XIII Congresso Nazionale AIAr

Palermo, 12 – 14 febbraio 2025

Book of Abstracts

Università degli Studi di Palermo

Palazzo STERI, Piazza Marina, 60 Palermo

Assemblea Regionale Siciliana ARS, Piazza del Parlamento 1, Palermo

COMMITTEES

SCIENTIFIC COMMITTEE

Prof. Mauro Francesco La Russa

Prof. Alessandro Re

Dott. Simone Caglio

Prof.ssa Anna Galli

Prof.ssa Jeannette Jacqueline Lucejko

Dott.ssa Donata Magrini

Dott.ssa Rosa Celeste Ponterio

Prof.ssa Maria Luisa Saladino

Prof. Franco Palla

Prof. Luca Sineo

Prof.ssa Chiara Portale

Prof.ssa Monica de Cesare

Prof.ssa Delia Chillura Martino

Prof. Giuseppe Lazzara

Prof. Santino Orecchio

Prof. Giuseppe Montana

Prof. Bartolomeo Megna

Dott.ssa Patrizia Capizzi

Dott. Massimo Limoncelli

Dott. Francesco Armetta

Dott.ssa Luciana Randazzo

Dott.ssa Marcella Scalisi

ORGANIZING COMMITTEE

Prof. Fabrizio Lo Celso
Dott.ssa Paola Sconzo
Dott. ssa Lavinia Sole
Dott. Dario Giuffrida
Dott. ssa Martina Maria Calvino
Dott. Alessandro Lo Bianco
Dott. ssa Chiara Tuccio
Dott.ssa Elena Varotto
Dott. Carmelo Sanfilippo
Guglielmo Zanghì
Alice Filippone
Dott.ssa Federica Balistreri
Dott.ssa Federica Palumbo

Organizzato da

Associazione Italiana di Archeometria
Università degli Studi di Palermo

Con il patrocinio di

Università degli Studi di Palermo – Terza Missione
UNIPA Heritage – Sistema Museale di Ateneo
Società Chimica Italiana
PALM
Soprintendenza del Mare
Regione Siciliana – Assessorato dei Beni culturali e dell'Identità siciliana
ARS
Fondazione Federico II Palermo

Sponsor

Consiglio Nazionale delle Ricerche – IPCF
Società Chimica Italiana – Divisione di Chimica Fisica
AAI – Associazione Antropologica Italiana
Associazione Amici Parco Archeologico Marsala
Fondazione Sebastiano Tusa
stArt-test
Crisel Instruments
fkv – Passione Idee Soluzioni
Morettino
zicaffè
Cantine Pellegrino 1880
Saponificio Zimmitti dal 1875
EPO – Estratti Piante Officinali
Ceramiche Artistiche De Pasquale

Hotel

camplus Palermo
B&B Hotels
la Terrazza sul Centro
Hotel Elite
Giove Turismo Group

PROGRAMMA

Mercoledì 12 febbraio
Complesso Monumentale dello Steri, Sala Magna

9:00	9:45	10:00	10:15
Registrazione dei Partecipanti	Saluti e apertura lavori *Chair: Prof. Mauro F. La Russa, Prof.ssa Maria Luisa Saladino*		I1 - *Premio Mario Milazzo* Prof. ssa Maria Perla Colombini *Archaeological organic residues: molecular profiles and biomarkers to provide a valuable insight of the past times*

10:45	Pausa caffè alla Gancia & Sessione Poster

Chair: Prof.ssa Jannette Jacqueline Lucejko, Prof. Franco Palla

11:15	11:30	11:45	12:00	12:15	12:30
O1 - Benedetto Pizzo - *The state of preservation of the ancient Roman ships of Fiumicino sixty years after their discovery*	O2-Maria Emanuela Mascaro - *Lying on the seabed: investigation of post-depositional phases in underwater ceramics*	O3- Ludovica Pia Cesareo - *Decoding climate impact on metal underwater artifacts: initial experiments and future directions*	O4- Justin Vernet - *INSU●LAB - An open in-situ laboratory for dissemination during the annual underwater survey campaign on the submersed site of the Battle of Egadi*	O5- Rosarosa Manca - *Multi-analytical study of mercury contamination in the botanical samples of the Herbarium Centrale Italicum*	I2 - *Premio Sebastiano Tusa,* Dott.ssa Patrizia Valeria Li Vigni *Protection and promotion of the material and non-material heritage*

13:00	Pranzo alla Gancia & Sessione Poster

Chair: Dott.ssa Rosina C. Ponterio, Prof.ssa Patrizia Capizzi

14:30	15:00	15:30	15:45	16:00	16:15
I3 - Prof. Manfredi Leone *Il sistema museale dell'Università di Palermo*	Minitalk Sponsor *EPO/Bruker/Metrohm*	O6-Raffaele Martorana - *Geophysical and Archaeological Insights into the Hidden Past of the Annunziata Garden in Cammarata*	O7 - Eva Luna Ravan - *Egyptian Blue: variability in production technology, material provenance and deterioration*	O8- Dario Giuffrida - *The Addaura Caves in Palermo: new challenges for the study, conservation, and public access*	O9- Roberta Iannaccone - *Unveiling the Bikini Venus from MANN. A multimodal approach to characterise the residual polychromy*

16:30	Pausa caffè alla Gancia & Sessione Poster
17:00	Visita guidata della Chiesa della Gancia e di S. Anna La Misericordia
19:00	Aperitivo di Benvenuto a Palazzo Bonocore

PROGRAMMA

Giovedì 13 febbraio Complesso Monumentale dello Steri							
Chair: Dott. Simone Caglio, Prof. Giuseppe Montana							
	9:00	9:30	9:45	10:00	10:15	10:30	10:45
SALA MAGNA	I4-Prof. Barbara Lydzba-Kopczynska - *Non-destructive and chemometric analysis of the provenance of fossil amber*	O10-Francesca Alberghina - *Mary Magdalene in ecstasy: revealing the historical-scientific results of an unpublished replica by Artemisia Gentileschi*	O11- Chiara Delledonne - *Discriminating superimposed historical inks exploiting a non-invasive strategy based on a novel multispectral approach*	O12-Simi Maria Emilia Mangani - *Archaeometric Analysis of Cu-Alloys in 1st Millennium BCE Northern Apennines: Exploring Etruscan Settlements and Resource Use*	O13 - Mauro Veronese - *Spectroscopic methods to disclose manipulations in Geoheritage*	O14 - Simone Campanelli - *A synergy between archaeological studies and experimental archaeology: the case of a prehistoric bronze dagger from Ripatransone*	O15 - Irene Ferrara - *Development of Smart Procedures for Automated Analysis and Data Integration in the Study of Historical Polychrome Surfaces*
Chair: Prof.ssa Anna Galli, Dott.ssa Fernanda Prestileo							
CHIESA S. ANTONINO		O28-Carmine Lubritto - *The stable isotope analysis to investigate the "way of life" of ancient community of Pompei*	O29-Silvia Vettori - *An EPR study of the marbles from ancient quarries to archaeological site of Hierapolis in Phrygia (Turkey): A contribution to the provenance assessment of materials with close relationships*	O30-Rosaria Galvagno - *Dating the Terme della Rotonda: Addressing Challenges in Stratified and Reused Materials Using SG-OSL Techniques*	O31-Marta Magalini - *Micro-Computed Tomography and micro-Laser Ablation to assist Ion Beam Analysis in lapis lazuli provenance investigation: methodology and application to beads from Ur (Mesopotamia, 3rd millennium BCE)*	O32 -Celestino Grifa - *The study of Pompeian pigments. A glimpse into ancient Roman colouring materials*	O33 - Sara Calandra – 2 abstract *Absolute and Relative Dating Challenges of Mortars from Public Buildings in Pompeii*

PROGRAMMA

11:00	Pausa caffè alla Gancia & Sessione Poster					
Giovedì 13 febbraio Complesso Monumentale dello Steri						
	11:30	11:45	12:00	12:15	12:30	12:45
	Chair: Prof. Celestino Grifa, Dott. Francesco Armetta					
SALA MAGNA	O16 -Daniel Bacerra Fernàndez María Luisa Loza Azuaga - *An approach to the spolia of Classical and Late Antiquity in the monumental complex of the "Real Alacázar" of Seville*	O17 - Marta Porcaro - *Bronze Anthropomorphic Statuette between Sardinia and Etruria: Comparison, Provenance and Trade Networks in the Iron Age Mediterranean*	O18 – Francesca Modugno - *Mass Spectrometry Techniques for Street Art Preservation: The SuPerStAr Project*	O19 - Sveva Longo - *Combined Macro-XRF and X-ray Radiography analysis of Renaissance masterpieces*	O20 - Giacomo Fiocco - *Comparative Ink Analysis of Alessandro Manzoni's Manuscripts through p-XRF and PCA*	O21 - Paola Di Leo - *Spectroscopic imaging by micro XRF: a non-destructive methodology to unravel ancient artifact technology and raw materials circulation*
	Chair: Prof. Giuseppe Lazzara, Prof.ssa Cristina Belfiore					
CHIESA S. ANTONINO	O34- Valeria Daniele - *A sustainable and promising approach based on the use of magnesium hydroxide*	O35- Martina Cirone - *Biopolymeric membranes: eco-friendly solutions to preserve the Baroque stone heritage of Val di Noto in south-eastern Sicily (Italy)*	O36-Eleonora Verni - *Sustainable Hydrogels for Cleaning Procedures: Incorporating Tannins into in-situ-Borax Crosslinked KGM Polymers*	O37-Maria Rita Caruso - *New oil in water bio-hybrid system stabilised by nanomaterials: Cellulose Nanocrystals*	O38- Gabriella Di Carlo - *Sustainable protective coatings for metal objects: innovative materials from waste and renewable sources*	O39-Sara Fiorentino - *Fostering resilience and sustainable territorial development through cultural heritage: lesson learnt from citizen engagement initiatives within RESTART and SIRIUS projects*
13:00	Pranzo alla Gancia & Sessione Poster					

	14:30	15:00	15:15	15:30
	Chair: Prof.ssa Monica Gulmini, Prof. Fabrizio Lo Celso			
SALA MAGNA	I5 - Dott. Orazio Spadaro - *The synergy between tradition, innovation and sustainability for the restoration of the historical heritage, with a special attention to circular economy*	O22 - Stefania Porcu - *Validation of 3D Fluorescence Mapping as a Non-Destructive Technique for the Study of Pigments Degradation in Cultural Heritage*	O23 - Ludovico Geminiani - *Evaluating The Light-Induced Damage Of Dyed Silk Textiles*	O24 - Francesca Sabatini - *Modelling clay materials in art: analytical approaches for disclosing their chemical composition and thermal properties*

PROGRAMMA

<table>
<tr><td colspan="7">Chair: Dott.ssa Gabriella Di Carlo, Prof.ssa Delia F. Chillura Martino</td></tr>
<tr><td></td><td>14:30</td><td colspan="2">15:00</td><td colspan="2">15:15</td><td>15:30</td></tr>
<tr><td>CHIESA S. ANTONINO</td><td></td><td colspan="2">O40- Antonella Tumminello - The restoration of the polychrome wooden Crucifix of the Chapel of the SS. Crocifisso of the Church of Sant'Anna la Misericordia in Palermo (Sicily)</td><td colspan="2">O41-Maria Rosalia Carotenuto - What factors can affect lead corrosion processes in indoor museum environments? Case studies in historical collections at the University of Palermo</td><td>O42-Marina Vieri de Mitri Fernandez - Preserving color and printed materiality: impact of low-temperature plasma on modern inks and pigments during disinfection treatment of paper-based artifacts</td></tr>
<tr><td>15:45</td><td colspan="6">Pausa caffè alla Gancia & Sessione Poster</td></tr>
<tr><td></td><td colspan="2">16:15</td><td colspan="2">16:30</td><td colspan="2">16:45</td></tr>
<tr><td></td><td colspan="6">Chair: Dott.ssa Francesca Alberghina, Dott. Giacomo Fiocco</td></tr>
<tr><td>SALA MAGNA</td><td colspan="2">O25 - Diletta Paghi - Vis-NIR hyperspectral imaging spectroscopy of Italian maiolica colours from Montelupo Fiorentino artifacts (14th-18th century)</td><td colspan="2">O26 - Anna Rosa Mangone - Technological connections among Sicily, Apulia, and the Tyrrhenian coast: human mobility and knowledge transmission from an archaeometric viewpoint</td><td colspan="2">O27 - Jacopo Orsilli - CdS1-xSex pigments: multidisciplinary study on the materials of the XIX-XX c. painters</td></tr>
<tr><td></td><td colspan="6">Chair: Prof. Carmine Lubritto, Prof. Bartolomeo Megna</td></tr>
<tr><td>CHIESA S. ANTONINO</td><td colspan="2">O43-Laura Guidorzi - Preventive conservation in action: microclimatic monitoring of heritage sites to mitigate indoor and outdoor climate-induced risks</td><td colspan="2">O44-Laura Medeghini - BIO-DUST: a green product for 3D printing</td><td colspan="2">O45-Francesca Porpora - Reversible adsorbent smart materials for the recovery of starch grains from stone tools</td></tr>
<tr><td>17:00-19:00</td><td colspan="6">Assemblea dei Soci e Premiazioni AIAR</td></tr>
<tr><td>19:00-20:00</td><td colspan="6">Visita guidata Monastero di S. Caterina</td></tr>
<tr><td>20:00</td><td colspan="6">Cena Sociale Monastero di S. Caterina</td></tr>
</table>

PROGRAMMA

Venerdì 14 febbraio
Sala Piersanti Mattarella, Assemblea Regionale Siciliana

Chair: Prof. Donata Magrini, Dott.ssa Lavinia Sole

9:00	9:30	9:45	10:00	10:15	10:30
I6 -Tenente Colonnello Gianluigi Marmora - *Il Comando Carabinieri per la Tutela del Patrimonio Culturale*	O46 -Antonella Privitera - *Authentication, attribution, provenance: the contribution of the diagnostics to the forensic investigations*	O47-Francesca Tansella - *CT on wind musical instruments: a way to bring them out of silence, preserving their state of conservation*	O48 - Leila Es Sebar - *Multispectral imaging investigation of Papal Bulls from the Santuario della Beata Vergine di Saronno*	O49-Nicole Manfredda - *Unveiling Workshop Practices: A Technical Study of Wooden Offering Bearer Sculptures from the Tomb of Minhotep*	Minitalk Sponsor *Bruker/Metrohm*

11:00	Pausa caffè

Chair: Prof. Luca Sineo, Prof. Alessandro Re

11:30	11:45	12:00	12:15	12:30
O50 - Gerlando Vita - *Chemical characterization of ochre from stains on Epigravettian tools and shells found in the M Trench in the San Teodoro cave (Acquedolci, Messina, Italy)*	O51 -Noemi Mantile - *From the Archaeological Context to the Laboratory: Challenges and Informative Potential of Stable Isotope Analysis of Organic Remains*	O52 - Josiah Olah - *Identification and characterization of ancient quarry sites in the Euganean Hills (Padova, Italy) through high-resolution UAV LiDAR measurements*	O53-Antonio Amatore - *Integrating Edge Computing and Environmental Sensors for Proactive Cultural Heritage Conservation*	O54-Sara Capriotti - *Deep Learning for ancient ceramic classification: Saliency maps as a tool for models interpretability*

12:45	Premiazioni e Chiusura
14:30	Visita guidata Cappella Palatina

Conoscenza e valorizzazione del Patrimonio Sommerso
Caratterizzazione e Diagnostica
Digitalizzazione 3D e nuovi linguaggi della rappresentazione del patrimonio culturale
Provenienza e datazione
Materiali ecosostenibili e nanotecnologie per i beni culturali
Conservazione preventiva e restauro
Intelligenza artificiale e applicazione nei BBCC
Archeometria dei resti antropologici

Indice

I1 - Archaeological organic residues: molecular profiles and biomarkers to provide a valuable insight of the past times 7

I2 - Protection and promotion of the material and non-material heritage 8

I3 - Il Sistema museale dell'Universtà di Palermo 9

I4 - The synergy between tradition, innovation and sustainability for the restoration of the historical heritage, with a special attention to circular economy 10

I5 - Il Comando Carabinieri per la Tutela del Patrimonio Culturale 11

I6 - Non-destructive and chemometric analysis of the provenance of fossil amber resins 12

O1 - The state of preservation of the ancient Roman ships of Fiumicino sixty years after their discovery 13

O2 - Lying on the seabed: investigation of post-depositional phases in underwater ceramics. 14

O3 - Decoding climate impact on metal underwater artifacts: initial experiments and future directions 15

O4 - INSU●LAB - An open *in-situ* laboratory for dissemination during the annual underwater survey campaign on the submersed site of the Battle of Egadi (Favignana, Sicilia) 17

O5 - Multi-analytical study of mercury contamination in the botanical samples of the Herbarium Centrale Italicum 18

O6 - Geophysical and Archaeological Insights into the Hidden Past of the Annunziata Garden in Cammarata (Sicily) 19

O7 - Egyptian Blue: variability in production technology, material provenance and deterioration 20

O8 - The Addaura Caves in Palermo: new challenges for the study, conservation, and public access 21

O9 - Unveiling the Bikini Venus from MANN. 22

A multimodal approach to characterise the residual polychromy 22

O10 - *Mary Magdalene in ecstasy*: revealing the historical-scientific results of an unpublished *replica* by Artemisia Gentileschi 23

O11 - Discriminating superimposed historical inks exploiting a non-invasive strategy based on a novel multispectral approach 24

O12 - Archaeometric Analysis of Cu-Alloys in 1st Millennium BCE Northern Apennines: Exploring Etruscan Settlements and Resource Use 25

O13 - Spectroscopic methods to disclose manipulations in Geoheritage 27

O14 - A synergy between archaeological studies and experimental archaeology: the case of a prehistoric bronze dagger from Ripatransone (Ap-Italy) 29

O15 - Development of Smart Procedures for Automated Analysis and Data Integration in the Study of Historical Polychrome Surfaces 31

O16 - An approach to the *spolia* of Classical and Late Antiquity in the monumental complex of the "Real Alacázar" of Seville 32

O17 - Bronze Anthropomorphic Statuette between Sardinia and Etruria: Comparison, Provenance and Trade Networks in the Iron Age Mediterranean 34

O18 - Mass Spectrometry Techniques for Street Art Preservation: The SuPerStAr Project 35

O19 - Combined Macro-XRF and X-ray Radiography analysis of Renaissance masterpieces 36

O20 - Comparative Ink Analysis of Alessandro Manzoni's Manuscripts through p-XRF and PCA 37

O21 - Spectroscopic imaging by micro XRF: a non-destructive methodology to unravel ancient artifact technology and raw materials circulation 38

O22 - Validation of 3D Fluorescence Mapping as a Non-Destructive Technique for the Study of Pigments Degradation in Cultural Heritage 39

O23 - Evaluating The Light-Induced Damage Of Dyed Silk Textiles 41

O24 - Modelling clay materials in art: analytical approaches for disclosing their chemical composition and thermal properties 43

O25 - Vis-NIR hyperspectral imaging spectroscopy of Italian maiolica colours from Montelupo Fiorentino artifacts (14th-18th century) 44

O26 - Technological connections among Sicily, Apulia, and the Tyrrhenian coast: human mobility and knowledge transmission from an archaeometric viewpoint 45

O27 - $CdS_{1-x}Se_x$ pigments: multidisciplinary study on the materials of the XIX-XX c. painters 46

O28 - The stable isotope analysis to investigate the "way of life" of ancient community of Pompei 47

O29 - An EPR study of the marbles from ancient quarries to archaeological site of Hierapolis in Phrygia (Turkey): A contribution to the provenance assessment of materials with close relationships 48

O30 - Dating the Terme della Rotonda: Addressing Challenges in Stratified and Reused Materials Using SG-OSL Techniques 49

O31 - Micro-Computed Tomography and micro-Laser Ablation to assist Ion Beam Analysis in lapis lazuli provenance investigation: methodology and application to beads from Ur (Mesopotamia, 3rd millennium BCE) 51

O32 - The study of Pompeian pigments. A glimpse into ancient Roman colouring materials 52

O33 - Absolute and Relative Dating Challenges of Mortars from Public Buildings in Pompeii 53

O34 - A sustainable and promising approach based on the use of magnesium hydroxide nanoparticles dispersed in aqueous medium for wood deacidification treatments 54

O35 - Biopolymeric membranes: eco-friendly solutions to preserve the Baroque stone heritage of Val di Noto in south-eastern Sicily (Italy) 56

O36 - Sustainable Hydrogels for Cleaning Procedures: Incorporating Tannins into *in-situ*-Borax Crosslinked KGM Polymers 57

O37 - New oil in water bio-hybrid system stabilised by nanomaterials: Cellulose Nanocrystals 58

O38 - Sustainable protective coatings for metal objects: innovative materials from waste and renewable sources 59

O39 - Fostering resilience and sustainable territorial development through cultural heritage: lesson learnt from citizen engagement initiatives within RESTART and SIRIUS projects 60

O40 - The restoration of the polychrome wooden Crucifix of the Chapel of the *SS. Crocifisso* of the Church of *Sant'Anna la Misericordia* in Palermo (Sicily) 61

O41 - What factors can affect lead corrosion processes in indoor museum environments? Case studies in historical collections at the University of Palermo 62

O42 - Preserving color and printed materiality: impact of low-temperature plasma on modern inks and pigments during disinfection treatment of paper-based artifacts 63

O43 - Preventive conservation in action: microclimatic monitoring of heritage sites to mitigate indoor and outdoor climate-induced risks 64

O44 - BIO-DUST: a green product for 3D printing 65

O45 - Reversible adsorbent smart materials for the recovery of starch grains from stone tools 66

O46 - Authentication, attribution, provenance: the contribution of the diagnostics to the forensic investigations 67

O47 - CT on wind musical instruments: a way to bring them out of silence, preserving their state of conservation 68

O48 - Multispectral imaging investigation of Papal Bulls from the Santuario della Beata Vergine di Saronno 69

O49 - Unveiling Workshop Practices: A Technical Study of Wooden Offering Bearer Sculptures from the Tomb of Minhotep 70

O50 - Chemical characterization of ochre from stains on Epigravettian tools and shells found in the M Trench in the San Teodoro cave (Acquedolci, Messina, Italy) 71

O51 - From the Archaeological Context to the Laboratory: Challenges and Informative Potential of Stable Isotope Analysis of Organic Remains 72

O52 - Identification and characterization of ancient quarry sites in the Euganean Hills (Padova, Italy) through high-resolution UAV LiDAR measurements 73

O53 - Integrating Edge Computing and Environmental Sensors for Proactive Cultural Heritage Conservation 74

O54 - Deep Learning for ancient ceramic classification: Saliency maps as a tool for models interpretability 75

P1 - The roasting of cereals and the preparation of whole-grain bread without yeast at the settlement of the Neolithic Late/ Final Neolithic of Valle di Maddaloni (Campania-Southern Italy) 76

P2 - Application of non-invasive XRF analysis to the study of osteo-archaeological remains 79

P3 - Coins from the Viminacium mint: a preliminary study on composition and alterations 80

P4 - Rock cores characterization to prevent water seepage in northern section of Beishan Buddha Bay of Dazu Rock Carvings (China) 81

P5 - Archaeological Excavation of the *Viale degli Zampilli* in the Medici Park of Pratolino (Vaglia, Florence): Preliminary Analyses Supporting Restoration and Refunctionalization 82

P6 - Tortorici

P7 - Assessing the impact of sampling strategies on archaeological stone tools and residues 84

P8 - A multidisciplinary approach to the evaluation of the impact of the marine-coastal environment on ancient Calabrian watchtowers (Southern Italy): preliminary data 85

P9 - Hadrianic concrete, a Roman archetype. Archaeometric characterization of construction materials from the Mausoleum of Hadrian, Rome 86

P10 - Analisi Minero-Petrografiche Con Finalità Archeometriche Dei Reperti Ceramici Medievali Provenienti Dallo Scavo Di Corso Tuköry A Palermo 87

P11 - The PITCH project: a laboratory-based phase contrast X-ray imaging system for Cultural Heritage analysis 88

P12 - Bridges still standing along the Via Appia: building materials and state of conservation 89

P13 - An Egyptian mummy of the Roman period with a painted shroud and gilded cartonnage: a multi-analytical study 90

P14 - Handheld digital microscopy and image analysis for examining the surface texture of patinated bronzes 91

P15 - Supply and use of limestones in the Roman architecture of the *X Regio – Venetia et Histria* (N-E Italy): methods and challenges in provenance identification 92

P16 - Novel X-ray imaging techniques for the noninvasive investigation of European Heritage within MOLAB platform of E-RIHS 93

P17 - SEM-EDS and µ-Raman characterisation of the contents of the medieval inkwell of Palazzo Paradiso (Ferrara, Italy) 94

P18 - Archaeometric study of fine glazed wares from Pisa (13^{th}-14^{th} century) 95

P19 - The Statue of Ramesses II (Cat. 1380) at Museo Egizio, Turin: a 3D Imaging and Raman Spectroscopy Study 96

P20 - Preliminary analysis of metal artefacts from the archaeological site of Spina (VI-III sec. a.C.) 97

P21 - PERSPECTIVE: a project dedicated to the development of innovative analytical strategies for the knowledge and preventive conservation of plastic heritage 98

P22 - Identifying textile fibres in Classical and Hellenistic Sicily: an archaeometry study of mineralised textile remains from burials 99

P23 - Microorganisms Assisted Formation of Calcium Oxalate on Cultural Heritage Materials 100

P24 - Thermographic Diagnostics Supporting the Restoration of the Frescoes in the Abbey of San Michele Arcangelo in Badia a Passignano (Florence) 102

P25 - Study of golden filigree manufacturing technique from the Chiaravalle Cross by means of high-resolution neutron tomography 103

P26 - Exploring biodeterioration through high throughput sequencing: a case study at Santa Maria della Grotta (Trapani, Italy) 104

P27 - *Madonna Odigitria fresco* from the Palatine Chapel of the Royal Palace of Palermo (Sicily): restoration and analysis updates 105

P28 - Multi-analytical approach to the study of the glyptic collection of the Musei di Arte Antica of the Municipality of Ferrara (Italy) 106

P29 - Highlighting the lost: hyperspectral imaging of frescoes in the House of the Ancient Hunt (Pompeii) 107

P30 - OCT measurements in cleaning treatments of ancient paintings 108

P31 - Quantitative Analysis for Elemental Characterization Using Muonic Atom X-Ray Emission Spectroscopy (µXES) 109

P32 - Ultrasonic Tomography of the Diana the Huntress statue (Salinas Museum, Palermo) 110

P33 - Multianalytical investigation on a miniature *phiale* 111

P34 - A multi-analytical study of Chinese bronzes and gilded bronzes from the Museo delle Civiltà 112

P35 - A precious official liturgical book of XVII century: ink, pictorial materials and artistic technique characterization 113

P36 - Beyond the Golden Glow: Analytical Study of Mural Paintings and Stuccoes in the Palatine Chapel of S. Anna 114

P37 - Insights into the wall painting pigments of the *Domus di Arianna* in Pompeii. Progress in the framework of the Arianna PRIN project 115

P38 - A multidisciplinary approach to an archaeological issue 117

P39 - Multi-technique approach for the study of the carbonised papyri of Herculaneum 118

P40 - Calcination of corals in ancient Sardinia. Early evidence from the Phoenician necropolis of Nora. 120

P41 - Archaeometric Analysis on Vegetal Inclusions in the Mortar Samples of Roman Aquileia 121

P42 - A rediscovery of Macedonian artists' rich palette: the in-situ investigation of the Hunt frieze of the tomb of Philip II at Aigai (Vergina, Greece) 122

P43 - Archaeometric study Etruscan Coarse Ware from Northern Apennines (6^{th}-4^{th} century BCE): Preliminary Results. 123

P44 - Preserving Paper-Based Cultural Heritage: Non-Invasive Techniques and Protocols for Assessing and Restoring flooded Ancient Books 125

P45 - The Archaic Shipwreck of Giglio-Campese: An archaeometric contribution to the study of the geomaterials in its cargo 127

P46 - Diagnostic analysis of the stucco fragments from the Hellenistic-Roman period at Lilybaeum. The domus of Via delle Ninfe and Via Diaz-Via Sibilla 128

P47 - Optical profilometry applied to quantitative use-wear analysis of percussive stone tools from Kenya 129

P48 - Stone decay in coastal cultural heritage: preliminary investigation of sea salt weathering at Mykonos Castle (Greece) 130

P49 - A preliminary investigation of Perugino's Florentine wall paintings: the *Last Supper* at the Cenacolo di Fuligno and the *Crucifixion* at Santa Maria Maddalena dei Pazzi 131

P50 - PERCEIVE Project. New technologies to preserve ancient colours of cultural heritage and digital art. 132

P51 - Analytical methods for the authentication of early 20th-century paintings 133

The PRIN Project MY-FORTLANDS: MobilitY of goods, men and knowledge in the FORTified LANDscape Scenario of southern Italy (Basilicata and north-central Apulia) in the Middle Age. 134

P53 - SENSORIA: Redefining Cultural Heritage Through Innovation and Accessibility 135

P54 - Public Engagement and Empowerment in Heritage 137

P55 - Promoting Sustainable Management and Enhancement of Cultural Heritage in Coastal Areas: Insights from the TECTONIC Project 138

P56 - Preservation of Submerged Cultural Heritage: insights from the SOUTH Project and preliminary results 139

P57 - Ànchors of the Soprintendenza del Mare-Regione Siciliana. The value of a collection that is too often underestimated 140

P58 - A non-invasive methodological approach to identify wreck wood chemical elements contamination 141

P59 - Crystallinity Index to Assess Thermal Alteration of Minerals in Manure: A Case Study from *Riparo Gaban* 142

P60 - How Melamine-Formaldehyde Treatment Changes Waterlogged Archaeological Wood: Challenges for Preservation 144

P61 - Decoding Molecular Degradation in Ancient Waterlogged Wood: Insights from FTIR and Pyrolysis-GC-MS Analysis 145

P62 - Quantifying Stone Ornament Deterioration for Heritage Preservation 146

P63 - Conservation methods for 19th century plaster replicas: understanding gypsum compositions and protective treatments 147

P64 - Evaluation of indoor and outdoor microclimatic conditions using indexes: a case study in an ancient church 149

P65 - A historical architectural heritage to be ride for: Sicily's abandoned railway lines and their annexes. 150

P66 - Diagnostic investigations on corbles of Pietra Serena sandstone 151

P67 - New Application Scenarios of Reaction Path Modelling for the Study of Weathering Processes in the Field of Cultural Heritage: Preliminary Presentation of a Novel Research Project and first data 152

P68 - Porosimetry inspection of Mesoporous Molecular Sieves combined with Tea Tree Essential Oil for Microbial Reduction in Cultural Heritage Spaces 153

P69 - An integrated approach to the conservation of two Mariano Rossi paintings (18th) in Palazzo Alliata di Villafranca, Palermo 154

P70 - Microscopic techniques and analytical approach to characterize constitutive materials and techniques of Mariano Rossi paintings 155

P71 - A Sustainable Approach to Self-Healing Mortars 156

P72 - Biotechnological restoration potential of the bacterial communities of three distinctively damaged mosaics from the coastal Calabrian area. 157

P73 - The Challenge of Archaeological Wood Restoration: Traditional Methods and Scientific Innovations 158

P74 - Documenting ancient stone quarries: a multi-scale geometric survey for the study of the extraction site of Le Grotte (Populonia, Italy) 159

P75 - 3D scanning, microscopic and radiographic analysis to study the Ripatransone treasure: the largest European hoard of daggers from the ancient Bronze Age. 161

P76 - First results on 3D documentation of the architectural/archeological complex of the Church of San Nicolò Regale in Mazara del Vallo (Italy) 162

P77 - Terravecchia of Caltavuturo: Digital Techniques from Excavation Documentation to University Teaching 163

P78 - Vanished Tarquinia: 3D Virtualization and a Virtual Museum Experience 164

P79 - In situ physico-chemical investigations on instruments for electrical measurements of the Politecnico di Torino scientific collections 165

P80 - A Neuro-Symbolic Approach for Archaeoceramological Analysis 166

P81 - The European Project "CheminNova": protecting cultural heritage in a changing climate by remote and non-invasive monitoring 167

P82 - X-Ray Fluorescence and Machine Learning to reveals the origin of bronze arrowheads 168

P83 - MML-ARCH Project: Machine Learning for prediction in archaeometry 169

P84 - Nanoscience and Conservation: New Strategies for Cultural Preservation 170

P85 - Geopolymers: An Innovative Resource for Cultural Heritage Conservation 171

P87 - Biohybrid Xerogels Incorporating Halloysite Nanoclay for Sustainable Removal of Pollutants 173

P88 - Sustainable conservation of bronzes by supramolecular silica nanoparticles releasing corrosion inhibitors 174

P89 - Sustainable materials for the protection of steel in concrete heritage: green corrosion inhibitors and smart nanocarriers 176

P90 - Sustainable sensing for Cultural Heritage: development of SERS-active devices based on cellulose and Ag nanostructured surfaces (SAMOTHRACE project) 177

P91 - PVA-Borax Hydrogels in Restoration 178

P92 - Innovation, sustainability and compatibility for on-site consolidation of natural stones and historic mortars by new nanolimes in water 179

P93 - Eco-sustainable nanostructured materials for the protection of bronze artworks: a surface science perspective 180

P94 - Potential use of agricultural wastes to develop sustainable Hydraulic Lime Mortars for the Conservation of Cultural Heritage 181

P95 - Innovative coatings and Non-destructive Techniques protocols for the investigation and the protection of marine outdoor bronzes: first insights of the MEDUSA project. 182

P96 - Refining Ceramic Rehydroxylation Dating Through Controlled Preheating and Hydroxyl Content Analysis 183

P97 - The Cala Tramontana hoard in Pantelleria: archaeometric study for the production of the Sardinian-Punic coins 184

P98 - Terracottas from the Athenaion in Castro (Apulia, Italy): further insight into the provenancing 185

P99 - Project Prin 2020 The Time of Castles: the raw materials for the production of castle mortars 186

P100 - True or false? Archaeometric study on the authenticity of a sculpture found in 1991 during archaeological excavations in Ustica (PA) 187

Archaeological organic residues: molecular profiles and biomarkers to provide a valuable insight of the past times

M.P. Colombini(*,a)

(a)Dipartimento di Chimica e Chimica Industriale, via Moruzzi 13 Pisa
* Presenting author

maria.perla.colombini@unipi.it

A detailed understanding of the organic chemical composition of archaeological objects and ancient paintings is crucial for identifying not only the original materials (adhesives, sealants, painting, and coating materials) used by the artisan/artist but also for enabling the detection of materials added during restorations or those induced by time and pollution. Additionally, it aids in comprehending the function of archaeological objects. The versatile applications of proteins, oils, gums, natural resins, and resinous materials in various cultural and practical contexts, such as flavoring, incense, cosmetics, medicines, and mummification balms, underscore the significance of their chemical characterization. This knowledge, when integrated with historical and archaeological data, has significantly advanced our understanding of past painting techniques and technologies.

