

7 - 11 September
Funchal, Madeira Island



**7th International Conference on Innovation
in Art Research and Technology**
Funchal, Madeira Island, Portugal

BOOK OF ABSTRACTS

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Her research combines non-invasive and micro-analytical techniques, and her research has particularly addressed the scientific examination of easel paintings, including 16th-century Portuguese-Flemish paintings, while also encompassing a broad range of Cultural Heritage materials. More recently, her work has increasingly explored the integration of advanced analytical methodologies with conservation questions, contributing to the development of sustainable approaches to the study and preservation of Cultural Heritage. Her activities further include project coordination, teaching, supervision of graduate students, scientific consultancy, training and outreach. She has participated in numerous national and international research projects and conferences, collaborating with universities, museums, conservation laboratories and research institutions across Europe, Brazil and India.

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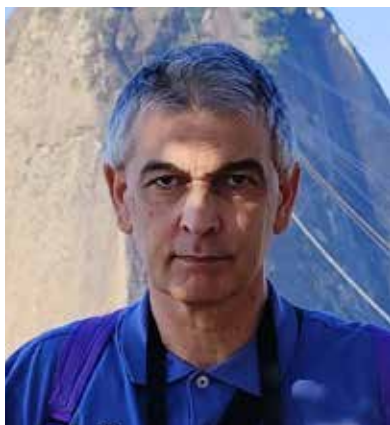
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Full Professor in Applied Physics at the Department of Mathematical, Physical and Computer Sciences of the University of Parma. He received the degree in Physics in 1992 and the PhD in Physics in 1997.

Author of more than 200 scientific publications in international journals and over 250 presentations and invited talks at national and international conferences and schools.

His research mainly concerns the structural and dynamic characterization of crystalline and amorphous materials through, in particular using the Raman spectroscopy. The main topics of its research are related to Cultural Heritage and Archaeometry, spectroscopy of minerals and rocks, characterization of reusing materials, analysis of semiconductors and systems for the production and storage of energy.

He is member of the Scientific Committee of inArt from 2016, and he organized and chaired the edition 2018 held in Parma.

He is managing editor for the European Physical Journal Plus (Springer).

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PhD and MSc in Production Engineering (COPPE/UFRJ) (2009 and 2002), with a specialized degree in Industrial Management and Economic Engineering (UFRJ/1993). Director of the Casa de Oswaldo Cruz (COC/Fiocruz) since 2021, where he served as deputy director from 2006 to 2021. He coordinates the Fiocruz Preservation Collections Complex. He is a permanent professor on the Professional Master's Programme in the Preservation and Management of Cultural Heritage in Science and Health (PPGPAT/COC). He is co-leader of the CNPq research group 'Health, City and Cultural Heritage'. Coordinator of the application for the "Oswaldo Cruz Foundation – Health, Science and Culture in Manguinhos" to be inscribed on the UNESCO World Heritage List. He works in the fields of cultural heritage and public management, with a focus on: preventive and integrated conservation, risk management, sustainability, preservation and digital access, cultural policies and memory.



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Lavinia de Ferri obtained her Master's degree in *Science for Cultural Heritage* from the University of Parma in 2008 and enrolled in a PhD programme at the University of Modena and Reggio Emilia in 2009. During her doctoral research, she investigated the structural modifications of medieval potash-lime glass induced by degradation processes and developed protective hybrid sol-gel materials for its conservation.

Following a one-year research fellowship at the Politecnico di Milano, she returned to the University of Parma, where she worked in the Department of Pharmacy, before moving to Venice. Since 2018, she has been working in Norway, first at the Norwegian University of Science and Technology (NTNU) in Trondheim and, subsequently, as Associate Professor at the Science for Cultural Heritage Laboratory (SciCult) of the Museum of Cultural History, University of Oslo.

Her current research spans the development of alkali-activated materials for cultural heritage conservation, the study of archaeological and historical textiles, provenance and technological investigations of Nordic Bronze Age ceramics, and the characterization of medieval Norwegian distemper paintings.



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Ludovic Bellot-Gurlet is Full Professor at Sorbonne University (Paris) within the MONARIS laboratory (Sorbonne University/CNRS). He studied physics and materials science at the University of Grenoble Alpes, where he obtained his PhD. Following teaching and research contracts at the University of Grenoble Alpes and Claude Bernard University (Lyon), he was appointed as Assistant Professor at Sorbonne University. His research has consistently focused on the fields of archaeometry and conservation science. His research, centred on the physical chemistry of cultural heritage materials and artefacts, is anchored in interdisciplinary approaches through the implementation and development of analytical strategies involving predominantly Raman and infrared spectroscopy, with the aim of developing methodologies applicable from archaeological and conservation sites to the laboratory. The skills, experience and awareness he has acquired enable him to work in teaching and research at the core of various interdisciplinary themes around archaeometry and conservation sciences.

He is the co-author of more than 120 peer-reviewed articles and 70 articles in conference proceedings, specialised publications or book chapters. He holds, or has held, various roles in organising and structuring research both at his university and more broadly within the French academic landscape.



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Luiz A C Souza is Full Professor of Conservation Science at the Federal University of Minas Gerais (UFMG), Brazil, where he coordinates LACICOR – the Conservation Science Laboratory. Trained as a chemist, he received his BSc (1986), MSc (1991) and PhD (1996) from UFMG - Federal University of Minas Gerais, in Brazil. His postdoctoral research includes a period at the University of Perugia, Italy (2014), working with the teams and laboratories of Professors Antonio Sgamellotti and Bruno Brunetti, and, in 2024, research at the Hercules Laboratory - University of Évora, Portugal, followed by a residency as a Scholar at the Getty Conservation Institute in Los Angeles.

His career has been dedicated to the development of Heritage Science through interdisciplinary research connecting materials science, conservation, scientific imaging, provenance and authentication, and, more recently, artificial intelligence and data science. He has held leadership positions in major international conservation organisations, such as ICOM-CC, ICOM, ICCROM. Prof. Souza is currently Deputy President of the International Institute for Conservation (IIC); Deputy President of the INCT IN2PAST.Br - Brazilian National Institute of Science and Technology - Research in Natural History, Cultural Heritage, Arts, Sustainability, and Territory; President of ANTECIPA - Brazilian National Association of Research in Technology and Heritage Science; Deputy Director of CECOR - Center for Conservation and Restoration of Cultural Heritage, in Belo Horizonte, Minas Gerais, Brazil.

His work places particular emphasis on international collaboration, capacity building, and the development of Heritage Science in Brazil and South America.



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Shujoy is the founding director of the Master in Design Degree at the University of Madeira, and a tenured Assistant Professor of Product Design at the Department of Art and Design (DAD).

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During his doctoral studies, Shujoy was attributed 2 competitive research fellowships funded by the Ministero dell'Istruzione, dell'Università e della Ricerca - Italia (MIUR) between 2009-2012. Shujoy was also awarded the Medal of Academic Merit (Civil Engineering) from The Institution of Engineers, India.

Shujoy is a fully integrated researcher in ESAD-IDEA research unit (since 2025) and was an affiliated researcher with Laboratório de Robótica e Sistemas de Engenharia (LARSyS) of Instituto Técnico Lisboa (2019-2025), advancing new knowledge creation medical product design, design process theory, product innovation and social robotics.

Shujoy has won 3 EU funded research projects as Principal Investigator (PI) through Prociência 14-20 and Madeira 2030 competitions co-financed by the European Regional Development Fund (FEDER) and Madeira Regional Government.

As PI he has won 2,30 million€ worth of funding deployed for capacity building and early career research grants attributions. As PI he coordinated the following: 1) project Future Industrial Kitchen with the Madeira Interactive Technologies Institute (M-ITI) and FN Hotelaria (2018-2019), 2) project BioMask



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(2022-2023) with the University of Madeira, Agência Regional para o Desenvolvimento da Investigação, Tecnologia e Inovação (ARDITI), and The Biomask Company Lda and most recently, 3) project REblister-biodegradable blister packaging (2026-2029).

Shujoy has built 2 Master degree programs in UMa (Spatial Design and Design), coauthored 5 book chapters of books, 2 journal publications, supervised 6 Master dissertation theses, and 13 scientific researchers. He has served on 9 Master degree admissions juries (2016-2026), 14 academic Master degree dissertation public defense juries, 11 scientific research fellowship grants attribution juries, various scientific committees of international congresses, reviewed 1 PhD dissertation thesis as external evaluator (IIT-Guwahati, 2020), invited as external international expert for 1 career promotion jury duty (IIT Bombay, 2023), 2 international design competition juries (SMART Label -Host Innovation Award; HOST Milano; PoliDesign-2017 - 2019), invited as external international accreditation evaluator of design degree programs (University of Saint Joseph, Macau, SAR China, 2022), and also appointed as external quality control officer for 1 EU capacity building project (Project DESINNO, 2021-2022).

His scientific research focuses on medical product design, shape coding, design process theory and design education. Shujoy teaches theory of design process, drawing theory, product design development, and New Product Innovation.



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Professor Wu holds a series of prestigious academic review and advisory appointments at national and provincial levels. He serves as an expert of the Academic Divisions of the Chinese Academy of Sciences, a technological talent evaluation expert of the China Association for Science and Technology, and a peer reviewer for major national research funding programs, including the National Natural Science Foundation of China, the National Social Science Fund of China, and key special projects of the Ministry of Science and Technology of China. He also undertakes review work for Macao SAR Science and Technology Fund projects, and is a registered expert member of the Jiangsu Provincial Philosophy and Social Sciences Expert Database and the Jiangsu Provincial Science and Technology Consultation Expert Database. Recognized for his outstanding academic performance and teaching capabilities, he was selected as an Outstanding Young Backbone Teacher in Jiangsu Province's elite "Qinglan Project".



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**The challenge of creating a
useful database for cultural
heritage data sharing**

KEYNOTE
AURÉLIE TOURNIÉ

**How LEDs are challenging
halogen sources for
hyperspectral reflectance
imaging spectroscopy?**



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KEYNOTES

KEYNOTE LUIZ SOUZA

The challenge of creating a useful database for cultural heritage data sharing

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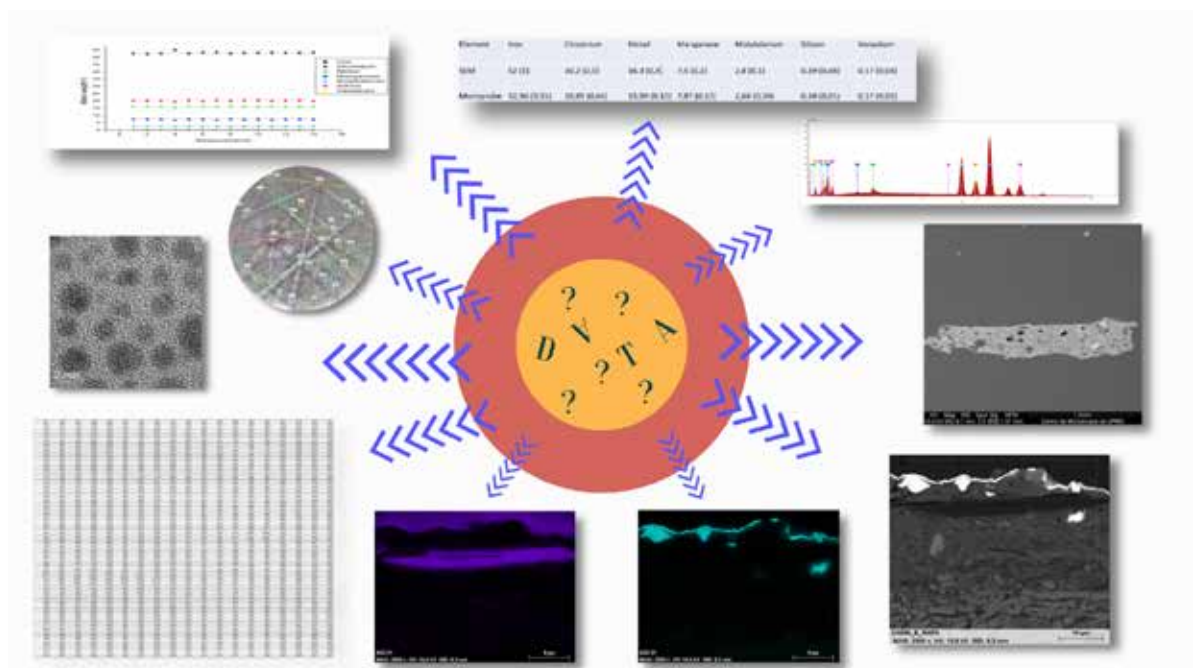
ABSTRACT

The characterization of materials is key to the understanding of a myriad of cultural heritage objects aiming at understanding who and how those objects were made and how those objects are inserted into various cultural aspects. The material characterization of cultural heritage objects is fundamental in the conservation and restoration processes as well as provenance and forensic studies. The last decades saw an increase in the accessibility of numerous techniques, from simple documentation with cameras into very sophisticated synchrotron radiation techniques [1]. Despite the expansion of research in this field, the data generated are still largely dispersed, heterogeneous, and difficult to access, which limits their comparison, integration, and reuse across projects and institutions [2].



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In this context, within the scope of INCT IN2PAST.BR, this work proposes to discuss the challenges involved in creating an integrated user-oriented database for research related to cultural heritage. The platform under development is intended to gather and connect different types of data, metadata and paradata considering laboratory good practices and protocols. More than a repository, this database is intended to function as a tool for knowledge sharing, interdisciplinary collaboration, and more sustainable management of heritage information.



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KEYNOTE AURÉLIE TOURNIÉ

How LEDs are challenging halogen sources for hyperspectral reflectance imaging spectroscopy?

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ABSTRACT

Diffuse reflectance HyperSpectral Imaging (HSI) is a very well-known non-invasive technique in conservation science [1]. Several systems are available in the market but to our knowledge, all are using halogen sources. They present significant limitations ; high surface heating with temperature rising from 20°C to 65°C, and uncontrolled light exposure (i.e. broad and diffuse illumination over the object surface). Both limitations are rather critical when analysing light and temperature sensitive materials. Above all limitations, scientist community faced a gradual phase-out of halogen production since a few years. With the growing availability of improved LEDs illumination over the VNIR range, new opportunities are offered toward a replacement of current halogen sources.

In this study, new linear LEDs system (designed to illuminate broadly from 400 to 1000nm) from ® Efflux, has been evaluated on pigments checker palette (® chsos) and historical wallpaper from the 19th century. This system maintains the surface temperatures and RH conditions within conservation-recommended limits and provide

improved spectral quality specially in the low and high wavelength ranges. They are particularly critical for i) the detection of organic pigments (i.e. below 450nm), ii) and the imaging of low contrast materials in the NIR domain (above 800 nm).

As such, using LEDs illumination for hyperspectral imaging is a major step forward improved and safer material identification of sensitive historical materials.



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SESSION 1

NON-INVASIVE AND NON-DESTRUCTIVE ANALYTICAL APPROACHES

SESSION CHAIR - ANTÓNIO CANDEIAS



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ORAL
ABSTRACTS

Hardware-registered Multimodal Optical Analyses for Cultural Heritage Characterisation

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ABSTRACT

The growing need for non-invasive, spatially resolved characterisation of cultural heritage artefacts is driving the development of increasingly integrated optical platforms. We present a custom three-axis scanning platform designed for the hardware-registered acquisition of multimodal datasets. The platform covers a measurement volume of $1000 \times 1000 \times 100 \text{ mm}^3$ with positioning accuracy of $\sim 20 \text{ }\mu\text{m}$ and is modular by design — additional instruments can be mounted and precisely co-registered using a videomicroscope-based calibration procedure, akin to payload integration on a satellite system.

A key feature of the platform is the use of 3D surface data to drive real-time autofocus correction during mapping, compensating for surface topography and ensuring optimal signal quality across irregular or textured surfaces. The system has already been validated through the acquisition of multimodal datasets including macro-Raman mapping, surface 3D scanning, and hyperspectral imaging in the visible. The hardware-registered nature of the datasets enables direct correlation between chemical,



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topographic, and spectral information, significantly enhancing the interpretability of results.

The platform is being progressively expanded, starting with Optical Coherence Tomography (OCT) mosaicking, imaging spectrometry from visible to mid-infrared, and multi-spectral video microscopy, remaining open to further analytical integrations. The new instrument is thus evolving into a fully integrated, non-invasive diagnostic tool for heritage science and will play a central role in the upcoming extension of the CNR-INO laboratory at the *Opificio delle Pietre Dure*.

Selected case studies illustrating the multimodal capabilities of the platform are presented and discussed.

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Multimodal optical approach for assessing structural integrity and interlayer degradation of polychrome wooden panel

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ABSTRACT

In recent years, evaluating the structural integrity of artworks has become increasingly crucial for conservation purposes. Since degradation phenomena often concealed from restorers' vision, non-invasive diagnostic methods are essential for their identification, and without a comprehensive evaluation of an artefact's state of conservation, it is not feasible to develop effective preservation and restoration strategies. This research employed a multimodal optical approach to investigate various degradation process affecting wooden panel paintings. Proven techniques, including 3D scanning and technical photography, are integrated with shearography [1], an unconventional method that has recently gained increasing relevance in the diagnostic examination of cultural heritage materials. Three case studies are presented: one is a wooden panel painting made near the end of the 15th century by the renowned Neapolitan artist Colantonio while the other two are liturgical cabinet doors, believed to have been created between the mid-16th and early 17th century by an unknown artist. The Museo Real Bosco di

Capodimonte in Naples houses these artefacts, with the first one in the permanent collection and the other in its storage. The initial art piece is "Consegna della Regola Franciscana", which it was once part of a larger altar cone. The remaining artworks are a "S. Giovanni Battista" and a "S. Stefano", both featuring a particular constructive typology.

This method has been beneficial and informative for restorers, providing a deeper insight into specific degradation mechanisms and enabling the identification of areas considered previously as not critical for the integrity of the pictorial layers (Fig.1), since they are not detectable through visual examination alone [2]. In conclusion, the proposed methodology improves comprehension of the wooden support's conservation condition, beneath the pictorial and preparation layers, aiding in a more complete assessment of the overall conservation state of art pieces, and supporting the development of a targeted and effective intervention methodology.

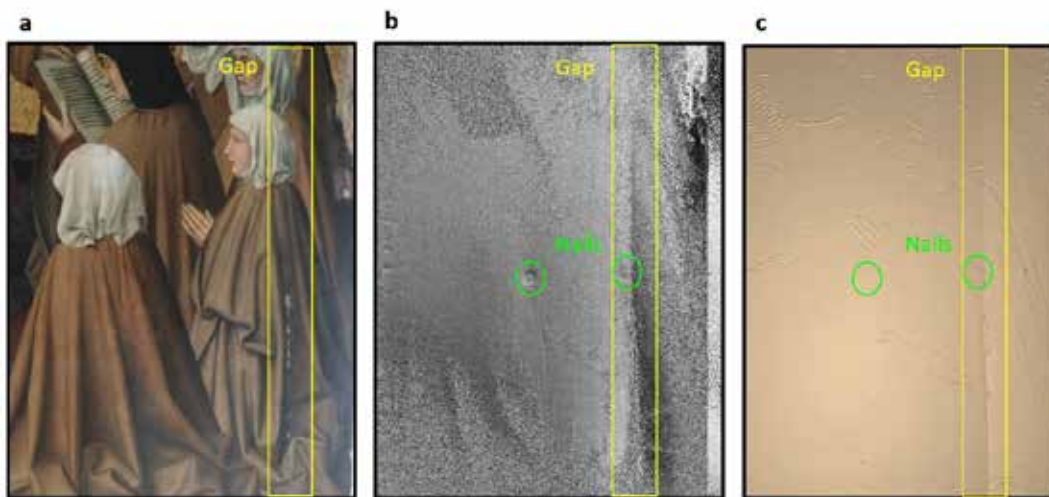


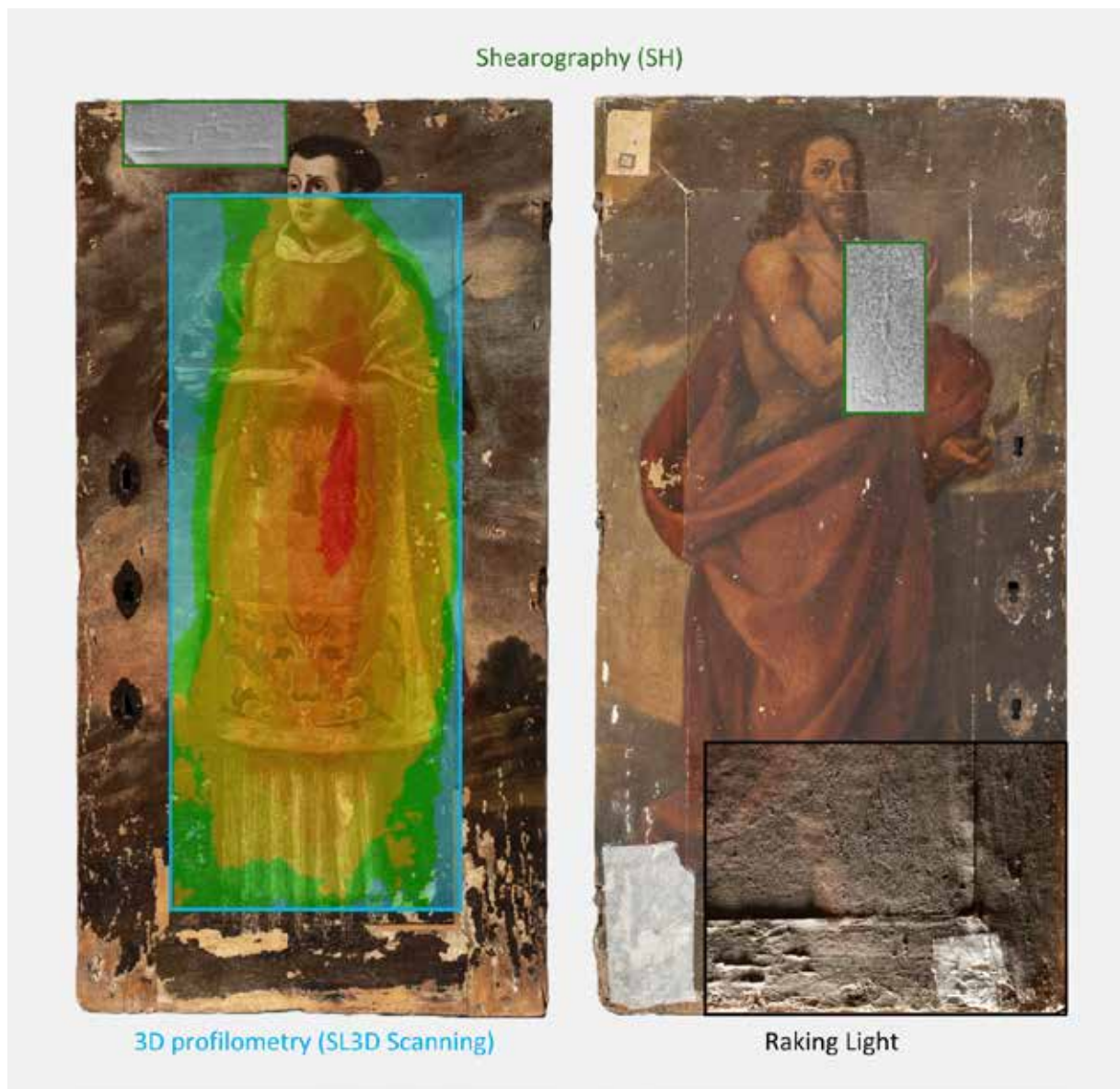
Fig. 1: Picture of structural defect detection by SH and 3D-S of the *Consegna della regola Franciscana*, wooden panel painting: (a) visible image, as reference, in which only the gap stands out clearly; (b) SH image displays the gap between two panels and other two irregularities, probably nails; (c) 3D model image, without texture, where gaps and nails are both visible (see ref.2). Reproduced by permission of MiC-Museo e Real Bosco di Capodimonte.

Acknowledgements

We thank the Museo e Real Bosco di Capodimonte's director and staff for enabling these investigations. Appreciation is extended to Angela Cerasuolo (University of Siena) and the restorers Giulia Zorzetti and Paola Foglia for their discussion on the Colantonio panel painting's experimental results. Gratitude is also due to professors Paola Fiore, Gianfranco Gargiulo (Naples Academy of Fine Arts) and the thesis students Liliana Gargiulo and Ugo Punzolo for their collaborative spirit regarding the cabinet doors. Chiara Saltarelli acknowledges the national node of E-RIHS-ERIC at CNR-ISPC for funding the PhD fellowship through MUR FOE E-RIHS.

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Preserved in rock, revealed by light:

Raman spectroscopy for crystallochemical analysis of Ancient Near Eastern stamp seals

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ABSTRACT

Stamp seals (Fig. 1a) are portable rock-based cultural artefacts, and one of humanity's oldest administrative tools. The first attestation of their use as marker of identity and property by impressing the objects into clay dates to the 7th millennium BCE in the Ancient Near East [1]. They function as the ancient equivalent of a personal signature, playing a central role in governance across societies ranging from small villages to vast empires. Remarkably, unlike the cylinder seal, stamp seals endure as the only ancient sealing tradition still in use for official institutional purposes today, highlighting their striking and lasting significance in human administrative history. Beyond their iconography with geometric ornamentation, that can hinder dating, and limited inscriptions, equally important information can be obtained by analyzing the mineral composition of

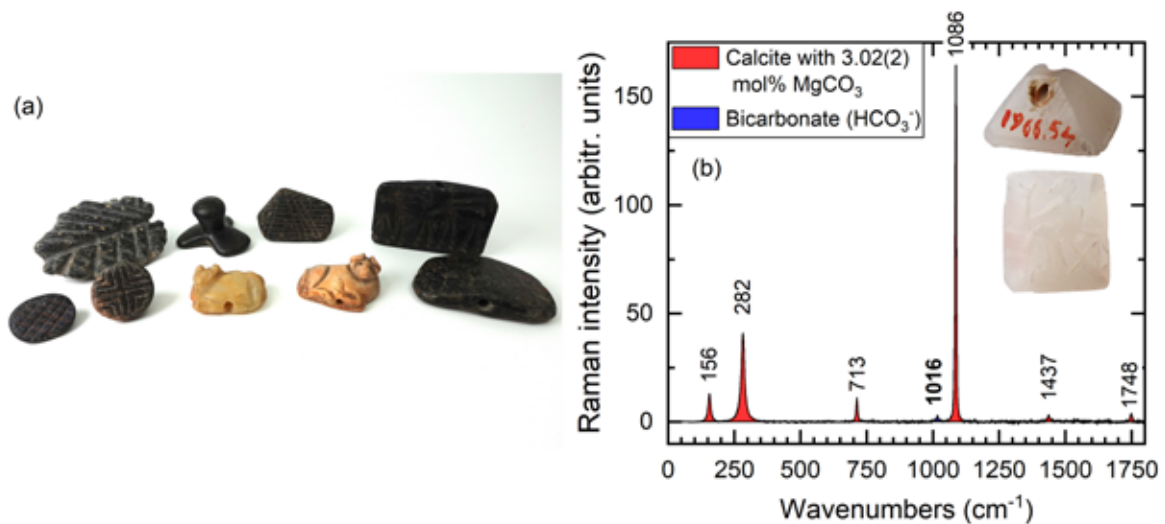


Fig. 1: (a) Selection of Prehistoric stamp seals (6th-4th mil. BCE) from the collection of MK&G, Hamburg and (b) Raman spectrum of an Early Dynastic stamp seal #1966.54 (3rd mil. BCE) made of biogenic Mg-bearing calcite, whose material was previously described as 'milk stone'.

such seals, which can advance provenance studies and identify possible treatment in modern times. For this purpose, non-destructive and non-invasive analytical methods capable of probing both chemistry and crystal structure, most notably Raman spectroscopy, are required for reliable identification of mineral phases in written artefacts such as stamp seals. Here, a series of 20 Ancient Near Eastern stamp seals, part of the collection of MK&G and dated between 6th-1st millennium BCE were analyzed by Raman spectroscopy following the methodological approach established for cylinder seals [2]. Our results demonstrate the insufficiency of classical gemmological characterization that should be revised (Fig. 1b), particularly when stamp seals consist of opaque minerals, and show that certain elements can be non-destructively quantified in phyllosilicate- and calcite-bearing seals among others.

Acknowledgements

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A photograph of an ancient Greek vase with a zoom lens in the foreground. The vase is dark with a light-colored band around the middle, featuring a figure. The zoom lens is on the left, partially obscuring the vase. The background is a museum setting with glass cases.

Extending the classical *in situ* Raman set-up: The case of the zoom lens

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ABSTRACT

Raman spectroscopy is widely acknowledged and used in archaeometrical research, amongst others for its *in situ* applicability. As such, this technique is now a well-established approach for obtaining molecular information during (mobile) measurement campaigns.

Typically, this approach largely depends on either direct contact of the instrumentation with the object that is analyzed, or by using a probe with a working distance of a few mm's. However, this required closeness to the surface can pose restrictions when analyzing cultural artefacts: sometimes it is not allowed to touch the objects due to their valuable or brittle nature. Moreover, artworks are often stored behind glass or in a glass display case, to protect the object by creating a physical barrier with the audience or to control the atmosphere to prevent (further) degradation. Removing the artefact away from this environment is thus often not advisable.

This raised the question to look beyond the classical approach. As such, coupling a



zoom lens (which typically has a working distance of several centimetres) with the laser probe was evaluated and showed promising results for application in the field [1].

In this study, different case studies are presented to reveal the potential of using a RTS201-NIR zoom lens (Metrohm) during mobile Raman measurements. In addition, the interference of the glass (thickness, type of glass, reflective coating) on the Raman acquisition is discussed.

Acknowledgements

The authors want to thank Meyvaert NV for the glass samples from display cases. In addition, we acknowledge all the people involved in the case studies. We want to thank the Ephorate of Antiquities of Phocis and the staff of the Delphi Archaeological Museum, especially the conservator Mr. Christos Pandermakis and the security personnel. For the case study under the AmphiPoly project, we would like to thank the Ephorate of Antiquities of Serres, as well as the staff of the Amphipolis archaeological museum. Part of this work (The Raman *in situ* measurements in September 2025) was financially supported by Research Foundation - Flanders (FWO): Short Stay Abroad (Grant number: K246424N). Financial support for the AmphiPoly project was received from the Greek Ministry of Culture.

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Statistical Analysis vs. Manual Interpretation in the Non-Invasive Study of 15th-Century Italian Tarot Cards

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ABSTRACT

This study investigates the pigments, inks, paper supports, and manufacturing techniques of eight illuminated tarot cards produced in Italy around 1435–1440, from the Rothschild collection of the Musée du Louvre. [1] Such illuminated cards are prestigious objects that have rarely been examined using non-invasive archaeometric methods. The identification of pigments is crucial for understanding the materiality of these rare artworks, of which only a limited number have survived.

Previous studies have examined the Milanese cards of the Visconti di Modrone tarot (c. 1441–1442, Yale University) and the Visconti-Sforza tarot (c. 1456–1458, Morgan Library). In contrast, the present research focuses on a corpus of Florentine cards attributed to the workshop of Giovanni del Ponte. [2] These cards are considered among the earliest

surviving European tarot decks. [3]

The methodology relies on the combined use of imaging and spectroscopic techniques. Infrared and ultraviolet false-color imaging provides an initial macroscopic assessment of pigments, inks, and dyes. These observations are complemented by reflectance imaging spectroscopy (RIS), 2D X-ray fluorescence (2D-XRF), Raman spectroscopy, and X-ray diffraction (XRD), enabling a more precise identification of coloring materials.

On one hand, data fusion, dimensionality reduction (t-SNE/UMAP), and clustering are applied to RIS and XRF-2D data cubes using DataHandlerP software [4]. On the other hand, traditional RIS and XRF-2D data processing methods (ENVI/SAM and PyMCA [5]) are used. The objective here is to evaluate the complementarity and limitations of both strategies in the analysis of 2D spectroscopic data. The results are further refined through point-based analysis (XRD and Raman). This work also aims to establish a robust methodological framework for the study of illuminated tarot cards providing new insights into the materials, techniques, and workshop practices of 15th-century Italian production.



Visible-light photograph of the Knight of Wands tarot card (©C2RMF, L. Clivet), alongside a clustering-based representation of the same card derived from analysis of a multimodal data cube combining three spectroscopic techniques (RIS-VNIR, RIS-SWIR, and XRF-2D) (©C2RMF, L. Pagnoux, E. Laval, K. Laclavetine, R. Moreau; ©LAMS, L. de Viguierie, L. Brunel).

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Decoding the Archaic Polychromy Palette:

A Collaborative Non-Invasive Investigation of 6th Century BCE Greek Architectural Masterpieces

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ABSTRACT

While the polychromy of Archaic Greek architecture was central to its original symbolic



and aesthetic power [1, 2], its systematic characterization remains a significant challenge due to the extreme fragility of surviving pigment layers. This research presents the results of a large-scale, multi-institutional collaboration between archaeologists, conservation scientists, and physicists. By pooling diverse expertise and laboratory resources, the team conducted a comprehensive, non-invasive investigation into three pivotal Late Archaic ensembles: the West Pediment of the Temple of Apollo at Delphi (plastered poros) [3], the Peisistratēion Telesterion at Eleusis (Parian marble), and the iconic marble lion-head waterspout (Akr. 69) from the Old Temple of Athena Polias on the Athenian Acropolis. This interdisciplinary synergy facilitated a complementary and non-invasive methodology that effectively bridges diagnostic mapping with targeted point-analysis. By utilizing a wide range of analytical techniques, spanning from Visible-Induced Luminescence (VIL), Remote Spectral Imaging and Hyperspectral analysis (SWIR 1000-2500 nm) to scanning Macro-XRF, pXRF, FORS and Micro-Raman spectroscopy [4, 5], a comprehensive characterization of the surviving surfaces was achieved. The findings from this research do more than just expand the known chromatic gamut of the 6th century BCE; they provide a mandatory diagnostic framework to guide future conservation, demonstrating that the survival of these masterpieces depends on the continued integration of collaborative heritage science.



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SESSION 2

NON-INVASIVE AND NON-DESTRUCTIVE ANALYTICAL APPROACHES: INSIGHTS FROM CULTURAL HERITAGE CASE STUDIES

SESSION CHAIR - LAVINIA DI FERRI



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ORAL
ABSTRACTS

A Multidisciplinary Study of António Carneiro's Triptych *Life – Hope, Love and Longing* (1899–1901): Insights into Material Preferences and Working Methods

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ABSTRACT

The case study of the triptych *Life – Hope, Love and Longing* (1899–1901) by the Portuguese Symbolist painter António Carneiro (1872–1930) is presented with the aim to elucidate the artist working methods and material preferences during his early period. Carneiro began the work in Paris for the 1900 Universal Exhibition—where the central panel was first displayed—and completed the right wing in Oporto [1,2]. The artwork is analysed alongside a compositional oil study and a red chalk drawing.

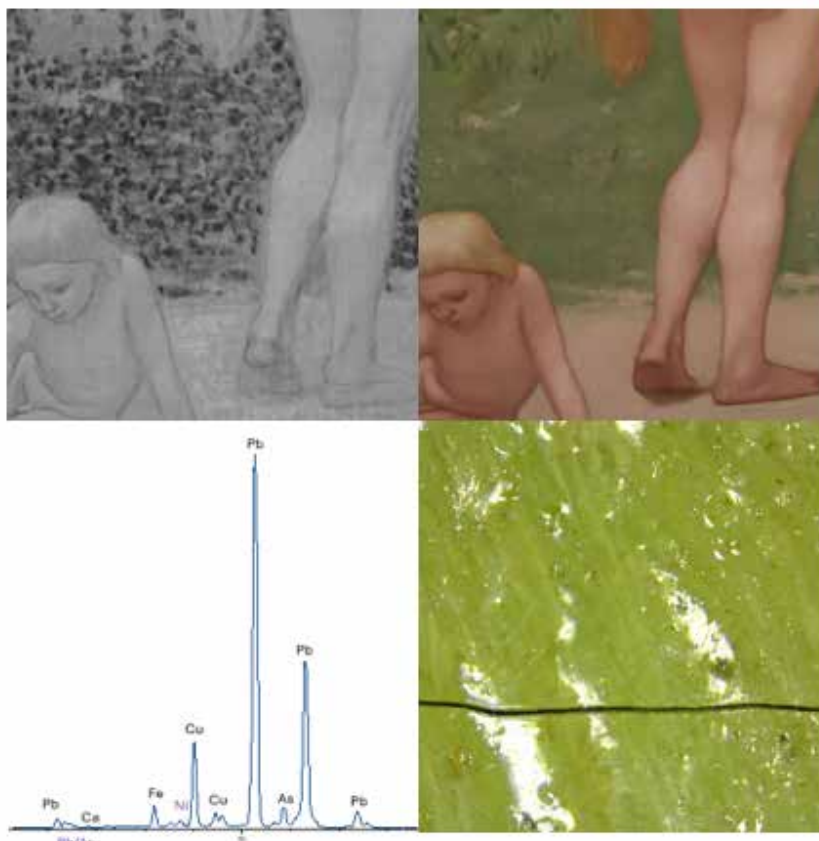
The research employed a suite of non-invasive analytical techniques, including digital photography, Infrared Reflectography (IRR), Ultraviolet Fluorescence (UVF), and X-ray Fluorescence Spectrometry (XRF).

Results indicate that Carneiro used industrially produced canvas supports with ground



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layers composed of lead, zinc and calcium. Analysis of the underdrawings revealed the use of transfer methods such as squaring and potentially mechanical instruments (e.g., pantograph or proportional divider) to ensure scale accuracy between the studies/drawings and the final composition. While XRF identified lead, iron, chromium, copper, zinc and mercury, the complex tonal ranges suggest the presence of other elements beyond the detection limits of the employed technique. A technical shift was identified in the final panel (*Longing*), suggesting a later and distinct execution compared to the two panels painted in Paris.



Acknowledgements

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Under a pale blue sky: The tale of three saints united in a 16th century Portuguese panel painting

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ABSTRACT

The 16th century Portuguese panel painting, depicting three saints (175×156 cm), and belonging to the National Museum of Fine Arts (inv. 1505 pint), constitutes an intriguing case due to the uncertainty surrounding its authorship, provenance, and the identity of the figures depicted. Preserved in the museum since 1913, the painting was in a complex material condition, showing signs of extensive structural interventions in the support and a painting surface almost entirely repainted. Given the limited information available about this work and considering it one of the rare early examples of Italian-inspired Mannerist values in the museum's collection, a conservation intervention was undertaken in the years 2024 to 2026.

To further advance the knowledge on this painting, the investigation was built on three pillars: 1) archival and bibliographic research; 2) systematic gathering of material

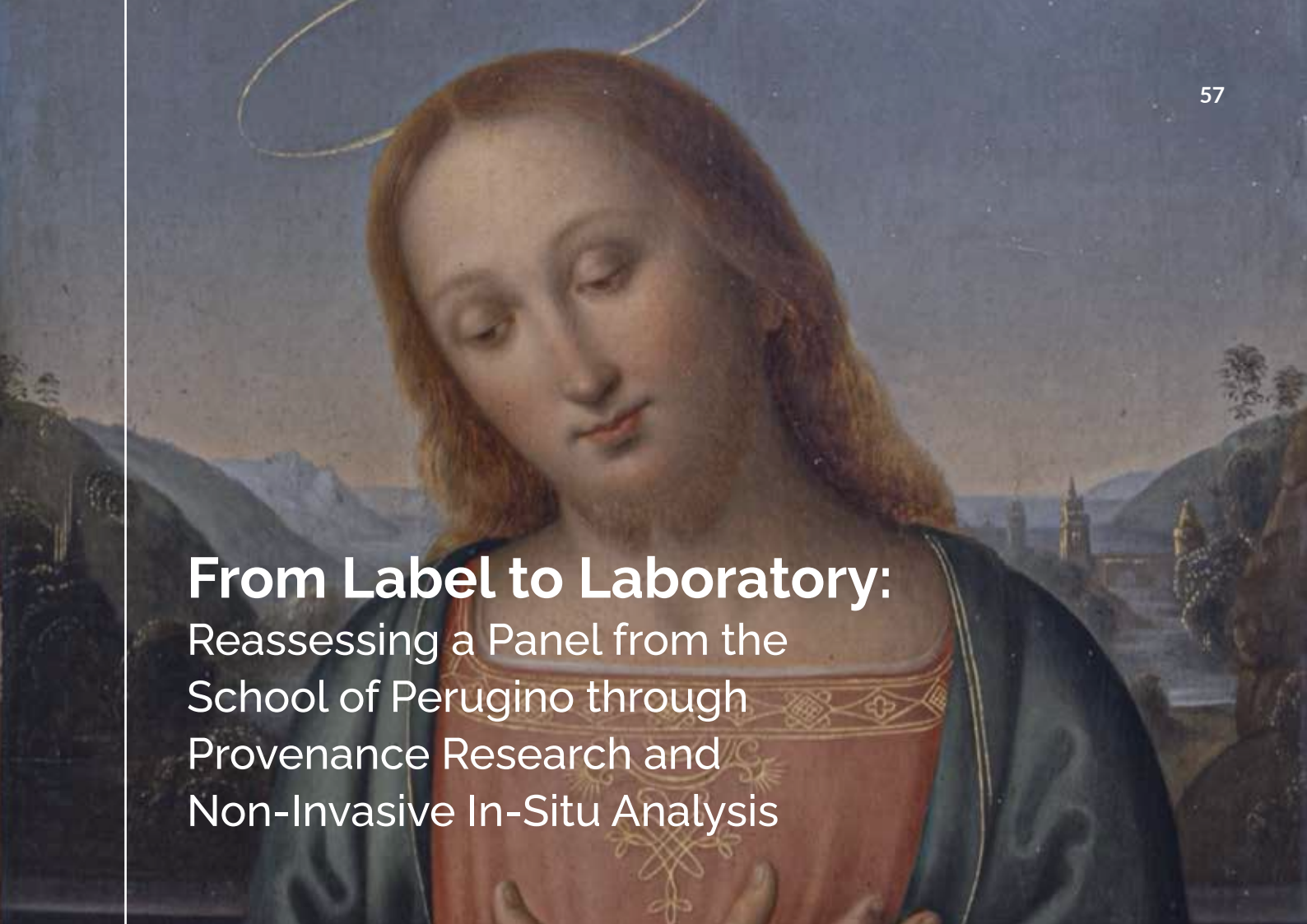
evidence during the conservation treatment, and 3) material analysis of the painting.

For the latter, the painting was investigated with complementary non-destructive imaging techniques, including visible and ultraviolet radiation, infrared reflectography, digital radiography, and 2D MA-XRF mapping (CRONO). Paint samples were collected, mounted as cross-sections, and the materials were analyzed with optical microscopy (OM), Fourier-transform infrared spectroscopy (FTIR) and scanning electron microscopy coupled with energy-dispersive X-ray spectroscopy (SEM-EDS).

Beyond the identification of painting materials common to the 16th century, this integrated approach contributed to the establishment, albeit partial, of the painting's material history, and highlighted particular characteristics of the underdrawing and painting technique that will assist in the identification of this painter. In this process, it unveiled surprising features about this artwork, notably that the three saints were never meant to be presented in a unified composition, as the wooden boards that make the panel were not originally assembled as they are now. The material understanding of this painting opened a new pathway of research. It also promoted a critical reassessment about which final image to be presented, and given the condition of the painting, if it would be materially possible to reach that goal.



Fig. 1: *Three Saints*, c. 1550, Portuguese School, 175 x 156 cm, before the 2024-26 conservation treatment (a); location of sample in the sky (b), and respective cross-section under OM-Vis (c). © Helena Melo, 2024-25.



