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SESSIONI	CODICE
Caratterizzazione e Diagnostica	C&D
Conservazione Preventiva e Restauro	C&R
Materiali Innovativi e Nanotecnologie per i Beni Culturali	M&N
Provenienza e Datazione	P&D
Tutela e Valorizzazione	T&V
BioArcheologia	B
Diffusione e Divulgazione nei Beni Culturali	D&D
Digitalizzazione 3D e Nuovi Linguaggi della Rappresentazione del Patrimonio Culturale	D&N
Interazione Uomo-Ambiente	U&A

Mercoledì 19 aprile 2023

Aula Cannizzaro

9.00 – 10.00 Registrazione dei partecipanti + welcome coffee

Aula Magna

10.00 – 10.45 Saluti istituzionali

- Prof. **Salvatore Cuzzocrea** - *Magnifico Rettore dell'Università degli Studi di Messina*
- Prof. **Domenico Majolino** - *Direttore del Dipartimento di Scienze Matematiche e Informatiche, Scienze Fisiche e Scienze della Terra (MIFT) dell'Università degli Studi di Messina*
- Prof. **Paolo Vittorio Giaquinta** - *Direttore della Classe di Scienze Fisiche, Matematiche e Naturali dell'Accademia Peloritana dei Pericolanti*
- Prof. **Mauro Francesco La Russa** - *Presidente dell'Associazione Italiana di Archeometria (AIAr)*

10.45 – 11.30 *Plenary Lecture*	**Marco Martini** - *Università degli Studi di Milano Bicocca* Dating in archaeometry (introduce **Mauro Francesco La Russa**)

11.30 – 13.20 Sessioni Parallele

Aula Magna		**Sessione orale 1: Caratterizzazione e Diagnostica Chairs: A. M. Gueli, C. Trigona**
11.30 – 11.50	**C. Germinario**	Geomaterials used for the construction and decoration of the House of *Petronia* (I 16, 5) in Pompeii: an archaeometric study
11.50 – 12.10	**A. Donato**	A combined analytical approach to define the best strategies to preserve natural and artificial stone materials employed in Gerace Cathedral (RC, Italy)
12.10 – 12.30	**M. F. Alberghina**	Three examples of *"cuoridoro"* of XVIII century in Sicily: knowledge, scientific investigation, conservation and valorisation activities
12.30 – 12.50	**M. Albano**	Do you know what ink Beethoven employed to write his music? Preliminary investigation on the manuscript held at the Angelo Mai Civic Library in Bergamo (Italy)
12.50 – 13.10	**V. Guglielmi**	The characterisation of the materials from a "Madonna with Child, Saint Catherine of Siena and a Carthusian Prior" polychrome earthenware bas-relief attributed to Giovanni Antonio Amadeo: a multi-analytical approach
13.10 – 13.20	**A. Cosentino (CHSOS)** [Technical talk]	Multispectral Imaging with Antonello by CHSOS, Low-Cost, and Educational tool

Aula Accademia Peloritana dei Pericolanti		**Sessione orale 2: Caratterizzazione e Diagnostica Chairs: M. Ricca, S. A. Ruffolo**
11.30 – 11.50	**V. Comite**	Use of climatic chambers to analyse the catalytic action of heavy metals in sulphation process
11.50 – 12.10	**M. Bernabale**	Evaluation of stress corrosion and micro-segregation in copper-based artefacts through X-ray Microscopy
12.10 – 12.30	**G. Montalto**	Durability tests of some mortars peculiar of the historic built heritage of Catania (Eastern Sicily): an experimental study
12.30 – 12.50	**F. Giacoppo**	Ceramic surfaces characterization through Confocal Laser Scanning Microscopy (CLSM): a pilot study
12.50 – 13.10	**C. Sabbarese**	Combining multispectral imaging and XRF analysis to examine *San Patroba che predica ai fedeli di Pozzuoli* by Massimo Stanzione

13.20 – 15.00	**Lunch**

15.00 – 16.40 Sessioni Parallele

Aula Magna		Sessione orale 3: Caratterizzazione e Diagnostica Chairs: V. Comite, P. Fermo
15.00 – 15.20	G. Berruto	Non-invasive archaeometric study of red coral on Iron Age jewellery: presentation of the analytical protocol and case studies
15.20 – 15.40	F. Cantini	Ancient Egypt bronze coffins investigation by Neutron Imaging
15.40 – 16.00	D. Cimino	The redemption of reflectance spectroscopy in *in situ* analytical campaigns: telling a conservation story
16.00 – 16.20	S. Capriotti	On-Tech: characterization of ancient mortars for the development of new sustainable materials
16.20 – 16.40	E. Cantisani	Ancient restoration practises in archaeological sites in Turkey: materials and technologies

Aula Accademia Peloritana dei Pericolanti		Sessione orale 4: Provenienza e Datazione Chairs: A. Galli, M. Martini
15.00 – 15.20	S. Calandra	Binder selection procedure of natural hydraulic mortars of Florentine historical buildings for radiocarbon dating
15.20 – 15.40	A. Agostino	The *Desana's Treasure*, Ostrogoths in north-western Italy
15.40 – 16.00	L. Guidorzi	Micro-PIXE and micro-IBIL characterization of lapis lazuli samples from Myanmar mines and implications for provenance studies
16.00 – 16.20	L. Panzeri	Exploring the occupation of the Valley of Assam through Luminescence Dating: results from new findings from a paleo-channel of Dihing River
16.20 – 16.40	M. Saleh	The impact of statistical analysis in OSL mortar dating

16.40 – 17.10	Coffee Break

17.10 – 18.50 Sessioni Parallele

Aula Magna		Sessione orale 5: Caratterizzazione e Diagnostica Chairs: C. Grifa, R. C. Ponterio
17.10 – 17.30	S. Dilaria	Vitruvian and "alternative" volcanic pozzolans in the ancient world. A brief review based on recent scientific advances
17.30 – 17.50	N. Manfredda	Ancient Egyptian wooden statuettes from the Tomb of Minhotep in the Museo Egizio
17.50 – 18.10	F. Armetta	Underwater degradation of archaeological metals from Mediterranean Sea
18.10 – 18.30	A. Piccirillo	The detection of Prussian blue in historical textiles: A systematic study based on tailored mock-ups
18.30 – 18.50	L. Vigorelli	An *OpenAIAr* project: X-ray micro-tomography for the investigation of roman glass sherds from Aquileia (UD)

Aula Accademia Peloritana dei Pericolanti		Sessione orale 6: Provenienza e Datazione/BioArcheologia Chairs: C. Lubritto, C. Pelosi
17.10 – 17.30	P. Santi	Volcanic millstone tracing human movements in central Italy during the Final Bronze Age (Arcevia, Marche)
17.30 – 17.50	A. Silvestri	Once upon a glass mosaic in the apse of *S. Sabina's* Basilica in Rome. Interdisciplinary study of a Late Antique/Medieval lost decoration
17.50 – 18.10	O. Yatsuk	Ashes to ashes, salts to salts: different origin of glass beads from Iron Age sites in Central Italy
18.10 – 18.30	C. Lambert	New insights from recent archaeometric studies on the Church of Sant'Ambrogio at Montecorvino Rovella (Salerno, Italy)
18.30 – 18.50	N. Mantile	Exploring the Potentiality of Osteoarchaeological Remains: Innovative Methodologies to Investigate Paleodiet Through Stable Isotope Analysis

19.30	Aperitivo

Giovedì 20 aprile 2023

Aula Cannizzaro

8.30 – 9.30 Registrazione dei partecipanti

Aula Magna

9.30 – 10.15 *Plenary Lecture*	**Fabrizio Tigano** - *Università degli Studi di Messina* Cultural heritage as a public resource (introduce **Valentina Venuti**)

10.15 – 10.45	**Coffee Break**

10.45 – 12.25 Sessioni Parallele

Aula Magna		**Sessione orale 7: Provenienza e Datazione/Caratterizzazione e Diagnostica - Chairs: V. Crupi, V. Venuti**
10.45 – 11.05	**R. Galvagno**	The amber collection in the Lentini Museum
11.05 – 11.25	**G. D'Angelo**	Archeometric Study on architectural terracottas from the Temple of Diana Nemorensis (Lazio, Italy): preliminary results
11.25 – 11.45	**G. Ricci**	Mortars and water: case studies in the Venice lagoon
11.45 – 12.05	**S. Vettori**	The first archaeometric analyses of Bronze Age vitreous materials from Paduli site (Colli sul Velino, Rieti) in central Italy
12.05 – 12.25	**N. Rovella**	Technological innovation and Roman engineering skills in the mortars of Villa dei Quintili (Rome, Italy)

Aula Accademia Peloritana dei Pericolanti		**Sessione orale 8: Caratterizzazione e Diagnostica/Tutela e Valorizzazione - Chairs: M. F. Alberghina, G. Stella**
10.45 – 11.05	**D. Magrini**	Colours for Eternity. Archaeometric data on the original polychromy of Etruscan alabaster urns from Sarteano (SI)
11.05 – 11.25	**S. Longo**	Reading the invisible: the role of optical investigations in the study of the Herculaneum papyri
11.25 – 11.45	**S. Ferrarese**	A new methodology to compare microclimatic conditions inside museum showcases
11.45 – 12.05	**S. Fiorentino**	The significance of things Investigating glass from materiality to intangible values
12.05 – 12.25	**J. J. Lucejko**	Evaluation of various preservation methods in the storage phase for waterlogged archaeological organic artifacts by pyrolysis-based techniques

12.45 – 14.20	**Lunch**

14.30 – 16.10 Sessioni Parallele

Aula Magna		Sessione orale 9: Materiali Innovativi e Nanotecnologie per i Beni Culturali/Digitalizzazione 3D e Nuovi Linguaggi della Rappresentazione del Patrimonio Culturale Chairs: F. Caridi, F. Stanco
14.30 – 14.50	M. Secco	The influence of Mg in the cementation processes of ancient binding composites
14.50 – 15.10	M. L. Saladino	Innovative nanostructured materials for the preservation of stone substrates
15.10 – 15.30	D. Giuffrida	An engraved prehistoric cup from Filicudi, Aeolian Islands: study and fruition through combined surveys and digital media
15.30 – 15.50	M. Gargano	Macro-3D multiband computational imaging applied to the study of materiality of Egyptian papyri
15.50 – 16.10	G. Sorrentino	3D morphometric analysis to trace surface depletion in ground stone tools replicative usage

Aula Accademia Peloritana dei Pericolanti		Sessione orale 10: Conservazione Preventiva e Restauro Chairs: S. D'Amico, G. Fiocco
14.30 – 14.50	E. Diana	Scientific study of a rare Chinese Buddhist silver reliquary
14.50 – 15.10	S. Carnio	The challenge of outdoor wall painting conservation: a comparative study of some protective treatments
15.10 – 15.30	S. Campanelli	The Fabrics of the Monsampolo del Tronto Mummies: Analysis, Restoration and Conservation
15.30 – 15.50	C. Pelosi	The "restoration of the restoration" on the wall paintings of Room E in the Roman *Domus delle Pitture* of Volsinii: analysis of the materials and degradation patterns
15.50 – 16.10	L. Es Sebar	In-situ diagnostic campaign on outdoor bronze artworks

16.10 – 16.45	Coffee Break

16.45 – 18.00 Sessione Poster - Aula Cannizzaro

Aula Magna [Technical talks]		Sessione tecnici/sponsors Chairs: D. Magrini, L. Panzeri
16.45 – 17.00	L. Laudi Testo S.p.A.	Protecting and monitoring works of art - even remotely
17.00 – 17.15	C. Vailati Bruker Italia S.r.l.	Bruker Nano Analytics, Company Presentation
17.15 – 17.30	A. Cipolla Metrohm Italiana S.r.l.	Raman Spectroscopy in Archaeometry
17.30 – 17.45	G. Bulla JEOL (ITALIA) S.p.A.	Pioneers of the progress and innovation since 1949
17.45 – 18.00	A. Cosentino (CHSOS)	The CHSOS technical photography kit, all-you-need for UV-VIS-IR photography

18.00 – 20.00 Assemblea Annuale dei Soci AIAr – Aula Magna

21.00	Cena Sociale

Venerdì 21 aprile 2023

Aula Cannizzaro

8.30 – 9.30 Registrazione dei partecipanti

Aula Magna

9.30 – 10.15 *Plenary Lecture*	**Gianluca Quarta** - *Università del Salento* Recent developments in AMS radiocarbon dating (introduce **Anna Gueli**)

10.15 – 10.45	**Coffee Break**

10.45 – 12.25 Sessioni Parallele

Aula Magna		**Sessione orale 11: Diffusione e Divulgazione nei Beni Culturali/Interazione Uomo-Ambiente Chairs: G. Paladini, A. Re**
10.45 – 11.05	**M. Di Fazio**	#ScienzeABC: pills of digital knowledge to tell the Sciences Applied to Cultural Heritage
11.05 – 11.25	**C. Ricci**	Buddha[10]: study and conservation of seven Buddhist painted sculptures as a bridge between East and West
11.25 – 11.45	**F. Caridi**	Assessment of the natural radioactivity content in pigments and estimation of radiological health risks
11.45 – 12.05	**L. Canesi**	Pre-Hispanic Stelae of the Archaeological Site of Oxpemul, Mexico: Material Characterization and Damage Assessment due to Climate Impact

Aula Accademia Peloritana dei Pericolanti		**Sessione orale 12: Conservazione Preventiva e Restauro Chairs: L. Randazzo, N. Rovella**
10.45 – 10.55	**D. Molina Konica Minolta Sensing Europe**	[Technical talk]) - Portable and Compact Hyperspectral Imaging: A Powerful instrumentation for Investigating Museum Objects and Unveiling the Secrets of Medieval Textiles
10.55 – 11.15	**S. Longo**	Six-year long monitoring of green bio-consolidants products applied to natural porous stones
11.15 – 11.35	**G. Marsiaj**	Assessment of low-temperature atmospheric pressure plasma treatments of natural and synthetic varnish
11.35 – 11.55	**A. Bergomi**	Indoor and outdoor comparison of particulate matter monitoring systems aimed at the safeguard of cultural heritage
11.55 – 12.05	**M. Gironda Bruker Italia S.r.l.**	[Technical talk] - Bruker Solutions, Novelties and Updates

12.15 – 13.00 Premiazioni e Chiusura dei Lavori – Aula Magna

14.00 – 19.00	**Visita Guidata nell'area archeologica di Tindari**

CARATTERIZZAZIONE E DIAGNOSTICA

ORALI: C&D-O

POSTER: C&D-P

Do you know what ink Beethoven employed to write his music? Preliminary investigation on the manuscript held at the Angelo Mai Civic Library in Bergamo (Italy)

Michela Albano[(a,b)*], Giacomo Fiocco[(a)], Francesca Volpi[(a,b)], Benedetto Ardini[(c)], Daniela Comelli[(c)], Cristian Manzoni[(d)], Federica Rovelli[(b)], Marco Malagodi[(a,b)]

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The manuscripts of Ludwig van Beethoven (Bonn, 1770 - Vienna, 1827) are a matter of numerous and different musicological research and studies, since they represent the key to unlocking the composer's creative process, which has yet to be fully elucidated. In the printed and published versions of Beethoven's works, in fact, it is not possible to appreciate the several changes and rewritten parts that the manuscripts teemed with. They include preparatory materials for his works, and notes for projects never completed, and notated from memory. While many aspects of Beethoven manuscripts, for instance the watermark of the paper and the characteristics of the pentagram were objects of studies [1], the research on ink-types is missing. Aiming at starting to fill the gap of knowledge regarding the ink(s) used by the composer in his sketchbooks, we analysed different areas of the manuscript MS BG0044 Piatti-Lochis PREIS.J1.9887 held at the Angelo Mai Civic Library in Bergamo (Italy). The manuscript is composed of two consecutives detached A4 format sheets and we focused on the erased (or scraped) notes with one or more ink strokes. It was non-invasively investigated carrying out the photographic documentation in the visible (VIS) and ultraviolet light (UV) to achieve the UV-induced fluorescence phenomenon from the manuscript surface. Additionally, the Hyperspectral Imaging (HSI) in the range from 450 nm to 1000 nm and the elemental analysis through X-Ray Fluorescence (XRF) spectroscopy were performed. Two of the four pages are displayed in Fig. 1 (under VIS and UV light). Combining HSI and XRF results proved effective in discriminating and characterising the inks of the manuscript [2]. Thanks to the analytical campaign the iron-based nature of the ink used by Beethoven was elucidated while the detection of different amounts of Cu resulted in discriminating two types of inks: the first used by the composer and the second used to trace the pentagram.

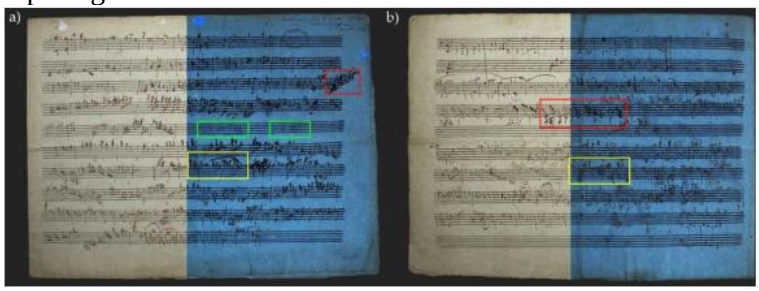

Figure 1: VIS and UVFL images of page 1 (a) and page 2 (b) of the Manuscript MS BG0044 Piatti-Lochis PREIS.J1.9887. The overlapping of ink strokes of different colour hues (red squares), and halos (yellow and green squares) are highlighted.

References

[1] Johnson D.P., Tyson A., Winter R.., The Beethoven sketchbooks: history, reconstruction, inventory. No. 4. Univ of California Press, 1985.
[2] Kim, S. J., Deng, F., & Brown, M. S., Visual enhancement of old documents with hyperspectral imaging. Pattern Recognition, 44(7), (2011), 1461-1469.

Three examples of “cuoridoro” of XVIII century in Sicily: knowledge, scientific investigation, conservation and valorisation activities

Maria Francesca Alberghina[*(a)], Serena Bavastrelli[(b)], Gloria Bonanno[(b)], Antonino Giannusa[(c)], Eloisa Guarneri[(b)], Enza Anna Passerini[(b)], Loredana Pasta[(b)], Salvatore Schiavone[(a)], Arcangela Valenti[(b)], Luigi Vinci[(b)]

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The paper illustrates the results of the non-invasive and micro-destructive diagnostic investigations carried out on three frontals in painted leather belonging to the museum collections of the IIS "Vincenzo Ragusa and Otama Kiyohara - Filippo Parlatore" (Palermo) and currently under restoration at the Regional Centre for Planning and Restoration applied to Cultural Heritage (CRPR, Palermo). The three artworks fall into the socalled “cuoridoro” typology, examples of a decorative art that developed starting to the 16th centuries also in Sicily which involved the creation of embossed and painted leather panels. The overlapping of inorganic and organic materials makes conservation of this type of artifacts very complex. Due to the aging of organic materials and the formation of superficial cracks, the main conservative challenges are due to the blackening of the silver leaf which causes its chromatic alteration [1]. Diagnostic imaging was performed for the study of the execution technique and the evaluation of the state of conservation, and analyses in XRF spectrometry and FORS spectroscopy for the identification of the pigments, supporting the methodological choices of restoration and the future conservation. A subsequent in-depth analysis for the characterization of the silver leaf and the documentation of the executive technique was obtained through stratigraphic analysis on the polished section of a fragment also subjected to morphological and compositional analysis by SEM-EDS. Furthermore, some samples were taken from the potentially critical areas identified, both of the constituent materials and of the observed alterations, on which the entomological and microbiological investigations and the characterization of the pictorial support were carried out, which results to be made up of sheep leather.

UV fluorescence revealed the absence of repainting and made it possible to locate micro drops of the oleoresinous varnish, to highlight the cracks and the distribution of the different chromophores based on their spectral behaviour. Infrared confirmed the absence of underdrawing or engravings, confirming the use of wooden moulds and inks to transfer the modular decorative motifs on the metal leaf. The XRF and FORS analyses showed historically used pigments (lead white, ochres, copper-based green pigment, vermilion, red lake) and Prussian Blue commercially available from the second decade of the 18th century. This synthetic blue pigment represents a *post quem* term for dating the three artworks studied. The cross-section showed the application of pure silver leaf using protein-based glue on a tanned leather support and subsequently gilded by *meccatura* with an oil-resinous paint with added pigments with a siccative and chromatic function. The SEM-EDS spectra showed that the alteration of the metal leaf is due to the formation of chlorides and not sulphides. The sulphur is therefore not attributable to silver degradation products but to be traced back to the composition of products used for the leather tanning. The results obtained find full confirmation with the historical and technical-executive knowledge on this artworks typology [2], allowing to reconstruct the context artistic and production of the three artifacts studied.

References

[1] M. Posthuma de Boer et al Gilt leather conservation: A critical review to promote improved conservation strategies ICOM-CC 18th Triennial Conference, 2017 Copenhagen.

[2] L. Mannina, A. Lombardo, Diagnostic Analyses for the Study of Materials, Technique and State of Preservation of a Gilt and Painted Leather of the XVIII Century, Procedia Chemistry 8:202-211, 2013.

Underwater degradation of archaeological metals from Mediterranean Sea

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The investigation of archeological metals recovered in underwater sometimes is a challenge for a chemist because of the reactions involved in the developing of their corrosion and the lack of information about the environmental conditions.
Here, some examples of investigation performed on different underwater archaeological metals is reported: the Montefortino-type helmets and the metals fragments from the Punic Ship exhibited at the Archeological Park Lylibeum (Marsala-TP, Italy) [1-2], the orichalcum ingots recovered in Gela seabed (Caltanissetta, Italy) [3], the roman and punic rostrum from the Egadi battles (second Punic war).

Figure 1. Photos of the Montefortino helmets and metals fragments from the Punic Ship.

For each of this case-study, an appropriate set-up of analysis was developed in order to answer to the archaeological questions, and help to reconstruct the history of the objects. In some cases, the main request regards the metal production, while in other cases the interest was mainly devoted to the determination of the processes involved in the deterioration of the metal and to the definition of the conservation state. So that, the used multi-analytical approaches were tailored by the application of conventional and non-conventional investigation techniques to determine the chemical composition. In detail, X-ray fluorescence and diffraction and neutron investigations have been a powerful micro and non-invasive means of studying the artifacts, by providing information about the nature and the processing of the metals.

The approaches developed for the investigation of the Montefortino helmets and of the metals findings from the Punic Ship will be presented to describe possible available information and at the same time clearly show the strong impact of the chemical-physical investigations to unveil a kind of degradation processes developed in the underwater archaeological metals.

[1] F. Armetta*, M.L. Saladino, A. Scherillo, E. Caponetti, Microstructure and phase composition of bronze Montefortino helmets discovered Mediterranean seabed to explain an unusual corrosion (2021) Scientific Reports, 11 (1), art. no. 23022.
[2] F. Armetta, R.C. Ponterio, I. Pibiri, M. L. Saladino*, New insight on archaeological metal finds, nails and lead sheathings, of the Punic Ship from Battle of the Egadi Islands (Submitted paper).
[3] E. Caponetti, F. Armetta*, L. Brusca, D. Chillura Martino, M. L. Saladino, S. Ridolfi, G. Chirco, M. Berrettoni, P. Conti, B. Nicolò, S. Tusa, Microchemical Journal, 2017, 135.

Evaluation of stress corrosion and micro-segregation in copper-based artefacts through X-ray Microscopy

Martina Bernabale[(*a)], Flavio Cognigni[(b)], Laura Medeghini[(a,c)] Marco Rossi[(b)] & Caterina De Vito[(a,c)]

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The role of alloying elements in production technology and corrosion process has been investigated in different type of archaeological copper-based artefacts from the Phoenician-Punic site of Motya (Sicily, Italy). For this purpose, a combination of multi-analytical techniques (Multiscale X-ray Microscopy, SEM, HR-FESEM- EDS and EMPA) has been carried out to investigate the inner bulk of the alloy, performing tomographic virtual slices of the objects, and exploring grain boundaries segregation at sub-microscale. All copper-based artefacts were exposed to bronze disease corrosion induced by the presence of the reactive cuprous chloride (CuCl) located at the interface between external corrosion layers and the surviving metal core. The results highlighted micro-segregation in a Cu-nail induced by As, which was forced outwards along inter-granular channels and combined with Fe atoms at Cu grain boundaries, leading to the formation of copper-iron arsenate, due to the high chemical affinity between these two elements. Binary and ternary alloys revealed marked Cu and Sn selective corrosion and thicker patina compared with Cu metal due to the presence of Sn in chlorine-rich environment. The dissolution factor of copper in these alloys showed a great variability. In addition, the occurrence of cracks inside the bronze needle acted as new corrosion interfaces and involved the formation of complex and periodic stratified corrosion layers, leading to a complete mineralized structure.

References

Bernabale, M., Cognigni, F., Mura, F., Nigro, L., Montanari, D., Rossi, M., De Vito, C. 3D imaging of micro-segregation and corrosion behavior of alloying elements in archaeological artefacts from Motya (Sicily, Italy), Corrosion Science, 211 (2023)110900.

Non-invasive archaeometric study of red coral on Iron Age jewellery: presentation of the analytical protocol and case studies

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Bronze ornaments characterised by whitish insets are widespread in Northern Italy and Switzerland in the early Iron Age; this material is generally identified as Mediterranean red coral (*Corallium rubrum*) bleached over time (De Marinis R.C., 2000; Peroni *et al.*, 1975; Perrin F., 2000). Despite the abundance of this type of material in archaeological contexts, its identification as *C. rubrum* is generally not supported by scientific analysis (Berruto *et al.*, 2021; Mangani, C., 2016; Fürst S. *et al.*, 2016; Schvoerer M. *et al.*, *2000*).

The necessity to fill this scientific gap, combined with the need to preserve and protect these artefacts, inspired the development of a specific totally non-destructive analytical protocol, which allows the precise identification of the possible presence of this raw material (Berruto *et al.*, 2021). This protocol has been improved in recent years, as part of Tech4Culture PhD project (University of Turin). It proved extremely useful in the comprehensive characterisation of Mediterranean red coral, as well as in identifying the use of other raw materials and traces of possible organic binders.

The procedure involves the combined use of micro-Raman spectroscopy (μ-Raman; to identify the molecular composition and in particular the possible presence of trace amounts of polyenes, the organic pigments characteristic of Mediterranean red coral), micro-X-Ray Diffraction (μ-XRD; to identify crystalline phases) and Scanning Electron Microscopy coupled with Energy Dispersive X-ray Spectrometry (SEM-EDS; for the morphological observation and chemical analysis of artefacts).

Figure 1- Bronze leech fibula with white insets from Como, Ca'Morta (CO), Tomb 177.

This approach is directly applicable on the archaeological finds in suitably equipped laboratories, or, if it is not possible to move the objects, the application of the complete protocol is also possible on micro-samples (≈ 300 μg) taken from the decorations. The developed protocol has been applied in the archaeometric study of the decorations of a typical class of bronze fibulae referable to the so-called Golasecca Culture: leech shaped fibulae with white or pinkish circular insets (north-western Italy, 6^{th}-5^{th} cent. BC).

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Ancient Egypt bronze coffins investigation by Neutron Imaging

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Currently, an interdisciplinary project is running at Museo Egizio of Torino (IT), in collaboration with INFNCHNet, that aims at studying animal mummies and related objects in its care. In this context, also the so-called "bronze votive coffins for animal mummies" came to the fore [1]. Among this group of objects, eight ronze artefacts from Museo Egizio, after preliminary analysis with X-Ray Fluorescence and Imaging, were investigated by Neutron Imaging and Neutron Activation at the TU Delft Reactor Institute. The study of metal artefacts of historical and artistic interest is based on the knowledge of the constituent materials and their methods of production. This knowledge could provide clues on the historical and cultural context and is essential for responsible conservation treatment. Since the traditional investigation of metal artefacts often relies on destructive sampling for composition and microstructural information, it is of primary importance to have diagnostic investigations capable of providing the maximum amount of information with a minimum level of invasiveness. Here, we show some Neutron Imaging results related to two votive bronze artefacts: a coffin with a shrew figurine on it, and a cat statuette (Fig. 1). It was suspected that these two bronzes housed mummies of the represented animals within. The goal of this study was twofold: to respond to some technological and conservation issues (such as assessing the state of conservation, evaluating the possible spread of cracks inside the statues, identifying restoration interventions, or repairing parts of the statues, characterize the microstructure of the alloy, obtain clues that would reveal details of the casting process) and identify and try to reconstruct, if present, faunal remains. Neutron Imaging has already proved to be a powerful probe for the study of metallic artefacts in the field of Cultural Heritage [2], but in this study we demonstrate its effectiveness also for the investigation of faunal remains sealed inside bronze votive coffins, allowing with a totally non-invasive single investigation technique, to obtain a complete characterization of both the bronze and the contents of the mummy bundle. This work was able to answer many analytical and conservative questions and allowed us to obtain unique and never-seen-before morphological details and microstructural information that can be easily linked to the manufacturing method.