Chemical analysis of these organic materials poses challenges for chemists due to their complex compositions, susceptibility to degradation processes from aging, environmental factors, and human activities (e.g., heating processes applied to plant resins). Moreover, these materials are often present in very low quantities compared to inorganic materials. To answer the above many questions, chromatography-mass spectrometric techniques are the techniques of choice.

Currently, techniques based on chromatography and mass, including SIFT-MS (selected ion flow tube mass spectrometry), EGA-MS (evolved gas analysis mass spectrometry), Py-GC-MS (pyrolysis gas chromatography-mass spectrometry), GC-MS, and HPLC-MS, play a crucial role in analytical procedures to characterize organic residues in archaeology. These techniques provide characteristic molecular profiles, that aid in the identification of materials and contribute to understanding degradation pathways, to identify geographical and botanical sources, to gain insights into ancient technologies, to uncover religious or ceremonial practices, and to trace trade routes and exchanges between different regions.

Moreover, this molecular-level knowledge is invaluable for making informed decisions in restoration processes, and to evaluate authenticity of ancient paintings, addressing a significant challenge that has grown in prominence in recent decades.

This lecture focuses on current analytical procedures based on chromatography-mass spectrometric techniques that allow the characterization of macromolecules and biomarkers in archaeological objects and paintings, demonstrating their utility in integrating historical and archaeological information. Several case studies, including studies on Domus de Janas paintings and Egyptian objects from the Egyptian Museum of Torino, are discussed to illustrate the practical application of these techniques in providing valuable insights into the composition and preservation of cultural heritage.

Protection and promotion of the material and non-material heritage

V. Li Vigni (*, a)

(a) Fondazione Sebastiano Tusa, via Principe di Belmonte 78 – 90139 Palermo
* Presenting author

valeria.livigni@regione.sicilia.it

The "Charter of Intent" for the promotion and preservation of the cultural and environmental heritage of Palermo, based on the collaboration of institutions, associations, foundations, and the active participation of citizens, aims to foster the sustainable development of cultural and sports tourism in the coastal areas of the city. Particular attention is paid to the protection of traditions and the involvement of local communities, through a collaborative and inclusive approach to overcome the challenges of the future, starting from the development of coastal areas, by respecting local traditions and the environment.

In this context, a significant aspect of the project is the enhancement of the underwater archaeological heritage, through an increase in the number of underwater itineraries for in situ documentation of wrecks, but also of the small communities and ports that formerly supported small-scale fishing in the coastal hamlets of the Gulf. Recovering and enhancing these traditions means revitalising small local economies which, although marginal compared to the big city markets, represent a fundamental cultural and social resource. Developing the marine heritage is therefore not only about respecting the environment and the heritage it preserves, but also about transmitting the historical and cultural memory still alive in the fishermen's know-how.

Local traditions, such as small-scale fishing, are an element of great value that must be preserved and passed on to future generations.

The Palermo Charter, which follows in the footsteps of the already existing Ustica Charter, born on the Rassegna del Mare (Ustica 2024), which was named after Sebastiano Tusa, represents a fundamental step in the process of enhancing and preserving natural resources and the archaeological, material and immaterial anthropological heritage, as well as safeguarding local traditions.

The project provides for initiatives for young people, such as cultural events, artists' residencies, sports activities and educational programmes, to promote greater awareness of the sea and its preservation, while fostering the sustainable development of our City's coastline.

Il Sistema museale dell'Universtà di Palermo

M. Leone*

(a) Manfredi Leone, Sistema Museale di Ateneo, Vicepresident

* Presenting author

manfredi.leone@unipa.it

SIMUA PALERMO

Il sistema museale di Ateneo attraverso la storia dei luoghi e delle esperienze.

Un rapido viaggio tra musei, siti speciali e collezioni provenienti da piu di due secoli di accademia palermitana.

Funzioni, accessibilità' e opportunità nelle relazioni tra luoghi, comunità' e societa'.

Unipa Heritage e la nuova frontiera della divulgazione e trasmissione della cultura.

The University museum system through the history of places and experiences.

A quick journey through museums, special sites and collections from more than two centuries of Palermo academy.

Functions, accessibility and opportunities in the relationships between places, communities and society.

Unipa Heritage and the new frontier of dissemination and transmission of culture.

The synergy between tradition, innovation and sustainability for the restoration of the historical heritage, with a special attention to circular economy

O. Spadaro ([a,*]), M. Spadaro ([a])

([a]) SPADAROCALCE1886, sede operativa: Via Sant'Alessandra, km 4,500 Rosolini (SR)
* Presenting author

orazsp@gmail.com

Lime is one of the oldest and most versatile binders used by Humanity and it has played an extremely important role in the development of art and construction, influencing aesthetic and technical evolution over millennia. In this regard, lime plays a crucial role in the restoration of historical works as well. Its compatibility with the original materials makes it possible to restore ancient structures without compromising historical integrity.

In 1886 Michele Spadaro transformed the limestone coming from the Modica countryside into a very valuable lime, by using a Catonian kiln. After several generations, Spadarocalce1886, making use of the experience handed down over the years, studies and produces specific materials for the restoration, structural consolidation and rehabilitation of historical buildings, according to design, historical traces and original local matters. Actually, all these features characterize the physical quality of the structures and the culture that accompanies it.

For these aims particular attention is paid to the environmental impact and problems related to climate change and pollution. Moreover, from the assumption that a conservative intervention must be sustainable, our efforts are involved in using raw materials largely coming from the reuse of demolition waste (antique tiles, solid bricks, removed plaster), thus designing formulations respecting traditional techniques, to reach prestigious and sustainable results and simultaneously triggering the virtuous way of circular economy.

Figure. The Church of San Giorgio in Castelmola (ME), before and after the conservative intervention. The complete reuse of the original plasters constituents has been carried out to reformulate the restored plasters.

Il Comando Carabinieri per la Tutela del Patrimonio Culturale

Tenente Colonnello Gianluigi Marmora

marmora.gianluigi@libero.it

In data 03.05.1969 è stato istituito il Comando Carabinieri TPC che risponde funzionalmente al Ministro della Cultura, assolvendo il ruolo di organo consultivo centrale.
E' costituito da una struttura centrale e da reparti investigativi, tra cui 16 Nuclei regionali per l'attività preventiva e repressiva di polizia giudiziaria.
In Sicilia, i reati più gravi avvengono nel settore archeologico in cui operano organizzazioni criminali costituite da tombaroli, ricettatori e destinatari finali dei reperti.
Uno strumento fondamentale per le attività investigative è costituito dalla "*Banca Dati dei beni culturali illecitamente sottratti*", gestita dal Comando Carabinieri Tutela Patrimonio Culturale.
Il Comando Carabinieri TPC ha anche una proiezione internazionale, mediante i "*Caschi blu della Cultura*", nell'ambito della "*Unite4Heritage*", una *Task Force* per l'intervento in aree colpite da emergenze, calamità o crisi, al fine di salvaguardare i siti archeologici, i luoghi della cultura e contrastare il traffico internazionale di beni culturali.

Non-destructive and chemometric analysis of the provenance of fossil amber resins

Barbara Łydżba-Kopczyńska (*,a)

(a) Cultural Heritage Research Laboratory, Faculty of Chemistry, University of Wrocław, F. Joliot-Curie 14, 50-383 Wrocław, Poland
* Presenting author

barbara.lydzba@chem.uni.wroc.pl

The earliest evidence of human use of amber (individual pieces or ornaments) dates from the Palaeolithic period and has only been discovered in a few archaeological sites. On the other hand, amber routes from the north to the south of Europe, understood as probable directions of distribution from amber collecting groups to users, started in the Late Neolithic and have evolved until modern times. Consequently, a crucial objective of archaeometric research is the accurate identification of the provenance of fossil amber, which involves determining its geographical and geological origin. The advancement of non-destructive and non-invasive analytical techniques, supported by chemometrics, that are suitable for the provenance study of cultural heritage items made of amber resins represents a significant challenge. The success of those investigations is influenced by the selection of appropriate methods and the use of a reference spectra database.

The Cultural Heritage Research Laboratory at the Faculty of Chemistry, University of Wrocław, Poland, runs systematic studies in order to develop analytical procedure applied in studies of amber provenance and systematically broadens spectral database of amber and other fossil resins. The database contains Raman, ATR, EPR [1] spectra and SEM-EDS data [2]. Each of the listed techniques has advantages, and limitations and gives unique chemical information about samples, which can be used for modelling purposes. Amber origin classification based only on data delivered by one technique is still challenging due to misclassification problems.

An analytical approach based on a variety of spectroscopic methods was employed to investigate a number of raw amber and historical amber artefacts discovered in Poland. This approach allowed for the identification of the provenance of a range of amber artefacts, including those from the Paleolithic period, amber jewelry from the Iron Age [3] and medieval amber discoveries [4]. Recently chemometric methods have been successfully used to determine the geological origin of amber originating from various localities in Europe, America and Asia [5]. Since 2015, the laboratory has been actively engaged in research projects focused on amber provenance within the framework of the Polish Node of the European Research Infrastructure for Heritage Science.

References

[1] B. Łydżba-Kopczyńska, K. Kruczała, T. Czaja, Data fusion of Raman, ATR, and EPR spectroscopies applied to the study of provenance and geological age of the amber, Book of Abstracts of the 11th International Congress on the Application of Raman Spectroscopy in Art and Archaeology 6-9 September 2023, Athens (Greece).

[2] Kosmowska-Ceranowicz B., Sachanbiński M, Łydżba-Kopczyńska B. 2017. Analytical characterization of Indonesian amber" deposits: evidence of formation from volcanic activity, Baltica, 2017, 30, 55-60

[3] B. Łydżba-Kopczyńska, B. Gediga, J. Chojcan, M. Sachanbiński, Provenance investigations of amber jewellery excavated in Lower Silesia (Poland) and dated back to Early Iron Age, J. Raman Spectrosc,2012, 43, 1839-1844.

[4] T. Łojewski and B. Łydżba-Kopczyńska Spectroscopy in the Analysis of Artworks: From Molecules to Functional Materials In book: Molecular Spectroscopy—Experiment and Theory, Springer Nature Switzerland AG, 2019, 483-517

[5] F. Armetta, M. L. Saladino, B. Łydżba-Kopczyńska, Amber resins provenience and datation by non invasive FTIR and chemometric, 2024. paper in preparation.

The state of preservation of the ancient Roman ships of Fiumicino sixty years after their discovery

B. Pizzo (*, a), N. Macchioni (a), L. Sozzi (a), S. Lazzeri (a), L. Fiorentino (a), E. Verdiani (a), M. Labriola (b), M. Massera (b), F. Romagnoli (b), T. Sòrgoni (c)

(a) Consiglio Nazionale delle Ricerche, Istituto per la Bioeconomia (CNR-IBE), via Madonna del Piano, 10. Sesto Fiorentino (FI)

(b) Consorzio Pragma, Restoration and conservation of Cultural Heritage, via della Pisana 247. Roma (consorziopragma@gmail.com)

(c) Funzionario restauratore conservatore in servizio presso il Parco archeologico di Ostia antica, Roma

* Presenting author

Email corresponding: benedetto.pizzo@ibe.cnr.it

The Fiumicino Ships were discovered in the late 1950s and 1960s during the construction of Rome's Leonardo da Vinci International Airport. They are at least seven wooden boats dating from the 2nd to the early 5th century AD. These boats are believed to have been abandoned in a peripheral area of the seaport of ancient Rome, *Portus Augusti Ostiensis*, the largest port of the Roman Empire [1]. Nevertheless, they are a very important testimony of the activities that took place in the *Portus*, such as those related to the supply and storage of foodstuffs needed by the close city. The ships were built using local timbers, the most abundant being oak, umbrella pine and cypress. The frames were connected to the planking or the keel with iron nails (ship Fiumicino 1) or with olive wood pegs (ship F. 4) [1]. The ships are now exposed in the Fiumicino Naval Museum, purpose-built during the excavations to preserve the vessels and opened to the public in 1979. However, in order to adapt the building to the current regulations, the museum was closed in 2002 and reopened to the public almost twenty years after, in October 2021, totally renewed. Before the 1980s, the ships were treated with resins, stains, and acrylic substances [2]. In the following years, a number of "maintenance" operations were carried out, with an expected protective function that however had an uncertain effect on the state of preservation of the material. It should also be noted that from 1979 until 2021 (the museum reopening), the building did not have an adequate air conditioning system. During the most recent restoration works, the museum management decided together with the restoration team to carry out a diagnostic campaign to assess the state of preservation of the wooden elements. Investigations revealed a high level of decay, so high that in many cases it was difficult to identify the wood species anatomically. The analyses also showed that the level of absorption/penetration of old treatments was minimal and that there was a certain degree of acidity in the wood, in many cases very pronounced. The purpose of the restoration works was essentially to remove the over-addressed substances in order to free the wood surface and allow it to "breathe" again[1]. A deacidification treatment was also carried out with excellent results. The cause of this highly acidic environment is still being investigated and probably results from the combination of several factors, not least the treatment products used in the past, but this event must be considered unusual, at least according to the information available.

References

[1] G. Boetto, Les navires de Fiumicino, in: J.P. Descoeudres (Ed.) Ostia, port et porte de la Rome antique, Musées d'art et d'histoire, Genève, et Georg Editeur, Paris (2001), 121-129, ISBN: 2-8257-0728-7

[2] R. Petriaggi, Il Museo delle Navi di Fiumicino: problemi di conservazione e restauro, I Beni Culturali, tutela e valorizzazione (1997), 6 (novembre-dicembre), 15-18, ISSN: 1122-2948

[1] The cleaning operations were c**arried out with mixtures of green solvents specially formulated for restoration.**

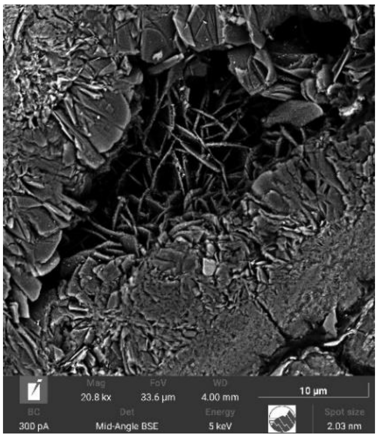
Lying on the seabed: investigation of post-depositional phases in underwater ceramics.

M.E. Mascaro [*, a], R. Auriemma [b], M. Miše R. [c], R. Chapoulie [d], L. Maritan [a]

(a) Department of Geosciences, University of Padova, Via G. Gradenigo 6, 35131, Padova, Italy.
(b) Department of Cultural Heritage, University of Salento, Via D. Birago 64, 73100, Lecce, Italy.
(c) Institute of Archaeology, University College London, 31-34 Gordon Square, London, WC1H0PY, UK.
(d) Archéosciences Bordeaux UMR 6034, CNRS, University of Bordeaux Montaigne, 19 Esplanade des Antilles, Pessac, France.
* Presenting author

mariaemanuela.mascaro@phd.unipd.it

Microstructural and compositional transformations in amphora fragments from various underwater archaeological sites on the Apulian and Dalmatian coasts were studied in order to investigate the post-depositional changes that occurred in ceramic materials buried on the seabed for centuries [1]. The results of mineralogical analysis (XRPD) and SEM-EDS microstructural characterisation performed on some representative samples are presented here. The outcomes suggested that, assuming a similar primary clay composition and firing temperatures, the environmental conditions of the underwater depositional context influence the precipitation and degree of crystallisation of some post-depositional phases. The presence of lamellar structures of hydrotalcite-like phases was detected in ceramic samples deposited at the greatest depths in both the Dalmatian and Apulian seabed. The occurrence of magnesium aluminosilicate hydrated phases (M-A-S-H) [2], was found around the pores or reaction edges in most of the examined samples as gels or in the form of a crystalline structure. Framboids of pyrite microcrystals were often found in pores or in voids left by fossils. All these phases are absent in on-land ceramic amphoras samples used for comparison. Gypsum and magnesium calcite were spotted as post-depositional phases especially in Apulian samples. The possible usefulness of cathodoluminescence imaging was also tested to highlight the chromatic alteration layers found in several underwater samples probably linked to the enrichment and/or depletion of specific chemical elements.



SEM-BSE image of hydrotalcite lamellar structure partially filling a pore.

References

[1] L. Maritan, Ceramic abandonment. How to recognise post-depositional transformations. Archaeol. Anthropol. Sci. (2020) 2, 199. https://doi.org/10.1007/s12520-020-01141-y
[2] M. Secco, Y. Asscher, G. Ricci, S. Tamburini, N. Preto, J. Sharvit, G. Artioli, Cementation processes of Roman pozzolanic binders from Caesarea Maritima (Israel), Constr. Build. Mater. (2022) 355, 129128, https://doi.org/10.1016/j.conbuildmat.2022.129128.

Decoding climate impact on metal underwater artifacts: initial experiments and future directions

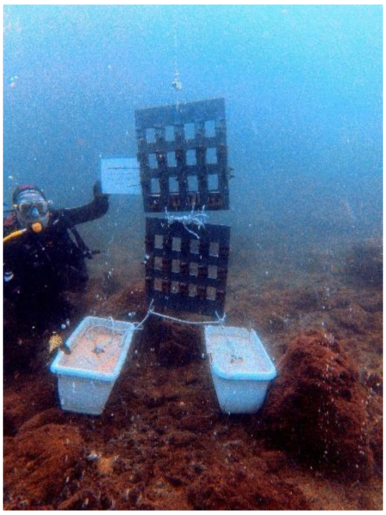
L. P. Cesareo [*, a], L. Germinario [a], I.D. MacLeod [b], S. Demesticha [c], L. Donnarumma [d], E. Loizides [e], F. Ruberti [f], A. Sorci [g], C. Mazzoli [a]

(a) Department of Geosciences, University of Padova, Padova, Italy
(b) Western Australian Museum, Perth, Australia
(c) Department of History and Archaeology, University of Cyprus, Nicosia, Cyprus
(d) Department of Science and Technology, University of Naples "Parthenope", Naples, Italy
(e) Department of Antiquities of Cyprus, Nicosia, Cyprus
(f) IANTD S.R.L., Marina di Pisa (Pisa), Italy
(g) Laboratorio del Ma.Re, Isole Tremiti, Italy

* Presenting author

ludovicapia.cesareo@phd.unipd.it

In underwater archaeological sites, metallic materials naturally undergo physical, chemical and biological changes influenced by water, sediments, and living organisms. But how is climate change influencing deterioration processes? This research, conducted within the THETIDA project (https://thetida.eu), aims to investigate the effects of deterioration associated with climate change, assess their evolution in different environments, and develop prediction models. The various pilot sites included in this study offer a range of historical backgrounds, metallic materials, depth, and marine ecosystems, enabling a comprehensive comparison. Shipwrecks are often considered time capsules, frozen at the moment of the sinking; however, in reality, they become living entities, constantly in dialogue with the surrounding marine environment [1-2]. Studying these materials can provide information about the past but, particularly with metallic elements, the thick surface encrustation layers act as protective barriers, preserving traces of the 'second life' of these sites. For these reasons, this study is currently using analytical techniques (e.g., X-ray Powder Diffraction (XRPD), Scanning electron microscopy with energy dispersive X-ray spectroscopy (SEM/EDS)) to investigate the composition of samples of metals, alloys, and encrustations collected from underwater archaeological sites (preliminary results are presented about the 18th century Nissia shipwreck in Cyprus). Based on comparisons with similar sites in the literature, we have selected seven representative metallic materials from various historical periods and from the shipwrecks under study. Mock-ups of these materials were created to conduct further experiments, using both a MicroEnvironment Simulator (MES) [3] and placing them in the marine environment at three different sites: near the protected marine area of the Cinque Terre National Park (SP), at the Tremiti Islands (FG) and in the Submerged Archaeological Park of Baia - Campi Flegrei (NA). In this last site, one of the two experiments was deployed close to CO_2 vents, naturally simulating an acidified sea future scenario [4-5]. The exposure time will last for 12 months, and during this year the mock-ups will be collected at defined intervals in order to analyze and measure for each material the decay processes step-by-step.



Experiment setting at Secca delle fumose, Submerged Archaeological Park of Baia - Campi Flegrei (Naples, Italy)

References

[1] M. Bethencourt et al., Study of the influence of physical, chemical and biological conditions that influence the deterioration and protection of Underwater Cultural Heritage (2018). Sci. Total Environ. 613: 98-114 (http://dx.doi.org/10.1016/j.scitotenv.2017.09.007).

[2] I. D. MacLeod, In-situ corrosion measurements of WWII shipwrecks in Chuuk Lagoon, quantification of decay mechanisms and rates of deterioration (2016). Front. Mar. Sci. 3: 38 (https://doi.org/10.3389/fmars.2016.00038). [3] L. Germinario et al., Underwater archaeological sites and climate change: experimental study of the impact of ocean acidification on historical stone materials (2024). In: ISA 2024 – 44th International Symposium on Archaeometry, 27–31 May 2024, Melbourne, Australia

[4] K. von Schuckmann et al., The state of the global ocean, in: 8th edition of the Copernicus Ocean State Report (OSR8) (2024), Copernicus Publications, State Planet, 4-osr8, 1, https://doi.org/10.5194/sp-4-osr8-1-2024

[5] L. Donnarumma et al., Environmental and benthic community patterns of the shallow hydrothermal area of Secca delle Fumose (Baia, Naples, Italy) (2019). Front. Mar. Sci. 6: 685 https://doi.org/10.3389/fmars.2019.00685

Acknowledgements This research has been funded by European Union's Horizon Europe research and innovation programme under the THETIDA project (Grant Agreement No. 101095253) (Technologies and methods for improved resilience and sustainable preservation of underwater and coastal cultural heritage to cope with climate change, natural hazards, and environmental pollution).

INSU●LAB - An open *in-situ* laboratory for dissemination during the annual underwater survey campaign on the submersed site of the Battle of Egadi (Favignana, Sicilia)

J. Vernet ([*, a,b]), M. Arena ([a]), E. De Palo ([a,c]), R. La Rocca ([d]), F. Maurici([d])

(a) Society for the Documentation of the Submersed Sites (SDSS), Via Traversa Sinerchia 4/3, Siracusa (SR), Italy

(b) Istituto per lo studio degli Impatti Antropici e sostenibilità in ambiente marino – Sede Genova, Consiglio Nazionale delle Ricerche (IAS-CNR), Genova (Ge), Italy

(c) Università degli Studi di Torino, Torino (TO), Italy

(d) Soprintendenza del Mare, Regione Siciliana

* Presenting author

justine.vernet@ias.cnr.it

Following the studies, insights, and tireless dedication of the late Prof. S. Tusa, underwater archaeological research on the submerged site of the naval Battle of the Egadi (241 BCE) in Sicily is currently being conducted by the *Soprintendenza del Mare* of the Sicilian Region, in collaboration with the expert divers of the Society for the Documentation of Submerged Sites (SDSS) and the American RPM Nautical Foundation, aboard the Research Vessel *Hercules,* equipped with remote sensing technologies (ROVs, AUVs, etc.). Year after year, the waters around the Egadi Islands continue to yield exceptional artifacts and invaluable information, significantly enhancing our understanding of Mediterranean history. **The INSU•LAB (In Situ, Underwater, Laboratory) project is an innovative outreach initiative aimed at bridging the gap between ongoing Sicilian underwater archaeological research and the general public.** By setting up an open laboratory during the 8th summer underwater archaeological research campaign at the *Ex-Stabilimento Florio* in Favignana (TP), the scientific team of SDSS volunteers, in collaboration with experts in diagnostic, conservation and restoration from the *Soprintendenza del Mare*, exhibited during the museum's opening hours the usually invisible post-excavations activities. This gave visitors the **opportunity to discover live the latest research progress on this extraordinary and inaccessible** archaeological site, including groundbreaking underwater techniques used by SDSS divers for deep exploration, photogrammetry of the site, artifact lifting and underwater documentation; post-excavation artifact cataloguing; initial conservation procedures such as desalination static bath and conductivity monitoring; artifacts cleaning and restoration activities; first diagnostic by handheld digital miscroscopy and x-ray spectroscopy. As a result, INSU•LAB facilitated increased collaboration between cultural institutions, professionals in Heritage Science and tech-diving citizen-science associations, providing a platform for future diagnostic and conservation field-operations. By highlighting all the steps, from the discovery of artifacts to their museal exhibition, it also enhanced public engagement and raised awareness on the protection of Sicilian Underwater Cultural Heritage, as well as deepened the public sensitivity to 'living science'. Additionally, the strong public engagement resulting from the initiative allows for better valorisation of the underwater collections held by local stakeholders.

Acknowledgements
INSU•LAB is a directly-promoted initiative of the *Regione Siciliana, Assessorato dei Beni Culturali e dell'Identità Siciliana, Soprintendenza del Mare*, carried out by the SDSS with the sponsorship of Favignana city. The authors would like to thank the RPM Nautical Foundation, specifically J. Goold and G. Robb Jr., the Prof. W. Murray (University of Florida) and all the SDSS participants to the 2024 survey campaign.

Multi-analytical study of mercury contamination in the botanical samples of the Herbarium Centrale Italicum

G. Marsiaj (a,b), R. Manca (*,a,c), F. Ciani (a), M. Chiari (b,d), M. Benvenuti (a,c,e), P. Costagliola (a), L. Giuntini (b,d), A. Mazzinghi (b,d), V. Rimondi (a,c)

(a) Università degli Studi di Firenze, Dipartimento di Scienze della Terra

(b) Istituto Nazionale di Fisica Nucleare, Sezione di Firenze

(c) National Biodiversity Future Center

(d) Università degli Studi di Firenze, Dipartimento di Fisica e Astronomia

(e) Consiglio Nazionale delle Ricerche, Istituto di Geoscienze e Georisorse

* Presenting author

rosarosa.manca@unifi.it

Museum herbaria, i.e. collections of dried plants, represent a unique historical record and a key resource for modern research on climate change and biodiversity. However, many herbaria in the world suffer of mercury (Hg) contamination due to the past use of corrosive sublimate ($HgCl_2$) as a pesticide for the conservation of plant samples. Elemental Hg (Hg^0) degassing from the samples and residuals Hg compounds on them prevent the full accessibility and valorisation of these collections and complicate their management. The Herbarium Centrale Italicum (HCI, University of Florence) is one of the most ancient and largest herbaria in the world and its mass digitisation is currently ongoing. In this framework, interventions for the reduction of contamination are being developed, making it crucial to have a deep understanding of its extension and characteristics. This work aims to characterize the composition, distribution and amount of Hg-based compounds in the herbaria samples of the HCI and the influence of environmental factors in their emissions of Hg^0 to the surroundings. Eight samples were studied: seven dated to the 19th century and belonging to the collections of renowned botanists of the time, and a recent, untreated one, used as a blank.