From Label to Laboratory: Reassessing a Panel from the School of Perugino through Provenance Research and Non-Invasive In-Situ Analysis

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ABSTRACT

This paper presents an interdisciplinary reassessment of a small Renaissance panel painting in the Museu Medeiros e Almeida (Lisbon), historically labelled *Head of Christ* and traditionally attributed to Gerino da Pistoia (1480-1529). The image, however, may not depict a bust-length Christ, making the object an especially productive case for testing how inherited attributions and iconographic identifications can be re-evaluated through the combined use of art-historical and scientific evidence.

The study integrates provenance research and comparative visual analysis with a noninvasive, in-situ analytical workflow. On the historical side, it revisits the attribution narrative associated with Bernard Berenson (1865-1959) while placing particular emphasis on the twentieth century collecting history of the painting, including its



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connection to a little-studied British art collector born in Funchal (Madeira), descended from an Anglo-Swedish family established on the island. This provenance strand is examined alongside a comparative reading of the painting's figure type and stylistic features within the School of Perugino and the wider Perugino-Raphael artistic milieu.

On the technical side, the object was examined through visible, UV, and reflected infrared imaging, IR false-colour, macro X-ray fluorescence (MA-XRF) elemental mapping, and hyperspectral imaging.

The results demonstrate the value of analytical integration for attribution-oriented research. Rather than isolating single datasets, the study combines elemental mapping and multimodal imaging to interrogate the painting's material structure, chromatic construction, and execution sequence in relation to art-workshop practice, and later reception. Without anticipating the full discussion, the analytical correlation also opens a particularly relevant line of inquiry concerning the painting's blue passages, with direct implications for how material choices and pictorial hierarchy are interpreted in this case.

By bringing a little-studied panel associated with the School of Perugino from a museum collection into focused scholarly discussion, and by demonstrating how integrated non-destructive in-situ analysis can materially reshape attribution pathways, this paper offers a high-value case study with the potential to generate broad debate on the visibility, interpretation, and research activation of overlooked works.

Acknowledgements

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Fit for a king:

Investigating the materiality of four Indian paintings from the Mughal period

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ABSTRACT

This paper presents the preliminary results of an investigation into the materials and techniques used in the production of four well-preserved Indian paintings on paper, painted in different locations across the Indian subcontinent. It provides an opportunity to compare the early imperial style with that of a Mughal province, and to gain information on the materiality of these complex objects, on which very limited comparable literature exists [1,2]. Two of the paintings were part of a Padshahnamah manuscript produced c. 1635–50 and formerly in the Mughal imperial library, which was sent as a diplomatic gift to King George III in 1798 and is today in the Royal Library, Windsor Castle, as part of the Royal Collection. The other two paintings were likely created in Murshidabad, the capital of the Nawabs of Bengal, around 1750. They were brought to Scotland by Archibald Swinton (1731–1804) when he returned home in 1766



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after a career in the East India Company and are today in the collections of National Museums Scotland.

The paintings were investigated non-invasively using X-ray fluorescence mapping (MA-XRF) and Fibre Optics Reflectance Spectroscopy (FORS) to study their constitutive materials and painting techniques and to evaluate their state of conservation. Where possible, they were also imaged using infrared, UV and X-ray technology. Initial results reveal the extensive use of a range of metals and an overall similarity in palette, which in most cases includes red lead, vermillion, Indian yellow, as well as organic pink colourants. Different green hues were obtained by mixing indigo with a yellow pigment, and with a range of copper-based minerals.

This work provides an opportunity to compare information obtained in different laboratory setups for cross-institutional collaborative work on Indian paintings and explores the potential that these materials insights have to tell us more about the multi-cultural societies which produced these small-scale masterpieces.



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Opaque *champlevé* (13th cent.) and translucent *basse-taille* enamels (14th cent.): First portable-based XRF mapping study

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ABSTRACT

Metal enamelling represent a key chapter of medieval goldsmithing. From the late 13th century, opaque enamels were progressively complemented and partly replaced by translucent ones, marking a major technical and aesthetic development. Over time, production centres such as Limoges, Paris, and Siena developed specialized procedures. Attribution of medieval enamelled metalwork remains challenging due to strong similarities across regions, limiting stylistic analysis alone and highlighting the importance of archaeometric approaches. Mostly, previous studies employed micro-destructive analysis [1] or laboratory-based micro-chemical mapping [2], restricting their application to valuable museum artefacts, with only a few examples of portable point-analysis approaches [3]. This study presents results from an in situ campaign using a portable X-ray fluorescence (Elio Bruker) spectrometer with XY mapping system to characterize opaque 13th-century *champlevé* enamels from a private collection and translucent 14th-century *basse-taille* enamels from Italian and French jewelled goldsmith works preserved in Italian museums [4,5]. The aim is to assess the potential of



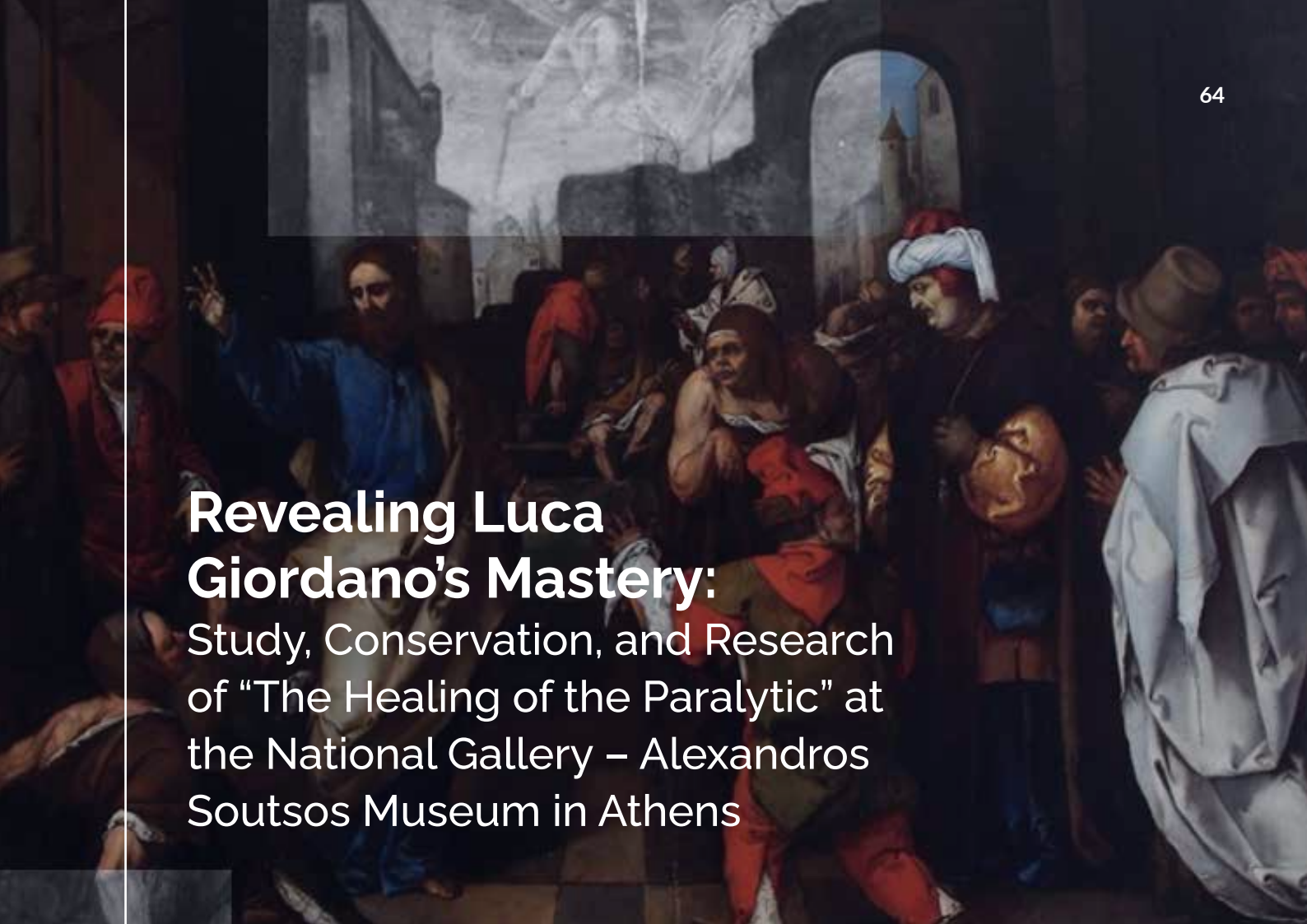
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portable XRF mapping for the *in situ* characterization of chromophores and opacifiers. Despite limitations in detecting elements associated with glass formers and fluxing agents, this approach represents one of the first systematic applications of portable XRF mapping to these materials. The results demonstrate a strong correlation with traditional destructive microchemical analyses, supporting the reliability of this non-invasive method and its potential for broader application in museum contexts.

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Revealing Luca Giordano's Mastery: Study, Conservation, and Research of "The Healing of the Paralytic" at the National Gallery – Alexandros Soutsos Museum in Athens

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ABSTRACT

The painting **"The Healing of the Paralytic"** by Luca Giordano (1634–1705), held in the European collection of the National Gallery – Alexandros Soutsos Museum, is an artwork of considerable importance by the Neapolitan artist and presents a particularly intriguing case of deception in the field of art history.

In 1653, Giordano—renowned for his "extraordinary virtuosity" in emulating the techniques of past masters—created this painting in imitation of Albrecht Dürer and sold it as a Dürer original. The work subsequently disappeared, and by 1933, all traces of it had been lost. In 1967, the painting was acquired by the National Gallery of Athens and catalogued as the work of an unknown artist. During the 1990s, suspicions arose regarding its true identity, suggesting it might be the lost Giordano, and its complex history gradually began to unfold.

The research methodology adopted a multi-analytical approach, integrating



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both non-invasive and micro-destructive diagnostic techniques. Initial investigations included:

- **Imaging techniques:** Technical photography for conservation documentation, multispectral imaging (UVF, IRR), and X-ray radiography, which enabled the detection of hidden features such as the artist's signature, date, pentimenti, underdrawings, and evidence of previous interventions.
- **Material analysis:** Separation methods, optical microscopy, and selective staining applied to characterize the painting's technique and stratigraphy, including pigments, binding media, and ground layers.

The painting had undergone restoration prior to its acquisition by the National Gallery; however, in 2008, it was decided that a comprehensive conservation treatment was necessary. These interventions stabilized the pictorial surface, removed oxidized varnishes, and revealed layers of overpainting that had obscured key elements of the original composition, including Dürer's monogram.

Today, the artwork constitutes a compelling case study at the intersection of art history, technical examination, and conservation science. Ongoing research employs advanced, non-invasive technologies—including imaging, X-ray-based methods, and spectroscopic instrumentation—for the *in situ* characterization of materials, artistic techniques, and degradation processes, in collaboration with other institutions.

By correlating historical archival data with analytical findings, this study offers a holistic account of the painting's trajectory, from the artist's studio to its present condition within the permanent collection of the National Gallery – Alexandros Soutsos Museum.

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Deconstructing deception:

New findings on Luca Giordano's

The healing of the paralytic (1653) in

the style of Albrecht Dürer (National

Gallery – Alexandros Soutsos Museum)

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ABSTRACT

According to contemporaries, the Neapolitan artist Luca Giordano (1634-1705) had devised a particularly creative strategy to market his works and direct attention to his artistic abilities. Giordano created several works in the style of other renowned artists, which were passed off as originals to unwitting clients. These deceptions were created carefully: from the selection of the prototype and correspondent painting materials to the application of darkening mixtures. Although the ingenious deceptions were occasionally derided, Giordano's contemporaries mostly lauded his chameleonic ability to transform his *maniera*. [1,2]

One of the most intriguing examples is *The healing of the paralytic* (1653) in the style

of Albrecht Dürer, currently held at the National Gallery-Alexandros Soutsos Museum. Arguably, this is the very painting that Giordano sold as an original Dürer to a prior, before triumphantly unveiling his own authorship. [2] Ever since Wilhelm Valentiner devoted an article to Giordano's Düreresque imitations in 1913, this crafty imitation has intrigued audiences and scholars alike.[3] A substantial body of scholarship has shed light on the socio-artistic context of Giordano's deception, yielding spectacular findings, such as the presence of a large *pentimento* and a second signature. [4-6]

In the context of the ERC-Consolidator Grant project ARTDETECT, hosted at Ghent University, we subjected *The healing of the paralytic* to a variety of non-invasive state-of-the-art research techniques. These included hyperspectral imaging (HSI), macro X-ray fluorescence (MA-XRF), Raman spectroscopy, and micro-XRF, micro-Raman and lead isotope analysis on existing samples. This was done to gain a deeper insight into the material genesis of Giordano's deception. By relating some intriguing new technical findings to a close reading of primary sources (both textual and visual), we can shed new light on Giordano's deceptive imitation and examine how it was produced, circulated and received within the wider context of his artistic practice and the historical period in which he lived.



Acknowledgements

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SESSION 3

NEW FRONTIERS IN CULTURAL HERITAGE SCIENCE: DIGITAL, TECHNOLOGICAL AND SUSTAINABLE INNOVATION

SESSION CHAIR - SHUJOY CHAKRABORTY



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ORAL
ABSTRACTS

Convergence and Collaborative Innovation: Construction Practices and Achievements of the China-Portugal Belt and Road Joint Laboratory on Cultural Heritage Conservation Science

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² The Palace Museum of China

ABSTRACT

The China-Portugal Belt and Road Joint Laboratory on Cultural Heritage Conservation Science was jointly established in 2020 by Soochow University, City University of Macau and the University of Évora. It is the only national-level international innovation platform in the field of architectural cultural heritage. This report systematically introduces its organizational framework, operational mechanism and representative achievements. The laboratory brings together more than 100 high-level researchers at home and abroad, with a four-center system covering cultural exchange, talent training, innovative R&D and new-quality industries.

In research, it focuses on heritage conservation theory and practice, conservation materials development, and heritage education and international communication, forming a complete system from methodology and key technologies to industrial application and global promotion. In cooperation, it has built a tripartite collaborative mechanism, initiated an international consortium for built heritage conservation, set up



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global offices, and established an international network cooperation covering more than 30 countries.

This model provides a replicable institutional example for transnational scientific and technological cooperation. Through the integration of science, technology and humanities, it contributes Chinese wisdom and solutions to the sustainable development of cultural heritage and mutual learning of civilizations worldwide.





Fatigue Testing of Painting-Like Samples under Transport-Induced Excitation

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ABSTRACT

While paintings are often perceived as static objects, they often undergo mechanical vibrations, which can gradually lead to material fatigue, hence painting deterioration. Besides various vibration sources originating from construction works, museum visitors or street traffic, art transportation remains one of the most significant factors, therefore requiring further investigation by conservation scientists. Transport-induced vibrations can be quantified through experimental measurements, with several studies reporting such measurements in the literature. However, a reliable tolerable vibration threshold, which would enable the explicit definition of objective protection criteria, is yet to be established. In order to set a meaningful fatigue threshold, the duration and level of vibration exposure should be considered additionally to the individual painting characteristics, such as material properties, aging state, layer structure and many more. In this regard, a closed-loop controlled fatigue test rig has been developed in [1], enabling the extraction of material specific S-N curves (stress vs. number of cycles). The curves are obtained by investigating the endurance limit of painting-like samples under the application of prolonged cyclic loads of stable amplitude. The use of painting-

like samples not only allows experimental investigation without risking damage to real artworks, but also ensures consistent reproducibility among specimens, while reducing complexity. Additionally, a harmonic excitation signal is employed owing to its practical advantages. As a natural extension to this work, the current project considers the application of the method under more realistic transport conditions. To address this, the study investigates the specimens' fatigue, when subjected to an actual transport-induced excitation signal. Due to its varying amplitude and spectral characteristics, a new dynamic and real-time control system is introduced within this framework, ensuring the signal's accurate reproduction. In this case, fatigue is estimated after decomposing the signal to its equivalent individual load cycles, using the rainflow counting method. The obtained results are then compared with our previously measured S-N curves to evaluate the transferability of fatigue behavior derived from harmonic loading to more realistic excitations.

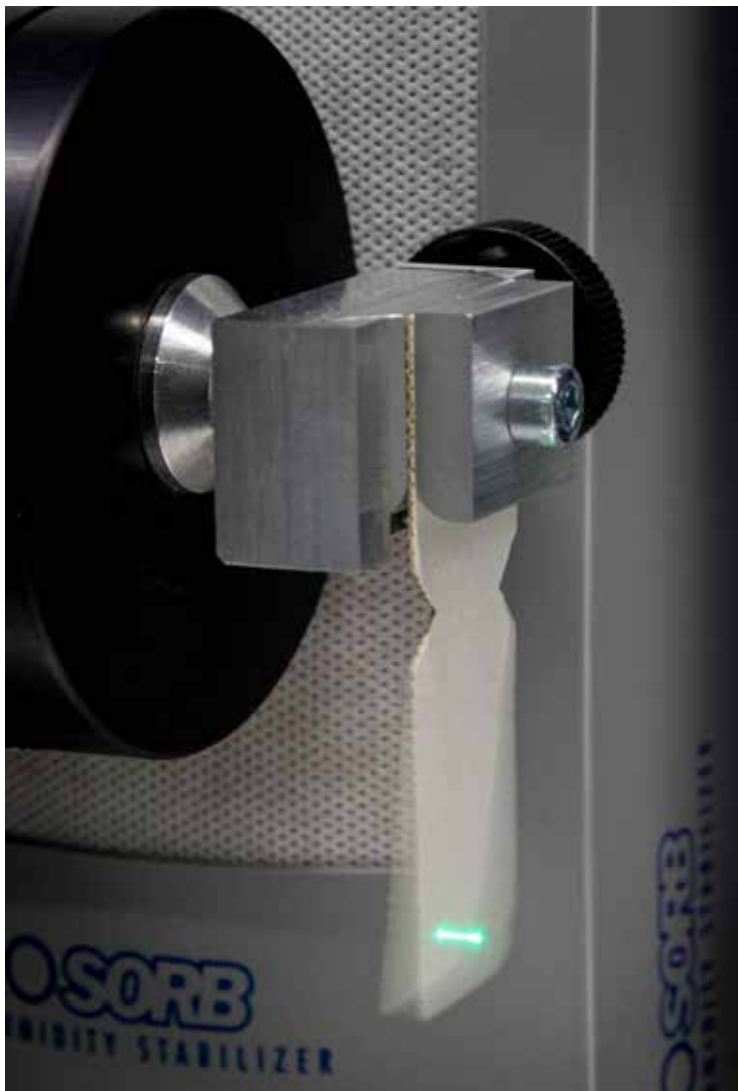


Figure 1: Vibration of the painting-like specimen under shaker excitation.

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FAIRification in Practice: From Interoperability to User-Centered Data Discovery in INFRA-ART

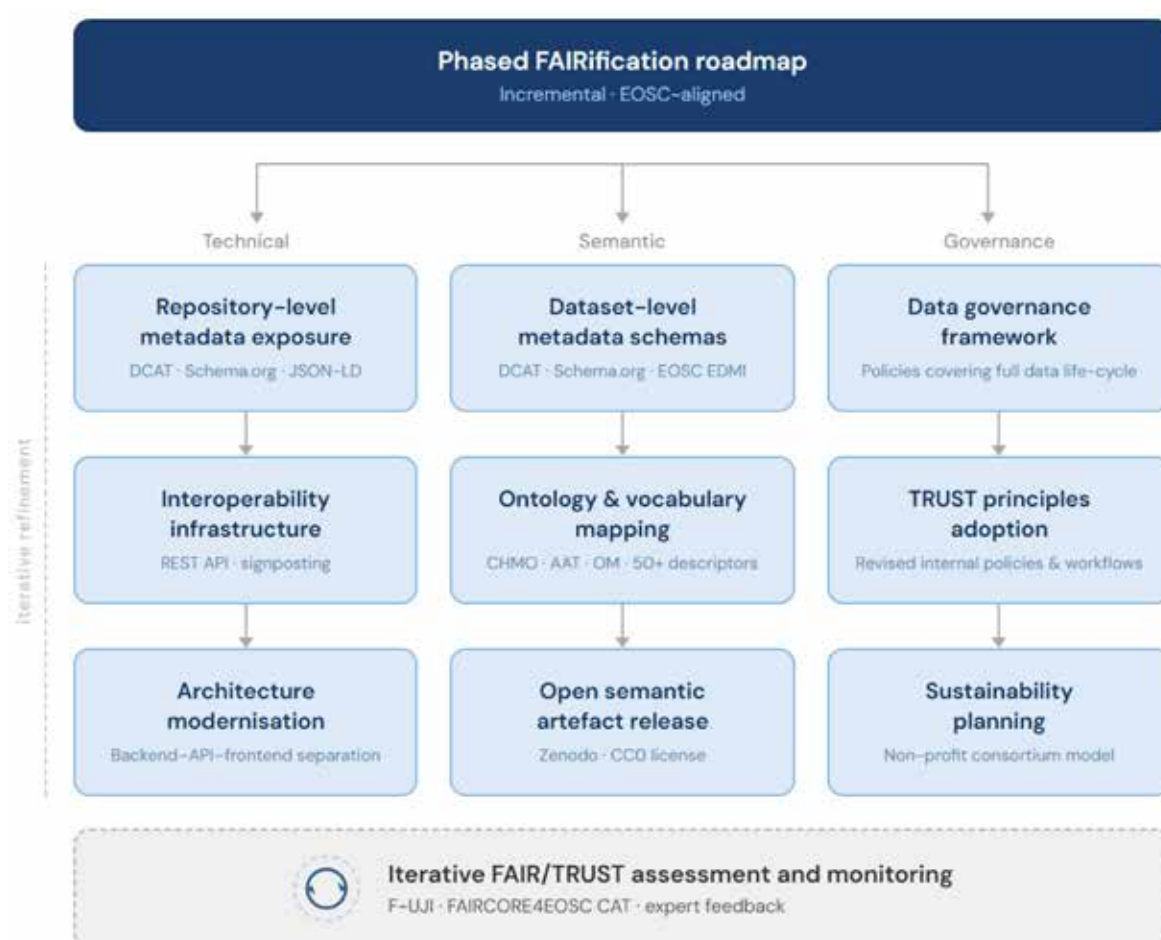
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ABSTRACT

The INFRA-ART Spectral Library (<https://infra-art.eu>) has recently undergone a FAIRification process, evolving from an open access but weakly interoperable database into an EOSC-aligned data research infrastructure [1]. This contribution presents the INFRA-ART FAIR journey as a case study, highlighting the interplay between policy frameworks, technical implementation, and user-centered service development. The FAIRification process followed an iterative, roadmap-driven approach aligned with the EOSC Interoperability Framework and complemented by the TRUST principles. Key developments include the implementation of machine-actionable metadata (DCAT, Schema.org), semantic enrichment through alignment with domain ontologies and controlled vocabularies, and the introduction of persistent identifiers and standardized access mechanisms. In parallel, the platform architecture was redesigned and now exposes a REST-based API, enabling programmatic access and integration with external services. Building on this technical foundation, a range of user-oriented search tools were developed to enhance data discovery and usability. These include an advanced

multi-criteria search, as well as dedicated analytical tools such as FTIR peak-based and XRF elemental search, enabling data-driven material identification and comparative analysis. All functionalities rely on manually curated data, ensuring high levels of accuracy and scientific reliability. The INFRA-ART case study demonstrates how FAIR and TRUST principles can be operationalized within a domain-specific, researcher-led infrastructure. It also highlights key challenges and lessons learned, particularly regarding semantic interoperability, resource constraints, and the need for sustained data stewardship. By linking FAIR policy frameworks with practical implementation and user needs, this work provides transferable insights for the development of sustainable, interoperable data services in heritage science and related fields.



The screenshot displays the INFRA-ART Spectral Library website. At the top, there are logos for FAIR (Findable, Accessible, Interoperable, Reusable), EOSC (European Open Science Cloud), and the INFRA-ART project. The main header features a large, colorful abstract painting. Below the header, a navigation bar includes links for ABOUT, DATABASE INDEX, DATA GOVERNANCE, COMMUNITY FEEDBACK, RESOURCES, and CONTACT. The central section is titled "Welcome to INFRA-ART Spectral Library" and describes it as a FAIR Open Access Digital Resource for Heritage Science, Conservation & Education. A search bar is prominently displayed with the following fields: "Keyword(s)" (containing "eg, Copper"), "Material class" (a dropdown menu), and "Data type" (a dropdown menu). A "Search" button is located to the right of these fields. Below the search bar, there is a section titled "Spectral Data Search" with a sub-section "Search by FTIR". This section includes a "Peak value(s) / cm-1" input field with a placeholder "Add peak value" and a "Material class" dropdown menu. A note below the input field states "Press enter to add values between 380 and 4000". There is also a checkbox labeled "Search +/- 2 cm-1 from entered values". To the right of the input field, there is a diagram of a person with arrows pointing to them, labeled "user-centered data discovery tools". Below the input field, there is a diagram of a document with a gear, labeled "manually curated datasets". A "Search" button is located at the bottom right of the "Spectral Data Search" section.

Acknowledgements

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Supervised segmentation of OCT image stacks for automated layer thickness mapping in paintings

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ABSTRACT

Non-invasive characterization of the stratigraphy of heterogeneous paint layers is a key challenge in art diagnostics, due to the presence of optically opaque materials that limit light penetration. Optical coherence tomography (OCT) is widely employed for this purpose thanks to its non-invasiveness, portability, and ease of use [1]. Conventional approaches for the precise measurement of micrometric layer thickness in paintings rely on manual identification of reflectivity peaks along individual A-scans [2]. However, this procedure is time-consuming, operator-dependent, and unsuitable to the statistically robust analysis of full volumetric datasets.

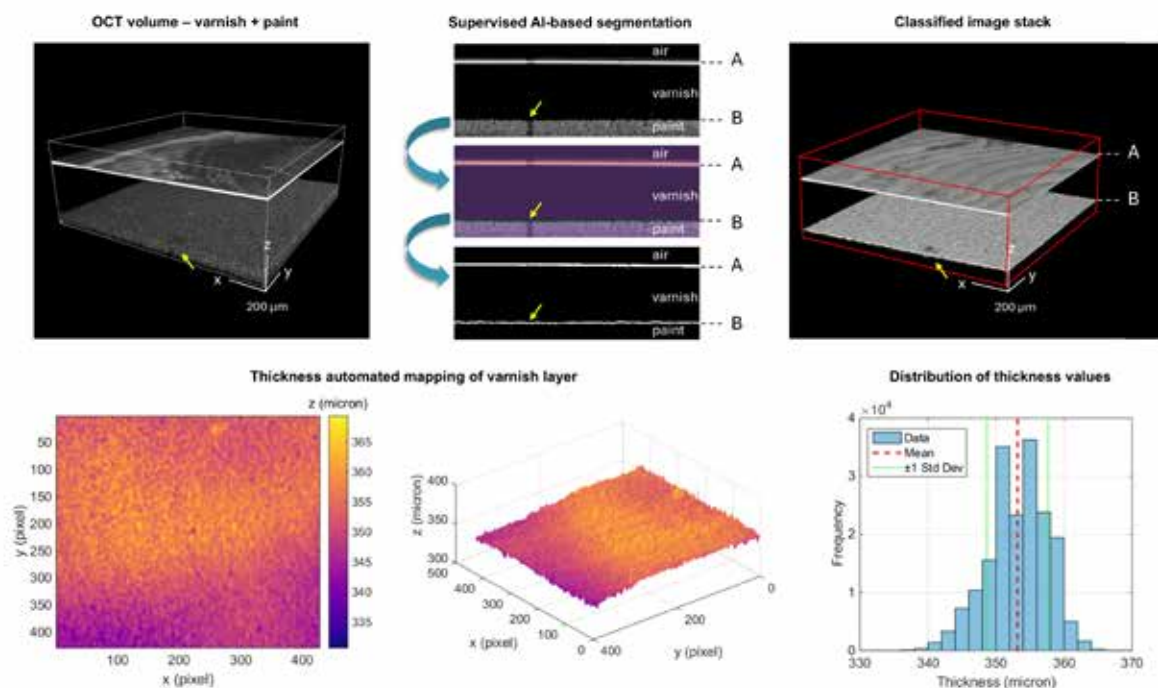
To address these limitations, we developed an automated framework that integrates supervised semantic segmentation of OCT B-scans with quantitative post-processing for layer thickness extraction. Segmentation is performed using a Random Forest classifier implemented in the Trainable Weka Segmentation [3] environment to delineate material interfaces, followed by automated interfacial distance computation via a custom MATLAB routine. The method enables pixel-by-pixel thickness quantification across



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entire OCT volumes.

To the best of our knowledge, this is the first application of a fully automated, AI-based segmentation and thickness quantification pipeline to OCT data in the cultural heritage domain. Our results demonstrate that the proposed approach is robust and generalizable across different samples and OCT systems, achieving levels of accuracy unattainable with traditional manual analysis. Importantly, the workflow is user-friendly, requires no advanced programming expertise, and can be extended to volumetric datasets acquired with other optical and imaging modalities.



Acknowledgements

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Sounding the Invisible: A 3D, Multi-Analytical, and Data-Driven Reconstruction of King João IV's Musical Library at Vila Viçosa

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ABSTRACT

This paper presents ARIA as an integrated heritage-science framework for the documentation, conservation, and digital reactivation of King João IV's former 17th century Musical Library at the Ducal Palace of Vila Viçosa. The project combines high-resolution 3D spatial recording, material and condition assessment of mural paintings, environmental monitoring, and acoustic analysis to study the library as an interconnected architectural, pictorial, and sonic environment. Rather than treating the site as a static historic interior, the project approaches it as a complex heritage ecosystem in which architecture, mural painting, microclimatic behaviour, and acoustics response effect, and musical repertory are fundamentally interconnected. By doing so, ARIA addresses a key issue in contemporary heritage research: how can fragile early modern spaces be transformed into rigorous, interoperable bodies of knowledge that support conservation and renewed interpretation?



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The project combines spatial documentation, material research, environmental assessments, acoustic analysis, and digital modelling to address this question. A technical analytical study of the mural paintings was also undertaken through in situ area-based examination using non-invasive methods, to characterize materials, execution procedures, and surface alteration phenomena. These performed tasks allowed to identify variations in pigment use, layering, and application techniques, as well as possible revisions and adjustments introduced during the painting process. By integrating these results with the spatial and decorative analysis, the project contributes to a more precise understanding of the creative process and working practices of the 17th century painters involved. The library rooms are reconstructed as a high-resolution, 3D environment capable of recording form, decorative phases, spatial relationships and acoustic behaviour, at a valuable level of precision for both scholarship and dissemination. At the same time, the painted surfaces are examined as material archives, whose condition, chromatic instability, and degradation reveal the site's long-term vulnerabilities. This technical reading is further enriched by the study of light, temperature, humidity, and acoustic response, allowing the room to be understood not simply as an image-bearing space, but as a performative environment shaped by atmosphere, use, and sound.

Aria's digital platform integrates dimensions for virtual acoustic reconstruction and immersive access, offering a robust, environmentally aware, and accessible heritage innovation model. Its unique approach shows how 3D reconstruction can be a critical tool for sustainable conservation, historical interpretation, and reactivating complex cultural heritage environments.

Acknowledgements

IN2PAST for financial support of the exploratory Project ARIA (EXPL/In2Past/2024/13 IN2PAST).

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The analytical evolution of an illuminated manuscript - from invasive microanalysis to spectral Imaging and Machine Learning

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ABSTRACT

The study of illuminated manuscripts has undergone a significant methodological reconfiguration over recent decades, moving from micro-sampling approaches based on laboratory molecular and elemental analyses towards increasingly non-invasive, spatially resolved, and data-driven methodologies. Rather than framing this transition as a linear technological progression, this paper reflects on the evolving analytical paradigms which shape the study of cultural heritage, emphasising the interplay between methodology, material knowledge, and interpretation. This perspective is explored through an exceptional heritage named *Harmony of the Gospels* (BPE CXXV/2-4), preserved at the Public Library of Évora (Portugal). The Gospel frontispieces retain two distinct phases of execution - a medieval illuminated initial and text, and a later Renaissance decorative frame - offering a rare opportunity to compare materials and painting practices within the same object. Approximately thirteen years ago, the manuscript was investigated using micro-analytical techniques (h-EDXRF, SEM-EDS,



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LC-MS, micro-FTIR), enabling the identification of pigments, extenders, and binding media through targeted sampling. More recently, it has been re-examined using non-invasive approaches, namely hyperspectral imaging (HSI) and multispectral imaging (MSI), specifically the XpeCAM Solution which combines the state-of-the-art of machine learning algorithms for material classification and mapping surfaces features. By placing these analytical moments in dialogue, this study aims to critically assess their scopes, limitations, and complementarities. Beyond resolutions, data interpretability, and applicability to complex systems, the core reinforces a key premise: technological advances do not replace earlier knowledge; they re-contextualise, and potentiate an expanded and deeper understanding.

Acknowledgements

This work was financially supported by strategic projects UID/04449/2025 and 10.54499/LA/P/ 0132/2020. Jani Santos acknowledges FCT for the PhD grant 2023.04832.BDANA. All the authors thank the Public Library of Évora and its members for their collaboration and support.



Project DT4SST-CH.PT - Digital Twins for Smart, Sustainable Tourism and Cultural Heritage Preservation. New synergies towards the future of CH management in Portugal

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ABSTRACT

The concept for DT4SST-CH.PT project appeared as a natural follow-up of the Património Cultural 360 initiative, where it was clear how the use of and implementation of technology and innovation is necessary to the Cultural Heritage sector in Portugal. Access, Interpretation and Prevention are key factors for a more sustainable future threatened by a persistent lack of resources, tourism related challenges and the unpredictability of climate change events.

Developed by a multidisciplinary and transdisciplinary team, this project proposes the application of Digital Twin technology to support the preservation, management, and public engagement of cultural heritage sites. The methodology encompasses the



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integration of LiDAR and photogrammetry-based 3D models with an AIoT environmental and anthropogenic monitoring system, allied with immersive interfaces to produce dynamic, operational digital replicas designed to serve both the public and the site managers, promoting effective heritage stewardship strategies.

The paper will focus on the results of six pilot implementations across the country, chosen for their historical and tourism significance and diversity, and conservation challenges. The methodology explores various technological solutions for supporting smart tourism, improving public engagement and immersive experiences, site management optimization and the creation of AI supported predictive systems towards the mitigation of degradation agents. By laying the groundwork for a replicable model and scalable framework, the project is expected to provide a roadmap for cultural institutions in Portugal to adopt smarter, more sustainable, and more engaging approaches to heritage preservation and public access.

SESSION 4

SUSTAINABLE CONSERVATION MATERIALS AND ENVIRONMENTAL MANAGEMENT

SESSION CHAIR - AURÉLIE TOURNIÉ



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ORAL
ABSTRACTS

Searching for a compatible material for future restoration of the Archaeological Park of Herculaneum: A study comparing twelve types of tuffs from Italian quarries

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⁷ Herculaneum Conservation Project, Ercolano, Italy

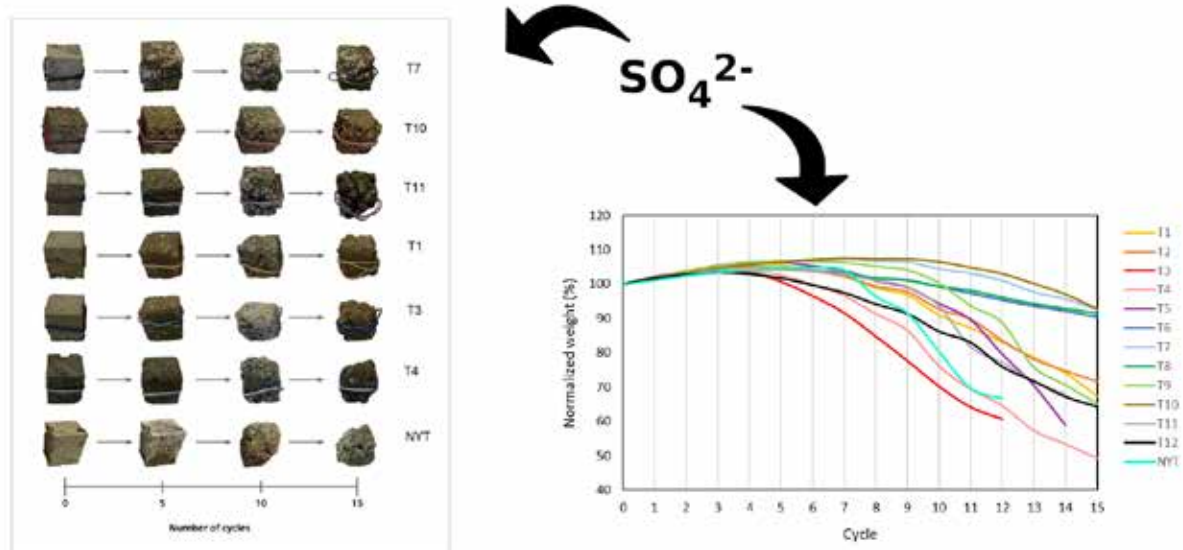
ABSTRACT

The Archaeological Park of Herculaneum is one of the best-preserved Roman sites in the world. Although the layer of volcanic material that covered it guaranteed its initial preservation, the excavation works accelerate degradation processes, including the deterioration of the Neapolitan Yellow Tuff (NYT) used in the construction of most of the buildings. This material is very vulnerable to the degradation known as “tuff rotting”; caused by the crystallisation of soluble salts that rise by capillarity from the ground.



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As the NYT quarries are closed, the Herculaneum Conservation Project (HCP) and the Archaeological Park of Herculaneum (PAErCo) are looking for a compatible volcanic tuff for future restoration. IBeA research group, in collaboration with HCP and PAErCo, is carrying out comparative studies of twelve different types of tuffs from Italian quarries to identify the best alternative to replace the degraded original tuff. Mineralogical analysis (XRD), elemental analysis (XRF), colorimetric, mercury porosimetry, mechanical compression tests on both dry and wet samples, and tests to determine the resistance to crystallisation of sulfate, nitrate and chloride salts were carried out. According to the results, some of the tuffs might be suitable for future restoration, and four were chosen for the next round of consolidation tests. The analyses also determined that the degradation of the tuffs is due to physical rather than chemical processes.



Acknowledgements

This work has been supported through the SIDIRE project (PID2023-146230OB-I00 funded by MCIN/AEI/ 10.13039/50110 0 011033 / FEDER, UE) and the Consolidated Research Group Project 2026-2029 (IT1862/26).

PFAS-Free Dendritic Coatings for Sustainable Protection of Stone Heritage

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ABSTRACT

Natural Stone is widely used in modern architecture and built and movable heritage, yet it is highly vulnerable to degradation driven by environmental, chemical, and biological factors. Among these, water is recognized as the primary agent responsible for stone decay and aesthetic alterations. For this reason, the development of novel, sustainable, and highly effective solutions to mitigate water-induced damage remains an urgent challenge with significant socio-economic and cultural implications worldwide.

Recent advances in coatings technology, particularly those based on fluorinated polymers, have shown promising hydrophobic and self-cleaning properties on stone substrates. However, these materials often exhibit limited durability, reduced long-term efficiency, and poor substrate compatibility. Moreover, fluorinated systems raise increasing environmental and health concerns due to their persistence and



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bioaccumulation potential, highlighting the need for safer and efficient alternatives.

In this work, organic coatings based on fatty acid-functionalized dendritic polymers were developed, combining antimicrobial and hydrophobic functionalities. G0 and G1 dendrons were synthesized through a simple two-step approach. The antimicrobial activity of the compounds was evaluated against microorganisms associated with stone biodeterioration, whereas coating performance was assessed in terms of hydrophobicity, aesthetic compatibility, and durability on stone substrates.

The results demonstrate the clear potential of these dendritic systems as innovative and sustainable materials for the effective protection of stone heritage.

Acknowledgements

The work is supported by Sustainable Stone by Portugal (C644943391-00000051) co-financed by the Portuguese Recovery and Resilience Plan and the European Union, and by FCT through projects UID/04449/2025 (doi: 10.54499/UID/04449/2025), UID/PRR/04449/2025 (doi: 10.54499/UID/PRR/04449/2025) and LA/P/0132/2020 (doi: 10.54499/LA/P/0132/2020).

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Transforming Museum Storage through Sustainable Environmental Management: The Lisbon Central Storage Case Study

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ABSTRACT

The management of museum storage facilities has become a critical area for institutional sustainability and heritage valorization, despite remaining one of the least visible aspects of museological practice. Since the 1970s, various international studies have highlighted the persistence of structural problems—insufficient storage solutions, lack of space, and inadequate buildings—that affect museums of different scales and geographies. In response, organizations such as ICCROM and ICOM have developed diagnostic methodologies, reference frameworks, and cooperation strategies aimed at strengthening the management of stored collections.

The new definition of a museum approved in 2022 reinforces this trend by shifting the emphasis from acquisition to collection, necessitating a review of documentation policies, preventive conservation, risk assessment, and infrastructure planning. In this context, storage facilities cease to be peripheral spaces and become strategic resources whose visibility and valorization are essential. The integration of environmental and social sustainability criteria drives the rationalization of these spaces, the optimization



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of workflows, and the adoption of collaborative models, including visible storage and modular solutions.

This study analyzes the application of these principles in the Central Storage of the Museum of Lisbon, demonstrating the transformative potential of an intervention based on sustainability, significance, and cultural value. The reorganization of the space improved energy efficiency, updated storage systems, and reinforced the security of the collections. Simultaneously, the significance assessment guided the internal reconfiguration of the holdings and underpinned the "Reserva Visitável" project, which democratizes access to heritage, increases institutional transparency, and strengthens relationships with local communities. The selection of the visitable cores was based on criteria of historical relevance, identity value, narrative potential, and feasibility of exhibition within the storage context.

The study demonstrates how the articulation between technical management, public mission, and sustainability can transform storage into an active space for knowledge, participation, and heritage valorization.