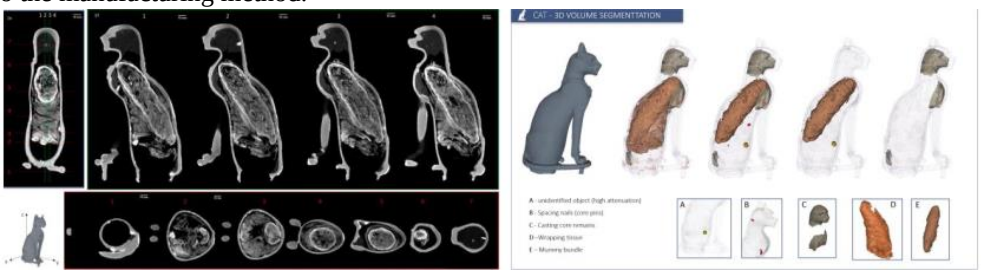

Fig. 1 Neutron Tomography reconstruction of the cat bronze statuette C. 0887. On the right side of the figure the 3D segmentation.

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Ancient restoration practises in archaeological sites in Turkey: materials and technologies

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The restoration of architectural monuments was a common practice in the ancient cities of Asia Minor (Turkey) due to the geological context of the region, characterised by high seismicity. The use of artificial materials in repairing blocks is attested both by literary sources and archaeological evidence (Ismaelli, 2021). However, the knowledge on these ancient bonding mortars and their components is conditioned by the limited number of archaeometric studies, despite the several traces of restorations detected on the monuments, obviously depending on the dynamics of deterioration of material and the numerous events that occurred to the artefacts, such as displacement, rework and destruction.

Samples belonging to the ancient cities of Tripolis and Hierapolis (Denizli region) offer an exceptional amount of information (Ismaelli, 2021; Cantisani et al., 2021), since their monuments were continuously restored and reconstructed over the centuries. The archaeological and architectural studies were coupled by a research line focused on the technology of ancient restoration, aimed at reconstructing the local knowhow and the cultural values of the restoration measures.

Thanks to the exceptional state of conservation of the public monuments of Tripolis and Hierapolis, their in-depth knowledge, and a multi-disciplinary team, our ongoing research offers new insight into this challenging topic. In particular, a multi-analytical approach was developed in order to identify raw materials and technologies used for repairs. The inorganic components were investigated using X-ray powder diffraction (XRPD) and Optical Microscopy (PLM and OM UV), the organic ones using FTIR spectroscopy, PY-GC-MS, GC-MS, HPLC-DAD and HPLC-MS techniques.

Complex mixtures made of calcite, silicate rock fragments and organic materials (i.e. beeswax, egg, resin, casein, plant oil, animal glue) have been found. The identified recipes show a certain variability, and they are analysed in relation to ancient literary sources, the function of repairs and their chronology, in order to understand complexity and strategies of the ancient building site.

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On-Tech: characterization of ancient mortars for the development of new sustainable materials

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One of the main challenges in the field of conservation is the development of innovative restoration products respecting the environment and the operator who works on cultural heritage. In this scenario, mortars and building materials require special attention especially because of the CO_2 production linked to the cement industry, which is the third anthropogenic source of this type of emissions. This project, therefore, aims to provide innovative mortars resistant and compatible with ancient materials, which minimize CO_2 emissions and are environmentally friendly. The mortars were produced starting from the ancient Roman recipe used for the Traiano-Paolo Aqueduct (Rome, I-II century A.D.) which proved highly resistant and durable thanks to a perfect mix of raw materials, grain size and production technology. The first phase of the study concerns the characterization of the starting raw materials considered perfect in terms of compatibility with ancient materials. In detail, pozzolans from different quarries around Bracciano Lake (Rome) were sampled to assess their characteristics. The mineralogical-petrographic and chemical composition have been studied through a multi-analytical approach. The results showed several differences in matrix, leucite crystals (presence, size, type), amount of phenocrystals (clinopyroxenes and feldspar) and porosity. For the experimental step the vesicular pyroclastic materials, with abundant crystals of leucite, clinopyroxenes and high porosity were chosen as starting material for the new formulations which were then characterized through the use of optical microscopy (OM), X-ray diffraction (XRPD), Fourier infrared spectroscopy (FTIR) and scanning electron microscopy (SEM-EDS).

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The redemption of reflectance spectroscopy in in situ analytical campaigns: telling a conservation story

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The main application of reflectance spectroscopy carried out in the ultraviolet -UV- and Vis range (200÷750 nm) on paintings made with different techniques focuses on the identification of pigments and colourants [1]. Other detectors can work in the infrared range as well (NIR and short wave -SWIR-), up to 2500nm, allowing more accurate identification of inorganic compounds (e.g. carbonates, sulphates) [2] but also of organic components such as lipidic or proteinaceous fractions [3]. Nevertheless, literature often highlights results pertinent to paint layers realised with inorganic and organic, pure or simple pigments mixture own to the tradition (i.e., no contemporary art) compared with ad-hoc mockups [4], since spectral features are susceptible, in terms of intensity and position, to changes in composition that affect the colour as hue and mechanism of generation. It is worth remembering, though, that paintings have not only complex composition but also complex stratigraphy where the upper layer might be a finishing one realised with a varnish applied over the paint. Usually, it is transparent, and colourless, but turns yellow with ageing, and its presence results in a lower intensity of the total spectrum (more saturated colour), since it flattens the surface. In some cases though, the varnish can contribute to characteristic features, not enough investigated.

This work introduces spectra obtained during the analytical campaign carried out on twenty Giovan Francesco Caroto's paintings, realised on canvas and panel, by tempera and linseed oil at the beginning of the XVI century. Since artworks were under exhibition in a location where it was not possible to avoid the contribution of natural light, thus there was no opportunity to perform UV-fluorescence imaging, reflectance spectra collected were used also to evaluate quickly the homogeneity of the finishing layer, besides being the base of pigments identification. Results were able to describe part of the conservation history of paintings of the same collection, pinpointing similar conservation treatments and highlighting similarities among artworks owned by different collections.

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Archeometric Study on architectural terracottas from the Temple of Diana Nemorensis (Lazio, Italy): preliminary results

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About thirty kilometres south-east of Rome, in the territory of ancient Aricia, the volcanic lake of Nemi, on its northern shore, preserves the vestiges of a Roman Republican sanctuary dedicated to the goddess of the woods: *Diana Nemorensis*. Archaeological excavations conducted around the temple have brought to light, between 2009 and 2020, a conspicuous number of architectural terracottas, some of them polychromatic, pertaining to the wooden roof of the sacred building. As part of a PhD project aimed at the diachronic reconstruction of the decorative roof systems of the Temple, an archaeometric study of some of the most representative architectural elements was initiated in order to investigate aspects of their production. Scientific interest in architectural terracottas from the Roman Republican period is in fact rather recent and the bibliography on the subject is very limited.

In the preliminary phase of the archaeometric investigations, non-invasive and micro-invasive analyses were performed on a significant number of terracotta samples using interconnected analytical techniques. Several chemical-physical characterization analyses were performed on the small fragments taken from each sample: Optical Microscopy, X-Ray Diffractometry (XRD), XRF Fluorescence Spectroscopy, Fourier Transform Infrared Spectroscopy (FT-IR). Analyses in orthogonal section of the sample allow the qualitative identification of microcrystalline phases, crystals of neoformation (occurring during firing) and aggregates present in the mixture; the presence of vacuoles, cracks, colour variations, grain size, provides information on processing and firing. The characterization of the crystal lattices of the mineralogical phases is determined by XRD analysis, which is able to obtain quantitative compositional information. FT-IR analysis provides information for the characterization of ceramic pastes, while XRF has been proved useful in identifying pigments present on polychrome samples. The analyses conducted on the ceramic pastes have been treated statistically in order to obtain a visualization of the variance of the sample dataset.

Archaeological information in connection with archaeometric data available in the literature is patchy and scarce on the production and composition of architectural terracotta of any period. Therefore, an innovative aspect of this research is the interdisciplinary approach using diagnostic instruments to obtain a compositional chemical dataset that is statistically processed in order to establish compositional materials, manufacturing technology, places of supply and connections to communication/transport and trade circuits of unprocessed materials and/or pottery.

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Vitruvian and "alternative" volcanic pozzolans in the ancient world. A brief review based on recent scientific advances

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The use of volcanic pozzolans to improve the hydraulic properties and cohesive capabilities of aerial lime-based mortars represents one of the most brilliant achievements of antiquity. Several Latin authors, such as Vitruvius and Pliny, celebrated the outstanding properties of the *pulvis puteolana*, a particular pyroclastic ash, outcropping in the territory around the Gulf of Naples, indicated for enhancing the longevity of concretes in underwater conditions. As demonstrated by recent research, the spread of the Neapolitan pozzolans in the Roman territories of the Mediterranean from the Augustan Age (beginning of the 1st c. CE) onwards grew in a short timeframe, and this product obtained the monopoly in the markets as an excellent material for the manufacture of long-lasting hydraulic mortars and concretes (Brandon et al. 2014; Dilaria et al. 2023). The reasons for this massive commercialization probably lie in trade logistics: the outcrops are located close to the coast of the Bay of Naples, where the large Roman harbors of *Puteoli*, *Baia* and *Miseno* were located. These factors played a key role in the commerce of the material, which travelled the sea as ship ballasts, together with handbooks and craftsmen, during Rome's rapid expansion throughout the Mediterranean Sea.
However, it was known by certain Roman engineers that the Vitruvian *pulvis* was not the unique pyroclastic product effective in improving the performances of ancient mortars, thus the exploitation in the Provinces of the Empire of possible "alternative" volcanic pozzolans (i.e. Columbu et al. 2019; Uğurlu Sağın et al. 2021) is a question that is gaining an increasing interest in the field of geochemistry and materials science of ancient construction materials.
The present contribution aims at reporting a brief overview of the state of the art on this topic. We will discuss some new evidences from different Mediterranean sites (Nora and Sant'Antioco in Sardinia, Aquileia in Friuli Venezia Giulia, Padova and Montegrotto in Veneto, Lio Piccolo in the Lagoon of Venice), currently under investigation by a joint collaboration between the University of Padova and the University of Calabria, on the different ways of utilization of "Vitruvian" and "alternative" volcanic pozzolans in ancient constructions, providing intriguing insights about the in-dept technological confidence of ancient craft in the properties of local land resources and in their optimal utilization, which should be investigated further for the refinement of sustainable concretes in modern civil engineering as possible replacements for Portland cement.

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A combined analytical approach to define the best strategies to preserve natural and artificial stone materials employed in Gerace Cathedral (RC, Italy)

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Stone materials, degradation forms and pigments from mural paintings of Gerace Cathedral [1, 2] (Reggio Calabria (RC), Calabria, South Italy), were analysed for the first time using a Non-Destructive and Micro-Destructive Techniques (NDTs and MDTs) approach.

The present study was carried out in two phases: a diagnostic approach on-site and an analytical phase in laboratory. In particular, the on-site diagnosis phase was carried out by means of visual inspections and InfraRed Thermography (IRT) [3] to preliminarily identify and evaluate the intensity of the degradation forms and to choose the most suitable sampling areas for a more in-depth study. Moreover, mural paintings were also investigated, evaluating their conservation state. Samples were undertaken to a complementary analytical approach, precisely: Polarizing Optical Microscopy (POM), Ion Chromatography (IC) [4, 5], X-Ray Powder Diffraction (XRPD) [6, 7], Scanning Electron Microscopy (SEM) coupled with EDS [8], and Electron Probe MicroAnalysis (EPMA) coupled with EDS [9].

The obtained data allowed to identify all pigments and the preparatory layer by a chemical point of view; at the same time the degradation forms were identified such as efflorescence and erosion related to capillary water rise.

These results achieved reveal important information about the raw materials used for the mural paintings and at the same time suggest the best solution for the future restoration and conservation strategies.

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Geomaterials used for the construction and decoration of the House of Petronia (I 16, 5) in Pompeii: an archaeometric study

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The House of Petronia (I 16, 5) is a dwelling built at the end of the 3rd century BCE with a testudinatum atrium. This architectural typology, rare in the roman period, is characteristic of the more ancient phases of Pompeii and is specific of the middle class. The dwelling was affected by several transformations over time.
In particular, at the end of the 2nd century BCE, it underwent a renovation that included an extension and the creation of a garden at the rear, from which several reception rooms were opened, including a large exedra covered with an elegant pavement, which probably had the function of a triclinium. At the beginning of the 1st century CE, the exedra was divided in three spaces: a reception room (15), a cubiculum (14), and a corridor (13) and these rooms were decorated with wall paintings in the 3rd style.
In order to obtain data on the workers' practices and identify the geomaterials and techniques used for construction and decoration of these rooms over time, a multi-analytical study including in situ nondestructive analyses and in-lab minero-petrographic investigation was performed, revealing interesting insights on a) the type of pigments used for the wall paintings, b) the production technology used for making plasters and bedding mortars, and c) the origin of stones used for the pavement.
Digital microscopy, X-ray fluorescence, Fourier Transform Infrared Spectroscopy and Raman spectroscopy performed on wall paintings allowed for the definition of the composition of pigments used for decorating the rooms overlooking the garden, revealing the use of a characteristic Roman palette. Different colours were obtained by using pure, natural, and synthetic pigments (calcite, red and yellow ochre, red lead, green earth, Egyptian blue, carbon black), also mixed together to obtain specific hues, such as mixture of red ochre and red lead for red and brownish tones, addition of Egyptian blue to red pigments for purple or brightening with calcite for pink, mixture of green earth and Egyptian blue for green shades.
Moreover, vibrational spectroscopy disclosed the presence of synthetic resins, likely spread on the decorated surfaces during previous restoration works for the conservation of wall paintings, and weathering products, mainly consisting in Ca-oxalates and Ca-sulfates, deriving from the alteration of organic compounds and Cacarbonate substrate, respectively. Spectroscopic techniques, in fact, also provided information on the composition of the underlying support, made of lime-based plasters.
Observations via Polarised Light Microscopy confirmed the use of lime binder to make plasters. The latter was mixed to volcanic aggregate showing a mineralogical composition consistent with local volcanic raw materials. The occurrence of leucite-bearing scoriae, garnet, and olivine along with crystals of plagioclase, clinopyroxene, juveniles (scoriae and pumices), and traces of amphibole and biotite, in fact, suggested the use of a volcanic sand from Vesuvius' environs. The bedding mortars were also prepared with the same raw materials, although with different mix-designs.
Regarding the pavement decorating the exedra of the 2nd century BCE phase, it consists of a cement floor with geometric decorative motifs in white cubic tesserae, very common in this period; however, it has the peculiarity of being enriched with polychrome stone inlays. Archaeometric data carried out on white, yellow, green, grey, black and red stones used for the decoration revealed that, except for the green stones, they are mainly constituted by calcium carbonate, occurring along with carbonaceous material in the grey and black stones and iron oxides and hydroxides in the red and yellow rocks, respectively.

Ceramic surfaces characterization through Confocal Laser Scanning Microscopy (CLSM): a pilot study

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While use-wear analysis is a developing field of archaeology, in particular in prehistoric lithic studies, the analysis of ceramic surfaces and wears is not very common. Most problems are related to the difficulty to distinguish wears, which have been produced by different processes during a vessel lifecycle, and associate them to specific mechanisms, and to reconstruct their overlapping sequence with conventional diagnostic technologies.
Some pioneering studies, however, suggested that high-tech microscopes and a traceological approach can be successfully used to characterize different kind of ceramic wears and to reconstruct their stratigraphy.
The aim of this contribution is to present the results of a Phd project, devised in Catania University and carried out by me in the last three years, and focused on the development of a procedure to characterize ceramic surfaces and identify traces of manufacture and usewears, with the Confocal Laser Scanning Microscope (CLSM).
This particular technology, mainly used in biomedical and biological sciences, offers many advantages over traditional optical instruments: it's a non-destructive and non-contact technology which doesn't require a previous preparation of the sample; it allows the elimination of image degrading out-of-focus information and the acquisition of high contrast and resolution images; it permits to obtain a three dimensional view of the analyzed object and to reconstruct microtopographies of surfaces, from which qualitative and quantitative information can be quickly and easily obtained. In archaeology, it is commonly used in stone tool analysis to identify and classify use-wear and post-depositional traces, but it has never been employed in ceramic surfaces analysis.
In this research, the microscope has been tested on experimental samples, shaped with different forming and finishing techniques and used in various domestic activities, involving the contact with different materials, which have produced cathegories of specific wears and abrasions on surfaces.
These traces were then analyzed with CLSM, trying to define measurable parameters to characterize them and to create a procedure for its application on archaelogical ceramics.

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Reading the invisible: the role of optical investigations in the study of the Herculaneum papyri

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Herculaneum papyri found during the discovery of the Villa dei Papiri in the XVIII century are our only knowledge about Greek philosophical schools. Unfortunately, the original manuscripts are in a precarious state of conservation and the currently available editions of them have largely been made obsolete by the latest technological progress. The aim of the Advanced Grant ERC project 'Greekschools' is to provide a new protocol based on optical methods to increase the text reading and
thus allow for a new critical edition of the whole treatise of Philodemus' Arrangement of the Philosophers. A multi-disciplinary approach is adopted and non-invasive techniques to Herculaneum papyri investigations such as Macro X-Ray Fluorescence Imaging (MA-XRF), Shortwave-Infrared Hyperspectral Imaging (SWIR), high resolution digital microscopy and Technical Photography were applied to read the text hidden on the verso, detect, classify, and replace overlapping layers and read the text concealed inside them. In this work some first preliminary results will be reported.

Colours for Eternity. Archaeometric data on the original polychromy of Etruscan alabaster urns from Sarteano (SI)

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This study presents the research carried out into the rich polychromy of two hellenistic etruscan alabaster urns coming from the Sentinates Cumere tomb. The urns are part of Bargagli collection, exhibited at the Siena National Archaeological Museum, and were discovered in the area called "Le Tombe" in Sarteano, in 1835.
Several articles describe the abundant colour traces, still visible on the urns surfaces, but this is the first time that an accurate analytical investigation is carried out on this very well-preserved polychromy. The analytical protocol has already been applied on coeval artefacts belonging to Florence National Archaeological Museum. This approach will allow the reconstruction of the painting palettes and to evaluate any similarities and choices in the use of pigments. The archaeometric study integrates multiband imaging techniques (MBI), X-ray fluorescence (p-XRF) and reflectance spectroscopy (FORS).
During the project, the 3D models of the urns were also acquired, which afterwards were used to map our findings.

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Ancient Egyptian wooden statuettes from the Tomb of Minhotep in the Museo Egizio

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The study we would like to present is a preliminary research, whose results have led to a PhD research, that will focus on insights on artistic and constructing techniques of wooden funerary sculpture in Ancient Egypt. In particular, the central point of this work is the funerary assemblage from Minhotep's tomb, presently housed in the Museo Egizio, due to its rather clear provenance and historical period, and the high number of wooden sculptures it includes. The Egyptian workforce hired by Ernesto Schiaparelli found Minothep's funerary assemblage in 1908 in the Asyut necropolis and, among other objects, it counted three "offering bearer" statuettes, two statues of Minhotep, a bakery model and four boat models, which most likely came from specialized workshops operating in the area during the early XII Dynasty.

Given the lack of technical literature about this topic, we would like to contribute with a multidisciplinary study based on the technical comparison between wooden sculptures belonging to the same context, in order to collocate them in a possible production field, underlining similarities and differences both for the construction techniques and for the materials of the painted decoration. The study has started from artefacts of the same type, and will be extended to all the objects of the *corpus*.

The focus of the preliminary study was on the comparison between two of the three painted wooden sculptures of female offering bearers (n◦ inv. S. 08795; S. 8796) [1-2]. X-ray Computed Tomography (CT) has a significant role as investigation tool in our research, due to its non-destructive capability to investigate the whole inner structure of precious and unique artefacts. This permitted to obtain useful information about the characteristics of the wooden structure, besides the thickness of the decoration materials, and previous interventions made on the structure. Despite the same provenance and iconography of the artefacts, we found some important differences in terms of manufacturing techniques, use of materials and state of preservation.

The importance of underlining similar and different features in terms of assembly, modelling technique and materials could suggest possible different hands in the realization of the objects. As starting point for future systematic studies, these specific characteristics could contribute in the correct understanding of finds coming from the same context, but not necessarily produced by the same artisans. In the future, the possibility to apply similar investigation strategy to other wooden artefacts and statuettes belonging to the same area will be explored. Analogies and differences will also support the Egyptological study aiming at the possible identification of different workshops active in Asyut in the early Second Millennium BCE.

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Durability tests of some mortars peculiar of the historic built heritage of Catania (Eastern Sicily): an experimental study

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In this contribution, the durability of two different volcanic-based mortars largely used in the historic built heritage of Catania (Eastern Sicily) has been tested. The two investigated mortars are distinguished according to their aggregate fraction, namely azolo and ghiara, both peculiar of the Etna territory. *Azolo*, in its ancient meaning, is an incoherent pyroclastic deposit with dark-gray color. *Ghiara* is a reddish material originating from the transformation of paleo-soils at highly oxidizing conditions induced by lava flows. Previous studies from literature have dealt with the identification of CSH and CAH phases and/or the quantification of the hydraulicity index of these two mortar types (Belfiore et al. 2010, 2022; Bultrini et al. 2008; Lo Faro et al. 2002), highlighting better hydraulic properties for the ghiara ones. However, no previous papers have focused on their durability performance. The latter has been here investigated on experimental specimens purposely manufactured in the laboratory according to ancient recipes, namely by using the same proportions between binder (slaked lime), volcanic aggregates and water (Battiato 1988). Both physical investigations and accelerated aging tests have been performed, including: a) capillarity water absorption test; b) water vapor permeability; c) resistance to salt crystallization; and d) degradation test induced by treatment with sulfur dioxide. At the end of these tests, analyses through scanning electron microscope coupled with energy dispersive X-ray spectroscopy (SEM-EDS) and colorimetric tests have been also carried out to investigate the changes undergone by specimens from both the morphological and chemical point of view.
The results obtained show that, due to their lower hydraulicity index, the azolo mortars were found to exhibit, in most cases, the worst performances, thus highlighting a poorer physical durability compared to the ghiara-made mortars.

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The detection of Prussian blue in historical textiles: A systematic study based on tailored mock-ups

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Prussian blue (also known as Berlin blue, chemical formula Fe4[Fe(CN)6]3 or KFe[Fe(CN)6]) is a blue compound synthesized for the first time in 1706 by J.J. Diesbach when he was working as a paint manufacturer in Berlin. Prussian blue was initially employed as a pigment, though various French chemists, such as Macquer and Le Pileur d'Apligny, foresaw and proved its effectiveness as a dye by using (soluble) iron (III) salts – such as ferric sulfate, nitrate, or chloride - and potassium ferrocyanide. The use of Prussian blue in textile dyeing experienced a dramatic increase in Europe at the beginning of the 18th century, and then continued to hold its popularity until about 1860, when the widespread availability of aniline dyes abruptly brought it to an end [1]. While the analytical response of Prussian blue when used as a pigment (in paintings, for example) has been the subject of comprehensive studies, the literature about its analysis on textiles is scarce. The detection of Prussian blue in historical textiles is relevant for their conservation as well, as the dye might show color changes or fading when exposed to low oxygen or anoxic atmospheres, such as those employed as safer alternatives to traditional chemicals for pest treatment or for long-term storage to prevent oxidation [2].
This contribution describes an in-depth experimental study aiming to provide a robust set of analytical evidence to be used when tackling the detection of blue dyes in historical textiles, with a special focus on Prussian blue. As a first step, a large set of mock-ups was prepared, including wool, silk, and cotton (in the form of clothes, threads, and flocks) dyed blue with iron compounds according to traditional recipes. In the general context of the use of iron dyeing baths as suggested in the literature [3], the dyeing conditions were tuned to produce a wide variety of blue and blue-green shades, with different color intensity and lightness. The color of each mock-up was documented through color measurements and reported in the CIE Lab space. Dyed fibers sampled from the cloths, threads, and flocks were observed by means of optical microscopy (Vis and UV light) and scanning electron microscopy (SEM) to document the dye distribution and particle morphology (if any). Blue fibers were also embedded in epoxy resin and mounted as transversal cross-sections to highlight - by means of backscattered electron images captured by SEM - the depth of penetration of the iron compounds into the fibers. Then, mock-ups were analyzed with a combination of non-invasive and micro-invasive spectroscopic techniques, with the final goal to highlight the most significant diagnostic features within the variety of colors and textile fibers. X-ray fluorescence spectroscopy (XRF), Fourier-transformed infrared spectroscopy (FTIR), Raman spectroscopy, and fiber optics diffuse reflectance spectroscopy (FORS) were then employed, gathering a wealth of information that will be used to support the selection of the most suitable approach for the detection of Prussian blue in historical textiles.

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Mortars and water: case studies in the Venice lagoon

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The archaeometric study of historical mortars can provide information related to the origin, production techniques, construction phases, dating, use and state of conservation of the materials constituting the archaeological buildings. The environment where historical binders are placed is a fundamental component to be evaluated both for the choice of raw materials to be used and for the secondary reactions that can perturbate composition and texture of materials during their service life and in the burial phase. In this regard, water and its salinity play a substantial role and can lead to the formation of unconventional phases such as hydrated calcium and magnesium aluminosilicates.
Magnesium-aluminosilicate-hydrate phases (M-S-H/M-A-S-H) are poorly crystalline compounds likely related to alteration processes and/or partial pozzolanic reaction between the carbonate binder and reactive silicates in a Mg-rich environment. M-S-H/M-A-S-H formation is promoted by high alkaline conditions and the availability of Mg in the mortar systems due to, for example, pozzolanic additions and/or decomposition of Mg-rich minerals.
High water salinity, as in the Venice Lagoon, has a key role in promoting the precipitation of M-S-H/M-A-S-H products by increasing the pH and, consequently, favouring the dissolution of silicates and carbonates (Bechor et al. 2020; Brew and Glasser 2005; Secco et al. 2020).
This contribution proposes an archaeometric study of the mortars sampled in various sites in the northern lagoon of Venice, such as: Ca'Ballarin, Lio Piccolo and Torrione di San Felice.
The selected mortar samples were studied with a multi-analytical approach employing X-ray powder diffraction (XRPD), optical microscopy (OM), and scanning electron microscopy coupled with energy-dispersive spectroscopy (SEM-EDS), to describe mortars from a minero-petrographic point of view and to define their mineralogical components and chemical composition in both qualitative and quantitative terms.
In this lagoon context, the mortars used have a pozzolanic character and show similarities with other samples studied from similar contexts such as Aquileia, Padua and Caesarea Maritima (Israel).

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Technological innovation and Roman engineering skills in the mortars of Villa dei Quintili (Rome, Italy)

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Villa dei Quintili is an important monumental complex located at the fifth mile of the famous Via Appia and about 10 km far from the centre of Rome. The construction of the villa dated back to the beginning of the second century A.D. until modern times and nine chronological phases were defined. The complex was object of numerous campaigns of archaeological excavation. In this work, 18 samples of mortar were taken in the imperial residence following the enlargements of the archaeological excavations, to determine their composition, the origin of the components and put them in relation to other samples previously studied (Belfiore et al., 2015; Crupi et al., 2015; Fichera et al., 2015). These latter ones had also been partially dated thanks to the analysis of the masonry technique used, the construction phases and thanks to the study of the brick stamps in situ. Thus, the study of this new series of samples means to complete the knowledge about the types of mortars present in the villa's area. In this regard, the sampling concerned both internal and external areas of the villa; respectively, on the hand, the large hall of the frigidarium, the so-called "median" cistern, the internal aqueduct, the rooms to the north of the garden, the private residence area the large "Pyramid sepulchre" which stands along the ancient Via Appia, perhaps the tomb of the two Quintili brothers. On the other hand, outside the villa, the mortar samples came from two monuments probably connected to the great imperial residence: the Torre Selce (originally *castellum aquae*?) and the so-called Quintili aqueduct to the South of the archaeological area.
The archaeometric approach applied to the mortar samples, aims at achieving crucial data about their textural features, chemical composition and raw materials used for their production by means of techniques such as polarizing optical microscope (POM), Scanning Electron Microscopy (SEM) and Energy Dispersive Spectrometry (EDS). The results will provide important information to complete the archaeological context about the building history of Villa dei Quintili and the evolution of the technological processes of Roman mortars manufacture.