Ion Beam Analysis provided information on the elements associated with Hg in the plants and paper supports of the samples (PIXE) and on the in-depth distribution of the Hg (RBS). X-ray radiography was used in the attempt to identify and visualize the distribution of heavy metals. A steady-state flux chamber, connected with a Lumex RA-915M analyzer, was used to determine the Hg^0 degassing rate (ng m^{-2} h^{-1}) from the samples; measurements were repeated at different (RH) conditions, highlighting a strong influence of this parameter on the emissions, which are significantly lower at RH below c. 65%. The acquired information is crucial to increase our knowledge on Hg contamination in historic herbaria and to make the HCI safely accessible for both scholars and the general public.

Acknowledgements

The curators of the Erbario Centrale Italiano, Università di Firenze are warmly thanked for their support. RM, VR and MB acknowledge the support of NBFC to Univ. of Florence/Department of Earth Sciences, funded by the Italian Ministry of University and Research, PNRR, Missione 4 Componente 2, "Dalla ricerca all'impresa", Investimento 1.4, Project CN00000033. MC acknowledges funding by IR0000032 – ITINERIS, Italian Integrated Environmental Research Infrastructures System (D.D. n. 130/2022 - CUP B53C22002150006) Funded by EU - Next Generation EU PNRR- Mission 4 "Education and Research" - Component 2: "From research to business" - Investment 3.1: "Fund for the realisation of an integrated system of research and innovation infrastructures".

Geophysical and Archaeological Insights into the Hidden Past of the Annunziata Garden in Cammarata (Sicily)

R. Martorana (*, a), P. Capizzi (a), A. Carollo (a), V. Genco (b), C. Giambrone (b), M. Mapelli (c), L.M. Simonello (d)

(a) Department of Earth and Marine Sciences (DISTEM), University of Palermo, 90123 Palermo, Italy
(b) I.I.S.S. Archimede, Cammarata, AG, Italy
(c) Independent Researcher, Cammarata, AG, Italy
(d) I.C. Giovanni XXIIII, Cammarata, AG, Italy
(*) Presenting author

Email corresponding: raffaele.martorana@unipa.it

This study combines geophysical and archaeological techniques to investigate the Annunziata Garden in Cammarata, Sicily, a site of potential historical significance associated with a long-destroyed Benedictine monastery. Using two-dimensional and three-dimensional Electrical Resistivity Tomography (ERT) alongside Ground Penetrating Radar (GPR), the research identified anomalies in the subsurface indicative of anthropogenic structures [1]. The 3D ERT model highlighted significant anomalies. The GPR surveys provided complementary insights, identifying high-reflectivity alignments corresponding to the resistive zones detected by ERT. These anomalies, further investigated through archaeological excavations, revealed the remnants of a defensive wall constructed in multiple phases. Coins and artifacts found near the wall suggest it dates to the 12th–13th centuries, although its origins may be earlier [2]. The findings underline the importance of integrating non-invasive geophysical methods in heritage conservation, enabling the identification of subsurface features while preserving the integrity of the site.

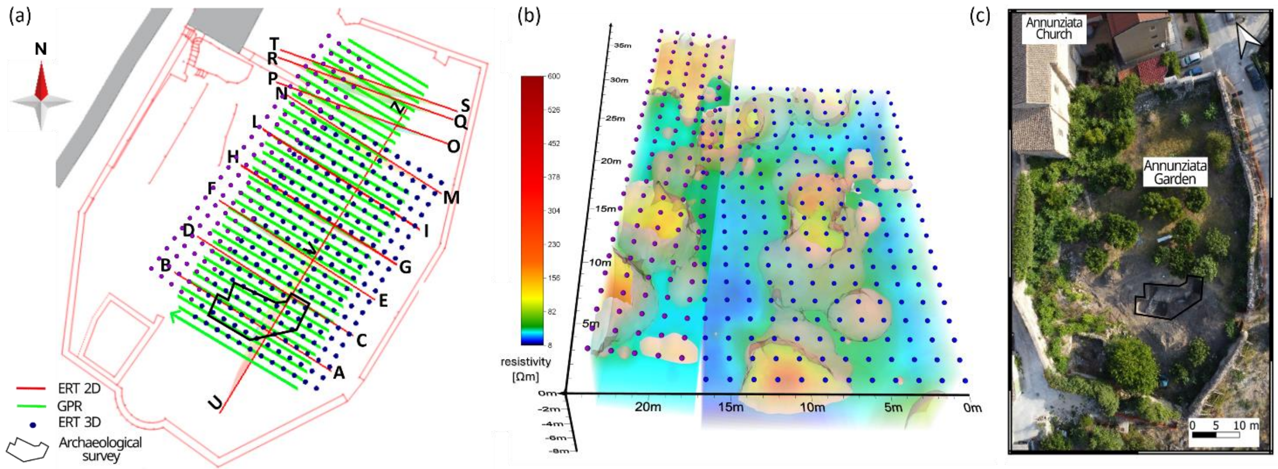


Figure 1. (a) Site map of the Annunziata Garden illustrating 2D ERT profiles, GPR tracks, excavation boundaries; (b) 3D-rendered resistivity model; (c) aerial view of the investigated zone.

References

[1] R. Deiana, G. Leucci, R. Martorana, 2018. New perspectives of Geophysics for Archaeology - a special issue. Surv. Geophys. 39 (6), 1035–1038. DOI: 10.1007/s10712-018-9500-4.
[2] R. Martorana, P. Capizzi, et al., *The "Annunziata" Garden in Cammarata (Sicily): Results of Integrated Geophysical Investigations and Initial Archaeological Survey*, Journal of Applied Geophysics, 2024, Vol. 227, 105436, DOI: 10.1016/j.jappgeo.2024.105436.

Egyptian Blue: variability in production technology, material provenance and deterioration

E.L. Ravan ([*, a,b]), H. Brecoulaki ([c]), A.G. Karydas ([d]), C. Miliani ([a]), F.P. Romano ([a,e]), C. Caliri ([a,e])

(a) CNR-ISPC, Via Biblioteca 4, 95124, Catania, Italy

(b) Sapienza University of Rome, Piazzale A.Moro 5, 00185 Rome, (Italy)

(c) Institute of Historical Research, National Hellenic Research Foundation, Athens, Greece

(d) Institute of Nuclear and Particle Physics, NCSR "Demokritos", Athens, Greece

(e) Istituto Nazionale di Fisica Nucleare, Laboratori Nazionali del Sud (INFN-LNS), Via Santa Sofia 62, 95123 Catania, Italy * Presenting author

evaluna.ravan@uniroma1.it

Egyptian Blue (EB), one of the most commonly used pigment in antiquity, served as the primary blue pigment in artists' palettes until the 4th century CE [1] and in rare cases beyond. Its distinctive color derives from the orientation of copper (II) in the copper calcium tetrasilicate crystals (CaCuSi4O10, its naturally occurring but rare counterpart is the mineral cuprorivaite) [2]. Nonetheless, EB is a multicomponent material, the variability in its color, that can range from dark blue to almost white, can be attributed to differences in grain size, proportions of various mineral phases in the final product and manufacturing technology [3]. In our study we adopted a non-destructive multi-modal methodology, incorporating mobile analytical X-ray techniques, to analyze EB samples sourced from a variety of well-documented archaeological sites. The investigation encompassed wall painting fragments from late Classical and early Hellenistic Macedonian tombs. We have combined highresolution 2D micro-XRF imaging (MXRF), 3D Confocal XRF mapping (CXRF) and 1D X-Ray Powder Diffraction (XRPD) available in the MOLAB platform of E-RIHS (ISPC-CNR, Catania, Italy). The non-destructive nature of this approach allowed for a thorough examination of the samples, yielding comprehensive analytical data. The findings offer deep insight into the choice of source materials, as evidenced by the XRF elemental analysis, and elucidate the crystalline environment of Cu-based pigments through XRPD. The use of micro-XRF imaging and 3D confocal XRF applied to the wall paintings fragments provides useful insights on the original painting techniques. The results of our research enable a better understanding of material provenance, technological changes, and the identification of ongoing deterioration mechanisms.

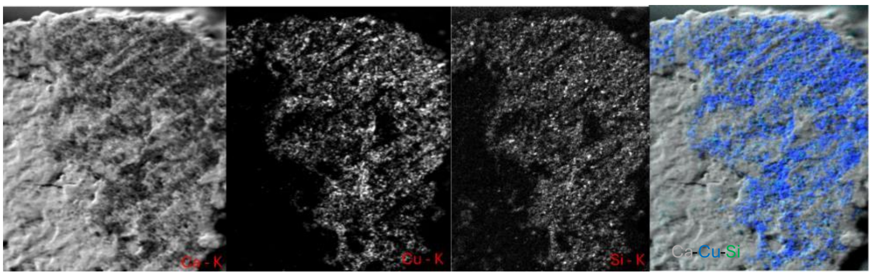


Figure 1 µXRF imaging (lateral resolution 10µm) of one of the Macedonian tomb fragments

References

[1] P. García-Fernandez, M. Moreno, J.A. Aramburu, J. Chem. Educ. 2016, 93, 111-117.
[2] V. Daniels, R. Stacey, A. Middleton, Studies in Conservation 2004, 49:4, 217-230.
[3] A. Kostomitsopoulou, F. Giannici, F. Caruso, Anal. Chem. 2021, 93, 11557-11567.

The Addaura Caves in Palermo: new challenges for the study, conservation, and public access

D. Giuffrida ([*, a]), M.L. Saladino ([b, a]), E.C. Portale ([c]), V. Forgia ([c]), F. Armetta ([b, a]), M.A. Buccheri ([d]), C. Polizzi ([e]), R.C. Ponterio ([a])

([a]) Istituto per I Processi Chimico-Fisici, Consiglio Nazionale delle Ricerche, V.le F. S. d'Alcontres 37, 98158, Messina, Italy

([b]) Dipartimento Scienze e Tecnologie Biologiche, Chimiche e Farmaceutiche, STEBICEF and INSTM UdR - Palermo, Università di Palermo, Viale delle Scienze pad. 17, Palermo, 90128, Italy

([c]) Dipartimento Culture e Società, Università di Palermo, Viale delle Scienze - Ed.15, 90128 Palermo, Italy

([d]) Consiglio Nazionale delle Ricerche, Istituto per la Microelettronica e Microsistemi, Via S. Sofia 64, 95123 Catania, Italy

([e]) Museo Archeologico Regionale "A. Salinas", Piazza Olivella, 90133-I, Palermo.

* Presenting author

dario.giuffrida@ipcf.cnr.it

The Addaura Caves are a complex of natural cavity or shelters located on the northern slopes of Monte Pellegrino, in the Gulf of Mondello (Palermo) [1]. Archaeological discoveries, made in the late 19th century and again in 1946, include lithic artefacts and a faunal assemblage, evidence of the human exploitation during the Late Pleistocene and the Early Holocene [2]. What sets these caves apart is a unique collection of prehistoric rock engravings. The *Antro Nero* preserves two figures of bovids engraved on the right wall. The *Grotta delle Incisioni* includes 13 animals, 17 anthropomorphic figures and numerous marks on the back and left walls. A minimum age of 14,000 cal BP was proposed for at least one of the images in the engraved panel (the bovid figure) [3] and applied to the entire "scene". The two caves were explored as part of the SAMOTHRACE project to update research, assess the conservation status, and provide media for public accessibility, since the safety and environmental conditions of the caves do not allow visits. Laser scanning was used to obtain accurate 3D measurements of the inner and external spaces, while photogrammetry was applied to capture the engravings details. Additional 3D models were collected on the casts made at the time of the discovery (preserved at the "Salinas" Museum) to compare them with the current on-site legibility. Alteration and degradation, caused by both atmospheric and biological agents (bacteria, fungi, etc.) over the years, were also investigated through micro-sampling and swabbing. Archival research on the original documentation is ongoing. Results will be integrated into a wider multi-layered system, where the 3D model will serve for study, monitoring and virtual access.

References

[1] G. Mannino, L'arte rupestre preistorica in Sicilia, A. Filippi (a cura di), Ediz. Storia e Studi Sociali (2017)

[2] M.A. Mannino, K.D. Thomas, M.J. Leng, R. Di Salvo, M.P. Richards, Stuck to the shore? Investigating prehistoric hunter-gatherer subsistence, mobility and territoriality in a Mediterranean coastal landscape through isotope analyses on marine mollusc shell carbonates and human bone collagen, Quaternary International, Volume 244, Issue 1, 2011, Pages 88-104, ISSN 1040-6182, https://doi.org/10.1016/j.quaint.2011.05.044.

[3] G. Di Maida, M.A. Mannino, J. Zilhão, D.L. Hoffmann, M. García-Diez, A. Pastoors, C.D. Standish, A.W.G. Pike, J. Olsen, V. Schimmenti, G. Battaglia, T. Terberger, Radiocarbon and U-series age constraints for the Lateglacial rock art of Sicily, Quaternary Science Reviews, Volume 245, 2020, 106524, ISSN 0277-3791, https://doi.org/10.1016/j.quascirev.2020.106524.

***Acknowledgements**: We thank European Union (NextGeneration EU), through the MURPNRR project SAMOTHRACE — Sicilian Micro and Nano Technology Research and Innovation Center (ECS00000022).*

Unveiling the Bikini Venus from MANN. A multimodal approach to characterise the residual polychromy

R. Iannaccone ([*, a]), C. Barandoni ([a]), F. Bonifazi ([a]), I. Cerato ([a]), D. Ferdani ([b]), M. Giacco ([c]), D. Magrini ([a]).

(a) Italian National Research Council, Institute of Heritage Science (ISPC-CNR), Firenze
(b) Italian National Research Council, Institute of Heritage Science (ISPC-CNR), Roma (c) MANN
* Presenting author

robertaiannaccone@cnr.it

The present study will be focused on the archaeometric campaign performed on the statue Venus in a Bikini, from Pompeii and belonging to the Archaeological Museum of Naples (MANN) collection [1]. The artifact preserves rich remnants of the original polychromy, and in particular a well-preserved gilding on the *strópHion* that wrapped around her breast, crossed her belly, and enveloped her hips. A preliminary visual examination, followed by high magnification inspection, technical photography and complementary non-invasive scientific techniques (XRF, FORS) were performed.
In parallel, a 3D reconstruction of the statue by photogrammetric acquisition of different datasets, as visible (VIS), ultraviolet induced luminescence (UVL) and visible induced luminescence (VIL) images was achieved. The detailed 3D reconstructions obtained, along with the ability to uncover and visualize residual polychromy, provide a more accurate and comprehensive understanding of ancient sculpture. This advancement not only improves scientific analysis but also enhances the historical and artistic appreciation of these artifacts, revealing aspects of their original appearance that were previously hidden. The acquisition protocol creates fully textured 3D models designed not only for detailed analysis but also for interactive exploration via web3D tools. This opens up new possibilities for public engagement and educational purposes.

3D model of the statue mapped with textures generated from the RGB, UVL, and VIL photographic datasets. Acquisition taken from Bikini Venus, Inv. 152798, courtesy of the MANN Museum.

References

[1] E. Künzl, "Venus vor dem Bade - ein Neufund aus der Colonia Ulpia Traiana und Bemerkungen zum Typus der "sandalen lösenden Aphrodite", Bonner Jahrbücher 170 (1970) 102.

Acknowledgements
The following research has been carried out in the framework of the Project PERCEIVE, funded by the European Union under grant agreement Nr. 10106115.

Mary Magdalene in ecstasy: revealing the historical-scientific results of an unpublished *replica* by Artemisia Gentileschi

M. F. Alberghina (*, a, b), D. Somma (c), M.F. La Russa (b), S. Schiavone (a)

(a) S.T.Art-Test di S. Schiavone & C sas, via Stovigliai, 88 93015 Niscemi (CL), Italy

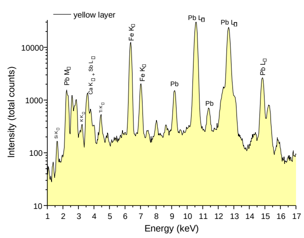
(b) Art historian and Art consultant, Piazza Martiri del Belfiore 4, Roma Italy

(c) Department of Biology, Ecology and Earth Sciences (DiBEST), University of Calabria, Ponte P. Bucci, Cubo 12b, II Piano 87036, Arcavacata di Rende (CS), Italy

* Presenting author

info@start-test.it

An unpublished painting has recently been proposed for attribution at Artemisia Gentileschi (1593 - 1653) thanks to the results of a complex and integrated historical and scientific research [1]. This canvas (110 cm × 83.5 cm), depicting "Mary Magdalene in ecstasy" belonging to a private collection, represent the same subject of the painting currently exhibited at Palazzo Ducale - Fondazione Musei Civici di Venezia [2]. In this context, the plan of investigations has been aimed at characterizing of the pigments and technique (preparatory drawing and *modus pingendi*) and at documenting the state of conservation to identify possible remakes not visible to the naked eye, which could modify the original layers. The Radiography revealed a partially executed underlying painting (suggesting a reuse of the support), and highlighted the absence of change or *pentimenti*, showing the exact coincidence with the final representation. The radiopaque areas make possible to give indications on the peculiarities of the methods of construction of the figurative composition.



XRF and FORS analyses detected the use of pigments available in the hypothesized period following the preliminary historical-stylistic evaluation (17th century): lead white, Naples yellow, vermilion (traces in mixture), ochres and earths (iron and manganese-based oxides and clay minerals). The use of bone black and red lakes has been verified on two micro-fragments through SEM-EDS analysis. Naples Yellow has been attested in other attributed her paintings dated in the same period. Sample analyses identified the preparation layer (calcium sulphate, ochres/earth pigment) and a primer consisting of red, yellow and black iron oxides and lead white. The scientific analyses provided several information coinciding with the data available in the literature, and the ongoing study on this unveiled painting allowed to deepen the theme of the *replica*, a technique taken from workshop of his father, within the Artemisia Gentileschi artistic production.

References

[1] D. Somma, L'estasi di Artemisia Gentileschi Indagine storico-scientifica di un'opera inedita, Tab Ed., Roma 2024

[2] C. Currie et al., Étude technologique d'un exceptionnel tableau d'Artemisia Gentileschi figurant 'Marie Madeleine en extase, in Annales d'histoire de l'art et d'archéologie 2017 vol XXXIX, Bruxelles, 2016.

Discriminating superimposed historical inks exploiting a non-invasive strategy based on a novel multispectral approach

C. Delledonne (*, a, b), M. Albano (b, c), B. Albini (a), P. Galinetto (a), M. Malagodi (b, c), F. Volpi (b, c) and G. Fiocco (b, c)

(a) Department of Physics, University of Pavia, Via Agostino Bassi 6, 27100, Pavia, Italy

(b) Arvedi Laboratory of Non-Invasive Diagnostics, University of Pavia, Via Bell'Aspa 3, 26100, Cremona, Italy

(c) Department of Musicology and Cultural Heritage, University of Pavia, Corso Garibaldi 178, 26100, Cremona, Italy

* Presenting author

chiara.delledonne@unipv.it

Within historical manuscripts, it is quite common to find textual parts modified or added after the original drafting. In some cases, these are erasures or overwriting made with inks chemically similar to those used for the original text, which affects the text legibility, as well as the understanding of the writing process. In this research, to overcome these limits and simplify the reading of these textual parts, Hypercolorimetric Multispectral Imaging (HMI) [1] was used, for the first time on inks, to achieve high-resolution images with spectral reflectance and colour coordinates for each pixel. This multispectral information, processed by implemented image processing tools, enabled us to increase the legibility and contrast between under- and over-writing. These include the likelihood tool, which generates a pixel-based multispectral similarity map after identifying a small reference area (Figure 1). The method was supported by traditional spectroscopic techniques, including single point and mapping methods such as X-Ray Fluorescence (XRF), Raman, and External Reflection Fourier Transform Infrared (ER-FTIR) spectroscopies, for the chemical and structural characterisation of inks [2-4]. The methodology was firstly tested and validated on laboratory samples, prepared using inks produced according to historical recipes dating from the 15th to 18th centuries (i.e. carbon, iron-gall, and logwood), and then applied to specific cases selected on original manuscripts from the University Library of Pavia (Pavia, Italy).

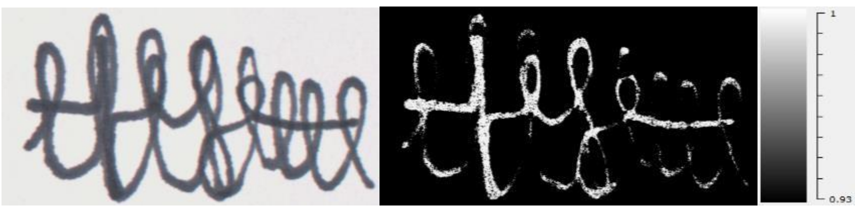


Figure 1. Left: Visible image of a laboratory sample made with two similar logwood inks. Right: Image-processing likelihood tool, areas of higher multispectral similarity within a given threshold, representing the underwriting, are highlighted in white.

References

[1] C. Colantonio et al., Hypercolorimetric multispectral imaging system for cultural heritage diagnostics: an innovative study for copper painting examination, *Eur. Phys. J. Plus* (2018), 133, 526, https://doi.org/10.1140/epjp/i2018-12370-9 [2] M. Bicchieri et al., All that is iron-ink is not always iron-gall, *J. Raman Spectrosc.* (2008), 39, 1074-1078, https://doi.org/10.1002/jrs.1995 [3] M. Albano et al., Toward a better knowledge of Beethoven's creative process through the ink characterization: A noninvasive study of the sketchleaves held at the Civic Library in Bergamo (Italy), *Spectrochim. Acta Part B At. Spectrosc*. (2024), 215, 106929, 1-8, https://doi.org/10.1016/j.sab.2024.106929

[4] F. Volpi et al., Unveiling materials and origin of reused medieval music parchments by portable XRF and ER-FTIR, *Microchem. J.* (2024), 205, 111224, https://doi.org/10.1016/j.microc.2024.111224

Archaeometric Analysis of Cu-Alloys in 1st Millennium BCE Northern Apennines: Exploring Etruscan Settlements and Resource Use

S.M.E. Mangani [*, a], E. Cantisani [b], L. Cappuccini [c], A. Gaucci [d], C. Moscardo [e], C. Trevisanello [d], L. Volpe [b], S. Raneri [f]

[a] Istituto di Chimica dei Composti Organometallici; CNR-Pisa. [b] Istituto di Scienze del Patrimonio Culturale; CNR-Sesto Fiorentino. [c] Dipartimento di Storia, Archeologia, Geografia, Arte e Spettacolo (SAGAS), Università di Firenze. [d] Dipartimento di Storia Culture Civiltà (DISCI), Università di Bologna. [e] Dipartimento di Studi Umanistici, Università Ca' Foscari Venezia. [f] Dipartimento di Scienze della Terra (DST), Università di Firenze.

* Presenting author

simi.mangani@pi.iccom.cnr.it

Numerous metal artifacts of uncertain classification have been discovered in Etruscan contexts. These objects are made of copper alloys and are characterized by various shapes, variable weight, and the absence of distinguishing marks on their surfaces. By the end of the 19th century, the term *aes rude* ("raw bronze") was proposed to describe these items, found in different contexts (sanctuaries, necropolises, inhabited areas; see Pellegrini et al. 2002 [1]), and several functions have been propounded: pre-monetary medium of exchange based on weight, semi-finished trade goods (due to their Cu-Fe composition), or symbolic value in sanctuaries and graves.

In the context of the PRIN 2022 project "APENNINESCAPE. Marginal landscapes and production processes along the Reno and the Bisenzio-Sieve valley districts during the 1st millennium BC" which focuses on Etruscan Apennine settlements, dated to the 6th-4th century BCE, and their production systems, thirty copper alloy samples and eight by-products (slags) were collected from Marzabotto (twenty-two alloys, six slags) and Gonfienti (eight alloys, two possible slags) sites.

The samples were analyzed using a combination of XRF, SEM-EDS, XRD, and lead isotopic analysis in order to:

- Determine the production processes undertaken/employed in both sites.
- Locate the area of origin of raw materials, possibly highlighting the exploitation of local resources and/or links with productions from North Etruria-Po valley (reconstructing so the relationship between available local resources and the Apennine settlements' production systems).

For comparative purposes, an additional set of thirty-three *Aera Rudia* from Padua [2] was also analyzed, along with several raw material samples from the Apennine region.

The preliminary results have revealed significant compositional differences among the various sets of Cu-alloys analyzed, highlighting notable variability in the composition of these artifacts likely related to the use of different raw material sources: Gonfienti samples exhibit higher Fe content, while the Padua samples are richer in Pb. Marzabotto, otherwise, shows a broader compositional variability, with some samples resembling those from Gonfienti and others more similar to those from Padua (and non-negligible Sn concentrations in approximately 50% of the samples).

Reinforcing and expanding the diagnostic campaigns conducted in previous decades [3], these results will contribute to reassess the role of the alloys used and how these may impact production choices in a macro-scale perspective.

References

[1] E. Pellegrini, R. Macellari, I lingotti con il segno del ramo secco. Considerazioni su alcuni aspetti socio-economici nell'area etrusco-italica durante il periodo tardo arcaico (2002), 192, ISBN: 978-88-8147-251-2.

[2] G. Gorini, Tracce di premoneta a Padova: un ripostiglio di Aes Rude, Traces of complexity, studies in hounour of Armando de Guio (2021), 325-337, ISBN: 978-88-99547-52-3.

[3] L. Chiarantini et al., Indagine archeometrica di alcuni resti di lavorazione metallurgica, Marzabotto. La Casa 1 della Regio IV (2010), 2, 439-454, ISBN 978-88-7849-057-4.

Acknowledgements

We acknowledge financial support under the National Recovery and Resilience Plan (NRRP), Mission 4, Component 2, Investment 1.1, Call for tender No. 104 published on 2.2.2022 by the Italian Ministry of University and Research (MUR), funded by the European Union – NextGenerationEU– Project Title APENNINESCAPE: Marginal landscapes and production processes along the Reno and the Bisenzio-Sieve valley districts during the 1st millennium BC – CUP J53D23000300006 - Grant Assignment Decree No. D.D. n. 969 adopted on 30/06/2023 by the Italian Ministry of Ministry of University and Research (MUR).

Spectroscopic methods to disclose manipulations in Geoheritage

M. Veronese (*, a), G. Artioli (a)

(a) Department of Geosciences, University of Padua, Italy

* Presenting author

mauro.veronese.2@phd.unipd.it

Keywords: diagnostic characterization, mineral forgeries, vibrational spectroscopies, UV photography

Natural geological samples, whose presence embellish cabinets of museums worldwide, are rightfully considered as part of cultural heritage thanks to their intrinsic aesthetic value as well as their contribution to historical, symbolical and technological evolution of humankind. In recent years, this long-established relationship has turned towards an economical meaning and the increasing demand of such collectables has promoted forged minerals flood into the market [1]. Numerous approaches have been employed to counterfeit geoheritage specimens, including dyeing, heat and irradiation treatments as well as polymer impregnation [2]. While an extensive body of literature exists on the forgeries of cut and isolated gemstones, there is still limited scientific research addressing the manipulation of uncut euhedral minerals within geological matrices. In this context, it is deemed necessary to characterize such specimens and identify the spurious materials involved in their manipulations, adopting similar strategies to those established in the art and archaeological fields [3]. Therefore, this study presents several case studies involving minerals onto geological matrices, focusing on samples from both contemporary and historical collections. An analytical approach that combines macroscopic optical investigation with vibrational spectroscopies is adopted to identify counterfeit materials. Indeed, whereas digital photographs taken under white light and UV illumination reveal the spatial distribution of spurious phases, vibrational spectroscopies characterization allows to chemically identify such incompatible materials (see Figure 1) [4]. Recognizing these materials is crucial for classifying the historical period of intervention, as different phases are employed extensively at different times.

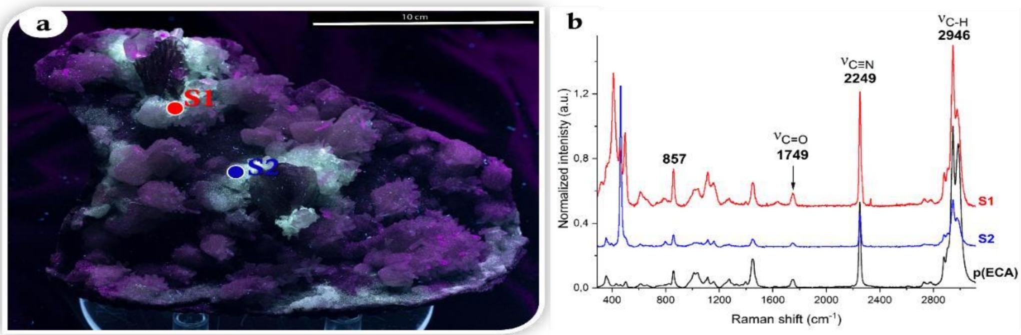


Figure 1: (a) Picture of a modern specimen under UVA light, revealing the distribution of luminescent phase at the interface of basalt matrix and heulandite crystals; (b) μ-Raman spectra excited at 532 nm of micro samples collected at S1, S2 region compared with that of poly (ethyl cyanoacrylate glue (pECA).

References

[1] SF. McClure, CP. Smith, Gemstone Enhancement and Detection in the 1990s, Gems & Gemology (2000), 36, 336–359, doi:10.5741/GEMS.36.4.336

[2] A. Calik, O. Karaca, C. Yasar, EU. Ulugergerli, Fake and Synthetic Minerals; A Way to Sustain the Gem Supply In Environmental Geotechnology, Singapore, Springer Singapore (2019), 319–328, doi:10.1007/978-981-13-70106_30

[3] G. Artioli, Authentication and the Perception of Fakes. Forgeries of Natural Specimens In Beyond Forgery: collecting, authentication and protection of cultural heritage, Padova, Padova University Press (2022), 67-78

[4] ND. Bernardino, CMS. Izumi, DLA. De Faria, Fake turquoises investigated by Raman microscopy, Forensic Science International (2016), 262, 196–200, doi:10.1016/j.forsciint.2016.03.041

Acknowledgements

We sincerely thank Stefano Castelli for photographing the investigated samples, as well as the *Museo della Natura e dell'Uomo* of Padova and its curator, Dr. Simone Molinari, for lending the mineral specimens from the historical collections for this study.

