, from 38,000 cal BP to modern times.

Zhaoguo Cave in Guizhou Province, south-western China, was excavated by Sichuan University and Guizhou Provincial Archaeological Bureau in the twenty-first century. The site was hailed as one of China's top ten archaeological discoveries in 2020. It is a cave site dated to 38,000 cal BP with occupation spanning almost forty thousand years from ancient times until present day. The cave is situated among the karst mountains of south-western China and is located in a modern day biodiversity hotspot. I carried out flotation on sediments extracted from hearths within the cave, and identified both plant and animal remains in the flotation samples. The results of occupation, including occupation spanning the last glacial maximum, are described in terms of glacial refugia.

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Grave Insights: Cross-Species Health in pig burials at Manihina cemetery (Marquesas, Polynesia)

Pigs in ancient Polynesia were more than a food source, diffusing religious and political value through the communities that managed them. This presentation examines pig burials from Manihina, a funerary site in Polynesia (Marquesas Islands). Our study investigates the health status of animals interred at the site, shedding light on their dietary patterns, environmental conditions, and potential human-animal interactions. Furthermore, this research makes the first systematic attempt at conducting a differential diagnosis on animal remains in the Pacific region.
We first discuss the benefits of developing a Polynesian counterpart to animal palaeopathology by outlining the complex roles of animals at Marquesan ritual sites and the unique insights about human-animal health that can be provided by these settings. An initial site wide analysis of the pig burials evaluates how combining data such as age-at-death and enamel health at non-subsistence sites can assist more holistic understandings of reciprocal interactions between cultural and environmental systems.
To look more acutely into this topic, a subsequent differential diagnosis investigates severe pathological lesions concentrated on vertebral and rib elements of one burial. After observing and recording these lesions, we integrate biological, cultural, and environmental information with preliminary results from CT scans and microscopy to discuss possible zoonotic causes and contributions. Establishing a replicable procedure for differential diagnoses at Manihina sets a precedent for future comparative studies, allowing new regional narratives about pig and inter-species health in pre-contact societies.

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Palaeoclimatic support for the Pleistocene 'superhighway' through central Australia

Our understanding of the climatic conditions faced by humans upon arrival in Australia is both temporally and spatially fragmented. A cave in the Ikara-Flinders Ranges contains speleothems that shed light on the palaeohydrology of Australia's southern arid margin through the Last Glacial Period. The timing of speleothem growth phases suggests there were three multi-millennial periods where the region experienced a more positive water balance, each of which aligns with Southern Hemisphere summer insolation maxima. This implies that moisture delivery was governed by the strength and/or latitudinal position of the Indo-Australian Summer Monsoon, meaning the continental interior to the north of the cave site would also be receiving monsoonal rainfall. These findings support the proposed 'superhighway' through central Australia (Crabtree et al. 2020; Bradshaw et al. 2023). A period of especially high moisture availability coincides with the earliest evidence of human presence at the Warratyi shelter, 250 km north of the cave site (Hamm et al. 2016).

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High-resolution paleoenvironmental reconstructions of MIS 3 Central Europe from oxygen and carbon isotope signatures in mammal teeth

In Europe, the period of approximately 50 to 35 ka BP during Marine Isotope Stage 3 (MIS 3) has been of key ongoing interest in archaeological studies, which is often referred to as the Middle to Upper (M-UP) Palaeolithic transition. During this time, there was a major expansion of anatomically modern humans (AMHs) across Eurasia, whilst Neanderthals (Homo neanderthalensis) became extinct. Some suggest that Neanderthal extinction may be related to the abrupt environmental changes that occurred during MIS 3. Understanding the extent to which climate change played a role in Neanderthal extinction requires reconstructions of local paleoenvironmental records at seasonal to sub-seasonal resolution. Stable isotope records from animal teeth provide one of the few paleoenvironmental proxies available at such resolution in the mid to high latitudes. Therefore, this study aims to reconstruct local, high-resolution paleoclimates in MIS 3 Central Europe using teeth of Pleistocene mammals.
Sveduv Stul and Pod Hradem are two caves located in the Moravian Karst, Czech Republic, and both have potentially been occupied by AMHs and/or Neanderthals during MIS 3. These caves also preserve an extensive Pleistocene mammal remains, some potentially present as a result of human hunting practices. Teeth of horses (Equus ferus) and cave bears (Ursus spelaeus) found in these two sites were studied for oxygen ($\delta 18O$) and carbon ($\delta 13C$) isotopes to reconstruct the paleoenvironments and paleovegetation respectively. Tooth enamel was sequentially drilled at millimetre resolution following the growth direction, and the obtained powder was then analyzed using isotope ratio mass spectrometry. These highly resolved isotopic records provide paleoenvironmental information at sub-seasonal to sub-monthly resolution, which help to reconstruct local precipitation, air temperature, hydrology and vegetation cover. They also enable further assessment of the complex interplay between animals, humans and their local environments in MIS 3 Central Europe.