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Combining multispectral imaging and XRF analysis to examine San Patroba che predica ai fedeli di Pozzuoli by Massimo Stanzione

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Diagnostic analysis on the painting depicting San Patroba che predica ai fedeli di Pozzuoli by Massimo Stanzione was carried out. The painting was done in 1635-1637 to decorate the choir of the Cathedral of San Procolo in Pozzuoli (Naples, Italy) where the author worked when Artemisia Gentileschi was also working there. Stanzione was a painter much appreciated by religious and lay clients, his paintings and fresco pictorial cycles decorate many Neapolitan churches including the Certosa di San Martino, the church of San Paolo Maggiore, the church of S. Maria Regina Coeli, the church of S. Maria la Nova, the church of San Lorenzo Maggiore, the church of S. Maria delle Anime del Purgatorio ad Arco.
His activity was a guide and model for other painters of his time such as Francesco Guarino, Pacecco De Rosa, Giuseppe Marullo and Agostino Beltrano, artists who traced his compositional schemes and pictorial style based on the fusion between Caravaggio's naturalism and delicacy of colour of Carracci School.
The painting under study is currently in the Cathedral of Pozzuoli and its conservation and study of the painting is part of the Puteoli Sacra project of social and cultural inclusion launched by the Regina Pacis Foundation.
The analysis of X-ray fluorescence (XRF) and multispectral images was applied on site to learn about the executive technique, the palette of the painting and the previous restoration works, as well as to understand the influence of the other painters active in Naples in that period.
Point XRF measurements were performed with the ELIO Bruker XGLab portable spectrometer (Scialla et al., 2023) to determine the elemental composition of the painting, which allows the identification of pigments and materials used in the paint and in the preparatory layers. The multispectral imaging investigations (Macchia et al., 2022) were made with a 28 MPX Samsung NX500 digital camera with a BSI sensor and appropriate filters and light sources. The painting was investigated with different wavelengths (VIS, IR and UV) to differentiate pictorial materials such as pigments, varnishes and dyes. The images were processed with graphics software.
The results of the research will be presented and discussed to draw general aspects and peculiarities of the technique used, of the restorations as well as to evaluate the state of conservation inside the cathedral.

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The first archaeometric analyses of Bronze Age vitreous materials from Paduli site (Colli sul Velino, Rieti) in central Italy

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Since 2011 the Sapienza-University of Rome has started a territorial research project in the Conca Velina and in the Piediluco lake aimed at the diachronic reconstruction of the human population. The survey and digs highlight a continuity of life of the lakeshore settlement of Paduli (Colli sul Velino, RI) from the Middle Bronze Age to the Early Iron Age. During the excavation campaigns, vitreous materials (i.e. several beads from blue to turquoise; a vessel fragment, bichrome blue and white; a "star" bead with light and dark blue bands; a blue barrel bead with white spiral decoration) have been found.

Here we present the first archaeometric study of a such materials of this period in central Italy, through a multianalytical approach: the first step was based on non-invasive techniques and, once acquired and evaluated the data, a second step is planned based on the collection of few microsamples from the objects to be analysed with micro-destructive techniques. In the first step, portable X-Ray Fluorescence (p-XRF), Fibre Optic Reflectance Spectroscopy (FORS) and X-Ray Diffraction (XRD) for acquiring information about elemental composition, chromophoric elements and crystalline phases in the glass matrix of materials, respectively. The results of the first step allowed to address the sampling to the more significant and representative objects, also reducing the size and number of samples. So, five samples were selected and analyzed to obtain microstructure information, chemical composition, colorants and Sr-Nd-Pb isotopes information not otherwise obtainable.

All samples were analysed by Scanning Electron Microscopy-Energy Dispersive Spectroscopy (SEM-EDS) for morphological and chromophoric investigation. Major and minor elements were analysed by Electron Probe Microanalysis (EPMA), whilst trace elements concentrations were obtained through Laser Ablation Inductively Coupled Plasma-Mass Spectrometry (LA-ICP-MS). Isotopic fingerprints of Sr, Nd and Pb were determined via Thermal Ionization Mass Spectrometry (TIMS).

Major elements indicate that four samples (i.e. 2 beads, the "star" bead and the blue barrel bead with white spiral decoration) are LMHK (Low Magnesium High Potassium) glasses, due to the low MgO and high K_2O content, which is a typical composition for protohistoric Italian glasses, with Frattesina (Rovigo) being one of the most active centers. The vessel's fragment shows high Na_2O and low MgO instead, and it can be classified as Natron Glass, possibly indicating a different production and/or trade route.

The data collected by the multidisciplinary study confirms the importance of the site where at the end of the II millennium BC phenomena of social complexity seem to emerge with the presence of nascent local elites capable of inserting themselves into the network of international traffic.

Spectroscopic analysis of bronze sculptures by Giuseppe Renda

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In this study the compositional analysis of three bronze sculptures by Giuseppe Renda (one of the most famous interpreters of the Neapolitan Verism in the 19th and 20th centuries), named "La Fortuna", "Scugnizzo" and "Non mi toccare", respectively, was performed, for the first time, both at the elemental and molecular levels, by means of portable X-ray fluorescence (XRF) and Raman spectroscopy [1-4].
The chemical composition analysis of the investigated artefacts, closely related to the sample preparation and preservation, was carried out with the aim to improve the knowledge of the Southern Italy bronze art of the second half of the 20th century and in order to suggest to restorers the best interventions to minimize the conservation problems that could affect the durability of the precious artefacts [5].
Noteworthy, the achieved results represent useful and essential tools to obtain information on the execution technique, in a completely non-invasive way, and to address management issues of the investigated artworks.

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Diagnosis on prehistoric Karstic cave using integrated geophysical methods

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An integrated geophysical survey using seismic refraction tomography (P and S-wave), two-dimensional electrical resistivity tomography (ERT) and ground-penetrating radar (GPR), was undertaken on a cave of great archaeological interest in southern Italy. This cave, named Grotta delle Veneri, is located in the archaeological site of Parabita (Apulia, southern Italy).
The presence of humans in the territory of Parabita dates back to 80.000 B.C. In fact, an artefact of Homo Sapiens Neanderthalensis (Neanderthal) and one of Homo Sapiens-Sapiens (Cro-Magnon) (35,000-10,000 B.C.) were recovered in the cave "Grotta delle Veneri" in 1966. Two statuettes (2.000-10.000 B.C.) representing two pregnant women were found in the same year.
The “Grotta delle Veneri” (Cave of the Venus) is one of the most important archaeological installations of the Salento peninsula, since its discovery confirmed the presence of the Neanderthal man in the Mediterranean Basin.
As it is well known, rock fractures constitute a serious problem in cave maintenance. In fact, progressive cracking within the bedrock is considered to be the main cause of collapse.
Interpretation of the integrated data from seismic refraction tomography, ERT and GPR (200 MHz antenna) allows the evaluation of some of the elastic characteristics (such as the Vp/Vs ratio) and the identifications of discontinuities in the rock.
Cracks within the bedrock were detected to a depth of about 2 m using GPR, which allowed identification of the loose zone around the cave.
GPR data were visualised in three-dimensional space using the iso-amplitude surface of the complex trace amplitude. The immediacy in revealing the spatial position of highly reflective bodies, such as the fractures related anomaly, makes the 3D visualization technique very attractive in engineering applications of GPR.

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The painted plasters of the temple of Cupra Marittima (AP, Central Italy) in its first arrangement

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Located on the *Civita di Marano* plateau, the archaeological site of *Cupra Marittima* (AP, Central Italy) hosted the main public and religious buildings built in the early Imperial age. The recent excavation campaigns confirmed the existence of a deep renovation work that also affected the temple, probably around the 2nd century CE. The restructuring of the temple has provided for an increase in the trampling level which was filled by fragments of the previous pictorial decoration. In fact, in a first phase dating back to the Augustan-Tiberian age, the inner room of the temple was decorated in 3rd Pompeian style. A decorative choice that finds rare comparisons in sacred buildings at a time when the use of stone was preferred for architectural decoration. Although destroyed as a whole and used as filler, the wide palette of colours has been found in an incredibly well-preserved state.

The present research examines 10 fragments consisting of painted multilayer plasters coming from the filling and selected on the basis of the different shades of colour to cover the entire chromatic range present in the decoration.

The pictorial layer was analysed with the aim of identifying the pigments (or the mixtures of pigments) used in the decorations of the temple in its first arrangement. Stratigraphic analysis of plasters allowed the identification of their individual components, which proved helpful in finding out more about the mural painting technique employed. The investigation of the pictorial materials was preliminarily performed by a multi-analytical approach by means of the Digital Microscopy (DM), X-Ray fluorescence (XRF) and Fourier Transform Infrared spectroscopy in Attenuated Total Reflectance mode (ATR-FTIR). The identification of the components of the plaster layers was performed by a minero-petrographic characterization via Polarized Light Microscopy (PLM).

The archaeometric characterization of pigments revealed the use of rather inexpensive, widely available pigments such as yellow and red ochres, green earth, and carbon black as well as the adoption of precious pigments, namely Egyptian blue and cinnabar. The identified pigments were used either in a pure form or in admixtures; the different shades, in fact, were obtained by mixing pigments with different colours (e.g., hematite was used in its pure form to obtain red painting and mixed to the Egyptian blue to obtain purple colour), or by using different pigments with the same colour (i.e., green hues were obtained by using green earth or a Cu-bearing pigment for the lighter shades).

Regarding to the plasters, they were made by using a multilayer technology. The mineralogy of aggregate suggests the exploitation of local aggregates by the ancient masters, probably coming from nearby river contexts active in ancient times.

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The exploitation of the stone resources of North-Eastern Italy in the Roman Age

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The project "The exploitation of the stone resources of North-Eastern Italy in the Roman Age" aims to characterize and define the provenance of the stones used for architectural purposes in North-Eastern Italy in Roman times in the framework of a wider research on the Roman architecture of Regio X - Venetia et Histria carried out by the Department of Cultural Heritage in collaboration with the Department of Geosciences of the University of Padua (Previato 2015; Previato 2018; Zara 2018; Previato, Zara 2018; Germinario et al. 2018; Boschetti et al. 2021). The research includes, on the one hand, a detailed study of the stone building materials and artifacts found in a selection of cities of the region, and, on the other, the identification and mapping of the possible quarry areas, in order to reconstruct the dynamics of selection, exploitation and management of natural resources that characterised the Roman age. The sites which are currently under examination are Oderzo (Opitergium), Concordia Sagittaria (Iulia Concordia), Bibione, Treviso (Tarvisium), Altino (Altinum), Vicenza (Vicetia), Padova (Patavium), Verona (Verona), Adria (Atria), and San Basilio di Ariano nel Polesine. The project is characterised by a strong multidisciplinary identity, as the stone materials, as well as the supply basins, are analysed both from an archaeological and archaeometrical point of view.

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Detecting a Hidden Fortification System at "Faraglioni" Middle Bronze Age Village of Ustica Island (Palermo, Italy)

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Geophysical research carried out with georadar (GPR) and electrical resistivity tomography (ERT) techniques in a village of the Middle Bronze Age on the island of Ustica (Palermo, Italy), allowed us to discover the buried foundations of an outwork fortification system that probably constituted the first line of defense of the settlement, a few meters in front of the still standing main wall belt. The hypothesis of an ante-wall barrier had already been presented by our group in a previous work (Russolillo et al., 2022), based on the alignments of some boulders emerging discontinuously from the ground, which were highlighted through drone photographic surveys and analysis of historical aerial images. The new geophysical outcomes also evidenced the existence of some structures (rooms?) between the two lines of defense.

We deployed an array of 16 steel electrodes (1 m apart) to acquire n 11 ERT profiles using a Syscal R2 (IRIS Instrument). We injected a bi-polar square pulse of 250 ms generated by a 100 V energy source, using both dipole–dipole and Wenner Schlumberger configurations, sensitive to horizontal and vertical changes in resistivity and thus suitable to accurately reconstruct shallow subsurface structures. For GPR data, we used an IDS HiMod equipped with 200 MHz and 400\900 MHz central-frequency antenna to acquire a set of pa-rallel profiles, with different lengths, within a survey grid of 16 x 30 m, also overlapping three ERT profiles.

Recovered resistivity sections highlighted a three-layered subsurface resistivity model with an uppermost moderately resistive cover, with variable thicknesses, on top of a conductive layer with sub-horizontal geometry. At depth, the models hint at an increase in resistivity. In the shallowest layer, a clear high-resistive anomaly, 2-3 m wide and less than 1 m depth, occur in all set of ERT profiles. As for GPR results, radargrams show a series of high-to-middle energy reflections in the first 1 m depth, most of which clearly fit with the abovementioned ERT anomalies, before the signal is attenuated around 2 m depth.

The Middle Bronze Age Faraglioni Village is located on the northern coast of the island of Ustica and is considered one of the best-preserved archaeological sites of his epoch in the Central Mediterranean. It was built on a stretch of coast bordered by high sea cliffs and protected on the landward side by a massive wall strengthened by buttresses. Ruins cover an area of about 7000 m^2. Since the 1970s several archaeological campaigns highlighted a multi-functional use of space and recovered abundant household goods, showing similarities to the coeval settlement of Thapsos, in south-eastern Sicily (Mannino, 1982; Holloway and Lukesh, 1995, 2001; Spatafora, 2016; Foresta Martin and Furlani, 2021). In light of new geophysical data, we can now redefine the complex picture of the defensive system that characterized this settlement. This discovery paves the way for new investigations, mainly aimed at defining the timing of the construction of the fortifications and the intended use of the others structures identified through geophysical prospecting.

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C&D-P5

A multi-technique setup based on a liquid anode X-ray source for the non-invasive characterization of materials

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In the last decades, a novel technology for X-ray sources based on the use of a liquid anode has been developed, in order to increase the maximum achievable brilliance by at least one order of magnitude compared to conventional microfocus sources [1].
With this innovative equipment, a High-Brilliance X-ray laboratory (HiBriX Lab) is presently under development at the University of Torino, hosted at the NIS inter-departmental Centre. It was designed by integrating different detectors and focusing optics to represent a unique laboratory in Italy and with a handful of comparable examples in the world. The aim is to cover several applications such as:
- material characterization via µXRD and µXRF maps;
- investigation of detector performances in terms of charge collection efficiency or as a function of damage effects;
- single cell level radiobiology;
- X-ray imaging (2D radiography and 3D computed tomography - CT) of objects having a wide size range.
Procurement of the different components has been almost completed and their integration is underway, also by means of the development of specifically dedicated software for system control. To date, concerning the microfocused branch of the lab, a minimum spot size of about 25 microns has been achieved by means of a set of twin paraboloidal mirrors, and a maximum flux density of 2.7×10^{10} ph s^{-1} mm^{-2} has been obtained with a polycapillary optics system specifically delivered by INFN X-lab in Frascati. On the other side, where a 30° cone beam is available, a versatile X-ray imaging setup is installed, which allows the acquisition of radiographs and tomographic scans of very different kinds of samples: objects of dimensions in the sub-mm to few tenths of cm range, with wide variability in atomic number and density values, such as the samples of interest in the field of cultural heritage.

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Historic Vehicles Preservation: A Diagnostic Approach

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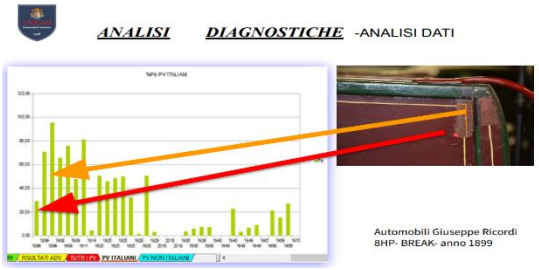
This study takes into consideration a particular type of cultural heritage, currently not included among the "classic" topics concerning the conservation of cultural heritage: the historic car and in particular the historic vehicles of the 1920s/30s. The period concerns the beginnings of large-scale industrial production of cars, but also the birth of new cultural movements: the Bauhaus, Italian Futurism, the Picasso period, the metaphysical painting of Carrà, of Le Corbusier with the "Ville Radieuse", of Mies van der Rohe with his rationalist architecture.The historic vehicle can therefore be considered as a cultural asset, a design product, a work of art in some cases. Laboratory analyses were carried out on samples of materials and paints to trace their composition and identify the parameters to establish a probable date, proposing the development of a dating methodology. We analysed all the samples taken with the X-ray fluorescence (XRF) technique, and the presence was highlighted, mainly of: Calcium (Ca), Titanium (Ti), Iron (Fe), Nickel (Ni), Copper (Cu), Zinc (Zn), Barium (Ba), Mercury (Hg), Lead (Pb). As regards the results on Lead, grouping the results by year, it was noted that the % detected varied on average in a decreasing manner according to the period (higher in older cars, down to zero in current cars). Lead was used because it accelerates the drying of the oil binder. It was therefore decided to investigate the correlation between the production period and the % lead content. In fact, the use of lead has been modified over the years with new regulations and laws which have limited its use; it is now banned in many countries due to its toxicity. A total of n. 21 historic vehicles from various periods were analysed, on which 57 samples were taken. Attention has been focused on the presence of lead (Pb) in different percentages. The results obtained cannot be considered statistically significant, due to the small number of samples, but this preliminary study is a prelude to a subsequent phase of study which envisages a significant number of samples from vehicles representative of the period from the beginning to the end of the 1900s. Ultimately, in the future, it will be possible to build a reference database for historic vehicles, both to date the painting/repainting operations carried out and to establish their originality.



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The painting on wood: the artistic technique in the *Annunciation* of Spermento by Giovanni Angelo d'Antonio

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The Annunciation of Spermento is attributed for the first time to the Master of the Annunciation of Spermento (Giovanni Angelo d'Antonio?) in 2002 by A. De Marchi and A. Di Lorenzo. Subsequently M. Mazzalupi confirmed that the author of the panel was Giovanni Angelo d'Antonio.
In 2021 the panel painting was analyzed to identify the preparatory drawing, to determine the pigments used and to study the pictorial details. The study traces the construction history of the painting on wood, i.e. the construction techniques of the support, the methods of application and the type of preparation used, using the results of the XRF analysis to confirm the presence of strontium (Sr) in the preparation of the plaster.
The study of the preparatory drawing was carried out using infrared reflectography and oblique light. The first highlighted not only the drawing, but also the pentimenti, some of which have a certain importance and extension. The second allowed us to see the extensive use of etching to create the painting's architecture. The XRF analysis carried out on the chromatic backgrounds made it possible to identify the pigments that made up the artist's palette. The results highlight the presence of Mercury (Hg), Iron (Fe), Copper (Cu) and Lead (Pb), furthermore the absence of some pigments within some color areas, suggests the use of some pigments not detectable with this technique. Infrared images in false colors have been added to the results of the XRF analysis which allow the integration of the information obtained with the XRF analysis and which highlight some chromatic reintegrations which took place with a pigment different from the original one.
With the use of macrophotographs, the following details have been highlighted: the technique used for the application of the egg tempera, the detail with which the artist realizes the details on the panel, the use of the engraving on the fresh tempera in the area of the floor for the creation of the joints between the tiles, the use of gouache and mission gilding and the use of punches to create the decoration of the halos.

Colore nel visibile	Falso colore	Tipo di pigmento
Azzurro	Rosso	INDACO
Azzurro	Rosso – Rosa	LAPISLAZZULI
Giallo	Verde chiaro	OCRA
Grigio	Grigio	NERO ORGANICO
Rosso	Giallo aranciato	CINABRO
Verde	Blu	VERDE DI RAME
Viola	Arancio	LACCA

Table - Comparison of visible color and false color infrared.

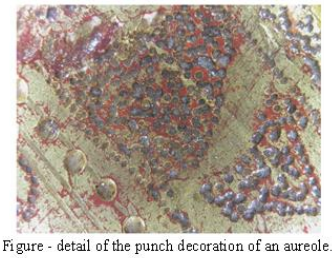

Figure - detail of the punch decoration of an aureole.

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Non destructive analysis of Bronze Patina

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Except for organic materials, bronzes (and metals in general) are those that mostly suffers from degradation processes. Indeed, metal corrosion takes place in nearly all the burial environments (Dillmann et al. 2014) resulting in some cases not only in the alteration of the surface, and in the complete loss of the surface decoration, but also on the loss of the structural strength (Scott 2002). Bronze can be affected by two different kinds of degradation: in the first case (*noble* patina) the surface is covered by a dark grey or green passivation layer characterized by an enrichment in tin (or a depletion of copper), it retains all the artistic features of the surface and does not reduce the structural resistance of the artifact; in the second case (*bronze disease*) instead, the formation of the corrosion layers shows the presence of copper compounds, cuprous oxides and copper chlorides (Robbiola et al. 1998), here the corrosion process can last creating irreparable damages to the object.
In our work we analysed two untreated Etruscan archaeological bronze artifacts. The fragments show a heavily corroded layer, composed of green and white minerals; the objects are extremely fragile, as many fragments have been generated during the shipping process. The aim of the study is to employ non-invasive techniques: X-ray fluorescence (XRF), Raman spectroscopy, FORS analysis and Optical Microscopy, to characterize the corrosion layer and the original bronze composing the samples (Robbiola and Portier 2006).
Through XRF the elemental composition of the different coloured patina and of the bronze bulk have been investigated, as the patina layer can be considered thin for the employed energy, it is not possible to retrieve it elemental composition; for this reason, we employed PCA to enhance the difference in composition among the different regions of the sample. The data collected with XRF have then been cross-referenced with the information obtained through Raman Spectroscopy, which instead, gives molecular information on the degradation products.
Instead, for the bronze bulk, which have been studied on the fracture surface of the samples, XRF analysis have been employed to retrieve the original bronze composition.

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Sonic test for decay assessment of historical stone coat of arms

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Coat of arms, since the 13th century, began to be widely used by many illustrious Florentine families. They represented a symbol of prestige, and their different figures and colour combinations were chosen to differentiate the families (Borgia, 1992). Coats of arms were made of several materials (stone, wood ecc.) and were placed at the entrances of palaces or in courtyards. In particular, the facades of the Florentine noble palaces were equipped with coats of arms made of the typical Florentine sandstones, Pietra Serena and Pietraforte, and were positioned on the main doors or at their corners.
Due to of their exposed position to external weather conditions, these elements exhibit many types of degradation, ranging from total loss of original design to the danger of detachment of entire portions. Good restoration practices are therefore valuable both to preserve the coats of arms and their symbols and to prevent the risk of falling on objects or people.
In this study, some Florentine coats of arms were investigated with Sonic Test, a non-destructive and non-invasive technique, useful for evaluate, through the calculation of wave velocities, the state of stone degradation and presence of detached portions. The data acquisition is performed by a point mechanical pulse from a hammer, and it is read by an accelerometer. A grid of measurement points is designed then constructed to investigate the whole object and to characterize the presence of weakness points. The resulting wave velocity is an average value of the local velocity along the paths. If the velocity value recorded deviates from the typical value of the intact material, it means that the wave is attenuated by the defects inside the material.
Based on this principle and measuring the velocities at each grid point along different paths, it is then possible to obtain a velocity distribution map of the whole investigated element.
To better visualize the distribution of the results obtained from the Sonic Test, data processing is performed on the 3D models acquired by Laser Scanner.
The 3D representation of the velocity distribution, allow us to better understand the geometries and the extent of degradation phenomena.
The velocity map can be compared with the degradation map and becomes an excellent diagnostic tool for identifying fractures or discontinuities that are not visible on the surface.

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Multi-analytical characterization of wall-paintings from the Roman *villa* of Negrar di Valpolicella (Verona, Italy)

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The poster offers a preliminary characterization of mortars and pigments used in the making of the wall-paintings of the Roman "Villa of Mosaics" recently unburied near Negrar (Verona, Italy). In the course of the excavations, several pictorial *nuclei*, originally constituting the ceilings and the wall revetments of the *villa*, have been uncovered. On the basis of their stylistic features and stratigraphical relationships, the collapsed wall-paintings were credited to the original 4th c. CE phase of the building.
In this poster, we report the analyses of the best preserve painted *nucleus*, referring to one of the collapsed ceilings. Centimetre-sized samples were collected from representative portions of the decoration, in order to characterize the number, thickness and petro-mineralogical composition of the preparatory layers constituting the *tectorium*. Further micro-samplings were carried out on crucial areas (i.e. overpainted zones) of the decorations, in order to define the *palette* of the pigments, their microstratigraphy and the application technique (*buon fresco*, *secco*).
The analytical methods we adopted are those traditionally employed for the characterization of historical mortars and pigments: we used Polarized Light Microscopy (PLM) in transmitted light on thin sections to define the texture and the provenance of raw materials employed in the production of the mortars. This technique was corroborated by X-Ray Powder Diffraction (XRPD) and Scanning Electron Microscopy coupled with Energy Dispersive System (SEM-EDS) analysis for the investigation of the mineralogical and chemical features of the binders and aggregates.
Reflected Polarized Light Microscopy was useful to determine the microstratigraphy of pictorial patinas, whereas the mineralogical composition of the pigments was determined by XRPD analysis, by mechanically scraping and analyzing each pigment of the *palette* individually.
The multi-analytical approach we adopted for characterizing the materials and methods of production of the wall-paintings of the Roman *villa* of Negrar aims to corroborate the actual state of art regarding the Late Antique painting techniques and production methods, which were just marginally considered in the field of Roman painting tradition.

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Brightness under the ashes: a compositional analysis of "Ori e gemme di Pompei"

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The archaeological excavations carried out in 1748 accidentally returned the remains of the ancient city of Pompeii. Along with an intact city, everyday objects, statues, jewels and pieces of Roman life return to shine after centuries buried under the ashes. How were they made? Which technologies are they realized with? These are some of the questions that the archaeologists asked. The huge gold jewelry collection, coming from the excavations in Pompeii and Herculaneum and dated back to the Roman period, are saved and exhibited at the National Archaeological Museum in Napoli. The collection also includes the preciousness "*Lucerna di Nerone",* a splendid oil lamp in solid gold, almost 900 grams, gift from Emperor Nero to Venus, tutelary deity of Pompei. No investigation about the composition of gold jewelry and the gems were performed until now.
Here, we report on a detailed investigation of a series of jewels, through the use of a portable XRF and Raman spectrometers as well as of an optical digital microscope in a completely non-invasive way.
All the analyses were carried out in several measurement campaigns in agreement with the management of National Archaeological Museum of Naples, and allowed to obtain the chemical composition of alloys, furthermore the *ad hoc* realization of reference metallic ingots allowed to obtain a calibration line and the carat weight of the objects.
All collected data, together with the results of gem analysis, allow to underline the preciousness and importance of the "Ori e gemme" of Pompei.

This study is performed in the framework of Progetto Sperimentale su Pietre e Gemme della Collezione delle Gemme e delle Oreficerie della Collezione del Museo Archeologico di Napoli (MANN) of Sapienza Università di Roma.

The Tribune of the Mother Church of Ciminna (Sicily): a multianalytical study of stuccos by Li Volsi workshop

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The Tribune in the main altar of the Mother Church of Ciminna, a town in the province of Palermo (Sicily), is a plastic work of art created by the Li Volsi family workshop [1]. These sculptors originally from Nicosia and Tusa were very active in Sicily especially in the 17th century in wooden sculptures, stucco decorations and decorative arts. The reference model of the Tribune di Ciminna was the one on the Cathedral of Palermo, built in the second half of the 16th century by Gagini workshop and removed from its original location at the end of the 18th century. During the recent conservative activities and the planning of the future restoration works, diagnostic investigations were conducted for the characterization of the original and past restorations materials. Moreover, the investigations were aimed also to study the manufacturing techniques typical of the Li Volsi with respect to the recipes of the Sicilian production of coeval stuccos [2]. The diagnostic analyses allowed also to characterize the stratigraphy and understanding the causes of the extensive darkening that alters the gilding on relief surfaces. All analysed fragments were sampled on the basis of the macroscopic aspects observed during the preliminary survey by the restores on different level of the Tribune. The chemical and minero-petrographic investigations have made it possible to characterize and differentiate the mortar and stucco samples taken from the different original and remake portions. The data confirmed the remakes portion hypothesized by a preliminary stylistic analysis and, moreover, within the portions indicated as "originals", the investigation highlighted differences attributable to two different recipes.