A synergy between archaeological studies and experimental archaeology: the case of a prehistoric bronze dagger from Ripatransone (Ap-Italy)

F. Fazzini [a], G. Roselli [b], S. Campanelli [b,*], F. Milazzo [c], M.Ferretti [d]

([a]) Independent Researcher

([b]) Diagnostic for the conservation and restoration Laboratory, University of Camerino, Via Pacifici Mazzoni 2, 63100, Ascoli Piceno, Italy

([c]) Restorer - ABAP Superintendence Provinces of Ancona and Pesaro and Urbino

([d]) ISPC Institute of Cultural Heritage Sciences CNR Rome
* Presenting author

graziella.roselli@unicam.it

We would like to highlight here the importance of studying the construction techniques of ancient metal artefacts for an increasingly detailed historical understanding of ancient manufactures, using experimental archaeology as an investigation tool in synergy with scientific investigations for a detailed chemical-physical characterization of the materials under study. This is essential to develop scientific protocols to follow during the reproduction experiments of the artefacts, but above all to provide the most accurate description possible of the transformation undergone by the materials during their processing and which can be a discriminating element for the identification of the ancient techniques of bronze casting and processing. In the study of the daggers from the Ripatransone hoard, Dr. Fazzini dealt in 2015 with the technical problems related to the casting and creation of the complex decorations that characterize these artifacts and proposed for their manufacture the use of a particular lost-wax technique with a bivalve matrix, which provides for the presence of geometric decorations already on the wax model. To further investigate this study, a copy of one of the daggers in the hoard was reproduced using this technique and X-ray fluorescence spectroscopy (XRF) and SEM analyses were performed on it to obtain a mapping of the composition of the metal alloy as a function of the processing. High-definition microscopy investigations were also performed on both the original and the reproduction specimens for a careful morphological characterization of the processing signs. Such data can be indicative both for an understanding of the transformations undergone by the metal material and represent a useful tool for identifying the manufacturing technique used for archaeological findings of this type in antiquity. The intention is to provide scientific data that allows us to compare archaeological studies on ancient artefacts with experimental archaeology studies as a tool with great potential for a better understanding of the ancient techniques of working with metallic materials and the composition of alloys used in the past. We hope that the sharing and publication of this information will be progressively enriched over time to create a database available for research, the result of the synergy between classical archaeology and experimental archaeology.

References

[1] F. Fazzini, L'Archeologia Sperimentale e la metallurgia del bronzo in Italia: storia degli studi e problematiche, Archeologie sperimentali. Temi, metodi, ricerche Journal (2020), 01, 100-107, ISSN 2724-2501
[2] F. Fazzini, F. Milazzo 20, Tecnological evidences and traces of use on exemples of preistoric bronze dagger from Ripatransone hoard (AP 2015), Italy in P.Della Casa, E.Deschler-Erb (a cura di), New research on ancient bronzes. Acta of the XVIIIth International Congress on Ancient Bronzes, Zurigo, 3-7 settembre 2013, Zurigo, pp.
55-59.

[3] F. Fazzini, Fibule a sanguisuga: metodi di produzione e decorazione nella prima età del ferro" in ALESSI D., RATTI E. (a cura di) Atti del secondo incontro di studi di archeologia sperimentale. Problematiche e soluzioni tra ricerca e divulgazione, La Spezia, 28 maggio 2017, La Spezia, pp. 52-65.

Development of Smart Procedures for Automated Analysis and Data Integration in the Study of Historical Polychrome Surfaces

I. Ferrara (*, a), P. B. Castellino (a), S. Gallo (a), A. M. Gueli (a), A. Incardona (a), G. Politi (a) and G. Stella (a)

(a) Department of Physics and Astronomy "Ettore Majorana", University of Catania, Via S. Sofia 64, 95123 Catania, Italy
* Presenting author

irene.ferrara@unict.it

The development of "smart procedures" aims to create an intelligent system to support researchers in analysing materials and solving problems related to archaeology and the conservation of historical and artistic heritage. This study has polychrome surfaces as its focus; in fact, datasets of Raman spectroscopic measurements (lasers at 532 nm and 785 nm), spectrophotometric measurements, color analysis and X-ray fluorescence (XRF) were constructed on 100 powder pigments from ©Kremer Pigmente, commonly used in art and historical painting. Data acquisition included a preliminary study of the optimal parameters and experimental conditions for each measurement. The main objective was to develop an automated process for analysing and matching information for faster and more accurate handling and interpretation of the collected data. For Raman spectroscopy, different methods and algorithms were explored for fluorescence background subtraction, normalization and peak recognition for precise chemical-physical characterization. In spectrophotometry, the acquired spectral reflectance curves optimised by smoothing and calculating the first derivative, thereby refining the data quality and reducing noise. The calculation of colorimetric coordinates based on standard and real CIE illuminants allowed the visual characteristics of the pigments to be accurately represented. Finally, the XRF analysis provided identification and a semi-quantitative estimate of the elemental composition of the materials. Automation was achieved via Python scripts, which rapidly integrate and compare complex datasets, thereby offering a comprehensive and scalable solution for the analysis of historical materials. The results present novel perspectives on the application of intelligent systems in the diagnosis and conservation of cultural heritage.

References

[1] R. Vulchi, V. Morgunov, R. Junjuri, T. Bocklitz, "Artifacts and Anomalies in Raman Spectroscopy: A Review on Origins and Correction Procedures", Molecules (2024), 29 (19), 4748, 10.3390/molecules29194748.
[2] V. I. Korepanov, "Asymmetric least-squares baseline algorithm with peak screening for automatic processing of the Raman spectra" Journal of Raman Spectroscopy (2020), 51 (10), 2061-2065, 10.1002/jrs.5952.
[3] A. Gueli, R. Galvagno, A. Incardona, E. Pappalardo, G. Politi, G. Paladini, G. Stella, "Correlation of Visible Reflectance Spectrometry and Portable Raman Data for Red Pigment Identification." Heritage (2024), 7(4), 2161-2175, 10.3390/heritage7040102.
[4] A. Gueli, G. Bonfiglio, S. Pasquale, S. O. Troja, "Effect of particle size on pigments colour", Color Research and Application (2017), 42 (2), 236-243, 10.1002/col.22062.
[5] A. Harth, "The study of pigments in cultural heritage: A review using machine learning", Heritage (2024), 7(7), 3664- 3695, 10.3390/heritage7070174.

Acknowledgements

This research activity was funded by the European Union (NextGeneration EU), through the MUR-PNRR project SAMOTHRACE (ECS00000022) "SiciliAn Micro and nanO TecHnology Research And innovation CEnter" – Innovation Ecosystem (PNRR, Mission 4, Component 2 Investment 1.5, Call n. 3277 del 30-12-2021), Spoke 1 – University of Catania – Work Package 6 Cultural Heritage.

An approach to the *spolia* of Classical and Late Antiquity in the monumental complex of the "Real Alacázar" of Seville

D. Becerra Fernández (*[a]) M. L. Loza Azuaga ([b]),

(a) Universidad de Málaga

([b]) Instituto Andaluz del Patrimonio Histórico

* Presenting author

dbecerra@uma.es

The decoration of the Royal Alcázar of Seville includes a large number of Roman and Visigothic pieces This process of reuse has gone unnoticed by current, compared to other aspects of great importance, such as architectural studies or the sequences of occupation of this important space.

The aim of this paper is to provide an overview of the process of reuse of materials from the Roman and Late Antique world, a process that continues to the present day. In bibliographical overview and

In this study, however, we focus on the presence of marble material [marmora] from Antiquity used in this complex. Antiquity is used in this palace complex, both with an ornamental and functional function, as well as for their value as pieces made during Antiquity.

We also want to show the possible actions for their enhancement or revaluation.

In short, the aim is to present in a synthetic way the most important pieces of spolia and to reflect reasons for their reuse in different spaces and periods.

Reused column shaft in the northwest tower of the "Real Alcázar" of Seville.

References

[1] D. Becerra Fernández, M.L. Loza Azuaga, *Spolia* presentes en conjunto monumental de Sevilla declarado Patrimonio Mundial de la Unesco, *Ciencias sociales, artes y humanismo como contenidos universitarios ("Colección Nueva Academia" - Estudios Aranzadi, n.º 21)* (2022), 101-116.

[2] M.L. Loza Azuaga, G. Restaino, J. Beltrán Fortes, D. Becerra Fernández, Rimpiego di materiali romani nel paesaggio urbano medievale di Siviglia, *Experiencing the Landscape in Antiquity 3. III Convegno Internazionale di Antichistica Università degli Studi di Roma 'Tor Vergata' (British Archaeological Reports, International series n.º 3178)* (2024), 167-172, https://doi.org/10.30861/9781407361550

[3] M.A. Tabales Rodríguez, Investigaciones en la primitiva puerta del Alcázar de Sevilla, *Anuario arqueológico de Andalucía* (1999) 2 (Actividades sistemáticas y puntuales): 195-211.

[4] M.A. Tabales Rodríguez, El Alcázar de Sevilla: reflexiones sobre su origen y transformación durante la Edad Media, *Memoria de Investigación Arqueológica 2000 – 2005* (2010).

[5] M.A. Tabales Rodríguez, E. García Vargas, Las estructuras portuarias del Patio de Banderas del Alcázar de Sevilla y el *emporium* de *Hispalis*. *Archivo Español de Arqueología* (2021), 94: e10. https://doi.org/10.3989/aespa.094.021.10

Acknowledgements

This work is part of the project 'ITALICA ADRIANEA: la Nova Urbs. Análisis arqueológico del paradigma urbano y su evolución, y contrastación del modelo (PID2020-114528GB-I00)' of the 2017-2020 State Plan for the Generation of Knowledge. In addition, Daniel Becerra Fernández has a contract for the incorporation of PhDs from the II Plan Propio de Investigación, Transferencia y Divulgación Científica of the University of Málaga; which has allowed him to develop this research.

Bronze Anthropomorphic Statuette between Sardinia and Etruria: Comparison, Provenance and Trade Networks in the Iron Age Mediterranean

Marta Porcaro (*, a), Caterina Canovaro (b), Gilberto Artioli (b), Barbara Barbaro (c), Rosario Maria Anzalone (d), Mario Mineo (e), Anna Depalmas (f) & Antonio Brunetti (g)

(a) Department of the Earth Sciences, University “La Sapienza” of Rome, Italy

(b) Department of Geosciences, University of Padova, Italy

(c) Soprintendenza Archeologia Belle Arti e Paesaggio per la provincia di Viterbo e per l’Etruria meridionale, Italy

(d) Musei Reali di Torino, 10122 Torino, Italy

(e) Museo Preistorico Etnografico Luigi Pigorini, 00144 Rome, Italy

(f) DUMAS Department, University of Sassari, Italy

(g) Biomedical Sciences Department, University of Sassari, Italy
* Presenting author

marta.porcaro@uniroma1.it

The Nuragic civilization, which flourished in Sardinia between the 18th and 8th centuries B.C., left a significant legacy in bronze metallurgy, evidenced, e.g., by the creation of anthropomorphic statuettes known as *bronzetti*, representing symbolic figures such as warriors, priests, and offerers. The stylistic similarities between these figurines and an anthropomorphic sample found at the Etruscan site of Gran Carro, on Lake Bolsena (VT, Italy), confirm the existence of possible cultural and commercial exchanges between Sardinia and Etruria during the Iron Age [1, 2]. The aim of the research is therefore to make a comparative study between these types of artifacts, and to provide further evidence of the contacts that occurred between the two cultures.

The Nuragic figurines were analyzed using a combination of non-destructive techniques, X-ray fluorescence (XRF) and Monte Carlo (MC) simulation, which allowed their structure and alloy composition to be characterized. The same non-destructive methodology was applied to the Bolsena statuette, on which, however, sampling was also performed to carry out micro-invasive analyses, including Scanning Electron Microscopy coupled with Energy Dispersive Spectroscopy (SEM-EDS), Electron Probe Microanalysis (EPMA), metallography, and Lead Isotope Analyses (LIA). The results obtained from isotopic analysis made it possible to trace the origin of the copper used in the statuette by comparing it with databases on Mediterranean deposits [3-5]. This made it possible to identify the mining district of origin, confirming Sardinia's role as an important center of metallurgical production and exchange and underscoring the trade links between the island and Etruria during the Iron Age.

References

[1] Matta V., and Vandkilde H. "The state of the debate: Nuragic metal trade in the Bronze Age and Early Iron Age." Open Archaeology 9.1 (2023): 20220280. https://doi.org/10.1515/opar-2022-0280

[2] Arancio, M. L., Moretti Sgubini A. M., and Pellegrini E. "Corredi funerari femminili di rango a Vulci nella prima età del ferro: il caso della Tomba dei Bronzetti sardi." Milano: Centro di Studi di Preistoria e Archeologia (2010): 169-213.

[3] Alpine Archeocopper Project, http://geo.geoscienze.unipd.it/aacp/welcome.html

[4] OXALID, Oxford archaeological lead isotope database. http://oxalid.arch.ox.ac.uk

[5] BRETTSCAIFE, https://www.brettscaife.net/lead/data/index.html

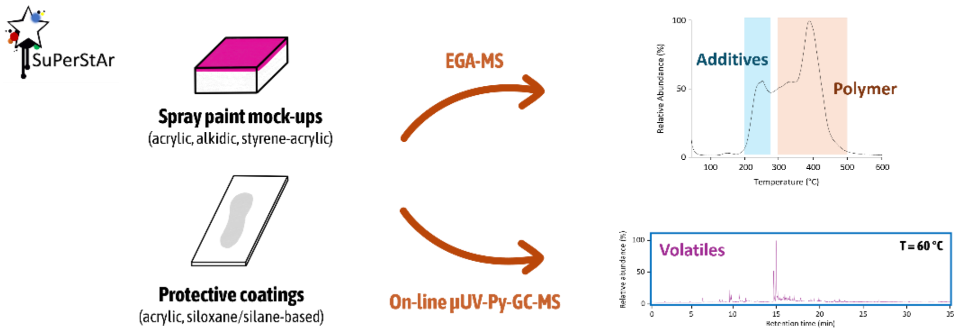
Mass Spectrometry Techniques for Street Art Preservation: The SuPerStAr Project

T. Nacci[*, a], J. La Nasa[a], I. Degano[a], S. Pizzimenti[a,b], F. Modugno[a]

[a] Department of Chemistry and Industrial Chemistry of the University of Pisa; [b] Department of Pharmacy, University of Pisa;
nacci95@hotmail.it

* Presenting author

Preserving urban art has become an emerging conservation concern, as contemporary muralism has gained significant attention from both the public and art historians, highlighting its unique social and cultural value. The open accessibility of murals, combined with their exposure to environmental and human factors, makes them vulnerable to neglect, vandalism, and degradation. However, strategies for their preservation and monitoring remain underdeveloped and challenging to define, primarily due to the complex formulations of modern paints and the diverse degradation processes they undergo, as well as the materials used in their conservation [1]. The durability and effectiveness of protective coatings and anti-graffiti treatments for murals have not yet been thoroughly assessed as well [2]. In this context, micro-analytical techniques based on mass spectrometry play a pivotal role in identifying material composition, assessing conservation risks, and evaluating the performance of modern paints and protective coatings [3]. As part of the PRIN 2020 project *SUPERSTAR: Sustainable Preservation Strategies for Street Art*, paint models and protective coatings subjected to artificial ageing were analyzed using evolved gas analysis-mass spectrometry (EGA-MS) and analytical pyrolysis-gas chromatography-mass spectrometry (Py-GC-MS) to chemically characterize their polymer content and additives. The latter was also coupled with an innovative system for the on-line irradiation in the UV-Vis range of micro-samples through fiber optics (µUV-Py-GC-MS). EGA-MS allowed for the detection of alterations in thermal profiles due to aging, while on-line µUV- Py-GC-MS enabled the identification of volatile compounds released during the degradation of paint materials. This analytical approach was also applied to assess the conservation state of Keith Haring's mural "Tuttomondo" in Pisa.



Pyrolysis-mass spectrometry investigation of materials paint models and protective coatings.

References

[1] Chatzidakis, Street art conservation in Athens: critical conservation in a time of crisis, Stud Conserv 61, 2016, 17, 10.1080/00393630.2016.1201757
[2] Pagnin, at al, Protecting street art from outdoor environmental threats: what are the challenges?, Coatings 13, 2023, 2044, 10.3390/coatings13122044
[3] Degano et al, Recent advances in analytical pyrolysis to investigate organic materials in heritage science, Angew Chem Int Ed 57, 2018, 7313, 10.1002/anie.20171340

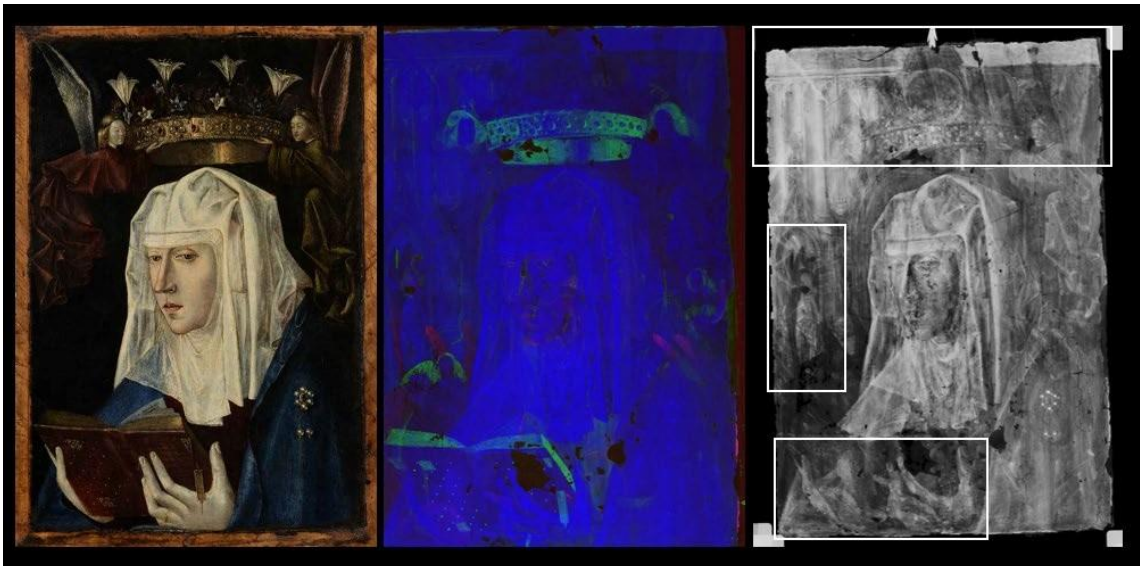
Combined Macro-XRF and X-ray Radiography analysis of Renaissance masterpieces

S. Longo ([*, a, b]), M. Botticelli ([a, b]), C. Miliani ([a]), E.L. Ravan ([a, b]), F. P. Romano ([a, b]), G. Santagati ([a, b]), C. Caliri ([a, b])

(a) Consiglio Nazionale delle Ricerche, Istituto di Scienze del Patrimonio Culturale (CNR- ISPC), Catania, Italy
(b) Istituto Nazionale di Fisica Nucleare, Laboratori Nazionali del Sud (INFN-LNS), Catania, Italy
* Presenting author

sveva.longo@cnr.it

Macro-X-ray fluorescence (MA-XRF) and X-ray radiography (XRR) are complementary, nondestructive techniques extensively utilized in the analysis of paintings. Macro-XRF employs focused beams measuring a few hundred microns (generated through polycapillary optics) to produce highresolution elemental images by scanning the entire painted surface and collecting the fluorescence signals emitted by the atomic species composing the pictorial materials. Conversely, XRR generates images based on the differential absorption of X-rays by materials with varying densities, uncovering hidden structures, compositions, and layers invisible to the naked eye. The integration of Macro-XRF and Digital X-ray radiography provides conservators, art historians and researchers with a deeper and more comprehensive understanding of the original material composition, artist's *modus operandi*, structural details, creative processes and historical context. Recently, the Macro-XRF scanning system and the new XRR platform developed at the XRAYLab of CNR-ISPC (Catania) were employed to conduct a study focused on panel paintings by Renaissance masters. The results that we will present in this work have enhanced our understanding of both the material composition and painting techniques, while also contributing to the reconstruction of the history of these iconic works of art.



From the left: a) The Reading Virgin, attributed to Antonello da Messina (ca 1430-1479); b) Macro-XRF map of Hg-L (red); Fe-K (green) and Pb-L (blue); c) X-ray radiography.

Comparative Ink Analysis of Alessandro Manzoni's Manuscripts through p-XRF and PCA

G. Fiocco (*,a,b), C. Delledonne (a,c), M. Albano (a,b), F. Volpi (a,b), T. Rovetta (a), M. Ferretti (d) C. Lee (a,d), M. Licchelli (d), M. Malagodi (a,b)

(a) Arvedi Laboratory, CISRiC, University of Pavia, Via Bell'Aspa 3, 26100, Cremona

(b) Department of Musicology and Cultural Heritage, University of Pavia, Corso Garibaldi 178, 26100, Cremona

(c) Department of Physics, University of Pavia, Via Agostino Bassi 6, 27100, Pavia, Italy

(d) Department of Chemistry, University of Pavia, Via Taramelli 12, 27100, Pavia

* Presenting author

giacomo.fiocco@unipv.it

I Promessi Sposi was written by Alessandro Manzoni between 1821 and 1842, when the final version called *Quarantana* was published. During this twenty-year period, Manzoni returned to the manuscripts several times by adding, removing, and modifying part of the text (Figure 1). Moreover, in the same years, he drafted other manuscripts (i.e. *Frammenti d'un libro d'avanzo*, *L'Adelchi*, *Storia della Colonna Infame*, *Gli Inni Sacri*) reusing, for a few sections, clippings coming from the papers of the various drafts of *I Promessi Sposi*.
This project is aimed at investigating and compare the composition of inks used by Manzoni in the writing of the drafts of his most important works, supporting Manzoni scholars and experts to deepen and resolve some outstanding doubts concerning the writing of *I Promessi Sposi* and the other works, whose original manuscripts are preserved at the Braidense Library in Milan. To these purposes, portable X-Ray Fluorescence (p-XRF) spectroscopy [1] was performed in-situ to obtain elemental composition of the different inks and papers. The obtained results were processed and further investigated through an unsupervised exploratory multivariate procedure, namely Principal Component Analysis (PCA) [2] to better understand the relationship between all the XRF variables and stand out the sample patterns according to variables' weight in the new reduced space defined by the PC components.

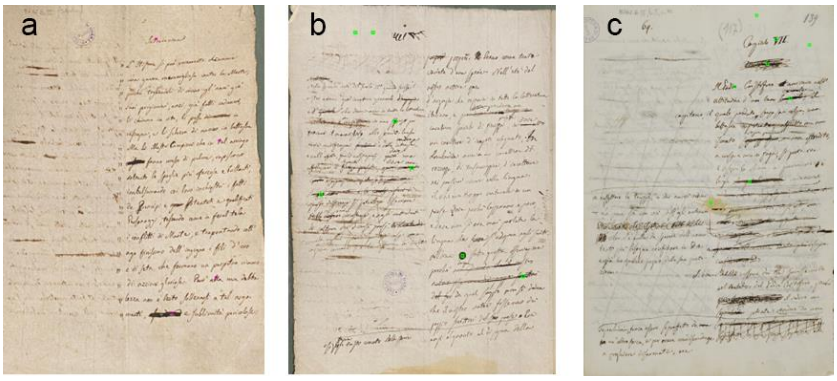


Figure 1. Images of the Introduction (a,b), and Chapter 7 (c) selected by Manzoni for the final version of I Promessi Sposi.

References

[1] M. Albano, G. Fiocco, F. Volpi, C. Delledonne, B. Ardini, C. Mazoni, F. Rovelli, D. Comelli, M. Malagodi, Spectrochimica Acta Part B (2024), 215, 106929, doi: 10.1016/j.sab.2024.106929
[2] M. Bacci, S. Baronti, A. Casini, F. Lotti, M. Picollo,S. Porcinai, MRS Online Proceedings Library (1996) 462, 39–44, doi: 10.1557/PROC-462-39

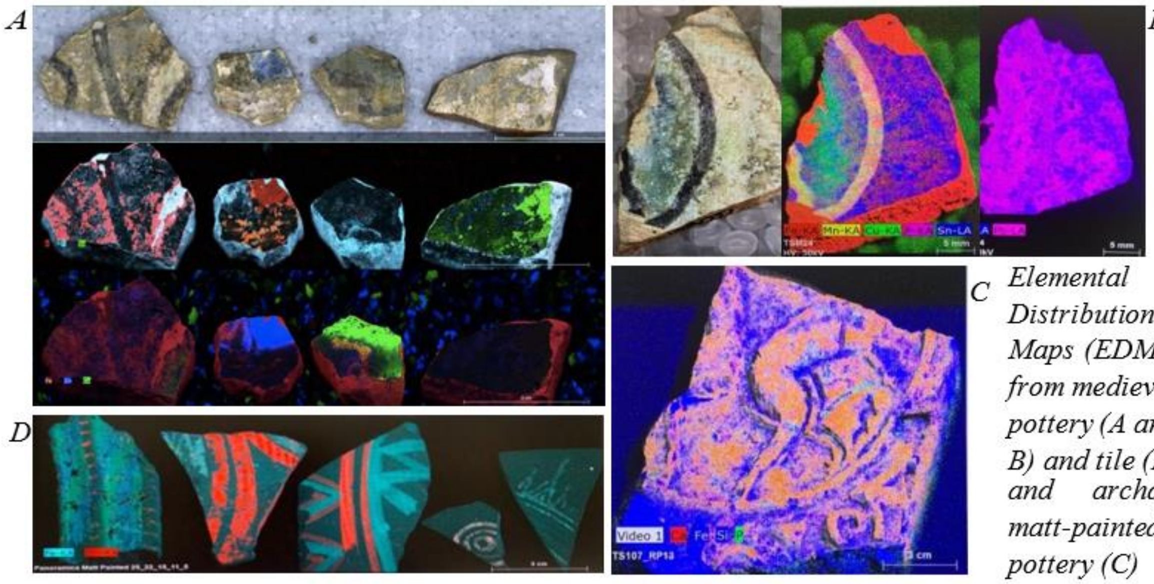
Spectroscopic imaging by micro XRF: a non-destructive methodology to unravel ancient artifact technology and raw materials circulation

P. Di Leo (*,a,b), G. Lubraco (c), L. Medici (a), B. Gargiulo (b), M.C. Di Marsico (b), F. Sogliani (b)

(a) CNR -IMAA, Istituto di Metodologie per l'Analisi Ambientale, Consiglio Nazionale delle RicercheTito Scalo (PZ), 85050, Italy
(b) DIUSS-SSBA, Dipartimento per l'Innovazione Umanistica, Scientifica e Sociale - School of Specialization in Archaeological Heritage, Università della Basilicata
(c) DIRIUM,Department of Humanistic Research and Innovation, University of Bari 'Aldo Moro', Italy;
* Presenting author

paola.dileo@cnr.it; paola.dileo@unibas.it

In the present paper are showed the results of spectroscopic imaging by micro-X-ray fluorescence (μ- XRF) relative to artefacts (ceramic and tiles) from emblematic archaeological contexts in Basilicata region (southern Italy) as innovative, effective and non-destructive diagnostic solutions to answer questions on technology and provenance. A complete information is in fact necessary to understand technological know-how, production areas and commercial relationships (i.e. export/import). The methodology has been implemented as a pilot project in the newly implemented LADA (Laboratory of Diagnostic for Archaeometry) facilities of the IRPAC Infrastructure and funded by the PRIN project MyFORTLAND and takes advantage of the remarkable versatility of μ-XRF as well as its ability to acquire data without destroying the sample, an extremely important aspect in the study of cultural heritage. The methodology is implemented by acquiring many Elemental Distribution Maps (EDMs) for planar and cross section ceramic fragments and tiles using the μ-XRF M4 Tornado (from Bruker) and integrates spectroscopic imaging with spot/area analysis and deep profiling. EDMs are thus calibrated by integrating them with micro-Raman spectroscopy (μ-Raman) and X-ray diffraction (PDXRD and μ-XRD) data. The information derived from the use of the implemented non-destructive methodology on many artefacts allow to characterize artifact coatings and decorations in details so that they can be used as "fossil guide" for technology and raw materials circulation.



Elemental Distribution Maps (EDMs) from medieval pottery (A and B) and tile (D) and archaic matt-painted pottery (C)

Acknowledgements. Funded by the PRIN project MyFORTLAND, 2022EHRJMZ, granted to F. Sogliani. Laboratorio di Diagnostica Archeometrica LADA (Scientific managers F. Sogliani; P. Di Leo), IRPAC Infrastucture - Infrastruttura di Ricerca per il PAtrimonio Culturale.

Validation of 3D Fluorescence Mapping as a Non-Destructive Technique for the Study of Pigments Degradation in Cultural Heritage

S.Porcu1 (*, a), D.Chiriu1 (a)

(a) Department of Physics, University of Cagliari, Cittadella Universitaria, SP n°8, 09042 Monserrato, CA, Italy
* Stefania Porcu

stefania.porcu@dsf.unica.it

In the field of cultural heritage preservation, it is essential to adopt non-destructive techniques to analyze the materials composing historical artifacts. This approach ensures the integrity of these valuable objects while allowing researchers to gather critical scientific information. The purpose of this paper is to validate 3D Fluorescence Mapping as an effective, non-invasive technique for assessing the condition and stability of pigments in artworks and other cultural heritage objects.

The 3D Fluorescence Mapping technique works by exciting the material with varying wavelengths, causing the pigments to emit light at characteristic wavelengths specific to their chemical composition. By analyzing this emission, scientists can gain insights into the material's current state and detect any chemical alterations that may have occurred over time. This technique is particularly advantageous for identifying subtle changes due to environmental factors such as light exposure, humidity, and temperature fluctuations.[1][2][3][4] 3D Fluorescence Mapping can reveal degradation processes like oxidation, fading, and molecular rearrangements, which are often invisible to the naked eye and challenging to detect with more invasive methods.[5]

Validating 3D Fluorescence Mapping as a non-destructive diagnostic technique addresses the need to replace more traditional methods, such as X-ray diffraction (XRD) and Fourier-transform infrared spectroscopy (FTIR).[3] Although effective, these methods often require sampling or are limited in their penetration depth or sensitivity to specific chemical changes. In contrast, 3D Fluorescence Mapping can be applied directly to the surface of an artifact without causing damage or requiring any material extraction.[5] This makes it ideal for the ongoing monitoring of fragile and valuable artworks, as repeated measurements over time do not affect the object’s integrity.

This study specifically explores the application of 3D Fluorescence Mapping on a selection of historically significant pigments and organic dyes. These pigments, known for their vulnerability to degradation under environmental stressors, are ideal candidates for testing the technique's sensitivity and accuracy. The pigments were artificially aged under controlled conditions to replicate common degradation processes such as photo-oxidation and thermal degradation. The luminescence signals from the aged samples were then analyzed and compared with those from unaltered control samples.