Jalene Nalbant 1
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Lake Sediments - An Archaeological Archive

Migration into Oceania marks the earliest open-ocean voyages in human history. Our understanding of this remarkable movement is largely based on archaeological records in Melanesia (stretching from the Bismarck Archipelago to Fiji in the east and New Caledonia in the south), leaving a large gap in knowledge of human migration to Micronesia (stretching from Palau to the Mariana Islands in the northeast and to Kiribati at the southeastern-most extent). Unfortunately, in tropical regions like Western Micronesia conditions are not conducive to the preservation of the archaeological record, greatly limiting our understanding of human history in this area. Tropical lake sediments are excellent archives of past environmental change and offer a method to reconstruct human-environment interactions, independent of the known archaeological record. Combining pollen, charcoal, and geochemical records obtained from lake sediment cores provide a comprehensive history of environmental change in the lake-catchment. The use of multiple proxies allows natural drivers of change (e.g. changes in climate) to be distinguished from anthropogenically driven changes (e.g. swidden agriculture). Palaeoenvironmental reconstructions for Western Micronesia are scarce, consequently I will use four sediment cores (three from Palau, one from Yap) to examine human-environment interactions in the Western Pacific. Two cores from Palau will be used to reconstruct natural environmental changes. These records will be compared to a third core, which was collected close to a known archaeological site in Palau, to better identify anthropogenically driven shifts in proxies. These records will then be compared to the fourth core from Yap, which is believed to have been settled around the same time as Palau. I will present preliminary findings from these reconstructions of human migration into Micronesia.

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The palaeoenvironmental context for early Pleistocene Homo dispersals in the Levant from multi proxy analyses of gastropod shells, Ubeidiya, Israel