Two original sample groups indeed are distinguishable due to the different binder/aggregate ratio and the presence of *cocciopesto*. The SEM-EDS analyzes confirmed the minero-petrographic study and showed the different composition between the bulk layer, based on magnesian lime with gypsum additive, and the finishing layer, made with magnesian lime, widely attested in Sicily of the 17th century. The finishing layer in the original stuccos is also characterized by crystals of spatic calcite deriving from the comminution of marble as constituents of the aggregate phase. These evidences are reflected in the recipes of the period which provided for the use of gypsum in the internal layer of the modelling to reduce the hardening times of the mortar and improve its workability. The remake parts are characterized by a higher gypsum and low magnesium lime content in the binder, and gypsum crystals in the aggregate phase associated with rare carbonate or quartz lithic fragments. The multi-analytical investigation verified a compositional uniformity on different level of Tribune both for the gold leaf, characterized by a low silver content, and the preparation layers. The red-brown preparation was constituted by iron oxides and clay minerals mixed with a lead-based pigment used both to obtain chromatic effects and for its siccative properties. The darkening that characterizes all preparation layers is due to the formation of lead sulphides, favoured by the thermohygrometric conditions and by the phenomena of sulphation of the stuccos.

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Micro-Computed Tomography for the analysis of Japanese pottery

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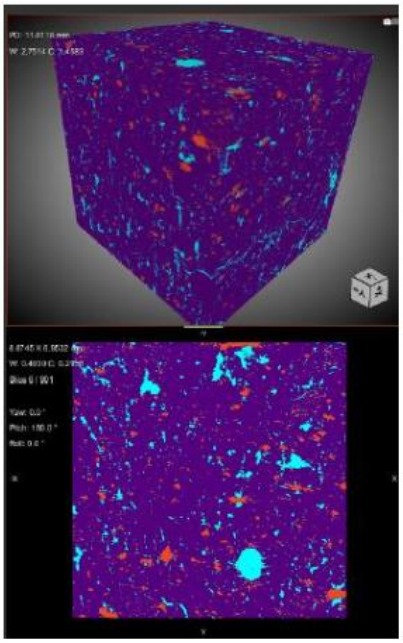
In the framework of the BeArchaeo European project, the archaeometric analysis of different kind of materials coming from several Japanese archaeological sites have been carried out. Among them, X-ray imaging has been applied to characterise pottery fragments: radiography for a first screening and Computed Tomography (CT) analysis for a complete volume reconstruction, 3D rendering and segmentation.
CT revealed to be useful to distinguish different characteristics of the sample (e.g. minerals, porosity, etc.): usually these results are obtained with a high spatial resolution in an invasive way by means of a Scanning Electron Microscope (SEM), while using CT these results can be obtained in a non-invasive way, even if with a lower spatial resolution. For this purpose, tomographic acquisition of the central part of every sample was performed (Local Tomography) to reach the maximum possible resolution in the final CT reconstruction. From this analysis it is possible to visualize internal porosity of the material (voids size and their directionality) and principal mineral components that can give valuable information on manufacturing and execution techniques of the artifact.
In order to obtain the best possible results, a methodology for processing the tomographic data has been developed and tested, which involves several steps of correction and processing of raw and intermediate images to remove artifacts that could afflict CT analysis, the so called "ring artifacts".
In the reconstructed tomographic images, the different ceramics components are clearly visible with different grey levels according to the material density and composition, since the grey level variations are due to the different X-ray attenuation coefficient of the present elements and their atomic packing, giving an indication of the chemical composition in a non-invasive way. Higher density areas, composed of more heavy chemical elements, are visible as brighter areas, while dark areas indicate the presence of voids and porosity that extends over the entire investigated volume. Areas with an intermediate grey level represent medium density material, such as other types of minerals or inclusions and the ceramic matrix.



The three-dimensional visualization of the CT images is usually performed to qualitatively characterise the microstructure of the sample. In this case threshold-based method for segmentation was used: different grey level correspondent to the different materials presents are separated and different colours are virtually assigned to each of them.
Linking the information obtained by the invasive techniques (petrographic examination, SEM-EDS, XRF, XRD etc..) with the one obtained by means of CT, it is possible to propose some correlations with different inclusions inside the fragments.

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C&D-P14

Non-invasive characterisation of Japanese pottery from the Tatetsuki burial mound (Okayama prefecture, Japan)

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The present study aims to enhance the archaeological classification of pottery sherds found from ancient Japanese burial mounds through a material science elemental approach using non-invasive techniques. To develop and test the procedure, we focused on a set of pottery sherds from the 2nd-century Tatetsuki burial mound in Kurashiki City (Okayama prefecture, Japan).

With its unique round shape bearing two rectangular protrusions and measuring about 83 meters in length, the Tatetsuki mound poses specific questions concerning the evolution of mounded tombs during the transition from the Yayoi to the Kofun period in Japanese protohistory. It is therefore a highly significant archaeological site in Japan and key to understanding the following Kofun period [1].

Fragmentary ceramic jars (*tsubo*) and stands (*kidai*) – used to support the vessels of the offerings for the funerary ritual – are normally recovered by archaeologists from Late Yayoi burial mounds in the Okayama region. These items are the prototype of *haniwa*, the pottery figures (sometimes representing humans, animals, or houses) that adorned the keyhole-shaped tombs of the Kofun period.

In this work, Optical Microscopy (OM) and Portable X-Ray Fluorescence (p-XRF) spectrometry were performed on more than 40 pottery sherds of jars and stands from the Tatetsuki mound. The research takes advantage of the recent acquisition by the Research Institute for the Dynamics of Civilizations (RIDC) of a p-XRF device, which was employed here to develop a proper procedure to address, on elemental bases, the problem of differentiating/clustering the sherds. Elemental information, in addition to morphological evidence, may provide clues to recognise the provenance of specific objects or to identify objects deriving from the same raw material.

Within this framework, the goal of the present study was to establish a procedure to highlight the compositional differences (if detectable) of three classes of sherds previously suggested by archaeologists based on typological analysis and place of discovery. This investigation is also based on a previous preliminary study performed, by an invasive approach, on samples prepared as thin sections investigated under the optical microscope [2].

The non-invasive p-XRF-based approach allows us to analyse in a reasonable time large sets of sherds, therefore producing "compositional references" with robust statistical significance that may support the interpretation of raw materials and their origin. The optimisation step for the analytical procedure and the results obtained on the sherds from the Tatetsuki pottery are discussed, along with a comparison with an invasive approach (XRF on powdered samples) applied on a subset of the samples.

This study has been financed by the European Union's H2020 RISE MSCA "Beyond archaeology: An advanced approach linking East to West through science, field archaeology and interactive museum experiences" (BE-ARCHAEO, grant agreement n. 823826).

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C&D-P15

Microchemical tests support conservation: a focus on paper

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This research was performed to develop an operative protocol to be used in the scientific laboratory or by a conservator-restorer to detect the production procedures and the raw materials originally employed to obtain the cellulosic felt in a paper sample.
Paper is a multi-purpose material, and it is normally encountered with different functions in a wide and varied array of items from the material cultural heritage. The interpretation of its origin, therefore, may represent a pivotal step to support the overall conservation process of an object.
Our attention was set on the microchemical tests, which are, at least potentially, a convenient and rapid approach to accomplish the task of characterising paper samples from an object that is going to receive conservation.
The literature offers a large set of microchemical tests that can be employed to detect fibre types, products of the pulping methods, degrees of mechanical refining [1]. The tests use reagents that exhibit specificity in the staining of lignocellulosic fibres and the products of their treatments in the paper-making process, with effects that can be easily detected using simple methods: from the naked eye to light microscopy. In this research, a large set of reagents was systematically tested to develop a procedure that will fit the needs of conservator-restorers treating valuable items from the cultural property.
The tests were initially performed on "large" samples (about 1 cm2 of paper of known composition) to select the most promising reagents. Then, the procedure was developed at the micro-scale, reducing the size of the sample to few fibres, and detecting the effects of staining under the optical microscope.
At the end of the work, a set of 6 microchemical tests was selected. An operative leaflet was prepared to guide the analyst in using/combining the tests in order to respond to the questions of the conservator-restorers.
The suggested procedures were then applied to (micro) samples from two items treated which were subjected to conservation treatments in the conservation laboratories.
The first one was an oil painting, produced by Marco Cardisco in the 16th century by spreading the paint on paper and then attaching it on a canvas. Some (micro) samples detached from this painting were analysed with the aim of highlighting inhomogeneities in the composition of the paper, that would indicate subsequent interventions. Two different types of paper were detected, thus providing crucial information to spot previous conservation treatments. Moreover, the response of one of the papers to the microchemical tests indicated that it was a product of the 19th century paper industry, therefore adding new knowledge to the conservation history of this painting.
The second case study is an 18th century "Papier peint" with oriental motifs (alla China). The question posed to the laboratory was if the typology of the paper could reveal its origin. In this case, a production related to China or Japan was highlighted through the typology of the fibres and the presence of polysaccharide-based finishing treatment.

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C&D-P16

Petrographic and mineralogical investigation of the roman amphorae from the site of San Marco and the wreck of Sant'Andrea (Island of Elba)

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This study is intended to provide an archaeometric contribution to the investigation of Roman remains from the archaeological site of San Marco in the Gulf of Portoferraio and from the underwater wreck of Sant'Andrea (Island of Elba, Italy).
Therefore, sherds of amphorae used for the transport of provisions, recovered from both the cited areas, were analysed. The materials are dated to a chronological period from the 1st century BCE to the 1st century CE.
Mineralogical and petrographic analyses, *i.e.* optical microscopy and XRPD analyses, were carried out with the aim of comparing the data obtained from the amphorae found in the two sites and providing information on the technologies and materials used for their production. A total of 11 samples were analysed.
Archaeometric analyses allowed to divide the samples in *petro-fabrics*, on the basis of textural and compositional criteria: the most numerous *fabric* in the San Marco site was named "Quartzite", due to the frequent presence of quarzite rock fragments as inclusions; also a few sherds from the wreck belong to this group. Moreover the "Pyroxene" *fabric*, attested on the wreck, has common inclusions of pyroxene fragments; the US 282 sample of San Marco has compositional features similar to the sherds of this *fabric*. Finally, four individual samples with unique characteristics were identified.
The good sorting of the inclusions and the low porosity of the less altered samples reflect a good production technology (Fabrizi et al. 2022), compatible with the advanced level of late-Republican Roman production, with only a few differences among the samples (Manca et al. 2016, Olcese 2020).
Therefore, the analyses showed the use of a variety of raw materials, suggesting that the transport amphorae found in the wreck of S. Andrea and those found in San Marco were made in different workshops and probably in many different geographical areas. Therefore, it was also possible to identify similarities between a few samples of the two sites, suggesting that they were made in the same place. This is an important result for our research on Roman amphorae and their trade concerning the reality of the Island of Elba.
Finally, degradation phenomena, due to the underwater environment of pottery from the wreck (Miše et al. 2021), were identified (high porosity and secondary mineralogical phases).

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An insight into glass compositions of Iron Age glasses in the collection of "Gaetano Chierici" museum in Reggio Emilia

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The "Gaetano Chierici" museum is part of the Musei Civici di Reggio Emilia. Its archaeological collection comprised with finds that reflect prehistoric and historic times material culture in the modern Emilia and beyond.
This study was focused on glass objects that belong to contexts dated from the 5th century BCE to the 1st century CE [1,2,3]. They represent mostly decorative pieces used as adornments (mostly beads and bangles, but other objects were also studied).
Since the objects were quite numerous and of high value, it was opted to use non-invasive methods of analysis with portable equipment, in order to operate inside of museum's premises. Optical Microscopy (OM), Fibre Optics Reflection Spectroscopy (FORS), and portable X-Ray Spectrometry (p-XRF) were used.
The results provided a complex picture of various colourants utilised to manipulate the appearance of the glass, which is a crucial part in jewellery making. Moreover, elemental data brought evidence of different sources of the raw glass and of the colourants.
The compositional features of objects were compared with the ones available in the literature for similar objects from other archaeological contexts, in order to determine whether the objects of Emilian origin are consistent with other European examples of similar appearance.
The majority of objects considered in this study contained cobalt as the blue colouring agent. Iron and copper also influenced the final colour of many samples in several ways. The question of the geographical origin of the raw materials used for colouring the glass was faced on compositional grounds, although the reduced set of quantitative analytical data – linked to the constraint of portability of the equipment – prevented a reliable identification of the sources of the raw materials. Nevertheless, an interesting division of yellow and white decorative elements into those coloured by Sb-containing crystals and those coloured by Sn-containing compounds emerged. This signifies that the shift from antimonates to stannates use could have started already in 2nd century BCE. These results highlight the importance of the collection to the illustration of glass-making technology development and use of glass in the everyday life throughout the discussed period.

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Crystallographic and petrographic characterization of two architectural terracottas from the sanctuary of Marasà (Locri)

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This study is referred to the terracottas revetement of the archaic temple of Marasà (Locri, Italy) which fragments are kept in the deposits of the National Archaeological Museum of Reggio Calabria. The temple was investigated for the first time in 1889-1890 by an Italian-German mission directed by Paolo Orsi and Eugen Petersen. The excavation was resumed in 1954 by Alfonso de Franciscis, who discovered over 4,500 fragments of Archaic architectural terracottas. Other excavations were carried out in the 1970s, 1990s and 2000s. More than 600 clay fragments of various types (antefixes, simas, cassettes, drips, slabs and tiles).

The appearance of ceramic body of the majority of the slabs is that of typical architectonic terracottas, but, in some cases, it shows unusual feature. In some fragments, which ceramic body are green or grey coloured, the texture is arenaceous, appearing more similar to a mortar than to a ceramic. In other cases, the paste colour is not homogeneous suggesting an uneven firing process. Our attention focused on these anomalous types with the intention of clarifying the technological processes that produced them. Polarized light microscopy and X ray powders diffractometry were used for petrographic and crystallographic characterization.

Investigation of street art contemporary murals in the PRIN Project *"SUPERSTAR - Sustainable Preservation Strategies for Street Art":* analytical pyrolysis for the characterization of paint materials

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In the last decade, works of street art, located outdoors in urban contexts, have received increasing attention from the public and art history due to their social and cultural relevance [1], but also from conservation science. The ephemeral character, free access, and exposure to the environment and anthropic actions, make indeed public paintings vulnerable to neglect, removal, vandalism, and degradation. Beyond that, the strategies aimed at their preservation and fruition are rather unclear or lacking. The Italian project PRIN 2020 "*SUPERSTAR: Sustainable Preservation Strategies for Street Art"* sets as a goal the definition of innovative guidelines for the preservation strategy of street art, aimed at safeguarding its powerful social and cultural message in the urban context [2]. The availability of effective analytical tools for the identification of artworks materials is thus crucial to support defining the best preservation practices. The cooperative consortium for the Project SUPERSTAR is composed of University of Pisa (project coordinator Prof. Francesca Modugno); University of Bologna (Prof. Silvia Prati), Politecnico di Milano (Prof. Lucia Toniolo), University of Turin (Prof. Dominique Scalarone) and CNR -Perugia (Dr. Laura Cartechini). Superstar project case studies include two prominent public mural paintings located in Milan, selected with the support of Comune di Milano (Area Museo delle Culture, Progetti Interculturali e Arte nello Spazio Pubblico, Dr. Marina Pugliese and Dr. Alice Cosmai): Or.Me by Orticanoodles in Via S. Faustino (2017) and Necesse by SMOE in via Ludovico di Breme (2021).

The two mural paintings have been the object of study of an extensive in-situ non-invasive campaign of measurements carried out by CNR-Perugia [3]. Within this analysis campaign, it was possible to collect some samples from damaged and altered areas in the mural paintings.

The poster describes the results obtained in the analysis of the paint samples by analytical pyrolysis coupled with gas chromatography and mass spectrometry (Py-GC-MS), applied to characterise paint binders and organic additives in the paint formulations [4]. The analyses allowed for the identification of paint binders in the two murals and were interpreted contextually with the results of non-invasive External Reflectance Fourier Transform Infrared spectroscopy (FT-IR). In particular, polyvinyl acetate plasticised with Veova and styrene-acrylic resins were detected in Or.Me, while a nBA/MMA acrylic resin was the binder in Necesse.

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Characterization of *bronze disease* for conservation purposes

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The present research study is based on the master's thesis work performed at the Conservation and Restoration Centre "La Venaria Reale". It focuses on the archaeometric investigations of the archaeological bronze basin with reference number 15007 and dated to the first century AD.
The find was unearthed from the *Insula Occidentalis* site in the Vesuvian area of Pompeii in the 1970s. More specifically, the basin was found in the grand complex of Marcus Fabius Rufus's House and the House of the Golden Bracelet. Then, it was stored at "Casa Bacco" deposits until 2015. [1] However, there was a lack of information about the specific context of the finding and the original purpose of the basin was unknown. Moreover, the find showed a highly fragmentary state, with several missing pieces and greenish patinas.
Here, the coupling of different techniques, such as ultraviolet photography, X-ray radiography, and vibrational spectroscopies allowed for evaluating the conservation state of the basin. Furthermore, the combination of microRaman analysis and X-ray powder diffraction was performed to in-depth characterize the corrosion patinas of three micro-fragments and a little amount of powder gently detached from the basin.
The results of the scientific investigations reveal the presence of a stratified structure made up of layered copper corrosion compounds, which can be related to the *bronze disease* phenomenon. The detection of paratacamite and clinoatacamite ($(Cu)_2(OH)_3Cl$) and of copper sulfide (covellite, CuS) reflected the long-term exposure in chloride-rich and anaerobic environments, like marine and volcanic sites. [2] Moreover, the identification of polybasite ($[(Ag,Cu)_6(Sb,As)_2S_7][Ag_9CuS_4]$) allowed getting insight into the chemical composition of the cupper-based alloy and manufacturing process. [3]
Thus, the archaeometric investigation offered the possibility to unambiguously identify corrosion products and integration materials employed in former restoration works. The obtained results proved to be precious for optimizing the restoration and conservation interventions of archaeological bronze artefacts.

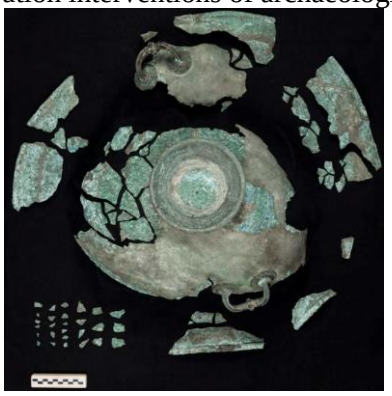

Figure 2. Top view of the external surface of the examined basin

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Reviewing and integrating methods for the conservation of European architectural finishes in urban heritage townscapes

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Article 15 of the Spanish Historical Heritage Law defines a historical unit as "[…] a group of immovable properties forming continuous or dispersed unit of settlement, covered by a physical structure representing the development of a human community in that it testifies to their culture or constitutes a value for the public use and enjoyment. A historical unit is also any individualised group of properties in a larger population unit having the same characteristics and that can be clearly delimited" (1).
Historical artistic units of Vegueta, Santa Maria de Guía, and Triana, on the island of Gran Canaria, were declared in years 1973, 1982, and 1993 consecutively. The historic catalogues of these ensembles list 715 protected buildings dating from the 16th to the 20th centuries (2). However, despite the efforts committed to protect these historical units, no attention has been paid to the original aesthetics and materials that constitute the façades of the buildings, thus defining only vague recommendations on the materials to be used in the restoration of historic exteriors. As a result, neglecting the use of original materials in conservation and restoration of the building effectively reduces the value of authenticity in these urban landscapes.
The CLEA project* aims to address these shortcomings by integrating and adapting research and analytical methods applied to the conservation of architectural finishes, understanding and preserving the historic pigments, mortars composition and plasters texture. The authors are currently analysing 51 samples from 16 buildings using non-invasive colour analyses (wireless digital colour reader) to identify the different colour layers. These are complemented by measurements of the layer's stratigraphy by optical microscopy, Raman spectroscopy, and XRD powder diffraction to characterize the materials. CLEA contributes to improving the methodology for characterising finishes, providing a useful tool for selecting materials and pigments for the conservation of historical aesthetics.

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*The project 'Reviewing and integrating methods for the conservation of European architectural finishes in urban heritage townscapes' (CLEA) has received funding from the European Union's Horizon 2020 research and innovation programme Marie Skłodowska-Curie under grant agreement No 101024606.

Characterization of pre-Colombian ceramic vessels using XRF, FTIR, Raman and SEM-EDX

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Maya ceramic painted vessels played an important role in the ancient Maya civilization, as artistic media, trade objects, religious offerings, and daily life containers [1]. Today, these vessels serve a vital purpose in uncovering artistic and historical information about this civilization [1].
This project focused on the scientific analysis of three Maya polychrome vessels (250 – 900 CE) from the preColombian collection hosted at the Los Angeles County Museum of Art (LACMA) [2]. The study concerned
the characterization of the red pigments used in the pictorial images, as well as the constituents of the clay body. The results of the project were achieved by integrating non-invasive and micro-invasive techniques. The first step was to visually examine the objects with the aid of a digital microscope, this was followed by a chemical assessment done using portable X-ray fluorescence (pXRF). Once this first step was concluded, two samples for each object were collected, one from the clay body and one from the red engobe. These samples were analysed with Fourier-transform infrared spectroscopy (FT-IR), Raman spectroscopy, and Scanning Electron Microscopy with Energy Dispersive X-ray spectroscopy (SEM/EDX). The study outcomes together with the literature review allowed the identification of the red colour as an iron oxide-based pigment and the clay body as aluminium silicate clay, characterized by a calcareous and quartz-rich matrix with impurities of anatase. Future work will be addressed to characterize the chemical, mechanical, and optical changes that happen upon drying and firing in both the ceramic body and the red engobe. To achieve this purpose reproducible mock-ups will be prepared by selecting raw materials according to the results obtained from this current research. Thus, the mock-ups will chemically mimic the key components of the Maya vessels and a comparison between the results could, lastly, be carried out.

Figure 1 Cylinder Vessel with Musicians and Dancer. Northern Guatemala or South-eastern Mexico. Maya, 600–900 CE.

Figure 2 Cylinder Vessel with Maize God Dancers and Dwarf. Guatemala, Petén, Xultun or vicinity. Maya, 650–850 CE.

Figure 3 Cylinder Vessel. Guatemala. Maya, 600-900 CE.

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CONSERVAZIONE PREVENTIVA E RESTAURO

ORALI: C&R-O

POSTER: C&R-P

Indoor and outdoor comparison of particulate matter monitoring systems aimed at the safeguard of cultural heritage

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Particulate matter (PM) is one of the many air pollutants that pose a significant threat to the conservation of cultural heritage [1]. Even though PM originates mainly from outdoor sources, numerous indoor activities can be responsible for the emission of particles, and penetration from the outdoors is also possible [2]. Various degradation phenomena may occur following the chemical-physical interaction between an artifact and suspended air particles which can be deposited on its surface; including, but not limited to, blackening, abrasion, and discoloration [3]. This interaction is influenced mainly by the chemical composition and size of the particles; the fine fraction being the one posing the greatest threat to the works of art [4].

To date, there is an absence of internationally-accepted regulations imposing limits on the concentrations of the main air pollutants. However, on a national level, different institutions indicate recommended values for the conservation of cultural heritage. These efforts prompted several museums to establish internal protocols focused on the enactment of monitoring campaigns to evaluate the levels of pollution in the environments surrounding the works of art, along with measures to contrast the presence of such dangerous species. There are however, sites other than museums (sanctuaries, churches, …) which also host important artifacts, that remain essentially unmonitored.

The current study was conducted inside the *Santuario della Beata Vergine dei Miracoli*, which is a marian sanctuary located in the small town of Saronno (VA), in the Lombardy region of Northern Italy. Numerous frescoes, paintings and wooden sculptures created by the most important Lombard artists of the time can be found in this site. With the aim of safeguarding these precious works of art, three different particulate matter monitoring systems have been tested within the Sanctuary to evaluate the indoor concentrations of this dangerous pollutant. The first is an optical particle counter (P-Dust Monit, conTec Engineering Srl) that allows the dimensional speciation of the particles into seven different classes. The second is a real-time air quality monitoring system (Polludrone, Oizom Instruments), previously cross-validated by intercomparison with gravimetric data. The third instrument is a newly-developed air quality monitoring system (Sensy, Sense Square) which possesses several characteristics that would make it ideal for applications in the cultural heritage field: it is silent, of low visual impact, and easy to install.

Following the results of a first monitoring campaign carried out in 2021 with the only use of the P-Dust Monit, which highlighted critical issues regarding the indoor concentrations of PM in the Sanctuary, a second campaign was performed in 2022 with the use of the two additional instruments cited previously. The systems were placed in parallel both indoors and outdoors to evaluate the concentration of the particles and to carry out a comparison between them. Thanks to this campaign, a step towards the validation of the Sensy air quality monitoring system has been taken and hopefully these systems can be soon implemented for particulate matter monitoring in the cultural heritage field.

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The Fabrics of the Monsampolo del Tronto Mummies : Analysis, Restoration and Conservation

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The discovery of the mummies of Monsampolo del Tronto dates back to July 2003 during the restoration works in the Church of Maria SS. Assumed. In the crypt of the church the remains of about twenty mummified bodies were found, many wearing clothes, jewels and votive medals; The discovery is of considerable historical-scientific importance and represents one of the most significant realities in the area not only for the presence of mummies, but also for the exceptional preservation of the clothes, made possible thanks to a particular and unique burial environment.
These studies have provided information on the characteristics and state of conservation of the fabrics of the clothes found on the mummies to support the subsequent restoration and allow for the best conservation conditions to be set up for the museum layout in which they are still exhibited.
A characterization was made of the fibers that compose them, of the type of dyes used, using specific analytical techniques such as: scanning electron microscopy, infrared spectroscopy, mass spectrometry and nuclear magnetic resonance.
The burial conditions allowed the preservation of vegetable textile fibers which were analyzed by SEM, while the dyes used were precisely characterized by FTIR and ESI mass spectrometry. Finally, by means of NMR it was possible to determine the state of degradation and conservation of the materials. All this has provided a precise scientific framework for determining the best and most appropriate methods of restoration and environmental conservation conditions.

The discovery of the mummies of Monsampolo del Tronto

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The challenge of outdoor wall painting conservation: a comparative study of some protective treatments

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Protective treatments of historical artifacts exposed outdoors are a recurring and fundamental issue for their conservation, but at the same time critical in their application because of the delicate balance between the object and its surroundings. Protective treatments have been extensively studied and tested for monuments made of natural and artificial stone materials, while scarce number of studies are found in literature for wall paintings, because the thickness of the paint layer and the complexity of the system make their protection much more risky. This study arose from the need to protect the late 16th-century paintings in the courtyard of honor of Villa Cicogna Mozzoni, an architectural complex of the same period located in Bisuschio (Varese province). The large fresco cycle is exposed outdoors, so it is permanently subjected to the action of atmospheric agents but, especially in the last century, its integrity and readability have greatly deteriorated. The selection of an appropriate protective treatment was intended to halt or at least slow down the inexorable loss of material from the paintings. As a first step, a limited portion of the painting has underwent several conservation and restoration treatments in order to stabilize it. Subsequently, a comparative study of some of the most commonly used protection treatments currently in use was developed, trying to identify, among them, the most effective and suitable for in situ application in the specific case. Four treatments, two inorganic (ammonium oxalate and ammonium phosphate) and two organic-polymeric (polysiloxane and alkyl alkoxy-silane) were compared after application on some replicas of painted plaster. The treated replicas were subjected to artificial weathering in a climatic chamber with changes in RH, T and water washout. Evaluation of the effectiveness of the treatments after aging was carried out by the following methods: capillary water absorption tests (Karsten tube and Contact sponge), water vapor permeability, portable digital microscopy and colorimetric measurements. The results obtained allowed some observations to be made with reference to the current regulations for evaluating protective treatments. The study highlighted that two treatments are not suitable for the specific context (ammonium oxalate and polysiloxane), while the best performing was di-ammonium-phosphate, which showed promising results for wall paintings conservation and was therefore proposed for in situ application.