In conclusion, this study validates 3D Fluorescence Mapping as a powerful non-destructive tool for examining pigment degradation in cultural heritage objects. Its sensitivity to chemical changes, combined with its ability to provide real-time data without damaging the object, makes it an invaluable addition to the techniques available to conservation scientists. With further refinement, 3D Fluorescence Mapping has the potential to become a standard method for monitoring pigment stability and ensuring the long-term preservation of cultural heritage artifacts.

References

[1] Anaf, W.; Schalm, O.; Janssens, K.; De Wael, K. Understanding the (in)stability of semiconductor pigments by a thermodynamic approach. *Dye. Pigment.* **2015**, *113*, 409–415. https://doi.org/10.1016/j.dyepig.2014.09.015.

[2] 13. Anaf, W.; Trashin, S.; Schalm, O.; Van Dorp, D.; Janssens, K.; De Wael, K. Electrochemical photodegradation study of semiconductor pigments: Influence of environmental parameters. Anal. Chem. 2014, 86, 9742–9748. https://doi.org/10.1021/ac502303z.

[3] Pisu, F.A.; Ricci, P.C.; Porcu, S.; Carbonaro, C.M.; Chiriu, D. Degradation of CdS Yellow and Orange Pigments: A Preventive Characterization of the Process through Pump–Probe, Reflectance, X-ray Diffraction, and Raman Spectroscopy. Materials 2022, 15, 5533. https://doi.org/10.3390/ma15165533.

[4] Paulus, J.; Knuutinen, U. Cadmium colours: Composition and properties. Appl. Phys. A Mater. Sci. Process. 2004, 79, 397–400. https://doi.org/10.1007/s00339-004-2646-6.

[5] Pisu, F.A.; Carbonaro, C.M.; Ricci, P.C.; Porcu, S.; Chiriu, D. Cadmium Yellow Pigments in Oil Paintings: Optical Degradation Studies Utilizing 3D Fluorescence Mapping Supported by Raman Spectroscopy and Colorimetry. Heritage 2024, 7(5), 2426-2443; https://doi.org/10.3390/heritage7050115.

Evaluating The Light-Induced Damage Of Dyed Silk Textiles

L. Geminiani ([*, a, b]), C. Corti ([b, c]), M. Luraschi ([b, d]), L. Rampazzi ([b, e, f])

(a) Department of Science and High Technology, Università degli Studi dell'Insubria, Via Valleggio 11, Como, Italy

(b) Centre for Cultural Heritage Studies, Università degli Studi dell'Insubria, via Valleggio 9, Como, Italy

(c) Servizio Gestione Piattaforme Di Ricerca, Università degli Studi dell'Insubria, Via Valleggio 9, Como, Italy

(d) Museo delle Culture, Villa Malpensata, Riva Antonio Caccia 5, Lugano, Switzerland;

(e) Department of Human Sciences and of Innovation for the Territory, Università degli Studi dell'Insubria, Via Valleggio, 9, Como;

(f) Istituto per le Scienze del Patrimonio Culturale, Consiglio Nazionale delle Ricerche (ISPC-CNR), via Cozzi 53, Milano, Italy

* Presenting author

lgeminiani@uninsubria.it; ludo.gemi@yahoo.it

Silk has always been considered one of the most precious yarn, due also to the rich hues which were obtained after dyeing. In particular, Asian textiles show one of the widest ranges of colours, which were traditionally obtained from a lot of different plants extracts [1]. Different mordants were used to obtain different hues from the same dye too. The present work studies how the various combination of dyes and mordants influence the degradation rate of dyed silk textiles. While the mordant-induced damage is commonly recognized [2], it seems that some dyes can accelerate or slow down the rate of the light-induced degradation, but there is no specific research on this issue. Light damage is not only limited to fading: overexposure can also cause weakening, discoloration, yellowing and embrittlement of the fibre [3].

Raw silk was obtained and underwent a controlled degumming process to eliminate sericin. 4 replicated samples of silk were dyed using traditional recipes and different dyeing bath, to assess the reproducibility of the dyeing conditions. 9 traditional dyes extracted from Asiatic plants were tested with 4 commonly used mordants (alum, potassium tartrate, iron sulphate and tannic acid). Indigo and safflower were also tested as direct dyes. Two sets of dyed silk mock-ups were artificially aged using either UVA or visible light to reproduce and compare the light-induced damage obtained with UVA respect to visible light. A similar set of mock-up samples of raw silk was aged under the same conditions.

UV-Vis reflectance spectroscopy was used to evaluate the colour variations during the accelerated ageing test. A protocol based on attenuated total reflectance and external reflection Fourier-transform infrared spectroscopy [4], X-ray diffraction [5], and thermal gravimetric analysis [6] was used to monitor the degradation extent. Data were manipulated by means of peak fitting analysis and chemometric tools. The crystallinity index was calculated from both X-ray diffraction, and thermal gravimetric analysis, showing a loss of crystallinity as degradation took place. FTIR spectroscopy permitted to study the ageing mechanism.

The results of this research are valuable in order to evaluate the light-induced damage on silk textiles. Some combination mordant/dye are particularly dangerous for the conservation of silk textiles. Thus, the information about the mordant and the dye, which can be obtained through commonly available and portable analytical techniques, can help evaluating the risk associated to the exhibition of particular kind of artifacts and planning the best preventive conservation practices.

References

[1] VV.AA. Color in Ancient and Medieval East Asia. (Dusenbury MM, ed.). Seattle, WA, USA: Spencer Museum of Art, the University of Kansas (USA); 2015.
[2] Timar-Balazsy, A.; Eastop, D. Materials. In Chemical Principles in Textile Conservation; Routledge: New York, NY, USA, 1998; pp. 3–66.
[3] Luxford N. Silk durability and degradation. In Understanding and improving the durability of textiles; Woodhead Publishing Limited: Cambridge UK, 2012; pp. 205-225
[4] Badillo-Sanchez, D., Chelazzi, D., Giorgi, R. et al. Understanding the structural degradation of South American historical silk: A Focal Plane Array (FPA) FTIR and multivariate analysis. Scientific Report, 2019, 9, 17239
[5] Drummy, L. F., Farmer, B. L., Naik, R. R., Correlation of the b-sheet crystal size in silk fibers with the protein amino acid sequence, Soft Matter, 2007,3, 877-882
[6] Gong, D., Zhang, X., Gong, X. Insight Into the Crystallinity of Chinese Ancient Silk by Synchrotron Radiation-Based and Conventional X-ray Diffraction Methods, Journal of Conservation Science 2020;36(1):001-014

Modelling clay materials in art: analytical approaches for disclosing their chemical composition and thermal properties

F. Sabatini ([*, a, b]), A. Nagliero ([a]), V. Comite ([c]), V. Verzoni ([d]), C. Lombardi ([c]), A. Beretta ([d]), S. Caglio ([e]), V. Termopoli ([a, b]), H. Lange ([a, b]), P. Fermo ([c])

([a]) Department of Earth and Environmental Sciences, University of Milano-Bicocca, 20126 Milan (Italy)
([b]) NBFC – National Biodiversity Future Center, 90133 Palermo (Italy)
([c]) Department of Chemistry, University of Milano Statale, 20126 Milan (Italy)
([d]) Scuola di Restauro di Botticino, 20126 Milano
([e]) Department of Material Sciences, University of Milano-Bicocca, 20126 Milan (Italy)

* Presenting author

francesca.sabatini@unimib.it

The denomination of *modeling clays* refers to a class of non-drying materials invented at the end of nineteenth century as an alternative to natural clay or beeswax for sculpture. They group materials of varying composition, including clay or not, evolving over time and across geographical areas. Plasticine, plastilin, plastilina were all products commercialized in that period, in which formulation was tailored to achieve physical and mechanical properties for their intended applications. Their malleability and versatility allowed artists to explore new forms and techniques, using them for both preliminary models and final artworks as attested by the sculpture of Edgar Degas and Auguste Rodin. The composition of a modeling clay generally shows primary components as oil-based clay or synthetic polymers, inorganic fillers, plasticizers, siccative or mineral oil or waxy binders, pigments and additives such as sulfur and preservatives. Given the variety of commercial compositions on the market, the scares information available and the very few studies carried out, the analysis of these complex matrices of organic and inorganic constituents is challenging and requires finetuned multi-analytical approaches.
For this study different modeling clays were selected including plasticine from three manufacturers, DAS®, FIMO® and natural clay. To allow a complete chemical characterization of the heterogeneous and polymeric matrix a combined approach of spectroscopic and separative techniques was carried out. Thus, spectroscopy in the Middle (ATR-FT-IR) and Near Infrared (FT-NIR), Scanning Electron Microscope with Energy Dispersive X-ray Analysis (SEM-EDX) and X-Ray Fluorescence (XRF) were mainly employed for getting information on the inorganic constituents while Pyrolysis coupled by Gas Chromatography and Mass Spectrometry (Py-GC/MS) and GC-MS were applied for assessing the precise composition of organic fraction. Different GC-MS extraction procedures were tested and compared to provide a qualitative and quantitative determination of the lipid components. Moreover, also the volatile molecules of these smelly materials were investigated by means of head space solid phase micro extraction (HS-SPME)-GC-MS. In the end, differences in the thermal properties were revealed amongst the materials thanks to the use of Evolved Gas Analysis coupled with Mass Spectrometry (EGA/MS) which was also determinant in tuning customized Py-GC/MS experiments. Mechanical properties were also evaluated. The data collected provide a thorough description of the selected materials, filling the gap of knowledge on their precise composition and paving the basis of a small database. As a prof of concept of the potentialities of the developed approach, four samples were taken and analyzed from a plasticine maquette of the artwork "Casa Fungo" by Liliana Moro (2004) providing an efficient characterization and identification of the constituting materials and conservation state of this object of Public Art.

Vis-NIR hyperspectral imaging spectroscopy of Italian maiolica colours from Montelupo Fiorentino artifacts (14th-18th century)

Diletta Paghi ([*,a]), Francesca Galluzzi ([b]), Aurélie Mounier ([b]), Simi Maria Emilia Mangani ([c]), Simona Raneri ([a]), Remy Chapoulie ([b]), Marco Benvenuti ([a,d]), Rosarosa Manca ([a])

(a) Dipartimento di Scienze della Terra, Università degli Studi di Firenze, Via La Pira 4, 50121, Firenze, Italy
(b) Archéosciences Bordeaux /UMR 6034 CNRS, Université Bordeaux Montaigne, Maison de l'Archéologie, Domaine Universitaire, Esplanade des Antilles, Pessac Cedex, 33607, France
(c) Istituto di Chimica dei Composti Organometallici (ICCOM - CNR), Via Giuseppe Moruzzi 1, 56124, Pisa, Italy
(d) Istituto di Geoscienze e Georisorse (IGG), CNR, Via Giuseppe Moruzzi 1, 56124, Pisa, Italy

* Presenting author

diletta.paghi@unifi.it

Maiolica (i.e. tin-glazed ceramic artifacts) hosted in museum collections represent a key resource for the study of production techniques and materials and their evolution over the centuries. These objects can be accurately and safely investigated by visible and near-infrared (Vis-NIR) hyperspectral spectroscopy (HSI), as it allows to perform the analysis directly in situ, thanks to the use of portable instrumentation, investigating large areas and a high number of objects with rapid times [1]. Vis-NIR HSI is well-established for the study of colouring materials in paintings, but only a few studies have been conducted on coloured ceramic glazes [1, 2, 3]. Therefore, a specific database on this type of material is currently missing. In this study, the pigments and colourants used in the decorations of fifty sherds of maiolica were analysed through Vis-NIR HSI. These artifacts, dated between the late 14th century and the 18th century, were produced in the important Italian ceramic center of Montelupo Fiorentino (Florence, Italy). The aim was to gain a deeper understanding of the colour palette used in this specific manufacture and to contribute to the creation of a reference dataset on the colours used in tin-glazed ceramics prior to the industrial revolution. In particular, two different imaging devices with different spatial and spectral resolution were employed: the Vis-NIR imager and the ultraportable Specim IQ push-broom hyperspectral camera. The devices provided compatible results, allowing to identify the main chromophore elements responsible for the colours: cobalt for blue, copper for green and turquoise, manganese-iron for purple-brown, iron for red, antimony and-iron for yellow and orange. MA-XRF, SEM-EDS, PIXE-PIGE and micro-Raman analyses conducted on the same set of samples [4] validated the HSI results by confirming the colour composition. The results achieved for the decoration of Montelupo maiolica allowed the construction of a reference dataset that will be useful for future studies on this type of artifacts.

References

[1] C. Sciuto, F. Cantini, R. Chapoulie, C. Cou, H. De la Codre, G. Gattiglia, X. Granier, A. Mounier, V. Palleschi, G. Sorrentino, S. Raneri, What Lies Beyond Sight? Applications of Ultraportable Hyperspectral Imaging (VIS-NIR) for Archaeological Fieldwork, Journal of Field Archaeology (2022), 47(8), 522-535. https://doi.org/10.1080/00934690.2022.2135066
[2] F. Galluzzi, R. Manca, M. Puntin, S. Raneri, C. Sciuto, M. Benvenuti, R. Chapoulie, Maiolica seen by Vis–NIR hyperspectral imaging spectroscopy: the application of an ultraportable camera at the Museo Nazionale del Bargello, The European Physical Journal Plus (2024) 139(7), 629. https://doi.org/10.1140/epjp/s13360-024-05405-7
[3] E. Beauvoit, A. Amara, R. Chapoulie, Q. Lemasson, A multianalytical approach for the study of relief polychrome glazed ceramics (France, 19th century), J. Archaeol. Sci. Rep. (2023), 51, 104-176. https://doi.org/10.1016/j.jasrep.2023.104176
[4] S. M. E. Mangani, Archaeometric study of Montelupo Maiolica, PhD Thesis in Chemical Sciences, 36th cycle, University of Florence (2023)

Acknowledgements

The Archaeological Superintendence of Florence and the Museo della Ceramica of Montelupo Fiorentino are acknowledged for providing the ceramic samples involved in this study.

Technological connections among Sicily, Apulia, and the Tyrrhenian coast: human mobility and knowledge transmission from an archaeometric viewpoint

Annarosa Mangone (*[a,b]), Patrizia Davit ([c]), Marco Serino ([d]), Diego Elia ([d]), Lorena Carla Giannossa ([a,b]), Claudia Biscotti ([a]) and Monica Gulmini ([c])

([a]) Dipartimento di Chimica, Università degli Studi di Bari Aldo Moro, Via Orabona 4 – 70125 Bari

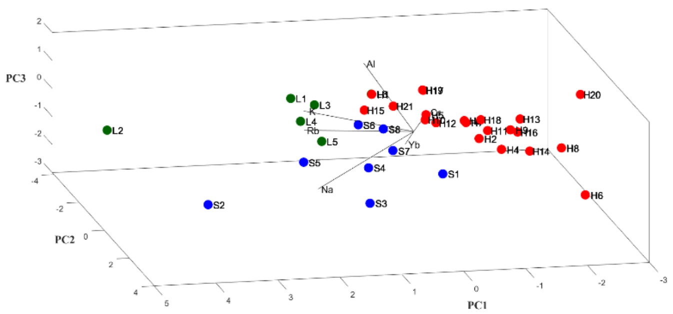
([b]) Laboratorio di Ricerca per la Diagnostica dei Beni Culturali, University of Bari “Aldo Moro”

([c]) Dipartimento di Chimica, Università di Torino, Via Giuria, 7 – 10125 Torino

([d]) Dipartimento di Studi Storici, Università di Torino, Via Sant’Ottavio 20 – 10124 Torino

annarosa.mangone@uniba.it

Recent studies of the emergence of red-figure pottery in Sicily in the late fifth century BC reveal a fragmented yet dynamic artisanal landscape, with workshops catering for different sub-regional markets and exhibiting notable mobility. Fragments of red figure pottery found at some of the most relevant archaeological sites in Sicily - namely Himera, Lipari, and Syracuse - have been examined by optical and electron microscopy (SEM-EDS), powder X-ray diffraction (PXRD) and atomic spectroscopy (ICP-OES and LA-ICP-MS) to better define the technological affinities and differences between various South Italian figurative productions. Analyses were performed on both the ceramic body and black gloss. The results allow us to distinguish between imported Greek and locally produced vases. Through compositional differences and other aspects related to the production technology belonging to a group of vessels coming from the same archaeological site, it is also possible to confirm the existence of multiple production centres in Sicily, providing a better characterization and identification of certain local productions and their technological procedures.



Scores and loadings diagram for the first three principal components related to the ceramic body of Lipari (green), Syracuse (blue), Himera (red) red figure pottery. The accounted variance is 83% of the total variance.

References

[1] A. Mangone, L.C. Giannossa, A. Ciancio, R. Laviano and A. Traini, Technological features of Apulian red figured pottery, J. ARCHAEOL. SCI., 35 (6), 1533-41, (2008), doi.org/10.1016/j.jas.2007.10.020.

$CdS_{1-x}Se_x$ pigments: multidisciplinary study on the materials of the XIX-XX c. painters

J. Orsilli [*, a, b], A. Galli [a], S. Caglio[a], C. Ferrara[a], F. d'Acapito[b]

(a) Department of Materials Science, University of Milano-Bicocca, U5, Via Roberto Cozzi, 55, Milano 20126, Italy

(b) CNR - Istituto Officina dei Materiali (IOM), c/o ESRF LISA CRG, Avenue des Martyrs 71, Grenoble 38000, France

* Presenting author

jacopo.orsilli@unimib.it

The analysis of paintings can be very complex as they are composed of a great number of materials. To create their piece, the artists mix and juxtapose different pigments (organic and inorganic) which are blended with a binder and covered with varnish. Then, the good or bad conservation of the paintings will affect the aging of the materials and their photochemical alteration [1–4]. When studying these artifacts, the lack of reference materials and the need to understand how the mixing of different materials affects the aging process require (I) the analysis of samples taken from the painting, or (II) the preparation of mock-up samples, and the correlation of the data collected on these samples with those collected on the artistic artifact. However, if only non-invasive analysis can be applied, only the second method can be followed.

The study here we propose has started with the analysis of the famous painting *'Quarto stato'* by the Italian painter Giovanni Pellizza da Volpedo, at the beginning of the XX century. We focused on the characterization of the yellow and red pigments used by the artist (and by many contemporary artists, such as van Gogh, Munch, Matisse, and Picasso…). Indeed, $CdS_{1-x}Se_x$[5, 6] is a family of pigments highly appreciated by artists of the late XIX and early XX centuries thanks to their vibrant hues and excellent covering power.

In this work, we will show the results of the characterization of a full set of $CdS_{1-x}Se_x$ pigments with the application of different non-destructive spectroscopic techniques i.e. combined macro XRF-Reflectance Spectroscopy (RS), punctual-XRF, XRD, XAS on the S, Cd (K and L_3) and Se-edges.

References

1. G. Van der Snickt, J. Dik, M. Cotte, K. Janssens, J. Jaroszewicz, W. De Nolf, J. Groenewegen, and L. Van der Loeff, Anal. Chem. **81**, 2600 (2009).
2. F. Assunta Pisu, P. C. Ricci, S. Porcu, C. M. Carbonaro, and D. Chiriu, Materials **15**, 5533 (2022).
3. M. Ghirardello, V. Gonzalez, L. Monico, A. Nevin, D. MacLennan, C. S. Patterson, M. Burghammer, M. Réfrégiers, D. Comelli, and M. Cotte, Microsc. Microanal. 1 (2022).
4. L. Monico, F. Rosi, R. Vivani, L. Cartechini, K. Janssens, N. Gauquelin, D. Chezganov, J. Verbeeck, M. Cotte, F. d'Acapito, L. Barni, C. Grazia, L. Pensabene Buemi, J.-L. Andral, C. Miliani, and A. Romani, Eur. Phys. J. Plus **137**, 311 (2022).
5. R. J. Traill and R. W. Boyle, Am. Mineral. 40, 555 (1955).
6. J. Wu, K. Li, X. Xu, Y. Zhang, X. Xu, and X. Lao, J. Wuhan Univ. Technol.-Mater Sci Ed 30, 1247 (2015).

The stable isotope analysis to investigate the "way of life" of ancient community of Pompei

C. Lubritto (*,[A]), V. Giacometti[(A)], N. Mantile[(A)], S. Altieri[(A)], M. R. Di Cicco[(A)], C. Cocozza[(B)], S. Soncin[(C),] M. A. Tafuri[(C)], C. Comegna[(D)], C. Corbino[(D)], V. Amoretti[(D)], G. Zuchtriegel[(D)]

[a]Department of Environmental, Biological and Pharmaceutical Sciences and Technologies, University of Campania "Luigi Vanvitelli" & MAReA Centre, Via Vivaldi 43, 81100 Caserta, Italy
[b]Max Planck Institute for GeoAnthropology, Kahlaische Str. 10, Jena 07745, Germany
[c]Department of Environmental Biology, Sapienza Università di Roma & MAReA Centre, Piazzale Aldo Moro 5, 00185 Roma, Italy
[d]Laboratory of Applied Research, Archaeological Park of Pompeii, Via Plinio 26, 80045 Pompei, Italy

* Presenting author

carmine.lubritto@unicampania.it

The study of food practices in historical communities provides a large quantity of information about the social, cultural, political, religious, technological, and environmental aspects of a specific site within a given timeframe
In this paper we present the results of a multidisciplinary research, in which, using different innovative methodology of isotopic mass spectrometry, the "way of life" of people of the ancient community of Pompei is analyzed.
In detail we present stable C and N isotope results from faunal and botanical remains from Pompeii, with the aim to provide new direct evidence for the local production or importation of food sources, reflecting on the management strategies of crops and animals adopted by the Romans in a time and location of rapid economic growth.
In addition to measuring isotopic baseline and ratios in human individuals we present high resolution methodologies employed at iCONa Laboratory[2] of the MAReA Centre - University of Campania, such as sequential analysis of primary dentin and measure carbon and nitrogen isotopic ratios in amino acids (CSIA-AA). This methodologies provides insights into the health status during the early years of life, including the effects of breastfeeding, and allows us to hypothesize about an individual's dietary sources and health, focusing on the relationships between adaptation to available resources and socio-economic choices. When integrated with anthropological and paleopathological analyses, it offers a comprehensive osteobiography, detailing the individual's life from infancy to death.
A final goal of this work is to initiate a dissemination activity that permits to add a new experience to view Pompei cultural heritage based on scientific methodologies

[2] https://www.icona-lab.it/ www.mareacentre.org

An EPR study of the marbles from ancient quarries to archaeological site of Hierapolis in Phrygia (Turkey): A contribution to the provenance assessment of materials with close relationships

S. Vettori ([*, a]), E. Cantisani ([a]), T. Ismaelli([a]), G. Scardozzi([b]), A. Buccianti([c]), F. Di Benedetto([a, d])

(a) Institute of Heritage Science, National Research Council of Italy (ISPC-CNR), via Madonna del Piano 10, Sesto Fiorentino, 50019 Florence, Italy

(b) Institute of Heritage Science, National Research Council of Italy (ISPC-CNR), via Monteroni, 73100 Lecce, Italy

(c) Department of Earth Sciences, University of Florence, Via G. La Pira, 4, Florence, Italy

(d) Department of Physics and Earth Science, University of Ferrara, via Saragat 1, 44122 Ferrara, Italy

* Presenting author

silvia.vettori@cnr.it

The analytical and spectroscopic discrimination of marbles coming from quarries used in historical times is a task object of a wide interest in archaeometric investigations. This task is even more difficult, when the goal of the provenance assessment is focused on marbles coming from historical quarries located in a close geographic area.

The results of a systematic Electron Paramagnetic Resonance (EPR) spectroscopy study are used, in combination with data of isotope geochemistry and petrological observation, to define criteria able to discriminate, firstly, the provenance of 47 marble samples from 5 quarries (i.e. Marmar Tepe, Gölemezli Hierapolis-Gök Dere, Thiounta and Denizli) located in the Denizli region (south-western Anatolia, Turkey) that in Hellenistic and Roman period provided building materials for the nearby city of Hierapolis of Phrygia (Turkey). The results of the experimental investigation, processed through robust compositional statistical techniques, provide evidence of a good discriminating ability of the proposed approach [1].

With the same approach, 65 marble samples, taken from the buildings of Hierapolis of Phrygia (i.e. Necropolises, North Agora, Sanctuary of Apollo Building A and Stoa of the Springs), have been investigated. The results, still in progress, are promising and it was possible to attribute the provenance of the archaeological materials to the ancient quarries in the surroundings of Hierapolis, in the Denizli Basin, improving the accuracy and reliability of previous studies.

References

[1] S. Vettori, E. Cantisani, T. Ismaelli, G. Scardozzi, A. Buccianti, F. Di Benedetto, An EPR study of the marbles from quarries of the Denizli region (Turkey): A contribution to the provenance assessment of materials with close relationships, Microchemical Journal (2024), 202, 110802-110810, https://doi.org/10.1016/j.microc.2024.110802.

Dating the Terme della Rotonda: Addressing Challenges in Stratified and Reused Materials Using SG-OSL Techniques

R. Galvagno[1*], C. Lahaye[2], M. Liuzzo[3], G. Margani[4], R. Reitano[1], G. Stella[1], C. Tardo[4], P. Urbanová[2], A.M. Gueli[1]

[1]Department of Physics and Astronomy "Ettore Majorana", University of Catania, Via S. Sofia 64, 95123 Catania
[2]Archeosciences-Bordeaux UMR 6034, CNRS-Université Bordeaux Montaigne, Esplanade des Antilles, 33607 Pessac, France
[2]Civil and Environmental Engineering, University of Enna "KORE", Cittadella Universitaria, 94100 Enna [4]Civil and Environmental Engineering, University of Catania, Via S. Sofia 64, 95123 Catania *
Presenting author rosaria.galvagno@phd.unict.it

This study presents the preliminary results of research conducted on the Terme della Rotonda, a significant Roman thermal site in Catania, as part of the PNRR Samothrace Project.
The Terme della Rotonda, built as Roman baths in the 1st–2nd centuries AD, later became the Byzantine church of "Santa Maria della Rotonda" [1]. Over time, it was reused as a necropolis and noble church before being hidden by urban expansion. Restoration between 2004 and 2008 reopened the site, highlighting its cultural and historical significance [2].
In this study, Single Grain Optically Stimulated Luminescence (SG-OSL) technique was applied to mortars with a focus on addressing the challenges arising by partial bleaching of quartz grains due to uneven heating in areas exposed to hot air circulation. Depending on the sampling location, whether from heated zones or cooler areas, it is possible to determine either the baths' final period of use or their initial construction [3].
The SG-OSL measurements were conducted using a Risø TL/OSL DA-20 reader, equipped with a bialkali photomultiplier tube (EMI 9235QB) and a Hoya U-340 filter for photon detection. Artificial β irradiations were carried out with a ^{90}Sr-^{90}Y source, and a 532 nm laser was used for single-grain stimulation at 125°C. These measurements enable accurate and reliable dating of the mortars. To determine the archaeological dose, the luminescence signals from individual quartz grains, sized 200–250 μm and extracted from mortars, were measured using the single-grain technique. A SAR protocol was applied to the aliquots to obtain the Equivalent Dose (ED) distributions. The identification of well-bleached grains, reset to zero during mortar preparation, was achieved through statistical analysis of equivalent dose distributions. Different models were used, such as the Central Age Model (CAM), Minimum Age Model (MAM) or the Internal-external consistency criterion (IEU) [4-6].
Preliminary results from this research will be presented, demonstrating the effectiveness of SG-OSL techniques in addressing dating challenges associated with stratified and reused materials in complex historical sites.

References

[1] F. Giordano, *La Rotonda. Mito e verità di un tempio catanese*, Edizioni Greco (1997), Catania.
[2] M.G. Branciforti, C. Guastella, *Le Terme della Rotonda di Catania*, Regione Siciliana (2008), Palermo.
[3] A.M. Gueli, M. Liuzzo, G. Margani, S. Pasquale, G. Politi, G. Stella, *An interdisciplinary approach for the investigation and dating of Roman thermal buildings: the Indirizzo Baths at Catania*, Sicily, TEMA (2021), 7(1), 43-66. https://doi.org/10.30682/tema0701e.
[4] R.F. Galbraith, G.M. Laslett, *Statistical Models for Mixed Fission Track Ages*, Nuclear Tracks and Radiation Measurements (1993), 21, 459–470. https://doi.org/10.1016/1359-0189(93)90185-C.

[5] R.F. Galbraith, R.G. Roberts, H. Yoshida, *Error Variation in OSL Palaeodose Estimates from Single Aliquots of Quartz: A Factorial Experiment*, Radiat. Meas. (2005), 39, 289–307. https://doi.org/10.1016/j.radmeas.2004.03.023.
[6] K.J. Thomsen, M. Jain, L. Bøtter-Jensen, A.S. Murray, H. Jungner, *Variation with Depth of Dose Distributions in Single Grains of Quartz Extracted from an Irradiated Concrete Block*, Radiat. Meas. (2003), 37, 315–321. https://doi.org/10.1016/S1350-4487(03)00006-4.

Micro-Computed Tomography and micro-Laser Ablation to assist Ion Beam Analysis in lapis lazuli provenance investigation: methodology and application to beads from Ur (Mesopotamia, 3rd millennium BCE)

M. Magalini (*, a), L. Guidorzi (a,b), A. Re (a,b), F. Tansella (a,b), F. Picollo (a,b), S. Sturari (a,b), P. Aprà (a) G. Herrmann (c), R. Law (d), Q. Lemasson (e,f), L. Pichon (e,f), B. Moignard (e,f), C. Pacheco (e,f), A. Lo Giudice (a,b)

(a) INFN Sezione di Torino, Via Pietro Giuria 1, Torino, Italy

(b) Dipartimento di Fisica, Università di Torino, Via Pietro Giuria 1, Torino, Italy

(c) University College London (UCL) Gower Street, London, WC1E 6BT, UK

(d) Department of Anthropology, University of Wisconsin, 5240 Sewell Social Sciences Building, 1180 Observatory Drive, Madison, USA.