Natural Hydrogels for Soluble Salt Removal in The Archaeological Park of Herculaneum

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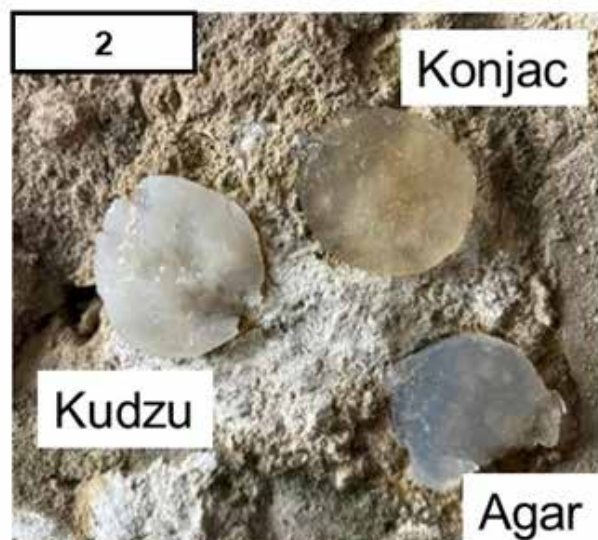
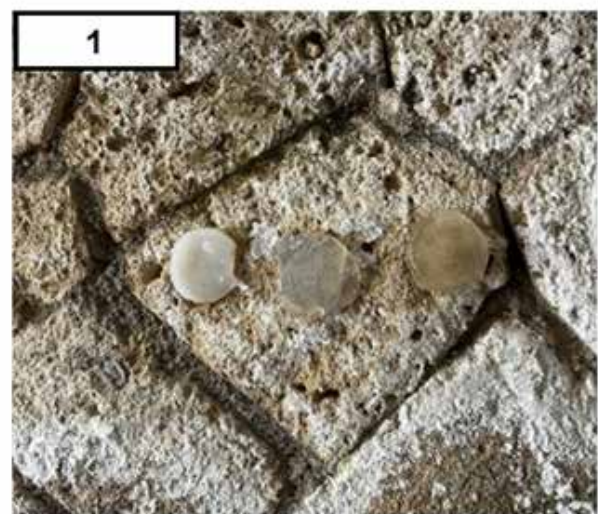
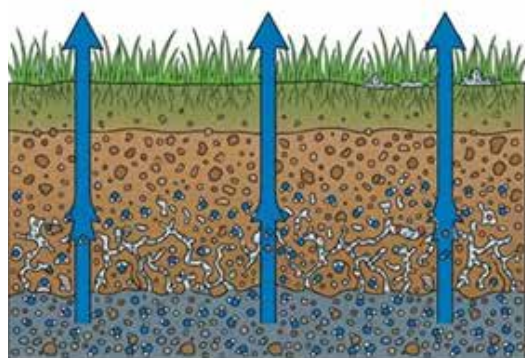
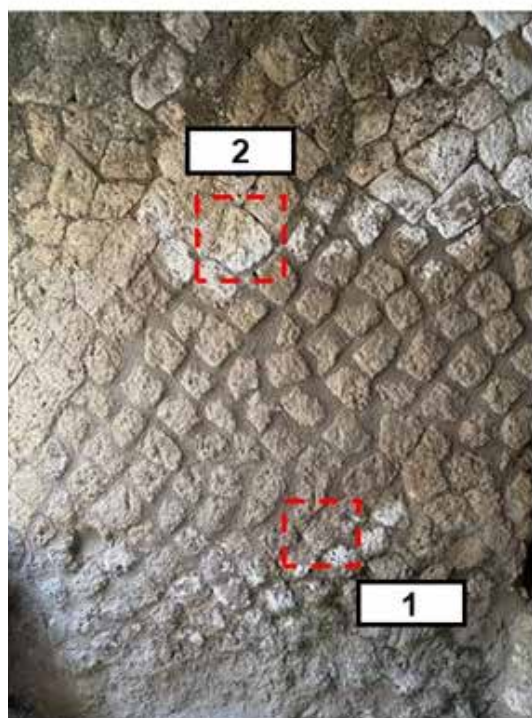
ABSTRACT

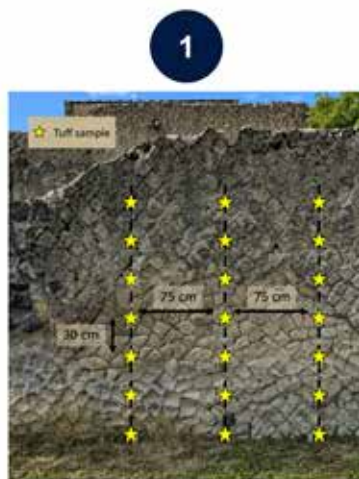
In 79 AD, the eruption of Mount Vesuvius buried Herculaneum, preserving its buildings until their discovery in 1709. Nowadays, after prolonged weathering, the Archaeological Park faces “tuff rotting”, a process causing the pulverization of tuff blocks that form the buildings. Previous studies by IBeA research group assessed that soluble salts from the soil migrate into the walls by capillary rise, contributing to this deterioration [1]. Therefore, reducing the salt content in the tuff is essential for its conservation. For this purpose, a methodology was developed to desalinate the tuffs using an innovative hydrogel-based cleaning method, including Agar, Kudzu and Konjac, used previously by



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IBeA for the removal of metallic leachates in marble surfaces [2,3]. First, the content of soluble salts in degraded tuff walls from the park was studied with the aim of preparing in the laboratory tuff mock-ups based on the same type and proportions of salts found in the analysed tuffs. For this, a soluble salts ageing process was developed. The mock-ups were analysed using ionic chromatography to compare the cleaning efficiency of the hydrogels. Finally, the hydrogels were evaluated in the real environment of Herculaneum in the autumn of 2025.

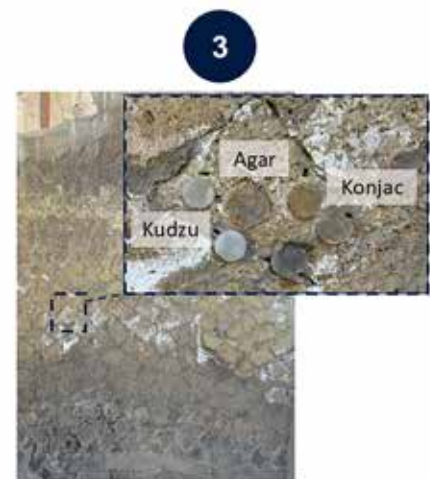




Analysis of soluble salt concentration
in tuffs



Assessment of the
desalination efficacy of natural
hydrogels in the laboratory



In-situ application of natural hydrogels

Acknowledgements

This work has been supported through the SIDIRE project (PID2023-146230OB-I00 funded by MCIN/AEI/ 10.13039/50110 0 011033 / FEDER, UE) and the Consolidated Research Group Project 2026–2029 (IT1862/26).

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Experimental simulation of textiles deterioration in evolving museum environments – Initial findings

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ABSTRACT

By using modelling to study the impact of climate change on indoor environments, Sesana et al identify textiles, particularly silk, as the most sensitive [1]. Beyond modelling, reproducing past, present and future museum atmospheres in a test chamber allow to identify the synergistic and cumulative impact of certain deterioration factors whose concentrations have varied over time.

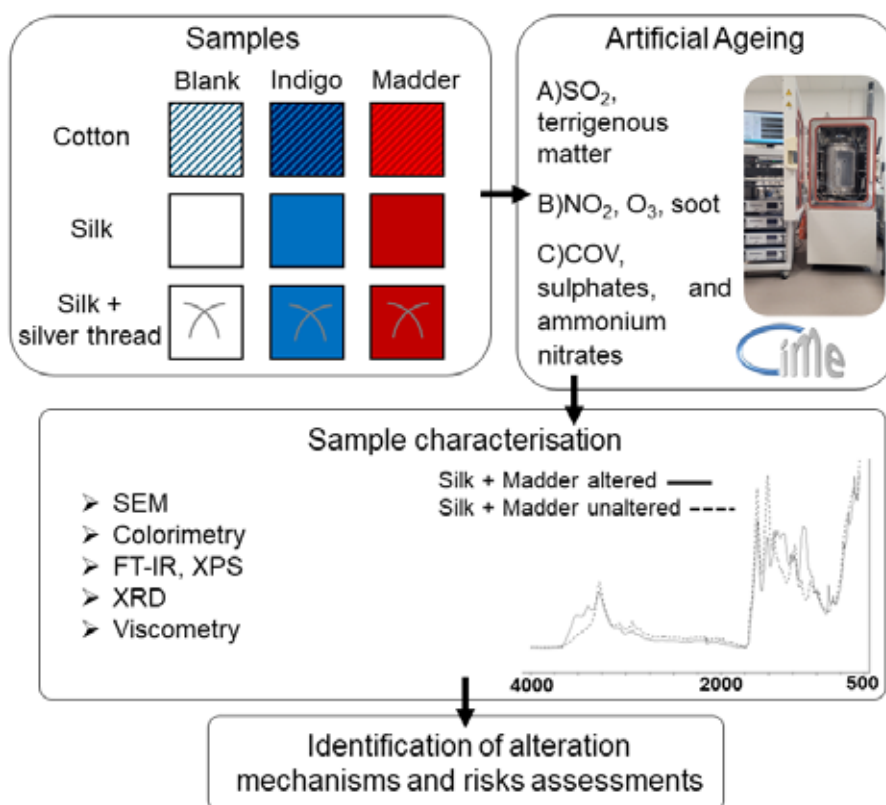
This approach, used in a previous study, highlighted first the dynamic and substrate-independent nature of particulate deposition on cotton, wool, and silk. It also demonstrated the high selectivity of textile sensitivity to certain gaseous pollutants [2-4]. These results, obtained on untreated textiles, must now be considered in the context of an additional complexity: the presence of finishes (colour, metallic embroidery) inherent to heritage textiles.

To assess the impact of environmental change on historical textile proxies, samples of



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cotton and silk were coloured with natural dyes: indigo and madder. Silver thread was also added to the silk samples to replicate embroidery. These samples were aged in the CIME chamber developed by the LISA. Three museum environments were replicated. The samples evolution is monitored using colorimetry, SEM, viscometry, XRD, FTIR, and XPS. Initial results confirm the variability in particulate deposition. Compared with undyed textiles, dyed textiles exhibit heightened sensitivity to gaseous pollutants.



Outline of the experiments conducted with an FTIR spectrum of madder tinted silk after exposition to SO₂ and terrigenous matter.

Acknowledgements

This project has received financial support from the CNRS through the MITI interdisciplinary programs.

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SESSION 5

ANALYTICAL APPROACHES TO CONSERVATION CHALLENGES

SESSION CHAIR - LUDOVIC BELLOT-GURLET



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ORAL
ABSTRACTS

Synthetic Dye Mixtures in Writing Inks:

A straightforward analytical approach for minute samples

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ABSTRACT

Many writing inks from 20th/21st century contain synthetic dyes which strongly influence their light stability. Depending on the ink quality, mixtures of different dyes, e.g. cationic (basic) and anionic (acid, solvent and direct) dyes, and/or synthetic organic pigments are involved in their formulations. Low lightfastness of everyday ballpoint pen and felt-tip inks used by authors of literary works worldwide require precise dye identification which is crucial for preventive conservation and appropriate lighting during exhibitions. We present combined analytical approach using accelerator-based SIMS with primary ions in MeV range and μ -Raman spectroscopy for analysis of minute ink on paper samples (ballpoint and felt-tip inks), taken from authors' notes on literary works (dated between 1960 and 2004, from Austrian National Library). As the minute ink samples were analyzed, the requirements guiding our analytical procedure were the identification of dye mixtures without chemical sample pretreatment, chromatographic separation or sample consumption during analysis.



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Measurements were carried out with a linear ToF-SIMS setup [1] with 8 MeV Si^{4+} primary ions in positive and negative ion modes. μ -Raman was performed with 532 and 785 nm laser excitation.

The results show complementarity of MeV SIMS and μ -Raman, with MeV SIMS being sensitive for cationic (basic) dyes and for aryl guanidines-markers for anionic dyes, and μ -Raman detecting solvent and acidic dyes in the same samples [2]. Furthermore, with μ -Raman, only a part of basic dyes identified by MeV SIMS was detected. The identification of aryl guanidines in this work is very important due to their ability to form salts with sulphonated solvent or acid dyes, influencing their stability and thus the stability of the inks.

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Determination of hydration mechanisms and kinetics of stained glass windows in atmospheric medium using dynamic vapor sorption

Aurélie Verney-Carron¹, Gauthier Fabre², Loryelle Sessegolo²

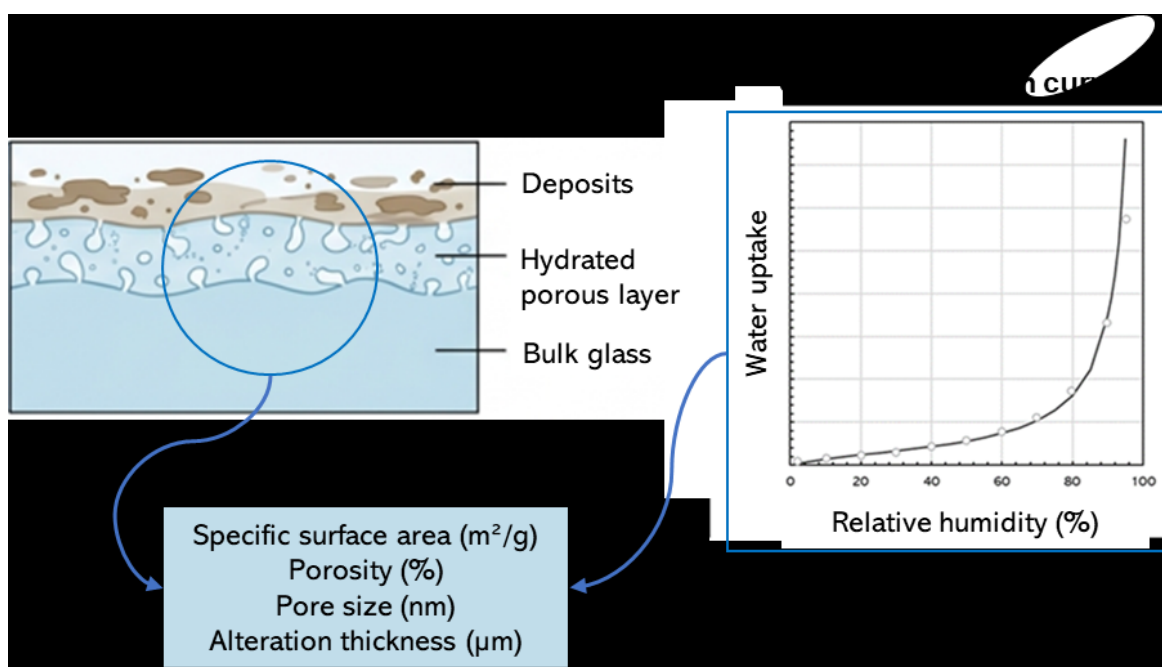
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ABSTRACT

Medieval stained glass windows deteriorate over time due to environmental hazards. This leads to the formation of an alteration layer and deposits that obscure the stained glass. Thus, the deterioration of stained glass windows has been extensively studied to better understand the alteration mechanisms, determine their rate, and quantify the influence of the glass (composition, roughness), as well as environmental parameters (e.g., rain, relative humidity, temperature, and microorganisms) on the alteration. To that end, laboratory experiments were conducted at various relative humidity (RH) levels. However, some studies have shown that hydration kinetics increase over time [1,2]. We hypothesize that this is caused by the sorption of water molecules, which increases as a hydrated, porous layer develops. To test this hypothesis, we conducted hydration experiments on a model medieval stained glass at 50 and 90°C, 95% RH and different time intervals ranging from three to 12 months. Then, we performed sorption measurements using dynamic vapor sorption on the hydrated samples. We also characterized the hydration process through microscopic observations, infrared

spectroscopy (IR), and time-of-flight secondary ion mass spectrometry (ToF-SIMS). The objective was to link sorption and hydration. Our results demonstrate that dynamic vapor sorption can characterize the porous network of the hydrated layer and deduce hydration kinetics that are consistent with those obtained using other methods. Therefore, this easy-to-use, non-destructive technique is promising for evaluating the hydration of stained glass windows in an atmospheric medium.



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Examining materials and deterioration in parchment manuscripts from the Great Mosque Library of Kairouan

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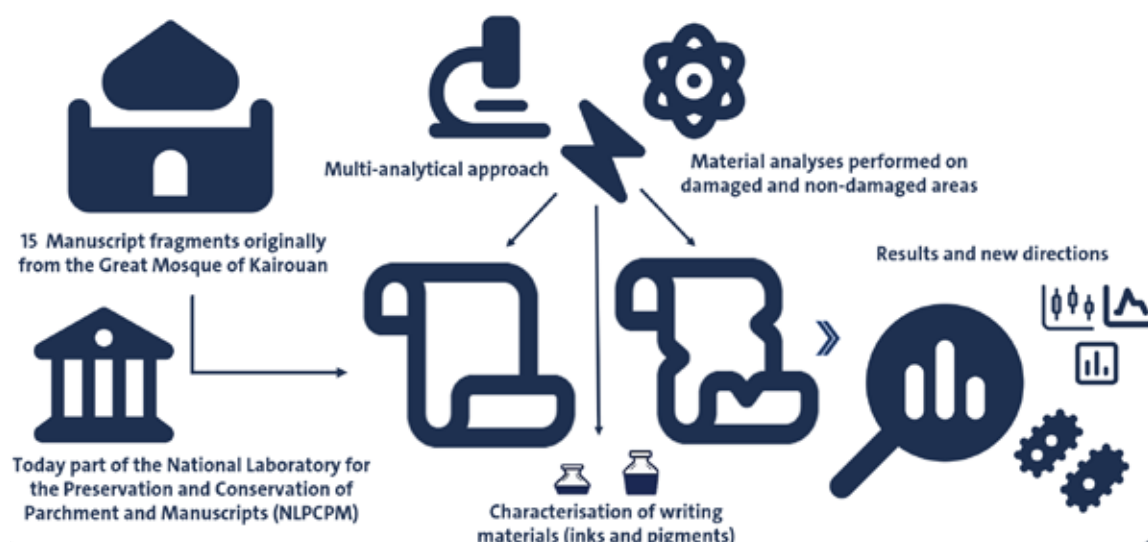
ABSTRACT

This contribution presents the main findings of a multi-analytical study focusing on the identification and characterisation of inks, pigments and deterioration phenomena present in several parchment manuscripts from the historical library of the Great Mosque of Kairouan, Tunisia. The manuscripts are now held at the National Laboratory for the Preservation and Conservation of Parchment and Manuscripts (NLPCPM) in Raqqada, Kairouan, a division of Tunisia's National Heritage Institute (NHI). This collection of Islamic parchment manuscripts is among the largest and most historically significant



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in the world [1]. The objects exhibit a progressive deterioration process first described by Murād al-Rammāh in 1995 [1] that spreads across their surfaces: cockling, hardening of the parchment substrate, and eventual irreversible denaturation and gelatine phases [2]. A combination of non-invasive techniques (MSI, digital microscopy, μ -XRF mapping, Raman and FT-IR spectroscopies) complemented by micro-invasive analyses (SEM-EDX and microbiological testing) were conducted on both damaged and undamaged areas of 15 manuscript fragments. The results reveal the scribes' materials used and elemental and structural differences between the intact and deteriorated areas of parchment, providing new insights into mechanisms of deterioration that are deserving of further research.



Acknowledgements

Funded by DFG, under Germany's Excellence Strategy – EXC 2176 'Understanding Written Artefacts', proj. n.390893796. We thank all the partners of the Kairouan Manuscript Project (<https://www.csmc.uni-hamburg.de/kairouan.html>), particularly the NHI and NLPCPM.

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Novel air purification systems based on mesoporous silica MCM-41 nanoparticles for Cultural Heritage applications

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ABSTRACT

This study presents an innovative air-purification system designed for the preventive conservation of Cultural Heritage (CH) environments. Utilizing MCM-41 mesoporous silica, distinguished by its high surface area and uniform hexagonal pores, as a delivery platform, we evaluated the encapsulation of three primary constituents (iso-eugenol, linalool, and 4-terpineol) of essential oils with a claimed antimicrobial activity. This approach addresses the urgent need for sustainable, non-invasive alternative to traditional chemical treatments, neutralizing airborne bacteria and fungi that threaten delicate organic substrates in museums and archives.

The materials were synthesized using both physisorption and a novel covalent post-grafting method to tune the guest-host interactions. Structural integrity and functionalization efficiency were verified via gas adsorption porosimetry, employing BET and BJH models to track changes in pore volume and distribution. To assess the system's efficacy, a controlled desorption program was implemented in microclimatic



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chambers, where volatilization kinetics were monitored through HS-GC-FID under varying parameters of temperature and relative humidity (RH). This characterization ensures the system's reliability across different indoor museum microclimates.

Results indicate that while physisorption allows for rapid biocidal action, covalent grafting ensures a long-term sustained profile. This "cold diffusion" mechanism maintains antimicrobial concentrations above inhibitory thresholds without risking liquid deposition or chemical staining on artifacts. Crucially, the MCM-41 framework exhibits excellent structural stability, allowing for the regeneration and recharging of the silica support once the biocide is exhausted. Ultimately, this research demonstrates a tunable, green and cost-effective technology for safeguarding indoor heritage sites through precise environmental control and advanced material science.



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SESSION 6

DIGITAL INNOVATION AND ADVANCED TECHNOLOGIES FOR CULTURAL HERITAGE COLLECTION MANAGEMENT

SESSION CHAIR - DANILO BERSANI



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ORAL
ABSTRACTS



Still life, set in motion. Art history, conservation and analytical research cooperation

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ABSTRACT

This paper arises from a research project prompted by a conservation and restoration treatment carried out on a set of four still-life paintings, executed in oil on canvas, which had been kept in storage for over a century in a very poor conservation condition. The paintings unquestionably form a coherent group; one of them bears a monogram indicating authorship (G.F.Z., suggesting Georges Frédéric Ziesel, 1757–1809) and a date (1700?), which is inconsistent with the proposed attribution. The monogram appears to have been intended to suggest a Flemish origin for the works.

The paintings were brought together in Porto by the collector Júlio Osório, who donated them to the former Municipal Museum of that city in 1911. At no point during the accession process was the origin or provenance of the four paintings recorded.



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The conservation intervention involved the consolidation of the paint layers and the removal of lining fabrics and varnish layers applied during ancient restoration campaigns. The removal of the varnish immediately enabled a systematic observation of the brushwork characteristics and a comparative analysis, leading to a reassessment of the attribution that rejects the authorship indicated by the monogram in favour of the Milanese painter Angelo Maria Crivelli (1660–1730). The removal of old linings also made it possible to identify an inscription on the reverse of one of the works, which proved crucial for understanding the specific geographical context of its production and its connection to the painter's sphere of activity.

The conservation treatment and the analytical study conducted in parallel were decisive in revising the catalogue entries for these works and, as such, in recovering their long-lost significance. The identification of their origin and the questions raised concerning the “false” authorship represent a highly valuable contribution to the understanding of collecting practices and market networks in European Baroque painting.

This work forms part of a broader set of institutional cooperation initiatives aimed at bringing previously overlooked groups of Old Master paintings back into view, through conservation and restoration treatments carried out in close conjunction with research and disseminated across multiple platforms.





From Storage to Access: Digital and Preventive Conservation Strategies for Small Community Museums

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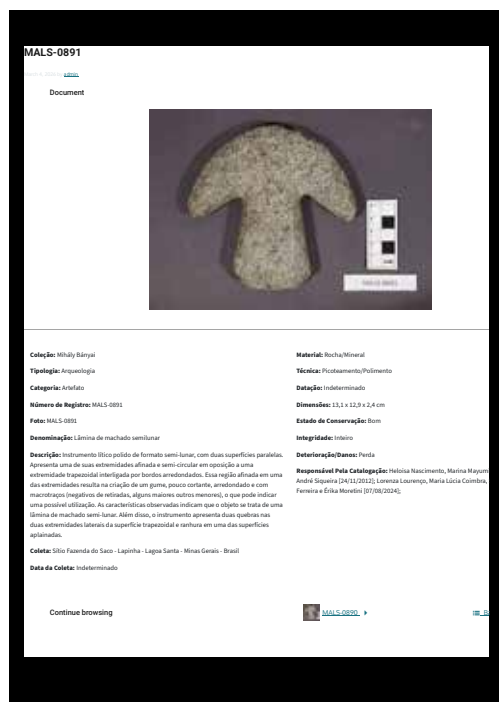
ABSTRACT

This research presents the development of a digital documentation and preventive conservation project for the archaeological, anthropological, and paleontological collections of the Archaeological Museum of Lapinha (Lagoa Santa, Brazil), funded by FAPEMIG. The project focuses on the implementation of an integrated system combining inventory protocols and physical reorganization of storage areas. Central to this initiative is the development of a structured database using the open-access platform Tainacan, supporting the standardization, accessibility, and long-term preservation of scientific collections. The study addresses the challenges of managing dispersed, partially documented, and physically vulnerable collections within a context of institutional transition and infrastructure adaptation.

The methodology is grounded in Conservation Science and museological documentation protocols, integrating inventory standardization, risk management, and digital data structuring. The research followed sequential stages, including collection

survey, documentation, cleaning, marking, packaging, and reorganization within the storage system. The inventory process was initially conducted using structured spreadsheets, later migrated to the Tainacan platform, ensuring data consistency and interoperability. The documentation framework is based on controlled vocabularies, classification systems, and standardized metadata fields, combining contributions from Archaeology, Anthropology, Palaeontology, Museology, and Information Science. Attention was given to preventing risks related to physical impact and dissociation during handling, transport, and storage processes.

The results show that integrating digital platforms and preventive conservation is essential for managing scientific collections. The case highlights the value of combining digital tools, standardized protocols, and conservation practices.



Acknowledgements

The authors acknowledge the financial support provided by the Research Foundation of the State of Minas Gerais (FAPEMIG).

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Integrated Risk Management in University Collections: Transdisciplinary Approaches to Preservation

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ABSTRACT

This research is structured as a collaborative network project for risk assessment, preventive conservation, and facilities qualification of scientific and cultural collections. It articulates two complementary projects funded by CNPq and FAPEMIG, operating within the institutional framework of the UFMG Museum Network. The CNPq project focuses on the revitalization of storage and exhibition infrastructure in the spaces of the Memory Centre of Dentistry (CMO), the Memory Centre of the School of Nursing (CEMENF), the Centre for Research, Memory and Documentation of the School of Education (CEDOC), and the Herbarium of the Centre for Taxonomic Collections (CCT). The FAPEMIG project expands this scope to include Imagem de Minas (Minas Image Collection), the Memory Centre of the School of Medicine (CEMEMOR), the Memory Centre of Physical Education, Sport and Leisure (CEMEF), and the Entomological Collection of the Centre for Taxonomic Collections (CCT). These initiatives are conceived as an integrated system for the implementation of risk assessment, physical organization of collections, and environmental monitoring strategies supported by Conservation

Science and scientific curatorship.

The methodology is based on international frameworks for risk management and preventive conservation, particularly the ABC method developed by ICCROM and the risk assessment models proposed by the Getty Conservation Institute. The research follows a structured risk management cycle, including the establishment of context, risk identification, analysis, evaluation, and the development of mitigation strategies, in accordance with the ICCROM guide for cultural heritage risk management [1]. Special attention is given to the specific condition of scientific collections and memory archives in universities, which require the integration of preservation, research, and accessibility functions. The approach is inherently transdisciplinary, combining Conservation Science, Information Science, Museology, and scientific curatorship, establishing a framework for documentation, management, and access to collections.



Acknowledgements

The authors acknowledge the financial support provided by the National Council for Scientific and Technological Development (CNPq) and Research Foundation of the State of Minas Gerais FAPEMIG.

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Non-Destructive Investigation of Cultural Heritage Objects by High-Resolution Portable X-ray Computed Tomography (ENCI)

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ABSTRACT

The investigation of cultural heritage objects often requires access to internal structures, hidden inscriptions, and manufacturing features that cannot be observed externally. However, many artefacts such as enveloped cuneiform tablets, fragile archaeological objects, and small sculptures cannot be opened or physically altered without risking irreversible damage. This creates a critical need for high-resolution, non-destructive techniques that can be applied in situ.

To address this challenge, we developed ENCI (Extracting Non-destructively Cuneiform Inscriptions), a portable high-resolution X-ray computed tomography system designed for the in-situ investigation of cultural heritage artefacts. The system combines high spatial resolution with a modular and transportable architecture, enabling on-site use in



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museums and collection sites.

The ENCI system has been applied to a range of cultural heritage artefacts, including enveloped cuneiform tablets, in collections such as the Louvre Museum (Paris), the Museum of Anatolian Civilizations (Ankara), and the Kayseri Archaeology Museum. Additional studies were conducted at the Centre for the Study of Manuscript Cultures (CSMC), University of Hamburg.

This contribution presents the ENCI system and its workflow, including data acquisition, reconstruction, and on-site three-dimensional visualization. The resulting datasets enable non-destructive analysis of internal structures and hidden inscriptions, allowing the reading of texts enclosed within clay envelopes without damaging or breaking them, and providing insights into material composition and manufacturing techniques, supporting non-invasive research in cultural heritage studies.

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Phase contrast X-ray imaging for the study and characterisation of cultural heritage materials: The PITCH project

Garagiola, Chiara^{1,2}, Di Francia, Elisabetta^{1,2}, Guidorzi, Laura^{1,2}, Lo Giudice, Alessandro^{1,2}, Boano, Rosa³, Giustetto, Roberto⁴, Ricchiardi, Gabriele⁵, Cerello, Piergiorgio², Fiorina, Elisa², Magalini, Marta², Marabotto, Miriana², Mosco, Nicola², Ramello, Luciano^{2,6}, Trocino, Daniele², Di Martino, Daniela⁷, Marcucci, Giulia⁷, Vigorelli, Luisa⁷, Pozzi, Federica⁸, Ricci, Chiara⁸, Re, Alessandro^{1,2}

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ABSTRACT

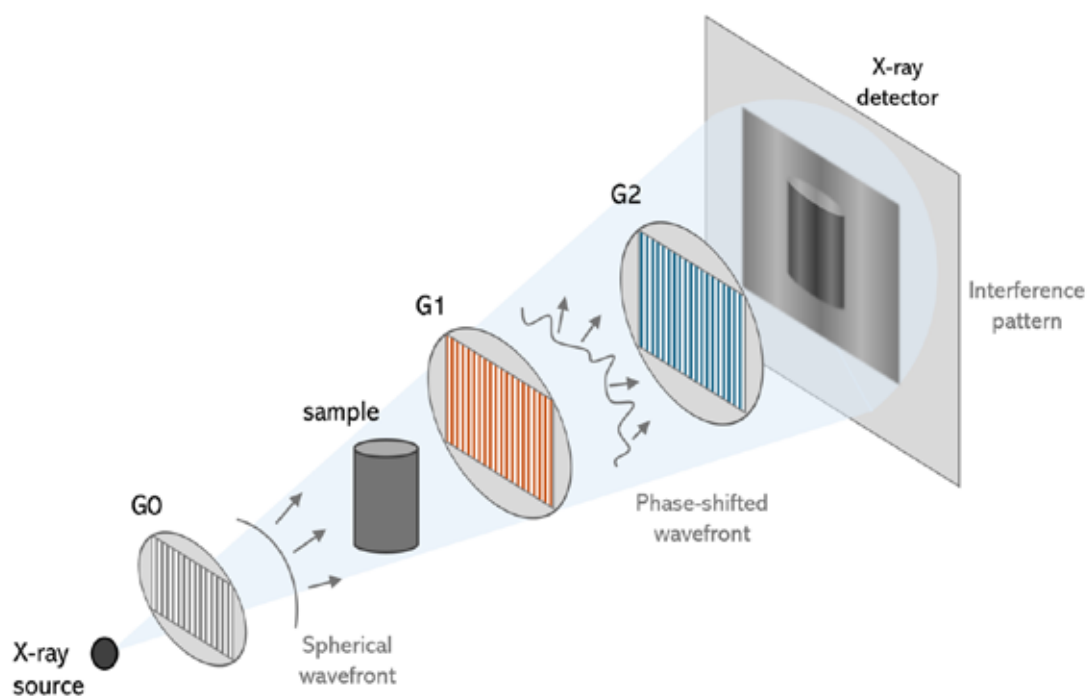
Phase-Contrast (PC) X-ray imaging is an effective tool for detecting low contrast details in weakly absorbing samples, as it enables high-quality visualisation of microstructural features [1], including those of low-density, heterogeneous, and organic components, opening extremely interesting perspectives in the cultural heritage (CH) field, such as conservation, archaeology, archaeometry, anthropology, paleopathology.



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The PITCH project, funded by MUR (PRIN2022 program), aims at designing, developing and characterising a laboratory Grating Interferometry PC imaging setup based on a liquid-anode X-ray source, as well as at investigating and developing different data acquisition methods and algorithms for signal extraction and tomographic reconstruction. The system will be optimised for the study and characterisation of CH materials.

For the refinement and optimisation of the new setup and the development of reconstruction algorithms, a selection of relevant materials for mock-up preparation used for preliminary tests has been made, including painted canvas, textile material, parchment, cartonnage and painted wood. Different sample geometries were selected as well. The preliminary analysis on mock-ups aims at characterising these materials and understanding possible related issues. This characterisation will lead to the study of real artifacts coming from museums and cultural institutions.



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A 3D Hyperspectral tool for preventive conservation

Fromager, Julie¹, Gauthier, Vincent¹, Martinez, Loïc¹, Forleo, Danilo², Serfaty, Stéphane¹

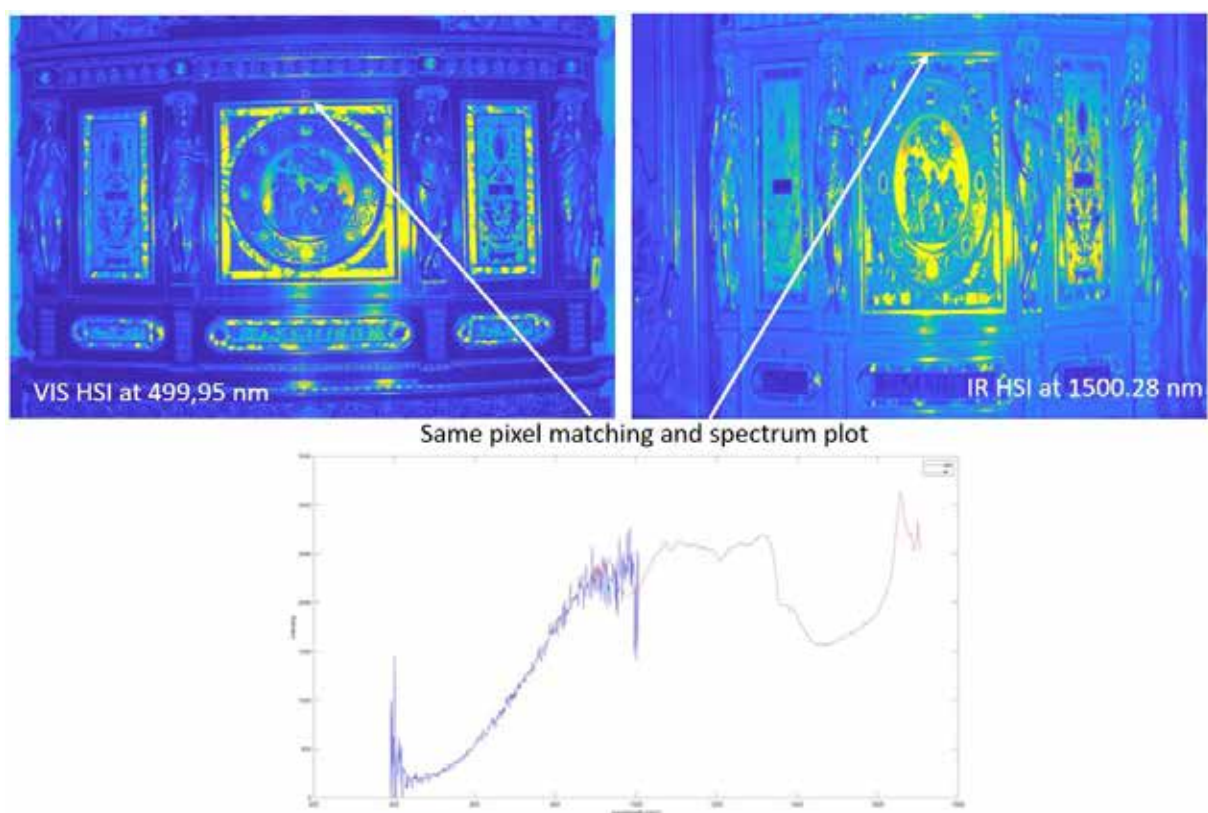
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ABSTRACT

With palace-museums facing the oddities of quick weather variations in a context of climate change, like sudden degradation of ceiling paintings or strong warping of tapestries, a need for monitoring tools and damage precursor measurements is emerging to help preventive conservation strategies. This can be achieved with new high-end multidimensional processing tools as decision-support system. To that end, the coupling of a hyperspectral imaging (HSI) system – covering both visible and short-wave infrared areas – and 3D LiDAR data was set up in the Queen's Bedroom and Mercury Room of the Versailles Palace for seasonal takes. A sample of representative elements was first selected according to the EPICO (European Protocol In preventive Conservation) [1] method for each room, then followed thoroughly as seasons changed for further investigation. Once per season, three sets of data are collected for each designated work of art: visible, infrared and surface data. This allows us to monitor their evolution in regards of their nature and the weather conditions. To this day, three seasons are already covered: Summer (July 2025), Autumn (November 2025) and Winter

(February 2026). The following example (fig. 1) showcases the Queen's "serre-bijoux" (jewel displaying case). This specific work of art is interesting as humidity levels can variate in materials such as wood and could be related to hygrometry fluctuations inside the rooms thanks to the infrared data [2]. For this purpose, the different takes of the serre-bijoux are compared, which upbrings technical levers: the angles can be different, the resolution of each camera and the distance too. This research aims at aligning these data in order to make them comparable and extract valuable content for preventive conservation purposes.

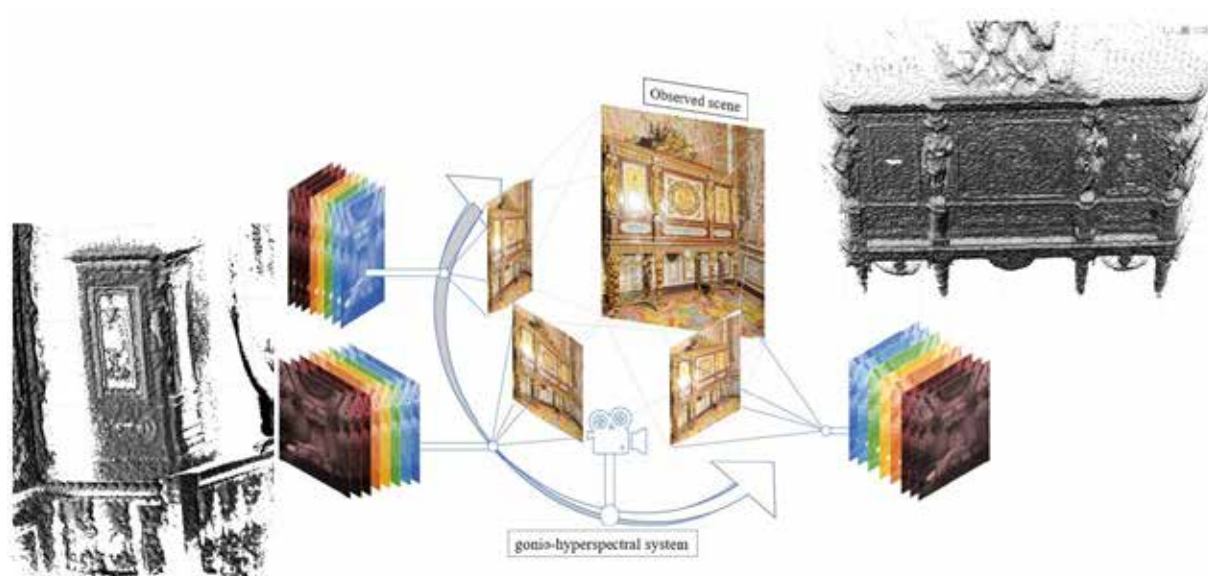


Acknowledgements

This HypErPICO work has benefited from French State aid managed by the Agence Nationale de la Recherche under the future investment program integrated into France 2030, bearing the reference ANR 21-ESRE-0050 EquipEx+ ESPADON and École Universitaire de Recherche Paris Seine Humanités, Création, Patrimoine - Fondation des sciences du patrimoine ANR-17-EURE-0021.

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SERS Characterization of Natural Organic Dyes at Liquid – Liquid Interfaces

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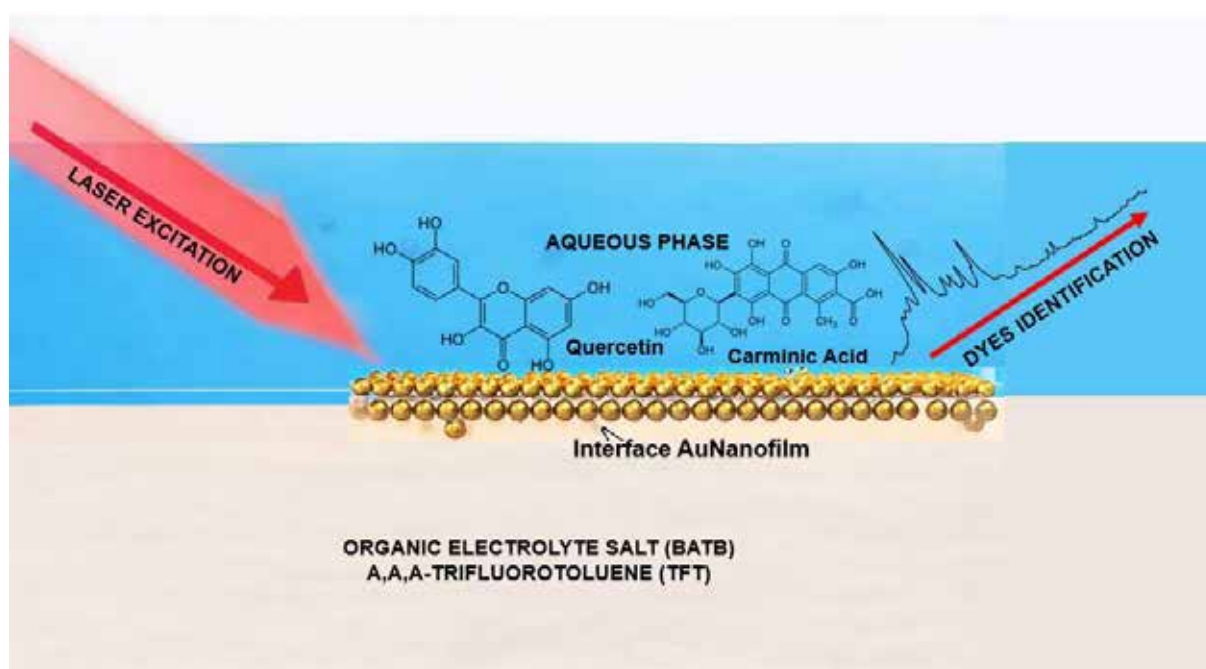
ABSTRACT

The analytical methods currently used to characterize textile dyes are mainly chromatographic techniques, which are highly sensitive and selective but destructive, as they require the extraction of several milligrams of material [1]. Raman spectroscopy offers a non-destructive, in situ alternative and is effective for inorganic pigments. However, its application to organic dyes is limited by strong fluorescence and the very low concentrations typically present. Surface-Enhanced Raman Spectroscopy (SERS) has emerged as a powerful tool for identifying natural organic dyes in archaeological artefacts and artworks [2]. The SERS effect is based on the enhancement of the Raman signal of molecules adsorbed onto nanostructured metallic surfaces. SERS substrates can be prepared either by aggregation of metallic nanoparticles, yielding very high enhancement factors ($>10^8$ – 10^{10}), or by lithographic fabrication of ordered nanostructures, which is more expensive and generally provides lower



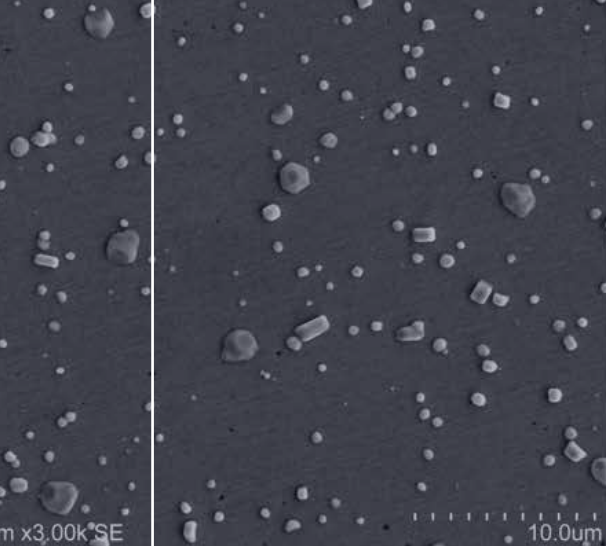
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enhancement ($\sim 10^5$) [3]. In this study, liquid–liquid interfaces were used as platforms for both substrate formation and analyte detection. The interface between 1,1,1-trifluorotoluene (TFT) and an aqueous phase containing gold nanoparticles and an aggregating salt enabled the spontaneous formation of compact and reproducible nanostructured films. Electrochemical reduction methods for the formation of gold nanofilms were also investigated, and a comparative evaluation was conducted to determine which approach yielded superior results. Three natural dyes were selected as model compounds: quercetin, carminic acid, and curcumin, characterized by flavonol, anthraquinone, and diarylheptanoid chromophores, respectively. Finally, archaeological textile samples dyed with organic colorants were also analysed.