Scientific study of a rare Chinese Buddhist silver reliquary

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During the Chinese Liao dynasty (AD 907-1125), miniature pagoda-shaped Buddhist reliquaries played a significant role, and many reproductions were realized to preserve previous holy artefacts. [1]
Even though several sophisticated gold and silver artefacts have been unearthed from ancient Chinese tombs, very little research has been done on Liao metalworks. Therefore, there is a knowledge gap about materials and executive techniques in producing silver reliquaries. [2, 3]
The present research study focuses on an archaeometric investigation of a delicate and rare Chinese Buddhist reliquary stylistically attributable to the Liao Dynasty. The examined find exhibits peculiar aspects. First, it is made up of five overlapping and untied thin silver-based foils. Stylistic analysis suggests that the five pieces might be taken from unrelated artefacts and genuinely assembled in ancient times. However, several doubts remained when examining the iconographical features and only little information about the *provenance* and former restoration treatments is available. The reliquary, stored in reserve collection of Museum of Oriental Arts in Turin, was found in a severe fragmentary condition and it was chosen as a case study for the University of Turin Master Degree in Conservation and Restoration of Cultural Heritage placed in the Centro Conservazione e Restauro La Venaria Reale.
The advanced corrosion process and the ensuing embrittlement state strongly affected the structural integrity of the find, and a clear examination was almost impeded by the presence of surface corrosion products.
Thus, a non-destructive approach was performed on six tiny micro-fragments, which spontaneously detached from different zones of the brittle reliquary. Complementary analytical techniques such as scanning electron microscopy coupled with energy dispersive spectrometry (SEM-EDS), X-ray powder diffraction (XRPD), and X-ray photoelectronic spectroscopy (XPS) were employed to investigate the silver alloy microstructure and examine the possible causes of the alteration phenomena.
The obtained results mainly highlights the unusual role of both chlorine and bromine in forming crystalline bromian-chloroargyrite [Ag(Br,Cl)] as dominant corrosion compounds in the dark *patina*, indicating the peculiar aerobic environmental conditions suffered by the buried find. Furthermore, the results reveal that the reliquary suffered intergranular corrosion-induced embrittlement due to the combination of several aspects related to the alloy composition, find's manufacture, and burial environment. [4]
The findings overall helped to get insight into the history of Liao silver reliquaries in terms of manufacturing process, burial conditions, and former undocumented restoration interventions,and to evaluate the material coherence between the five components.

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In-situ diagnostic campaign on outdoor bronze artworks

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Studying the atmospheric corrosion of metallic works of art exposed outdoors is a fundamental step in the development of long-lasting preservation strategies.
As a matter of fact, the scientific approach to the conservation of metallic works of art is nowadays based on the concept of preventive conservation, which is based on the principle that deterioration is not inevitable and 'aging' is only the result of known and controllable causes most of them correlated to the interaction between the materials and the surrounding environment. According to the Conservation Committee of the International Council of Museums (ICOM-CC) preventive conservation is defined as "all measures and actions aimed at avoiding and minimizing future damages". Thus, the methodology of preventive conservation is indirect: controlling its causes reduces artifact deterioration.
In this contest, non-invasive diagnostic techniques and in situ measurements are very important tools for conservators to obtain valuable information on the artifact conservation state and on the environmental conditions to which the objects are exposed, allowing long-lasting monitoring campaigns to be scheduled.
This paper deals with a long-lasting in-situ diagnostic campaign carried out on several bronze artworks, part of the Gori Art Collection, situated in Fattoria di Celle, in Santomato (Pistoia, Italy).
The campaign, which started in 2019 and is still in progress, is carried out by employing multiple portable analytical techniques. Electrochemical Impedance Spectroscopy (EIS) is employed to study the corrosion processes that are affecting the metallic artworks [1]; moreover, X-rays fluorescence (XRF) and Raman Spectroscopy are employed for chemical and microstructural characterizations [2, 3]. Finally, a 3D photogrammetry survey is carried out to create a complete documentation of the artworks.
Indeed, the developed multi-analytical approach allowed us to identify the composition of the corrosion products present on the metallic surface, characterize their chemical and microstructural features, together with their electrochemical stability, and correlate them to the exposure conditions. Furthermore, it was possible to document all the analysis performed on the artworks and to integrate this information into a virtual 3D model, that can be stored and shared with curators and conservators. Eventually, it is important to underline the importance of establishing the monitoring campaign in different periods (every 6-12 months) to highlight the presence of dangerous situations and the need for restoration. Indeed, by means of the presented multianalytical approach, it was possible to highlight the surfaces that were more exposed to the aggressive agents present in the atmosphere and the washing action of the rain. In fact, these environmental factors induced the formation of reactive corrosion products and selective degradation of the protective coating applied previously on the metallic surface. The collected data were employed by conservators to tailor their actions, paying particular attention to the areas identified to be at risk.
The results of the in-situ monitoring campaign obtained till now will be presented and discussed, highlighting the advantages of the proposed approach, and discussing the challenges still open in the development of tailored safeguard methodologies for outdoor bronze artifacts.

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Six-year long monitoring of green bio-consolidants products applied to natural porous stones

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Biorestoration, thanks to its affinity to green chemistry, has a large application in stone conservation, but most of the studies performed are focused on the use of bacteria for bio-cleaning purposes [1]. Few studies were conducted on bio-consolidants and their long-lasting properties [2]. The aim of this research involves the effectiveness of green bio-consolidants products compared to conventional ones applied to natural stones through a multi analytical approach. A six-year-long monitoring was carried out (first tests in 2016). Pietra Colombina di Avesa (Middle Eocene), which belongs to the geological formation of the Pietra Gallina, near Verona, was chosen and tested. This stone is a fine-grained white limestone, hard and of homogeneous aspect, more mechanically resistant than the Pietra Gallina and Pietra di Avesa, that are more soft and richer in fossils. Samples were treated with ethyl silicate, Biominéralisant calcite (Biocal + Nutrical) and Nanorestore® consolidant products. Non-invasive techniques (i.e. colourimetric analysis, Water Absorption evaluation (WA) by sponge test and Evanescent Field Dielectrometry (EFD)) were adopted and combined with conventional methods, such as Drilling Test Measurement System (DRMS) in order to evaluate treatments performance.
The results showed how the products efficiency change in time: the ethyl silicate treatment continues to keep an hydrophobic effect, while Biominéralisant and Nanorestore® effectiveness return at the initial state.
Moreover, the study highlights how the EFD analysis, originally and usually applied to frescoes [3] and concrete building moisture control [4], is a valid tool for on-site monitoring of treatment performance. The potential of the method and its encouraging results may represent the crossing of a new technological and practical frontier for treatments assessment on porous materials.

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Assessment of low-temperature atmospheric pressure plasma treatments of natural and synthetic varnish

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In recent years, cold plasma at atmospheric pressure has attracted the interest of scientist, conservators and restorers [1]. Several experiments conducted with plasma under vacuum have produced interesting results and have brought the research towards the experimentation of atmospheric pressure systems [2]. Removal of surface deposits due to oxidation and reduction of corrosion products from metal artifacts are some of the possible application in the field of conservation. The use of this new technology for heritage conservation is proposed as an alternative, or support tool, to other consolidated cleaning methods based on chemical and physical approach. In this work three varnishes, dammar, mastic and Paraloid B72, commonly used for paintings on canvas and wood have been selected for testing. The varnishes, specially prepared with solvents, were spread on glass slides and artificially aged before carrying out treatment tests with a DBD (Dielectric Barrier Discharge) plasma system at atmospheric pressure, using Ar as ignition gas and a mixture Ar and O_2 at 2%. The plasma effects were monitored after 15, 30 and 60 minutes of treatment using ER-FT-IR analysis, digital comparator, precision balance and optical microscope acquisitions. The morphological and molecular aspects of the overall process were assessed by checking the surfaces before and after the treatments through confocal microscope, FTIR-ATR analysis and micro-ATR FTIR imaging. On Paraloid B72, the treatment demonstrated good efficacy with almost total removal of the varnish. In the case of mastic and dammar, a thinning was obtained with different dynamics, but both have reported dulling of the surface. The opaque residue might be loose and easily removed with slight mechanical action, however it was not removed for more analysis. The molecular changes, highlighted by chemical imaging with FPA detector (LUMOS II FT-IR Microscope, Bruker) on the treated area (about 1 cm in diameter), show a significant increase in the absorption band of the C=C bonds. The plasma treatment at atmospheric pressure seems a useful tool for cleaning of varnishes on paintings also in combination with other methods (chemical and laser), even though further studies are needed to better investigate the mechanisms.

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The "restoration of the restoration" on the wall paintings of Room E in the Roman *Domus delle Pitture* of Volsinii: analysis of the materials and degradation patterns

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The pilot restoration carried out on the middle and lower register of the back wall of Room E of the *Domus delle Pitture* of Volsinii (Bolsena, Viterbo, Italy) stems from a first preliminary phase of study. The critical analysis of the archival documents and of the graphic and photographic documentation has made possible to identify and reconstruct the ancient modernization interventions of the Domus and its decorative apparatuses and to study the conservation history of the artefacts. Furthermore, by using scientific methodologies it was possible to deepen the knowledge on the constituent materials, and to identify a further pictorial phase which is placed chronologically between the 2nd (present on the back wall and on the right wall of Room E) and the 3rd one (visible on the back wall and on the right wall in the form of traces, the latter not removed during a previous restoration). The scientific approach has completed the theoretical approach, based on the observation of artifact and on the study of documentary sources, in some uncertain or incomplete aspects. The previous interventions were studied and evaluated, in particular as regards the materials and methodologies adopted, the objectives and the choices made. The objective of the restoration was the recovery of the artwork, a palimpsest resulting from a series of modernizations carried out in antiquity, whose levels and iconography had been partly eliminated in the first intervention following the discovery and partly hidden in the last, and the conservation history of the artefact.

The intervention did not follow a pre-established line, but saw the selection of appropriate methods and the calibration of the procedures and materials chosen according to the context and the area gradually to be treated.

As investigation methods, a preliminary ultraviolet fluorescence photography was made in order to evaluate the conservation status and the restoration materials. Pigments were investigated through portable X-ray fluorescence spectrometer (p-XRF) with some focus by µ-Raman spectroscopy.

Further investigation was performed by cross-section analysis under polarizing microscope and scanning electron microscopy coupled with energy dispersive spectroscopy (SEM-EDS).

At last, Fourier transform infrared spectroscopy was applied to study binders and possible degradation materials.

The analysis revealed the presence of traditional pigments used in Roman wall paintings, such as ochres, earths and Egyptian blue, but also of some pigments used in previous restoration containing titanium and chromium.

Between the most interesting results, the analysis revealed the presence of a probable degradation compound containing arsenic, copper, lead and vanadium, elements revealed by SEM-EDS in samples where a green-yellow alteration was mapped on the wall painting. In these samples, µ-Raman spectroscopy detected calcium oxalates but also a copper arsenate, probable conichalcite, whose presence on the wall paintings is quite difficult to explain. Different hypotheses are proposed on the base of the scarce examples found in the literature and of the previous treatments carried out on the wall paintings as reported in the archive documents.

This result is highly relevant from an analytical point of view and in relation to the restoration decisions. In fact, the green-yellow areas on the wall paintings, appearing as irregular stains are difficult to understand and a decision should have been made if removing or leaving them.

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Combining geophysical measurements, remote sensing techniques and satellite images to protect cultural heritage in a sandy beach environment

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Coastal erosion is a phenomenon of key importance to the Maltese Islands as the coast is one of the most intensely used and visited areas. Since sandy beach systems occupy a small portion of the entire coastline, pocket beaches play a key role both from an environmental and touristic point of view. In several cases, cultural heritage is found in the vicinity or within the pocket beaches. This is the case for the Roman villa site located in Ramla (Gozo). Archaeological remains founded indicate that human activity in the bay and its environs has been ongoing since antiquity. During Roman times the bay was used as a place for anchorage and sea-faring as evidenced by the Roman anchor found offshore (Epsilon, 2014).
The site was extensively excavated in 1911 and fully documented (Mifsud 2021 and reference therein). However, for some aspects, the knowledge of this site remains generic and partial and certainly, it deserves more attention. Nevertheless, this archaeological site, besides being protected by the dune, is constantly exposed to the threat of coastal erosion. In fact, over the last decades remains of the roman villa have been exposed by natural actions (e.g. sea waves, wind etc); Mifsud (2021) reports that in 2010 an alignment of ashlar blocks was exposed and visible on the beach following a large storm hitting the Islands.
Research and development in the downstream Earth Observation (EO) sector is key to achieving reliable and cost-effective monitoring of coastal erosion, and within the project SIPOBED, we aim to use Persistent Scatterer Interferometry (PSI) to provide detailed estimates of sediment variations through time at the selected site. These estimates will be validated through measurements taken by the means of in-situ sensors. In addition, high-resolution Digital Elevation Models of all study areas will be acquired using LIDAR-equipped drones both for the submerged and the terrestrial part of the investigated area. A preliminary detailed digital elevation model of this pocket beach environment has been derived by Colica et al. (2018). Data are integrated within a GIS system (with the possibility of extending the approach to a Web-GIS) to provide a tool, freely available, to potential stakeholders. The system could serve also as a key element for the planning of risk mitigation activities and conservation purposes.

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Artificial weathering and consolidation techniques of some Central Italy building stones

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Degradation affects all stone monuments and artifacts, although the effects vary with the lithotype involved, as well as with the exposure to atmospheric agents, the climatic conditions, the urban/industrial pollution and the natural hazards. In the future, also climatic change will contribute negatively to increasing degradation problems in the cultural heritage, calling for actions to restore or prevent damages.
In the frame of a research relative to the stone restoration of monuments damaged due to Central Italy 2016 seismic events, in particular in this work the alteration process has been studied, occurring to a series of lithotypes used as construction and ornamental materials, commonly found in Central Italy historic buildings: sedimentary rocks of Umbria-Marche series like travertine, limestones and sandstones, volcanic rocks like tuffs from Mt. Vulsini and Alban Hills, Carrara marble to be used as reference. The aim of the work is to provide a database of information useful for the evaluation of the rock behaviour in highly alteration conditions for different lithotypes to be then tested with consolidation products.
The rock samples have been preliminarily evaluated by optical microscopy, X-ray Diffraction and by physical tests aimed at determining mineral composition/texture, density, porosity, absorption by total immersion and by capillarity, durability. All samples have been artificially weathered by heating them at 400°C for an hour [1], then the tests have been repeated to evaluate the effects of the artificial weathering on the samples. The results of these tests have demonstrated how the artificial weathering allows to simulate in the laboratory an accelerated alteration, showing that affected strongly the porosity and permeability of all the lithotypes, although to different extents depending on the rock type.
Different inorganic consolidants (such as ethyl silicate, nanosilica, limewater, diammonium phosphate and ammonium oxalate) have been chosen and tested by treating the surface of the lithotypes with the aim to verify the effects of the consolidation treatments. The effects of the consolidation, evaluated by observations under the petrographic microscope and electron scanning microscope, have been compared. The capillarity absorption tests have been carried out to enlighten the possible permeability variations after the consolidation, to be compared to the natural samples.
Surficial color changes occur after the thermal treatment and after the consolidation treatments and were measured by a spectrophotometer. Undesired color variations have been detected in some samples treated with a poultice of ammonium oxalate for 72 h or with pure nanosilica (30%): this problem has been solved reducing the poultice time and diluting nanosilica after carrying out some preliminary tests. Nanosilica precipitates if applied on a surface containing salts, therefore, depending on the lithotype, a correct procedure of salts extraction should be performed before the consolidation.
All the consolidation treatments have contributed to decrease the surface permeability, especially using ethyl silicate, which determines however a high surficial hydrophobicity. Diammonium phosphate has provided the best results since it does not cause hydrophobicity and the color variation has resulted acceptable. Also, the testing has suggested that ethyl silicate could be successfully substituted in some cases by diammonium phosphate with advantages about the sustainability of the restoration process and the safeguarding of operators' health.

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The Byzantine wall mosaics of the First Church of San Nicolò del Lido (11th c. AD). Characterization of mortars, pigmented *sinopia* and stone *tesserae*

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This paper reports a step-by-step investigation of the making method and materials of the wall mosaic of the First Church of San Nicolò del Lido in Venice (11th cent. AD), recovered in a fragmentary state in the collapse debris of the medieval building during 1980s excavation activities (Tombolani 1983).
A recent collaboration between the Italian Ministry of Culture - Soprintendenza ABAP for Venice and Lagoon and IVBC (Veneto Institute for Cultural Heritage) with the scientific collaboration of the Department of Cultural Heritage of the University of Padua targeted at the restoration and reconstruction of the fragmented mosaic for conservation, musealization and divulgation purposes. The results reported in the present work of the archaeometric analyses on the preparatory mortars, on the pigments constituting the *sinopia* underlaying the mosaic, and on the stone *tesserae* were therefore useful for defining the state of preservation of the artifact.
The analyses were carried out at the laboratories of the University of Padua adopting a multi-analytical approach, that integrates Polarized Light Microscopy on thin sections (PLM), X-Ray Powder Diffraction Analysis (XRPD) and Scanning Electron Microscopy with Energy Dispersive System (SEM-EDS) for a detailed characterization of the composition and provenance of raw materials and evaluation of the overall mosaic's executive technology.
Several features indicate that the artifact was produced by high experienced crafts paying great attention to details, as in high-quality Middle Byzantine mosaic production.

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Sodium Alginate and Konjac Glucomannan gels for cleaning smooth and rough musical instruments' wooden surfaces

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The cleaning of wooden artifacts can be challenging due to peculiar roughness of the surface and/or finishing treatments which favour the deposition of dirt and contaminants [1]. The most common cleaning system used by conservators is agar gel, characterized by its rigidity and brittleness, which challenges the cleaning of rough and irregular surfaces typical of most wooden artifacts. In this work, Alginate crosslinked with calcium (CA) and Konjac Glucomannan crosslinked with borax (KGB) gels (Figure 1) were proposed to solve this issue [2,3]. They were prepared and applied to smooth- and rough-surfaced soiled and sweated mock-ups, to (i) understanding the mechanical properties (i.e., tensile strength, hardness, and elasticity) of CA and KGB gels, as well as their stability over 60-day storage time, and (ii) providing a detailed analytical evaluation at the microscale level of their cleaning efficacy.
The mechanical properties of the two gels were evaluated by a texture analyser, while cleaning efficacy was analytically evaluated by non-invasive X-Ray Fluorescence (XRF) mapping and profilometric investigation. Compared with the rigid agar gel, CA gel appeared to have a higher tensile strength and elongation at break. KGB gel was shown to be soft and resilient, indicating its suitability for cleaning rough surfaces. After repeating the cleaning application 3 times on the rough-surfaced mock-ups, both the CA and KGB gels were shown to have cleaning efficacy.

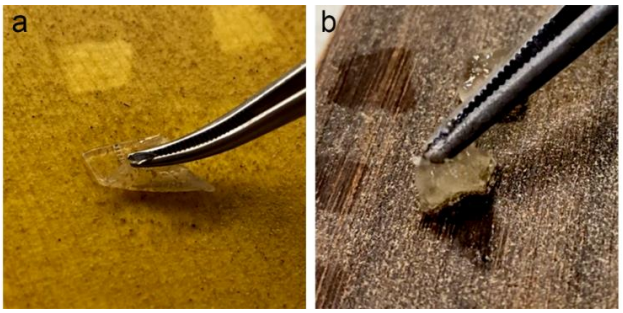

Figure 1. Images of cleaning applications of (a) CA gel on the soiled-WM and (b) KGB gel on the soiled-EAM surface.

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The funerary monument of Francesco Campitelli, Earl of Melissa (KR- Italy)

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On 27 January 1624, after the death of Annibale Campitelli, his twenty-eight-year-old younger brother Francesco, knight of San Giacomo, took over as earl of Melissa and prince of Strongoli. Francesco Campitelli, the new earl of Melissa, exercised his power over the territory for forty-four years and, he did not enjoy an excellent reputation.
This study, in addition to knowing the history of Earl Francesco Campitelli, was aimed at characterizing the artistic and material aspects of his funerary monument constituted by two different portion: the emblem and the sarcophagus with the earl's statue. The artifact that commemorates the earl, preserved for many years in the Church of San Giacomo Apostolo di Melissa (KR), is currently kept in the restoration laboratories of the University of Calabria in order to undergo restoration work. The monument, which probably suffered a *damnatio memoriae* in an unspecified time, is extremely fragmentary. The analysis of the fragments made it possible to distinguish two different types of natural stone. The emblem above the funerary monument is made up of white marble; the sarcophagus with the human-sized representation of the earl is made of a white-cream colored marble breccia.
The characterization of three white marble samples coming from the emblem, was carried out to determine their provenance. The samples were analyzed by means of two different methodologies: polarized optical microscopy (POM); and the electron probe micro analyzer coupled with an energy dispersive spectrometer (EPMA-EDS). The results provided important information about the emblem suggesting that we can hypothesize a possible Carrara provenance.

The funeral monument of Francesco Scarlato (1898). Diagnostic investigations for knowledge and restoration.

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The sandstone funeral monument of Francesco Scarlato from 1898, belonging to the Calabrian master stonemason, is located in the Cemetery of the Municipality of Fuscaldo (CS).
The diagnostic investigations carried out on samples taken in situ, have allowed us to deepen the knowledge of the local quarries and the conservation of the sandstone in an outdoor environment. It was also possible to test in situ a product, recently introduced on the market, with protective and consolidating properties.
In order to obtain a complete picture of the peculiarities of the monument from a historical-artistic and conservation point of view, as well as an in-depth study of the written archive sources and those inherent to the oral tradition, a diagnostic-cognitive campaign was carried out, useful for the characterization of the constituent material and for the study of the phenomena of alteration and degradation present on the surfaces.
In the wide range of preliminary investigations for the design of a conservation intervention with products with protective and consolidating properties, colorimetric measurements (NorMaL 43/93), peeling test (ASTM D 3359-08), water absorption measurements by capillarity (UNI EN 15801:2010) and contact angle measurements (NorMaL 33/89) were conducted on quarry specimens. The comparison between the results obtained on treated and untreated specimens allowed, after appropriate evaluations, to apply the product in situ. The experimentation on the original monument was carried out with the aim of evaluating the behavior of Siox-5 RE50 in a context of real exposure and not only in the laboratory, and evaluating its effectiveness and performance properties in situ. This experimentation requires longer times to determine the long-term effects of Siox-5 RE50 and evaluate its application on the entire monument. The research represents a first approach to the study of a protective and consolidating product that has not yet been tested and has recently been placed on the market for the treatment of outdoor sandstone monuments.
The encouraging results recorded during this study demonstrate the effectiveness of Siox-5 RE50 and encourage the continuation and deepening of research with the aim of making the tested product a valid alternative to the systems usually applied in the treatment of monument surfaces made of sandstone in an outdoor environment.

Diagnostics applied to archaeological cultural heritage. The mosaics of the Roman Villa of Palazzi di Casignana (RC).

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The Palazzi di Casignana site is currently one of the most important and interesting examples of a large extra-urban villa in Roman Calabria. Located along State Road 106, 15 km south of Locri, between the towns of Bianco and Bovalino, in the area called Palazzi, it dates back to a period between the 1st and 4th century AD and it occupies an area of about 15 hectares.
The villa of Casignana contains the largest nucleus of mosaics known up to now in Roman Calabria. The villa is characterized by over 50 rooms that include both residential and thermal areas. Specifically, 25 of them occupy an area of about 500 m^2 and are characterized by some magnificent mosaic floor decorations with both geometric and figurative motifs. The oldest ones date back to the 3rd century AD and are mainly made with large green and white tesserae, while the more recent ones were made with smaller tesserae and can be dated back to the 4th century AD.
The diagnostic investigations and the restoration operations were carried on two detached fragments belonging to the same floor level, removed from the original site and kept in the deposits of the Municipality of Casignana. The two mosaic fragments are part of the Southern nucleus of the residential complex, in the Eastern area of the villa, now located between the railway and the S.S. 106. The excavation that took place in 1999 allowed the discovery of six small rooms, three of which were cut by the passage of the road. The mosaic fragments, dating back to the 3rd century AD, belong to the N environment, are polychrome and were made in *opus tessellatum*, and with large white and green tesserae. The decoration consists of bell-shaped flowers enclosed within circles and surrounded by a large green frame.
In order to carry out the diagnostic analyses and the conservation operations, the fragments were transported to the Restoration Laboratory of the Department of Biology, Ecology and Earth Sciences (DIBEST) of the University of Calabria (CS).
The diagnostic investigations were aimed at both characterizing the original mortar and to determine the petrographic characteristics of stone materials of the mosaic tesserae. The results were used in order to create, during the restoration phase, a new mortar as similar as possible to the original. On the contrary, the determination of provenance of stone tesserae helped to reconstruct the ancient trade routes of the Mediterranean Sea, which has always been a crossroads of peoples and cultures.
In order to be able to determine the characteristics of the original mortar and to create another one as similar as possible to it, a comparison was made between the results of the analyses carried out both on the mortar samples taken from the back of the mosaic and on the samples made in the laboratory. The results showed that the original mortar was composed (as reported by the chemical investigation carried out and established by the UNI EN 159-1:200 standard) by "properly hydraulic lime (NHL 3.5)" and by silica sand of variable grain size ranging from 2 mm to 0.06 mm. As for the mosaic tesserae: the green tesserae are very similar to each other. They are classified as micritic mud according to Folk (1959, 1962) and mudstone according to Dunham (1962). Instead, the white marbles show different petrographic features. On the basis of the MGS measurements and the SEM-EDS analyses of accessory phases, the marble tesserae indicate a Greek provenance from Proconnesus and Ikarian quarries.
The restoration work carried out on the two mosaic fragments included all the operations aimed at the conservation and the creation of a new support with the aim to expose them in a museum.
In view of the diagnostic results, the archaeological site of Casignana (RC) is not only a cultural asset to be protected, but a resource in which to invest for an economic return that can help the territorial development of Calabria. The historical and artistic value of archaeological sites such as Casignana underlines how archeology, diagnostics and restoration are in close and constant connection since the moment of discovery in order for archeological findings to be better known and to be displayed in museums.

CRIMAC_UNALTERABLE PROJECT: New generation coatings to prevent fouling of underwater cultural heritage

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Abstract: Since the in situ preservation of submerged Cultural Heritage (CH) must be the first option, the aim of the CRIMAC_UNALTERABLE project is to design and test new antifouling/coatings to apply on stone materials of different nature (i.e. marble, limestone, mortar, etc.) to protect stone surfaces from micro- and macro-foulers. In this context, a new generation of antifouling coatings based on Ionic liquids (ILs) technology is proposed. At this aim, coating surface active-ILs (SA-ILs), already tested in terrestrial trials have been selected and applied in combination with different nano silica consolidants (Nano Estel, ESTEL 1000 and TEOS). We report here the results of tests obtained during the first step of the project performed on both limestone and marble probes, and in particular: a) coatings characterization by colorimetric, contact angle and water absorption measurements; b) coatings durability by ageing tests in aerial and water environments. The results have shown that these coatings do not affect the original properties of the stones (aspect, degree of water absorption and hydrorepellency), they are quite stable on the stone surfaces. For this reason, stone probes (marbles and calcarenites) will be tested in marine environment up to 12 months and different analysis (microscopic, molecular and micrbiological) will be performed at regular intervals (0-1-6-12) for the evaluation of antifouling properties.

Keywords: SA-Ils-based antifouling coatings; submerged cultural heritage; biofoulers.