(e) Centre de Recherche et de Restauration des Musées de France, C2RMF, 14 quai François Mitterrand, Paris, France

(f) UAR 3506 Lab-BC (CNRS, Ministère de la Culture, Chimie ParisTech), 14 quai François Mitterrand, Paris, France

* Presenting author

marta.magalini@to.infn.it

Lapis lazuli is a semi-precious blue stone, used since the VII millennium BCE for the manufacturing of small carved artifacts (such as jewels, decorative and votive objects) in the Ancient Middle East and in part of Central and Southern Asia (current Turkmenistan, Afghanistan, and Pakistan). This work presents an upgrade to the methodology adopted to investigate the provenance of the raw lapis lazuli material developed by the University of Torino in the past years [1,2]. Samples from archaeological excavation contexts frequently display superficial degradation processes affecting the crystals of the mineral phases useful for provenance attribution (especially pyrite). To address this issue, an innovative workflow has been developed, centred on the application of X-ray micro-computed tomography (μ-CT) and micro-cleaning treatments with a pulsed laser source prior to investigation with Ion Beam Analysis (IBA) [3]. High-resolution μ-CT is employed to evaluate the alteration state of pyrite crystals within the entire volume of the lapis lazuli rock, and, if required, to identify the most suitable crystals on the surface for subsequent laser treatment. The micro-cleaning procedure aims to create a small breach in the superficial altered layer (the irradiated areas are ~65 × 65 μm^2), thereby exposing the preserved crystal beneath and allowing for the analysis of its trace element contents with IBA. The methodology of the workflow is presented, together with its first application to archaeological lapis lazuli material: three precious beads from the ancient Royal Cemetery of Ur (Mesopotamia, 3rd millennium BCE). The results are complemented by the application of a provenance protocol already validated that proved, for the first time using a micro-invasive analytical approach, a match between the Afghan quarry district and the raw material used to carve these beads. Data obtained in this study will be useful to develop new protocols in the framework of CoMAR project.

References

[1] A. Lo Giudice et al, Archaeol. Anthropol. Sci. 9 (2017) 637–651. https://doi.org/10.1007/s12520-016-0430-0
[2] L. Guidorzi et al, Eur. Phys. J. Plus 138(2), 175 (2023). https://doi.org/10.1140/epjp/s13360-023-03768-x
[3] M. Magalini et al, Micro-Computed Tomography and Micro-laser ablation on altered pyrite in lapis lazuli to enhance provenance investigation: a new methodology and its application to archaeological cases, Eur. Phys. J. Plus, accepted for publication

The study of Pompeian pigments. A glimpse into ancient Roman colouring materials

Celestino Grifa ([a,b]), Chiara Germinario ([a]), Sabrina Pagano ([a,c]), Andrea Lepore ([a,c]), Alberto De Bonis ([b,d]), Mariano Mercurio ([a, b]), Vincenzo Morra ([d]), Gabriel Zuchtriegel ([e]), Sophie Hay ([e]), Domenico Esposito ([f]), Valeria Amoretti ([e])

[a]Department of Science and Technology, University of Sannio, Benevento, Italy
[b]CRACS, Center for Research on Archaeometry and Conservation Science, Naples, Italy
[c]Department of Science of Antiquities, Sapienza University of Rome, Rome, Italy
[d]Department of Earth Sciences, Environment and Resources, University of Naples Federico II, Naples, Italy
[e]Archaeological Park of Pompeii, Naples, Italy
[f]Institute of Classical Archaeology, Freie Universitat, Berlin, Germany

* Presenting author

celestino.grifa@unisannio.it

Pigments played a vital technological role by enabling the development of advanced artistic techniques, preserving cultural heritage through durable materials like frescoes and facilitating innovations in early chemistry, such as the creation of synthetic colouring compounds.

This contribution presents pigments from some exceptional Pompeian contexts spanning the 3rd century BCE to the 79 CE eruption covering an ancient painter's entire palette. Most of them are preserved in their original pots that, in the last decades, have attracted the interest of researchers, who performed studies mainly aimed at identifying the main colouring compounds. Some of them were unearthed during the more recent excavations performed at the archaeological site of Pompeii, representing an absolute novelty.

Their composition has been revealed thanks to a non-invasive analytical approach designed to preserve these invaluable archaeological resources, illuminating that the artists skillfully mixed the colouring materials to achieve the desired hues. Digital microscopy, coupled with spectroscopic techniques (Fiber Optics Reflectance Spectroscopy in the visible range, portable X-Ray Fluorescence spectroscopy, Fourier Transform Infrared Spectroscopy in Attenuated Total Reflectance, Raman spectroscopy), revealed that the ancient palette was made of natural and synthetic pigments of inorganic and organic nature.

Quantifying any individual colouring compound enabled a review of recipes as reported by ancient sources and modern scientific literature and opened new scenarios in the artistic process that likely started in the *pigmentarium*. Moreover, advances were made to digitally replicate and reconstruct the original colours of Pompeian frescoes, taking advantage of colourimetric data and percentages of individual colouring compounds.

In the analysis of the mixtures, the role of Egyptian blue and red lead in the variation of shades, which are almost ubiquitous as additional components in paint mixtures, is worth noting, unveiling a "cutting edge" technology in the mixing of pigment compounds.

Only in one case were we forced to collect a micro-sample for a deeper investigation, which led us to discover a new pigment mixture. One of the samples, in fact, uncovered the earliest known use of a light green compound containing baryte and alunite, providing the first definitive evidence of barium sulfate being utilised in the Mediterranean during ancient times, previously known only from the 18th century.

Absolute and Relative Dating Challenges of Mortars from Public Buildings in Pompeii

S. Calandra ([*, a]), M.M.N. Franceschini ([b,c]), G. Casa ([b]), T. Ismaelli ([c]), E. Cantisani ([c]), C. Conti ([d]), S. Barone ([e,f]), L. Liccioli ([e]), M. Fedi ([e])

([a]) Department of Earth Sciences, University of Florence, 50121 Florence, Italy.

(b) Department of Ancient Studies, Sapienza University of Rome (UNIROMA1), 00185 Roma, Italy

(c) Institute of Heritage Science (ISPC), National Research Council (CNR), 50019 Sesto Fiorentino, Italy

(d) Institute of Heritage Science (ISPC), National Research Council (CNR), 20125 Milano, Italy

(e) National Institute of Nuclear Physics, Unit of Florence, 50019 Sesto Fiorentino (Fi), Italy

(f) Department of Physics and Astronomy, University of Florence, 50019 Sesto Fiorentino (Fi), Italy

* Presenting author sara.calandra@unifi.it

A multidisciplinary archaeometric study was carried out on bedding mortars from public buildings in Pompeii (e.g., Eumachia Building, Temple of Apollo, and Macellum) to identify raw materials and construction technologies, and to assess the feasibility of radiocarbon dating. Mortars were characterized to understand construction strategies before and after the 62 CE earthquake, with a focus on post-earthquake restoration techniques and the influence of the selected materials on relative dating [1]. Petrographic, mineralogical, chemical and geochemical analyses were performed using techniques such as OM, SEM-EDS, XRPD, TGA, ATR-FTIR, and micro-Raman spectroscopy. These revealed that the binders came from Mg-rich limestones, probably from the Monti Lattari, while the aggregates were compatible with Somma-Vesuvius products. The hydraulic properties were obtained by mixing lime with pozzolanic materials, which contributed to the complexity of the material and the difficulties in dating. Samples with suitable minero-petrographic characteristics were selected for further characterization of binder or lump powders (using non-destructive techniques, XRPD, OMCL, ATR-FTIR, micro-Raman, SEM-EDS, according to [2]). Radiocarbon dating of lump and binder fractions by AMS, after CO_2 extraction by dissolution line combined with Lilliput graphitization reactors. Most samples yielded anomalously older ages, with the exception of two that were consistent with their archaeological context. The study highlights the variability of Pompeian mortar production over time and the complexity of radiocarbon dating in such materials. However, these data pave the way to understanding the nature of the material and its influence on the dating results.

References

[1] M. M. N. Franceschini, G. Casa, S. Calandra, T. Ismaelli, C.Grifa, M. Mercurio, E. Cantisani, Raw materials and building technologies in the public buildings of Pompeii after the earthquake of 62/63 CE: A diachronic analysis of mortars, *Case Studies in Construction Materials* (2024), *21*, e03943. https://doi.org/10.1016/j.cscm.2024.e03943

S. Calandra, E. Cantisani, C. Conti, *et al,* A new multi-analytical procedure for radiocarbon dating of historical mortars, *Sci Rep* (2024) **14**, 19979. https://doi.org/10.1038/s41598-024-70763-2N.

Acknowledgements

The authors wish to thank A. Russo, G. Scarpati, V. Amoretti, G. Zuchtriegel of the Archaeological Park of Pompeii.

A sustainable and promising approach based on the use of magnesium hydroxide nanoparticles dispersed in aqueous medium for wood deacidification treatments

V. Daniele ([*, a]), C. Mondelli ([b]), G. Chaumat ([c]), L. Arrizza ([d]), O. Spadaro ([e]), G. Taglieri ([a])

(a) Department of Industrial and Information Engineering and Economics, University of L'Aquila, 67040 Monteluco di Roio (AQ)

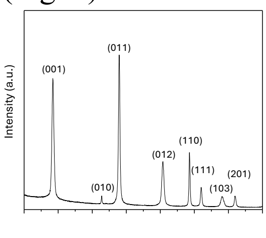
(b) CNR-IOM-OGG, Institut Laue Langevin 71 Avenue des Martyrs 38042 Grenoble Cedex 9 France

(c) ARC-Nucleart CEA, 17 Avenue des Martyrs 38054 Grenoble Cedex 9

(d) Microscopy Centre, University of L'Aquila, Via Vetoio, 67100 Coppito (AQ), Italy ([e]) Spadarocalce 1886 Srl, Via dell'Industria 2, 67100 L'Aquila (AQ), Italy

Corresponding Author: valeria.daniele@univaq.it

Alkaline nanoparticles (NPs) dispersed in no aqueous medium have been frequently employed to neutralize acidity in wood samples and to provide an alkaline reserve inside the wood. Nevertheless, despite the promising results obtained on small wooden artefacts, to date a satisfactory solution to extend the use of alkaline NPs on large-scale deacidification treatments has not still been found, mainly due to intrinsic limitations of the synthetic routes involved [1]. At the University of L'Aquila, we developed an innovative synthetic procedure, based on an ion-exchange process [2], to produce magnesium hydroxide (MH) NPs for wood deacidification treatments on an extensive scale. This method represents a versatile, sustainable and cost-effective route, acting in water and starting from cheap or renewable reactants. Following this method, we can obtain, in a single-step and in only 60 minutes, almost 10 kg/week of pure and crystalline MH NPs (Fig.1), by working at ambient conditions of pressure/temperature, guaranteeing low environmental impact and a high yield of NPs production. In addition, the use of water as a solvent is vital for large-scale applications, avoiding the use of volatile organic compounds, harmful for the environment and for human health.
We examined the deacidification efficacy of the produced MH NPs on archeological wood samples coming from a Gallo-Roman shipwreck [3]. From the results obtained, the pH of the treated acidified samples changed from acid (pH □ 1,6) to almost neutral (pH □ 6,7), underling the fundamental rule of MH NPS in the deacidification process. Moreover, the treatment does not alter the chromatic features of the surface. Finally, as concerns the penetration of the treatment into the volume of the samples, from SEM-EDX microanalysis, the presence of Fe, S, and traces of Mg was detected, and the mapping of Mg confirmed a homogeneous distribution of MH NPs throughout the whole depth of the samples (Fig. 2).



10 20 30 Angle (2 Theta)40
50 60 70 80

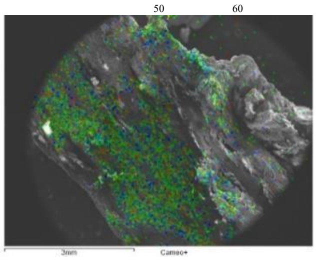


Figure 1. *XRD pattern of MH dry powders. Bragg peaks are indexed by Miller notation.*

Figure 2. *SEM-EDX image showed the penetrations of MH NPs inside the sample, following the Mg mapping.*

References

[1] Schofield, E.J.; Sarangi, R.; et al. Nanoparticle deacidification of the Mary Rose, Materials Today 2011, 14, 354-358.
[2] Volpe, R.; Taglieri, G.; Daniele, V.; Del Re, G. A process for the synthesis of $Ca(OH)_2$ nanoparticles by means of ionic exchange resin. European patent EP2880101 (2016).
[3] Taglieri, G.; Daniele, V.; Macera L.; et al. "Sustainable Nanotechnologies for Curative and Preventive Wood Deacidification Treatments: An Eco-Friendly and Innovative Approach", Nanomaterials 10, 1744 (2020)

Biopolymeric membranes: eco-friendly solutions to preserve the Baroque stone heritage of Val di Noto in south-eastern Sicily (Italy)

M. Cirone ([*, a, b]), N. Rovella ([a, b]), M.F. La Russa ([a]), C.M. Belfiore ([c]), Á. Török ([d]), F. Galiano ([b]), D. Bellizzi ([a]), R. Mancuso ([e]), B. Gabriele ([e]), M. Taverniti ([f]), S.A. Ruffolo ([a]), A. Figoli ([b])

(a) Department of Biology, Ecology and Earth Sciences, University of Calabria, Via P. Bucci Cubo 12/B, Arcavacata di Rende (CS), 87036, Italy

(b) Institute on Membrane Technology, CNR-ITM, Via P. Bucci Cubo 17/C, Arcavacata di Rende (CS), 87036, Italy

(c) Department of Biological Geological and Environmental Sciences, University of Catania, Corso Italia 57, 95129, Catania, Italy

(d) Department of Engineering Geology and Geotechnics, Faculty of Civil Engineering, Budapest University of Technology and Economics, Hungary

(e) Laboratory of Industrial and Synthetic Organic Chemistry (LISOC), Department of Chemistry and Chemical Technologies, University of Calabria, Via P. Bucci Cubo 12/C, Arcavacata di Rende (CS), 87036, Italy

(f) Institute of Informatics and Telematics, CNR-IIT, Via P. Bucci 17/C, Arcavacata di Rende (CS), 87036, Italy

* Presenting author

martina.cirone@unical.it

The Baroque built heritage of Val di Noto (south-eastern Sicily, Italy) is renowned for its unique decorative architecture. Unfortunately, these monuments are affected by biodeterioration and degradation processes which cause the development of many decay forms such as efflorescence, alveolization, differential erosion, granular disaggregation, flaking, and exfoliation. Recent studies dealt with sustainable, low-toxicity antimicrobial solutions to protect damaged surfaces.

In this work, the focus is on three types of calcarenite, i.e. Comiso, Modica and Ragusa stones, used in many historical buildings of the Val di Noto. The investigation involved two main tasks: a) the detailed characterisation of the stones and b) the synthesis of eco-friendly membranes. Through targeted analyses, the mineralogical composition, the textural features and the physico-mechanical properties of the three limestones have been studied to better understand their different responses to degradation. The investigations included: i) optical microscopy observations, ii) X-ray diffraction analysis (XRD); iii) water absorption tests; iv) measurement of the ultrasonic velocity; v) uniaxial compressive strength, vi) flexural strength, and vii) elastic modulus. Additionally, accelerated aging tests by salt crystallization have been also carried out.

At the same time, experiments have been conducted to develop biopolymeric membranes, based on Polylactic acid (PLA) and essential oils (limonene, thymol, menthol), and consequently assess their antimicrobial properties. Analyses by means of Fourier-transform infrared spectroscopy (FTIR) and Nuclear Magnetic Resonance spectroscopy (NMR) confirmed the ability of membranes to incorporate and release natural biocides, suggesting their suitability to develop optimized formulations. Additional analyses for the characterization of membranes included: mechanical tests, contact angle measurements and scanning electron microscope (SEM) observations.

Future research steps will attempt to evaluate in situ membranes stability, their interaction with the underlying stone, and the antimicrobial efficacy on historic surfaces.

Sustainable Hydrogels for Cleaning Procedures: Incorporating Tannins into *in-situ*-Borax Crosslinked KGM Polymers

E. Verni (*, a, b), F. Sabatini (b, c), C. Lee (a, d), G. Fiocco (a, e), M. L. Weththimuni (d), B. Vigani (f), H. Lange (b, c, g), M. Malagodi (a, c), F. Volpi (a, e)

(a) Arvedi Laboratory of Non-Invasive Diagnostics, CISRiC, University of Pavia, 26100 Cremona, Italy
(b) Department of Earth and Environmental Sciences, University of Milano-Bicocca, 20126 Milan, Italy
(c) NBFC – National Biodiversity Future Center, 90133 Palermo (Italy)
(d) Department of Chemistry, University of Pavia, 27100 Pavia, Italy
(e) Department of Musicology and Cultural Heritage, University of Pavia, 26100 Cremona, Italy
(f) Department of Drug Sciences, University of Pavia, 27100 Pavia, Italy
(g) Biochemical Process Engineering, Division of Chemical Engineering, Department of Civil, Environmental and Natural Resources Engineering, Luleå University of Technology, SE-971 87 Luleå, Sweden

* Presenting author

eleonora.verni@unipv.it

Hydrogels are promising means to effectively combine moistening characteristics with adsorption of various types of dirt on delicate wooden surfaces, both in form of inorganic or organic particulates as well as in form of grease, soil, sweat, etc. When basing such hydrogels on polymers derived from lignocellulosic biomass waste, both material compatibility and environmentally friendly disposal are guaranteed.

Konjac glucomannan (**KGM**) is a long-chain polysaccharide recognized for its biodegradability and non-toxic nature. Its high water absorption and retention capacity make it an ideal candidate for the development of such innovative hydrogel systems for cleaning of delicate wooden surfaces.[1]

This study focuses on optimizing **KGM**-based hydrogels crosslinked using borax, generated *in-situ* from the reaction of boric acid and sodium hydroxide (NaOH). The resulting hydrogels exhibited uniform crosslinking, with modifications to their microstructure, which enhanced water retention capacity, tensile strength and extensibility, with respect to **KGM**-based hydrogels crosslinked with regular borax.[1] Further improvement of the hydrogel matrix was achieved by incorporating tannins, which sustainably provided additional strength to the crosslinking system. Two types of tannins were assessed: condensed tannins from *Vitis vinifera* (***Vv***) and hydrolysable tannic acid (**TA**) derived from oak.[2] Tannins were integrated either via physical bonding or through the use of epichlorohydrin (**ECH**) to covalently link tannins, **KGM**, and borax. Hydrogels with physically bonded tannins exhibited increased hydrophilicity, enhanced mechanical strength, and reduced deformability. Tannin-functionalized hydrogels further demonstrated improved solvent release control, tensile strength, and hardness.

Among the systems developed, the most effective formulation to be promisingly applied for cleaning purposes was the **KGM**-based hydrogel crosslinked with *in-situ* borax and reinforced with **TA** functionalized via **ECH**. This hydrogel showed overall convincing cleaning performances while being also from a materials perspective the intereting candidate.

The use of hydrogels generated on the basis of lignocellulosic polymers is thus a promising way to foster sustainability also in the area of cleaning means for delicate wooden surfaces.

New oil in water bio-hybrid system stabilised by nanomaterials: Cellulose Nanocrystals

M. R. Caruso([*,a]), O. Gómez Laserna([b]), G. Cavallaro([a]), F. Caruso([c]), G. Lazzara([*,a]), M. Maguregui ([c])

([a]) Department of Physics and Chemistry "Emilio Segrè", University of Palermo, Viale delle Scienze, Ed. 17 Stanislao Cannizzaro, 90128 Palermo, Italy. Mariarita.caruso02@unipa.it

(b) Department of Analytical Chemistry, Faculty of Science and Technology, University of the Basque Country UPV/EHU, Barrio Sarriena s/n, 48940 Leioa, Spain.

(c) Department of Analytical Chemistry, Faculty of Pharmacy, University of the Basque Country UPV/EHU, Paseo de la Universidad 7, 01006 Vitoria-Gasteiz, Spain.
* Presenting author

The removal of varnish layers in art conservation is a highly complex and challenging process. Any new solution proposed for the removal of these organic coatings must ensure the absence of any residual of the potential for progressive and controlled cleaning action. Recently, pickering emulsions (Pes) have emerged as a safer alternative to conventional surfactant-based emulsions in many fields, also in art conservation, offering controlled and effective cleaning of artworks [1-2]. The nanometric version of cellulose, the most abundant biopolymer on Earth, has been identified as effective stabilizers for oil-in-water (o/w) PEs [3]. This study explores the use of cellulose nanocristals (CNCs) in stabilizing PEs for the removal of aged natural resin varnishes from canvas paintings. Sustainable solvents like ethyl acetate were incorporated as environmentally friendly alternatives to traditional petroleum-based solvents in the o/w PEs. The research examined the effects of CNCs concentration and oil-to-water ratios on the formation, stability, size, and viscosity of PEs. Rheological studies, zeta potential analysis, and dynamic light scattering measurements complemented these investigations. The effectiveness of the most promising formulations was evaluated on canvas paintings, using optical observations and colorimetric analysis to monitor the removal process. The results highlight the efficacy of CNCs as stabilizers in forming ethyl acetate-based o/w PEs. CNCs concentration significantly influenced particle behavior at the o/w interface, affecting the hydrodynamic radius of nanoparticles and PE stability. The stable formulations effectively removed aged varnish layers, with ethyl acetate proving particularly suitable within the PE system when optimized oil-to-water phase ratios were used. These promising results provide the foundation for developing tailored PE solutions for various varnish types and painting supports. This approach offers a versatile and environmentally conscious approach for art conservation.

References

[1] Ming, L., et al., Evolution and critical roles of particle properties in Pickering emulsion: A review, Journal of Molecular Liquids, 2023, https://doi.org/10.1016/j.molliq.2023.122775.

[2] Cavallaro, et al., Pickering Emulsion Gels Based on Halloysite Nanotubes and Ionic Biopolymers: Properties and Cleaning Action on Marble Surface, ACS Applied Nano Materials, 2019, DOI: 10.1021/acsanm.9b00487.

[3] Chuye Ji, Yixiang Wang, Nanocellulose-stabilized Pickering emulsions: Fabrication, stabilization, and food applications, Advances in Colloid and Interface Science, Volume 318, 2023, https://doi.org/10.1016/j.cis.2023.102970.

Acknowledgements

This work has been supported by grant TED2021-129299A-I00, funded by MICIU/AEI/10.13039/501100011033 and by the European Union NextGenerationEU/PRTR, by PON "Research and Innovation" 2014-2020, Asse IV "Istruzione e ricerca per il recupero", all'Azione IV.5 "Dottorati su tematiche green". DM 1061/2021, by the University of Palermo and by European Union—Next Generation EU (PRIN 2022 PNRR—NANOEURO project—Cod. B53D23025300001) and by Project MML-ARCH - "Metodologie di machine learning applicate all'archeometria: una nuova frontiera per l'interpretazione materica dei Beni Culturali", Programma "CHANGES Cultural Heritage Active iNnovation for Sustainable Society" CUP B53C22003890006 - Codice Identificativo PE_00000020, finanziato dall'Unione Europea – Next Generation EU sui fondi PNRR MUR – M4C2 – Investimento 1.3 "Partenariati estesi a Università, centri di ricerca, imprese e finanziamento progetti di ricerca.

Sustainable protective coatings for metal objects: innovative materials from waste and renewable sources

F. Boccaccini, A. Barbetta, E. Messina, M. Pascucci, C. Riccucci, G. Di Carlo (*)

Institute for the Study of Nanostructured Materials (ISMN), National Research Council (CNR), SP35d, 9, 00010 Montelibretti (Rome), Italy

* Presenting author

gabriella.dicarlo@cnr.it

The conservation of cultural heritage objects is typically based on the use of protective materials that can hinder degradation processes. Different strategies can be used to protect unique and valuable objects. Among them, the application of new active protective coatings has received increasing attention [1-2].

Recently, in the framework of the European GREENART project, our activities have been mainly addressed to the design and development of new effective and safe solutions based on sustainable materials and methods for the long-term conservation of metal artefacts (e.g. copper and silver alloys). To this purpose, biopolymers obtained from renewable natural sources or from the recycling of waste products (e.g. fish industry waste, cellulosic materials) are used. Their protective properties are optimized by adding specific fillers and additives to prolong their effectiveness over time. Our research efforts have been addressed to materials that can provide long-lasting protection, while preserving the aesthetic features of artworks. This activity, aimed at the protection of modern and archeological objects, is carried out in strict collaboration with conservators from museums and from the Italian Ministry of Culture.

Moreover, representative mock-ups were selected and prepared to reproduce modern polished surfaces and the most common naturally grown and artistic patinas to be used for the laboratory validation of the new protective materials.

From fish waste to highly transparent solutions and coatings

References

[1] C. Giuliani, M. Pascucci, C. Riccucci, E. Messina, M. Salzano de Luna, M. Lavorgna, G.M. Ingo, G. Di Carlo, Chitosan-based coatings for corrosion protection of copper-based alloys: A promising more sustainable approach for cultural heritage applications, Progress in Organic Coatings (2018), 122, 138, doi.org/10.1016/j.porgcoat.2018.05.002

[2] F. Boccaccini, C. Giuliani, M. Pascucci, C. Riccucci, E. Messina, M.P. Staccioli, G. Di Carlo, Toward a Green and Sustainable Silver Conservation: Development and Validation of Chitosan-Based Protective Coatings, International Journal of Molecular Sciences (2022), 23, 14454, doi.org/10.3390/ijms232214454

Acknowledgements

This work was financially supported by the Horizon Europe research and innovation program under the research project GREENART (GA: 101060941).

Fostering resilience and sustainable territorial development through cultural heritage: lesson learnt from citizen engagement initiatives within RESTART and SIRIUS projects

S. Fiorentino ([*, a]), M. Vandini ([a]), A. Mecozzi ([a]), G. Paggi ([b]), A. Casini ([b])

(a) Department of Cultural Heritage, University of Bologna - Ravenna Campus
(b) Emilia Romagna Region – Regional Agency for Territorial Security and Civil Protection

* Presenting author

sara.fiorentino2@unibo.it

A growing body of research stresses the role that cultural heritage plays in promoting disaster risk reduction, highlighting the necessity of developing a heritage-driven resilience [1-5]. Studies on disasters and cultural heritage frequently concentrate on how vulnerable heritage is to disasters and how to protect it from environmental, social, and geophysical threats [6-8]. However, heritage may also help communities become more resilient by, for instance, diversifying sources of income, fostering social bonds, and incorporating local knowledge of prior disasters. Heritage can be viewed as a more dynamic phenomena that may be used as a useful resource by communities to deal with shocks, strains, and other disruptions [9-10].
RESTART and SIRIUS projects are promoting citizen awareness actions to support, on a local scale, a strategic and sustainable vision of participatory conservation and safeguarding, encouraging an active role of citizens in heritage protection processes [11-12]. The contribution will present two initiatives organized on the European Researchers' Night 2024 in collaboration with *Io Non Rischio*, the public communication campaign of the Civil Protection Department which aims to increase awareness of territorial risks, promoting responsible actions to prevent them or reduce their effects [13]. The *Guardians of Monuments*, dedicated to children, stimulated, through interactive play, a reflection on the culture of prevention, reasoning together on conscious behaviours to adopt to protect ourselves and our heritage in emergency situations. For adults, the *Urban trekking of monuments at risk* led to the discovery of the natural and anthropic risks that affect the territory of Ravenna, relating them to the most representative cultural places of the city. Last, the contribution will discuss the outcome of a cycle of scientific aperitifs *Between Past and Present: images and dialogues on cultural heritage*, which actively involved the Ravenna residents through participation in a dedicated photographic contest.
Each initiative will be considered also as a generator of social impact, since every activity examined how risk factors and historical-artistic environment interact, emphasising the need of preserving heritage as a means of fostering social solidarity and elevating local identity. Strengthening citizen involvement through efforts that promote knowledge of the Regional Agenda 2030 Strategy in their respective spheres of life is one way to observe the primary impacts on the territory and citizenship [14].

References

[1] C. Costantino, A. Calleo, A.C. Benedetti, C. Bartolomei, G. Predari, Fostering Resilient and Sustainable Rural Development through Nature-Based Tourism, Digital Technologies, and Built Heritage Preservation: The Experience of San Giovanni Lipioni, Italy. Sustainability (2024), 16(13), 5588-5613, doi:10.3390/su16135588.

The restoration of the polychrome wooden Crucifix of the Chapel of the *SS. Crocifisso* of the Church of *Sant'Anna la Misericordia* in Palermo (Sicily)

A. Tumminello (*, a), M. F. Alberghina (b), E. Messina (c), S. Schiavone (b)

(a) Freelance art conservator, A.R.T. di Tumminello Antonella, via Ferla 14, 90015, Cefalù (PA), Italy (b) S.T.Art-Test di S. Schiavone & C sas, via Stovigliai, 88 93015 Niscemi (CL), Italy.

(b) Assistant conservator - via Pietragrossa 29bis, 90015, Cefalø (PA), Italy.

* Presenting author

antonella.tumminello@libero.it

The paper presents the results of the restoration works carried out on the polychrome wooden Crucifix of the Chapel of the *SS. Crocifisso* in the Church of *Sant'Anna la Misericordia* in Palermo (Sicily); an artwork attributable to the typology of the Living Christ. The intervention allowed for an in-depth historical-artistic and technical-material study that contributed to attributing with greater certainty the crucifix to the sculptor Gaspare Di Miceli, active in the 17th century. Digital direct Radiography *in situ* investigation allowed to investigate the artistic technique of the sculpture, with particular reference to the complex system of the mobile tongue, a rare and technically sophisticated element. Furthermore, the restoration of the turtle shell-covered cross represented a significant challenge, leading to the development and application of an innovative technique for the mimetic reintegration of the precious covering, using compatible materials that guarantee respect for the original and the reversibility of the intervention.

Photographic documentation of the before and after the restoration; frontal X-ray view of Christ's face and plastic and pictorial reconstruction of the tortoiseshell covering.

This project has been configured not only as an intervention to safeguard, but also as an opportunity to enhance an important example of sacred art, deepening knowledge of it and promoting its valorization involving the general public.

References

[1] A cura di T. Pugliatti, S. Rizzo, P. Russo, *Manufacere et scolpire in lignamine.* Scultura e intaglio in legno in Sicilia tra Rinascimento e Barocco,. Giuseppe Maimone Editore, 2012.

[2] C. Baracchini, G. Parmini (a cura di), *Scultura lignea dipinta. I materiali e le tecniche,* Studio Per Edizioni Scelte – Firenze 1996.

D. Graham and T. Eddie, "X-Ray techniques in art galleries and museums".

What factors can affect lead corrosion processes in indoor museum environments? Case studies in historical collections at the University of Palermo

M.R. Carotenuto ([*,a]), A.Agliolo Gallitto ([a]), G.Cavallaro ([a]), I.Chinnici ([b]), G.Lazzara ([a])

(a) Department of Chemistry and Physics "Emilio Segrè", University of Palermo, Italy
(b) National Institute for Astrophysics (INAF) – Astronomical Observatory of Palermo, Italy

* Presenting author

mariarosalia.carotenuto@unipa.it

Lead, due to its extensive historical usage in scientific instruments, is a common material in museum collections. Its degradation poses notable challenges, particularly in composite objects where it interacts with other materials. Volatile organic compounds (VOCs) emitted by materials used for displaying and storing artifacts, combined with inappropriate humidity and temperature conditions, can trigger severe degradation processes affecting both the lead and the materials in contact with it [1–3]. This study investigates the issue of lead corrosion, focusing on the role of acetic and formic acids, through case studies from the Historical Collections of Physics and Chemistry Instruments at the University of Palermo. Significant damage was observed mainly in instruments where lead was in contact with wood and brass. A monitoring program was recently started using lead coupons as corrosion dosimeters, prepared according to ISO 11844 standards to assess air corrosivity within the enclosures [4]. Analytical techniques, including X-ray fluorescence (XRF) and X-ray diffraction (XRD), identified corrosion products such as plumbonacrite, hydrocerussite, and cerussite, providing insights into the underlying degradation mechanisms. Preliminary results highlight that acid emissions and microclimate conditions in the Chemistry collection display cases create more aggressive conditions than those in the Physics collection, as evidenced by greater colorimetric changes (ΔE) in lead coupons. By examining case studies and air quality tests, the study aims to identify the key factors driving lead corrosion in museum environments, providing a basis for developing targeted preventive conservation strategies to mitigate further deterioration and protect cultural heritage.