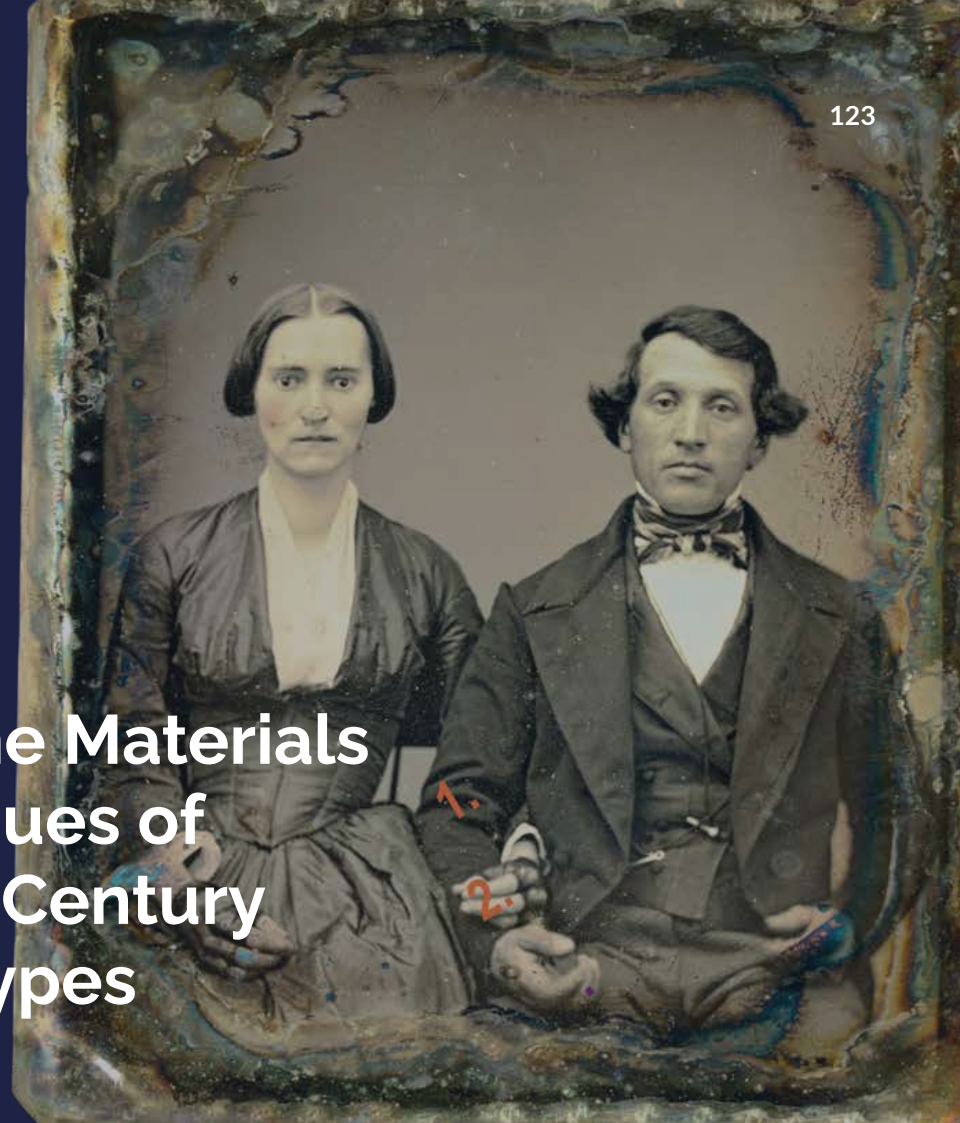


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Decoding the Materials and Techniques of Nineteenth-Century Daguerreotypes



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ABSTRACT

Daguerreotypes, introduced in the early nineteenth century as the first commercially successful photographic process, were produced on polished silver-coated copper plates sensitised with silver halides. Light exposure in a camera obscura generated a latent image that was developed with mercury vapour, forming silver–mercury amalgam image particles. Owing to their susceptibility to abrasion and tarnishing, daguerreotypes were typically sealed behind glass within ornate protective cases. Natural colour photography was not yet established, so hand-colouring was often applied, particularly to enhance facial tones and jewellery. Despite their historical and technological significance, analytical studies remain limited due to their rarity and fragility, with research predominantly focused on degradation and image recovery [1], while materiality and manufacturing practices are limited [2,3].

This study presents a multi-analytical investigation of two 19th-century daguerreotypes affected by surface tarnish and corrosion. Photographic documentation under different lighting identified surface features, hand-colouring, and degradation patterns. SEM observations revealed the morphology and distribution of image-forming particles, providing further insight into manufacturing practices. At the same time, EDXRF and μ -Raman revealed that the decorative elements consist mainly of Au and that the pink tones derive from the natural colourant cochineal. Degradation analysis by μ -Raman and μ -FTIR identified silver sulfide as the main cause of image tarnishing and the presence of oxalates and carbonates, likely associated with the degradation of organic material or microbiological activity. XRD analysis further confirmed the presence of cuprite on the backside of the copper support, indicating substrate corrosion.



Acknowledgements

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SESSION 7

ARCHAEOOMETRY OF CULTURAL HERITAGE: MATERIALS, TECHNOLOGIES, PROVENANCE AND CHRONOLOGY

SESSION CHAIR - PETER VANDENABEELE



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ORAL
ABSTRACTS

Organic residues from the Lavau Princely Tomb: Archaeological evidence revealed through interdisciplinary micro-invasive molecular approaches

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ABSTRACT

Following the discovery by INRAP in 2015 of the extensive Celtic funerary complex at the Lavau site in Champagne (Early Iron Age, La Tène A1, 5th century BCE), numerous grave goods were entrusted by the French Ministry of Culture to the C2RMF for interdisciplinary scientific analysis and conservation-restoration studies. The expertise of the C2RMF Research Department, particularly in analytical organic chemistry, was mobilised. Approximately forty micro-samples of organic materials from eleven objects were analysed. The molecular characterisation of archaeological organic residues relies on micro-invasive analytical strategies requiring minimal sample quantities, as well as on separation techniques coupled with advanced molecular analyses, including gas chromatography-mass spectrometry (GC-MS) and high-resolution mass spectrometry



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omics approaches (nanoLC-ESI-FTMS).

The results obtained from the Lavau organic residues were made possible by a key yet only partially understood process of organometallic complexation. This phenomenon enabled the exceptional preservation of organic matter, normally highly susceptible to degradation, through its association with metals.

Furthermore, access to these fragile organic residues was facilitated by close collaboration between the Research and Conservation Departments of the C2RMF. Careful observations by conservators allowed sampling as soon as organic material was detected or suspected, prior to any conservation or restoration treatment that might have altered or removed these sensitive remains.

This study highlights an integrated interdisciplinary approach based on continuous dialogue between analytical expertise and material-based knowledge, enabling the investigation of targeted research questions under particularly favourable preservation conditions.



Micro-sampling of the leather scabbard for proteomic analysis, © A. Lattuati-Derieux/C2RMF



Precious Ornaments from the Necropolis of Lovere: Chronology, Materials, and Craftsmanship

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ABSTRACT

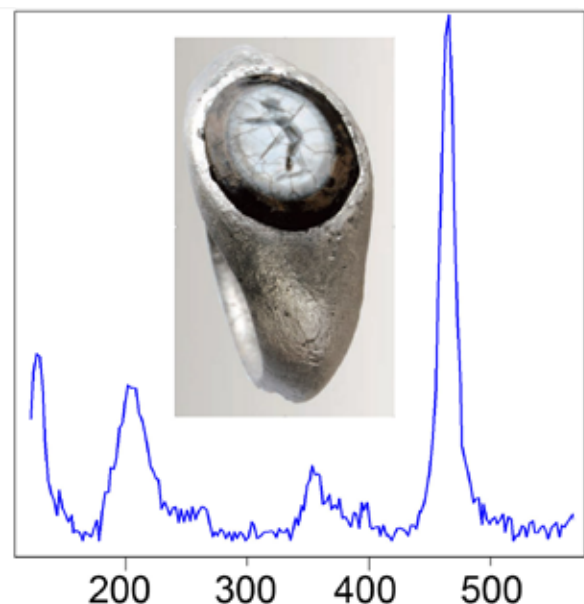
The study of jewelry and precious ornaments, aimed not only at identifying their constituent materials but above all at acquiring information about the societies that produced them, necessarily requires a multidisciplinary approach. Such a perspective allows the integration of analytical data with archaeological and anthropological considerations, in order to achieve the most comprehensive understanding possible of the relevant cultural contexts.

This study examines a significant corpus of precious ornaments recovered during archaeological excavations carried out in 1907, 1996, and 2015 at the necropolis of Lovere (Bergamo, Lombardy). The assemblage stands out within the regional framework for the high number of gemstone rings, the overall quality of the artifacts, and the

extensive use of precious metals, in contrast to more commonly attested materials such as iron and bronze.

The corpus is characterized by marked chronological heterogeneity—ranging from the mid/late 1st century BCE to the 4th century CE—as well as by a wide typological, material, iconographic, and technological variability. This complexity required the adoption of a multidisciplinary approach, including the analysis of decorative motifs, goldsmithing techniques, and material features.

In order to obtain analytical data on material composition, investigate manufacturing techniques, and propose hypotheses regarding the provenance of gemstones and glass artifacts, an in situ analytical program based on non-destructive methods and the integration of multiple instrumental techniques was designed. Gemmological and technological observations were carried out using digital microscopy, while elemental analyses of metals were performed using portable EDXRF instrumentation. Gemstones were characterized through Raman spectroscopy, and the composition of garnets was subsequently estimated using dedicated software. The integration of archaeometric, technological, and gemmological analyses enabled not only the identification of numerous gemstones, including garnets, pearls, sapphires, and emeralds, but also the formulation of hypotheses concerning their provenance and the reconstruction of the chaîne opératoire of the artifacts, providing insights into their conception, production, and function within their cultural context.



Acknowledgements

The authors wish to thank Dr. Stefania De Francesco (Soprintendenza Archeologia, Belle Arti e Paesaggio for the Provinces of Bergamo and Brescia) and Drs. Anna Provenzali and Sara Loreto (Museo Archeologico di Milano) for their kind and professional assistance throughout all phases of the research.

Production technologies at the Roman *villa* in Fiumana (Forlì-Cesena, Italy): The case study of the fictile tubules

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ABSTRACT

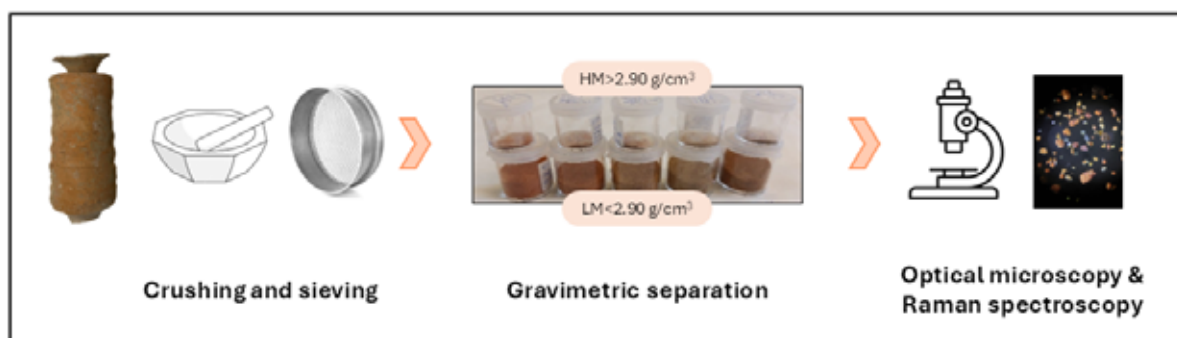
The archaeological site of Fiumana (Forlì-Cesena, Italy) represents an important settlement, mostly occupied from the Late Republican period to the Early Middle Ages. Since 2022, the site has attracted considerable interest: archaeological campaigns have restarted, under the direction of Prof. Villicich (University of Parma, Italy), and archaeometric investigations have been performed through dedicated laboratory protocols. [1,2] A wide variety of materials have been found during the excavations: coins, marbles, glasses, mortars, wall painting fragments, lamps and, noticeably, different types of pottery. Among them, fictile tubules (the so-called “syringe-shaped” type) used in vault construction were also recovered, both in fragmented form and intact - sometimes still interlocked - within sealed collapse layers. They were found in well-defined stratigraphic contexts, from a thermal complex (3rd century AD) and from spoliation



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phases (5th century AD).

In this work, archaeometric analyses have been performed to characterize the fictile tubules, with optical microscopy, micro-Raman spectroscopy and X-ray powder diffraction. A dedicated protocol for gravimetric separation of heavy minerals was applied and the mineral composition acquired, fingerprinting the provenance of raw materials. [1,3] The archaeometric analyses provided valuable information on the production technologies and centres. The possibility of reuse phenomena will also be discussed, to verify whether tubules belonging to the 3rd-century phase could have been reused within the building phases of the 5th century AD.



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Pre-Roman Glass Beads in the Iberian Peninsula and Balearic Islands: Overview and Archaeometric Analysis

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ABSTRACT

Glass ornaments were highly valued materials in Mediterranean Protohistory, yet the technological demands of their production exceeded the capabilities of local workshops in the Iberian Peninsula. This discrepancy underscores the importance of long-distance exchange networks at that time. Within this context, a remarkable research initiative significantly expands the archaeometric understanding of pre-Roman glass objects in Iberia. The LITHOSCHYTOS project assembles the largest analytical dataset to date for pre-Roman glass beads and pendants from the Iberian Peninsula and the Balearic Islands, documenting the presence of over 27,000 glass beads across



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more than 480 pre-Roman archaeological sites. Moreover, this database currently includes detailed morphological and archaeometric data, obtained using Raman spectroscopy and X-ray fluorescence (XRF) together with the development of analysis tools based on AI, for more than 500 items from over 35 archaeological sites, including the UNESCO World Heritage necropolis of Puig de Molins (Ibiza, Spain). In addition, an in-depth, non-destructive study including computed X-ray micro-tomography (μ -CT) of a selection of 27 exceptional polychrome beads and extraordinary Phoenician glass pendants provides unprecedented resolution on manufacturing sequences, pigment usage, and raw glass provenance. The combined datasets constitute one of the most comprehensive archaeometric corpora for pre-Roman glass in the western Mediterranean. Together, they offer novel insights into technological choices, craft specialization, and intercultural connectivity, enriching current models of interaction among pre-Roman cultures in Iberia and illuminating the long-distance networks that shaped the circulation of ancient glass.



Acknowledgements

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Phase identification and alloy composition of heritage Indian bronze gongs and cymbals using SR-XRD and PIXE

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ABSTRACT

This communication is part of a PhD project aimed at understanding the acoustic role and impact of the manufacturing process of high tin bronze gongs and cymbals from South-East Asia, China and India (20-25 weight%). The studied corpus is here based on a selection of 19th century Indian gongs curated at the Musée de la Musique (Paris) whose alloy compositions were measured by PIXE (Particle Induced Xray Emission) at the C2RMF. The literature on the manufacturing processes of these instruments establishes that the tuning process is performed by cold hammering. This key step can however only be achieved if a water quench has been performed beforehand [1]. This heat treatment produces typical martensitic phases whose ductile properties are sought after. Since the heritage status of the collections under study forbids any



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invasive analysis, the identification of quenching and the conditions under which it was performed was carried out directly on the objects using X-ray diffraction on the DiffAbs beamline at the SOLEIL synchrotron. These analyses were compared with a set of lab-produced samples, allowing for the study of the different heat treatments. This presentation will outline the methodology for data acquisition and processing, rendered challenging by working directly on the objects rather than on powdered samples. In particular, the use of azimuthal scanning performed using the CirPAD detector [2] will be detailed in how it allows for a complementary analysis to conventional diffractograms, yielding information on the texture and relative crystallite sizes of the analyzed objects. The results highlighted the systematic presence of martensitic phases within the studied collection. Furthermore, data analysis based on principal component analysis raises new questions about the role of specific martensitic phases in the manufacturing process of high tin bronze gongs and cymbals.

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POSTERS



2D Materials for Cultural Heritage Wall Paintings Protection – A Sustainable Approach

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ABSTRACT

Wall paintings and lime frescoes are among the most vulnerable cultural heritage assets, threatened by environmental factors such as humidity, salt crystallization, and photo-oxidation. Traditional protective coatings often lack reversibility, alter the visual appearance of the surfaces, or rely on solvents with significant environmental and health impacts [1]. Natural minerals such as phyllosilicates represent sustainable raw materials for obtaining 2D structures. They can be produced by cost-effective and scalable liquid-phase exfoliation method [2]. This study explores the potential of mineral-based 2D materials for the conservation of wall paintings. This approach directly supports Sustainable Development Goal (SDG) 11 by safeguarding cultural heritage, SDG 12 through greener formulations, and SDG 13 by reducing the carbon and toxic footprint of conservation interventions. Mock-up fresco samples reproducing the surface of 16th-

century paintings from the Serbian monastery of Crna Reka were prepared and coated with phyllosilicate thin films. Atomic Force Microscopy and Fourier Transform Infrared Spectroscopy confirmed the formation of a continuous ultrathin film at the nano-scale, exhibiting a chemical structure characteristic for exfoliated phyllosilicates. Raman spectroscopy, X-ray Photoelectron Spectroscopy, and colorimetric measurements were employed to assess the compatibility of the deposited coatings on the mock-up fresco samples in terms of structural integrity and visual appearance. Furthermore, the reversibility of the applied coatings was evaluated. Results demonstrate that phyllosilicates can be applied to fresco surfaces with minimal alterations in optical properties, and removed without altering the original material, showcasing their potential as a reversible protective coating. By coupling advanced nanomaterial characterization with sustainability and ethical conservation principles, the study proposes a replicable model for the responsible adoption of novel 2D nanomaterials in cultural heritage protection.



Acknowledgements

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Exploring the palette of *Femme Lisant* (1922) by Henri Matisse using hyperspectral imaging techniques

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ABSTRACT

Henri Matisse (1869-1954), a major figure in modern art, is widely recognized as a precursor of Fauvism, an artistic movement that privileged the expressive power of colour over the strictness of drawing. Colour remained the central element of the painter's work, as evidenced by the composition *Femme Lisant* (Woman reading) from 1922, belonging to the collection of the Royal Museum of Fine Arts of Belgium (RMFAB), which deals with a subject often explored by the artist: a female figure indulging in the leisurely pursuit of reading.

As part of the project *Face-to-Face*, which consists of the technical study of the representation of faces in European painting from the 15th to the 20th century, this canvas was studied in situ using the mobile laboratory of the European Centre for Archaeometry (CEA) of the University of Liège, composed of imaging methods (high-resolution photography, infrared reflectography and digital microscopes) and analytical



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techniques such as MA-XRF, Raman spectroscopy and hyperspectral imaging in the visible range (400-1000nm) as well as in the short wave infrared range (1000-2500nm). All these techniques are non-invasive and highly complementary.

The analysis reveals that the artist conceived the composition directly on the canvas, without the use of a grid or preparatory drawing, reflecting an approach consistent with Fauvist principles. Subtle *pentimenti* reveal adjustments made during the execution of the pictorial layers. This study also identifies the pigments composing the palette and highlights how the artist executes colour in his composition: in pure flat areas, through superimposition, or through mixtures, thereby highlighting an essential aspect of his pictorial practice.

Deciphering green pigment composition and alteration processes in martyrdom palms of 18th-century *simulacra* found in Portugal: A multi-analytical investigation

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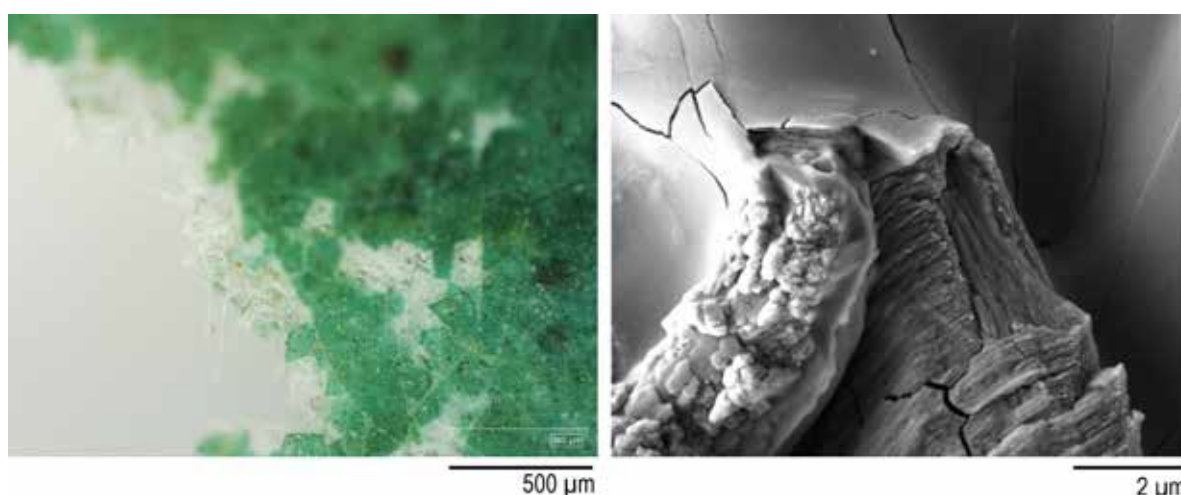
ABSTRACT

Simulacra are composite reliquaries from the 18th and 19th centuries incorporating the skeletal remains of presumed early Christian martyrs (*corpi santi*) exhumed from the Roman catacombs [1]. A palm carved on the loculus stone signalled martyrdom, hence *simulacra* were later accompanied by the martyrdom palm. In the last century, little attention has been given to *simulacra*, and their martyrdom palms remain understudied. In this study, we investigate the composition and alteration processes of the green pigments used in the martyrdom palms from four *simulacra* preserved at Santa Casa da Misericórdia and one at the Palácio Nacional de Queluz. A multi-analytical approach combining OM, FEG-SEM, FT-IR, and Py-GC/MS was employed to identify a Cu-



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based pigment applied to the paper support with a proteinaceous binding medium. The pictorial layers show significant pigment leaching, with Cu and Ca oxalates as the dominant phases, indicating extensive pigment alteration. Although many have documented the formation of metal oxalates associated with Cu-based pigments in oil paintings [1], this phenomenon remains largely unexplored in proteinaceous binding media and even more in paper works. Therefore, we investigated the use of metal halide salts to produce sample cross-sections, which were then chemically imaged by ATR- μ FTIR, revealing the spatial distribution and abundance of metal oxalates and other alteration products within the pictorial layer stratigraphy. For a more in-depth characterisation, synchrotron-based μ XRF, μ XANES, and μ XRD were employed to characterise pigment composition and probe Cu speciation and coordination environments. These techniques delivered new insights into the pigment alteration processes and revealed yet unreported potential metal proteinate complexes and verdigris phases. Overall, this work advances understanding of metal oxalate formation in paper-proteinaceous systems and highlights how material studies unveil *simulacra* in Portugal.



Acknowledgements

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Limitations of XRF Scanning:

A Comparison of Exposure Times in the Seconds and Milliseconds Range for Pigment Identification on example of a painting assigned to J. M. W. Turner

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ABSTRACT

XRF scanning is a non-invasive tool nowadays widely applied for XRF analysis of paintings from different centuries. As well known, this technique can visualize the elemental distributions which are then correlated to pigments used in paints. Many XRF scanners from different companies and/or self-built instruments (e.g. University of Antwerp group around K. Janssens, etc.) are used in the field of cultural heritage, with the growing tendency to fast scanning with pixel times (exposure times) in range of milliseconds. This allows for benefits concerning shorter analysis time, especially in cases when large paintings have to be analyzed, but also undergo limitations, as pigments in lower concentrations and/or in paint mixtures can be overseen.

This work compares exposure times in seconds (s) and milliseconds (ms) range for XRF scanning of the oil on canvas painting *“Venice, seen from the Canale Giudecca, with the Santa Maria della Salute Church”* attributed to J.M.W. Turner, painted around 1840. The painting belongs to the so-called late Turner’s paintings (roughly 1835-1851), which are characterized by his experimental, dynamic painting manner with prioritized light,



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color, and atmosphere over precise form, resulting in impasto paint applications and immersive compositions (so-called “painting set free” style). This painting technique results in areas containing several paint mixtures instead of defined superimposed paint layers usually known from traditional paintings of earlier times. Analyzing such impasto paintings, challenges occur when XRF scanning is applied for pigment identification and distribution. We could show that exposure times within the range of seconds enabled clear detection of cobalt yellow (aureolin, a potassium cobaltinitrite) in yellow paint areas on impasto beneath, whereas this information could not be obtained in all analyzed “mixed paint” areas by applying exposure times in ms range. Cobalt yellow was not mentioned previously in J.M.W. Turner’s palette [1] and it’s detection suggests that it was used very early on, since it was not yet in commercial use at that time. The presence of the pigment was confirmed by FTIR spectroscopy. These results show that performing XRF scans with exposure times in ms range may result in the loss of important information and overseeing the pigment in mixed paint areas. X-ray intensities of K Ka and/or Co Ka lines collected within ms range were too weak to give clear conclusions, especially when found together in yellow areas on cobalt blue.

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Automatic pigment identification using registered VNIR and MA-XRF hyper-spectral imaging

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ABSTRACT

The identification of pigments in historical paintings is essential for understanding artistic practice, informing conservation decisions, and detecting later interventions. Visible–near-infrared (VNIR) hyperspectral imaging and macro-X-ray fluorescence (MA-XRF) spectroscopy are two complementary, non-invasive techniques widely used for this purpose: VNIR captures the spectral reflectance signature of paintings, while MA-XRF maps their elemental composition.

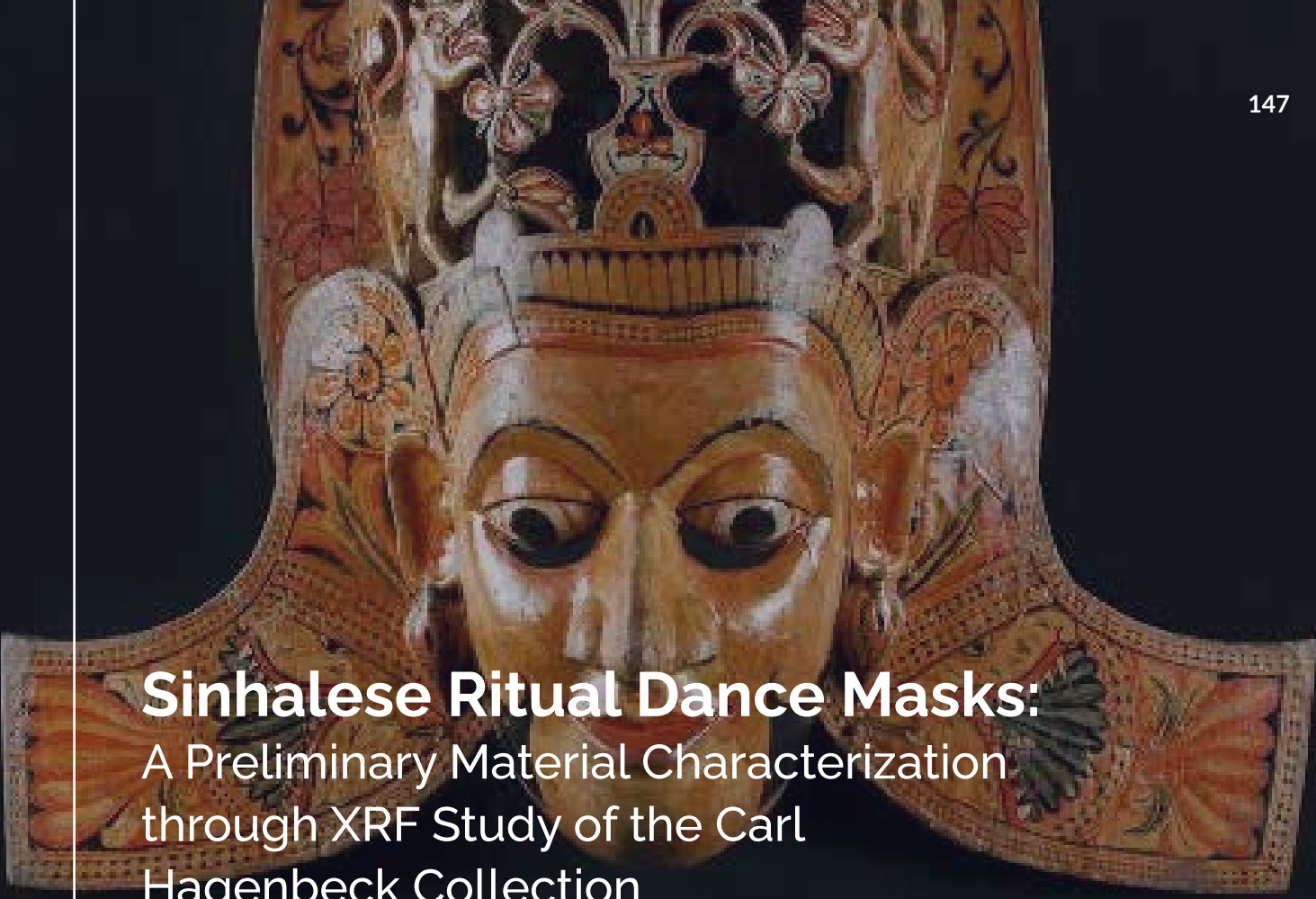
This work presents a pipeline for automated pigment classification that combines registered VNIR and MA-XRF data through machine learning. The two hyperspectral datacubes are first brought into a common spatial reference using a mutual-information-based registration method consisting of an affine coarse alignment followed by a B-spline non-rigid refinement. Once co-registered, each pixel is described by both its spectral reflectance profile and its elemental signature, enabling multimodal classification.



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Classifiers are trained on reference colour charts manufactured by Blockx, a Belgian oil paint maker. A well-preserved rectangular chart dating from 1936 serves as training dataset, while an older colour chart from 1909 from the same manufacturer is used for validation. While both colour charts are from the same manufacturer, aging and conservation conditions are sources of data variation.

Several classifiers are compared including support vector machines, random forests, and gradient boosting using both individual modalities and their fusion. Fusion strategies range from early concatenation of feature vectors to calibrated probability-weighted combination. First results indicate that the VNIR modality carries the primary discriminative signal, while XRF features improve separation of chemically distinct but spectrally similar pigments. Certain classes, notably cadmium-based yellows, exhibit different VNIR spectral signatures due to conservation conditions and are thus prone to misclassifications.



Sinhalese Ritual Dance Masks:

A Preliminary Material Characterization through XRF Study of the Carl Hagenbeck Collection

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ABSTRACT

The Museum of Cultural History in Oslo acquired a significant collection of 19th-century Sri Lankan ritual dance masks, from the company of Carl Hagenbeck in 1887. These masks were used in Sinhālese ritual ceremonies specially known as *Sanniyakuma* and *Kōlam Theatre*. They represent various human, mythical beings and faunas related to Sinhalese ritual legends and in ceremonies to heal people suffering from supernatural illnesses. This collection of carved wooden masks represents a unique intersection of native rituals, color symbolism, craft traditions, materials, techniques and colonial trade.

This study presents preliminary analytical results aimed at identifying traditional materials of the restricted palette used in these objects during a transformative period in Sri Lankan art and craft history. Literature [1] reports that traditional palette was

composed by six colors – white, red, yellow, black, blue and green – ranging from inorganic to organic sources.

Non-invasive elemental analysis was performed on a representative group of eight masks, focusing on characterizing the inorganic components of the paint and ground layers. The analysis targeted the six pigments to determine the use of traditional minerals versus early synthetic alternatives available in the late 19th century. XRF spectra indicates a palette largely consistent with traditional Sinhalese art and craft practices. It includes mercury-based reds (likely cinnabar/vermilion) and arsenic-based yellows (orpiment). The data provides a chemical fingerprint of the “Hagenbeck” group, offering a baseline for comparing these masks with those collected in situ in Sri Lanka during the same era.



Mask, Mahā-Sammathā Rāja/ Legendary Human
Ritual Function and Context: Kōlam theatre
Photo: Mårten Teigen, Museum of Cultural History,
University of Oslo

Acknowledgements

Olav Hamran and Ralfs Znotins, Department of Ethnography, Numismatics, Classical Archaeology and University History of the Museum of Cultural History, are gratefully acknowledge for facilitating the access to the Sinhālese masks collection.

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Between Anonymity and Masterpiece: Attribution Studies of a Unique Baroque Painting from the Archdiocesan Museum in Wrocław

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ABSTRACT

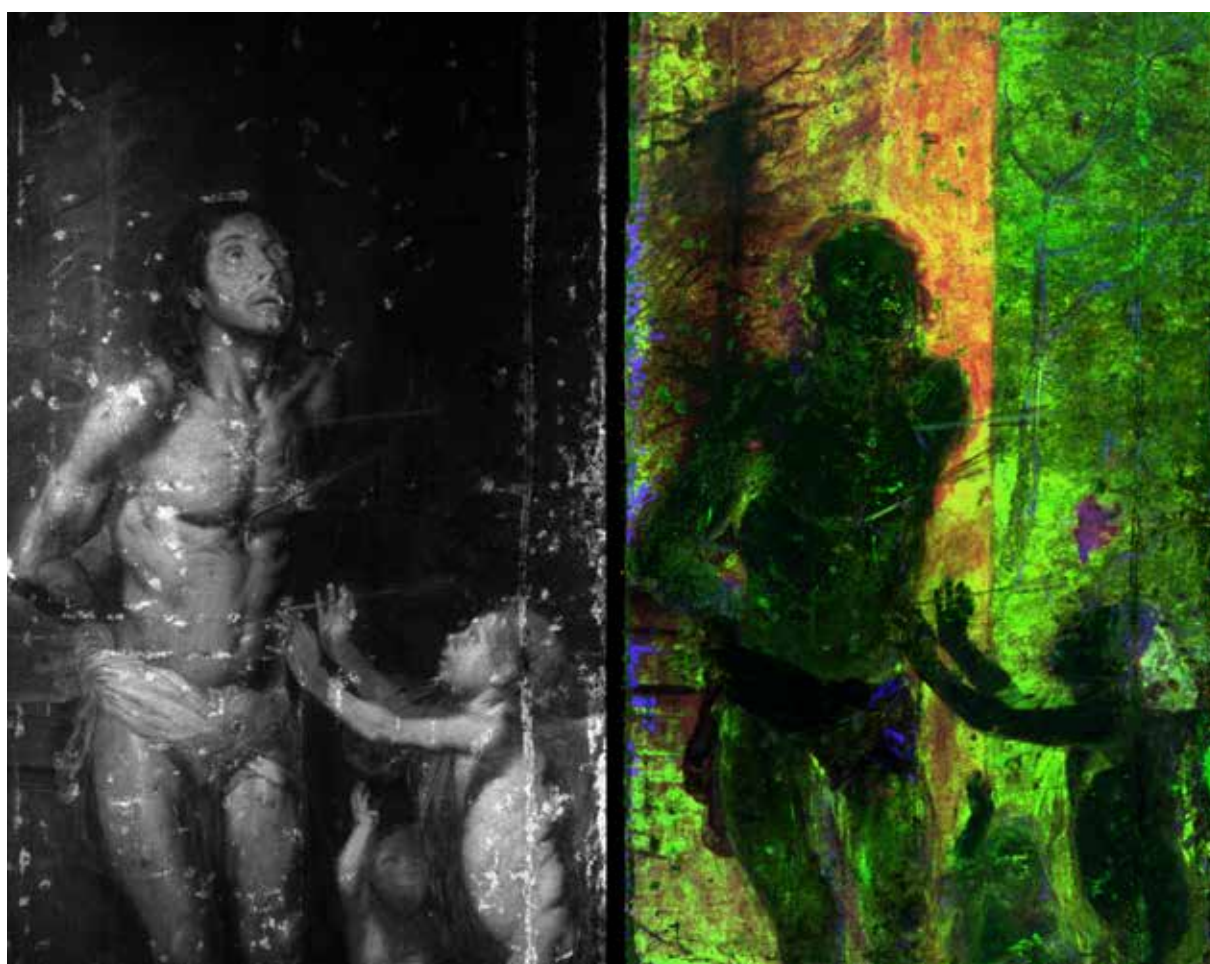
In December 2024, Wrocław's Archdiocesan Museum reopened after five years of renovation work, during which time it adopted the latest display techniques. The museum's Baroque collection includes a painting by an unknown artist entitled "*The Martyrdom of St. Sebastian*". Despite its high quality, the work has not been studied enough. The aim of this project was to establish the painting's authorship and probable date of creation. Preliminary art historian analysis suggests that the artist may have been Michael Willmann, known as the '*Silesian Rembrandt*'.

This study provides a comprehensive physico-chemical characterisation of the painting, focusing on its constituent materials and stratigraphic structure. Non-invasive imaging (UV, IR and NSI imaging) will assess the state of preservation and reveal underdrawings, retouching, or later alterations. Elemental mapping via MA-XRF will offer spatially



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resolved data on inorganic components Micro-samples will undergo cross-sectional analysis using optical microscopy (VIS, UV) and SEM-EDS to determine layer structure and pigment morphology. Finally, Raman spectroscopy and GC-MS will be employed for the identification of pigments and the characterisation of organic binders. The gathered data were compared with the reference database referring to the Willmann painting techniques [1] built by the Wrocław laboratory over two decades of research into the artist's works. his multi-analytical approach produced a detailed characterization of the painting's material history. These findings elucidate its dating and provenance, providing a critical foundation for attribution and the reconstruction of its historical identity.



Acknowledgements

Project funded by Polish National Node of European Research Infrastructure for Heritage Science ERIHS ERIC.

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Digital Ontologies of Cultural Heritage: Integrating Advanced Imaging Techniques with Heritage Science Research Infrastructure

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ABSTRACT

Heritage science increasingly relies on material analysis and non-invasive techniques, while digitization in GLAM (Galleries, Libraries, Archives, and Museums) institutions is still predominantly treated as a tool for documentation and access. This project reconceptualizes digitization as a research-oriented, data-generating process that directly supports material and conservation studies.

The proposed approach integrates collection analysis, advanced imaging methods (including multispectral imaging and Reflectance Transformation Imaging, RTI), and interoperability standards to produce structured, reusable datasets. These data enable material characterization, condition assessment, and provenance research. An important example of this is the non-invasive way in which watermarks in manuscripts and early printed books can be identified and analysed, which supports more precise dating and attribution.

Central to the model is the implementation of the IIIF standard (International Image



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Interoperability Framework), which ensures interoperable image delivery, comparative analysis, and integration with external research environments. In combination with OCR technologies, this allows the simultaneous examination of textual content and material features within a unified analytical environment.

By treating digitization outputs as research data, the model complements physico-chemical analyses and supports conservation decision-making without direct intervention. This approach, developed within the E-RIHS.PL infrastructure, enhances the research capacity of heritage institutions and ensures the long-term sustainability of digitization initiatives.



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Development of a Multiwavelength OCT System for the Analysis of Cultural Heritage Materials

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ABSTRACT

Over the past two decades, Optical Coherence Tomography (OCT) has become an indispensable, non-invasive technique for examining cultural heritage materials [1]. However, commercial OCT systems have mostly been developed for biomedical applications and operate at central wavelengths of around 800 nm, 1300 nm or occasionally 1500 nm, achieving micrometre-scale resolution and penetration depths of 1–2 mm in biological tissues [2]. In highly scattering media such as paintings, longer wavelengths are preferred because they increase penetration depth; however, achieving similar resolution at these wavelengths requires much larger bandwidths. This compromise is fundamental to the design of OCT systems. For instance, the optimal spectral window for imaging the subsurface structure of paintings, localising underdrawings, and characterising most historic artists' pigments is approximately 2.2 μm [2], as demonstrated in an in-house-built 1960 nm OCT [3]. OCT systems operating at



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1300-1500 nm provide a good compromise between axial resolution, lateral resolution, and penetration depth [4]. By exploiting two NIR wavelength bands within the same instrument, which allows correlative OCT imaging at the two wavelengths to be performed at ease, this work proposes developing a multi-wavelength OCT system to image semi-transparent materials at different depths and scales with high resolution. Experiments on mock-up samples of multilayered pigments on canvas demonstrate that this setup will enable faster, non-invasive analysis of artistic materials while addressing challenges in studying artefacts.

Acknowledgements

This work has benefited from French State aid managed by the Agence Nationale de la Recherche under the future investment program integrated into France 2030, bearing the reference ANR-21-ESRE-0050 EquipEx+ ESPADON, and supported by the French "Fondation des Sciences du Patrimoine" ANR-17-EURE-0021.

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Unveiling Pompeii's Palette: Integrated Analyses to Understand Technique and Colour Making

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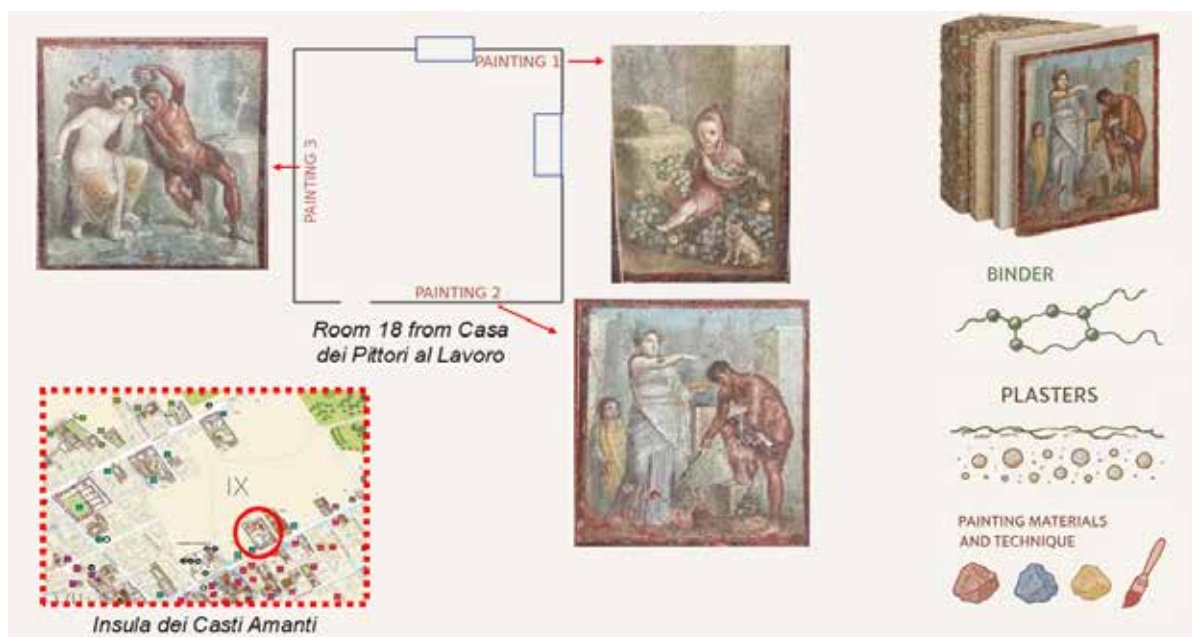
ABSTRACT

This study presents the preliminary results of a multi-analytical investigation carried out in Room 18 of the *Casa dei Pittori al Lavoro (Insula dei Casti Amanti, Pompeii)* to ascertain the used colour palette. In this room, three different mural paintings were analysed, apart from all the details and drawings throughout the room. The combined use of in-situ (multispectral and hyperspectral imaging in the range of visible and near-UV, X-ray fluorescence, Raman spectroscopy, optical microscopy, and thermographic imaging) and laboratory techniques (stratigraphic analysis, SEM-EDS, and FT-IR) enabled the identification of pigments while providing new insights into both the painting techniques and the conservation state of the wall paintings.