The Levant was a key corridor for hominin dispersals from Africa to Eurasia during the early Pleistocene. However, there is debate over the extent to which climatic fluctuations may have influenced these dispersals, and whether early Pleistocene Homo showed behavioural plasticity by adapting to different landscapes and environments, or simply took advantage of an expansion of grassland environments at this time. Whilst global and regional palaeoclimatic trends are well established, there is a paucity of local-scale palaeoenvironmental reconstructions associated with early Pleistocene Homo dispersals. The site of Ubeidiya, Israel contains some of the earliest evidence for hominin dispersals outside of Africa (1.4 ± 0.2 Ma) and a rich faunal assemblage including abundant Melanopsis spp. freshwater gastropod shells which enable local palaeoenvironmental reconstructions via multi-proxy analyses.
In this study we characterise the local environment and hydroclimate from Ubeidiya using geochemical and sclerochronological analyses of Melanopsis spp. shells sampled from the 1960-1999 Ubeidiya excavations. We analysed bulk and high-resolution sequential oxygen (δ18O) and carbon (δ13C) stable isotopes using both conventional isotope ratio mass spectrometry and sensitive high-resolution ion microprobe (SHRIMP), and clumped isotopes on bulk shells. The bulk analyses revealed that hydrological conditions fluctuated between wetter and drier conditions several times throughout both the older limnic inferior (LI) and the younger fluviatile inferior (FI) deposits, with clumped isotopes also indicating fluctuating temperatures throughout the sequence. Melanopsis shells grow continuously throughout the year, capturing the full range of seasonal variability. The sequential analyses revealed high amplitude δ18O variability during the FI cycle at around 1.58 Ma, possibly indicating a more seasonal distribution of rainfall at this time. In agreement with other proxies emerging from this site, this evidence suggests that early Pleistocene Homo were not reliant on grasslands but were adaptable to new habitats and were resilient to significant palaeoenvironmental fluctuations. By providing local, high-resolution palaeoenvironmental context for the early Pleistocene Levant, this study facilitates a more nuanced understanding of early Homo dispersal patterns out of Africa.
Sveduv Stul and Pod Hradem are two caves located in the Moravian Karst, Czech Republic, and both have potentially been occupied by AMHs and/or Neanderthals during MIS 3. These caves also preserve an extensive Pleistocene mammal remains, some potentially present as a result of human hunting practices. Teeth of horses (Equus ferus) and cave bears (Ursus spelaeus) found in these two sites were studied for oxygen (δ18O) and carbon (δ13C) isotopes to reconstruct the paleoenvironments and paleovegetation respectively. Tooth enamel was sequentially drilled at millimetre resolution following the growth direction, and the obtained powder was then analyzed using isotope ratio mass spectrometry. These highly resolved isotopic records provide paleoenvironmental information at sub-seasonal to sub-monthly resolution, which help to reconstruct local precipitation, air temperature, hydrology and vegetation cover. They also enable further assessment of the complex interplay between animals, humans and their local environments in MIS 3 Central Europe.

Chloe Stringer 1, Russell Drysdale 1, Vladimir Levchenko 2, Henri Wong 2, Amy Prendergast 1, Jillian Garvey 3, Jan-Hendrick May 1, First People of the Millewa Mallee Aboriginal Corporation 4

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People, mussels, and Country: Investigating human-mussel-environment relationships during the Late Quaternary on Ngintait and Latji Latji Country, south-east Australia

Freshwater mussel shells are commonly recorded in Aboriginal archaeological sites in the Central Murray River Basin (CMRB) of south-east Australia, from Ngintait, Latji Latji, and First People of the Millewa Mallee Country. Middens containing freshwater mussel shell are found in great number along the banks of the Millewa (Murray River). Different from coastal middens, these freshwater inland middens are composed of thin, long lenses of shell, containing only a couple of mollusc species. Freshwater shells have been used to determine that CMRB has been inhabited for at least 29,000 years. Yet, so far, it has been difficult to understand the cultural and economic importance of this resource to the region's inhabitants.

This research aims to gain a more holistic understanding of human-mussel-environment relationships in CMRB through the incorporation of evidence from a variety of knowledge systems and different techniques. Traditional Ecological Knowledge (TEK) through collaboration with the Ngintait, Latji Latji, and First People of the Millewa Mallee community is combined with several western scientific techniques. The application of sclerochronology unlocks the high-resolution climate record stored within the freshwater mussel shell itself, allowing for the seasonal climate at the time that the mussels were collected to be determined. These estimations of time-of-year of collection can provide insight into resource habits and movement of Ngintait and Latji Latji peoples across Country, while providing a better understanding of the relationship between people, the mussels, and Country. Nutritional analysis of modern specimens collected throughout the year can also help us to understand whether season of collection may be linked to changes in the nutritional value of the mussels themselves. A more holistic understanding of human-mussel-environment relationships will allow us to best interpret the cultural and economic importance of freshwater mussels in the CMRB and understand how this relationship may have changed through time.