Living Sensors based on Sansevieria Cylindrica for Microclimate Monitoring in the Santuario della Beata Vergine dei Miracoli

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Indoor air quality and microclimatic conditions contribute to the degradation of the works of art [1]. Limits for air quality parameters and physical quantities of interest for microclimate, in order to assure the longest conservation of the works in time, have been widely suggested for museums [2]. In particular, temperature, humidity, illuminance, particulate matter and gaseous pollutants concentrations arouse interest in the context of the monitoring. The study here presented aimed at monitoring ambient conditions through the adoption of innovative green and mimetic sensors based on plants, in the *Santuario della Beata Vergine dei Miracoli* [3]. This sanctuary was built between the 15th e 17th centuries, following a miraculous event, in Saronno, a small town of northern Italy. It hosts works of art from some of the most renowed and influential artists of the time. Bernardo Luini decorated the apse and presbytery of the church with some masterpieces such as the *Marriage of the Virgin*, while the dome was entirely frescoed by Gaudenzio Ferrari. The sculptor Andrea da Corbetta carved the marvelous *Deposition* and *Last Supper*. Following the nature of the place, it is not easy to keep ambient conditions under control and to perform measurements, considering the large number of people involved in the sanctuary. Keeping in mind the importance that the visual impact of the ambient has on the worshipers, classical measurement systems cannot be adopted for monitoring the area. The developed device regards a living sensor based on Sansevieria cylindrica plant for measurements of radiations, both visible and UVA, which could affect paintings inside the sanctuary, thus they represent important parameters to be considered for preventive conservation of cultural heritage. The working principle of the sensor is based on the metabolic processes of plants and the activity of soil micro-organisms [4-5]. This solution goes beyond "classical" approaches such as microelectronic devices and silicon devices, having several advantages: low cost, biodegradable, eco-friendly, nontoxic and capable to reduce the CO_2 during the working phase by using photosynthesis processes. It is worth noting that this family of devices is able to operate without the adoption of batteries, by using its self-generating transduction property, and it is also mimetic. Thanks to this latter characteristic, the device is capable to avoid any form of visual pollution and, for this reason, the proposed solution is suitable for indoor and outdoor applications of historical and artistic interest. It is worth noting that several sensors have been applied, since October 2022, in the *Santuario della Beata Vergine dei Miracoli* with the aim to monitor the level of radiation with the objective to ensure that its value does not cause damage to the work of art in accordance with the legislation.

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The *Branciforti* embroidery at the *Palazzo dei Normanni* in Palermo: the ongoing conservative activities and the investigations to characterize the original materials and past restoration

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The *Branciforti* embroidery is a textile artwork from the first half of the 17th century of Sicilian manufacture and owned by the Sicilian Regional Assembly, preserved and exhibited, before the restoration, in the *Torre Pisana* inside the *Sala della Presidenza* at *Palazzo dei Normanni*, also known as the Royal Palace in Palermo. The large work of art (cm 365 × cm 400) is a rich embroidery performed on in relief levels with polychrome silk yarns and gilded metallic yarns on a very damaged and incomplete silver canvas. The textile artwork is made with eight bands as pilasters, executed on a design from a single underdrawing on cartoon,
albeit with some differences. In the last century, the *lacunae* were the subject of a harmful intervention with the use of vinyl glue and the repainting of part of decorations. In recent months, the large embroidery has been involved in the first stages of a delicate restoration necessary to solve conservation and aesthetic problems. The complexity of this artwork, the dimensions, the overlapping of previous restorations and the specific features of current intervention make it an interesting case study which needed to an extensive diagnostic campaign. The scientific investigations were therefore aimed to document the conservation layer, to characterize the original materials and artistic technique and to identify the materials added during past restorations. Initially, visible fluorescence investigations induced by calibrated UV sources were performed for localize the different chromophores and the repaintings areas. Observations by digital optical microscope were carried out on selected areas to document the morphology and state of conservation of the original yarns of different colours, of the yarns with gilding metallic sheet and of the repaintings.

Then, a systematic chemical analysis was performed by X-Ray Fluorescence using a portable spectrometer aimed at identifying the inorganic chromophores on the restoration pictorial layers, metallic yarns and original yarns for a first analysis of extenders or mordants of lacquers or dyes organic. For the latter, Optical Fiber Spectral Reflectance Spectroscopy (FORS) measurements were carried out to identify the dyes and to verify the effectiveness of the conservative treatments through the comparison of the colorimetric data cquired before and after the cleaning tests. The FT-IR analysis allowed to characterize the adhesive used for the application of the background fabric applied in the past, providing useful indications to guide the laser cleaning. The XRF and FTIR investigations, allowed respectively to identified the titanium white in the pictorial repaintings and a polyvinyl acetate-based glue, providing clear indications on the last intervention which heavily modified the basic structure of the embroidery. Finally, a sample with metal foil was analysed by SEM-EDS for morphological and compositional characterization, verifying the use of a thin sheet (˜ 7 µm × ˜ 500 µm), twisted on the textile fibers, in silver and copper with low lead content, with external gilding.

Acknowledge: The Authors would like to thank the Sicilian Regional Assembly, owner of the Branciforte embroidery, for authorizing the publication of the preliminary results of the ongoing restoration and the data of the diagnostic study.

DIGITALIZZAZIONE 3D E NUOVI LINGUAGGI DELLA RAPPRESENTAZIONE DEL PATRIMONIO CULTURALE

ORALI: D&N-O

POSTER: D&N-P

Macro-3D multiband computational imaging applied to the study of materiality of Egyptian papyri

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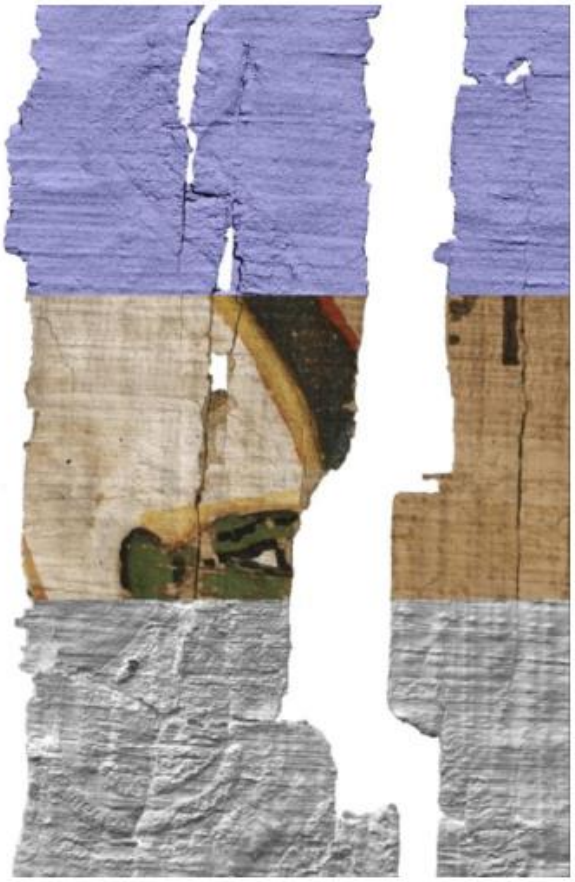
Historical documents such as those written on paper, papyrus or parchment are most often digitized in high resolution to ensure their effective documentation for the future and to enhance and facilitate their readability. Being quasi-planar artifacts, they are rarely scanned threedimensionally for the purpose of magnifying textural details or highlighting conservation problems. This paper aims to propose an unconventional approach to multi-band 3D surveying at ultra-close range of documents where flatness and depth of field represent the main technical-operational challenges. The conservation intervention of six papyri belonging to the collection of the Museo Egizio of Turin (Italy) was an interesting opportunity to adopt this workflow. In addition to the usual multiband 2D imaging set (UV-VisNIR-VIL), two approaches were used to derive morphometric information: RGB and VIL Structure from Motion on motorized x-y-axes and Reflectance Transform Imaging (RTI). While VIL provided the immediate distribution of Egyptian blue brush strokes, macro-SfM and RTI allowed us to appreciate the textural qualities of the supports, pictorial film, and quantify surface losses with a micrometric level of detail. The results allow restorers to perform a precise intervention giving also a knowledge on the materiality of such fragile materials which is hardly documentable since they are stored in mounts, made from two pieces of glass taped around the edges.



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An engraved prehistoric cup from Filicudi, Aeolian Islands: study and fruition through combined surveys and digital media

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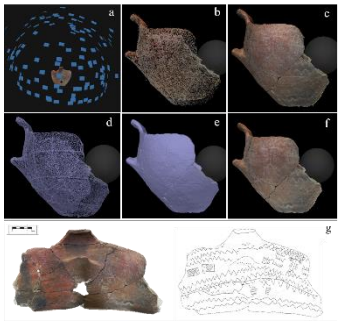
This work shows a multi-disciplinary study carried out on an interesting engraved prehistoric cup, found in 2009 during the excavation of the settlement of Filo Braccio in Filicudi (Aeolian Islands) now displayed in the Regional Museum of Lipari. The artifact looks singular against the backdrop of the pottery classes characterizing the contemporary 'Capo Graziano facies' (2nd millennium BC) [1,2] and its interpretation is still a conundrum. With the dual aim to help the archaeological studies out and create digital media for visitors, we performed a combined survey using 3D photogrammetry and multispectral imaging [3, 4]. The result consists of a three-dimensional model with very high spatial resolution and metric accuracy, which can be browsed according to the user's levels of interest. For instance, it can allow scholars to analyze the artifact for the purposes of technological, metric and interpretative study, as well as make proposals for restoration, digital integration of the missing parts and 3D prints. The final textured model, properly decimated for web-visualization, was uploaded into a web-based platform (Sketchfab) for 3D and AR visualization and enriched with interactive data: http://wwgis.ipcf.cnr.it/modelli3d/tazza-filicudi.php. The realization of the 3D survey also proved to be useful for aiding the global reading and the interpretation of the marks engraved along the external body of the cup: in fact, thanks to the planar projection and the digitization of the marks engraved along the outer surface of the cup it was possible to better appreciate the organization of the "scene", which seems to be characterized by a horizontal development on three superimposed levels. Moreover, we are also working to integrate the multispectral imaging data. In conclusion, the work therefore made it possible to obtain a digital dataset that goes beyond the mere representation of the artifact but itself is an analysis tool aimed at improving the understanding of the find and generating new knowledge.



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3D morphometric analysis to trace surface depletion in ground stone tools replicative usage

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A quantitative approach to use-wear analysis is the "dream achievement" for all traceologists, consequently long is the legacy of scholars engaged in this challenge (Macdonald et al. 2018). Over the decades, the technological upgrading of different imaging devices like microscopy (3D digital microscopy, Confocal, AFM and FEG-SEM), photogrammetry/3D scanners, micro-topographical scanning – by using white light and/or laser scanners –, ending with typical tribological tool allowed by profilometry, granted far more detailed capturing of micro-to-submicron-scale surface texture. However, this escalation mostly interested the flaked assemblages, and only few attempts were applied to ground stone tools (GSTs) (de la Torre et al. 2013; Caruana et al. 2014; Benito-Calvo et al. 2018; Zupancich et al. 2019; Paixão et al. 2022).

Of great support for the comprehension of tools' function(s) are the analytical techniques that allowed a 3-dimensional visualization of the samples. Our analytical procedure was designed and tested on slabs and pebbles to replicate the use-wear traces observed on Upper Palaeolithic ground stone tools, with the intention of building a site-specific reference collection, tailored on the artifacts from the Aurignacian level (cultural level III) of the Brînzeni I cave (north-west Moldova) (Allsworth-Jones et al. 2018). The experimental replicas were used to treat plants starch-rich storage organs (USO and ASO, namely under and above surface storage organs) selected among the flora resources attested across the Pontic steppe during the Marine Isotopic Stage 3. The data were acquired during lab-controlled sequential experiments using pebbles and slabs – purposely collected along the Racovăț river flowing just beneath Brînzeni I cave – to process rhizomes, tubers, seeds and nuts.

Here we focus on the macro-scale data acquired with photogrammetric techniques at different stages of the replicative usage. Different acquisition setup and elaboration were tested to measure the progression of the depletion of the surface, also demonstrating common errors in 3D data acquisition, elaboration and analysis.

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An *OpenAIAr* project: X-ray micro-tomography for the investigation of roman glass sherds from Aquileia (UD)

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In the framework of the OpenAIAr project [1], investigation on some ancient Roman glass fragments through micro-tomographic analysis was conducted at the laboratory of the Physics Department of the University of Torino and INFN. X-ray Computed Tomography (CT) is a non-invasive technique already successfully applied to study and analyse the internal structures and features of different types of cultural artefacts, thus obtaining information on the composition, the manufacturing techniques, and the state of conservation [2,3]. The high heterogeneity of the constituent materials, the shapes and sizes of cultural heritage objects need specific experimental set-ups that have been developed and optimized over time. In this work, due to the dimension of the investigated samples and the high-resolution needed for the project aims, a micro-CT setup specifically designed and developed for the analysis of Cultural Heritage materials was employed [4]. The final aim was to explore, in a non-invasive manner, the 3D inner structure and material differences of ancient glass fragments coming from the archaeological site of Aquileia (UD). Both degraded and decorated glass samples were analysed, for a total of 12 samples; all of them were fully scanned by laboratory μCT. For some of the degraded samples affected by diffused 3D cracking, further analyses through synchrotron phase-contrast μCT were conducted. μCT scanning allowed to visualize the cracks of the degraded sherds in the reconstructed volume and to appreciate their internal structure and size. Several cracks totally filled with mineralized material, possibly coming from the soil in which the object was buried for centuries, extend into the bulk below the glass surface as visible. Furthermore, it was possible to observe the distribution of the material filling the fractures: soil grains were clearly distinguishable, as well as the areas into the cracks where air is present. About the decorated samples, some interesting information about the manufacturing and decoration techniques were obtained, as the use of different type of coloured glasses. Furthermore, additional radiopaque micrometric particles were found inside the glass bulk, which can be associated to precipitated colorant or opacifier used. The results obtained from this project confirm high-resolution μCT as a valuable technique to investigate archaeological glass objects in a completely non-invasive way, supporting restoration interventions and conservation treatments.

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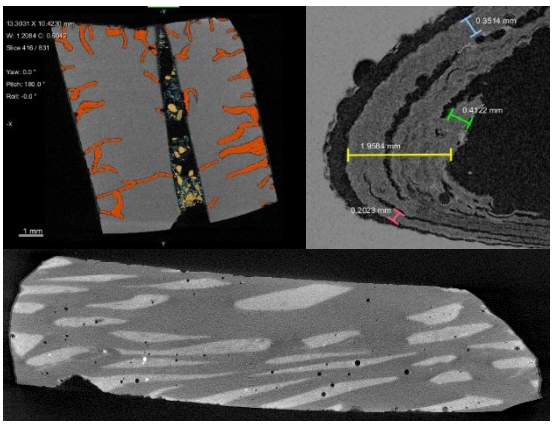

Tomographic slices of altered and decorated glasses

Application of Dimensional X-ray Tomography principles to the study of Cultural Heritage

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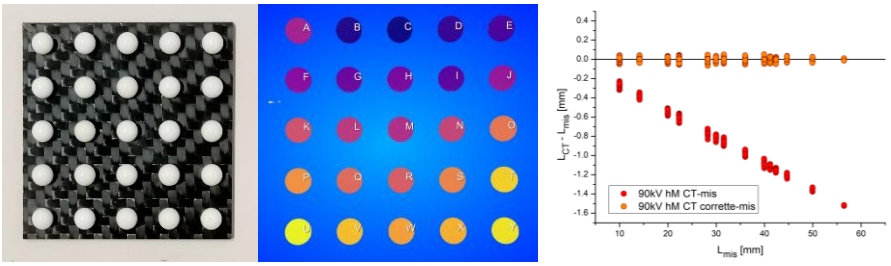
Computed Tomography (CT) is a non-destructive technique based on X-rays that allows to obtain information on the internal structure of the analysed object without the need to take samples. CT is nowadays used in the Cultural Heritage field, because of the necessity of non-invasive techniques for the investigation of archaeological and historical artefacts, maintaining so their integrity [1]. CT allows the visualization and study of the inner features and characteristics of different kind of objects based on the field of application. Since CT data contain complete volumetric information about the measured part, it is possible, after the reconstruction of the two-dimensional projection images, to perform dimensional measurements of external and internal structures and provide accurate dimensional and geometrical information. This is why in industrial applications, CT is often used for quality control, in order to reveal defects in the manufacturing and also measurements of components containing hard-to-access internal micro structures. To achieve this objective, it is necessary to evaluate and analyse different aspects concerning a tomographic measurement, also through the use of standard reference objects.

This type of analysis approach is increasingly used in industry [2], but it is rarely applied to Cultural Heritage because in most of the cases, the need is the qualitative investigation of artefacts structure. However in some applications a quantitative evaluation of some features through dimensional CT measurements is a very important issue. This is the case with wind musical instruments in order to get playable 3D printing replicas with acceptable tolerance respect to the original artefacts. In particular, in our work, woodwind musical instruments dated towards the end of the 18th century are studied [3]. For these reasons, the principles of industrial dimensional CT analysis were adopted, i.e., the characterization of CT parameters during the acquisition and the reconstruction phases is performed thanks to the use of calibration objects [3], like ball bars (often used for metrological aims), to assess the reproducibility of measurements in terms of dimensions.



CT calibration object (ball plate) and correction factor calculation

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Multispectral 3D models for monitoring in conservation of wooden statues

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Digitalization techniques, such as photogrammetry, are attracting the interest of experts in the field of cultural heritage. Photogrammetry allows the creation of three-dimensional virtual replicas of historical artefacts acquiring data about the overall appearance of an item, its geometry, and texture by using 2D digital images.
Among several image-based techniques exploited for the conservation of artefacts, multispectral imaging (MSI) is useful for the non-invasive investigation of the materials employed for the creation of historical items. MSI finds great application in the study of pigments, binders, varnishes, and other materials since it may aid their characterization by taking advantage of their different response when exposed to specific wavelengths of the electromagnetic spectrum [1].
Nevertheless, MSI techniques are traditionally applied only at a 2D level photogrammetry.
Despite the combination of geometric and radiometric information in a 3D model could represent a powerful tool in the field of conservation of cultural heritage, MSI techniques and photogrammetry are often used as separate tools.
The possibility of integrating data coming from MSI and photogrammetry can notably expand the information carried by a 3D model. 3D models can represent virtual documentation useful for study, preservation, and research aims, preventing the acquisition of incorrect dimensional and metrical data is of paramount importance. In spite of this, nowadays there is no unique way to assess the dimensional accuracy of 3D models in the Cultural Heritage field [2].
Therefore, this paper presents a metrological approach for the integration of geometrical and spatial information coming from photogrammetry and radiometric data of multispectral imaging in a unique 3D model. A novel research methodology and experimental setup, that enable the acquisition of multispectral 3D models, combining the outcomes of photogrammetry and multispectral imaging in a single coordinate system, is presented [3]. To verify its application in the cultural heritage field, this approach has been developed both on standards and case studies.
In particular, a multispectral imaging campaign and the creation of a 3D model have been exploited for the study of the state of preservation of a wooden sculpture belonging to the collection of the Museo di Arte Orientale (MAO) di Torino. The artefact is one of a group of seven Chinese Buddhas studied and restored at the Centro Conservazione e Restauro "La Venaria Reale".
The creation of a multispectral 3D model was performed to investigate the materials present on the surface, both the original ones and the ones applied in previous treatments, to provide information that could support the design of suitable conservation treatments.

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Data acquisition for *Nummi Digitali*, a project for the fruition of the numismatic collection preserved at the Salinas Museum in Palermo

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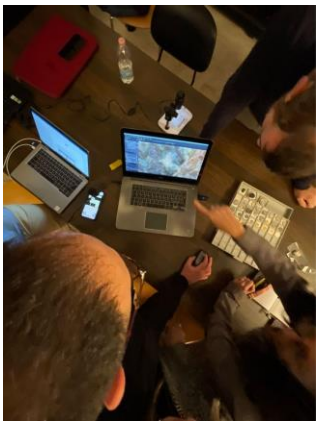
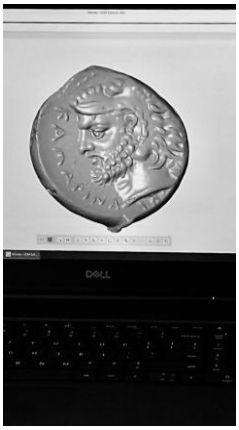
The poster shows the activities of digitization of numismatic collection preserved at the Regional Museum "A. Salinas" of Palermo, carried out as part of the ongoing project "Nummi Digitali" (PON "Research and Innovation 2014-2020). The latter is conceived and curated by Lavinia Sole, Numismatic Researcher of Culture e Società Department-University of Palermo, with the supervision of Chiara Portale (P.O. Classical Archaeology-University of Palermo) and Caterina Greco (director of the Archaeological Museum "A. Salinas" of Palermo) and with the technological coordination of Webgenesys S.p.A. The project goal is the full fruition of the rich medal collection of the Museum, counting about 50,000 numismatic items, through the creation of a digital database easily accessible and consultable by both scholars and the public. The database will be designed with a usable front-end where the user will be able to view the coin cards and the related high-resolution photographs and 3D model, thanks to points of interest that will allow access to specific hypertexts and multimedia contents.
Here we present the data acquisition and 3D modelling of the first 25 samples, acquired using a portable ultra-performing instrument: the Atos Q by GOM (Zeiss), mounted on a tripod and combined with the GOM ROT 350 rotation table [1]. The instrument is designed to acquire a detailed point cloud of small objects with very high resolution (point distance 0.04 -0.15 mm). The control software is able to turn the point cloud into a 3D mesh model. Since the instrument does not provide RGB values or textures, a photogrammetric image-base survey was also performed on the same samples, in order to acquire a coloured texture data and to generate a photorealistic model. The final 3D models are now being optimized in order to be embedded into the database and the project web page.



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Visible and UV RTI imaging system for Cultural Heritage

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Among photographic techniques applied to Cultural Heritage field [1], the Reflectance Transformation Imaging (RTI) has acquired a great importance in the last decades, especially thanks to the possibility of being applicable to a wide range of materials. The method is based on the acquisition of a set of images with a fixed camera and variable direction of light [2]. This computation photographic method highlights roughness, relief, and shape of the surface of an object exploiting the variation of light angles through a hemisphere. This way it is possible to capture the surface shape and colour of the artefact and enable interactive re-lighting of the object from any light direction. The variation of luminance of the surface is recorded by a per-pixel methodology, and therefore, it is possible to obtain an interactive model of the artefact itself. As a matter of facts, the way in which the light interacts with the object is very important because the features of the material, reflectance behaviour, and texture can give interesting information about the artefact production and conservation state.

In this work, a visible and UV RTI imaging system recently developed at Politenico di Torino is presented. The system is composed of a 3D-printed dome, equipped with a total of 36 LEDs, of which 18 white LEDs and 18 UV LEDs (365 nm) placed neatly along the arches of the dome. A fixed camera is placed on the top of the dome to acquire the images at different light angles. In order to have the exact position of the LEDs during the acquisition, a shiny black sphere has been used to extrapolate the location of the lights and to compensate for any LEDs misalignment. All the acquired images were processed with Polynomial Texture Mapping (PTM) [3] and Hemispherical Harmonics (HSH) [4] methods, calculating the luminance of each pixel in function of the light.

RTI Builder was the open source software employed for creating the RTI image, subsequently displayed with the RTI Viewer software.

The RTI developed system has been employed for the study of some Chinese bronze coins with the final aim to investigate the surface decorations and to achieve RTI virtual models where surface morphological details and spectral properties are interactively available.

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INTERAZIONE UOMO-AMBIENTE

ORALI: U&A-O

POSTER: U&A-P

Pre-Hispanic Stelae of the Archaeological Site of Oxpemul, Mexico: Material Characterization and Damage Assessment due to Climate Impact

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The present contribution is part of the research activities conducted in the framework of the H2020 MSCA RISE SCORE (Sustainable Conservation and REstoration of built cultural heritage) project and aims at study pre-Hispanic Stelae of the Oxpemul archaeological site, located in the Calakmul Biosphere Reserve (Mexico), which hasn't been thoroughly researched due to its difficult accessibility (Menéndez et al., 2022).
The primary goal is to characterise the materials constituting the Mayan stelae and to provide an evaluation of their state of conservation considering the particular environmental condition of the area. In order to determine the environmental context, a selection of the most appropriate monitoring stations (Escarcega, Dzibalchen, Nicholas Bravo, Shipyard, Villa Hermosa and Xpujil) near the site of interest, recording climate parameters of temperature, relative humidity, rainfall amount and wind speed have been selected and the relative 10-year data for the period 2011-2021 were collected and elaborated. Moreover, environmental data of temperature, relative humidity and PM10 were collected by performing a monitoring campaign directly at the site of Oxpemul between the years 2017 and 2022. The collected data were purposely elaborated in order to utilize the modified Lipfert's damage function for quantifying the surface recession imposed by the impact of rain, considering for the case under study the contribution of clean rain (L=18.8 R), being it located in a remote and non-polluted area. Regarding the material characterization, a sampling campaign was conducted at the archaeological site in 2017 and 18 samples were collected from the Mayan stelae, together with samples coming from 5 prehispanic quarries located at Oxpemul. A series of analyses were carried out for the mineralogical and petrographic characterization and damage assessment, among them Polarized Light Microscopy (PLM), X-Ray Powder Diffraction (XRPD) and, Scanning Electron Microscope (SEM). Results reveal that a systematic trend conveying higher temperatures during the wet seasons is observed in all the monitoring stations. Temperature and relative humidity data throughout the period of 10 years (2011-2021) show that their average doesn't have significant changes during the time and particular attention was also given to analyse climate parameters trends during the dry and wet seasons and wind speed variations over time, that could result in deposition of dust and consequent weathering of the building materials. Moreover, the most appropriate monitoring stations for the microclimatic evaluation of the Oxpemul case study turned out to be Villa Hermosa and Xpujil. Both stelae and quarry specimens have been classified as limestone with calcite, dolomite and quartz as main minerals present, and preliminary results reveal surface sulphation and biological degradation to be the major damage processes. Further analyses are in progress for better understanding the provenance of stone materials constituting the Mayan Stelae and the damage processes they undergo due to the impact of atmospheric forces.

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Assessment of the natural radioactivity content in pigments and estimation of radiological health risks

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As it is well known, characterization of pigments in historical, archaeological, and artistic sites, through the employment of complementary non- or, at least, micro-destructive methodologies, represents a fundamental source of information to give answers concerning open problems such as execution technique, dating, and provenance of cultural heritage objects [1-4]. Recently, the growing awareness of the radiological health risks due to the external exposure to ionizing radiations shifted the focus towards a relatively new aspect, poorly explored in the literature, concerning the characterization of pigments (embedded in building/constituent materials of both historical-artistic and modern structures) in terms of natural radioactivity content and, starting from it, the assessment of any radiological hazards upon indoor and outdoor exposure.
In this framework, the natural radioactivity content (^{226}Ra, ^{232}Th, and ^{40}K) in fifty samples of ten different typologies of pigments was successfully quantified through High Purity Germanium (HPGe) gamma spectrometry. In particular, the background levels of natural radioactivity in the analysed samples were properly estimated. Then, the radiological health risks assessment was achieved by estimating indexes developed over the years in order to evaluate the radiological risk related to ionizing radiation exposure.
It is worth of note that the knowledge of the aforementioned aspects not only could provide useful insights in the view of the development of a database on the natural radioactivity content in pigments, but also would support the optimization of methods and guidelines to be used for the evaluation of the radiological risk in a large variety of both old and modern pigmented materials.

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Acetic acid and cellulose acetate films: artificial ageing and preliminary risk assessment of climate-induced impact

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Most cellulose acetate film archives are affected by the vinegar syndrome (Bigourdan, *et al.*, 2000). This spontaneous and self-catalytic process leads to a rapid (i.e., in a few years) deterioration of film materials, which rate increases under unfavourable thermo-hygrometric storage conditions. Therefore, the actual problem facing archives is the preservation of collections that are not yet in acetic syndrome (or in its early stage), since films in advanced stages of decay are unrecoverable and can only be handled and digitised before their definite loss. This paper presents a study in laboratory in which the ageing of films in real storages has been reproduced in a climate chamber under different conditions of temperature (T), relative humidity (RH), and acetic acid concentration. Some laboratory tests have been conducted to investigate the state of conservation and deterioration before and after different ageing experiments. Subsequently, specific dose response functions (Fenech, *et al.*, 2013) (Menart, *et al.*, 2014) related to archival materials have been exploited for assessing the climate-induced risk predicted specifically for cellulose acetate films in an acetic acid polluted environment.
Selected samples of virgin cellulose acetate films were artificially aged in a climate chamber (i.e., with constant RH and variable T) with known concentrations of acetic acid (i.e., order of magnitude 10^1, 10^2, 10^3, 10^4 parts per billion). To qualitatively detect the presence of gaseous acidic compounds, Acid Detection (A-D) strips (developed and produced by the Image Permanence Institute - IPI) were used. Then, the state of conservation of the materials before and after the different ageing experiments was evaluated by means of non-destructive UV-visible spectrophotometry and contact surface pH measurement coupled with Fourier Transform InfraRed spectroscopy (FTIR), in order to quantify the degree of (de)polymerization of the cellulose.
The impact of different acetic acid concentrations under variable thermo-hygrometric conditions was estimated. The change in colorimetric features of the cellulose acetate films was measured by UV-visible spectrophotometry, while the chemical degradation was obtained in terms of the acidification (pH) of the material associated with the appearance of characteristic peaks of aldehyde and ketone compounds in the FTIR spectra as a consequence of cellulose hydrolysis. The results are expressed in terms of the retention percentage of the capacity to handle and display the film after artificial ageing. The life expectancy calculation method was deduced from existing dose-response functions applied to the experimental data obtained. These data reproduce real archival conditions, in which films in excellent condition and films suffering acetic syndrome (i.e., contaminating the surrounding atmosphere with acetic acid) are stored in the same space. Therefore, the research outcomes are useful for estimating life expectancy of cellulose acetate films in real case studies.