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Visible and near-UV range enhanced the legibility of tonal modulation, brushwork, and shadow hatching, while no preparatory drawing or *pentimenti* were detected; only incised guidelines were identified. Microscopy and cross-sections analyses revealed a two-layer lime-based plaster (*arriccio* and fine coat) with pigments applied predominantly into a *fresco*, though textural brushstrokes indicate subsequent a *secco* interventions. Pigment analysis identified a palette dominated by earth pigments (red and yellow ochres), hematite, Egyptian blue, green earth, and occasional cinnabar and a pigment composed by lead. Environmental diagnostics detected rising damp and crystalline efflorescences on the southern wall of the room. FT-IR and Raman analyses identified gypsum as the main salt, while IC confirmed a sulphate-dominated saline system with a significant magnesium contribution, providing essential data for understanding moisture-related deterioration processes. These results contribute to reconstructing the artist's technical choices and inform future conservation strategies for the room's decorative program.



Acknowledgements

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Beyond Iron Gall Ink: Analytical Insights into Mica - and Brass Particles in Blotting Sands

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ABSTRACT

The project focused on the conservation, restoration, and scientific study of archival manuscripts belonging to the historical collection of the Evangelical-Augsburg Parish in Kraków. The materials, dating from the seventeenth and eighteenth centuries, include parish books, chronicles, correspondence, and documents authenticated with wax seals. Alongside conservation treatments, an extensive diagnostic programme was carried out to assess the condition and material characteristics of the writing media, with particular emphasis on iron gall inks.

A wide range of analytical methods was employed, including the Dutch method for evaluating ink corrosion, chemical analyses, pH measurements, multispectral imaging, scanning electron microscopy, FTIR spectroscopy, microfading tests, and macro-XRF scanning. These complementary techniques enabled a detailed understanding of the



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inks' composition, degradation patterns, and interactions with the paper support.

The research revealed significant diversity among the iron gall inks used in the manuscripts. Of particular interest was a group of decorative, metallic inks, produced by enriching traditional iron gall formulations with mica flakes and brass particles derived from blotting sands. These additions created a shimmering, gold-like effect, while simultaneously introducing new conservation challenges. The combination of metallic additives with the inherently acidic and reactive nature of iron-gall inks resulted in complex degradation phenomena, requiring carefully tailored conservation strategies.

The outcomes of the project include the development of practical recommendations for the treatment and long-term preservation of manuscripts written with both standard and modified iron gall inks, including the rare brocaded variants. The findings also shed new light on historical writing practices within the Kraków Evangelical community and highlight the importance of interdisciplinary approaches in the study and safeguarding of documentary heritage.



Mica flakes and brass particles derived from blotting sands identified in iron gall ink through analytical examination, from the collection of the Evangelical-Augsburg Parish in Kraków.

Biogenic Heavy Metal Mobilization in Polychrome Artworks: Unveiling Novel Microbial Structures through Integrated Analytical Approaches

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ABSTRACT

The presence of microorganisms on pictorial surfaces is widely recognised. However, microbial activity may cause the biogenic mobilisation of heavy metals, such as lead (Pb), in polychrome artworks of high cultural and historical significance. We aim at developing an innovative approach to study the correlation between specific microbiological morphologies and the presence of elements such as Pb, Cl, and P, suggesting the occurrence of active biotransformation processes.

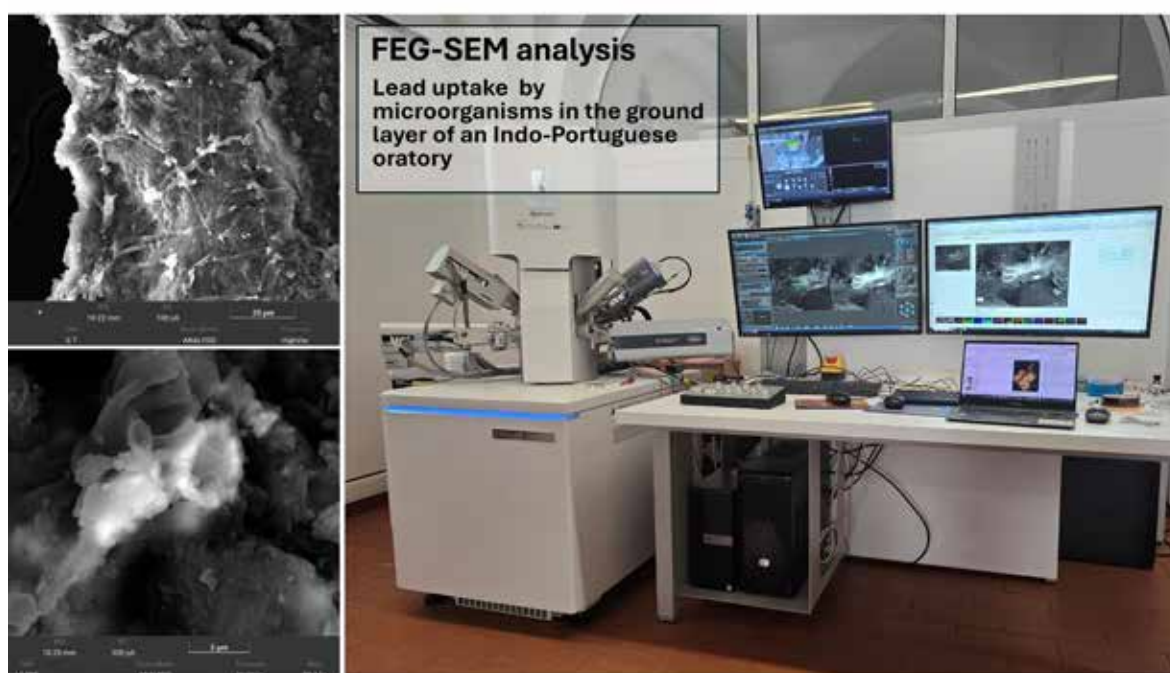
Through the integrated application of advanced analytical techniques, including field



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emission gun scanning electron microscopy (FEG-SEM), scanning electron microscopy coupled with energy-dispersive X-ray spectroscopy (SEM-EDS), Fouriertransform infrared spectroscopy (FTIR), Raman spectroscopy, and X-ray diffraction (XRD), the project aims to elucidate how microorganisms interact with heavy metalcontaining pigments. These interactions may lead to processes of alteration, solubilisation, or reprecipitation of materials such as lead white (PbCO_3 , Pb(OH)_2), thereby affecting the material stability of the artworks.

By advancing knowledge of biodeterioration processes associated with these systems, this research contributes to the development of more effective and sustainable preventive conservation strategies, tailored to the specific vulnerability of polychrome objects.



Acknowledgements

Helena Melo acknowledges the Portuguese Foundation for Science and Technology (FCT) for the postdoctoral grant (SFRH/BDP/109296/2015). Vanessa Antunes acknowledges support from FCT through the public employment contract CEECIND/04141/2018/CP1552/CT0002. The authors also thank the ERISH.pt Lacca Indiana and Saint Vincent Panels project teams, Parques de Sintra – Monte da Lua, and NRestauros Lda for providing additional access to micro-samples in the framework of the BioArt Project.



Digitalising the sacred: 3D documentation and virtual access to *simulacra* in Portugal

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ABSTRACT

The digital documentation of vulnerable and poorly accessible heritage has become a key strategy for ensuring its preservation, accessibility, and long-term transmission. This is particularly relevant in the case of *simulacra*, full-body reliquaries incorporating skeletal remains of presumed early Christian martyrs, a largely unknown and fragile category of religious heritage in Portugal. Many of these reliquaries remain hidden, insufficiently documented, or at risk of gradual loss through neglect and diminishing cultural awareness. Digitalisation and VR thus emerge as critical strategies for ensuring their long-term preservation and visibility.

Within the framework of the Holy Bodies project (<https://holybodies.uevora.pt/>), an interdisciplinary approach was developed to digitally document, archive, and communicate *simulacra*. Around sixty have been identified, and a significant subset has been recorded using high-resolution 3D scanning technologies, enabling the creation of accurate digital replicas that capture complex geometries and surface details. These models constitute the basis of a growing digital repository designed to support research, conservation planning, and long-term data preservation. In parallel, an immersive virtual environment was developed to provide contextualised access to these reliquaries, integrating architectural design, narrative strategies, and interactive visualisation. This virtual exhibition allowed users to explore *simulacra* within a reconstructed spatial and symbolic framework, overcoming physical, ethical, and conservation constraints associated with direct access to sacred objects containing human remains.

By combining 3D documentation, digital archiving, and virtual dissemination, this work demonstrates how digital tools can enhance the management, visibility, and sustainability of sensitive heritage collections, ensuring their preservation and transmission to future generations.



Acknowledgements

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Embodying sanctity in Portugal:

Analytical overview of
materials and techniques in
simulacra reliquaires of early
Christian martyrs

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ABSTRACT

Simulacra, full-body reliquaries incorporating skeletal remains of presumed early Christian martyrs (*corpi santi*), constitute complex engineered religious artefacts at the intersection of material science, craft, and devotion. In Portugal, three main typologies were identified: reclining lateral, semi-recumbent, and fully recumbent, defining a continuum of material transformation from partially exposed skeletal assemblages to fully concealed anthropomorphic representations. All typologies share a structural core based on metallic armatures supporting assembled skeletal remains, integrated within multilayered composite systems combining textiles and modelling materials, reflecting specialised artisanal practices. The reclining lateral typology preserves visible skeletal elements beneath translucent coverings such as gauze, emphasising the relic dimension and material heterogeneity. Semi-recumbent examples show progressive

concealment through layered gauzes, resulting in more unified surfaces. The fully recumbent typology exhibits the highest degree of transformation, where polychromed moulded elements, such as wax or plaster, often incorporating hair, dominate the visible body and obscure the skeletal core [1].

A multi-analytical approach integrating in-situ digital radiography and endoscopy with chromatographic (Py-GC/MS) and spectroscopic techniques (ATR-FT-IR, Raman, SEM/EDS) enabled the characterisation of internal structures, binding media, and composite interfaces of examples from the different typologies of *simulacra*.

By framing *simulacra* as complex, evolutive material systems, this study establishes a correlation between structural organisation and material composition, providing a framework for understanding the manufacture and material evolution of *simulacra*, contributing to their reassessment within heritage science and religious studies.



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St Bonifácio | Igreja de S. Nicolau • Lisbon

Acknowledgements

This work was funded by the Holy Bodies Project (10.54499/2022.01486.PTDC) and strategic projects UID/04449/2025 and 10.54499/LA/P/0132/2020. M. Nunes and J. Palmeirão acknowledge, respectively, the JDC2024-053901-I grant funded by MICIU/AEI/10.13039/501100011033 and ESF+, and a postdoctoral scholarship under the Holy Bodies Project.

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Rock Art at Risk: Materiality, Environment, and Conservation Challenges at the Archaeological site of Lapa da Sucupira (Brazil)

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ABSTRACT

Brazilian rock art represents a key source for reconstructing the cultural and symbolic practices of pre-colonial populations. Beside extensive stylistic and iconographic studies, research gaps regarding the materials and techniques used in the production of rock art, as well as the post-depositional processes affecting its preservation are still present. In this research, the pigment chemical/mineralogical composition and physical/biological weathering mechanisms acting on rock art panels developed on a limestone substrate at the Lapa da Sucupira archaeological complex in Minas Gerais (Brazil) have been investigated adopting a multianalytical and minimally invasive methodological approach (pXRF-μXRD-Raman Spectroscopy-Microbiological analyses).



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Situated within the rapidly expanding Metropolitan Region of Belo Horizonte (*Serra do Cipó*), the site is increasingly exposed to severe environmental stressors driven by rapid urban development and anthropogenic vandalism. Preliminary results identify a palette of iron-based pigments (hematite and goethite), manganese-rich concretions, kaolin, and carbonates. These results are particularly relevant for conservation, as the limestone substrate is highly vulnerable to local environmental conditions. Extreme temperature variations cause the rock surface to flake and detach, while water-related processes create white mineral patinas that gradually obscure the paintings. These issues are further worsened by biological growth, such as lichens and insect nests, alongside modern human impacts, necessitating urgent and specialized preservation strategies.



Acknowledgements

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When Images Speak:

Decoding artistic practice and revealing unknown restoration layers through non-invasive imaging and analysis

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ABSTRACT

This research, carried out within the framework of the ARIA Project (Art, Rhythm, Intonaco, Analyses), addresses key questions concerning the technique, authorship, and conservation history of a seventeenth-century mural painting (1637–40) located on the vaulted ceiling of the Sala da Música Profana, Paço Ducal de Vila Viçosa. Traditionally attributed to the Portuguese painter Manuel Franco, with alternative hypotheses suggesting the involvement of the Venetian painter Bernardino del Agua, the painting raises fundamental questions regarding its execution. Central to the investigation was whether more than one hand was involved and how their respective contributions might be distinguished. The painting was also believed to have undergone only an emergency conservation treatment in the 1990s, with no evidence of earlier interventions. To address these issues, a non-invasive, image-based analytical approach was implemented, privileging technical photography (visible, visible raking light, and UV-induced fluorescence) and portable optical microscopy as



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primary tools for in situ examination. The results demonstrate the central role of imaging techniques in reconstructing the artist's *modus operandi*. Raking light and microscopic observation enabled the identification of *giornata* boundaries, preparatory incisions, and underdrawings, as well as a wide range of pictorial strategies. Variations in brushwork, layering, and modelling point to the involvement of more than one hand within a workshop context, while also providing insight into surface morphology and condition—particularly in the more unstable blue and green areas. Importantly, the imaging campaign revealed the presence and extent of previously undocumented restoration intervention. Differences in fluorescence response, surface texture, and pigment behaviour exposed widespread overpaints and retouches, significantly reshaping the understanding of the painting's conservation history. These findings highlight the value of non-invasive imaging and optical microscopy as primary diagnostic tools in fieldwork, informing technical interpretation, generating new data for technical art history, and supporting conservation assessment.

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Forgotten Murals, Recovered Histories:

Integrating non-invasive imaging
and in situ analysis in the study
of the 1956 mural paintings of
the former bus Station in Évora
(southeast Portugal)

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ABSTRACT

This study, initiated in 2023 as part of the ALMADA Project, focuses on the technical, material, and conservation assessment of a set of mural paintings executed in 1956 on the walls of the former bus station in Évora (southeast Portugal). These murals, depicting past agricultural activities from regions served by the Setubalense transport company, constitute the only known surviving examples of the artist mural painting production. Produced by a self-taught worker-artist named Carlos Alberto employed by the company- these paintings offer a rare insight into mid-twentieth-century mural practices developed outside canonical artistic circuits. Moreover, the absence of documented conservation interventions makes this ensemble an exceptional case study for the in situ investigation of original paint materials and techniques and how prolonged exposition to bus exhaust fumes have impacted in the current state of conservation. The methodology highlighted in this paper integrates non-invasive imaging and in situ analytical techniques, combining technical photography (visible, raking light, UV-induced fluorescence, and infrared imaging) with colourimetry, visible spectrophotometry, portable X-ray fluorescence (p-XRF), and p- optical microscopy



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which is further complemented by micro analytical analysis of paint layers samples. First imaging analysis reveals a highly opaque paint surface, with evident impasto and a certain unctuous quality, while UV-induced fluorescence shows heterogeneous fluorescent emissions across the painted surface. Preliminary results suggest that these features may be related to binding media and/or surface coatings, in line with initial analytical data by PY-GC/MS indicating compounds associated PVA/PVAc, fatty acids, and resinous materials. Colorimetric measurements (CIE Lab*) show the richness and variability of the chromatic palette across the three murals studied, while initial p-XRF analyses reveal a complex elemental composition—including Fe, Ca, Cu, Zn, Ba, and Sr—suggesting the use of a range of pigments and extenders of both natural and modern origin within the pictorial layers. These preliminary findings establish a first material and technical framework for an ongoing archaeometry master investigation in archaeometry, contributing to a broader understanding of modern mural painting practices in Portugal.

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Ageing of Synthetic Conservation Materials in Lime-Based Mural Paintings: Assessing Compatibility and Retreatment in Changing Environmental Conditions

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ABSTRACT

This study examines the long-term behaviour of synthetic materials used in past conservation interventions on lime-based mural paintings, taking as a case study the works by Almada Negreiros (1945–49) at the maritime stations of Alcântara, Lisbon. Documentary research combined with in situ diagnostic analysis enabled the identification of polymer-based materials applied during interventions carried out in the 1970s, including Mowiol, Gelvatol, and Paraloid B-72, used to address issues of cohesion and adhesion of the paint layers. More than fifty years after their application, these materials provide an opportunity to assess their ageing and performance within porous lime-based systems. A non-invasive multi-analytical approach was adopted, combining technical imaging (visible, raking light, and UV-induced fluorescence), in situ microscopy, and targeted micro-analytical techniques. These methods enabled the identification of intervention layers and the assessment of their interaction with original substrates. Rather than addressing reversibility—largely unattainable in such



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systems—the study focuses on compatibility and retractability. The results show that polymeric materials, still widely used under different commercial formulations, behave differently from original lime- and sand-based substrates, potentially leading to adverse effects over time. Similar concerns arise in relation to materials used in chromatic reintegration, whose ageing may alter their optical properties and affect the perception and reading of the original pictorial layers. These findings raise questions regarding long-term performance and conditions of use, particularly under increasing environmental pressures and in relation to concentration and application. The study promotes discussion on the use of polymeric materials in lime-based mural paintings and highlights the importance of anticipating their ageing and behaviour in the face of deterioration phenomena.

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Exploring the potential use of photocatalytic nanomaterials for the preservation of cultural heritage materials

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ABSTRACT

In recent years, photocatalytic treatments have been explored for their potential role in cultural heritage conservation, whether on architectural surfaces, such as stone monuments, or on paintings. This growing interest is mainly due to their self-cleaning properties, which make them a promising solution for preserving and maintaining materials exposed to degrading environments. Titanium dioxide (TiO₂) nanomaterials are well known for their ability to degrade organic and inorganic contaminants under light irradiation, facilitating dirt removal and reducing the adhesion of contaminating particles [1].

In painting conservation, particularly for easel paintings, the use of TiO₂ nanoparticles



emerges as an innovative approach for cleaning pictorial surfaces and creating protective layers that can deaccelerate the accumulation of dirt and, consequently, material degradation. However, to be successfully implemented, this approach must overcome several constraints, due to the combination of the structural complexity of the paintings, which are composed of distinct organic and inorganic layers, and the photocatalytic mechanisms of TiO_2 , which may interact with components of the paint, such as organic binders.

To date, only a limited number of studies have reported on the potential use of photocatalysts on easel paintings [2]. This research aims to advance the state of the art in this field by investigating the application of photocatalytic nanomaterials on sensitive cultural heritage materials, such as easel paintings, while identifying the key limitations and risks associated with their implementation in real conservation contexts.



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Next-Generation Bioactive Compounds Developed via Ugi-4CR for Cultural Heritage Preservation

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ABSTRACT

Cultural heritage is increasingly threatened by biodeterioration caused by microorganisms such as bacteria, fungi, algae, and yeasts. In Portugal, high humidity and the abundance of protein-based materials in artworks enhance microbial colonisation, posing significant conservation challenges. [1]

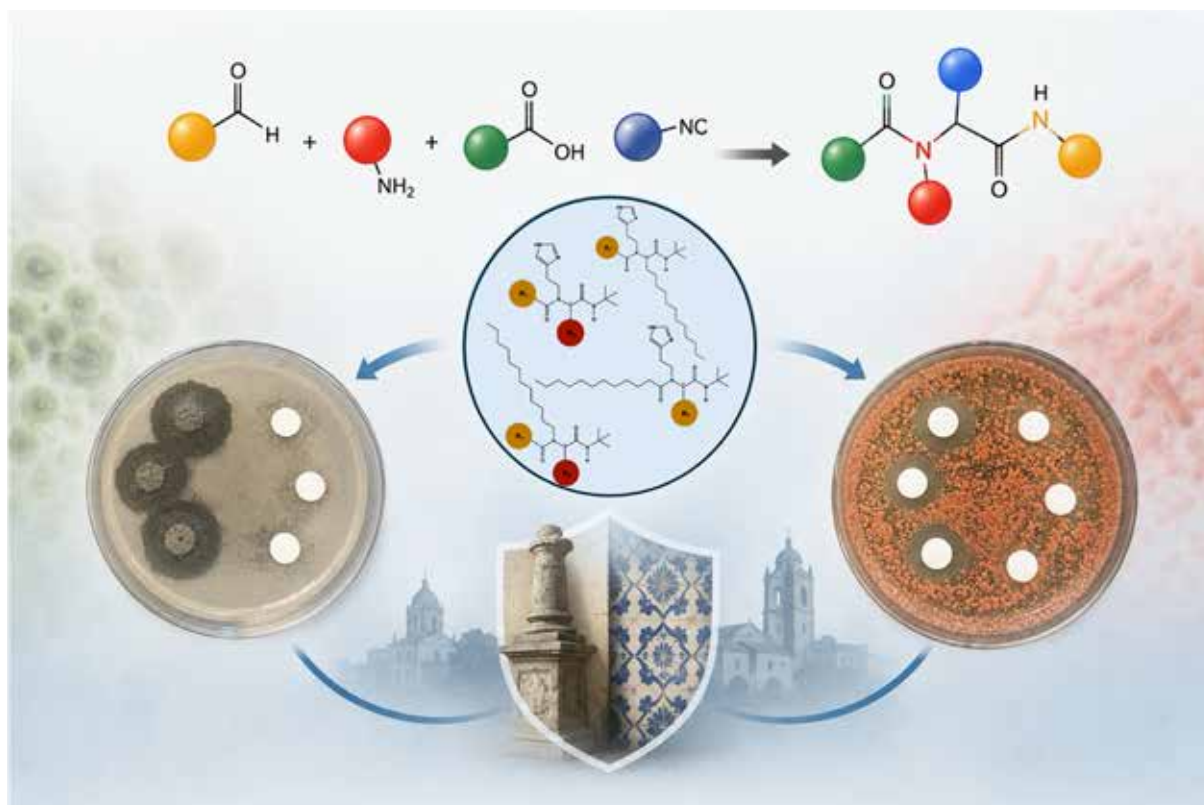
Conventional chemical biocides, while effective, raise concerns due to toxicity, environmental impact, and limited long-term efficacy, highlighting the need for safer alternatives. [2] Natural antimicrobial compounds, such as cyclic lipopeptides from *Bacillus* species, show promise but face limitations in stability and material compatibility. [3]

In this context, multicomponent reactions, especially the Ugi four-component



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reaction, offer a versatile and sustainable synthetic platform to design novel bioactive compounds. This work aims to develop low-toxicity, cost-effective peptidomimetic molecules with tailored physicochemical properties, capable of controlling biodeterioration while ensuring compatibility with cultural heritage substrates.



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Balancing analytical performance and invasiveness: SERS strategies for historical textile dyes

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ABSTRACT

The identification of natural dyes by vibrational spectroscopies in ancient artefacts remains a significant analytical challenge. Surface-Enhanced Raman Spectroscopy (SERS) is particularly well suited for detecting these organic molecules on textiles. We will focus on optimising the detection conditions for three red anthraquinone dyes with very similar molecular structures, while progressively increasing the degree of invasiveness of the SERS measurement process.

SERS substrates are based on nanostructured plasmonic metals, which, depending on their shaping, will require implementation methods involving varying degrees of invasiveness. Our approach will range from non-invasive SERS-active removable gel [1] applications to dye microextraction mixed with colloidal nanoparticles. Depending on the situations and artefacts under study, it is necessary to adapt the approaches in order to successfully obtain reliable characterisation of the present dye molecules. To



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provide an optimal range of analytical solutions, the different SERS platforms are refined by tuning some of the properties of the nanoparticles used-namely the morphology and size- each of which is closely linked to the plasmonic behaviour of the system. Further optimization is achieved through the selection of the most suitable Raman excitation wavelength.

In this study, effective strategies are first evaluated using dyed-fiber mock-up samples and then validated on archaeological artefacts from diverse chronocultural contexts. This work provides insight into the parameters influencing signal amplification, particularly resonance effects and SERS substrate design. Furthermore, the results obtained from the ancient samples help to document the use of dyeing resources for textile colouring.

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Heritage Science Applied to Preventive Conservation: The Role of LaCoP in the Preservation of Fiocruz's Architectural Heritage

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ABSTRACT

The conservation of the architectural heritage of the Oswaldo Cruz Foundation (Fiocruz) is the responsibility of the Casa de Oswaldo Cruz (COC), through its Department of Historical Heritage (DPH). Over the years, restoration and conservation interventions have been carried out in the Architectural and Historical Complex of Manguinhos (NAHM), and since 2009, increasing attention has been devoted to preventive conservation strategies. Established in 2024, the Preventive Conservation Laboratory (LaCoP/DPH) aims to contribute to the preservation of Fiocruz's cultural, scientific, and health-related heritage. This study aims to present the ongoing activities of LaCoP within the framework of Heritage Science. As a methodological approach, priority was given to the development of protocols to guide laboratory activities, with particular emphasis on safety procedures and waste management. This approach addresses both operational and environmental risks. To this end, regulatory documents were developed,



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and technical cooperation was established with institutions and specialized consultants in the field of Heritage Science. Among the main outcomes, scientific investigations for the characterization and provenance of heritage materials stand out, providing support for conservation and restoration interventions, as well as for scientific dissemination. Examples include: the assessment of the deterioration state of ceramic bricks used in façade cladding, employing wavelength-dispersive X-ray fluorescence (WDXRF) and micro-computed tomography (MicroCT); the analysis of Portuguese and German tiles using non-invasive techniques such as portable X-ray fluorescence (pXRF) and fiber optic reflectance spectroscopy (FORS); and the characterization of ornamental stuccoes through X-ray diffraction (XRD), pXRF, and scanning electron microscopy (SEM), among other techniques. Future perspectives focus on consolidating LaCoP as a reference laboratory, fostering the integration between academic research and laboratory practices. These studies support the Conservation Plan, and further efforts will be directed toward expanding interinstitutional partnerships for the development of new materials and intervention methods that reconcile heritage preservation with occupational safety and environmental sustainability.



Microbial Diversity and Biodeterioration in Paintings: A Comparative Study in Different Environmental Contexts

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ABSTRACT

The biodeterioration of cultural heritage results from interactions between microbial communities, material substrates, and environmental conditions. This study compares paintings showing some signs of biodeterioration, belonging to three collections from distinct contexts: the Viceroy's Gallery of Goa (India), the storage reserves of the National Museum of Ancient Art (MNAA, Lisbon), and the Art Gallery of Silpakorn University (Thailand). The aim was to investigate how the interplay between microbial communities, substrate characteristics, and environmental conditions shapes microbial diversity and biodeterioration processes. Microbial identification was performed using Next-Generation Sequencing (Illumina MiSeq), complemented by scanning electron

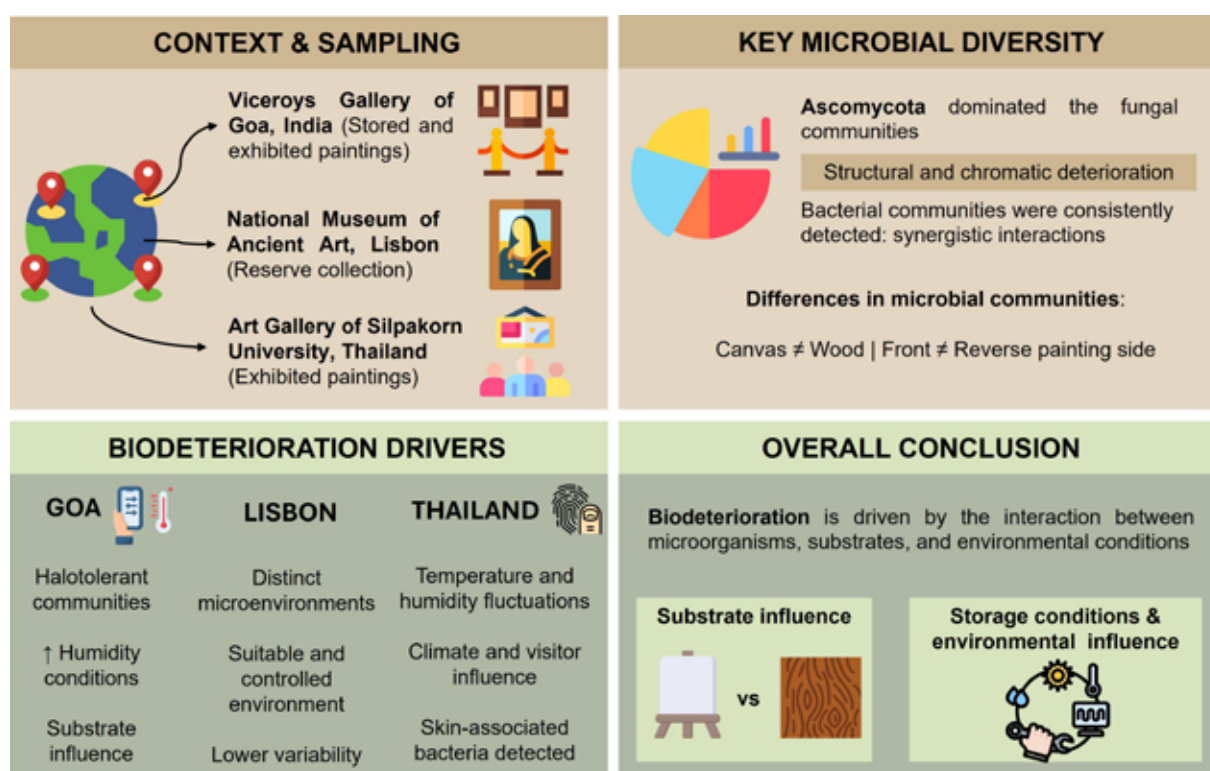


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microscopy and antimicrobial assays.

Fungi, particularly from the phylum Ascomycota, were the dominant colonizers, associated with structural degradation and chromatic alterations. Bacterial communities were also consistently present, suggesting potential synergistic interactions. Despite common patterns, differences between locations were evident: Goa paintings showed halotolerant microorganisms linked to high humidity and poor environmental control; within the MNAA reserves, variability between paintings - and even between front and reverse surfaces - highlights the influence of microenvironments, despite overall controlled conditions; and the Thailand paintings illustrate how tropical climate and human exposure can shape microbial communities.

Overall, biodeterioration in paintings is a multifactorial process shaped by microorganisms, substrates, and environmental conditions, requiring context-specific conservation strategies.



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Conservation-Driven Scientific Analysis of the Sara Hessix Portrait: Insights into Frans Hals's Workshop Practice

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ABSTRACT

Frans Hals (c. 1582–1666) remains one of the most debated figures of the Dutch Golden Age, renowned for his dynamic brushwork and influence on portraiture. His workshop practices and the involvement of assistants have generated ongoing scholarly controversy, complicating the distinction between autograph works and those produced by followers or within his studio [1,2].

The Sara Hessix Portrait, from the Calouste Gulbenkian Museum, dated around 1626, forms part of a pair of portraits, offering key insight into its original context and function although the existence of her husband's portrait is uncertain [3].

This study presents the results of a comprehensive technical and material investigation aimed at supporting both art historical interpretation and conservation decision-making.



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A multi-analytical in situ approach was employed, combining imaging and physicochemical techniques, including visible and raking light photography, UV fluorescence, infrared reflectography (IRR), X-radiography, MA-XRF 2D elemental mapping (CRONO), and hyperspectral imaging. Digital microscopy under UV radiation enabled the differentiation of three distinct varnish layers, from which representative micro-samples were collected and analysed using Py-GC-MS. These scientific examinations not only supported the evaluation of the painting's condition but also provided deeper insight into its technical execution, allowing comparisons with other works attributed to Hals [2]. The results offer important data on materials, painting techniques, and workshop practices. Furthermore, they formed the basis for the development of a tailored conservation and restoration plan, ensuring that proposed interventions are fully aligned with the material characteristics and current preservation state of the artwork.



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Revisiting the Late Roman Coin Hoard from Chaira (Vinhais, Bragança, North-east Portugal) through Coins, Ceramics and Organic Residues

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ABSTRACT

Discovered in 1934 and currently on display at the Abbot of Baçal Museum (at Bragança, north-eastern Portugal), the Chaira Treasure is one of the most significant numismatic finds from the Late Roman period in the north-east of the Iberian Peninsula. This assemblage comprises thousands of bronze coins, originally stored in a ceramic container that fragmented at the time of discovery. Although traditionally seen as a deposit of a votive or ritual nature, existing studies have focused primarily on numismatic analysis, with the ceramic container remaining largely understudied.

The present study proposes a reassessment of the functional and symbolic role based on an integrated analytical approach. The analysis of organic residues preserved in a bowl associated with the assemblage, together with the characterization of the ceramic fabric, suggests that the container may have had a prior function distinct from coin deposition, or may have been specifically prepared for ritual use.



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With regard to the numismatic assemblage, representative samples reflecting the identified typological diversity were selected and subsequently subjected to chemical analyses in order to determine the composition of the metal alloys. The results obtained made it possible to assess the conformity of these alloys with known standards for the Roman period, contributing to the distinction between official and possible imitative productions. The analysed coins were also digitalized, enabling the creation of a detailed digital record and the comparison with official reference coins. Additionally, the data collected allowed for an estimation of the total volume occupied by the numismatic assemblage, providing relevant information for understanding the conditions of deposition and the original scale of the hoard.

Tracking Microbial Community Shifts in Pink-Stained Stone Surfaces of Cultural Heritage

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ABSTRACT

Rosy chromatic alterations on stone surfaces are a recurrent and challenging form of biodeterioration in Cultural Heritage. Often associated with carotenoid-producing microorganisms adapted to environmental stress, the associated microbiota was investigated on the granite portico of Palácio do Vimioso, an outdoor architectural element located in the UNESCO Historic Centre of Évora, Portugal.

To monitor the evolution of this phenomenon, biofilms were sampled non-invasively with sterile swabs, followed by eDNA extraction and Illumina Next-Generation Sequencing (NGS) of the 16S rRNA and ITS regions. In the first year, prokaryotic communities were



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strongly dominated by *Rubrobacter* (67.3%), together with *Pseudoalteromonas* (7.7%) and *Gemmobacter* (7.3%). One year later, the community became more heterogeneous, with *Rubrobacter* remaining prevalent (57.7%) but *Bacillus* (28.0%) and *Pseudokineococcus* (2.4%) also emerging. Eukaryotic communities also changed, shifting from a dominance of *Cladosporium* (47.0%) and *Knufia* (18.1%) to one enriched in microcolonial and dematiaceous fungi, namely *Cladosporium* (remaining stable at 47.1%), *Knufia* (40.0%), and *Aureobasidium* (14.8%). These changes in microbial communities suggest that this phenomenon is driven by an ecological shift in which radiotolerant pioneer species initially stabilize the niche, enabling the recruitment of additional microbial groups that increase biofilm density and intensify the pinkish discoloration.

These findings highlight temporal NGS monitoring as a valuable non-destructive diagnostic tool for anticipating biodeterioration risks and informing preventive conservation strategies tailored to the dynamic evolution of microbial communities.

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From chemotype to archetype in heritage:

Biochemical mapping of Alentejo gastronomic matrices as biocultural fingerprints of territorial identity

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ABSTRACT

Heritage is a living legacy and matrix of a people's identity, constituting a dynamic system of territorial resilience. In this context, aromatic culinary herbs and spices (AHPs), integral to the Mediterranean Diet (UNESCO), transcend the classification of ingredients or spices to serve as vectors of the economy, health, and identity. Alentejo gastronomy constitutes a living repository of ancestral knowledge where the tangible (chemotype fingerprint) and the intangible (archetype) become inseparable. This study proposes an integrative framework to reinterpret the chemical profiles of traditional Alentejo gastronomy, aiming to decode the selection criteria of aromatic culinary herbs and spices. By linking chemotype characterization, shaped by *terroir*, with culturally



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transmitted use archetypes, it characterizes essential oil profiles as biochemical markers underlying the structuring logic of this intangible cultural heritage system.

Thus, condiment AHPs from Alentejo Gastronomy were selected and their chemotype determined. The *in vitro* antioxidant potential and antimicrobial activity against bacterial strains and filamentous fungi were evaluated. The results suggest a direct correlation between chemical composition and gastronomic potential. The high antioxidant capacity of essential oils suggests a critical role in the oxidative stabilization of foods and in mitigating oxidative stress through the diet, while also highlighting their potential as alternatives to salt, thereby contributing to the prevention of hypertension and neurodegenerative diseases. Moreover, the broad antimicrobial spectra of their essential oils reinforce the ancestral use of aromatic plants in food preservation and underlines their potential for the development of food ingredients with antimicrobial properties. In conclusion, validating this knowledge is essential for valuing Natural Heritage and safeguarding territorial identity, highlighting the inherent connection between biodiversity and *terroir* from the preservation of cultural memory.

Acknowledgements

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Revealing Materiality, Enhancing Value: Material Analysis of the Gulbenkian Collection of Gold Boxes

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ABSTRACT

The Calouste Gulbenkian Museum in Lisbon preserves an interesting yet understudied collection of around fifty gold boxes, including sealing wax and needle cases, snuffboxes, *bonbonnières* and *étui-nécessaires*. These objects exemplify the technical virtuosity and aesthetic refinement of major 18th-century European centres of production of small luxury objects, such as Paris, London, Geneva and Hanau.

This multidisciplinary research intends to investigate this collection through an integrated historical-artistic and analytical approach, complemented by dissemination initiatives including the renewed display of the objects in the Museum's permanent galleries, the incorporation of updated research and 3D models into the *Online Collections*, and the preparation of a comprehensive collection catalogue.



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The analytical study of this collection aims to enhance its valorisation by improving knowledge of the materiality, manufacture and technological complexity of each object, thereby supporting its interpretation and public display. Through the identification of metal alloys, enamel compositions, and manufacturing practices, the project seeks to refine attributions to production centres, techniques, and chronology, while also assessing the correspondence between detected gold standards and those documented in historical and contemporary sources.

The analytical approach combines in-situ EDXRF and 2D MA-XRF mapping, allowing an initial assessment of the metal composition and the chemical distribution of materials used in glazing and other decorative elements. This integrated approach provides new insights into the manufacture, decorative strategies and technological choices associated with these objects.

Beyond its research dimension, this study contributes directly to the improved interpretation and exhibition of the collection, providing robust scientific data to inform curatorial narratives and enhance public engagement. This analytical study is already demonstrating a high level of innovation for this type of collection—its closest parallel being the study of the Wallace Collection's gold boxes [1]—and thus has the potential to represent a significant contribution to these research and museum-practice fields at an international level.



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Advancing parchment analysis through mitochondrial DNA mini-barcodes and genomic approaches

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ABSTRACT

Parchment, a traditional writing substrate produced from animal skin, has been fundamental in safeguarding human knowledge and cultural heritage for centuries. Nevertheless, the analysis of DNA in parchment is often hindered by harsh manufacturing procedures and consequent molecular degradation.

In this study, it is reported the development and validation of mitochondrial DNA (mtDNA) mini-barcodes for the identification of animal species in parchment. A set of 38 primers, comprising universal primers and species-specific primers, was designed to target short mtDNA fragments from the 12S rRNA, 16S rRNA, and Cytochrome b genes. These primers were initially assessed through *In silico* analysis and subsequently validated *In vitro* using reference animal tissues. From the initial set, the highest



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performing primers were selected and applied to modern and historical parchment samples obtained through diverse sampling approaches. Among these, the four most effective primers were further tested on illuminated manuscripts belonging to the Évora Public Library. To complement the results, a shotgun sequencing approach was employed to enable comparison with the targeted mini-barcode results.

Most universal primers effectively amplified degraded mtDNA, whereas species-specific primers demonstrated high accuracy in identifying targets. The recently developed primers performed better than standard literature primers, especially with historical samples.

Overall, the combined targeted and shotgun strategy offers a robust and sensitive framework for determining the biological origin of parchments, contributing valuable tools for applications in archaeological, archival studies, and cultural heritage conservation.

Acknowledgements

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Hybrid Nanoparticle-Based Antimicrobial and Hydrophobic Coatings for Natural Stone

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ABSTRACT

Natural stone is among the most common construction materials used in both historical and contemporary built heritage, but its preservation is often compromised by degradation phenomena. Among the main factors contributing to deterioration is microbial colonization, which is facilitated by the presence of water and affects not only the aesthetics but also the structural integrity of natural stone. In this context, this work focuses on the development of new hybrid and non-toxic coatings with antimicrobial and hydrophobic properties for application on natural stone, aiming to provide more effective and sustainable conservation strategies for built cultural heritage.

The newly developed coatings consist of an organic matrix based on first-generation L-lysine dendrimers, functionalized with fatty acids, into which inorganic nanoparticles of different chemical compositions (ZnO, TiO₂, SiO₂, CaSiO₃, Al₂TiO₅, and Ca₂B₆O₁₁·5H₂O)

were incorporated. Three types of natural stone of Portuguese origin (limestone, granite, and marble) were selected as substrates to evaluate the performance of the developed formulations in terms of color compatibility, stone breathability, and biocidal and hydrophobic properties. The results obtained show a reduction in water absorption and promising antimicrobial activity, depending on the composition of the hybrid formulations, which along with color compatibility suggests the newly developed products have a high potential for use as protective coatings for natural stone.



Acknowledgements

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The applications of MA-XRF technology in the research of Cultural Artifacts with curved surface

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ABSTRACT

MA-XRF technology is significant for obtaining elemental distribution information of cultural artifacts, particularly those demonstrating significant effects on the non-visible elemental distribution caused by factors such as obstruction and corrosion. In addition to two-dimensional plane cultural relics, such as calligraphy, paintings, and oil paintings, obtaining the surface elemental distribution of cultural relics with curved surfaces is required. This study uses a spectrometer with the capability of curved surface X-ray fluorescence scanning imaging to analyze and study two cultural relics that require curved surface elemental distribution information. The first type is bronzeware with an inlaid gold and silver structure and a curved surface. The elemental distribution results obtained from the curved surface scanning reveal the patterns, shapes, and sizes of the inlaid gold and silver parts, which are significant in the study of inlaid gold and silver craftsmanship. The second category includes stone cultural relics. The elemental distribution information obtained from the curved surface MA-XRF analysis provides



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the types of pollutants, distribution areas, and inconsistent distribution thickness, which is an important basis for analyzing the sources and components of pollutants and their removal. The above two cases provide a new technical method for studying the elemental distribution of cultural relics with curved surfaces and demonstrate the important role of MA-XRF technology in curved surface scanning.

Acknowledgements

This work is supported by Archaeological Talent Promotion Program of China (2024-281) and the National Key Research and Development Program (2023YFF0906600).

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Preventive Conservation Strategies for Underwater Cultural Heritage in Sustainable Tourism Contexts

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ABSTRACT

Underwater Cultural Heritage (UCH) represents a fragile and non-renewable resource whose preservation increasingly conflicts with the growing demand for public access, particularly within the expanding sector of diving tourism. While sustainable tourism offers significant opportunities for the valorisation of submerged archaeological sites, it also introduces complex and often underestimated risks affecting their long-term conservation.

This study, carried out within a master's thesis in the Erasmus Mundus Joint Master in Archaeological Materials Science (ARCHMAT), proposes a methodological framework for the preventive conservation of UCH in tourism-driven contexts, explicitly addressing the trade-off between accessibility, protection, and operational site management. The approach is grounded in a multidisciplinary analysis combining international regulatory frameworks (UNESCO 2001 Convention, ICOMOS Charter, ICCROM guidelines), national



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legislation, and current management practices in underwater archaeological sites.

Particular focus is placed on risk assessment methodologies, integrating the analysis of physical, chemical, and biological degradation processes with the evaluation of anthropogenic pressures induced by diving activities. Within this context, the research advances the use of high-resolution underwater photogrammetry as a quantitative monitoring tool, enabling the generation of time-consistent 3D models for detecting and measuring changes in the conservation state of submerged assets.

The proposed framework incorporates continuous monitoring, risk quantification, and adaptive management strategies, supporting a transition from static conservation approaches to dynamic, data-driven decision-making processes. The methodology is designed to be scalable and transferable across different UCH scenarios and is validated through pilot applications within the BlueCulTour project.