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Underwater archaeological sites and climate change: experimental study of the impact of ocean acidification on historical stone materials

Seas and oceans are the guardians of millions of submerged ruins, settlements, wrecks, and artifacts worldwide, whose protection requires the knowledge of ancient materials and their interaction with the marine environment, also in view of climate change. The EU-funded project WATERISKULT (https://wateriskult.geoscienze.unipd.it) aims at providing the first quantitative assessment of the climate change risk to underwater cultural heritage, focusing on ocean acidification and its effects on archaeological stone materials. The research approach is based on mixed laboratory and field experimentations. On one hand, laboratory tests with a custom-made microenvironment simulator (MES) allow monitoring the erosion of selected stone materials in controlled conditions, at changing seawater pH and constant temperature and pressure/depth. On the other hand, by field tests with underwater exposure setups (UES), the same materials are investigated in natural conditions (at different pH levels nearby CO2 vents), thus including the contribution of marine biodeterioration. The stages and rates of stone decay related to dissolution processes are determined by sequential sample analyses with techniques of 3D surface imaging, texture quantification, and microscopic observation. The results provide downscaled reconstructions of stone deterioration trends in underwater sites, according to past and future scenarios of ocean acidification.

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The influence of Mg in the cementation processes of ancient binding composites

Binding composites (mortars, plasters, concretes) constitute relevant evidence of the technological advancement of ancient societies, being the structural core of heritage architecture since the Pre-Pottery Neolithic. Most binding systems are calcium-based. The ionic form of the element chemically binds in the reaction phases with divalent anionic molecules (e.g., carbonate in lime binders), or with silica and alumina in pozzolanic and hydraulic systems, forming structural species like calcium aluminosilicate (C-A-S-H) and calcium aluminate hydrates (C-A-H).
However, ancient binding systems often deviate from this homogeneity due to poor standardization of raw materials. This leads to a shift in reaction processes outside the lime-silica-alumina ternary system under specific ionic activity conditions. Magnesium, a crucial element in ancient binding composites, can be derived both from binders like magnesian limes and various aggregate types, both natural and artificial. Its incorporation in anthropogenic binding products leads to structurally more stable crystal phases compared to standard calcium-based counterparts, thanks to the lower ionic radius of magnesium allowing a more ordered octahedral coordination.
This study reviews case studies where the chemical characteristics of ancient binding composites and reactive systems facilitated significant magnesium incorporation. It explores the influence of mix design, particularly focusing on binders and aggregates promoting high magnesium activity. This often involves specific enrichments of ionic and bacterial species in the fluid medium of composites, fostering unique reaction processes.
Additionally, the study presents a comprehensive crystal-chemical characterization of binding phases, with a focus on determining the degree of polymerization of para-pozzolanic magnesium aluminosilicate hydrates (M-A-S-H). Analytical methods include XRPD, MAS-NMR, FTIR, and SEM-EDS.
Finally, the study addresses the beneficial effects of magnesium incorporation within ancient binding composites, emphasizing increased mechanical properties and durability. This sheds light on the advanced technological knowledge of ancient craftsmen and offers valuable perspectives for the development of novel, sustainable, heritage-inspired building materials.

Matilde Quilici 1, Jan Elsen 1, Patrick Degryse 1
1- Ku Leuven

A Geochemical approach for tracing the Provenance of Mortar Binders – a case study from Sagalassos

This work presents the results of the examination of mortars from the city of Sagalassos in southwestern Turkey. A key aspect of mortar technology is represented by the provenance of raw materials. Specifically, the sources of mortar binders remain a subject largely unexplored apart from few attempts that examined lumps (white carbonatic inclusions) and source materials using LA-ICP-MS for elemental composition. In this study, 15 specimens dating back to the 1st-5th century CE were selected from different buildings across the site of Sagalassos. The mortars and corresponding lumps of these samples were analysed by ICP-OES and ICP-MS. Then, these results were compared to possible limestone source materials previously characterized geochemically. This approach highlighted that the raw materials to produce the binders most likely consisted of limestones coming from the immediate surrounding landscape. Overall, this research contributes to a better understanding of construction technology at Sagalassos during the Roman Imperial Period, a time when the city reached its greatest influence in the region and mortar materials were systematically used. Finally, a more accessible technique for the examination of binder provenance has been developed

Salvador Piña Guido 1

1- Universidad Nacional Autónoma de México

Developing an analysis technique of earthen architecture materials through soil micromorphology