References

1. O. Chiantore and T. Poli, Indoor Air Quality in Museum Display Cases: Volatile Emissions, Materials Contributions, Impacts, Atmosphere (2021), 12, 364, doi:10.3390/atmos12030364
2. J. Tetreault et al., Corrosion of Copper and Lead by Formaldehyde, Formic and Acetic Acid Vapours. Stud. Conserv (2003), 48, 237–250, doi:10.1179/sic.2003.48.4.237
3. M.T. Molina et al., Corrosion Risk to Metal-Based Artefacts in a Scientific and Technical Museum: An Assessment of Environmental and Exhibition Conditions, Materials (2023), 16, 4239, doi:10.3390/ma16124239
4. M. Kouril et al., Lead Corrosion and Corrosivity Classification in Archives, Museums, and Churches, Materials (2022), 15, 639, doi:10.3390/ma15020639.

Acknowledgements

This work was financially supported by Project MML-ARCH - "Metodologie di machine learning applicate all'archeometria: una nuova frontiera per l'interpretazione materica dei Beni Culturali", Programma "CHANGES Cultural Heritage Active iNnovation for Sustainable Society" CUP B53C22003890006 - Codice Identificativo PE_00000020, finanziato dall'Unione Europea – Next Generation EU sui fondi PNRR MUR – M4C2 – Investimento 1.3 "Partenariati estesi a Università, centri di ricerca, imprese e finanziamento progetti di ricerca.

Preserving color and printed materiality: impact of low-temperature plasma on modern inks and pigments during disinfection treatment of paper-based artifacts

M. Vieri de Mitri Fernández (*, a,b), R. Giorgi (c) , B. Salvadori (b) & C. Riminesi (b)

(a) Department of Science of Antiquities, University of Rome La Sapienza, Piazzale Aldo Moro 5, Roma

(b) National Research Council, Institute of Heritage Science, Via Madonna del Piano 10, Sesto Fiorentino (FI)

(c) Department of Chemistry "Ugo Schiff", University of Florence, Via della Lastruccia 3, Sesto Fiorentino (FI)

* Presenting author

marina.vieridemitri@uniroma1.it

In a context where adherence to ecological principles and health protection is essential, the use of new physical technologies for dry cleaning in cultural heritage conservation becomes necessary. In the realm of surface cleaning and disinfection, methods that effectively eliminate biodeteriorationcausing microorganisms while preserving substrate integrity and minimizing eco-toxicological impact are particularly valued. Among these emerging technologies, plasma for microbial decontamination has garnered attention in recent years, extending its applications beyond the medical field to the conservation of heritage materials, such as paper. Although research in this field is still limited, initial results are promising [1, 2]. Nevertheless, the existing literature offers scant insight into the secondary effects in its entirety, encompassing not only the alterations occurring within the paper matrix itself but also the potential repercussions on the diverse materials constituting paperbased artifacts [3]. In this context, the present study examines the interactions between cold plasma — specifically a pure argon-oxygen mixture — and the inks and pigments present on modern paper to thoroughly assess whether microbial decontamination can be achieved without compromising the integrity and properties of these materials. To fulfill this purpose, mock-ups consisting of pigments of known composition applied to different artificially aged paper substrates, as well as 19th-century journals, books, and paper-based substrates — thus, each containing distinct inks and pigments — have been initially subjected to an extensive analysis. The selected analytical techniques, including hyperspectral imaging (HSI), FT-IR spectroscopy, and optical microscope, have been employed both prior to and following plasma treatment. The findings provide valuable insights into optimizing plasma treatment for effective paper conservation strategies, ensuring the safe application of this technology while preserving the materiality of the legacy of past generations imprinted on paper.

References

[1] D.E. Rusu, L. Stratulat, G. Ionid, A.M.Vlad, Cold High-Frequency Plasma Versus Afterglow Plasma in the Preservation of Mobile Cultural Heritage on Paper Substrate, IEEE Transactions on Plasma Science, (2020), 48(2), 410– 413, 10.1109/TPS.2020.2970227

[2] R. Jiao, F. Sun, S. Zeng, J. Li, Application of low-temperature plasma for the conservation of cultural heritage: A brief review, Journal of Cultural Heritage (2023), Vol. 63, pp. 240–248, 10.1016/j.culher.2023.08.009

[3] K. Vizárová, B. Kaliňáková, R. Tiňo, I. Vajová, K. Čížová, Microbial decontamination of lignocellulosic materials with low-temperature atmospheric plasma. Journal of Cultural Heritage (2021), 47, pp. 28–33, 10.1016/j.culher.2020.09.016

Preventive conservation in action: microclimatic monitoring of heritage sites to mitigate indoor and outdoor climate-induced risks

L. Guidorzi ([*, a,b]), S. E. Favero-Longo ([c]), M. Morando ([c]), M. Cicardi ([c]), G. Rao Torres ([c]), S. Ferrarese ([a,b]), D. Bertoni ([a]), Alessandro Re ([a,b]), A. Lo Giudice ([a,b]), S. Guion ([d]), D. Elia ([d]), M. B. Failla ([d])

([a]) Dipartimento di Fisica, Università di Torino – Via Pietro Giuria 1, Torino, Italy
(b) INFN Sezione di Torino – Via Pietro Giuria 1, Torino, Italy
(c) Dipartimento di Scienze della Vita e Biologia dei Sistemi, Università di Torino – Viale Pier Andrea Mattioli 25, Torino, Italy
(d) Dipartimento di Studi Storici, Università di Torino – Via S. Ottavio 20, Torino, Italy * Presenting author

laura.guidorzi@unito.it

In recent years, society has increasingly recognized the relevance of preventive conservation, as it is a proactive approach aimed at mitigating risks to Cultural Heritage and ensuring its long-term preservation. Unlike remedial or restorative conservation, it focuses on non-invasive measures that minimize deterioration before it occurs, preserving the integrity and authenticity of artefacts, monuments and collections. This multidisciplinary practice involves the identification, assessment and management of environmental, biological and human-induced factors threatening cultural assets.

In this framework, the PNRR-PE5 CHANGES project aims at further understanding the degradation mechanisms of heritage materials induced by climate changes, to support the development and definition of monitoring strategies and preventive conservation guidelines for heritage items at risk of deterioration. The studies carried out within the project, and specifically in Spoke 6, are comprehensive of several types of monitoring (e.g. air quality, temperature, humidity, biological activity), from which the parameters for guidelines will be extrapolated. Both indoor and outdoor environments are taken into account, where temperature and relative humidity are the first factors being evaluated. In the King Apartment in Palazzo Reale (Turin, Italy) a microclimatic study, involving the measurement of the main quantities in 23 different sites at different levels, started in May 2024 and is still ongoing. The identification of the conditions inside the apartment at its current state of disuse will pave the way for guidelines to follow in the event of a future public fruition for exhibition purposes. A different situation is investigated in the House of the Ancient Hunt in Pompeii (VII,4,48), where the lithobiontic (re-)colonization on the wall surfaces exposed to atmospheric agents is evaluated cross-comparing the photosynthetic activity of the lithobionts with the variations of surface temperature assessed via passive thermal imaging. Surfaces representative of the different lichen communities, and others hosting mosses and phototrophic biofilms, are seasonally monitored with the aim to establish microclimatic thresholds to be set for future preventive interventions and to recognize the surfaces exceeding these limits.
First results from both measuring campaigns will be presented, reporting the preliminary indicators found as useful for CHANGES guidelines.

Acknowledgements

The PNRR - Partenariato Esteso 5 project "CHANGES: Cultural Heritage Active Innovation for Next-Gen Sustainable Society" Spoke 6: history, conservation and restoration of Cultural Heritage is acknowledged for financial support.

BIO-DUST: a green product for 3D printing

L. Medeghini ([*, a]), V. Stagno ([a]), F. Carfì Pavia ([b]), S. Lima ([b]), S. Racioppi ([c]), G. Gasperuzzo ([c]), A. Antonacci ([c])

(a) Department of Earth Sciences, Sapienza University of Rome, Rome, Italy

(b) Chemical Engineering Department, Università di Palermo, Palermo, Italy

(c) Institute of Crystallography, National Research Council, Department of Chemical Sciences and Materials Technologies, Monterotondo, Rome, Italy

* Presenting author

laura.medeghini@uniroma1.it

The aim of BIO-DUST (BIO-circular 3D printable prodUctS for cultural heritage) project is to produce a new green material for 3D printing, starting from waste. This product could be used to fill in missing pieces of statues, to reproduce copies of artworks in the exhibition itinerary or in museum shops and will be important for educational purposes in an idea of wide accessibility and inclusive perspective. Indeed, by reintegrating touch and other senses into cultural experiences, we can improve accessibility and engagement for individuals with learning difficulties, children, the elderly, and the visually impaired.

In a sustainable perspective, BIO-DUST will be synthetized mixing phosphates from food industry waste with algal-derived polysaccharides, to create safe, green and nontoxic compounds. During the first phases, particular attention has been given in the selection of green methods both for preparation of inorganic fraction from waste materials as well as in the extraction of microalgal polysaccharide mixtures.

Hydroxyapatite and bone char have been synthesized starting from eggshells, mollusc shells and animal bones from food waste, using different procedures. Parameters such as calcination temperature and time, power and exposure time to microwaves, have been optimized in order to develop a sustainable production process. Both hydroxyapatite and bone char have been characterized by SEM-EDS, XRD and FTIR to better define the purity of the synthetized material, the grainsize and microstructure.

BIO-DUST project

BIO-DUST PRIN2022 (n. 2022R5RATP) CUP Master B53D23006340006

Settore ERC PE08 - macrosettore PE Physical Sciences and Engineering settore PE08 "Products and Processes Engineering"

Reversible adsorbent smart materials for the recovery of starch grains from stone tools

F. Porpora (*, a), S. Baldini (a), E. Carretti (a,b), G. Sorrentino (c), E. Semenzin (c), L. Longo (c), C. Cagnato (c), E. Badetti (c), L. Dei (a)

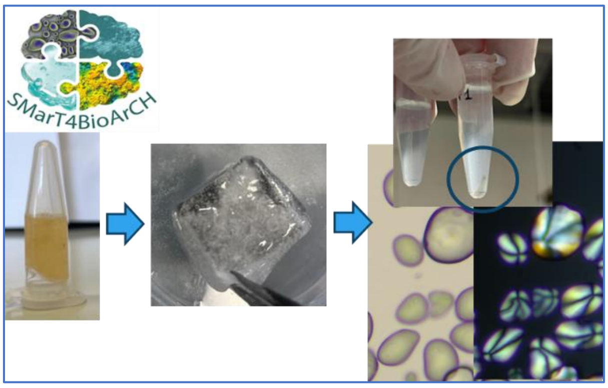
(a) Chemistry Department "Ugo Schiff", University of Florence and CSGI, Via della Lastruccia 3-13, 50019, Sesto Fiorentino, Italy.

(b) CNR-INO, Largo E. Fermi 6, 50125 Florence, Italy.

(c) Environmental Sciences, Informatics, and Statistics Department, University of Venice, Via Torino 155, 30170, Venezia Mestre, Italy.
* Presenting author

francesca.porpora@unifi.it

Starch grains entrapped inside pores and fractures of ground stone tools are very important bioarchives able to provide information about the environment, technical development, and diet of populations in the Late Pleistocene [1]. The SMarT4BioArCH project's main aim is to develop an innovative method based on the use of smart reversible adsorbent systems to recover and extract archaeological starch grains from stone tools. In this framework, two systems made of polyvinyl alcohol crosslinked with borax (PVA-borax) [2] and a polyacrylic acid and Fe^{3+} ions coordination complex (PAA*Fe) [3], were selected as promising candidates because of their rheological properties as well as for their pH- and photo-reversibility, respectively. Their chemical-physical characterization was performed via Fourier Transform Infrared Spectroscopy (FTIR), Thermogravimetric analysis (TGA), and Rheology. In addition, the effect of the interaction between the starch and these systems was evaluated in terms of preferential adhesion (starch extraction yield from stone mockups) and eventual alteration in the chemical composition (FTIR, TGA) and morphological structure (optical microscopy) of the sampled starch.



Scheme of starch extraction from a stone mockup with a smart reversible adsorbent system.

References

[1] L. Longo et al., Environmental Archeology (2021) 1-29, https://doi.org/10.1080/14614103.2021.1975252.
[2] E. Carretti et al., Soft Matter (2014) 10, 4443-4450, https://doi.org/10.1039/C4SM00355A.
[3] Peng, F. et al., Journal of the American Chemical Society (2008), 130, 48, https://doi.org/10.1021/ja807087z.

Ministero dell'Università e della Ricerca (MUR) of Italy, Project PRIN 2022 2022XX8BRT PNRR, "SMarT4BioArCH", CUP Master B53DZ3014020006, financed by the European Union – Next Generation EU, is gratefully acknowledged for financial support.

Authentication, attribution, provenance: the contribution of the diagnostics to the forensic investigations

A. Privitera (*, a), M.F. Alberghina (b), S. Schiavone (b), A. Sodo (a)

(a) Dipartimento di Scienze, Università degli Studi Roma Tre, via della Vasca Navale, 84, 00146 Roma (RM), Italy (b) S.T.Art-Test, Via Stovigliai, 88, 93015 Niscemi (CL), Italy

* Presenting author

antonella.privitera@uniroma3.it

Ancient paintings represent a significant slice of the objects appreciated in the international art market and in collecting. Often even paintings of cultural interest, subject to protection provisions, may be introduced in the antiques market in conditions of unlawful possession and provenance. When intercepted by the police, it is necessary to correctly classify these artworks in court trial, to guarantee their protection and to proceed with the return to the rightful owner or confiscation.

The technological-scientific investigations represent a decisive step in the forensic expertise, in ascertaining their authenticity and to obtain useful hints for indirect dating, attribution and provenance. Moreover, together with the humanistic anamnesis and documentary/archive research, the diagnostics contribute to formulating a solid and incontrovertible judge's opinion in a forensic setting.

In this work, different Italian paintings on wood panels, attributable to the late Gothic and Renaissance period, were investigated after their seizure by the Carabinieri of Command for the protection of Cultural Heritage (Operative Department, Rome), by a multi-analytical protocol. In particular, first non-destructive imaging techniques were performed in order to investigate the paintings stratigraphy and to evaluate the different materials and techniques: UV-Induced Visible Fluorescence (UVF), multi-band Infrared Reflectography (IRR) and Digital Radiography (RX). Then, multi-elemental analysis by portable X-ray fluorescence ($p-$XRF) and molecular-vibrational analysis by micro-Raman Spectroscopy ($\mu-$RS) were performed in selected areas and on microsamples, respectively, in order to fully characterise the pigments composition.

The obtained results allowed us to identify a fake painting imitating the Renaissance style, to shed light on the historical original context, to identify the executors' painters and their manufacturing techniques and, finally, to recognize previous pseudo-scientific or fraudulent restoration interventions.

Acknowledgements

The authors are grateful to the holder of the court trial, the judge Dr. Antonio Baldassare, for allowing the publication of our results.

CT on wind musical instruments: a way to bring them out of silence, preserving their state of conservation

F. Tansella (*,a,b) A. Re (a,b), G. Ricchiardi (c), L. Guidorzi (a,b), A. Lo Giudice (a,b), G. Rossi Rognogni (d), M. Staropoli (e,f), F. Xiccato (g)

(a) Dipartimento di Fisica, Università degli Studi di Torino, Torino, Italy

(b) INFN, sezione di Torino, Torino, Italy

(c) Dipartimento di Chimica, Università degli Studi di Torino, Torino, Italy

(d) Royal College of Music, Prince Consort Road, London SW7 2BS, UK

(e) Conservatorio di Musica "Giuseppe Tartini", 34132 Trieste, Italy

(f) Conservatorio di Musica "Giuseppe Verdi", 10123 Torino, Italy

(g) freelance engineer

* Presenting author

francesca.tansella@unito.it

X-ray imaging techniques find wide application in the field of Cultural Heritage due to the possibilities to non-invasively provide information about internal structure and preservation status [1]. Specifically, with the aid of dedicated 3D rendering software for Computed Tomography, it becomes feasible to reconstruct 3D volumes that can be measured, virtually sectioned, and rotated into various positions for a direct inspection of the areas of utmost interest [2]. Computed tomography is thus a non-destructive imaging technique that gives significant information about: characteristics of internal structure, construction techniques, state of conservation, presence of previous modifications or restoration interventions. The challenge of this work lies in harnessing this technique as a starting point for creating replicas of wind instruments. By studying the geometry of the internal structure, it is possible to obtain the necessary information for the faithful reproduction of ancient musical instruments. The primary goal of this work is to simultaneously preserve the musical instrument and its peculiar sound, often overlooked in favor of material object conservation. Indeed the use of wind instruments involves the introduction of air and saliva into the instrument, leading to a modification of moisture content and, consequently, the onset of physical and chemical reactions that can be particularly dangerous to the preservation of the musical instrument [3]. Through this work, it is firstly possible to investigate the preservation status of such instruments. Specifically, for wooden instruments, it is possible to determine the extent of a fracture [4]. For ivory instruments, it is possible to highlight the presence of fractures in their early stages, before they reach the external surface. In both cases, it is also possible to highlight the presence of previous interventions or internal gaps. The final aim is to conduct CT with reference elements regarding dimensions and X-ray absorption capability, obtaining crucial data for the analyzed sample's dimensions. This information proves invaluable for 3D printing to create accurate copies, offering the opportunity to play these instruments, avoiding the risk of damaging the originals and preserving their state of conservation.

References

[1] Howe, R.et al. Early Music. 2014, 42, 529–536.

[2] Morigi, M.P et al. Three-dimensional X-ray Computed Tomography. Disegnarecon 2010, 3, 27–42.

[3] Lehmann, E.H. et al. J. Archaeol. Sci. Rep. 2018, 20, 239–243. [4] Tansella et al.; J. Imaging 2022, 8, 260C.

Multispectral imaging investigation of Papal Bulls from the Santuario della Beata Vergine di Saronno

L. Es Sebar ([*, a]), F. Di Iorio ([a, b]), P. Fermo ([c]), A. Gueli ([d]), S. Grassini ([a]), G. Politi ([d])

(a) Department of Applied Science and Technology, Politecnico di Torino, Corso Duca degli Abruzzi 24, 10129 Torino

(b) Fondazione Centro Conservazione e Restauro dei Beni Culturali “La Venaria Reale”, 10078 Venaria Reale (TO)

(c) Department of Chemistry, University of Milan, Via Golgi 19, 20133 Milano

(d) Department of Physics and Astronomy "Ettore Majorana", University of Catania, Via S. Sofia 64, 95123 Catania
* Presenting author

leila.essebar@polito.it

This study presents the first diagnostic campaign performed on a selection of Papal Bulls belonging to the Archive of the Santuario della Beata Vergine di Saronno (Varese, Italy). The Sanctuary was founded in 1498, and its archive was recognized for its considerable historical interest by the “Soprintendenza Archivistica e Bibliografica della Lombardia” in 1997. The archive contains over 30,000 documents, including 385 account books, ledgers, registers, and 106 papal bulls. Four papal bulls were investigated with a non-invasive and multi-analytical approach. In particular, a bull of Pope Alexander Borgia dated 1502, a bull of Pope Paul III dated 1540, and two bulls of Pope Pius IV dated 1560 and 1561, respectively, were selected. These bulls have never been studied before through analytical methodologies. Thus, any insights into their composition, including the ink, the seals, and the parchment, can help gather valuable information for reconstructing their history and for developing preserving conservation strategies.

The present study involved a non-invasive investigation using multispectral imaging (MSI), employing wavelengths in the range from ultraviolet to infrared. Since each wavelength interacts differently with the manuscript surface, MSI allows the uncovering of hidden details and reveals features that can enhance the visibility of parchment, inks, pigments, surface treatments, or stains. MSI can help reveal information layers that are not visible to the naked eye. In particular, several techniques were employed, including UV-induced luminescence (UVL), UV reflectography (UVR), infrared reflectography (IRR), UV false-colour (UVFC), and IR false-colour (IRFC) imaging. By UVL imaging, it was possible to highlight the readability of damaged text, to detect the presence of several stains on the parchment, and to identify the degradation and migration of inks. IRR and IR- FC imaging allowed us to detect the underdrawing lines, and to discriminate among ancient and modern inks. The MSI investigation was fundamental not only to assess the state of preservation but also to guide the selection of relevant areas to be deeply investigated by Particle Induced X-ray Emission (PIXE). PIXE measurements were carried out at the Accélérateur Grand Louvre d'Analyse Elémentaire (AGLAE) of the Centre de Recherche et de Restauration des Musées de France (C2RMF) located in the Louvre Museum in Paris. By PIXE, it was possible to study the chemical composition of the parchment ink and seal of the four bulls and to produce elemental maps to identify also the presence of ink migration.

Acknowledgments: This publication is part of the project PNRR-NGEU, which has received funding from the MUR – DM352/2022); the activities were also funded by the Cultural Heritage Active Innovation for Sustainable Society (CHANGES) Project, funded by the European Union – NextGenerationEU, under the National Recovery and Resilience Plan (NRRP) Mission 4 Component 2 Investment Line 1.3.

Unveiling Workshop Practices: A Technical Study of Wooden Offering Bearer Sculptures from the Tomb of Minhotep

N. Manfredda ([*, a,b]), P. Buscaglia ([c, e]), P. Del Vesco ([g]), F. Tansella ([b, d]), L. Vigorelli ([l]), L. Guidorzi ([b, d]), A. Re ([b, d]), T. Poli ([i]), C. Ricci ([e, f]), T. Cavaleri ([e]), M. Borla ([h]), A. Lo Giudice ([b, d])

(a) Department of Calssics - University of Rome "La Sapienza", Roma, Italy

(b) Department of Physics - University of Torino, Torino, Italy

(c) Politecnico di Torino, Torino, Italy

(d) INFN - Sezione di Torino, Torino, Italy

(e) Centro Conservazione e Restauro "La Venaria Reale", Venaria Reale, Torino, Italy

(f) Department of Earth Sciences, University of Turin

(g) Fondazione Museo delle Antichità Egizie di Torino, Italy

(h) Soprintendenza ABAP-TO, Torino, Italy

(i) Department of Chemistry, University of Turin, Turin, Italy

(l) Department of Physics, University of Milano Bicocca: Milano Lombardia, Italy; INFN - Sezione di Milano

* Presenting author

nicole.manfredda@uniroma1.it

In the framework of a PhD research project focused on the study of funerary wooden sculptures from the tomb of Minhotep (early 12th Dynasty), housed in the Museo Egizio, Turin, this contribution aims to explore further the technical study of the three sculptures of offering bearers. Using a multidisciplinary diagnostic approach, the research examines three offering bearers from the assemblage, focusing on their manufacturing techniques, materials, and state of preservation, adopting a comparative approach, analyzing similarities and differences in materials and techniques that could be indicative of peculiar workshop practices. A multidisciplinary diagnostic plan was developed to investigate their construction techniques and materials. Non-invasive methods are central to this study, especially micro-X-ray Computed Tomography (CT), X-Ray Fluorescence (XRF), Fourier-transform infrared spectroscopy (FTIR). These outcomes were integrated with some micro invasive analysis, as stratigraphic samples analysed with Scanning Electron Microscopy (SEM-EDS), with a particular focus on the pigments, which have yielded interesting results, indicative of the division of labour within the workshop. The study of the carving techniques and the pictorial layers highlights a huge technical diversity and material choices between the sculptures that suggest the complexities of workshop practices, where tasks such as carving and painting may have been divided among specialized artisans. Moreover, this multidisciplinary approach to the research underscores the importance of combining scientific and historical analyses to reconstruct the production, use, and post-excavation history of such artifacts.

References

[1] Vigorelli, L., Re, A., Guidorzi, L., Cavaleri, T., Buscaglia, P., Nervo, M., Del Vesco, P., Borla, M., Grassini, S., Lo Giudice, A., Multi-analytical approach for the study of an ancient Egyptian wooden statuette from the collection of Museo Egizio of Torino (2022) ACTA IMEKO 11, 1, https://dx.doi.org/10.21014/acta_imeko.v11i1.1089

[2] Vigorelli, L., Re, A.,Buscaglia P., Manfredda N., Nervo M., Cavaleri T., Del Vesco P., Borla M., Grassini S., Guidorzi L., Lo Giudice A., Comparison of two ancient Egyptian Middle Kingdom statuettes from the Museo Egizio of Torino through computed tomographic measurements (2022) Journal of Archaeological Science: Reports, 44, 1, https://dx.doi.org/10.1016/j.jasrep.2022.103518

Chemical characterization of ochre from stains on Epigravettian tools and shells found in the M Trench in the San Teodoro cave (Acquedolci, Messina, Italy)

Gerlando Vita [a,*], Mirko Andrea Vizzini[b], LucaSineo[c]

(a,*) University of Palermo, Dipartimento di Scienze della Terra e del Mare (DISTEM), Via Archirafi, 22, 90123 Palermo, Italy

(b) Geolab srl, Via de Spuches, Carini, Italy

(c) University of Palermo, Dipartimento di Scienze e Tecnologie Biologiche, Chimiche e Farmaceutiche (STEBICEF), Palermo, Italy

*Corresponding author: Gerlando Vita

gerlandovita03@unipa.it

The latest excavations at the San Teodoro Acquedolci Cave in Sicily, an important Pleistocene site for the study of both fauna and ancient human populations, have focused on a recently opened excavation area called Trench M. It is a vertical cavity, about 2 meters deep and on average less than 80 cm wide, that revealed layers rich in Epigravettian industries, pigments, and ornaments. Chemical analyses by EDS (Energy Dispersive X-ray Spectroscopy) of the red pigment that stained a pestle (Fig. 1) and two shells have been performed. The results showed that this red pigment is of inorganic origin and that it is different from the organic one used to cover the Epigravettian burials ([1]; [2]). These results stimulated a discussion on the hypothesis that the Epigravettian managers of this site used either or alternatively organic red pigment from ferrobacterial mud, from several still existing springs nearby the site, or mineral red pigments collected elsewhere. At present the possibly coincident order of events of these different attitudes have not yet been explored by absolute chronology.

Fig. 1. A. Eight-shaped pebble, with the left side rounded and smooth, displaying traces of ochre (green arrow). B, C, D. Details of traces of ochre and pebble use (magnifications 10X)

References

[1] Graziosi, P., 1947. Gli uomini della grotta di S. Teodoro (Messina). Rivista di Scienze Preistoriche 2, 123-224.
[2] Garilli, V., Vita, G., La Parola, V., Pinto-Vraca, M., Giarrusso, R., Rosina, P., Bonfiglio, L., Sineo, L., 2020b. First evidence of Pleistocene ochre production from bacteriogenic iron oxides. A case study of the Upper Palaeolithic site at the San Teodoro Cave (Sicily, Italy). Journal of Archaeological Science 123, 105221. doi: 10.1016/j.jas.2020.105221.

From the Archaeological Context to the Laboratory: Challenges and Informative Potential of Stable Isotope Analysis of Organic Remains

N. Mantile ([*, a]), S. Altieri ([a]), M.R. di Cicco ([a]), V. Giacometti ([a]), C. Lubritto ([a])

([a]) Dipartimento di Scienze e Tecnologie Ambientali Biologiche e Farmaceutiche, & Mediterranean bioArchaeological Research Advances (MAReA) centre, Università degli Studi della Campania "Luigi Vanvitelli", Via Vivaldi 43, 81100, Caserta, Italy.

* Presenting author

noemi.mantile@unicampania.it

Stable isotope analysis of organic remains—including osteoarchaeological, zooarchaeological, and archaeobotanical samples—has become a well-established tool for exploring past dietary habits, mobility, human-environment interactions, agricultural practices, and animal management strategies. However, conservation challenges can affect the reliability of these techniques, as organic remains are vulnerable to environmental and human-induced degradation, which can alter their *in-vivo* isotopic signatures.

To ensure the integrity of these materials, it is essential to understand diagenetic issues and develop tailored conservation strategies. For museum collections housing organic remains, the adoption of multiparameter monitoring stations can provide real-time data on microclimatic conditions, thereby contributing to the long-term preservation of these archaeological remains.

Recent advancements in isotopic techniques and pre-treatment protocols have significantly reduced the material needed for analysis, enabling researchers to work with smaller samples while preserving data quality. Despite these advancements, the inherently destructive nature of isotopic analysis leads to varying degrees of sample loss. Consequently, sampling strategies and pre-treatment protocols must be carefully tailored to the physical-chemical properties of the samples, the specific isotopic measurements, and the research objectives. Moreover, assessing potential diagenetic or contamination issues through quality control measures is essential for accurately reconstructing multiple aspects of past populations.

The growing significance of stable isotope analysis in bioarchaeology has led to initiatives focused on compiling extensive isotopic datasets, which enable multi-scale investigations of past human behaviours. Projects like the Pandora and IsoMemo Initiative (https://isomemoapp.com/) exemplify how large datasets can enhance cross-validation and foster collaborative efforts to enrich our understanding of isotope-based historical narratives.

This contribution thus aims at addressing the challenges of stable isotope analysis performed on organic remains, focusing on diagenetic issues, sampling strategies, and pre-treatment protocols. Additionally, it seeks to highlight the valuable insights that can be gained from these analyses by utilizing Big isotopic datasets.