The results provide operational guidelines for heritage managers, policymakers, and tourism operators, contributing to the development of sustainable exploitation models that ensure both preservation and accessibility. Ultimately, this work supports the integration of digital monitoring technologies into conservation strategies, promoting a more resilient and informed management of underwater cultural resources.

Research on X-ray CT images processing of cultural relics based on the deep Learning Methods

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ABSTRACT

Based on the application and analysis experience of X-ray CT equipment used by the Palace Museum in different types of cultural relics in recent years, this study has attempted image processing technology based on deep learning methods through the study of simulated cultural relics and applied it in actual cultural relics.

The deep learning algorithm combined with X-ray CT image post-processing realizes the intelligent segmentation and extraction of different materials in cultural relics. This not only improves the efficiency of segmentation and extraction between different materials of cultural relics, but also provides a convenient and safe means for the archaeological excavation of unknown cultural relics. At the same time, it can guide the laboratory archaeological excavation route and avoid damage to cultural relics caused by misoperation during the excavation process. The safety and reliability of laboratory archaeological excavations have been enhanced.

This study validated the feasibility of applying X-ray CT results in archaeological

relics through preliminary experiments, primarily evaluating the reliability of the data outcomes and the effectiveness of the segmentation methodology. The findings demonstrate that these results can be successfully applied to actual archaeological relics when combined with deep learning-based post-processing techniques for intelligent segmentation and extraction of target image regions from X-ray CT images.

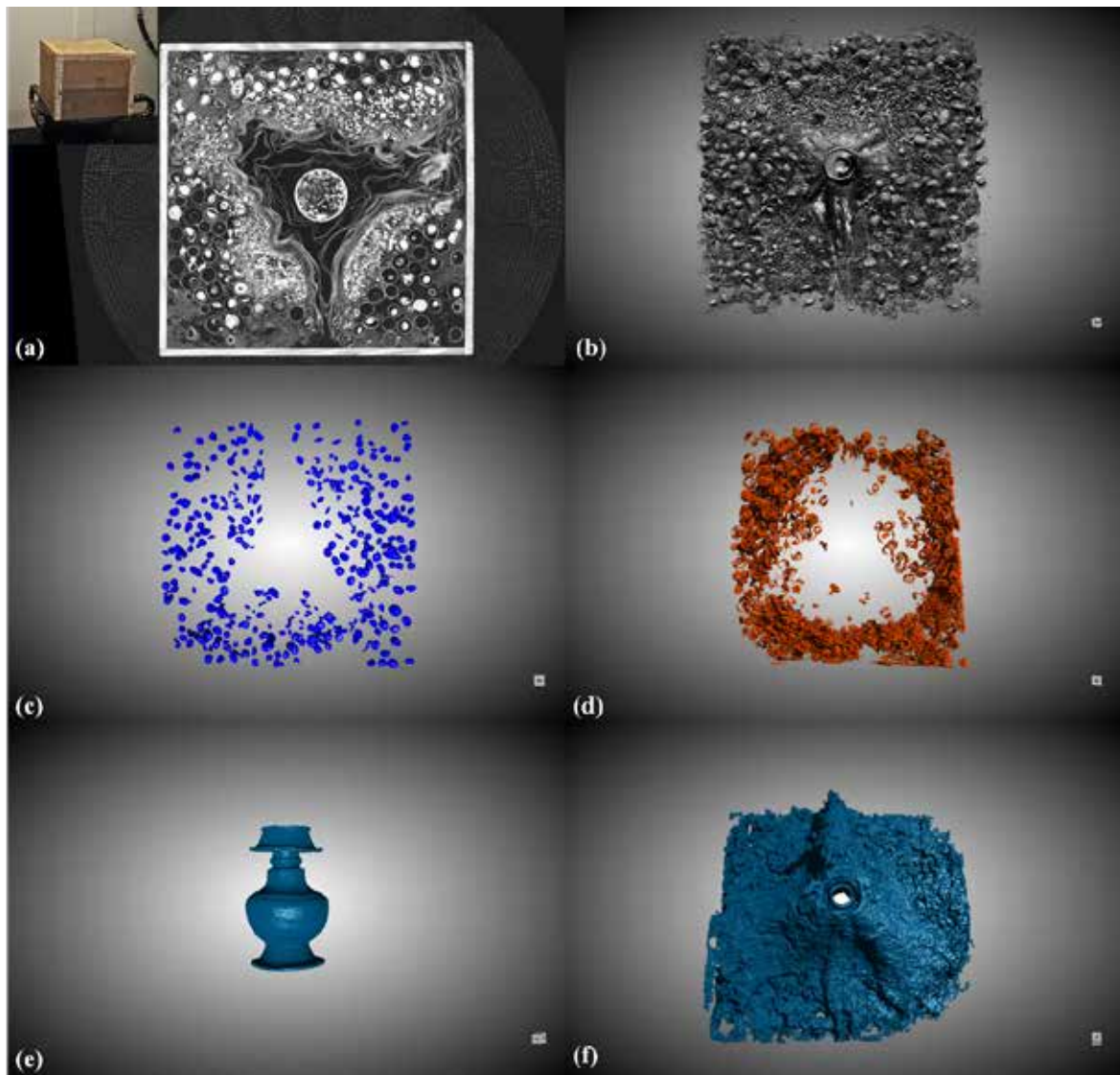


Figure 1: The application results of internal image segmentation of cultural relics in the Palace Museum.

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Digital Heritage for All - A Collaborative Approach in the Autonomous Region of Madeira

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ABSTRACT

The preservation and access to cultural heritage in outermost regions such as Madeira Island continue to face very practical constraints: limited funding, infrastructure that is not always fully adequate, and a shortage of specialised technical skills. Against this background, the Regional Directorate for Archives, Libraries and Books (DRABL) has been developing a digitisation support strategy built on cooperation between institutions and on adapting to the real conditions of each organisation.

The approach relies on sharing digitisation equipment and, just as importantly, on transferring technical know-how. The goal is to broaden access to documentary heritage while keeping digitisation work within acceptable quality standards. In practice, the model is organised into two complementary frameworks:

- **Entities without their own equipment:** Institutions without suitable equipment's use DRABL facilities, where digitisation takes place in a controlled environment with technical supervision. At the same time, staff members receive hands-on training

focused on document handling and digitisation workflows. This keeps projects going and at the same time helps build practical skills inside the organisation.

- **Entities with their own equipment:** Where institutions already have equipment, DRABL's role is mainly to provide technical and methodological support. This includes guidance on metadata creation and structure, workflow design, and file format choices, with the aim of ensuring consistency and long-term preservation in line with recognised international practices.

Overall, this model has helped make better use of public resources and has encouraged more structured cooperation across the region. Instead of responding to isolated situations, it is slowly shaping a shared working environment where digitised heritage can be accessed, integrated, and preserved for the long term, benefiting both cultural work and research.



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Exploring Biosynthetic Diversity in Undersea Cave Bacteria from the Algarve Coast

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ABSTRACT

Undersea caves are extreme and poorly explored environments that host unique microbial communities with high potential for novel bioactive compound discovery. These oligotrophic ecosystems drive microorganisms to develop specialized metabolic pathways, leading to the production of diverse secondary metabolites with relevant biological activities.

Given the increasing global burden of cancer and the limitations of current treatments, there is a pressing need for new therapeutic agents. Microorganisms from isolated



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environments such as marine caves represent promising sources of compounds with antioxidant and anticancer properties.

This study aims to assess the biosynthetic potential of bacterial isolates collected from undersea caves along the Algarve coast (Sagres, Portugal). Special focus is given to nonribosomal peptide synthetases (NRPS) and polyketide synthases (PKS), key enzymatic systems responsible to produce structurally diverse and pharmacologically important metabolites.

Molecular screening of NRPS and PKS genes, using PCR with degenerate primers targeting conserved domains, enables the identification of strains with high biosynthetic capacity. Overall, this approach supports targeted bioprospecting efforts, facilitating the discovery of novel bioactive compounds with potential pharmaceutical applications and also represents an opportunity to value these Natural, Genetics and Cultural Heritages.

Acknowledgements

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Yeast-derived bioactive compounds as sustainable antimicrobial agents for cultural heritage conservation

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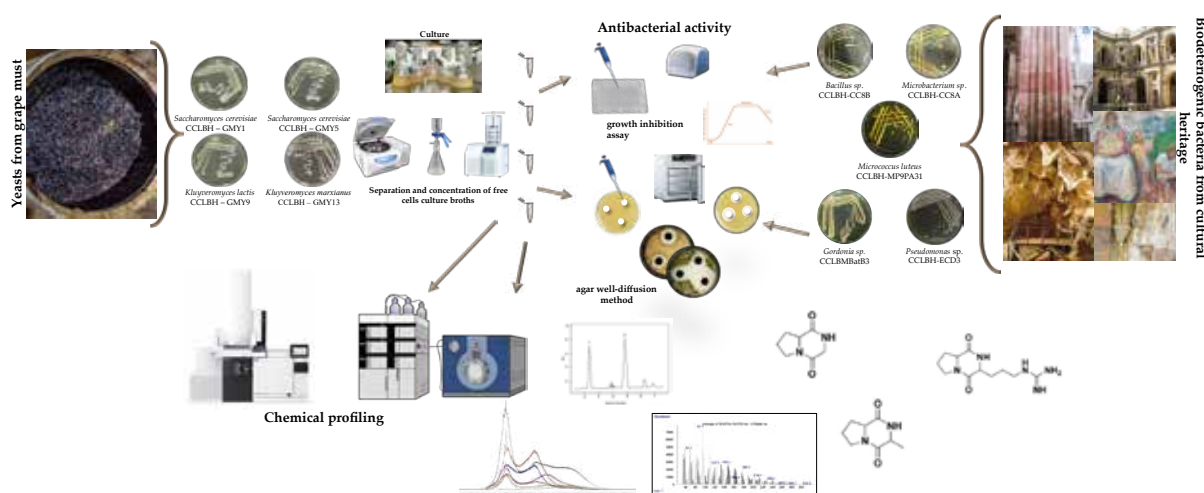
ABSTRACT

Microbial biodeterioration remains an important challenge in the preservation of cultural heritage materials, reinforcing the need for more sustainable and environmentally friendly conservation strategies. In this context, yeasts have emerged as promising sources of extracellular bioactive compounds with potential relevance for heritage conservation. In the present study, yeast strains isolated from grapes must were explored in order to assess their activity against biodeteriogenic bacteria associated with cultural heritage materials and to obtain a preliminary overview of their extracellular chemical profiles using different analytical techniques such as High-Resolution Analytical Pyrolysis (UH-Py), evolved gas analysis (EGA/MS) and traditional



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liquid chromatography. The results revealed strain-dependent behavior, with some yeast isolates showing greater biological activity than others. These findings support the idea that yeasts may represent a valuable source of compounds of interest in the search for greener approaches to biodeterioration control. In parallel, a preliminary analysis of selected extracellular fractions highlighted compositional differences among the most promising strains, suggesting variability in the compounds released into the culture medium. This analytical approach provides an initial basis for the future characterization of yeast-derived metabolites and their possible relevance in conservation contexts. Overall, this work highlights the potential of yeasts as a sustainable biological resource for the development of innovative strategies in cultural heritage conservation.



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NCC/MSN Hybrid Treatment for Consolidant and antimigration of Iron Gall Ink in Historical Documents

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ABSTRACT

Iron gall ink (IGI), one of the most widely used writing materials from the 5th to the 19th century, poses a major conservation challenge due to its well-documented degradation mechanism. The hydrolysis of iron (II) sulfate and the subsequent oxidation of Fe^{2+} to Fe^{3+} generate sulfuric acid and reactive oxygen species, leading to severe cellulose chain scission through both acid-catalyzed hydrolysis and Fenton-type oxidative reactions. Current consolidation treatments remain limited in their ability to simultaneously address structural weakening of the paper support and the ongoing iron-catalyzed degradation of the ink layer [1].

This work presents the development of a novel hybrid consolidant based on nanocrystalline cellulose (NCC) and mesoporous silica nanoparticles (MSN), designed for surface applications on IGI-bearing documents. NCC serves as a reinforcing agent, exploiting its exceptional mechanical properties and chemical compatibility with

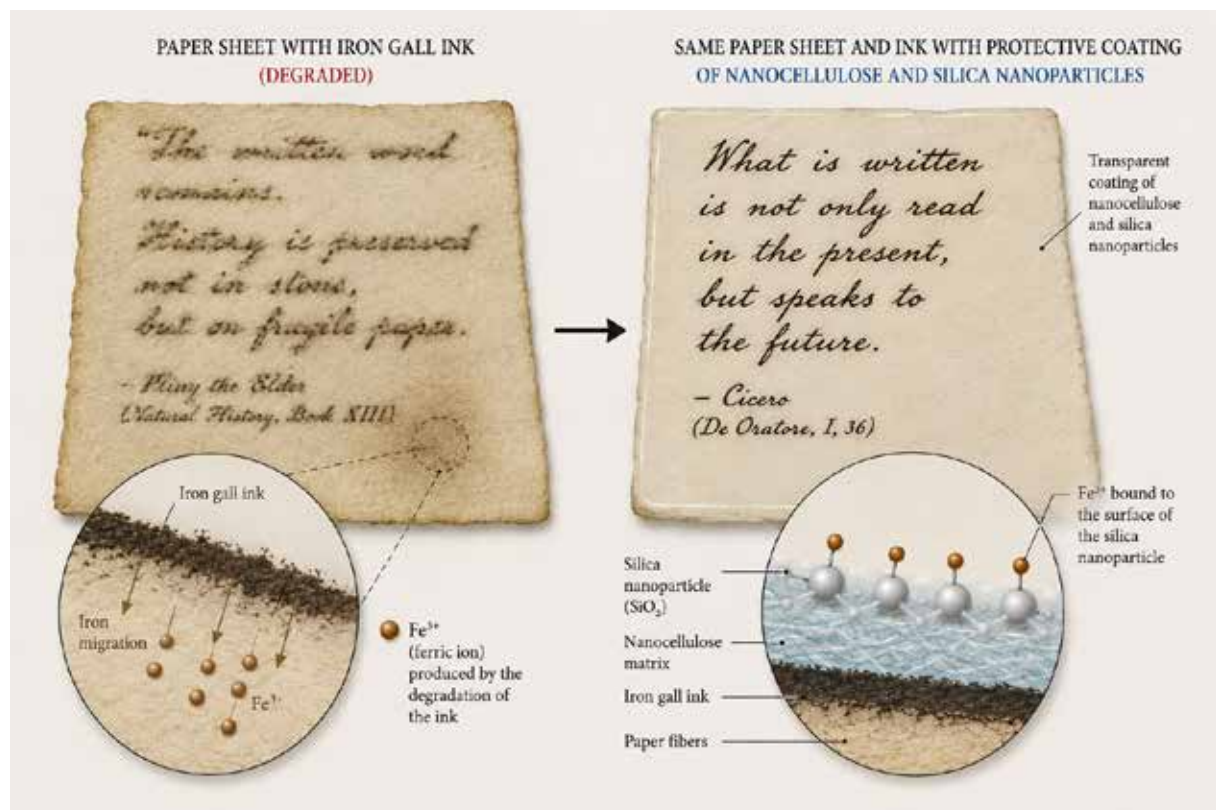


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cellulose fibers to restore cohesion to degraded paper. MSN, amine-functionalized to act as Fe^{3+} chelating agents, limiting further acid and radical generation.

The treatment was applied on the surface of paper mockups written with iron gall ink and artificially aged. Characterization through scanning electron microscopy (SEM) confirmed the homogeneous distribution of NCC/MSN within the paper matrix and the typical morphology of MSN with iron ion attached, confirming the chelation of Fe^{3+} coming from the iron gall ink deterioration. Mechanical testing demonstrated a significant improvement in tensile strength compared to untreated degraded samples.

These results establish the NCC/MSN system as a promising dual-action consolidant/antimigration of IGI, opening new perspectives for the preservation of iron gall ink manuscripts through a single, minimally invasive intervention.



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Materiality and Conservation of Easel Paintings in Museum Narratives: A Restorer's Perspective

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ABSTRACT

Museum narratives significantly influence the public interpretation of artworks through exhibition design, curatorial texts, and institutional storytelling. However, these narratives frequently prioritize stylistic, iconographic, and historical interpretation while overlooking the materiality of artworks, their conservation history, and the insights revealed through technological investigation. Drawing on David Carrier's theoretical approach to writing about visual art, this presentation examines how the conservation of easel paintings and their material condition remain insufficiently integrated into museum interpretation practices.

The presentation approaches cultural heritage interpretation from the perspective of a conservator-restorer, emphasizing the artwork as a materially complex and historically changing object. Conservation interventions, structural modifications, material degradation, and traces uncovered during restoration processes are essential for understanding authenticity, artistic practice, and the historical transformations

of paintings. Nevertheless, these aspects often remain invisible within conventional museum communication.

Particular attention is given to interdisciplinary collaboration between conservator-restorers, art historians, museum professionals, and heritage scientists. The presentation discusses the role of non-invasive technological investigation methods, including infrared reflectography, technical imaging, and material analysis, as important tools for revealing underdrawings, compositional alterations, hidden interventions, and other invisible layers of easel paintings. Such methods contribute not only to conservation practice but also to broader museum storytelling and heritage interpretation.

The presentation argues for a more integrated museum narrative in which materiality, conservation processes, and technological research become visible components of public interpretation strategies. This approach expands traditional art historical discourse while strengthening connections between the humanities, conservation practice, and heritage science. The role of the conservator-restorer is therefore presented as a mediator between scientific investigation and cultural interpretation, contributing to more transparent, interdisciplinary, and materially informed museum narratives.



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Preliminary study:

In situ non-destructive characterisation of historic sculptures in highly porous limestones

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ABSTRACT

A collection of sculptures from XV-XVI centuries and a significant number of stone tombs, carved from highly porous limestone, have an inestimable historical and artistic value in Portuguese history. Currently, they underwent serious deterioration processes, requiring a well-founded approach to their study and conservation [1]. In recent decades, the development of non-invasive and non-destructive analytical methods allowed to characterise materials, artistic techniques, degradation processes, and evaluation of conservation treatments in cultural heritage. However, there are still significant limitations in the *in situ* analysis of stone sculptures, mainly related to restrictions on sample collection. Due to the significance of the objects examined, only a limited number of tests can be considered for use [2]. The methodological approach involves a detailed analysis of the surface, integrating various non-destructive *in situ* tests,

including photography with a portable digital microscope, measurement of surface hardness with a durometer, determination of water absorption with *Karsten* tubes and sponge method, assessment of surface cohesion with the peeling tape test, and colour measurement of surfaces with a colourimeter. The results obtained will be analysed and compared, assessing the condition of the sculptures stone before and after the application of consolidating products. It is expected that the non-destructive methods will allow to understand the relationship between the stone's physical properties and the performance of conservation treatments, thereby contributing to the development of more effective methodologies for conserving stone heritage.



Acknowledgements

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Supporting Material Identification Workflows through Open-Access Spectral Data Search and Discovery Tools

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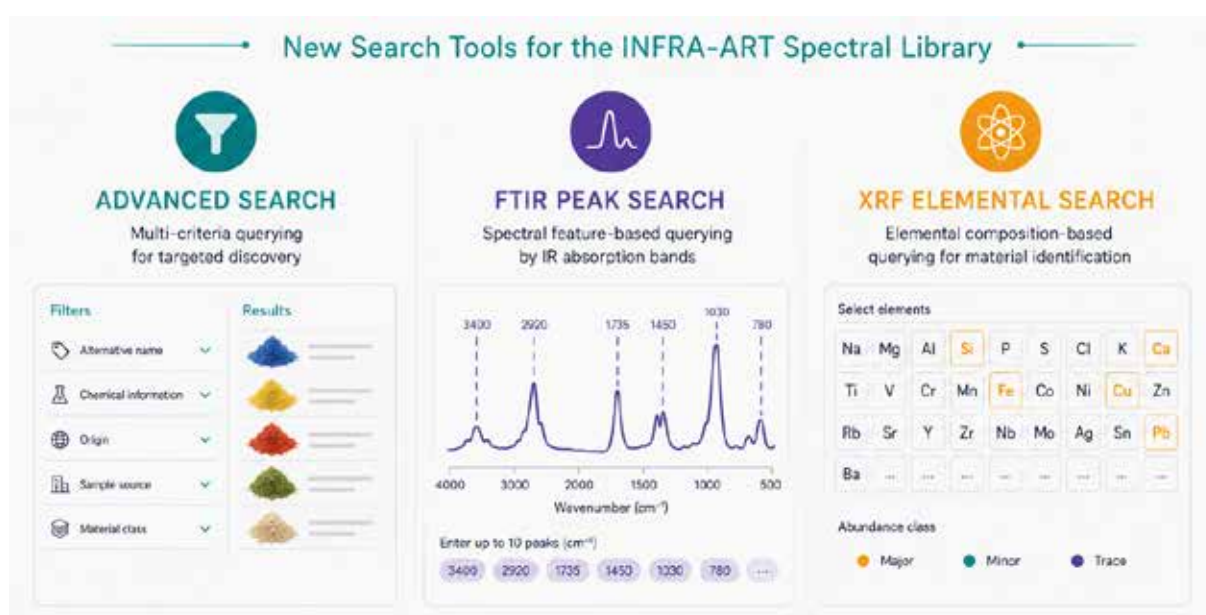
ABSTRACT

The INFRA-ART Spectral Library (<https://infra-art.eu>) has recently been relaunched as an EOSC-aligned research infrastructure [1]. Alongside infrastructure upgrades, one of the key priorities has been improving how users discover, explore, and interact with the growing collection of samples and analytical datasets available within the INFRA-ART database. This contribution presents a new suite of search tools designed to enable more precise and meaningful exploration of spectral data, following a user-centered approach [2]. In response to user needs and analytical workflows, several dedicated analytical search tools have been developed. The FTIR peak search tool allows users to query the database using infrared absorption peak values, facilitating the identification of samples with similar spectral characteristics. Complementarily, the XRF elemental search tool enables querying based on elemental composition, supporting material identification and comparative analysis, particularly for inorganic and complex materials. Both tools rely on manually curated data, ensuring a high level of accuracy and scientific



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reliability. In addition, an advanced search tool enables users to combine multiple criteria and perform targeted queries across heterogeneous datasets, improving the precision and efficiency of data retrieval within an expanding collection. Together, these developments support data-driven material identification workflows and significantly enhance the reuse potential of spectral data. Their integration within an open-access, EOSC-aligned infrastructure represents a step forward in enabling reliable, discovery-driven access to spectral data in heritage science where comparable analytical search tools remain underdeveloped.



Acknowledgements

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Characterization of Biodeterioration Processes on the Concrete Facade of the Faculty of Civil and Geodetic Engineering

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ABSTRACT

This study presents an integrated microbiological, genetic, and vibrational spectroscopic characterization of biofilms colonizing the façade of the Faculty of Civil and Geodetic Engineering, University of Ljubljana. Microbial samples were collected from multiple façade locations and analyzed using culture based quantification, fluorescence microscopy, ITS/16S rRNA sequencing, and FTIR/Raman spectroscopy.

Genetic identification revealed a diverse assemblage of biodeteriogenic fungi, including *Cladosporium*, *Alternaria*, *Penicillium*, *Neosetophoma*, *Aureobasidium*, and *Tolypocladium*, and environmental bacteria such as *Bacillus*, *Micrococcus*, *Microbacterium*, *Anaerobacillus*, and *Clostridium mobile*. Several isolates exhibited strong metabolic activity relevant to material degradation: alkaline metabolite production (pH up to 9.3), localized acidification (pH ~6.7), and CaCO_3 dissolution halos of 2–5 mm, confirming their capacity for chemical deterioration of carbonate based



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substrates.

FTIR spectroscopy identified proteins, lipids, oxalates, chitin, and mineral phases including calcite, dolomite, quartz, clay minerals, talc, $\text{Al}(\text{OH})_3$, and styrene–acrylate binders, indicating a mixture of biological residues and façade material components. Raman spectroscopy further detected carotenoids, titanium dioxide (rutile, anatase), and in sample FGG 2 the cyanobacterial pigment scytonemin, a UV protective metabolite indicative of phototrophic colonizers.

Collectively, the results demonstrate that the façade hosts a complex, metabolically active biofilm, in which fungi, bacteria, lichens, and mosses interact synergistically. These organisms retain moisture, secrete organic acids and alkaline metabolites, produce pigments, and mechanically and chemically modify the mineral substrate.

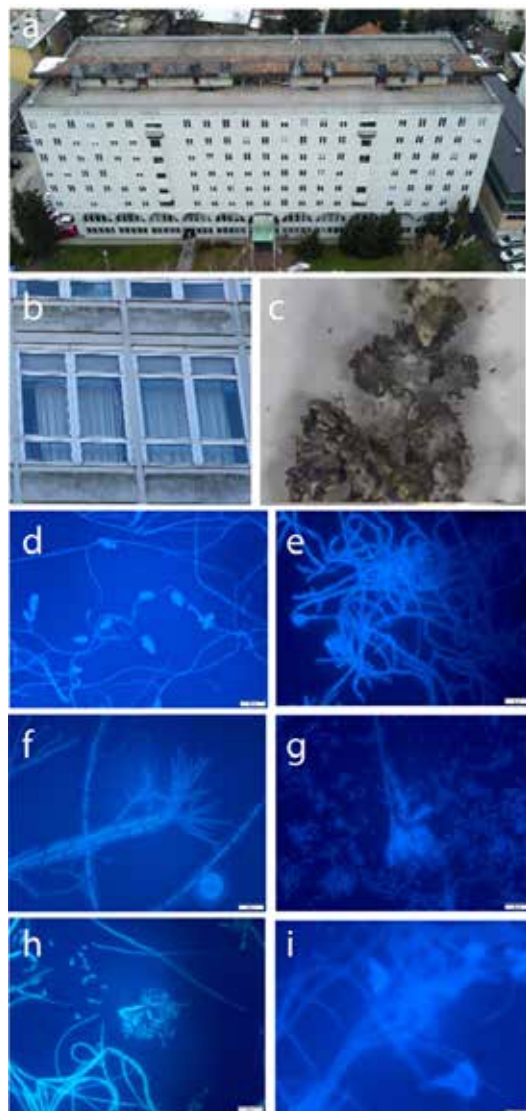


Figure 1: Biological and microbiological characterization of the facade of the Faculty of Civil and Geodetic Engineering, University of Ljubljana (UL FGG). **(a)** Aerial overview of the investigated building facade. **(b)** Close-up view of the concrete facade detailing zones affected by biological growth and colonization. **(c)** Stereomicroscopic photograph showing the detailed morphology of a lichen specimen collected from the facade surface. **(d–i)** Widefield fluorescence microscopy images (excitation: 359 nm, emission: 457 nm) of distinct microbial isolates stained with Calcofluor White, revealing the characteristic structures of isolated filamentous fungi and cyanobacteria (e.g., *Penicillium* sp., *Alternaria* sp., *Cladosporium* sp., *Rhizopus* sp., and *Arthrinium* sp.). Scale bars are provided at the bottom right of each microscopy panel.

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Spectroscopic Analysis of Historical Wax Seals and Lead Bullae from the National Museum of Slovenia

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ABSTRACT

Seals have been used since the earliest civilizations, and from the 10th century onward wax seals became the principal means of authenticating royal charters, a practice that soon spread throughout medieval society. A seal (*sigillum*, *Siegel*), from the Greek *sphragis* meaning "sign," is an impression of an engraved image in a soft material such as wax or metal that hardens to secure and validate documents. Seals functioned as identifiers, closures, and safeguards against tampering. The popes and Venetian doges used lead bullae, a tradition still preserved in the papal chancery. Imperial seals were typically made in red wax, while green wax was used by some monasteries, white by chartered towns, and black by grandmasters of knightly orders. These distinctions gradually disappeared in the 16th century as red wax became increasingly common.[1]

This study presents a comprehensive spectroscopic investigation of historical seals from the collection of the National Museum of Slovenia. Beeswax, often modified



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with pigments, resins, or oils, was the primary sealing material, while lead, clay, and precious metals were reserved for seals of higher institutional or social status. Beyond characterizing wax composition, we sought to identify the coloring agents used in red, green, and black seals, determine degradation products on both wax seals and metal bullae, and establish the material composition of the cords suspending seals from charters. Using Raman and FTIR spectroscopy, we examined four papal bullae, one Venetian ducal bulla, two seal casts, and numerous seals belonging to the nobility. Results gained by portable instruments were complemented by microscopic in-situ measurements. The findings provide new insights into the composition, preservation, and production techniques of medieval and early modern seals.



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The Mural Painting Technique of Parmigianino: Complexity Hidden Beneath the Surface

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ABSTRACT

Parmigianino (Girolamo Francesco Maria Mazzola, 1503–1540) is one of the most important painters of the Italian Manierismo. The development of his master's mural painting technique has been investigated through two multi-technique diagnostic campaigns carried out by a research team from the University of Parma. The first study focused on an early work by the artist in the Church of San Giovanni Evangelista in Parma (1522) [1]. The second campaign examined one of the last artist's works in the eastern arch of the Church of Santa Maria della Steccata in Parma (1531-39) [2].

The comparison between these two diagnostic campaigns has made possible to reconstruct Parmigianino's working method and to identify the evolution of his artistic language. His early mural paintings have a less sophisticated technique, producing a less engaging visual result. Whereas his more mature technique at the Steccata, after the significant experiences of the artist in Rome and Bologna, reveal a far more complex and experimental execution. The comparison between Parmigianino's youthful and

mature mural painting technique outlines the profile of a meticulous and highly refined artist, deeply engaged with early sixteenth-century artistic innovation.



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Reconstructing meaning from fragments: Conservation and interpretation of Pietra Paesina stone slabs

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ABSTRACT

A set of fifteen small decorative rectangular panels with stone inlays and metal frames from the Museu Nacional de Arte Antiga (MNAA, Lisbon) was received at the José de Figueiredo Laboratory (LJF-MMP, E.P.E.). The ensemble displays a rare and complex material composition in the Portuguese context, notably including Pietra Paesina [1], alongside lithotypes possibly identifiable as Rosso Verona, Verde Alpi, and schist, as well as metal elements, bedding materials, and wooden fragments. Preliminary observation and comparison with reference objects suggest these panels were used to decorate drawer fronts from a 17th-century Italian cabinet, raising the question of how such a fragmented and decontextualised set of decorative stone slabs can be studied, interpreted, and conserved. The research follows an interdisciplinary approach integrating the Stone, Metals, Furniture, and Analytical Laboratory departments. Initial work includes documentary research, comparative analysis with 16th–17th-century Italian furniture, and ongoing collaboration with international institutions, including the Opificio delle Pietre Dure (Florence). Imaging techniques (visible, raking, ultraviolet-reflected,



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and ultraviolet-induced visible fluorescence), preliminary condition assessment, and sampling for microscopy, FTIR, and XRF analyses have been initiated, with micro-XRD planned. The ensemble shows varying degrees of fragmentation, material loss, and traces of past interventions. This study aims to support the material and functional interpretation of a decontextualised set, highlighting the potential of conservation and restoration as tools for historical research and heritage reconstruction. The project's future development involves further analytical study, the definition of intervention methodologies, and the presentation of a proposal for the physical and/or virtual reconstruction of the original complex for public enjoyment.

Acknowledgements

The authors would like to acknowledge the support and collaboration of Maria João Furtado of the Metal Area, Joana Amaral of Preventive Conservation and Margarida Cavaco of the Furniture Area of LJF-MMP, E.P.E., as well as Patrícia Machado, Luísa Penalva, and Celina Bastos from the MNAA.

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From Social Shelter to Museum Storage:

The Adaptive Reuse of the Abrigo dos Pequeninos Building for Museu do Porto Storage

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ABSTRACT

The rehabilitation of the former Abrigo dos Pequeninos — a historic social welfare building in Porto — into the centralized storage facility of the Museu do Porto from Porto City Hall represents a significant case study in the adaptive reuse of built heritage for cultural infrastructure. This project addresses a longstanding challenge faced by the institution: the dispersal of its collections across multiple storage locations, with inconsistent environmental conditions and limited capacity for conservation work.

The new storage consolidates previously scattered assets into a single, purpose-adapted space, enabling integrated collection management and significantly improving long-term preservation outcomes. Central to the intervention is the installation of controlled environmental systems and purpose-built storage equipment, ensuring that diverse collection typologies — from archival materials to three-dimensional objects — receive appropriate housing conditions aligned with current conservation standards.

A dedicated conservation and restoration laboratory was established within the facility,



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conceived not merely as a treatment space but as a hub for research into the museum's heritage, supporting the study and documentation of the collections through non-invasive and invasive analytical methodologies. The concentration of multidisciplinary human resources — including conservator-restorers, conservators, curators, and collection managers — within a shared environment fosters collaborative practice and institutional knowledge-building.

A key dimension of this project lies in the design compromises required to convert a building with a distinct social identity and spatial logic into a technically demanding museum infrastructure, while respecting its heritage character. The solutions developed offer transferable lessons for similar adaptive reuse challenges across other museums.

This poster presents the project's conceptual framework, the technical and programmatic responses adopted, and reflects on the broader implications for collection management practices in urban museum contexts.



Paint it black: A multi-analytical characterization of a 15th century paint box and its discolorations

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ABSTRACT

A paint box, dating back from the 15th century and linked the Cistercian Abbey of Nieuwenbosch in Ghent, is divided into four separate compartments with each containing a distinct colour/pigment. However, over the centuries, degradation had taken place in the painting box. The once so vivid colours had faded and multiple black discolouration spots had formed. For one compartment, the degradation was even so severe that the original blue colour was no longer visible and the paint had turned into a rather hard and black material.

To reveal the degradation processes that had taken place and to uncover the original paint materials, the painting box was analyzed with Raman spectroscopy. It was able to show that the original paint materials were vermilion (HgS), goethite (FeOOH) and lead



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white ($2\text{PbCO}_3 \cdot \text{Pb(OH)}_2$) for respectively the red, yellow and white compartment.

Micro-XRF was used as a complementary technique to identify the degradation products. It revealed that the black material from the blue compartment mainly consists out of copper. This hinted that the original blue colour was most likely the Cu-based pigment, azurite $\text{Cu}_3(\text{CO}_3)_2(\text{OH})_2$. It is known that this pigment is relatively unstable, however its most common degradation process is the colour change to green. Degrading to a black material is less common, but it can occur when azurite transforms to tenorite (CuO) or covellite (CuS) [1]. As, micro-XRF showed high intensity for S, the transformation to covellite was suggested and this hypothesis was confirmed by Raman spectroscopy by the characterization of the copper sulphide.

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Connecting Conservation, Heritage Science and Collections: A Sustainable Approach with ResearchSpace

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ABSTRACT

This poster presents the implementation of ResearchSpace as a sustainable digital innovation within the Collection Care Department at The National Archives, UK. In this context, ResearchSpace supports the day-to-day documentation and integration of conservation and heritage science knowledge, from funded research projects to object preparation for loans and exhibitions. Developed as a linked-data platform and underpinned by the flexible CIDOC Conceptual Reference Model, ResearchSpace enables the structuring of complex relationships between objects, materials, analytical data, and conservation treatments.

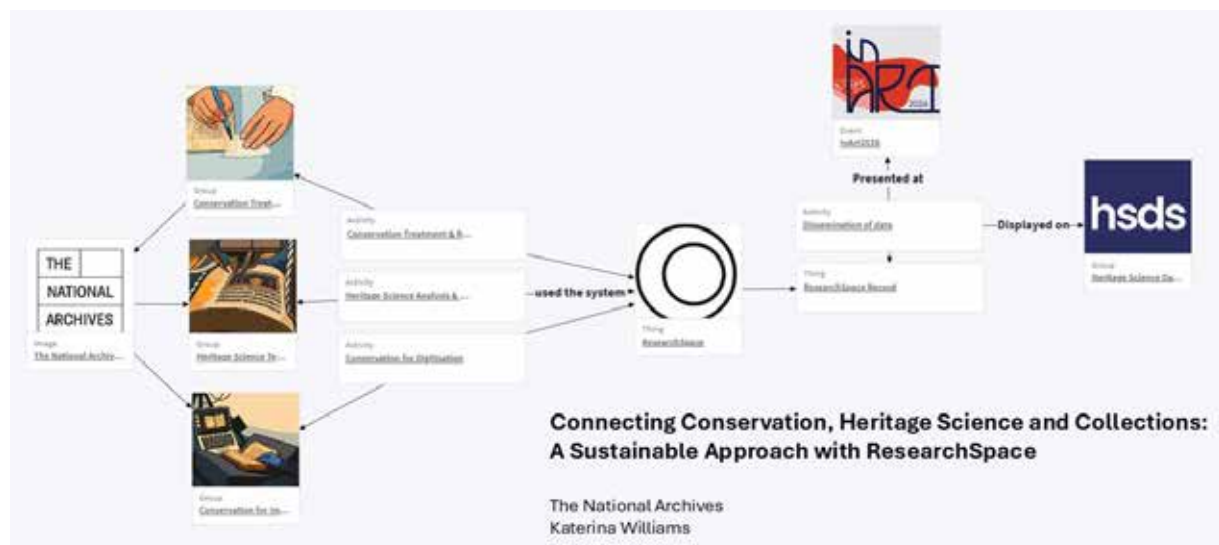
In parallel, the Heritage Science Data Service (HSDS), part of the Research Infrastructure for Conservation and Heritage Science (RICHeS), provides critical infrastructure for the storage and management of scientific datasets. By establishing workflows between HSDS and ResearchSpace, we demonstrate how heritage science data—including collection item and project-specific metadata, analytical results, and treatment records—can be transferred, connected, and contextualised within a broader collection framework.



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This integration allows data that is often fragmented or siloed to become part of a shared, evolving knowledge environment, supporting more holistic understandings of collection items and their histories. The flexibility of the underlying data model ensures that information can be extended, reinterpreted, and reused over time, contributing to more sustainable data practices. This approach also supports long-term digital preservation and accessibility by ensuring that heritage science and conservation systems remain structured, interoperable, and reusable within collection management systems.

By embedding ResearchSpace directly within collection care workflows, this work highlights how linked-data approaches can move beyond experimental or project-based applications to become an integral part of institutional practice. Its integration further enhances collection management, supports interdisciplinary collaboration, and enables long-term knowledge sharing across the cultural heritage sector.



Bronze Age Pottery Production in Norway: Preliminary Archaeometric Data from the Østfold Region

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ABSTRACT

Ceramic production is among the few Nordic Bronze Age activities that leave substantial traces in the archaeological record in South-East Norway, offering multiple avenues for investigating past societies. The PhD project "Clay and Community – Investigating knowledge-sharing communities through northern European ceramic production technology between 1100 BC and 400 BC" uses archaeometric data to explore (i) how local landscapes were used in prehistoric pottery production, (ii) the ceramic chaîne opératoire, and (iii) the transfer of technological knowledge.

The study covers 12 Bronze Age sites dated between 1100 BCE and 400 BCE in south-east Norway and comprises more than 70 sherds, 11 complete vessels, and 12 reference clays. The materials have been analyzed using combined non-invasive and invasive approaches (pXRF, XRD, and ceramic petrography) in order to: i) define methodological protocols accessible to professionals with different backgrounds; ii) distinguish the



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informational value of different sample preparations; iii) establish a reference framework for raw materials local to the prehistoric sites and address the challenges of provenance and raw paste recipes.

This poster focuses on distinguishing the chemical and mineralogical contributions of tempers and clay minerals, and on assessing whether observed differences are best explained by distinct paste recipes or by raw material provenance. Invasive pXRF and XRD analyses were performed on samples of prehistoric pottery and reference clays before and after sieving at 25 µm and after decantation, to isolate as far as possible the contributions of clays and tempers. This experimental protocol was complemented by ceramic petrography, which identified seven petrofabrics and contributed to a more detailed understanding of these prehistoric ceramics.

At the same time, this research asks what methodological and interpretive approaches are appropriate when working with archaeological ceramics produced from locally obtained clays and tempers. When dealing with pottery made from raw materials collected in the surrounding landscape, it is crucial to recognize that some objects in the past were produced in non-centralized, domestic contexts, rather than as standardized imports from specialized workshops. The study thus challenges common narratives in ceramic studies and highlights how archaeometric approaches must be adapted when engaging with "difficult" material culture produced in small-scale, non-standardized settings.



The Nordic Bronze Age ceramic production: Material sourcing and production technology at Hunn (Østfold, south-east Norway)

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ABSTRACT

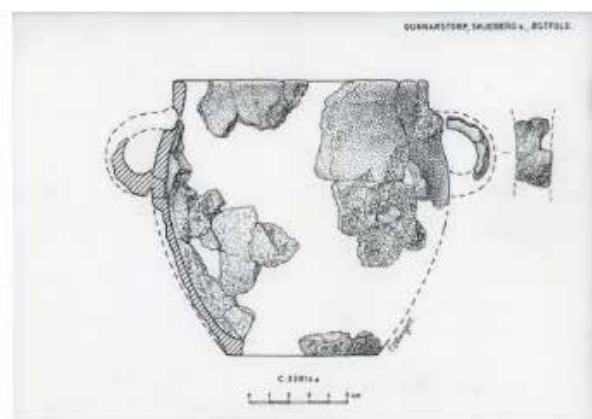
This work, the first of its kind in Norway, presents the results obtained on a set of ten ceramic sherds from the Bronze Age (c. 1100–700 BCE) site of Hunn (Østfold, south-east Norway), as a first step towards a broader analysis of Bronze Age ceramic technology in the southeastern region of the country.

Ceramic fragments were selected based on their cross regional characteristics (e.g. shape of vessels, surface treatments, etc.). A multi analytical approach (pXRF, FTIR-ATR, XRD, ceramic petrography, colorimetry and SEM- EDS) was applied to determine both their production technology and provenance of raw materials (clays and tempers) in order to ascertain the local or remote origin of the original objects. Pottery data were compared with clays sampled at possible supply sites, both in the vicinity of the excavated site, and from areas in Poland and Germany with known contemporaneous



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cultural connection to the archaeological finds at Hunn. Firing experiments conducted at different temperatures on the reference clays helped defining similarities in terms of thermal responses of the materials. This, together with the archaeometric results confirmed that examined pottery was made with locally sourced raw materials. In addition, thin-section petrography revealed possible occurrence of chamotte, as well as the survival of mineral phases such as chlorite, pointing at firing temperatures lower than 700°C in reducing conditions. This is compatible with the typology of firing structures known for the populations and the period. Similar characteristics were previously found in Bronze Age ceramics from the southern Scandinavian Peninsula as well as from the Lusatian Culture in northern Central Europe. Thus, results reinforce the previously published hypothesis of technological correspondence across the Bronze Age sites in the southern Scandinavian Peninsula and the Lusatian Culture (northern central Europe), a set of archaeological cultures from between c. 1300-500 BCE, mainly in what is now Poland, western Ukraine, Czech Republic, Slovakia, and Northern Germany.



Analysis of Materials and Manufacturing Techniques of Historical Maps (17th–18th c.) from the M. Batrinos' Collection

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ABSTRACT

The paper presents the analytical examination of historical maps (17th–18th century) from the Batrinos' Collection [1]. The study of such documents is highly significant, as historical maps are not merely geographical records, but also vital monuments of material history, printing, and the evolution of science during the pre-industrial period.

Despite their value as monuments of material history, printing, and science, literature often lacks data on their manufacturing technology. This research fills that gap, providing the scientific documentation needed to understand their specific preservation state.

Using an interdisciplinary methodology, the study applied laboratory and physicochemical analyses, including microscopic imaging, micro-multispectral imaging, Transmitted Narrow Band Imaging (TNBI), and SEM/EDS to examine the structural characteristics [2] and chemical composition of the paper, printing inks, and coloring materials.