Earth construction has been used to satisfy the human need for shelter since the Upper Paleolithic to nowadays all around the world, however, it's a material poorly studied by archeology. Describing any earth construction as adobe has had repercussions on the interpretation of these contexts because it reduces a large number of existing construction techniques to one when there are over twenty, each one with different manufacturing processes and particular properties.
Micromorphology is an analytical technique to study the natural soil formation processes in soil science. Up to now, its use in archaeological buildings has focused on identifying the origin of the raw material by characterizing its mineralogical components. In Europe, it has been used for over twenty years to identify construction techniques. In Mexico, this methodology began to be used in 2017 on construction samples from Mesoamerican sites.
The present study proposes to improve the methodology by analyzing samples that result from an experimental exercise known as the Carazas Test, in which the water added and the intensity of compaction of the construction mixtures are controlled. These will allow us to compare the micromorphological properties of experimental blocks of known manufacturing process with those of archaeological materials.
This is a preview of a pioneering research with the main objective of developing an analysis technique to understand the manufacturing process of earth materials through the comparative analysis of the micromorphology of experimental and archaeological samples to have an approach to the building techniques used in the past.

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An archaeometric study of two sets of decorated wall plasters from the Agora of Nea Paphos, Cyprus

Painted wall plasters have been frequently unearthed in the Agora of Nea Paphos by the Paphos Agora Project. The uncovered samples date from the late Hellenistic to the late Roman Age, and display aesthetic and compositional similarities across the different periods. This study aims to analyse two selected sets of wall plasters with the same decoration typologies and comparable structure, yet attributed to non-coeval phases. Employing x-ray diffraction, thermal analysis, scanning-electron microscopy, and Raman spectroscopy we characterize the binder, the bulk composition and the pigments in order to observe parallels or inconsistencies between our samples.
The first set of samples counts three specimens of lime-based plasters with two superimposed layers topped by a pigment film; which creates a decoration with alternated vertical bands. The samples have been attributed to either the Hellenistic or Early Roman periods. The second set counts two samples of lime-based mortar, covered by a pozzoloanic layer and topped by Egyptian blue pigment. The samples were collected from stratigraphic levels dated respectively to the Hellenistic and Early Roman.
Our analyses display how the comprehensive composition, including aggregates type and b:a ratio, remains substantially unvaried diachronically. Furthermore, it was possible to recognise in the locally available geological range the raw material sources for the production of these two specific categories of wall plasters.

Myrto Kalofonou 1, Ioannis Ioannou 1, Athanasios Vionis 1
1- University of Cyprus

Building cisterns in ancient Cyprus: A diachronic study of plaster application and use.

The study of plasters and mortars has played an important role in understanding the architectural heritage in Antiquity. Cyprus has a strong tradition in producing hydraulic plasters, since the intentional use of artificial pozzolans in plasters has been common since the Late Bronze Age.
This study focuses on material from Cyprus dating from the Cyrpio-Classic until the Late Roman period, in pursuance of understanding the evolution of plasters used for the construction of cisterns. The cisterns that were studied have been used for water storage, in production areas, as pools, fish tanks and in bath complexes. The archaeological sites chosen for sampling are the palatial complex of the city kingdom of Idalion, the ancient port of Kition, Hellenistic & Roman building complexes in the archaeological site of Nea Paphos and the Hippodrome Villa in Akaki.
A plethora of techniques were implemented to identify the main physiochemical characteristics of the plasters. These included macroscopic observations (hand-held microscope, Munsell color identification), chemical analysis using a portable hand-held X-ray Fluorescence spectrometer, mineralogical analysis with X-ray Diffraction analysis, Thermal Analysis, and petrographic analysis. The results of this study provide a diachronic overview of the evolution of hydraulic plaster production in Cyprus, which was influenced by the locally available raw materials and the technology adopted in each chronological period.