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How will climate change impact underwater stone heritage?

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The question posed in the title is what kick-started the European project WATERISKULT, funded under the Marie Skłodowska-Curie Actions, presented in this contribution in its early stage of implementation and experimentation (https://wateriskult.geoscienze.unipd.it). The project aims at filling the gap in heritage science research pertaining to the future vulnerability of underwater cultural assets, with most studies dealing so far on historical sites and landscapes on land. WATERISKULT wants to provide the first quantitative assessment of the decay and vulnerability of underwater archaeological materials in a changing climate by focusing on stone, one of the most important natural resources used all through human history and prehistory. The research approach is multidirectional, in terms of both the disciplines engaged (petrography, marine biology, oceanography, underwater archaeology, hydraulic engineering, and analytical chemistry) and the methods applied (in the field and in controlled laboratory conditions, involving simulations, field-exposure tests, sampling, analysis, and monitoring of archaeological materials). The key-factors of climate change under investigation include ocean acidification (with the concurrent action of sea level rise and ocean warming) and extreme weather events (cyclones and high-intensity currents). The findings about the future expected risk will be supported by the investigation of the actual decay observed underwater and its bond with the variability in material properties and environmental settings, choosing the Mediterranean Sea as pilot area. This contribution will present the first experimental steps with the material testing in the laboratory and the fieldwork during a first campaign of scuba dives in the Gulf of Naples in southern Italy, an area rich of archaeological and natural wonders.

Surveying a Roman mosaic during the fieldwork

in the underwater archaeological site of Baia, Italy

MATERIALI INNOVATIVI E NANOTECNOLOGIE PER I BENI CULTURALI

ORALI: M&N-O

POSTER: M&N-P

Innovative nanostructured materials for the preservation of stone substrates

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In the last two decades, several nanostructured materials have been developed and applied for the restoration and conservation of stone artefacts. Their particular properties make this class of compounds very interesting and useful, mainly in all the circumstances where the size of the materials needs to be controlled to achieve the best results and where the environmental parameters are crucial for the maintenance of a good conservation state.
Although their applicability has been demonstrated in various case studies, it is necessary to implement the number and kind of applications on different types of artefacts and environments in order to evaluate their performances.
In this presentation, some examples of development and application of nanostructured materials for the stone preventive conservation to some case studies are described. In detail:
- mesoporous silica as biocides or controlled release systems of biocides [1-2].
- nanoparticles dispersed in polymers layers [3,4].
In all cases, before and after the application, characterization measures have been performed on the artefacts to verify their action.

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

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Binding composites (mortars, plasters, concretes) constitute one of the most widespread material evidences of the technological advancement of ancient societies, being the structural core of heritage architecture since the Pre-Pottery Neolithic. According to the state-of-the-art scientific literature, most of ancient and modern binding systems are calcium-based, where the ionic form of the element in the reacted compounds is chemically bound either with simple divalent anionic molecules, such as carbonate in the case of aerial lime binders and sulphate in the case of gypsum binders, or with silica and alumina in pozzolanic and hydraulic systems, forming complex and stoichiometrically variable structural species such as calcium aluminosilicate and calcium aluminate hydrates (the so-called C-A-S-H and C-A-H phases).

Nevertheless, such marked homogeneity can be often perturbed in ancient binding systems, notoriously characterized by a poor chemical standardization of raw materials, with a consequent shift of reaction processes outside the conventional lime-silica-alumina ternary system if specific conditions of ionic activity within the reacting environment are satisfied. Amongst the various chemical elements commonly available in ancient binding composites apart from calcium and aluminosilicates, magnesium is likely the most relevant, deriving both from the binder itself, as in the case of magnesian limes, and from reactive fractions of several types of aggregates, both natural such as volcanic pozzolans, magnesian limestones and structurally disordered clays, and artificial such as crushed ceramics and combustion residues of organic materials. Furthermore, under a crystal-chemical perspective, the incorporation of magnesium within the structure of several anthropogenic binding products allows the formation of crystal phases that are structurally more stable with respect to the standard calcium-based counterparts, thanks to the lower ionic radius of magnesium allowing a more ordered octahedral coordination with oxygen ions.

This work reports a comprehensive review of several case studies where the chemical characteristics of ancient binding composites and reactive systems allowed a relevant incorporation of magnesium within the anthropogenic compounds. The influence of mix design will be tackled, with a particular focus on the employed binders and aggregates favouring a high magnesium activity, often in combination with specific enrichments of ionic and bacterial species in the fluid medium of composites, fostering peculiar reaction processes such as alkali-carbonate reactions or bio-mediated precipitation.

Furthermore, a comprehensive mineralogical and crystal-chemical characterization of the binding phases will be presented, with a particular focus on the determination of the degree of polymerization of para-pozzolanic magnesium aluminosilicate hydrates (M-A-S-H phases), thanks to a combined mineralogical-spectroscopic-microstructural analytical approach employing X-ray powder diffraction (XRPD), magic angle spinning nuclear magnetic resonance spectroscopy (MAS-NMR), Fourier-transform Infrared Spectroscopy (FTIR) and scanning electron microscopy coupled to energy-dispersive microanalysis (SEM-EDS).

Finally, the beneficial effect of magnesium incorporation within ancient binding composites will be tackled, in terms of increased mechanical properties and durability, shedding new light on the advanced technological knowledge of ancient craftsmen and giving valuable perspectives for the development of novel sustainable heritage-inspired building materials.

Evaluation of the applicability of non-toxic and eco-sustainable products for the conservation of pictorical surface

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The advances made in the methodological design for the evaluation of the applicability, compatibility, efficacy and risk regarding methodologies and treatments of non-toxic, ecological and sustainable cleaning in art restoration are presented. The study is based on assessing the incidence of cleaning in pictorial finishes. The objective is to replace or modify the methods and products of greater toxicity for the worker and the environment with others that are less toxic and more sustainable. Non-toxic and more sustainable materials being studied, applied and valued include cleaning methods with agar gels, sustainable chemistry products such as biogels and new ecofriendly solvents.
For these studies, paint specimens have been prepared, which have been subjected to a process of artificially aged dirtying and varnishing, according to standardized work, with the aim of generating a layer of material to be eliminated by chemical methods using the selected products. The specimens have been characterized previously and after the application of the cleaning treatment by means of microscopic techniques (stereoscopic microscopy, optical microscopy, SEM), spectroscopic (EDX, FTIR-ATR, RAMAN), chromatographic separation techniques, as well as measurements pH, conductivity, color coordinates and brightness. These techniques make it possible to assess the incidence of the treatment by observing the changes in texture and morphology of the pictorial surfaces, the study of the effectiveness of the treatment (level of cleaning reached), of its risk (possible removal of constituent materials -pigments and binders-), possible optical changes generated (variation in color and brightness), and determination of the possible generation of by-products or the permanence of residues.

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PROVENIENZA E DATAZIONE

ORALI: P&D-O

POSTER: P&D-P

The *Desana's Treasure*, Ostrogoths in north-western Italy

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The *Desana's treasure* owes its name to the small town near Vercelli in Italy, where it was discovered. It is a *unicum* in contextualizing the Ostrogothic presence in north-western Italy, and it encompasses a series of objects (gold, silver, gemstones) of both ornamental and daily use testifying to the permanence of this culture in the Po Valley. Archaeologists say that the huge amount of objects found in this single site and their high quality are the result of a long period of selection, accumulation and use. Objects that all testify to the evolution of goldsmith's art in Ostrogothic Italy and represent an extraordinary tangible trace of the interbreeding between barbarian and Roman peoples since the fifth century. Due to the importance and uniqueness of the objects, the *Desana's treasure* has been investigated in this study here with non-invasive instrumental analytical techniques, namely optical microscopy (MO), fibre-optic diffuse reflectance UV-visible spectrophotometry (FORS) and X-ray fluorescence (XRF) spectrometry for the determination of the chemical features of precious stones, coloured glasses and precious metals that make up these objects.

Ostrogothic fibula

This archaeometric research is part of an international project which investigates the migration routes of the barbarian people, correlating them to the supply routes of the gems and the precious stones used in the manufacture of jewellery. In particular, the study of garnets allowed us to typologically classify almandines based on their chemical composition and reflectance features.

In addition, the integration of the analytical data was determinant to formulate a robust hypothesis on the provenance of precious stones, that suggests India as a source for sapphires and most of the garnets, whereas the determination of the origin of emeralds is more complex, as they can be attributed to different sources including Pakistan, India and Egypt. The instrumental investigation allowed us to reveal the chromophores and some compositional features of the decorative glasses, and to determine the composition of the precious silver and gold alloys, offering an interesting overview also on daily use objects (i.e., spoons).

The presence of garnets throughout the Ostrogothic production proves to be pivotal for formulating hypotheses of trade relationships in the 5th - 6th century. In particular, this study highlighted compositional differences among the present jewels and coeval ones, recorded in the north of the Alps, revealing how the process of merging with the late Roman civilisation was occurring.

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Binder selection procedure of natural hydraulic mortars of Florentine historical buildings for radiocarbon dating

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The raw materials used for the preparation of mortars in historical buildings provide information on the supply areas, original recipes and ancient technologies allowing us, in some cases, to support the identification of construction phases. In the last years, from the pioneering studies of Labeyrie and Delibrias, (1964), the feasibility to absolute dating historical mortars has become a challenge. In principle, the datable carbon fraction is represented by the so-called anthropogenic calcite ($CaCO_3$), i.e. the carbonate binder resulting from the hardening of the slaked lime [$Ca(OH)_2$] that reacts with CO_2 from the atmosphere. The feasibility to date an aerial mortar by radiocarbon relies on the complete separation of the binder from all the aggregates. The aim of our research is to apply a binder selection procedure for the dating of historical mortars from the Florentine territory. The historical mortars in Florentine area were typically produced with natural hydraulic lime binders obtained by burning marly limestones (Alberese limestone, characterized by various percentage of clay minerals) (Cantisani et al., 2021). The setting and hardening occur both through carbonation of calcium hydroxide and through hydration of calcium silicates and calcium aluminates.

Our procedure for binder selection consists of: i) chemical, minero-petrographic characterization of mortar samples to identify the type of binder and aggregates; ii) mechanical separation of lumps or/and bulk samples and their characterization using non-destructive methods, to evaluate the origin of calcite and then to select the most suitable fraction to be dated; iii) extraction of the anthropogenic CO_2 by acid dissolution combined with Lilliput graphitization reactors (Fedi et al., 2020) and measurement of the radiocarbon concentrations by accelerator mass spectrometry (AMS).

To assess the feasibility of dating natural hydraulic mortar samples, our procedure has been applied on mortars from Castello del Trebbio, an important architectural Cultural Heritage in the surroundings of Florence (Italy). 27 mortar samples, belonging to different constructive phases, were analyzed with OM, XRPD, TGA, SEM-EDS in order to characterize binder and aggregates. On selected datable portion of binder and lumps OM-CL and ATR-FTIR were also applied to identify the origin of calcite (Calandra et al., 2022). Our procedure has allowed us to select suitable mortar samples, obtaining reliable dating results, comparable with the historical construction phases of the castle.

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The amber collection in the Lentini Museum

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The Archaeological Museum of Lentini has a collection of amber samples mostly from the necropolis of S. Eligio located on the Ciricò hill. The necropolis includes two types of tombs: a circular-shaped burial chamber, which is older, and an artificial cave tombe with an access hall and a quadrangular-shaped burial chamber. The use of the necropolis ranges from the Early Bronze Age to the Copper Age. The collection consists essentially of beads and pendants, forming part of the funerary set found in several tombs within which members probably belonging to the same family nucleus were interred.
Thanks to a collaboration between the Archaeological Heritage Park of Lentini and the University of Catania, an amber characterization study was undertaken aimed at solving problems concerning the origin and provenance of the artifacts constituting the collection. The identification of their geographical origin can provide useful archaeological information on past trade routes [1].
From a material point of view, amber is a fossil organic substance derived from the transformation of resin from different families of trees over a long period of time [2] resulting in different degrees of maturation [3].
Depending on geological conditions, the maturation process results in changes in the physicochemical nature of the resin at the time of burial leading to amber formation. Various amber deposits have been discovered around the world [2]. The most common type of amber in Europe is succinite, also known as "Baltic amber" because of its geographical origin [4]. Several amber deposits have also been found in Italy. Sicily is the source of rare amber, called simetite, because it is found along the Simeto River.
In this context, the main objective of this study is to identify the type of amber constituting the various artifacts and to distinguish any groups related to the burial objects of the different tombs and periods. On this occasion, preliminary results obtained from the in-situ application of Raman spectrometry and contact spectrophotometry for colour measurements are presented. Raman spectrometry measurements were carried out using a B&W Tek Inc. portable Raman spectrometer equipped with a 785-nm laser and a CCD detector.
Spectra were recorded with 2 s integration time. The laser output power was adjusted to maximise the signal-to-noise ratio and to minimise the integration time. The spectrophotometric measurements on the samples were conducted using a Konica Minolta CM-2600d spectrophotometer, selecting an area of 6 mm in diameter (Small Average Value, SAV). The results are related to the D65 illuminant and to the 10° observer. Scale adjustment was performed using the CM-A145 white calibration plate as a target for the maximum lightness and the device CM-A32 for the minimum lightness.
The experimental results that will be shown are meant to compare Raman and spectrophotometric spectra with the aim of discriminating the geographic origin of ambers. The study is still in progress, but the preliminary results are of high importance from a methodological point of view.

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Micro-PIXE and micro-IBIL characterization of lapis lazuli samples from Myanmar mines and implications for provenance studies

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Although the historical source for lapis lazuli used in antiquity is commonly known to be the Badakhshan Province (Afghanistan), other hypotheses have been suggested and their confirmation on a scientific basis could be pivoting for the reconstruction of ancient trade routes. In the last years, our group have proposed and successfully applied to lapis lazuli objects a protocol to identify the provenance of the source material by means of a micro-analytical non-invasive methodology [1]. The protocol is based on differences in the physicochemical properties measured with non-invasive techniques (Ion Beam Analysis (IBA)), making it suitable also for precious ancient artefacts. In particular, μ-PIXE (Proton Induced X-ray Emission) and μ-IBIL (Ion Beam Induced Luminescence) techniques are used to detect trace elements and characteristic luminescence of some rock-forming minerals in lapis lazuli, specifically diopside, wollastonite and pyrite.
To date, the protocol has included Afghan, Tajik, Siberian and Chilean provenances, but recently 12 new lapis lazuli rock samples were acquired in situ from the Mogok quarry (Myanmar). Prepared as petrographic thick sections (ca. 100 μm), they have been primarily characterized via petrographic and SEM-EDX analyses [2]. The samples have been now investigated with IBA and measurements were carried out on 43 diopside and 8 pyrite crystals. The analyses have been performed both in vacuum at INFN-LNL (Legnaro, Padova, Italy) with 2 MeV protons and with extracted beam at NewAGLAE (Paris, France) using 3 MeV protons.
Micro-IBA investigations allowed to determine similarities and differences of Myanmar samples with respect to other provenances and to compile an updated analytical protocol, proposed to include all five lapis lazuli origins [3]. Provenance markers such as presence/absence of wollastonite, altered pyrites and Sr content are still valid to discriminate the Myanmar lapis lazuli from Chilean or Siberian ones. New weaker markers (Zn content in diopside, Se and Cu contents in pyrite) are proposed for the discrimination of Myanmar from Afghan or Tajik provenances.
The new protocol is then applied to a lapis lazuli tessera retrieved near the royal tombs of Tanis (capital of the XXI Egyptian dynasty, I millennium BCE), attributing the origin of the source material to an Afghan provenance.

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New insights from recent archaeometric studies on the Church of Sant'Ambrogio at Montecorvino Rovella (Salerno, Italy)

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The church of Sant'Ambrogio alla Rienna in Montecorvino Rovella (SA) has been involved on archaeological excavations and specialistic studies for several decades which have led the publication of various multidisciplinary researches [1-3]. The complex had the function of an aristocratic private church, whose donors wanted to build a place of prayer placed under the aegis of the Virgin and of Saints extraneous to the region, but whose devotion derived from probable contacts with the Milanese culture and religiosity, more Carolingian than Lombard. The chronology of the site, until now essentially based on stylistic assessments relating to the apse wall paintings was the subject of a recent revision which takes into account historical-cultural and historical-artistic considerations and seem to point towards the middle of the 9th century CE. The latest excavation campaign interested the large quadrangular space (already discovered in 1992) in front of the façade occupied by a funerary structure almost contemporary with the church. This contribution describes the results of the recent campaign of scientific investigations carried out on terracotta fragments sampled from four structures: a layer of floor of the apse sealed between two layers of mortar and three tombs found in the external quadrangular area.

The investigations were aimed at dating by thermoluminescence (TL) on each of the four structures and at minero-petrographic characterization by means of a polarized-light optical microscopy. Within the measurement error, generated both by the composition of the aggregate and by the evaluation of the water content for the different structures characterized by different environmental exposure, ages obtained by the calculation of the Paleodose and the Annual Dose are compatible with the considerations based on architectural and historical-cultural and stylistic features concerning the wall paintings of the apse (9th century CE). Therefore, the hypothesized contextuality between the church and the avant-corps is also confirmed. Furthermore, the minero-petrographic analyses demonstrated a similarity between homologous parts of the tombs (walls of tombs T1 and T7; covering tiles of tombs T7 and T15), further supporting the simultaneity of construction and/or maintenance over time the use of the same raw materials and production techniques. Some textural differences concerning the occurrence of volcanic temper were found in the apse flooring sample compared to the characteristics identified for the tomb covering tiles. This evidence could suggest a different technological choice related to the function of the architectural element.

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Exploring the occupation of the Valley of Assam through Luminescence Dating: results from new findings from a paleo-channel of Dihing River

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Assam is a state in northeastern India along the Brahmaputra and Barak Rivers. During ages several human groups migrated from different places to Brahmaputra Valley of Assam. In 1228 AD Prince Sukāphā entered the Brahmaputra Valley with about nine thousand followers from the southeastern part of China, following the course of Dihing River; those people were later known as the Ahoms. When Prince Sukāphā entered the valley, only found some primitive tribal villages. However, there are some historical notes which indicate the presence of a stratified state in Dihing Valley before the entering of Sukāphā into Assam (Elias, 1876).

Recently, an important archaeological structure was unearthed on the bank of a palaeo-channel of Dihing River: a pre-Ahom brick temple with some granite stone sculptures. Interestingly, granite is not available in the entire Dihing Valley, and the nearest granite available source is far away from the temple. So, the temple builders should have the capacity to carry granite blocks from a long distance away, which indicates a well-organized group of people. There is a very old interesting folk song on migration of the Dihing River. According to that song, the River Dihing changed its course and created a devastating flood. It has been hypothesized that the flood has some relation with the destruction of the Ahom state.

The present study is aimed to identify the age of the lost civilization in Dihing Valley of Upper Assam, the cause of its decline, and the stage of technological development in Dihing Valley Civilization. It was done determining the age of the temple bricks and palaeo-channel sediments. Moreover, the age of the sediments is expected to throw a light on the history of palaeo-flood, which may be used as a tool for the study of climate changes through geological time.

The materials used for the manufacture of the bricks will be determined by using X-ray diffraction (XRD), Scanning Electron Microscopy (SEM) and Fourier Transform Infrared Spectroscopy (FTIR). From the data obtained from these experiments, we were able to get information on the stage of technical development among the inhabitants.

In this work the preliminary dating results obtained with Thermoluminescence (TL, Aitken, 1985) and Optically Stimulated Luminescence (OSL, Aitken, 1998) on the brick samples of the temple are reported. The measurements were performed on the polymineral fine-grain fraction (Zimmermann 1971) extracted from each brick; the Equivalent Dose (ED) values were evaluated through the Multiple Aliquots Added Dose (MAAD) procedure (Aitken 1985) for theTL measurements and the SAR (Single Aliquot Regenerative, Murray and Wintle 2000) protocol for the OSL ones.

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The impact of statistical analysis in OSL mortar dating

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The accuracy and precision of mortar dating are still debated issues. Research on mortar dating is based on the principle that it is a material ad hoc prepared for the building under construction. Indeed, the uniqueness of mortar lies in the fact that it is the only potentially non-recyclable masonry material. Furthermore, the hardening process of mortar is irreversible, so it is prepared in a time frame comparable to that of the structure being analysed. So far, mortar dating has been performed using two methods in parallel: Radiocarbon and Optically Stimulated Luminescence (OSL) [1].

Here, we would like to discuss the contributions of OSL to this research topic and the support of statistical studies to the results of this method.

The principle of OSL dating of mortars depends on the quartz grains bleaching of the sandy aggregate during the mixing and laying of the mortar in daylight. Therefore, OSL ages are highly dependent on the bleaching of the quartz [2]. Often the exposure of the sand to light is not sufficient to erase all the luminescence signal of the quartz grains. In this way the age obtained with OSL will be overestimated.

The supporting statistical analysis aims to improve the results previously pursued on mortars from two locations in Northern Italy: the ancient Roman theatre in Padua and the medieval Cannero's castle on a small island in Lake Maggiore. Indeed, the OSL ages previously obtained on these samples did not match the preliminary radiocarbon ages and the archaeological and historical context of these locations. [3]

The combination of various data analysis techniques was investigated, including (a) studying the distribution of EDs, (b) identifying exclusion criteria using different statistical indicators such as skewness, kurtosis, and (c) conducting statistical analysis by selecting the appropriate age model (descriptive statistics, Central Age Model, Minimum Age Model) [4–6].

Moreover, attention was paid to the analysis of the raw OSL curve looking at: distribution of residuals, kinetic parameters and the percentage contribution of each OSL component to the overall signal [7].

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Volcanic millstone tracing human movements in central Italy during the Final Bronze Age (Arcevia, Marche)

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The site of Monte Croce Guardia was settled during the Recent Bronze Age (13th-10th century BCE) and flourished in the Final Bronze Age (1150-925 BCE), when it was densely inhabited (Cardarelli et al. 2017). The presence of "exotic" materials, such as amber and glass ornaments, testifies the relevance of the settlement and that it was part of a long-distance exchanges network. The interest in stone findings made of vesiculated lavas, referable to parts of querns, mortars, and/or pestles lies in the fact that this Final Bronze Age settlement was built upon limestones belonging to the sedimentary sequence of the Marche-Umbria Apennines (central Italy), far away from potential volcanic raw materials. A petrologic study of 23 grinding tool fragments clearly indicates a provenance from the volcanic provinces of central Italy: Latium and Tuscany Regions. Few leucite tephrites (5) and one leucite phonolite lavas have a clear magmatic affinity with the high-K series of the Roman Volcanic Province (Latium) whereas the most abundant volcanic lithotype (17 samples) is represented by shoshonites (K-series) whose thin section texture, modal mineralogy and major-trace elements contents closely match with the shoshonite lavas from the Radicofani volcanic centre of the Tuscan Magmatic Province. At Radicofani (a volcanic neck in the eastern sector of Tuscany) a Final Bronze Age site, coeval to that of Arcevia, is present and a potential pathway corridor from that site towards Arcevia (air-line distance of ca. 115 km) is dotted with many settlements of the same age. Using analytical algorithms based on different human-dependent cost-functions (Alberti, 2019; 2022), the best route from Radicofani to Monte Croce Guardia, approximately 140 km long, was simulated, with a walking time of 25-30 hours. The presence of several water supplies (lakes and rivers) along this route may have also contributed to choose the pathway to go. It is worth to note that three thousand years ago the Apennine Mountains did not thus constitute a barrier for human movements. Regarding the remaining, less abundant volcanic grinding tools of the high-K series (leucite tephrites and phonolite) the precise quarrying sites were not defined although the provenance from the Roman Magmatic Province (Latium) is well constrained by mineralogical and chemical data. In addition, at least for the leucite phonolite sample, a provenance from the well-known quarrying site near Orvieto (between the localities of Buonviaggio and Sugano) is very likely. As already pointed out by many authors (*e.g.* Santi et al. 2022, and reference therein) the lava millstone quarrying and manufacturing from volcanic areas were very widespread in antiquity, and transport/trade of grinding stones represent a valuable tool to unravel human movements, cultural interactions and terrestrial and/or water-way routes.

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Once upon a glass mosaic in the apse of *S. Sabina's* Basilica in Rome. Interdisciplinary study of a Late Antique/Medieval lost decoration

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The results of the interdisciplinary study on the glass mosaic in the apse of the Basilica of *S. Sabina*, carried out within a wider research project on early Medieval wall paintings and mosaics in Rome, are here discussed. In particular, the present study focuses on the loose tesserae, which are stored within the General Archive of the Order of Preachers, and are the only proofs of this Late Antique or Medieval decoration, now lost and substituted by the current frescoes, dated to 16th cent AD.

The glass tesserae from *S. Sabina* were investigated by means of a laboratory analytical protocol, already applied on other in situ glass mosaics, such as the glass mosaics from *S. Agnese fuori le Mura* in Rome [1] and which included optical microscopy (OM) for preliminary morphological observations, scanning electron microscopy, coupled with energy-dispersive spectrometry (SEM-EDS) for high-resolution morphologic inspection of glass and qualitative chemical analyses, electron microprobe (EMPA) to determine quantitative chemical composition of glassy matrix, and X-ray powder diffraction (XRPD) to define the crystalline phases of opacifiers/pigments used in the tesserae.

Results of the archaeometric analyses reveals how the tesserae from the apsidal mosaic of *S. Sabina* were mostly obtained by using production technologies, in line with the supposed date of this mosaic, i.e., the 5th century AD, both as regards the glassy matrix and the opacifiers/pigments. This suggests that most of the tesserae were produced *ad hoc* for the apsidal mosaic, especially in the case of green and light green tesserae, even if a later dating cannot be excluded. The dark green tesserae show greater variability: a couple of dark green tesserae, showing both glassy matrix and opacifiers/pigments typical of the Roman period, can be interpreted as reused tesserae. Other tesserae, having glassy matrices typical of the late antique period, but opacifiers typical of the Roman age, can be interpreted as recycled tesserae.

The comparison with the tesserae coming from the counter-façade mosaic of *S. Sabina*, still *in situ* and analysed by Verità and Santopadre [2], reveals how the two mosaic cycles are not very comparable, both as regards the glassy matrices and the opacifiers/pigments. In the counter-façade mosaic, in fact, both the glassy matrices and the opacifyers/pigments are typical of the Roman era. This suggests that the counter-façade mosaic, at least on the basis of the archaeometric results, appears to have been mainly obtained from re-used tesserae.

Further comparisons with other coeval mosaics from Rome and the Mediterranean area are in progress, to broaden the understanding of the production and circulation processes of glass tesserae in the early Middle Ages, and on the exchanges between Rome and the various areas of the Mediterranean in the period considered.

In conclusion, the present results underline, once again, the importance of an interdisciplinary approach in the study of ancient glass mosaics, as the apsidal mosaic of *S. Sabina*, now lost but never forgotten.

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Ashes to ashes, salts to salts: different origin of glass beads from Iron Age sites in Central Italy

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Glass beads are frequently found in burial contexts dated from the Early Iron Age (EIA) in the central part of the Italian peninsula [1]. The period was characterised by changes in glass compositions across the entire Mediterranean [2]. The set of samples discussed here includes several types of intensely coloured beads, some of which were typologically attributed to the Final Bronze Age (FBA) production.