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The documentation led to the recognition of print techniques, paper origins, and raw materials used, such as gypsum as filling material in the paper, or cinnabar in red coloring. The findings provide crucial data to assess the maps' state of preservation, contributing to be applied best practices for the preservation of historical maps.

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Modal analysis and sound synthesis of a Southeast Asian bronze drum

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ABSTRACT

Bronze drums from Southeast Asia are highly renowned. Their production began in the protohistoric period (5th century BC) in northern Vietnam and has continued across various part of the region until the present day. Although these drums are primarily designed to produce sound, acoustic studies are rare. The present research aims to better understand the drum acoustics by combining both experimental and finite element modal analyses and sound synthesis. The study is carried out on a Karen drum from the National Museum of Archaeology (France). This drum was likely brought back from a French expedition to China or mainland Southeast Asia in the late 1850s before being given to Napoleon III. As idiophones, bronze drums exhibit an acoustic behaviour that is heavily influenced by their material. Therefore, a precise knowledge of the mechanical properties of the alloy is essential for accurate numerical simulations,

which requires the study of the fabrication process and the analysis of the metal composition. A precise geometric model of the instrument is also needed. To this end, the bronze drum was first scanned using a structured-light 3D scanner, and a complete metallurgical study was conducted (ICP-MS, X-ray imaging, technological examination). Then, both experimental and numerical modal analyses were combined in order to obtain the resonant frequencies and mode shapes of the drum. Besides, sound synthesis of the drum was also implemented. The bronze drum under study is in an excellent state of conservation, which allows for the acquisition of experimental acoustic and vibration data for comparison with the numerical simulation. Once the calculated properties are validated by the experimental measurements, such numerical simulation will be used for sound synthesis of ancient altered drums that cannot be experimentally excited anymore or that do not sound as they originally did due to the presence of cracks or voids.



Karen bronze drum, H.: 48 cm, D.: 65 cm, MAN86190, MAN (© MAN/Valorie Gô)

Colourful designs: Non-invasive analysis of mid- 18th century painted silks from Europe and China

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ABSTRACT

Painted silks decorated with colourful floral designs were fashionable in Europe in the mid-18th century, as desirable imports and as 'Chinoiserie' styles inspired by products of East Asia. Although these silks are today extensively found in fashion collections, the identification of the painting techniques and materials used in their productions remains very little studied [1,2]. To address this gap of knowledge, we considered a small group of painted silks from National Museums Scotland collections which were either produced in Europe or produced in China for the European market.

The painted silks were investigated non-invasively using X-ray fluorescence mapping (MA-XRF) using a Bruker CRONO system and Fibre Optics Reflectance Spectroscopy (FORS) using a Spectral Evolution PSR+ 3500 spectroradiometer measuring over the visible to short-wave infrared wavelength range (350-2500 nm). Where possible, micro-sampling was undertaken for Liquid chromatography (UPLC-PDA) and infrared microscopy (FTIR) to identify specific colours containing organic materials and/or



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complex mixture of pigments.

These initial results showed the extensive use of blue, green, pink and purple colours, often applied in successive layers with different hues. The palette of pigments contains malachite or verdigris, azurite, Prussian blue, vermillion, organic red (madder) and organic purple (indigo). The presence of silver-based outlines, appearing to be a distinguishing criterion between Chinese and European productions [1,2].

This work explores the potential that these materials insights have to support workshop attribution or places of production of these delicate and colourful textiles.

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The colours of Ginori Porcelain (Italy, 18th-19th century): a non-invasive ion beam analysis study

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ABSTRACT

The earliest porcelain production of the Ginori Manufactory in Doccia represents one of the most important European technological experiments of the eighteenth century. Archival sources describe the manufactory as a true centre of experimentation, both in the formulation of porcelain bodies and in the development of decorative technologies. Despite the historical importance of Doccia production, a systematic analytical investigation of pigments and glaze compositions has so far remained limited. This study presents the results of a non-destructive analytical investigation based on Ion Beam Analysis (IBA) techniques, including PIXE, PIGE, and RBS, applied to a selected group of Ginori porcelain objects produced between the earliest phases of the manufacture, founded in 1735, and the end of the eighteenth century. The measurements were performed with a 3 MeV proton beam at the external-beam for cultural heritage analysis of the INFN LABEC 3 MV Tandem accelerator in Florence.



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The research revealed the use of both hard- and soft-paste glaze technologies, including Pb- and Sn-rich compositions, connected to maiolica technology. The analytical results identify cobalt-based underglaze blues, Sb-Pb- and Fe-based yellow pigments, and Cu-based green colours. Red decorations are Fe-based and were also employed as preparatory layers for gilding applications. The analyses provide evidence for the use of high-purity gold in most cases, compatible with the documented use of gold sequins. The presence of Purple of Cassius is supported both by archival recipes and by the detection of Au and Sn. In later productions of the 19th century, chromium green was identified, consistent with archival records documenting the pigment import from Paris. The analysis of the rare Nankin colour, characterised in this study for the first time to the authors' knowledge, revealed the presence of iron, zinc and lead. A particularly relevant aspect concerns the role of fluxes and additives in coloured glazes, suggesting the coexistence of multiple experimental recipes and technological variability within the production process. Among these, particularly interesting is the use of borax, whose presence is often overlooked by common analytical techniques such as XRF and SEM-EDS. PIGE analysis allowed its identification in this study.

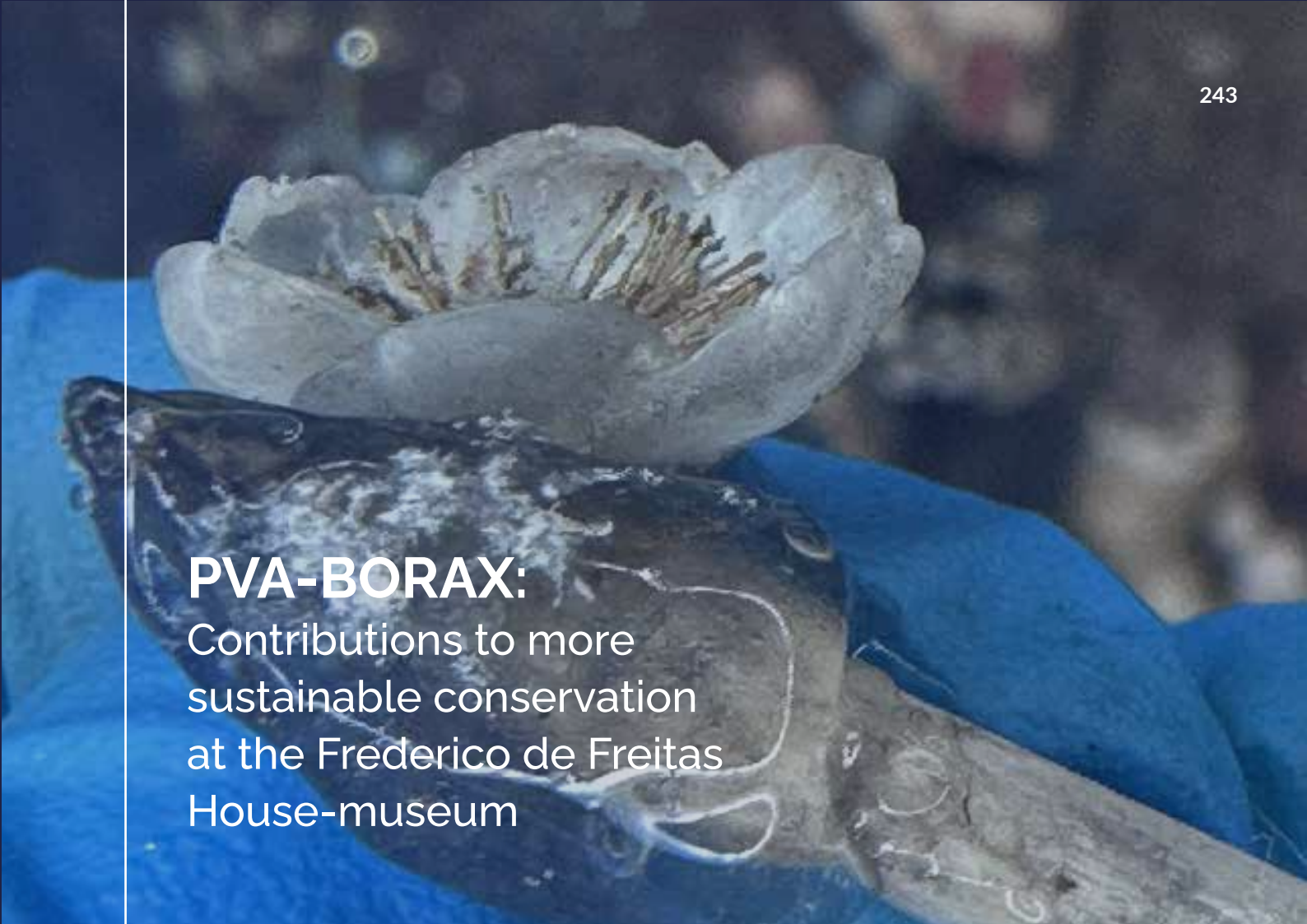
Although the research is still ongoing and aims to expand the analytical dataset, the present results define a colour palette comparable with contemporary European productions such as Meissen and Du Paquier. At the same time, the study highlights previously unexplored aspects related to fluxes and additives, offering new insights into the technological experimentation that characterized the earliest Ginori production at Doccia.

Acknowledgements

The authors are grateful to the Fondazione Museo Archivio Richard Ginori della Manifattura di Doccia and its curators Oliva Rucellai and Rita Balleri, the Soprintendenza Archeologia, Belle Arti e Paesaggio per la Città Metropolitana di Firenze e la Provincia di Prato and Marzio Cinelli (private collection) for providing access to the objects examined in this study.



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PVA-BORAX: Contributions to more sustainable conservation at the Frederico de Freitas House-museum

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ABSTRACT

This proposal shares the experience of using PVA-Borax gel and its variants in conservation interventions on the collections of the Frederico de Freitas House-museum (Madeira Island, Portugal), emphasising its potential as a low-impact solution for cultural heritage conservation [1,2]. It also encourages reflection on the adoption of more sustainable conservation strategies, particularly in institutional contexts with limited human resources and intervention time. The Frederico de Freitas House-museum is characterised by diverse collections comprising objects of highly varied materials, techniques and typologies. Routine conservation, as well as the integration of items from private collections in temporary exhibitions, requires versatile, safe and adaptable solutions capable of addressing different intervention needs.

In this context, PVA-Borax gel has proven effective in a range of conservation and maintenance procedures. Its application enables controlled cleaning with reduced moisture release, minimising risks to sensitive surfaces and heterogeneous materials [1]. The system's versatility allows adaptation to different object typologies and states of

conservation [2], while optimising intervention time and available resources.

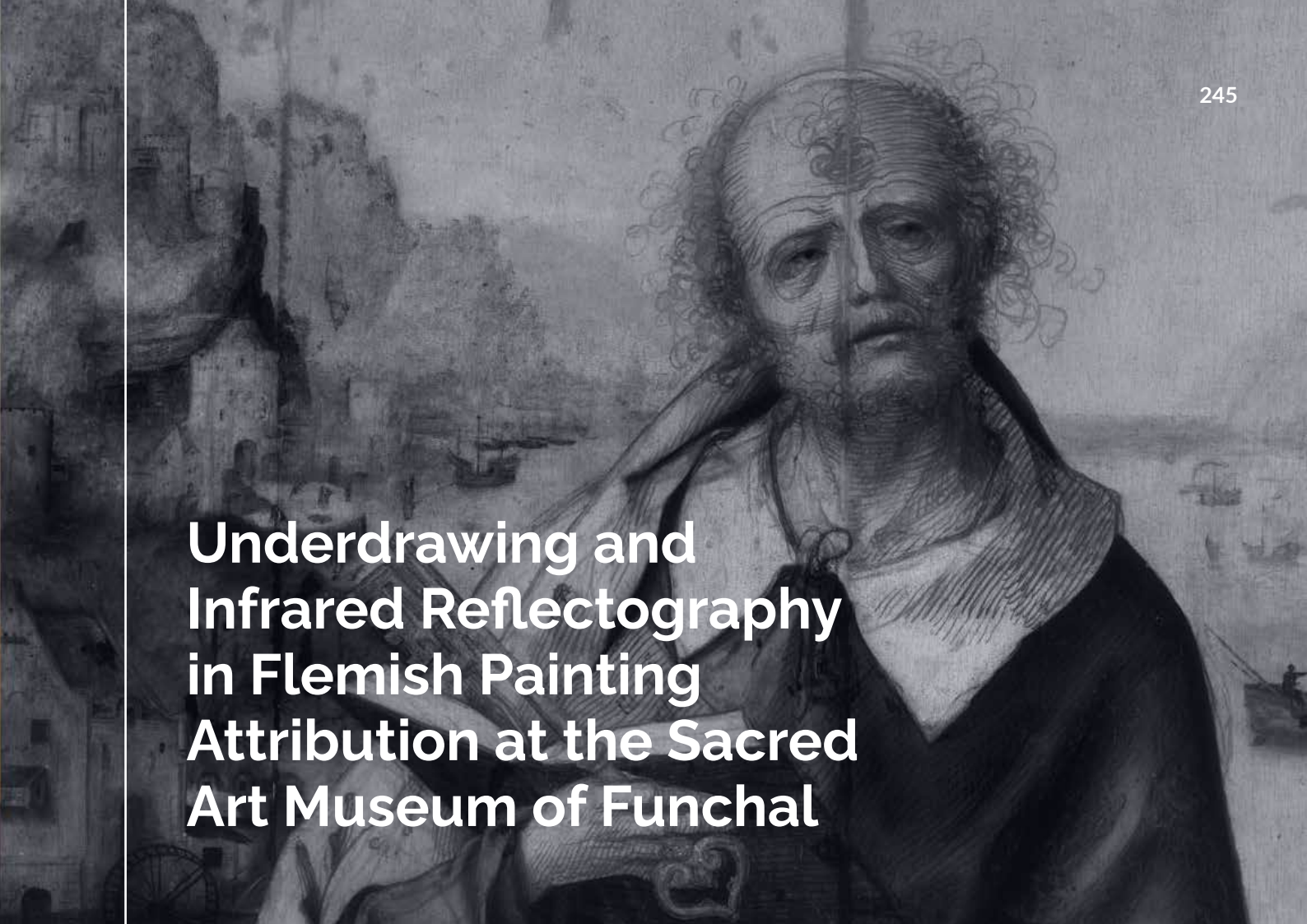
This methodology represents a significant step towards sustainability, enabling more localised and controlled interventions, reducing impact on objects, decreasing solvent and disposable material use, and strengthening preventive conservation strategies. Moreover, preparing the material in varying quantities, storing it under controlled conditions for extended periods, and reusing it in specific cases contributes to waste reduction and improves environmental, economic and operational efficiency.

In parallel, less invasive and potentially less harmful methodologies promote safer working practices for conservators-restorers, reduce impacts on the constituent materials of artworks, and foster greater awareness of the environmental implications of conservation interventions. Within this framework, PVA-Borax gel stands out as a viable tool for sustainable conservation strategies in museum contexts.



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Underdrawing and Infrared Reflectography in Flemish Painting Attribution at the Sacred Art Museum of Funchal

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ABSTRACT

This study analyses the underdrawing in a group of 15th and 16th-century Flemish paintings from the Sacred Art Museum of Funchal (MASF). It aims to assess the contribution of infrared reflectography as a non-invasive imaging technique for technical and material characterisation and for supporting artistic attribution. This work is part of a doctoral research project on the conservation and restoration of Flemish paintings in Madeira Island (Portugal) [1].

The application of infrared reflectography made it possible to observe the underlying paint layers, allowing the preparatory drawing to be analysed in terms of line morphology, transfer methods, compositional structure, and changes during pictorial execution. This approach also enabled a systematic comparison of the corpus of works

under study, revealing variations in the underdrawing that suggest different workshop practices across the corpus of works.

The results obtained demonstrate that the study of underdrawings provides significant evidence for assessing technical and authorship affinities. This corroborates previous attributions established on stylistic grounds and contributes to the reassessment of others. A comparative analysis reveals differences in drawing solutions that suggest different attributions and production contexts within workshops.

This work emphasises the importance of non-invasive imaging techniques, particularly infrared reflectography, as vital tools in interdisciplinary art history and conservation research. These techniques provide access to technical and material information that is not visible to the naked eye, contributing to a more informed approach to attribution and the study of artistic workshops.



Acknowledgements

HERITAS Doctoral Programme (FCT) – Research Fellowship Ref. PD/BI/113897/2015; ARDITI – Regional Agency for the Development of Research, Technology and Innovation of the Autonomous Region of Madeira – Doctoral Fellowship (Project M1420-09-5369-FSE-000002).

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Molecular Insights into Historic Paint Vestiges and Biodeterioration at the Temple of Hephaestus in Athens: Elucidating the Origin of Pink Staining

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ABSTRACT

Situated atop the hill of Kolonos Agoraios, at the western boundary of the Ancient Agora of Athens, the Temple of Hephaestus stands as one of the most complete and best-preserved monuments of classical antiquity. The temple's decorative program once included extensive polychromy, an aspect long overlooked due to the enduring misconception of Greek temples as monochromatic marble edifices. Furthermore, the temple's conversion into the Christian



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church of St. George Akamatis, likely during the 7th century AD, introduced significant architectural modifications, such as the addition of an eastern apse, alongside fresco decorations (Kiilerich 2021; Camp 2004; Travlos 1980). This structural and decorative transition created a complex, multi-layered surface stratigraphy. Although largely stripped after 1834 to restore the monument's classical form (Camp 2004), the micro-traces and subsequent alterations of these medieval vestiges present a complex diagnostic challenge for molecular differentiation. Mid-20th-century cleaning and conservation interventions brought to light critical evidence of both iconoclastic damage and surviving traces of polychromy. These included remnants of blue backgrounds, red drapery, and green elements of the landscape scenery, confirming the monument's originally rich decorative palette (Frantz 1954; Thompson 1954). Understanding original polychromy, both ancient and historic, provides insights into ancient technologies and informs conservation strategies by elucidating degradation mechanisms. To investigate surviving traces at the Temple of Hephaestus, a non-invasive approach combining hyperspectral imaging and μ -Raman spectroscopy was employed. The results enabled the identification of iron-based pigments, primarily yellow and red ochres, confirming the use of mineral colourants in the decorative scheme. However, several pinkish surface areas raised a critical diagnostic challenge regarding whether they represented intentional ancient painting or modern biological colonization. To resolve this dilemma, complementary microbiological analyses were undertaken to characterise the microbial communities associated with these coloured deposits. Non-invasive swab sampling was performed under semi-sterile conditions. Microbial community profiling was carried out through Next-Generation Sequencing (NGS) using an Illumina platform, targeting the V3–V4 hypervariable regions of the 16S rRNA gene for prokaryotes and the ITS region for eukaryotic microorganisms. Simultaneously, samples were cultured on general-purpose culture media and colonies exhibiting pinkish-red pigmentation were isolated and taxonomically identified using Sanger sequencing. This multidisciplinary approach demonstrates that the pink discoloration observed on the Temple of Hephaestus is associated with a highly adapted, carotenoid-producing microbial consortium dominated by *Bacillus* sp., *Arthrobacter* sp., and *Fusarium* sp., rather than intentional polychromy. The metabolic activity of these pioneer species contributes to both aesthetic alterations and biochemical deterioration, highlighting the vital importance of biomolecular differentiation for the long-term conservation of this emblematic monument.

Acknowledgements

The authors wish to express their sincere gratitude to the Ephorate of Antiquities of the City of Athens, and especially to its Director, Dr. E. Kountouri, and the Head of the Department of Conservation of Antiquities, Ms. Argyro Tsingri, for granting permission to study the Temple of Hephaestus in the framework of the co-author's (G. Frantzi) PhD dissertation. We also express our gratitude to the technical staff of the archaeological site for their support and invaluable assistance with the scaffolding and logistics.

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The AUTOMATA project:

A new automated and robotized set up for non-invasive, fast 3D modeling and archaeometric study of archaeological artefacts

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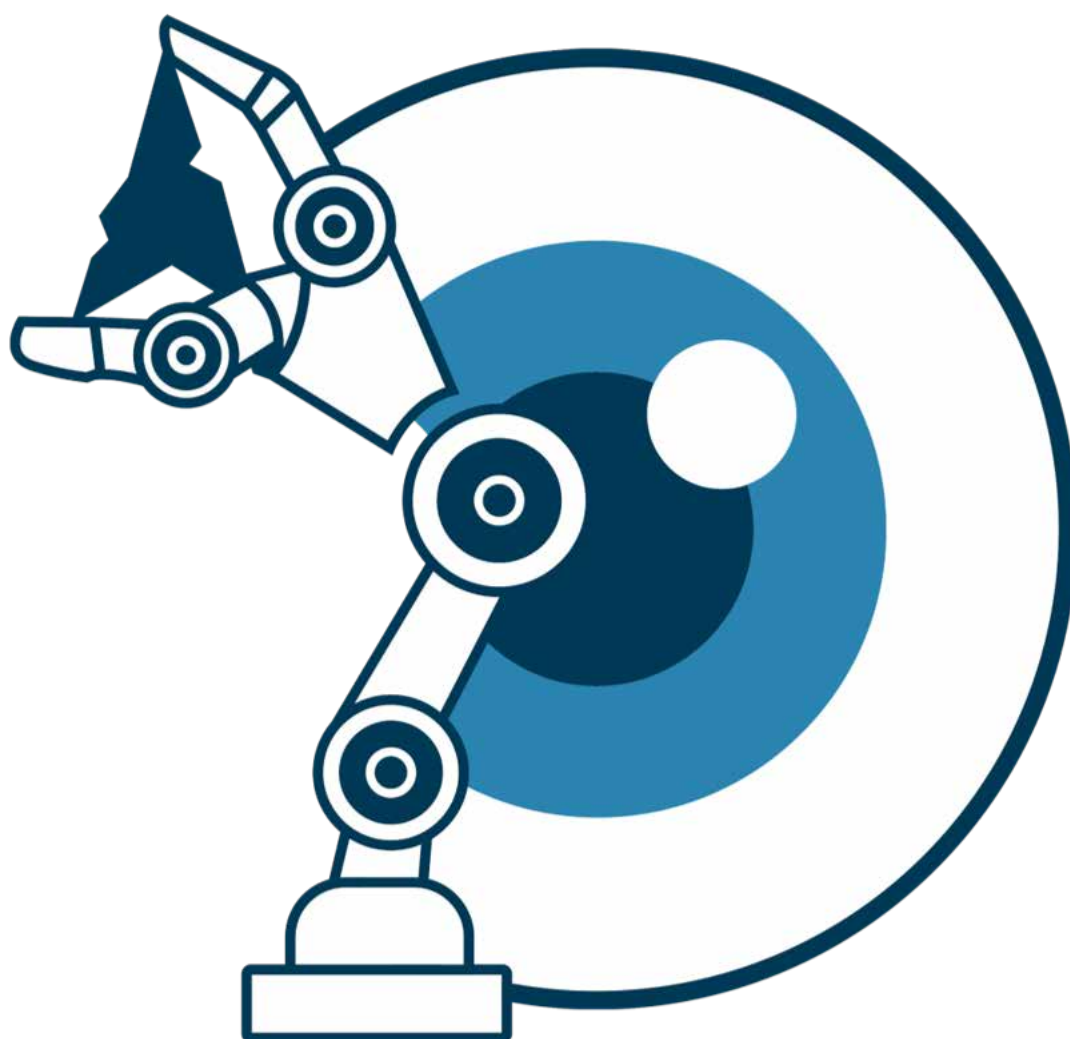
ABSTRACT

As one of the most ubiquitous archaeological finds, ceramics and lithics offer unparalleled insights into ancient technologies, cultural practices, and trade networks. Yet, the systematic study of collections is often hamstrung by the sheer volume of artifacts, limited resources, and a shortage of specialists—leaving many collections unstudied and at risk, despite their potential to illuminate past societies. The AUTOMATA project (Horizon Europe – *European Collaborative Cloud for Cultural Heritage*) addresses this challenge by automating the large-scale digitization of artifacts, producing reproducible 3D models enriched with archaeometric data (such as compositional and structural analyses). This integrated approach enables a holistic understanding of ceramic and lithic corpora, combining shape, decoration, and material properties for comprehensive contextual interpretation. By leveraging multi-sensor acquisition (photogrammetry, hyperspectral imaging, portable X-ray fluorescence, and Raman



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spectrometry) and AI-driven data processing, the project unlocks new insights into production techniques, provenance, and cultural connections. All data will be accessible through a 3D Reference Information System, ensuring interoperability, long-term preservation, and global research collaboration. AUTOMATA does more than advance technical capabilities—it redefines how ceramic and lithic artifacts are studied, shared, and understood in the digital age, bridging art, archaeology, and applied science.



Acknowledgements

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Why Are Pompeii's Fountains Turning Red? Looking at Cyanobacteria, Light Stress and Pigment Adaptation

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ABSTRACT

Several fountains in the Archaeological Park of Pompeii began to show reddish biological deposits some years ago. In 2018, a preliminary study was conducted, and microscopic analysis suggested the presence of 4 cyanobacterial species: *Calothrix fusca*, *Gloeotheca palea*, *Chroococcidiopsis thermalis* and *Leptolyngbya boryana*. Under normal environmental conditions, all identified microorganisms exhibited a greenish colour. However, the literature indicates that these strains may increase their phycoerythrin concentration (a red pigment) when exposed to extreme lighting



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conditions, including changes in light intensity and spectral composition [1].

This issue has persisted and spread throughout the park. During a sampling campaign in September 2025, 12 new samples of reddish patina were collected from four fountains for further study. Samples were obtained using sterile swabs, refrigerated, and subsequently cultured in BG-11 medium for isolation under laboratory conditions. A total of 34 macroscopically distinct colonies were selected, representing at least 12 different morphologies based on microscopic observation. DNA extraction and amplification of the 16S rRNA gene were successfully performed in 29 samples using PCR, followed by sequencing for molecular identification. In parallel, pigment analysis was conducted using Raman spectroscopy. Preliminary results revealed greater cyanobacterial diversity than previously reported and indicated the presence of different carotenoids.



Acknowledgements

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Salt contamination of low-health-impact black crust removal methods

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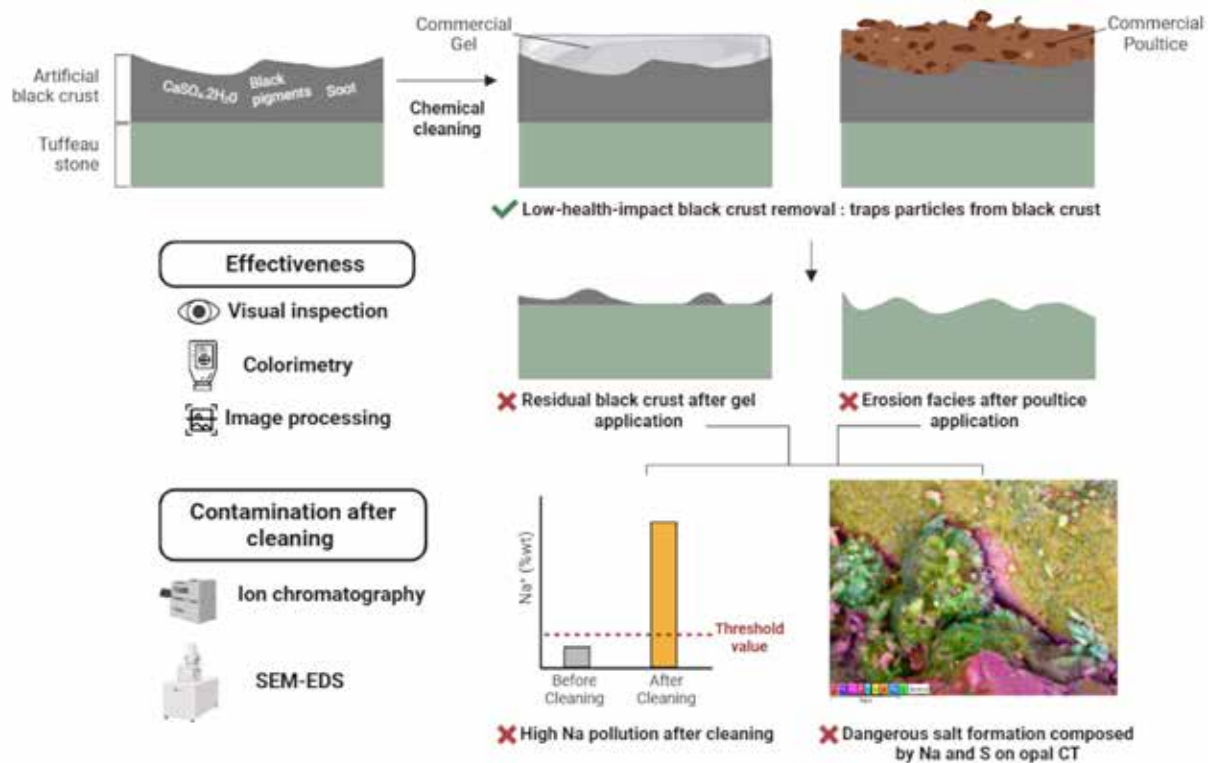
ABSTRACT

Built cultural heritage is exposed to the formation of black crusts, mainly composed of gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$) and atmospheric particles such as soot, formed by the reaction of sulphur dioxide and calcite in calcareous stone. This weathering crust can threaten the conservation of buildings. Traditional methods (e.g. sandblasting), harmful to human health and environment, are now being discarded in favour of chemical methods, such as polymer gels and clay poultices which trap black crust particles. To evaluate black crust removal and potential harmful effects, two commercial products (one polymeric gel and one clay poultice) has been applicated on the Tuffeau stone originated from Loire Valley, with an artificial black crust. Macroscopic observation, colorimetry and image processing showed that the poultice was more effective than the gel but also caused erosion during cleaning. Also, sodium pollution was highlighted after cleaning for both products (up to 50 times higher than before cleaning) and pose severe conservation risk. Furthermore, SEM-EDS observations indicate crystallizations of sodium and sulphur, suggesting the harmful formation of sodium sulphate. Therefore,



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these findings reveal that although chemical cleaning is considered better for human health and environment, they may induce significant alterations for the conservation of the stone and the built heritage.



Reactivity of vanadyl markers in embalming materials of Ancient Egypt

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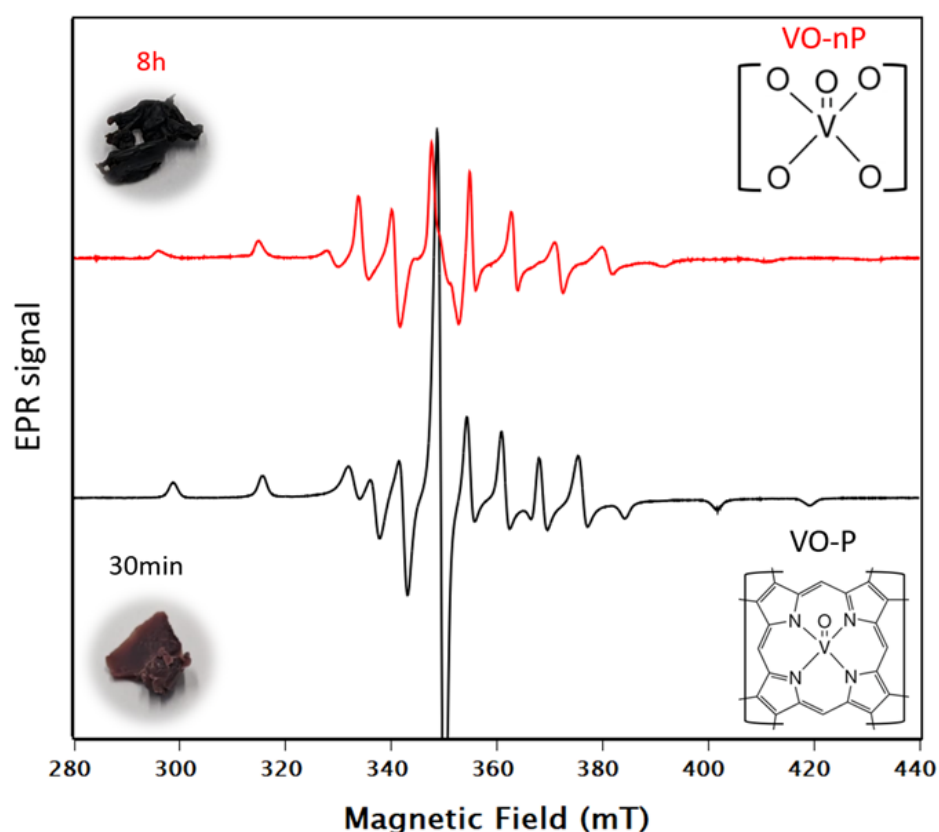
ABSTRACT

One of the most interesting features of the ancient Egyptian civilization is certainly the funerary practices, which at the New Kingdom had reached a high degree of sophistication. These practices often employed a viscous black material for the coating of funerary objects, the anointing of the mummies or the soaking of the tissues used for their stuffing. These embalming materials are complex mixtures of inorganic and natural organic substances, of which bitumen, in variable amounts, is often suspected. The asphaltene fraction of bitumen contains carbonaceous radicals and vanadyl porphyrins (VO-P) that are detectable by non-destructive electron paramagnetic resonance (EPR) techniques and can serve as stable markers of this substance. Previous work on Egyptian embalming materials from various periods and locations revealed the presence of organic radicals as well as vanadyl porphyrins, indicative of bitumen, but also non-porphyrinic vanadyl species (VO-nP), coordinated with four oxygenated ligands [1]. The presence of these oxygenated vanadyl complexes is intriguing, as they



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are missing from the pure raw bitumen sample. This observation raises the question of whether these species derive from the pristine VO-Ps as by-products of the fabrication processes of the embalming materials and/or from their long-term alteration. To investigate this hypothesis, model systems were prepared by mixing and heating pure VO-Ps or reference asphalt with natural organic substances commonly used in the creation of these balms, and the profile of the vanadyl complexes was monitored using EPR and UV-vis spectroscopy. This approach revealed that VO-Ps can indeed transform into the oxygenated VO-nPs when heated in a mixture with organic substances. Interestingly, the different organic substances of the recreation show different overall kinetics, with the presence of the various carboxyl groups of these substances playing an especially important role. This work highlights the potential of a non-destructive analytical approach to better understand the chemical interactions among the components of the embalming materials and to identify molecular markers that can help trace back the production conditions of these ancient balms.



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Multi-analytical and multidisciplinary study of parchment production technology in the Early Islamic period

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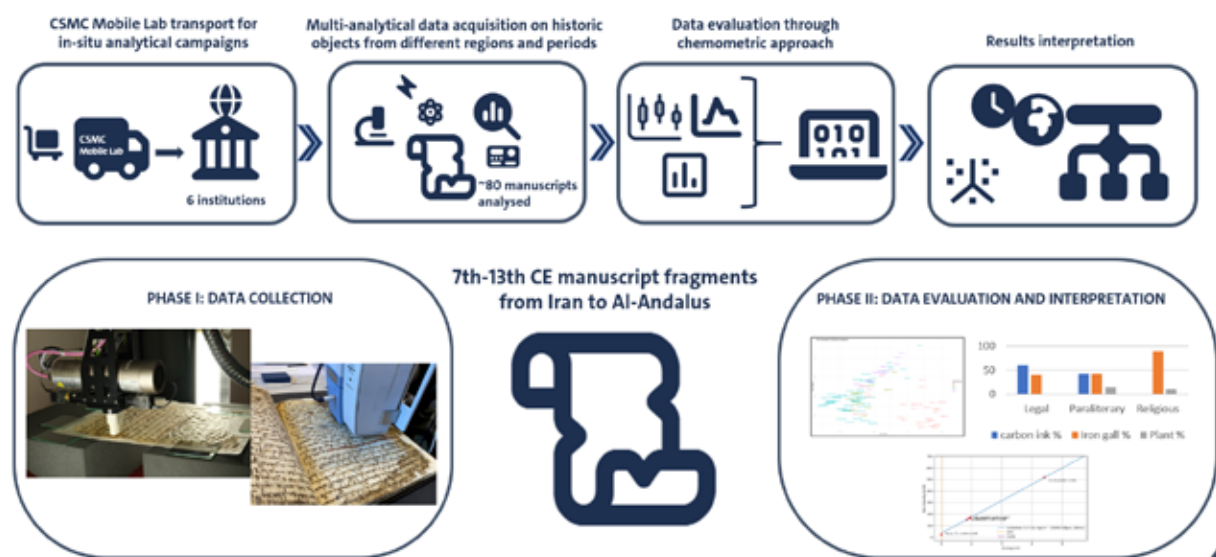
ABSTRACT

Parchment was employed as writing support — alongside papyrus — at the beginning of Islam, during the formative phase of the Muslim written tradition. The majority of the early Qur'anic manuscripts were written on parchment, but this writing support was also used to produce private documents and other non-religious texts. [1] While most material research has focused on European and Hebrew parchment manufacture [2], parchment manuscripts from the Muslim world remain comparatively understudied. After three years of data acquisition with transportable equipment (CSMC mobile lab), this study combines archaeometry, philology, codicology, palaeography, and chemometrics to investigate the history and production techniques of parchment in the early centuries of Islam (7th to 13th century CE). By applying micro- and macro-X-ray fluorescence spectrometry (XRF/ μ -XRF) mapping, external reflection Fourier



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transform infrared (ER-FTIR) spectroscopy, Raman spectroscopy, as well as reflectance transformation imaging (RTI) to ca. 80 early Islamic manuscripts from 6 different collections, it identifies purpose and regional- or time-dependent variations. Particularly, ER-FTIR data were analysed with supervised and unsupervised chemometric approaches to identify patterns through the traces of production technologies. By integrating historical sources and physical evidence, this research seeks to establish a deeper understanding of the material dimension of early Islamic parchment within its historical context of production and use.



Acknowledgements

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A multimodal analytical study of nanocellulose hydrogel–paper interactions in foxed paper: cleaning performance and underlying mechanisms

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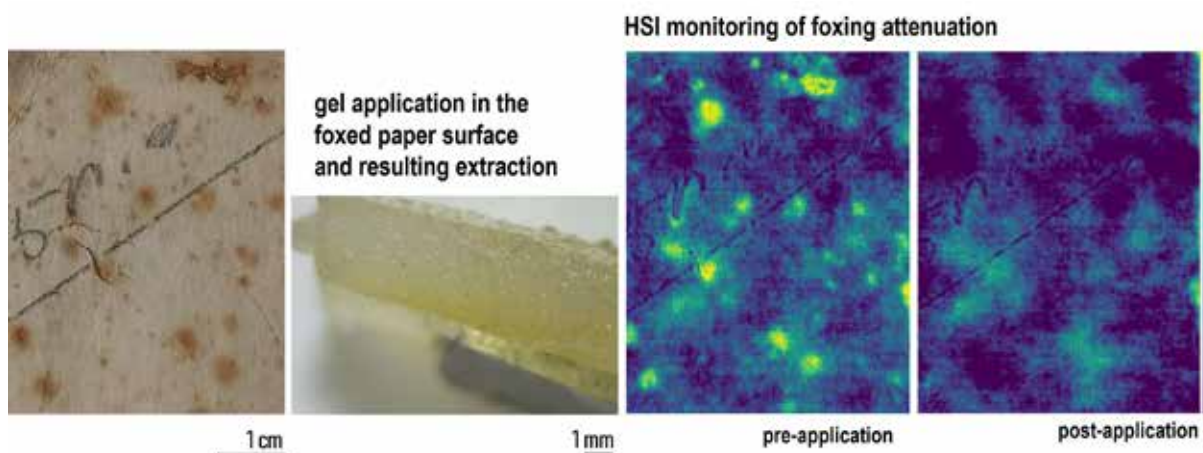
ABSTRACT

Over the last decade, gels have significantly expanded conservation treatment possibilities for Heritage objects. Their ability to provide localised cleaning and controlled-selectively remove degradation or exogenous compounds makes them strong alternatives to traditional solvent-based methods. Several decades ago, gels (e.g., agarose and gellan gum) were also introduced in paper conservation as alternative candidates to conventional aqueous treatments. Their controlled moisture release and paper-compatible composition make them suitable for treating water-sensitive supports [1]. So far, hydrogels' application has mainly focused on water-related stains, metallic-based inks migration and degradation promoted by microbiological activity [1,2]. However, their performance on foxing stains is yet to be explored. Foxing typically manifests as scattered stains with rust-like or yellowish hues on the paper surface, often involving both biotic and abiotic components. Therefore, understanding their composition is key to tailor conservation strategies and to elucidate gel–support



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mechanisms. This study has a twofold aim: (i) to investigate the potential use of chelator-free nanocellulose hydrogels cross-linked with glycine, developed within the ENCLOSURE project, to reduce foxing stains; and (ii) to explore gel–paper interactions through an multimodal analytical approach, to better understand the mechanisms underlying stain attenuation and support the fine-tuning of gels formulations for a more effective and safe conservation. Loose 20th-century paper samples containing foxing stains were selected and characterised before and prior to gel application by and analytical approach including, optical microscopy, CIELab assessment, FTIR spectroscopy, and SEM inspection. In parallel, FTIR analysis were conducted on the gels, and the compounds extracted during treatment were recovered and analysed through UV–Vis and pH measurements. Colourimetric results showed an increase in paper lightness, and a shift towards a more neutral paper hues, while FTIR analysis showed no alterations in the cellulose fingerprint region, indicating preservation of the cellulose structure. Additionally, FTIR analysis of the gels after application revealed changes in the NH_3^+ and COO^- band pair features of the hydrogel, suggesting that gel–paper interaction is primarily governed by H-bonding and ionic exchange mechanisms, enabling the extraction of low-molecular-weight oxidation products associated with foxing phenomenon.



Acknowledgements

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Multi-Analytical studies on gold leaf and part gold – Introducing Ion-Milling for the re-examination of more than 100 pre-existing cross-sections

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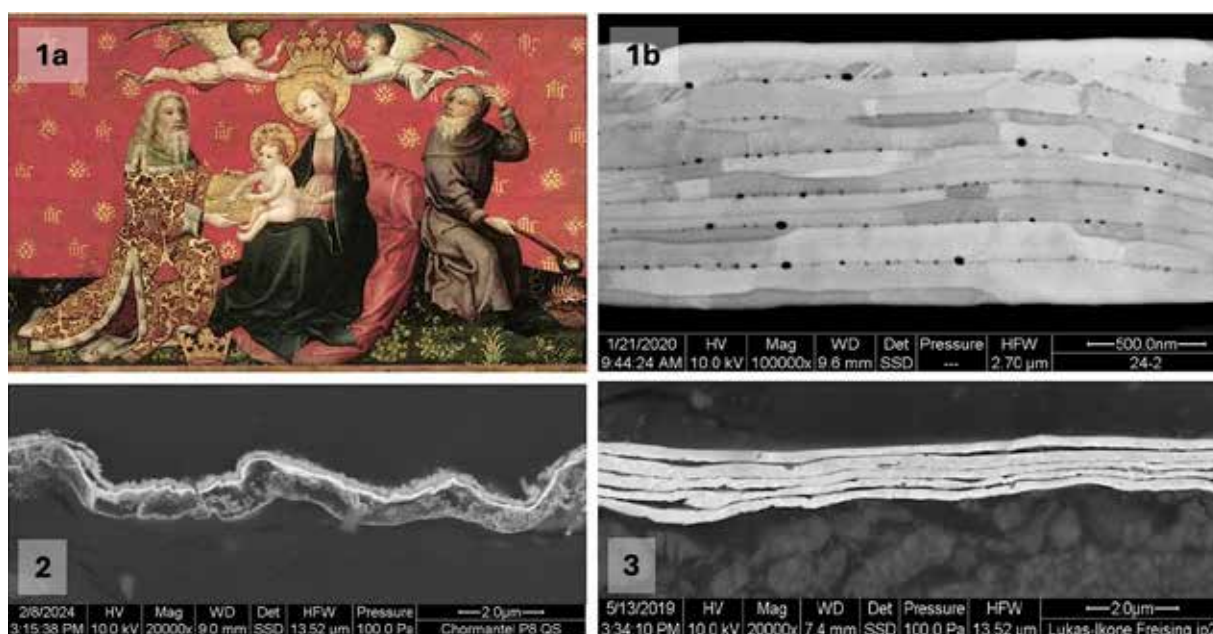
ABSTRACT

At the heart of this study lies a collection of over 140 gilding samples from 52 artworks, which were loaned by various museums and institutions. The main objective was to study gold leaf and part gold/Zwischgold in terms of their thickness, elemental composition, and application in gilding, including the number of leaves used and the type of gilding employed. More than 100 of these samples were already provided as cross-sections, most of which had been prepared over 20 years ago, and some over 50 years ago. Following ion polishing (flat milling in the Hitachi IM 4000), the samples were analysed using a high-resolution FEG-ESEM with secondary and backscattered electrons (SE and BSE) in combination with EDS. The precise depiction of extremely thin gold layers (in Zwischgold sometimes less than 10 nm) and the visualisation of

egg yolk granules (EYGs), as well as ageing and corrosion phenomena on metals and pigments, demonstrated the significant advantages of combining ion beam preparation and high-resolution SEM for analysing paint and gilding layers. Working primarily with pre-existing, archived samples proved that this approach is highly sustainable, enabling superior surface preparation and re-examination without significantly altering the format or integrity of the cross-sections.