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Practical advances towards safer analysis of heritage samples and objects

The increasing brightness or fluence of modern accelerator-based sources provide valuable benefit for fast analysis especially when studying traces or diluted species in complex media as usually found in heritage samples. However, the use of high intensity beams can also result e.g. color change or mechanical fragility of the analysed sample. Art, archaeological, palaeontological or palaeoenvironmental samples or objects can suffer from potential radiation damage during the analysis what can also lead to a possible misinterpretation of the results.
To minimize radiation damage, we propose risk management strategies [1] including detection and monitoring any material changes before, during and after the experiments. Emerging trends include detailed mechanistic studies on more specific systems, the development of statistical methods to reduce the doses required to study samples, and the development of integrated early warning systems capable of feeding back into the experiment while an acquisition is in progress.

Mary Kate Donais 1, Abigail Desrochers 1, Sarah Hummel 1
1- Saint Anselm College

Spectroscopic Characterization of Historic Fabrics: The Bossi Book, the Journal of the American Chemical Society, and other Surprising Sources of Dyestuff Samples

The Bossi book, a bound volume containing handwritten dyestuff recipes and corresponding fabric samples dated to 1902, is in the archives of the Manchester Historic Association (New Hampshire, USA). The book was kept by Arnold L. Bossi, a colormaker employed by the local textile mills. Literature research on textile production processes was conducted and led to the identification of additional sources containing not only dye chemistry information but also fabric samples for specific dyes and printing styles. These publications include The Principles and Practice of Textile Printing (1924), a note in vol. 1 of the Journal of the American Chemical Society by H Morton (1879), and three separate articles in the Journal of the Chemical Society by WH Perkin (1870, 1873, 1876). Nondestructive spectroscopic characterization of the fabrics in the latter publications has led to the creation of a database for known dyes/styles. Visible spectra were collected via a phone-app-based reflectance spectrophotometer. Elemental data were collected via a handheld X-ray fluorescence spectrometer. The utility of the database for matching historic fabric colors to known dyes/styles was evaluated. The database was then used to decode the handwritten dye recipes of colormaker A.L. Bossi. This presentation, though focused mostly on the Bossi book, also will include aspects of the history and chemistry of textile production in the late 19th and early 20th centuries.

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Can X-ray analyses help in authentication of papyrus dealer provenance narratives?

Papyrus sheets were widely used as writing supports for more than 3000 years, and in the Ptolemaic Period (332-30 BC), written sheets were first recycled to make mummy cartonnage. Ancient papyri can enter collections through purchases from antiquities dealers; however, buyers may be misled in order to purchase papyri with uncertain or illegal provenance. In this research we develop a method which indicates whether or not papyri have come from cartonnage, to help confirm or question dealer provenance narratives. X-ray fluorescence (XRF) spectrometry and X-ray diffractometry (XRD) were used to characterise elemental and mineralogical compositions of papyrus fragments held by the Macquarie University History Museum, Sydney, which date back to the Ptolemaic Period in the third century BC. Elemental analyses revealed that papyri from cartonnage have distinctively high concentrations of calcium, which is characteristic of the usage of papyrus sheets as a support layer in cartonnage. Mineralogical analyses revealed calcite ($CaCO_3$) in the preparation layer of cartonnage.

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1- Jagiellonian University in Krakow
2- Warsaw University of Technology

Procedural modelling as a tool for the study of ancient port developments. Nea Paphos case study

The aim of our presentation is to demonstrate the possibility of using procedural modelling to analyse the capacity of ancient ports. The solution will be presented using the example of the Hellenistic-Roman port of Paphos. This port city, located in south-west Cyprus, was one of the most important trade centres in the eastern Mediterranean. Founded in the late 4th century BCE, the city was situated on a bay suitable for the creation of a harbour. Today, the remains of the city form part of the UNESCO Archaeological Site of Nea Paphos. Although the harbour has been the subject of research by many scholars, the most important questions are still unresolved. There are still several hypotheses in the scientific discourse, relating both to the spatial organisation of the port itself and the possible existence of auxiliary ports. By applying the possibilities offered by procedural modelling, the main port of Nea Paphos will be reconstructed in different variants in order to be able to confront the versions proposed by scholars with the source accounts of how many ships were supposed to berth there. Results of reconstruction will be presented using game engine technology for interactive visualisation, which allows a better understanding of the examined space and enhances immersive experiences in analysing different variants of port.

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See you at ISA 2026 in Torino!