An analytical study of these beads was therefore designed to confirm or disprove the attribution made on typological basis, and to provide chemical data to investigate glass provenance and its circulation in the area. The beads were non-invasively analysed within the Museo Nazionale Etrusco di Villa Giulia and the Museo delle Civiltà (both in Rome, Italy) using portable X-Ray Fluorescence spectrometry (p-XRF), and Fibre Optics Reflection Spectroscopy (FORS). Several selected samples were subjected to an in-depth compositional characterisation using also Scanning Electron Microscopy coupled with Energy Dispersive X-ray Spectrometry (SEM-EDS), micro-Raman spectroscopy (μ-Raman) and Laser Ablation Inductively Coupled Plasma Mass Spectroscopy (LA-ICP-MS). These analytical techniques allowed us to preserve the integrity of most precious objects from the museum collections while gaining accurate compositional data. Different levels of alkali and alkali-earth elements, in addition to correlations emerging between some trace elements, suggested that certain typological groups have different origin from one another. The typological attribution to FBA for some of the selected beads was confirmed on compositional grounds and, as a consequence, their separate provenance.

For many other samples, an Eastern Mediterranean provenance was suggested, according to the correspondence of glass composition to the Bronze and Iron Age examples from Egypt and Mesopotamia. One of the earliest examples of glasses prepared by the use of evaporitic, high Na deposits and imported from the Eastern Mediterranean was attested for the Central Italian peninsula. A small group of objects within the set was suggested to be of a local, EIA production, though more compositional data is needed to strengthen this conclusion.

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Methods and instruments for the origin determination of ceramic artefacts. The case study of *Laus Pompeia* amphorae (I B.C.-I A.D.).

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A large set of Roman transport fragmentary amphorae, dated from I B.C. to the beginning of I A.D. and found in *Laus Pompeia* (the modern town of Lodi Vecchio), had been studied in a former archaeological project in which the provenance of the pottery was determined on a typological base, considering also the macroscopic evaluation of the clay. This was the starting point for the present work that aims to study the origin of these artefacts through an archaeometric evaluation of raw materials, with the help of the few stamps related to the production workshops. Indeed, the provenance aspect is fundamental to understand the different trade routes passing through *Laus Pompeia* at the Roman time and the archaeological classification already obtained identified samples from the whole Adriatic cost of Italy.

We have considered a completely non-invasive approach on 36 selected samples for comparison with the previous archaeological evaluations. The first overview of the ceramic body composition has been obtained by ED-XRF (Energy Dispersive X-Ray Fluorescence) exploiting a home-made portable spectrometer (FUXYA 2020); multivariate analyses has been applied to the obtained results so to relate grouping with specific production areas. The classification has been compared, and corrected, with the help of minero-petrographic analysis, also performed without sampling, exploiting a portable digital microscope (Dino-Lite Premier AM7013MZT); the obtained images have allowed to distinguish between the native geological components, such as the clay matrix, and clusters produced by the manufacturing and the firing.

Preliminary results show the presence of six groups, in accordance with the archaeological classification and the workshop stamps: we differentiate samples from the Istria region, the generic north Adriatic area, the Venetian sub-alpine area located north to the Po valley, the northern Po valley towards the Adriatic coast, the Adriatic coast of Marche and Abruzzo until the river Pescara, and the Adriatic coast southern to the river Pescara, between Molise and Puglia. Both XRF and minero-petrographic analysis give comparable results, recognising the six provenance areas listed before.

This non-destructive approach is promising; nonetheless, to get a complete and reliable picture, we plan to perform small sampling for XRD (X-Ray diffraction) to get the crystalline components so to improve results, especially for ambiguous cases or loosely defined groups.

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Insights into the most used carbonatic building stone in the historical centre of Urbino (Bugarone Group Formation, central Apennines)

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The historical centre of Urbino (included in the UNESCO list since 1998) is mainly built, along with bricks, using sedimentary rocks (limestones and sandstones) coming from the adjacent Apennine Chain. The most used carbonatic formations of the local Umbria-Marche Succession are the Calcare Massiccio, Bugarone, Maiolica, Scaglia Bianca/Rossa and Bisciaro (Conti et al., 2020), all characterized by light colours. These geological formations were exploited since the Roman times as big ashlars for the defensive walls, slabs and squared blocks in some portals, stone cladding, and flooring. Nevertheless, the most used carbonatic rock in the historical centre is the white Bugarone Group Formation with which the architect Giuseppe Valadier re-built the majestic façade of the Cathedral strongly damaged by some local earthquakes occurring in the XVIII century AD. This stone was also employed (at the beginning of the XIX century AD) for paving the two typical porticos of the city (with an overall length of about 270 m) near the *Repubblica* Square and numerous portals and stairs of historical palaces. In very recent time, some blocks were reused as ornaments for flooring the *Duca Federico* Square. The Bugarone Group Formation (Jurassic in age) consists of chert-free, fossil-rich and bioturbated, more or less dolomitized, nodular limestones with greenish marl intercalations. Fossils are mainly represented by well-preserved, sometimes large-sized, internal moulds of Toarcian Ammonoids representing, together with limonitized pyrite nodules, the distinctive features of the Bugarone lithology. The maximum thickness shown by this carbonatic formation is of about 50 m (Cecca, 1990; Donatelli and Tramontana, 2014). Some ancient quarries, at present inactive, are recognizable in the northern Marche Apennine, such as those in (*i*) the Monte Nerone anticline along the *Fosso del Bugarone* locality from which the scientific name of the formation derives and (*ii*) the Monte Pietralata-Monte Paganuccio anticline in the Furlo area from which the popular name of *Pietra del Furlo* (Mazzini, 1982; Negroni, 1993). The aim of this work was to map the use of the Bugarone Group Formation in the different architectural sites of the historical centre of Urbino, distinguishing it from the other local carbonatic stones. Petrographic and physico-mechanical features (porosity, degree of saturation, uniaxial compressive strength, freezing) were defined on samples from some abandoned quarries and also from outcrops representing possible/potential exploitable areas having implications for the planning of conservation strategies and the definition of the restoration priorities (*e.g.* detachments, pitting, staining).

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Geological insights on the calcareous tufa (*Pietra Sponga)* used as building and ornamental stones in the UNESCO historical centre of Urbino (Marche, Italy)

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The historical centre of Urbino (Marche, Italy), listed in the UNESCO World Heritage Site since 1998 is characterized by the presence of ornamental and building stones approached with harmony to the main brick architecture. This work deals with a carbonate lithotype used in some contexts of the historical centre of the city, known with the popular term of *Pietra Sponga* or *Pietra Spugna* (*i.e.* spongy stone) because of its spongy/porous appearance (Rodolico, 1953). This stone, largely used in Urbino during the Roman Period, is represented by ashlars in some remnants of the most ancient walls (3^{rd}-2^{nd} century BCE), or as reused building blocks throughout the historical architectural framework. It was employed also as outdoor ornamental stones in portals and finally used indoor to create cave-like spaces in some monuments and churches (*e.g.* Oratorio delle Grotte, Oratorio della Morte, all around the Federico Brandani's putty sculpture of Nativity in the Oratorio di San Giuseppe). *Pietra Sponga*, made of carbonatic encrustations of vegetation such as reeds, frustules, and leaves, is often and generally considered a travertine rock-type. More precisely, it should be classified aa a calcareous tufa *stricto sensu* (Pedley, 1990, 2009) representing freshwater rocks deposited by chemical precipitation from low-temperature calcium bicarbonate-rich waters under subaerial conditions in a large variety of continental depositional and diagenetic settings (Capezzuoli et al. 2014, and references therein). This work is addressed at the geological origin and provenance of the *Pietra Sponga* used in the historical centre of Urbino, also investigating active deposition of calcareous tufas near the city, along the Metauro River (Busdraghi and Veneri, 2003) where some ancient buildings (house and church) are even entirely built with this kind of lithotype, clearly suggesting a local exploitation. Because of obvious conservation reasons, only few grams of samples were collected from ashlars and blocks of calcareous tufas of the historical center of Urbino, mainly addressed to radiocarbon (^{14}C) datings and stable isotopes ($\delta^{13}C$ and $\delta\ ^{18}O$) analyses. In this way, a comparison with the main calcareous tufa deposits from Italy (and Europe) dating back to the Holocene Atlantic climatic optimum was performed.

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Provenance discrimination of the white marbles from the ancient quarries in the region of Hierapolis and in the southern sector of the Denizli basin (Turkey)

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Whereas the application of a single analytical method is not enough for provenancing a marble, the most suitable methodological approach involves minero-petrographic analyses, determination of C and O stable isotopic ratios and analysis of EPR spectra of calcite. These data were used to create some databases of known ancient quarries [1, 2]. Discrimination among provenance groups in the database was usually accomplished through multivariate statistical data analysis, which enables the assignment, with a good probability, of the quarry from which a marble artefact was obtained.

The discovery of new ancient quarries or extraction areas raises the issue of database updating for all the collected data. This is the case of the ancient marble quarries in the region of Hierapolis and in the southern sector of the Denizli basin in Turkey. These quarries include both extraction areas previously unknown and never sampled, such as the Marmar Tepe and Gölemezli quarries, and others already known but not systematically investigated, such as the Hierapolis-Gök Dere, Thiounta and Denizli quarries. In the last cases, the new investigations allowed for the better characterization of marbles and their varieties [3, 4].

In the present study, a set of 47 marble specimens sampled at five different historical quarries (Marmar Tepe, Gölemezli, Hierapolis-Gök Dere, Thiounta and Denizli) were investigated through a multi-analytical approach which included EPR spectroscopy, minero-petrographic analyses, and determination of C and O stable isotopic ratios. These latter data were part of a previous study on the subject. The newly registered EPR spectra were parameterized through the identification of three relevant parameters for the hyperfine and Zero-field splitting interactions. A new database including all quantitative parameters of the chosen set of samples was assembled and analysed through a robust approach of multivariate statistics. The preliminary results of the statistical discrimination confirm the relevant role played by the EPR spectroscopy and suggest a full discrimination of some quarries and a partial discrimination of the others.

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TUTELA E VALORIZZAZIONE

ORALI: T&V-O

POSTER: T&V-P

A new methodology to compare microclimatic conditions inside museum showcases

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Museums showcases conserve and protect ancient and precious artworks from accidental shocks and dust deposition. Moreover, temperature and relative humidity fluctuations in the room are mitigate inside the showcases. The Performance Index, defined as the percentage of time in which the measured temperature and relative humidity values lie within a specific range identified by the exhibit curator or by the UNI10829 normative, is usually used to evaluate the thermo-hygrometric quality level of a museum room or a showcase (Corgnati et al., 2009, Corgnati et al., 2010, Ferdyn-Grygierek et al., 2020, Schito et al., 2016, Sciurpi et al., 2015).

Recently, Ferrarese et al. (2018) proposed an index (IME, Index of Microclimatic Excursions) using the thresholds in the UNI10829 normative to compare microclimatic conditions in different showcases. The same method was applied outside the showcases, in museums rooms by Lucero-Gomez et al (2022). The weak point of all the proposed procedures is the determination of the thresholds, that are applied to classify the microclimate conditions as acceptable or critical. Usually, the thresholds are fixed by the norms or by the experience of curators, but nowadays there is no general criterion for defining the allowed ranges.

A new index, unrelated with the normative thresholds is here presented (IMV, Index of Microclimatic Variability). The index considers the distribution of daily excursions in temperature and relative humidity weighted on their maxima values. The index is computed by an algorithm that is independent from fixed thresholds, and it can be easily used to compare and evaluate the microclimatic conditions inside different showcases in different positions in the museum (Ferrarese et al., 2022).

In the present work, the method has been applied at the microclimatic dataset collected inside some showcases at the Museum of Physics, University of Turin, during two periods longer than two years.

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UNI 10829, Beni di interesse storico artistico - Condizioni ambientali di conservazione, misurazione ed analisi (Italian Standard UNI 1999)

The significance of things
Investigating glass from materiality to intangible values

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Glass is one of the earliest pyro technologies, along with ceramics and metals. An increase in the awareness of traditional knowledge underlying the millenary tradition of glass manufacturing has recently been seen with the inscription of the art of Venetian glass beads in the UNESCO list of Intangible Cultural Heritage of Humanity (https://ich.unesco.org/en/RL/the-art-of-glass-beads-01591). The Murano beads have been recognised as repository of knowledge and mastery of skills, reflecting the use of traditional tools and technologies inherited from the past. Is it conceivable to apply this analysis of the significance of glass to other historical periods and types of objects? If so, to what extent?

Over the past decades, research has allowed for the clarification of several technical, economic, and political aspects underlying the production and trade of glass (Rehren and Freestone 2015). However, the potential that glass holds to rediscover the flows and exchanges of technological knowledge in the past has marginally been explored. As a consequence, issues more closely linked to the intangible values and the socio-cultural significance of glass, are still sporadically addressed (Chinni et al.2023).

Moving from Central Europe (Vandini et al.2018) to the Adriatic Sea (Chinni et al. 2020) and across the Mediterranean (Fiorentino 2021; Fiorentino et al.2020), the paper will discuss upon how the investigation into the materiality of objects can unravel technical and cultural knowledge beyond their manufacture. Archaeometric data can play a key role in enhancing our understanding of intangible values behind material culture - like lexicon, gestural competence, technological flows, and know-how. The argument is that the connection between man and object has shaped the history of humankind, and it has given physical objects the ability to signify things: objects can provide meaning as markers of value and identity, they can construct selfhood, and they can encapsulate networks of cultural and political power (Sainsbury et al.2021). From a broaden perspective, the paper will lay the groundwork for a wider discussion on how archaeometry is ultimately investigating not the object itself, but the people and culture behind it.

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Evaluation of various preservation methods in the storage phase for waterlogged archaeological organic artifacts by pyrolysis-based techniques

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This work is part of the JPI StAr project "Development of Storage and Assessment methods suited for organic Archaeological artefacts" 2020-2023 which aims not only to broaden knowledge on the processes occurring in wooden remains and in the surrounding environment but also to explain the temporal relationships between changes in the chemical and physical properties of wood and changes in the conditions of their deposition.
One of the topics of the StAr project is the development of strategies that allow organic archaeological discoveries to be stored for long periods of time (several months) in a waterlogged state (i.e. under pre-treatment conditions), without compromising the scientific evidence they contain.
Various types of materials and additives have been considered for use in the pre-treatment storage, with a focus on keeping microbiological contamination at a low level by using an additive in the water bath. Other characteristics of the additive considered were: non-toxicity, absence of interaction with organic material of the artefact, commercial availability, cost, ease of removal.
Treatment effectiveness was evaluated by biological and chemical characterization. Chemical stability was assessed mainly by analytical pyrolysis-based techniques (Py-GC/MS and EGA-MS), which proved capable to highlight the chemical changes that occurred both in the lignin and in the polysaccharidic fractions of the wooden archaeological remains. The adopted investigation approach allowed us to evaluate the depletion and depolymerization of polysaccharides, and side chain shortening, oxidation or demethylation processes that occurred in the lignin polymer in wood.
The aim of this work is a contribution to the understanding of the biochemical processes in wood degradation and their relationship with the chemical-physical environmental changes of the burial environment, and to an optimisation of the storage environment and conditions awaiting the final conservation treatments.

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Multidisciplinary approach for the characterization of authentic and false ceramics: an analytical protocol for their discrimination

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The phenomenon of clandestine excavations affects the whole national territory, but the most affected area is certainly southern Italy, the cradle of Magna Graecia. The value of cultural heritage is determined by the relationship between the artifacts and their context of origin: taken from it by excavations and clandestine thefts, archaeological finds and works of art are nothing but silent objects, or almost so. Illegal excavations and looting represent a decontextualization of the work from its original context, depriving it of its identity and history. This attack on cultural heritage makes it difficult to study those artefacts that are often seized by the authorities. Analysing a work, an artefact, is important for restoring the history of past populations, he commercial and cultural exchanges they entertained, the customs and identities they represented and still represent. It is in such criminal contexts that forgery is born and developed to deceive collectors, museums and private individuals with the sole aim of receiving huge financial returns; phenomenon which among other things is facilitated by the wide availability of raw materials equal to those used in antiquity. The presented study shows how to characterise ceramics in order to discriminate their authenticity, through forensic investigations and a multidisciplinary approach. Identifying a find as fake or authentic emerges from a set of elements that consider all the characteristics of the object: i.e. compositional, microstructural, chronological, typological-stylistic, etc. The finds analysed so far belong to a large batch of archaeological material seized by the Cosenza Carabinieri Unit for the Protection of Cultural Heritage and Anti-Counterfeiting (Calabria, Italy). To date, eight intact or almost intact finds belonging to different ceramic classes have been selected, specifically: a) indigenous Daunian Subgeometric production, b) red-figure ceramics of Italiote production, c) black-glazed ceramics of Magna Graecia production and d) overpainted ceramics from Gnathia. The analyses conducted so far concern an archaeometric study, including both an in-depth stylistic-iconographic and analytical investigation by means of Dinolite microscopy, XRD and XRF. The scientific results obtained did not reveal any elements that could discriminate the samples as fakes, a result justified by the probable use of l raw materials originating from the territories of ancient Apula, which still have the same compositional characteristics as the raw materials used in antiquity. On the contrary, the archaeological-stylistic study, thanks also to comparisons with the literature, has made it possible to identify the finds as fakes, thanks above all to evident iconographic inconsistencies. Dating analyses are in progress, specifically, the finds will be subjected to Thermoluminescence. This study aims to build a protocol for the study of finds from clandestine excavations and to collect the data in a database to be used as a tool for institutions operating for the Protection and Conservation of Cultural Heritage.

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BIOARCHEOLOGIA

ORALI: B-O

POSTER: B-P

Exploring the Potentiality of Osteoarchaeological Remains: Innovative Methodologies to Investigate Paleodiet Through Stable Isotope Analysis

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In the last four decades, stable isotope analysis ($\delta^{13}C$, $\delta^{15}N$, $\delta^{18}O$, $\delta^{34}S$, $^{87}Sr/^{86}Sr$) of collagen, the organic component of bones, has become a well-established tool in bioarchaeology to investigate multiple aspect of past human lifeways, including paleodiet, climate changes, social status, exploitation of local resources, migrations, weaning age, breeding and farming practices. Recently, there has been a growing interest towards new ways of gaining a higher resolution of the dietary habits of past populations. We hereby present a selection of innovative methodologies to explore infant and adult paleodiet, investigated on human teeth and bones. Whereas bones remodel every 5 to 10 years, this process does not occur in teeth, therefore the isotopic signature reflets the diet assumed during its time of formation. Multiple isotopic studies have been performed upon the analysis of incremental dentine, leading to the development of different methods of teeth sectioning to reconstruct dietary patterns with a high temporal resolution. We performed the sampling technique involving the slicing of 1mm horizontal sections on teeth of individuals from the Roman sites of Pompei and Ostia. Every section of the tooth reflects a precise chronological range in which the dentine has been deposited, retaining a specific isotopic signature that indicates the diet assumed by an individual from infancy to adolescence, the time range necessary for the tooth's formation from crown to apex.
Secondly, we explore the potentiality of Bayesian modelling applied to bioarchaeology. We focus on the 'ReSources' model that allows the estimation of the caloric contribution for macronutrient components (carbohydrates/lipids and protein) of food sources. Moreover, 'ReSources' offers the opportunity to insert constraints obtained through secondary sources (e.g. archaeobotanical/zooarchaeological evidences, historical sources, etc.), with the aim of a more accurate reconstruction of dietary habits of past populations.
This analysis was carried out on human samples from the Roman sites of Pompei and Ostia.
These innovative methodologies, together with AA-CSIA (Amino acid compound-specific isotope analysis), have the common purpose of increasing the accuracy of stable isotope analysis and paleodiet reconstruction, offering an insight of the growing attention paid towards bioarchaeology and the potentiality of multidisciplinary approaches in the study of osteoarchaeological remains.

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From a bioarchaeological record, the reconstruction of the eating habits of a Bronze Age settlement in Acerra (NA): two dough fragments referable to the making of wholemeal bread and a unicum for the combination of charred cereal remains on a turtle carapace fragment for the making of a soup

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During the excavation campaign in June 2018, in the course of the construction of the high-speed railway line Naples - Cancello path, some burnt faunal bone fragments were found from the sifting of the fill of a Bronze Age pit, in particular a fragment of c.a. 10 cm of rib plate of a carapace, belonging to the *taxon Testudo hermanni*, affected by profound biotic alterations, to which were adhered charred caryopses of medium emmer (*Triticum dicoccum*), fragments of barley caryopses *(Hordeum vulgare*) and lumps of thickened and agglutinated carbonaceous organic substance, which can be traced back to the remains of a soup (Fig.1). Within the same settlement, two fragments of cereal caryopsis mixture, indicate the remains of unrefined bread cakes (Fig.2).

Fig.1 Tortoise carapace with carpological fragments attributable to the leftovers of a cereal soup.

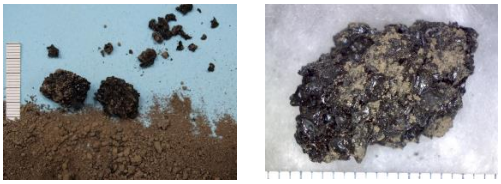

Fig.2 fragments of cereal dough that can be traced back to wholemeal bread.

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DIFFUSIONE E DIVULGAZIONE NEI BENI CULTURALI

ORALI: D&D-O

POSTER: D&D-P

#ScienzeABC: pills of digital knowledge to tell the Sciences Applied to Cultural Heritage

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In recent years, also due to the COVID-19 pandemic, the use of the internet and social networks has significantly increased, both for personal entertainment and for study/ training needs. No topic has been spared by digitization: even the humanities and sciences have had a significant increase on the main search provider since February 2020. These disciplines are often considered diametrically opposed but, above all in the Cultural Heritage field, science and art merge in the creation phase of a work of art as much as in its conservation process. The idea of starting and managing an Instagram profile about sciences applied to cultural heritage (called @scienze.abc) stems from the desire to contribute to reduce the distance between art and science, promoting greater visibility of STEM subjects, with the aim of spreading the knowledge of the Sciences Applied to Cultural Heritage and to introduce the younger audience to the degree course focused of these disciplines. The project fits into the context of digital learning, applying the tools (e.g. posts, reels and stories) provided by the social network platform Instagram. Pills of scientific knowledge, fun facts and advises about Cultural Heritage are proposed combining short and simple captions with impressive images.
In particular, the topics selected for the daily posts concern the activities of scientific experts for Cultural Heritage (Conservation Scientist) carried out in the laboratory and in-situ, the tools of the trade, news from national and international scientific community, curiosities from the world of Cultural Heritage and historical-archaeological-artistic places of interest, more or less known. The language chosen is essential and at the same time scientific and informative, using the typical register of the social networks. The target audience belongs to the age group of 15-25, i.e. those who mostly get information through digital platforms.

Buddha[10]: study and conservation of seven Buddhist painted sculptures as a bridge between East and West

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Buddhist visual and material cultures are often understood in relation to their circulation from India to the rest of Asia, while little attention has been paid to understanding their westward migration, although numerous examples are preserved in public and private collections. Most of the artefacts, coming from different geographical and cultural contexts in Asia, travelled to Europe during the last centuries as trade commodities and pieces for the art market, thus being completely decontextualized and losing all devotional values in favour of aesthetical ones, often adapted to western taste to appeal to collectors.

This contribution focuses on a heterogeneous group of polychrome wooden sculptures belonging to the Museo d'Arte Orientale (MAO) in Turin, which has never been exhibited before and is currently the core of a MAO exhibition titled "Buddha[10]. A Fragmented Display on Buddhist Visual Evolution" (October 2022 – September 2023) [1]. All these objects come from China, likely from different regions and religious sites, although their exact provenance is in most cases unknown. According to the concise museum entries, they are likely dated between the 16th and 18th century. The sculptures have undergone an in-depth study and conservation treatment at Centro Conservazione e Restauro "La Venaria Reale" (CCR) in 2022, aiming to distinguish what belongs to the original techniques from the western taste adaptations, in addition to supporting current hypotheses on provenance. This project provided an invaluable opportunity of collaboration with Buddhist art specialists, taking as much as possible into account both European and traditional Asian perspectives while balancing treatment goals [2]. A multi-analytical campaign was designed to expand the current knowledge of the objects and to assess their conservation condition. Multispectral imaging techniques, XRF, and FTIR analyses were first used to characterize the polychromy. Micro-samples were removed and investigated using optical microscopy and SEM-EDX to examine the stratigraphy, revealing a number of overlapping paint layers on most of the sculptures. In addition, micro-samples were also taken for wood identification. Radio-tomographic investigations were also carried out to explore the hidden structure of the objects; in addition to this, photogrammetry and radiometric data of multispectral imaging collected from two of the artefacts were integrated in a unique 3D model within an ongoing partnership with the Politecnico di Torino.

The outcomes of this study contributed to an improved understanding of the artistic technique and guided some of the choices related to the conservation intervention. Moreover, certain conservation problems were highlighted, such as traces of fungal deterioration phenomena, previously unknown. Finally, results helped address questions regarding authenticity and transformations that have occurred to the sculptures in their transition from devotional objects to private collection artworks and, again, to museum holdings. The collaboration between CCR and MAO has greatly enriched the "Buddha10" exhibition with multimedia materials (e.g., microscope images and interviews with conservation professionals) that are displayed along the visit itinerary. A seminar about all the above-mentioned aspects of this project was also given in October 2022 within the course on "Asian Material Culture" developed by the MAO in collaboration with the University of Turin.

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D&N-P1	L. Vigorelli, C. Donazzolo, F. Tansella, G. Ricchiardi, A. Re, S. Grassini, A. Lo Giudice	Application of Dimensional X-ray Tomography principles to the study of Cultural Heritage
D&N-P2	S. Croci, L. Es Sebar, L. Lombardo, P. Buscaglia, S. Grassini, C. Ricci	Multispectral 3D models for monitoring in conservation of wooden statues
D&N-P3	D. Giuffrida, F. Armetta, M.L. Saladino, O. Adinolfi, M. De Crescenzo, L. Sole, R.C. Ponterio	Data acquisition for *Nummi Digitali*, a project for the fruition of the numismatic collection preserved at the Salinas Museum in Palermo
D&N-P4	A. Vietti, M. Parvis, M. Latino, N. Donato, S. Grassini, L. Lombardo	Visible and UV RTI imaging system for Cultural Heritage
U&A-P1	L. Vergelli, F. Frasca, G. Boccacci, B. Bartolucci, G. Favero, C. Bertolin, A. Nucara, A.M. Siani	Acetic acid and cellulose acetate films: artificial ageing and preliminary risk assessment of climate-induced impact
U&A-P2	L. Germinario, I. Moro, M. Munari, C. Mazzoli	How will climate change impact underwater stone heritage?
M&N-P1	L. Ferrazza, D.J. Barber, M.T. Pastor Valls	Evaluation of the applicability of non-toxic and eco-sustainable products for the conservation of pictorical surface
P&D-P1	L. Bonizzoni, A. Francesconi	Methods and instruments for the origin determination of ceramic artefacts. The case study of Laus Pompeia amphorae (I B.C.-I A.D.)
P&D-P2	P. Santi, A. Renzulli, F. Veneri, G. Tonelli, M. Tramontana	Insights into the most used carbonatic building stone in the historical centre of Urbino (Bugarone Group Formation, central Apennines)
P&D-P3	P. Santi, A. Renzulli, F. Veneri, G. Tonelli, M. Tramontana, M. Taussi, G. Quarta	Geological insights on the calcareous tufa (Pietra Sponga) used as building and ornamental stones in the UNESCO historical centre of Urbino (Marche, Italy)
P&D-P4	S. Vettori, E. Cantisani, F. Di Benedetto, A. Buccianti, T. Ismaelli, G. Scardozzi	Provenance discrimination of the white marbles from the ancient quarries in the region of Hierapolis and in the southern sector of the Denizli basin (Turkey)
T&V-P1	M.P. Albanese, A. Taliano Grasso, M.F. La Russa,M.F. Albreghina, M. Ricca	Multidisciplinary approach for the characterization of authentic and false ceramics: an analytical protocol for their discrimination
B-P1	M. Stanzione, P. Aurino, B. Albanese	From a bioarchaeological record, the reconstruction of the eating habits of a Bronze Age settlement in Acerra (NA): two dough fragments referable to the making of wholemeal bread and a unicum for the combination of charred cereal remains on a turtle carapace fragment for the making of a soup