The samples mainly originated from polychromed sculptures and panel paintings dated between 1200 and 1500. These included the Tyrol Castle altarpiece (1370/72), the Heisterbach altarpiece (c. 1440), the Golden Panel from Lüneburg (c. 1420) as well as the Ghent altarpiece (completed 1432). Earlier artefacts featured in the study were the so-called "Icon of Saint Luke" from the Freising Diocesan Museum (Byzantine, c. 1000 CE), the panel from Trogir Cathedral (late 13th century) and the Aschaffenburg Panel (1240–1250).

Comparative analyses were carried out on modern gold and part gold leaves, as well as on specially created gilding samples, using additional methods such as colour, gloss and roughness measurements, RBS, XRF and NAA. Investigating two recent types of part gold by means of FIB-SEM, TEM/STEM, TOF-SIMS and AES provided new insights into the internal structure and the potential corrosion mechanisms. A valid explanation for the unique colour of part gold could be deduced by combining the results of material analysis, microscopy and optical simulations. One corrosion phenomenon that was studied in more detail was the reaction between silver and cinnabar. In several historical samples, as well as in corrosion experiments, the gradual replacement of mercury (Hg) by silver (Ag) within the pigment particles (diadochie), and the formation of a silver amalgam outside the particles, could be observed.



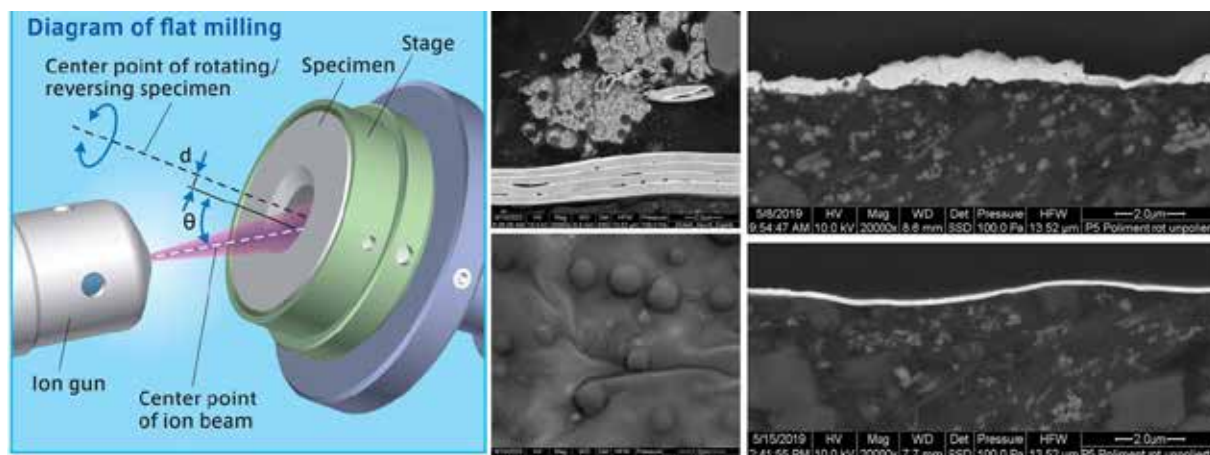


Figure 1: From left to right: Diagram of flat milling (source: URL: <https://www.hitachi-hightech.com>); gilding sample with four part gold leaves covered by tempera paint with egg yolk granules (orange arrows) surrounded by silver corrosion (red arrow), SEM-BSE, 20.000x and detail of tempera paint containing egg yolk granules, SEM-SE, 50.000x; gilding on red bole (one gold leaf) before and after ion milling, SEM-BSE, 20.000x.

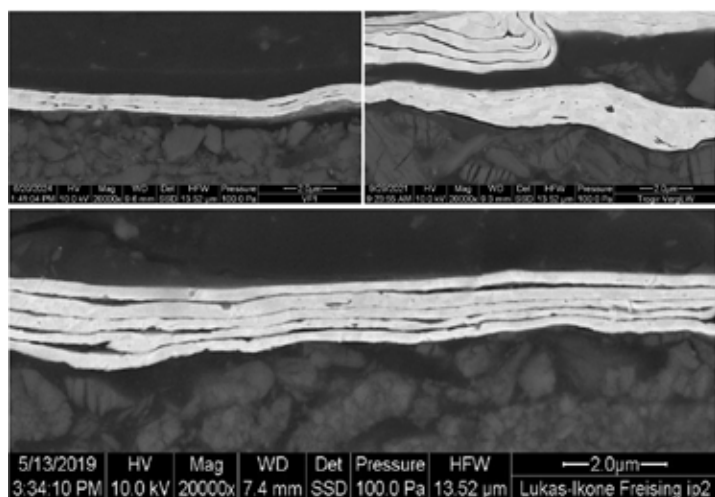


Figure 2: Water-gilding with multiple leaves, either with no bole or with a very thin layer of bole, SEM-BSE, 20.000x. Above: Gilding (three 24-carat leaves) in the background of an inner panel of the Tyrol Castle altarpiece (c. 1370, left), and multiple 24-carat gold leaves pressed together from the background of the panel from Trogir Cathedral (late 13th century). Bottom: Thick ground gilding (four to five leaves, 22.63 carats) on the Icon of Saint Luke from Freising (c. 1000 CE, Byzantium).

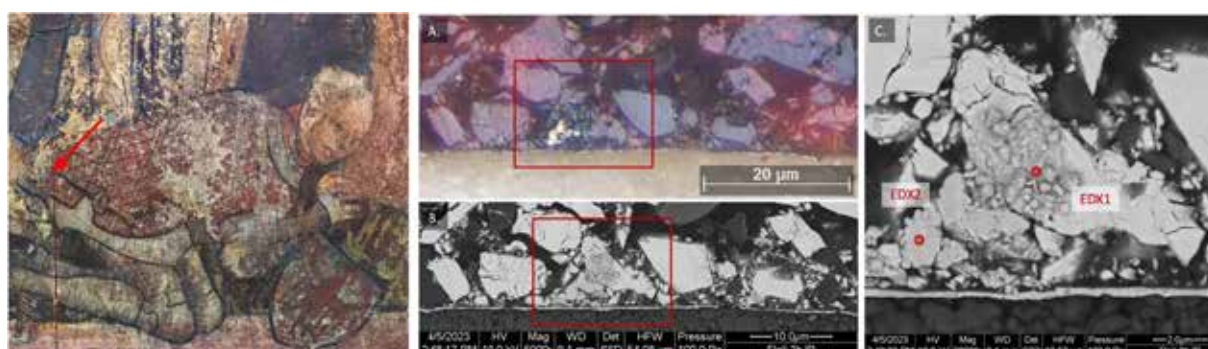


Figure 3: Example for the reaction between cinnabar and silver. From left to right: Detail from the outer wing of the Tyrol Castle altarpiece, sampled area (sgraffito pattern in red cinnabar paint over silver leaf); A.+ B. Cross-section of the sample with visibly altered cinnabar particles on top of silver (red frame), Optical Microscopy (Bright Field, 1000x) and SEM-BSE, 5.000x; C. Detail of the corroded pigment particle with Ag_2S on the inside (EDX1) and silver amalgam (EDX2: 24 At.-% Hg, 76 At.-% Ag) on the outside, close to the silver leaf, SEM-BSE, 20.000x.

Crystals of the Past: Spectroscopic Insights into Ancient Salt Production

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ABSTRACT

Along the coastline of the Gulf of Baratti (Centro Velico, Piombino, Tuscany), a protohistoric site has been identified, within which ceramic materials have been recovered that allow the working area to be dated to the Final Bronze Age (ca. 10th century BCE), thereby making it one of the oldest sites of this type currently known in Italy [1]. The primary archaeological question concerns the possibility of reliably confirming whether the site was used as a facility for salt production or for the processing of salted food, and thus of demonstrating the use of artificially induced evaporation techniques through the application of heat. Indeed, the production of salt, or halite, relies on two main processes: natural evaporation (in salterns) and artificial evaporation. Determining which of these production methods was employed at the site provides crucial insights into the socio-economic organization of the society under investigation [2]. In order to address this question, salts were experimentally produced

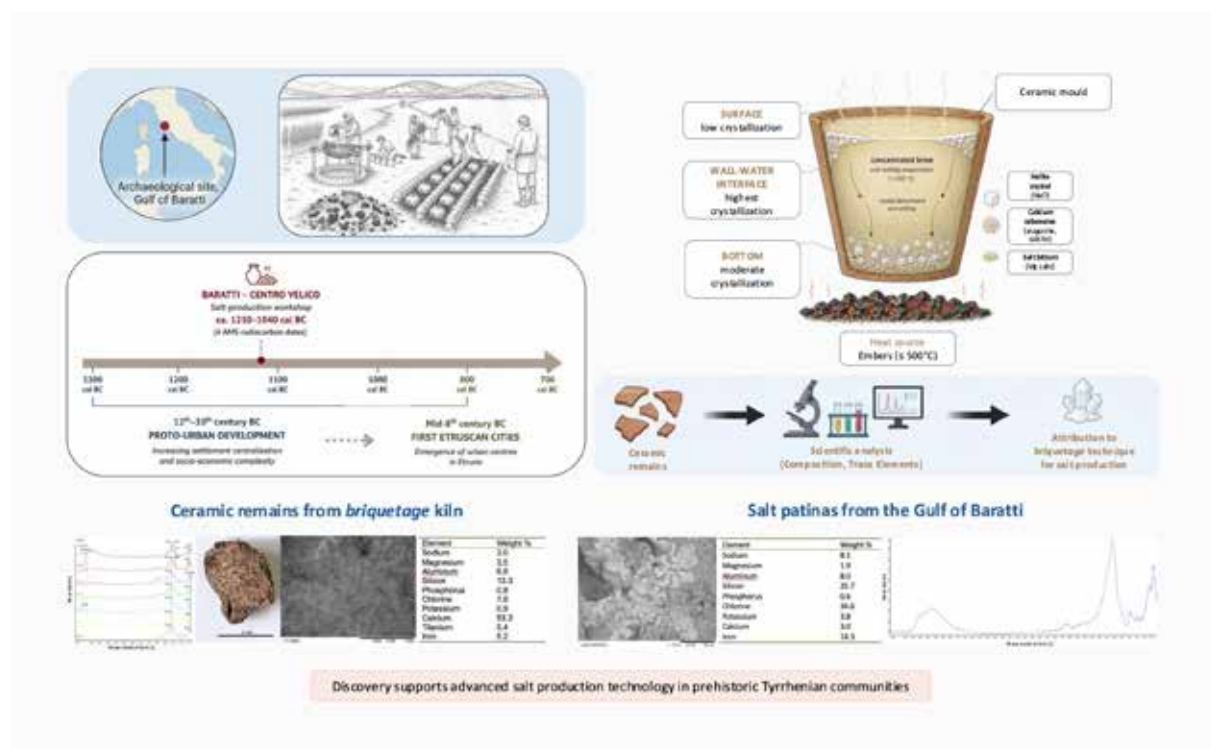


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under controlled laboratory conditions at different temperatures, starting from seawater collected from the Bay of Baratti. The resulting samples were subsequently analysed using a range of analytical techniques, including X-ray powder diffraction (XRPD), infrared spectroscopy in both the mid-infrared (MIR) and far-infrared (FAR-IR) regions, scanning electron microscopy coupled with energy-dispersive X-ray spectroscopy (SEM-EDX), and Raman spectroscopy.

These initial analyses made it possible to identify the presence of aragonite and to observe variations in mineralogical composition among the different prepared standards. The results further demonstrate that higher temperatures promote the formation of aragonite, which can therefore be employed as a diagnostic spectral marker.

In light of these promising results, it was decided to extend the application of spectroscopic techniques to the ceramic samples and sediments recovered from the archaeological site. In addition, gas chromatography coupled with mass spectrometry (GC-MS) was employed in order to detect the possible presence of food residues alongside inorganic salts.



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Archaeometric Insights into the Materials and Technology of the Monomachos Crown

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ABSTRACT

During the Middle Ages, enamelworks were highly respected and considered among the most valued creations of the Byzantine Empire. For many centuries, Byzantium almost exclusively produced cloisonné enamel on gold, a technique that became strongly linked with the imperial court of Constantinople. However, only a few enamels have survived to the present day. Despite their rarity and significance, modern archaeometric studies in the literature are scarce (Biron, 2015). Investigations on pieces found in Hungary have recently begun. One of these enamelworks is the Monomachos Crown, on display in Budapest, Hungary. The Monomachos Crown, composed of seven semi-circular Byzantine gold plates, was found in 1860-61 at Nyitraivánka (Ivanka pri Nitre, Slovakia; Bárány-Oberschall, 1937). Two discoid gold plates that could possibly be connected to the Crown were also found. First, UV photography and reflection FTIR (Fourier-Transform InfraRed) measurements were carried out to reveal the condition of the plaques and where previous restorations had affected them. After 2D and 3D microscopy, regions of interest were chosen for non-destructive analyses. μ -XRF was



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carried out to reveal the distribution of major and trace elements in the enamels and to map out the heterogeneities inside the glasses. Raman analyses were conducted on the glassy matrix of the enamels to provide additional chemical information on the pigments and opacifiers used. The analysis of the major and trace elements of the base glasses, combined with the identification of pigments and opacifiers in the enamels, may enable us to reconstruct the recipes and the possible provenance of the studied enamels. Results show that in the blue and yellow colours of the Monomachos Crown calcium-antimonate was used as an opacifier. On the contrary, for the two gold plates tin-oxide was also used as an opacifier, suggesting a different production technology or workshop.

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Visual Standardization for Damage Mapping in Stone Heritage: Chromatic Systems (RGB, Hex, and CMYK) and Graphic Identity)

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ABSTRACT

This study discusses the terminological systematization and graphic representation of material culture in heritage conservation. It is grounded in a historical framework beginning with the Athens Charter (1931). The research addresses the need for standardized methodologies in diagnosing deterioration processes. Its main objective is to propose structured approaches for damage mapping in cultural heritage.

The research adopts a theoretical and applied approach, combining historical analysis and a case study. It integrates contributions from Art History, Geology, Architecture, and Conservation Science, employing photogrammetric survey techniques and HBIM as an information modelling platform for the development and structuring of damage maps. The study proposes a standardized visual methodology for damage mapping based on the chromatic parameterization of damage using digital colour systems (RGB, Hex, and CMYK), enhancing precision, interoperability, and consistency in the graphic



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representation of stone heritage. *The Illustrated Glossary on Stone Deterioration Patterns* [1] was applied in a case study at the Church of Saint Francis of Assisi in Ouro Preto, Minas Gerais, Brazil. The research was conducted within a project funded by CNPq, titled "Risk Management Protocols for Cultural Heritage: Scientific Documentation and Monitoring Using Damage Maps through HBIM and 3D Reconstruction Techniques."

The study demonstrates the importance of controlled vocabularies for standardizing damage identification and documentation. The results contribute to improving precision and interoperability in cultural heritage diagnostics.



Cor	Hex (web)	RGB (tela)	CMYK (impressão)	Tipo
	#FFFF00	255, 255, 0	0%, 0%, 100%, 0%	Fratura
	#FFA500	255, 165, 0	0%, 33%, 81%, 0%	Fissura

Cor	Hex (web)	RGB (tela)	CMYK (impressão)	Tipo
	#FF0000	255, 0, 0	0%, 100%, 0%, 0%	Lavagem
	#8B0000	138, 0, 0	0%, 94%, 94%, 46%	Descamação

Cor	Hex (web)	RGB (tela)	CMYK (impressão)	Tipo
	#D8BFD8	218, 195, 255	14%, 20%, 0%, 0%	Adesão
	#800080	128, 0, 128	34%, 57%, 0%, 37%	Furo
	#800080	128, 0, 128	44%, 59%, 0%, 0%	Erosão
	#8A2BE2	138, 43, 255	58%, 79%, 0%, 0%	Lacuna

Cor	Hex (web)	RGB (tela)	CMYK (impressão)	Tipo
	#ADD8E6	173, 196, 222	30%, 17%, 0%, 7%	Depósito
	#4682B4	70, 130, 181	36%, 0%, 0%, 19%	Pátina
	#2F4F4F	47, 79, 79	62%, 32%, 0%, 55%	Sujeidade

Acknowledgements

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Virtual Reality as a new learning tool

Guerreiro, Luis¹

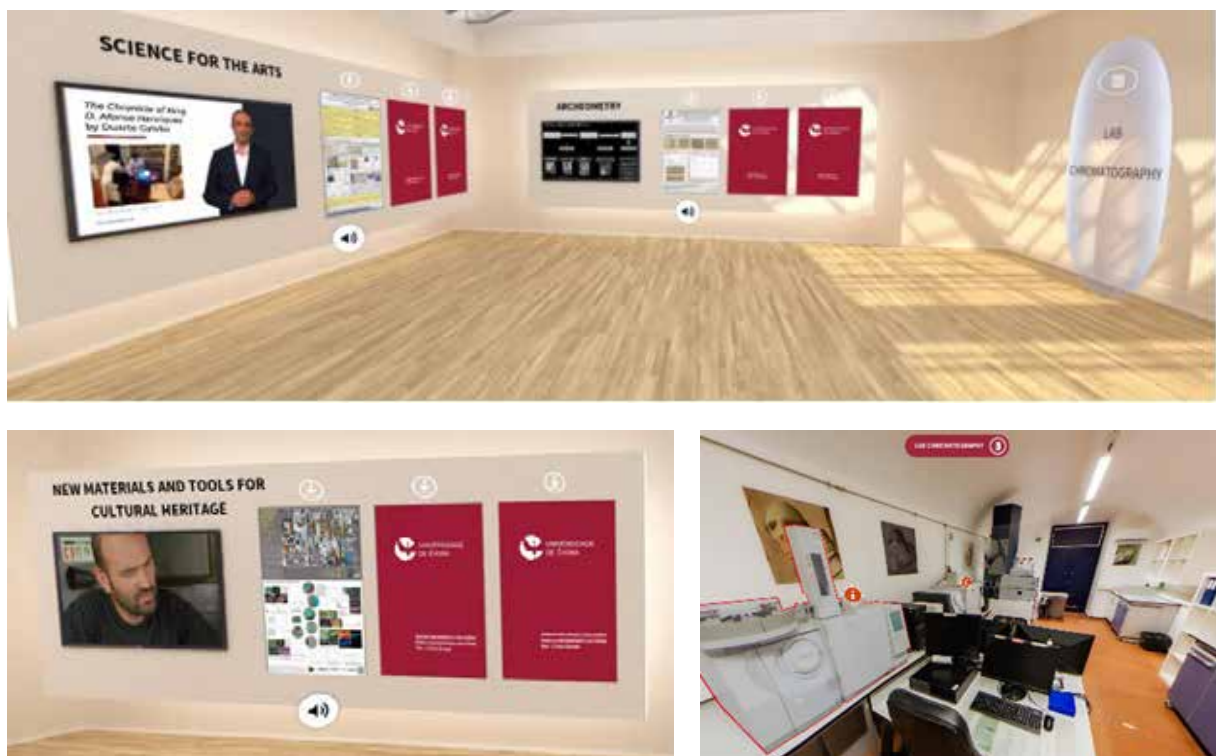
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ABSTRACT

The investigation performed was focused on creating Virtual Reality (VR) scenarios to be used as a new learning tool. Existing videos, digital files, images as well as online courses are possible to be integrated into VR experiences. Additionally it is possible to create virtual and augmented reality content to be used as new digital learning content. This includes creating new scenarios and multimedia content to be used in training sessions with 3D glasses as well as the creation of specific VR courses which can enable learning at a distance in an immersive environment. This methodology is easy to be applied in a classroom environment, as well as in a company or a short workshop for training purposes [1].

The Virtual Reality scenarios have been created using specific 3D Insta 360 Air and Insta X3 cameras with up to six wide lens cameras that can capture reality of a certain location in a 360° perspective. The camera has been placed on top of a tripod and 6 pictures using a time clock were taken. At a later stage, the images captured at the same spot, have been merged together using Insta360 Studio software. Special care

of certain parameters was necessary like the light brightness, the exact position of the camera namely (height and levelling), capture mode, distance between different shots. Two specific VR platforms (KuulaPro, GoHexaVR) were used in order to integrate the content and VR scenarios developed [2]. The Hercules Virtual LAB, included the creation of virtual scenarios merged with 360° real pictures taken at the Cultural Heritage LAB located in Evora. Existing and new digital content (audio, digital files, videos, videos 3D) was integrated in an attractive VR experience that can be assessed both through the web, or in an immersive way using 3D glasses. Moreover, videos were produced in a professional Multimedia Studio, having a 4K image resolution and voice recording. The Platform *GoHexaVR* was used to create the VR scenarios. Users can navigate through the virtual space of the different rooms of the laboratory, can choose the content they want to learn more about by clicking on the additional information sign (referred with the letter “i”), and having the possibility to download certain files that can be saved on a local drive. or seeing additional available 3D videos.



Acknowledgements

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Non-invasive Identification of Crocoite (PbCrO_4) in Medieval Wall Paintings of the Brandenburg Cathedral Cloister (Germany): Insights into the Use and Provenance of a Rare Pigment

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ABSTRACT

The late medieval wall paintings (c. 1440s) in the former library of the Brandenburg Cathedral Cloister (Germany), depicting the Liberal and Mechanical Arts, have been investigated since 2017 by an interdisciplinary team of art historians, conservators, and heritage scientists. [1] An *in situ* analytical campaign combining Raman spectroscopy and MA-XRF identified lead chromate (PbCrO_4) in the yellow remains of what is interpreted as the cover of a late medieval codex. Detailed evaluation unequivocally confirm that the yellow layer is original, suggesting the use of natural crocoite. Its identification represents both the first *in situ* non-invasive detection of natural crocoite and the first documented occurrence as pigment in Germany. How crocoite was used as a pigment in Europe, despite the limited availability of natural sources, remains an open question. Until recently, its presence in historical paintings has often been interpreted as non-



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original material associated with the use of synthetic lead chromate introduced in the 19th century. Only a few case studies [2-4] have confirmed the intentional use of crocoite as a pigment. This study aims to demonstrate how natural and synthetic lead chromates can be distinguished using Raman spectroscopy. Results from the investigation of mineralogical samples from Germany, Russia, Brazil and Tasmania, synthetic chrome yellow pigments as well as a micro-sample from Brandenburg are presented (Fig.1). LA-ICP-MS analysis were carried out to explore the possibility to highlight compositional differences among potential mining sources.

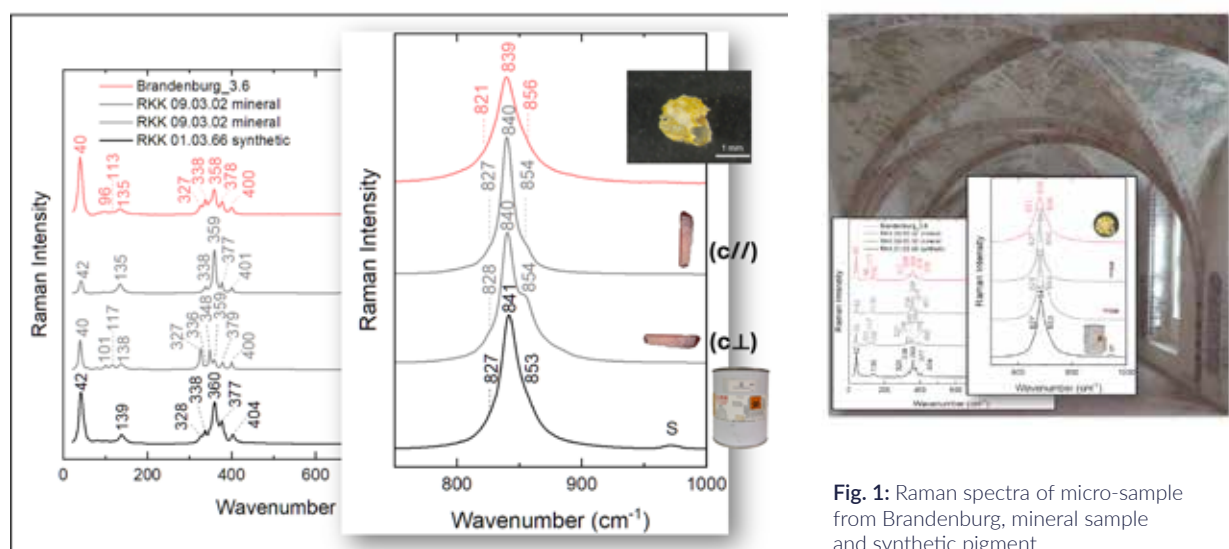


Fig. 1: Raman spectra of micro-sample from Brandenburg, mineral sample and synthetic pigment.

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Characterization of the gilding applied to the altars of the Cathedral of Funchal

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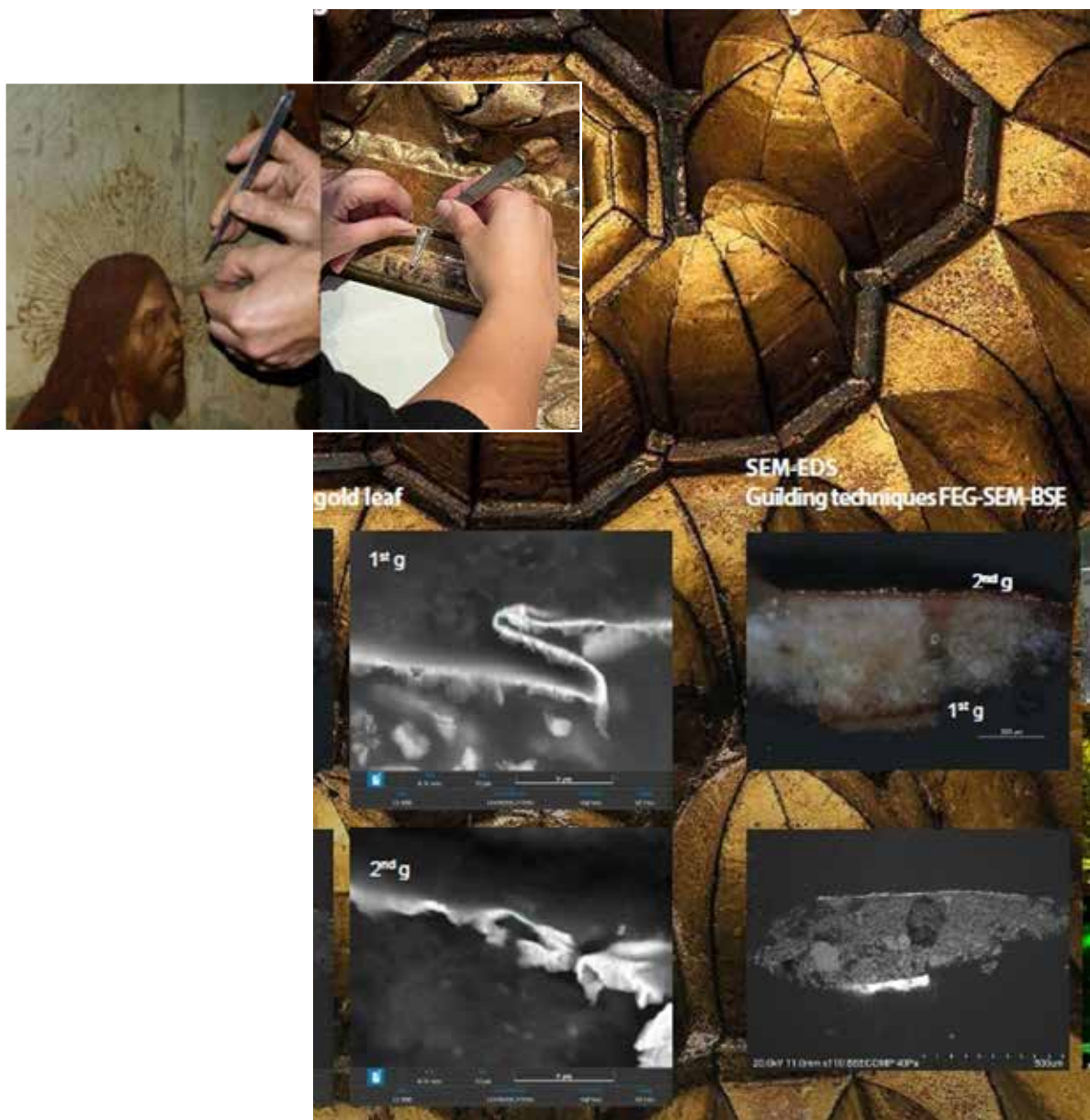
ABSTRACT

Since 2011, the polychrome decoration of the artworks in the Cathedral of Funchal, located on the island of Madeira, has been the focus of study, particularly emphasizing the application of gold on various surfaces, including wood and stone. Contemporary publications and the Cathedral's archives reference two major campaigns of restoration—one in the 16th century and another in the 17th century—that, while not specifically detailed, are known to have incurred significant financial costs. The main altar, the Mudejar ceiling, the side altars, and those in the transepts of the church, as well as the stone arches separating the central nave from the side aisles, have all been conserved and restored. The project “Studies on Gilding in the Cathedral of Funchal,” supported by the Portuguese infrastructure E-RIHS.pt, involved various examination



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and analysis methods. This scientific approach combined in-situ analysis using EDXRF of gilded decorations in the eight altars of the Funchal Cathedral with the analysis of micro-samples collected during the MoLab campaign, employing optical microscopy (OM/stratigraphic analysis), scanning electron microscopy-energy dispersive X-ray spectroscopy (SEM-EDS), Raman spectroscopy (μ -Raman), and micro-Fourier transform infrared spectroscopy (μ -FTIR). We now propose to present our findings, observing similarities and disparities in materials and techniques, characterizing the gilding process through images of stratigraphic cuts, and identifying the materials and techniques employed during different periods of execution of the artworks in the Cathedral of Funchal.



Methodology:

The categorization and study of the wood carving and gilding of Funchal Cathedral

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ABSTRACT

The construction of the Cathedral of Funchal was part of an urban planning initiative that accompanied the growth of the town, which was elevated to city status in 1508. The building was constructed between 1493 and 1517 and was consecrated on October 18 in honour of the Blessed Virgin Mary. In 1514, Pope Leo X (1513-1521) elevated it to Cathedral status, making it the seat of the largest diocese in the world, whose ecclesiastical jurisdiction encompassed the lands occupied or conquered by Portuguese kings. The transition from the late 15th century to the early 16th century was driven by the production and trade of sugar — referred to as “white gold” — which marked the golden age of the island's economy. Between April 2013 and November 2023, the Government of the Autonomous Region of Madeira, in collaboration with the Diocese of Funchal, the World Monuments Fund - Portugal, the José de Figueiredo



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Laboratory (reference institution of the Museums and Monuments of Portugal E.P.E.), the HERCULES Laboratory at the University of Évora, and the E-RHIS program, conducted various study and material identification campaigns using non-invasive methods. These campaigns focused on wood gilded decorations, employing various decorative techniques on integrated altar elements, such as the main altar, the choir stalls of the main chapel, the lateral altars, and the altars of the side chapels, as well as the ceiling in Mudéjar style (reflecting Islamic artistic tradition) and the polychrome stone arches of the nave of the Cathedral of Funchal. The set of methods, techniques, and procedures applied in the research and project aimed to achieve a specific objective: to create a “map” or action plan that would define the path to be taken in order to obtain reliable results in characterizing the gilding used across different periods and in various artistic elements of the Cathedral of Funchal. This proposal seeks to establish a deep understanding of the Cathedral's historical and artistic significance.

The Superartefact in Practice: Digital Technologies and Archaeology of Architecture in the Restoration of the Mariana Town Hall and Jail

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ABSTRACT

This paper presents a critical analysis of the restoration process of the *Mariana Town Hall and Jail (Casa de Câmara e Cadeia) de Mariana* (Brazil), grounded in the concept of the architectural “superartefact”, whose understanding requires the articulation between material reading techniques and interpretative frameworks derived from Archaeology of Architecture and tectonic theory. Within the restoration process initiated in 2021, the mandatory archaeological monitoring established by National Institute of Historic and Artistic Heritage (IPHAN) highlighted the need for rigorous documentation and methodologies compatible with interventions in protected heritage.

In this context, digital technologies were integrated with archaeological and architectural approaches to generate robust datasets supporting both interpretation and decision-making. The methodology combined laser scanning (point clouds and sections), systematic photographic documentation (including drone imagery), and technical drawings (AutoCAD/DWG), ensuring precise and standardized records. These



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data were integrated within a BIM environment, enabling the consolidation of geometric, material, and chronological information in a collaborative platform for analysis and interdisciplinary coordination.

The results show that integrating digital technologies with Archaeology of Architecture enhanced analytical rigor and decision-making. The combined use of point clouds, stratigraphic analysis, and photographic records enabled precise identification of constructive phases and transformations, supporting an evolutionary model that guided key conservation actions.

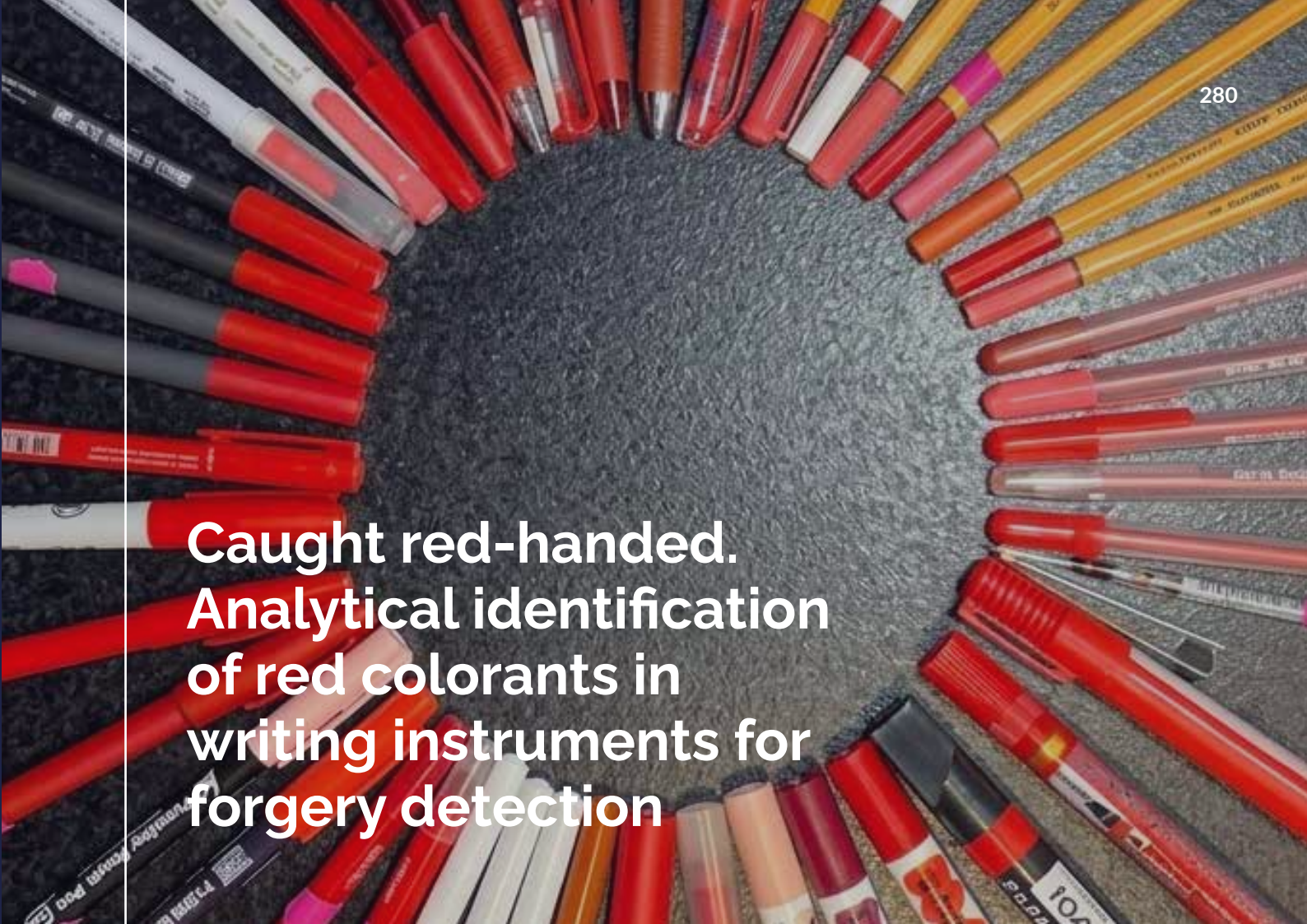
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Caught red-handed. Analytical identification of red colorants in writing instruments for forgery detection

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ABSTRACT

When it comes to document forgery, criminals are rarely careful enough not to leave a trace - but identifying the exact source of an alteration remains a challenge. The variety of pens on the writing instruments market makes tracking ink compositions difficult. Although blue and black inks are well-documented, red inks remain largely under-studied, despite being frequently used in signatures, official stamps, and document alterations [1,2]. The project explores the colorant composition of 49 red inks, focusing on building a complete multimethod reference database, combining invasive and non-invasive analytical methods. By screening a wide range of red writing materials (ballpoint, gel, fineline, and felt-tip pens), using thin-layer chromatography (TLC), liquid chromatography with UV-Vis and mass spectrometry (LC-UV-Vis-MS), and Raman spectroscopy, a reliable method to authenticate red inks was established. The resulting database offers a practical, straightforward tool for forensic document examiners and

art experts to spot modern forgeries quickly and accurately, ensuring that counterfeiters are, quite literally, caught red-handed.

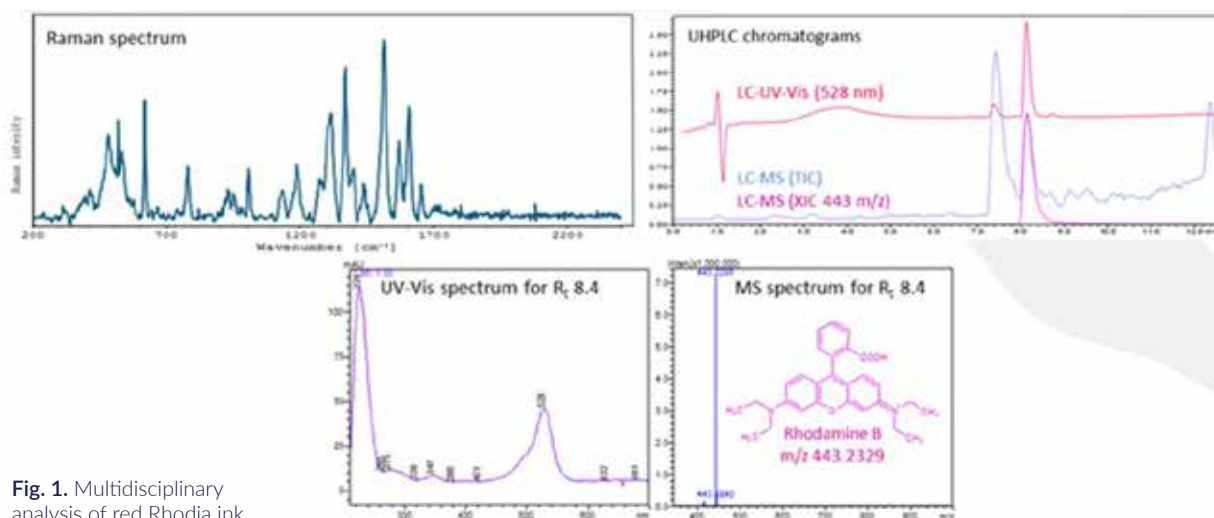


Fig. 1. Multidisciplinary
analysis of red Rhodia ink.



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Stratigraphic Unit-Based damage mapping in HBIM:

A scan-to-HBIM workflow for complex stone heritage

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ABSTRACT

Scientific documentation of built cultural heritage has increasingly incorporated methodologies capable of integrating geometric, material, and diagnostic data within interoperable digital environments. While Heritage Building Information Modelling (HBIM) addresses the limitations of traditional 2D damage mapping, accurately transposing complex material and stratigraphic pathologies into 3D spaces remains a significant technical challenge. This study presents a structured methodology for 3D damage mapping utilizing a Scan-to-HBIM workflow organized around the concept of Stratigraphic Units (SUs), applied to the highly complex soapstone medallion on the frontispiece of the Church of São Francisco de Assis in Ouro Preto, Brazil [1]. The methodological framework integrated geometric data acquisition via non-destructive techniques, specifically terrestrial and aerial photogrammetry, alongside mobile LiDAR

and structured light scanning to achieve sub-millimeter precision. To effectively manage the monument's formal complexity, the resultant 3D model was segmented into 14 independent SUs corresponding to the physical blocks of the sculpture, establishing a localized reference for damage analysis. The open-source software Blender, paired with the Bonsai add-on, were employed for mesh optimization (retopology), semantic segmentation, and advanced texture projection. Custom thematic layers and simplified identification forms, utilizing terminologies adapted from ICOMOS and UNI 11182 standards, were linked to each SU to map fissures, material loss, and biological colonization. The findings demonstrate the viability and efficiency of this SU-structured open-source workflow for documenting intricate stone ornaments, successfully organizing historical, geometric, and pathological information into interpretive digital layers. Ultimately, this research advances digital heritage practices by offering a systematic, low-cost diagnostic instrument with potential for Industry Foundation Classes (IFC) export, thereby facilitating preventative conservation, structural monitoring, and sustainable management of architectural heritage.



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Digital technologies applied to built heritage:

Church of São Francisco de Assis,
Ouro Preto – Brazil

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ABSTRACT

This study analyzes the role of digital technologies in the documentation and conservation of cultural heritage assets, using as a case study the Church of São Francisco de Assis in Ouro Preto, Brazil — the first Brazilian city recognized as a UNESCO World Heritage Site in 1980. The research highlights the integrated use of high-resolution photography, terrestrial photogrammetry, and aerial photogrammetry as diagnostic tools for Non-Intrusive Inspection (NII), demonstrating their ability to generate accurate three-dimensional models for damage mapping in accordance with the Historic Building Information Modelling (HBIM) methodology. The applied methodology shows how the combination of digital techniques enhances the understanding of the monument's physical condition and provides support for preventive conservation strategies. In addition to contributing to the field of conservation, the study reinforces the relevance of Ouro Preto as an international reference. The study concludes that



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the integration of photogrammetry and aerial photogrammetry using Remotely Piloted Aircraft (RPA), together with the HBIM methodology, constitutes consolidated and promising tools for 3D damage mapping applicable to the sustainable management of built heritage [1].



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