References

[1] A. Boethius, H., Hollund, J. Linderholm, S. Vanhanen, M. Kja¨llquist, O. Magnell, et al. (2020). Quantifying archaeoorganic degradation – A multiproxy approach to understand the accelerated deterioration of the ancient organic cultural heritage at the Swedish Mesolithic site Ageröd. PLoS ONE 15(9): e0239588. https://doi.org/10.1371/journal.pone.0239588

[2] N. Mantile, R. Fernandes, C. Lubritto, C. Cocozza (2023). IsoMedIta: A Stable Isotope Database for Medieval Italy. Research Data Journal for the Humanities and Social Sciences, 8(1), 1-13. https://doi.org/10.1163/24523666-bja10032 [3] P. Vaiglova (2023). Sampling archaeological remains for isotopic analyses. In Field Sampling for Laboratory Analysis in Archaeology, edited by E. Margaritis, E. Nikita, A. Oikonamou, T. Rehren. Te Cyprus Institute. ISBN 978-9925-7759-4-1

Identification and characterization of ancient quarry sites in the Euganean Hills (Padova, Italy) through high-resolution UAV LiDAR measurements

J. Olah (*, a), M. Secco (a), C. Miele (b), F. Carraro (c), S. Dilaria (a), J. Turchetto (a)

(a) University of Padova, Department of Cultural Heritage (dBC)

(b) Archetipo S.r.l.

(c) Freelance Archaeologist

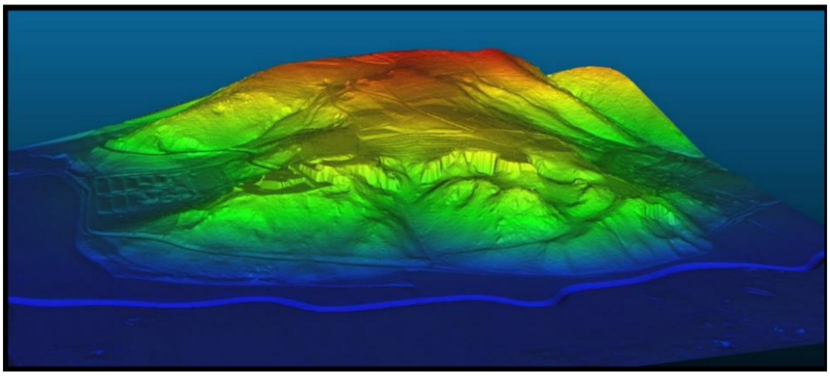
* Presenting author

josiah.olah@studenti.unipd.it

This research explores the application of UAV LiDAR, GIS, and statistical analysis in the archaeometric study of quarry sites in the Euganean Hills, Veneto, Italy. High-resolution UAV LiDAR surveys identified 89 potential extraction sites, focusing on volcanic breccia quarries in the central and eastern regions. Comparative analysis demonstrated the superiority of UAV LiDAR over publicly available datasets, enabling the detection and 3D modeling of previously unknown anthropogenic features in the forested landscape. The increased accuracy and resolution produced precise digital terrain models (DTMs), improving quarry identification and spatial analysis.

By characterizing and measuring the attributes of 50 extraction sites, statistical analysis differentiated modern from historic quarries, revealing patterns in morphology and spatial organization that may indicate periods of use. Field validation confirmed the anthropogenic nature of key features and the physical traces of quarrying activities. Case studies of two potential Roman-period breccia quarry complexes, identified through the survey, highlighted their role in pozzolanic material production and demonstrated the value of site-specific LiDAR analysis in understanding ancient extraction activities and the functional interconnectivity of associated quarry features.

This study underscores the potential of UAV LiDAR and GIS in archaeometry, especially for detecting and characterizing anthropogenic features. The findings highlight how these technologies aid in reconstructing historical quarry landscapes and offer new insights into ancient extraction practices and their broader cultural significance.



3D visualization of the Villa Draghi breccia quarry complex produced through mesh processing of ground classified point cloud data collected through high-resolution UAV LiDAR surveys.

Integrating Edge Computing and Environmental Sensors for Proactive Cultural Heritage Conservation

Antonio Amatore ([*, a]), Andrea Patti ([a]), Alessio Barbaro Chisari ([a]), Wladimiro Carlo Patatu ([a]), Stefano Reitano ([b]) Antonio Astuti([c])

([a]) EHT S.C.p.A. – Viale Africa, 31, 95129 Catania, Italy
(b) Power Evolution Srl-Bivio Aspro Z.I.Piano Tavola , Belpasso Italy
(c) Meridionale Impianti SpA Via S.Simonetta 26D, Caponago , Italy
* Presenting author

antonio.amatore@eht.eu, andrea.patti@eht.eu, alessio.chisari@eht.eu, vladimiro.patatu@eht.eu

Introduction: The management of cultural heritage is complex due to the interaction of anthropogenic and environmental factors that accelerate the deterioration of assets. Traditional conservation strategies are often reactive rather than preventive, meaning they intervene only after damage has already occurred. The preventive approach, on the other hand, focuses on continuous monitoring and timely intervention to prevent damage before it happens. This paper proposes an innovative system that integrates edge computing and advanced sensors to monitor environmental and anthropogenic impacts in real-time, enabling a more proactive management approach. The results demonstrate the effectiveness of this approach in improving the understanding of degradation dynamics and optimizing conservation interventions. **Related Work:** In recent years, research on preventive conservation has shown a growing interest in the use of digital technologies. Many studies have explored the application of sensors to monitor environmental parameters such as temperature, humidity, particulate matter and lighting, which are crucial for assessing deterioration risks. In parallel, Artificial Intelligence has found an additional application in image analysis and the identification of signs of degradation, such as cracks, discoloration, or corrosion in cultural assets. However, there is still a significant challenge: integrating these technologies into a single scalable system capable of addressing multiple environmental variables simultaneously and providing a comprehensive view of the risks to cultural heritage. **Proposed Method:** The designed system integrates advanced technologies to monitor and analyze data within exhibition spaces, enhancing both visitor management and artwork preservation. Cameras are connected to an edge computing infrastructure that runs AI algorithms to count visitors in real time, ensuring privacy by processing data locally without transmitting sensitive information to the cloud. Environmental sensors, strategically placed, monitor microclimate parameters . These data are used to identify potential correlations between visitor presence and variations in environmental parameters that could negatively affect the conservation status of the artwork. Real-time data analysis enables timely decisions, such as adjusting lighting conditions or controlling temperature and humidity. **Conclusions:** The proposed system represents a significant advancement in the proactive management of cultural heritage conservation. The adoption of such a solution marks an evolution in cultural heritage management, taking preventive conservation to a new level by integrating advanced technologies that provide a global view of risks, intervention needs, and addressing the challenges posed by deterioration while ensuring the protection of heritage for future generations.

Acknowledgements

This work has been partially funded by the European Union (NextGeneration EU) through the MURPNRR project SAMOTHRACE (ECS00000022).

Deep Learning for ancient ceramic classification: Saliency maps as a tool for models interpretability

S. Capriotti (*, a), A. Devoto (b), S. Scardapane (b), S. Mignardi (a), L. Medeghini (a)

(a) *Department of Earth Sciences - Sapienza, University of Rome, P.le Aldo Moro 5 00181, Rome, Italy*

(b) *Department of Information Engineering, Electronics and Telecommunications (DIET), "Sapienza" University of Rome, Via Eudossiana 18, 00184 Rome, Italy*

* Presenting author

Sara.capriotti@uniroma1.it

Ancient ceramic artifacts are important remains within archaeological contexts. They represent indicators of social and human activity, giving information on production techniques, technological development, and raw materials provenance to reconstruct relationships and trade routes among past societies [1]. Tracing ancient trade interactions is still challenging due to the subjectivity and the time-consuming nature of the current procedure, which is mainly based on minero-petrographic analyses of pottery. In the last decade, there has been growing interest in the application of automatic methodologies for ceramic grouping. The use of classification algorithms has significantly contributed to recognize specific compositional, technological or stylistic patterns [2, 3]. The present study aims to classify Levantine ceramic thin sections using Deep Learning (DL) models, specifically Convolutional Neural Networks (CNNs) and Vision Transformers (ViT). The objective was to group these ceramic samples into their respective petrographic *fabrics* and compare the results of both models to evaluate their classification effectiveness. A further goal was to provide a partial interpretation of the CNN and ViT model results by applying model processing based on saliency maps (heat maps) to visualize the distinctive features that contributed to the classification of the samples [4].

The results are promising and highlight the importance of the application of saliency maps, which help identify the specific elements of the input data that are most relevant in determining the output.

References

[1] A. M. Hunt, "*The Oxford handbook of archaeological ceramic analysis*". Oxford University Press (Ed.) (2017), chapter 2, 7.

[2] S. H. Bickler, "Machine learning arrives in archaeology". *Advances in Archaeological Practice* (2021), *9*(2), 186191, https://doi.org/10.1017/aap.2021.6

[3] M. Lyons, "Ceramic Fabric Classification of Petrographic Thin Sections with Deep Learning". *Journal of Computer Applications in Archaeology (2021)*, *4*(1), 188-201. https://doi.org/10.5334/jcaa.75

[4] X. Zhong, B. Gallagher, S. Liu, B. Kailkhura, A. Hiszpanski, & T. Y. J. Han, "Explainable machine learning in materials science". *npj computational materials*, (2022), *8*(1), 204. https://doi.org/10.1038/s41524-022-00884-7

The roasting of cereals and the preparation of whole-grain bread without yeast at the settlement of the Neolithic Late/ Final Neolithic of Valle di Maddaloni (Campania-Southern Italy)

M. Stanzione ([*, a]), D. Citro ([a]), A. De Bonis ([b,c]), M. Verde ([c,d]), C. Grifa ([c,e]), C. Germinario ([e]), S. Pagano ([e,f]), A. Tomeo ([g])

(a) External associate archaeologist for the Superintendence Archeology, Fine Arts and Landscape for the provinces of Benevento and Caserta, Palazzo Reale, Caserta, Italy
(b) DiSTAR - Department of Earth, Environmental and Science Sciences. University of Naples Federico II, Naples, Italy
(c) CRACS Center for Research on Archaeometry and Conservation Science, Naples, Italy
(d) DiARC - Department of Architecture, University of Naples Federico II, Naples, Italy
(e) DST- Department of Sciences and Technologies. University of Sannio, Benevento, Italy
(f) Department of Science of Antiquities, Sapienza University of Rome, Rome, Italy
(g) Superintendence Archeology, Fine Arts and Landscape for the provinces of Benevento and Caserta, Palazzo Reale, Caserta, Italy

* Presenting author

monicastanzione.1969@gmail.com

Within the project of the Railway Line "Itinerary Naples-Bari" (viaduct San Michele in locality Piscinale I) in Valle di Maddaloni (Campania region), archaeological investigations were performed in an area of ca. 4000 m^2 in the valley of the Isclero river that, since prehistoric times, has been one of the routes connencting the easternmost part of the plain of Campania with the Apennine forks for Sannio and Puglia.
The anthropogenic evidence here discovered, dated back from a period of transition from the Late Neolithic (4500-4000 BC) to the Final Neolithic (4000-3800 BC), consists of the remains of 12 open-fire pyrotechnological installations identified as fire hot-places, as suggested by the presence of *concotti* with convex surface and recessed bases, traces of heat-irradiated rubefactions, remains of burnt earth, stones altered by fire, deposition levels of coal and ash in the surrounding areas (Fig. 1). The habitat was characterized by the biome broad-leaved forest/temperate mixed forest, suitable for the hunting, fishing and the supply of plant resources and raw materials for the construction and production of pottery and lithics.
The archaeological investigations of one of the fireplace (US 632 - Fig. 2) unearthed a carpological assembly formed by 63 caryopses of dressed cereals (Fig. 3) and a fragment of amorphous organic matter carbonized attesting the practice of roasting cereals, necessary for the food use of seeds, mainly consisting in medium spelled (*Triticum dicoccum L.)* and barley (*Hordeum vulgare L.*).
The carbonized organic fragment was collected along with and *concotto* samples from the surface of the combustion plate of the hearth and investigated by using minero-petrographic techniques (Polarized Light Microscopy -PLM-, X-ray Powder Diffraction –XRPD- Scanning Electron Microscopy coupled with Energy Dispersive X-ray Spectroscopy -SEM-EDS-), which revealed interesting information on the nature of biological materials and technology used for their treatment. The archeometric analyses carried out on the carbonized organic fragment by SEM-EDS at high magnification permitted the identification of the rest of a whole-grain bread composed of seeds held by an amorphous matrix associable with flour (Fig. 4). The observations via PLM and XRPD data on the *concotto* allowed us to estimate the temperature on the surface, which achieved ca. 900°C.

Fig. 1 Overview of the investigated area highlighting the hearths on the plate

Fig. 2 US 632 Hearth on plate, archaeological excavation phases

Fig. 3 Macroscopic analysis, screening and dry extraction of cereal seeds

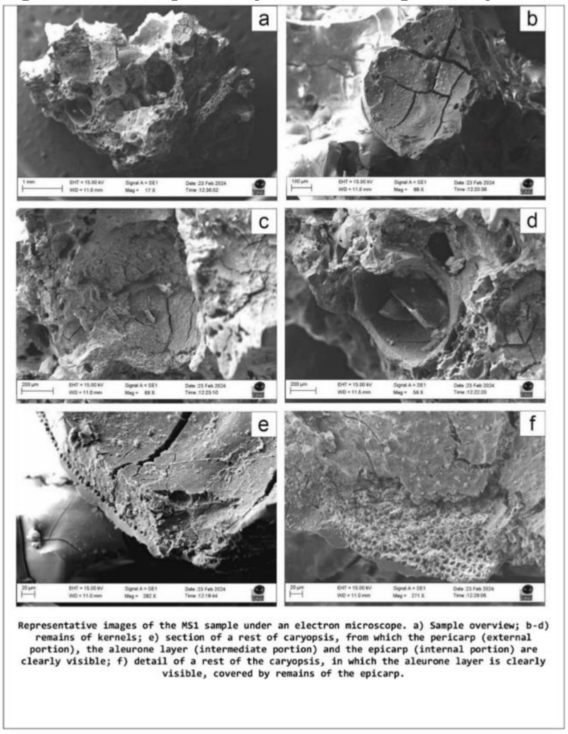


Fig. 4 Representative images of the SEM

References

G. Cera, Il rapporto uomo acqua nelle scelte insediative e nell'organizzazione antropica del territorio: il contributo della Carta Archeologica della Campania, in Riparia (2008), vol. 4, pp. 90-110

C. Conati Barbaro, Cooking. Working and burying in ancient Neolitic: the ovens of Portonovo (Marche, Italy). Origini XXXV (2013), pp. 31-82

A. De Bonis, G. Cultrone, C. Grifa, A. Langella, A.P. Leone, M. Mercurio, V. Morra, Different shades of red: the complexity of mineralogical and physico-chemical factors influencing the colour of ceramics. Ceramics international (2017), 43, 8065-8074

J. Gascò, Structure de combustion et préparation des végétaux de la Préistoire récente et de la Protohistorire en France méditerranéenne, Civilisations (2002), 49, pp. 285-309.

N. Mulder-Heymans, Archaeology, experimental archaeology and etnoarchaeology on bread ovens in Syria, Civilisations (2002) 49, pp. 97-221.

M.L. Nava, D. Giampaola, E. Laforgia, G. Boenzi, Fra il Clanis e il Sebeto: nuovi dati sull'occupazione della piana campana tra il neolitico e l'età del bronzo, Atti IIPP XL, (2007), I, pp. 101-126.

P. Petrosino, D. Pirrie, L. Santoro, R. de' Gennaro, Scanning Electron Microscopy (SEM) in Forensic Geoscience, in M. Mercurio, A. Langella, R.M. Di Maggio, P. Cappelletti (Eds.), Mineralogical Analysis Applied to Forensics: A Guidance on Mineralogical Techniques and Their Application to the Forensic Field. Springer Nature, 2023, pp. 61–91. https://doi.org/https://doi.org/10.1007/978-3-031-08834-6

S. Pignatti, Flora d'Italia, Edagrigricole, 1982

A. Tomeo, I. Matarese, Ricerca e territorio: il villaggio eneolitico di Valle di Maddaloni (CE), in Landscapes-Paesaggi culturali, Roma 30 maggio 2019, Museo Nazionale Etrusco di Villa Giulia, Romarchè. Parla l'archeologia 10 (2019), pp. 124-128

Acknowledgements

The authors thank Italferr Gruppo delle Ferrovie dello Stato Italiano, Professor Carmine Guarino Department of Science and Technology (DST) of the University of Sannio (BN), Professor Vincenzo Morra Director of the Department of Earth Sciences, of the Environment and Resources (DISTAR) of the University of Naples Federico II, Dr Barbara Albanese external associate archaeologist for the Superintendence Archeology, Fine Arts and Landscape for the provinces of Benevento and Caserta, Palazzo Reale, Caserta, Italy.

Application of non-invasive XRF analysis to the study of osteo-archaeological remains

L. Bonizzoni ([*, a]), D. Mazzarelli ([b]), M. Gentile ([a]), L. Valente ([b]), D. Petrosino([b]), C. Cattaneo ([b])

([a]) Università degli Studi di Milano, Dipartimento di Fisica Aldo Pontremoli

([b]) Università degli Studi di Milano, Laboratorio di Antropologia e Odontologia Forense (LABANOF), Dipartimento di Scienze Biomediche per la Salute, Università degli Studi di Milano, Milan, Italy

* Presenting author

Letizia.bonizzoni@unimi.it

The present contribution is the result of a collaboration between the Department of Physics and the LABANOF (Anthropological and Odontological Lab) of Milan University and aims to present the joint research activity, with particular attention to the application of energy dispersive X-Ray Fluorescence (XRF) technique to the study of osteo-archaeological remains.

Two strands will be explored in depth: the possible applications on mixed remains, for both lead contamination study and attribution of bones to specific subjects, and the study of the relics for conservation purposes, through the example case of Saint Theopista, virgin and martyr in the first century, whose remains are preserved in Monsampolo del Tronto (AP).

Indeed, during the study of archaeological remains, the problem of mixed osteological findings often arise. This, obviously, involves numerous problems during the study of individuals: in particular, for the calculation of the NMI, i.e. the minimum number of individuals present, a parameter which is the starting point for the attribution of the bone remains and for an accurate study of the context. We thus tested the possibility of exploiting XRF, coupled with multivariate analyses. Prior to this, it has been necessary to verify the effectiveness of non-invasive analyses in the detection of trace elements in osteological material in order to be able to repeat and improve the results obtained through destructive toxicological analyses. The occasion has been the study of bone remains from the burial ground of the Ospedale Maggiore in Milan [1]. These samples all have lead contents indicating lead poisoning. Anyway, the random distribution of lead content within the same place of burial (different burial chambers of the same crypt) could also suggest external contamination due to the burial environment [2], possibly due to lead-rich water infiltrating the soil.

References

[1] E. Sguazza, D. gibelli, M. Caligara, D. Di Candia, P.M. Galimberti, C. Cattaneo, The role of toxicological analyses in anthropology: a case report on lead intoxication, Archaeometry (2016) 58, 152–158 DOI: 10.1111/arcm.12169
[2] N. Surname1, N. Surname2, N. Surname3, title article, Journal (year), volume, pages, DOI
N. Ludwig, L. Bonizzoni, M. Gargano, B. Bernasconi, E. Bertolaja, B. Cerrai, Reliquie multispetrali: i Santi alla luce della fisica, in Apparuit Thesaurus Ambrosius. Le reliquie di S. Ambrogio e dei martiri Gervazio e Protasio tra storia, arte e fede. Silvana Editoriale

Acknowledgements

The authors would like to thank the students who collaborated in the research: B. Bernasconi and G. Vigorito.

Coins from the Viminacium mint: a preliminary study on composition and alterations

A. Cavagna ([a]), A. Galli1([b]), S. Caglio ([b]), J. Orsilli, ([b]), M. Lorenzetti ([c]), A. Tedeschi ([a]), L. Bonizzoni ([*,c])

([a]) Università degli Studi di Milano, Dipartimento di Studi Letterari, Filologici e Linguistici

([b]) Università degli Studi di Milano-Bicocca, Sipartimento di Scienza dei Materiali

([c]) Università degli Studi di Milano, Dipartimento di Fisica Aldo Pontremoli

* Presenting author

Letizia.bonizzoni@unimi.it

The present work is the result of a collaboration between the Department of Literary, Philological and Linguistic Studies and the Department of Physics of Milan university, and the Department of Material Science of Milan-Bicocca University and is a first approach to the study of coins (sesterzî, dupondî and asses) minted in Viminacium, capital of the province of Moesia, in present-day Serbia.

The coins minted in Viminacium are made of bronze: the denominations minted are sesterzî, dupondî and asses, with the presence of a few medallions relating to the years XII of activity and XIII. In general, the sestertius has an average modulus of 30 mm and an average weight of around 18 g, but often exceeding 20 g; the dupondium, identifiable by the radiated head of the emperor, weighs around 7 g, while the axis, minted only in the first two years of the mint, weighs around 3.5 g. As the years passed, there was a general downsizing of coins; the production of the smaller nominals dropped drastically, including that of the dupondî, which became much lighter than the older ones. The sesterces saw a loss in weight, which averaged around 12 g but could reach 6 g, linked to a reduction in the modulus of the coin itself.

The first steps of our research demonstrate that these modifications are linked to a change in composition. The elemental characterization was primarily obtained by characteristic X-ray fluorescence spectroscopy (XRF), even though corrosion processes led to high uncertainty in the alloy composition. For each coin, six different areas were subjected to XRF analysis, three per face, and the spectra obtained were used to carry out a qualitative and quantitative analysis, determining the composition of each coin in terms of majority and minority elements. The study of the elemental composition was followed by data analysis with statistical tools, in order to identify similarities and differences between the samples, investigating the possible presence of a temporal evolution in the alloy used for minting. Attention was also focused on superficial alterations and how they influence the results obtained.

The results obtained were implemented with an XRF mapping and a diffuse reflectance (RS) scan on a selection of samples. This allowed us to further characterize the influence of surface degradation, which in some cases appears particularly non-homogeneous, as also highlighted by the Digital Optical Microscope images. Finally, one of the sesterzî was analyzed measured on the BM08-LISA line of the ESRF synchrotron in Grenoble, exploiting the XAS (X ray Absorption spectroscopy) technique in TEY (Total electron-yield) mode to study the surface alterations (around 100 nm).

Rock cores characterization to prevent water seepage in northern section of Beishan Buddha Bay of Dazu Rock Carvings (China)

Celestino Grifa ([a]), Chiara Germinario ([a]), Simona Boscia ([a,*]), Andrea Lepore ([a]), Mengjun Jia ([b]), Xiao Ma ([b])

[a]Department of Science and Technology, University of Sannio, Benevento, Italy
[b]Department of History of Science and Scientific Archaeology, University of Science and Technology of China, Hefei, China

* Presenting author

simona.boscia@studenti.unisannio.it

Dazu Rock Carvings are one of the most representative works of late Chinese grotto art renowned with Dunhuang, Yungang, Longmen and were inscribed on the UNESCO World Heritage List in 1999. Beishan grottos, one of the most important components of Dazu Rock Carvings, are located in the north of Dazu District in Chongqing, China. The carvings of Beishan grottos were constructed from the late Tang Dynasty to the Southern Song Dynasty (late 9th century to the mid-12th century) and are renowned for their fine carving, exquisite craftsmanship, and elegant refinement, representing the Chinese folk Buddhist beliefs and grotto art styles in these historical periods. These carvings are a significant part of China's cultural heritage and are considered as one of the last great monuments of Chinese grotto art. For decades, the Dazu Rock Carvings Research Institute and related Cultural Heritage conservation units, along with scientific researchers, have devoted significant efforts to the protection and restoration of the cliff carvings at the northern section of Beishan Buddha Bay, Dazu Rock Carvings, achieving substantial results. However, due to the complexity of managing water damage in this area and various constraints, serious seepage problems have emerged in the northern section.

This contribution deals with the characterization and testing of two rock drill cores from the northern section of Beishan Buddha Bay, intending to enhance our understanding of the rock formations of the Dazu Rock Carvings to provide critical insights for understanding seepage damage and formulating conservation strategies, such as the selection of proper conservation materials or protocols.

Rock samples from two drill cores carried out on the back of the cliff were collected following changes along the core regarding rock macro-texture, grain size and colour. The core sampling covers the entire rock cliff carved by Beishan stone monuments.

A full mineralogical, petrographic and geochemical investigation was carried out for a precise characterisation of the rock sequences, along with assessing the pore system and analysing the fracture net in the rock body, allowing the evaluation of the water circulation system.

The present research illuminates significant differences between the two rock cores despite their short horizontal distance, highlighting the pivotal role of small-scale rock characterization in designing proper and effective conservation strategies for the Chinese grotto heritage.

Archaeological Excavation of the *Viale degli Zampilli* in the Medici Park of Pratolino (Vaglia, Florence): Preliminary Analyses Supporting Restoration and Refunctionalization

L. Di Bilio ([a,*]), M. Fraiese ([a]), G. P. Cianchi ([a]), C. Bigagli ([b]), A. Palchetti ([b]), A. Galli ([c]), F. Maspero ([c]), L.Panzeri ([c]), E. Pecchioni ([d]), T. Salvatici ([d]), G. Ziguri ([d]), C.A. Garzonio ([d]), S. Calandra ([d])

([a]) Metropolitan City of Florence, Italy

([b]) B&P ARCHEOLOGIA - ARCHEOLOGIA E BENI CULTURALI, via F. Ferrucci 95/D, Prato, Italy

([c]) Department of Materials Science, University of Milano-Bicocca, via R.Cozzi 55, 20125, Milan, Italy

([d]) Department of Earth of Earth Science, University of Florence, Via G. La Pira 4, 50121 Florence, Italy

* Presenting author

lorenzo.dibilio@cittametropolitana.fi.it

Recent archaeological excavations in the Medici Park of Pratolino, located in the municipality of Vaglia (Florence, Italy), have uncovered a complex hydraulic system leading to the Villa of Pratolino, known as the *Viale degli Zampilli*. The Medici Park of Pratolino is a unique example of a Renaissance historic garden has been listed in the UNESCO World Heritage Site "Medici Villas and Gardens in Tuscany," since 2013. Designed by architect Bernardo Buontalenti at the request of Francesco I de' Medici (1569–1575), the park and villa were celebrated for their grottoes, fountains, and water features. However, over time, both the villa and the *Viale* fell into disuse, culminating in the villa's demolition and the abandonment of the *Viale* in the early 19th century.

Since 2022, the Metropolitan City of Florence has promoted an ambitious project to restore and refunctionalize the *Viale degli Zampilli*. To reconstruct a detailed understanding of the lost hydraulic system and provide critical guidance for the restoration project, comprehensive studies were carried out on the unearthed remains.

Historical research and archaeological excavations, coordinated by the Soprintendenza Archeologia, Belle Arti e Paesaggio (SABAP) for the Metropolitan City of Florence and the provinces of Pistoia and Prato, revealed the structure of the *Viale degli Zampilli*, a 290-meter-long marvel of hydraulic engineering. The name Viale degli Zampilli is derived from the double water effects: vertical and arched jets, that form a unique pathway that allows one to pass through without getting wet. The monumental structure was surrounded by walls with decorated stone slabs and had walkways on both sides. The waterspouts were fed by masonry pipes housed in the two side walls of the viale. The vertical jets were fed by pipes set into the walls, while the arched jets were fed by pipes in the foundations. Several repairs were made to the water pipes and the masonry in order to preserve the original water system, which was maintained by the Medici and later by the Lorraine family until the mid-18th century.

Mortar and brick samples were collected from the walls and water pipes of the *Viale degli Zampilli* in order to investigate the construction techniques and chronological phases.

The samples were analysed using optical and scanning electron microscopy (SEM-EDS), X-ray powder diffraction (XRPD) and physical characterization methods to better understand the construction techniques and the raw materials used at different times.

Finally, thermoluminescence (TL) dating was used as a powerful method for dating the original firing of bricks and water pipes to narrow down the chronology of the canal and masonry.

F. Tortorici ([*, a]), S. Giacobbe ([b])

([a]) Curator of Cultural and Archaeological Heritage, Specialized in Judicial Archaeology and Crimes against Heritage

([b]) Department of Chemical, Biological, Pharmaceutical and Environmental Sciences, University of Messina

* Presenting author

ftortorici73@gmail.com

Marine bioconcretions, to date, are treated as waste, which hides and disfigures the underwater archaeological find. As such, they are eliminated to allow adequate restoration and conservation action.

The only recent studies conducted on them are of a biomarine nature, and concern aspects that are pertinent to marine biology. But in the course of recent research on bioconcretions for expert purposes, significant results have emerged, which place these materials in a different perspective that need to be explored in a scientific context.

This study has shown that they develop as a stratigraphy, storing data useful not only biologically, but for an adequate historical reconstruction of the repertoire as well as verification of the position, in a temporal space that we have defined as “immersive”.

These conclusions are the result of adequate diagnostic investigations, still in an initial and almost experimental phase.

Assessing the impact of sampling strategies on archaeological stone tools and residues

Giusi Sorrentino ([*, a]), Clarissa Cagnato ([a]), Laura Longo ([a]), Marco Paggi ([b]), Fabrizio Antonelli ([c]), Laura Falchi ([a]), Elena Semenzin ([a]), Antonio Marcomini ([a]), Francesca Porpora ([d]), Emiliano Carretti ([d]), Luigi Dei ([d]), Elena Badetti ([a])

(a) Department of Environmental Sciences, Informatics and Statistics, Ca' Foscari University of Venice, Scientific Campus, Via Torino 155, 30172 Mestre (VE), Italy

(b) IMT School for Advanced Studies Lucca, Piazza S. Francesco, 19, 55100 Lucca, Italy

(c) LAMA, Iuav University of Venice, Calle della Laca, San Polo 2468, 30125 Venice, Italy

(d) Chemistry Department “Ugo Schiff”, University of Florence and CSGI, Via della Lastruccia 3-13, 50019 Sesto Fiorentino (FI), Italy * Presenting author giusi.sorrentino@unive.it

The retrieval and study of starch grains from archaeological contexts, particularly from ground stone tools (GSTs), are essential for reconstructing artifacts use-histories and, in turn, understanding aspects of ancient human behavior, such as plant processing activities, as well as offering valuable insights into ancient flora. Therefore, the careful study and preservation of these biogenic residues are of utmost importance. Traditional starch grain analysis involves extracting residues from artifacts using wet or dry procedures, followed by separation from soil and other biogenic materials allowing for their morphological analysis and characterization through microscopy [1]. Moreover, analysis of contextual surface modification on GSTs is needed. We tested the impact of these procedures on both the stone tools and the starch grains themselves. The results suggest that using silicone-base compounds, one of the steps to copy the surface texture, may affect stone surface integrity and the release of eventual residues entrapped in this process. Moreover, once starch is extracted from the archaeological artifact’s surface, additional separation is necessary to isolate it from soil and other residues [2]. This latter step involves various chemicals, which might affect the physicochemical properties of the starch grains in a manner not documented to date. To evaluate and refine these processes, fresh and aged starch proxies from modern plants, as well as experimentally tested GSTs, were used to assess the impact of the entire proposed extraction procedure.

The obtained methodological advancements enhance the investigation of biogenic residues, enabling a more reliable and minimally invasive recovery of starch from archaeological GSTs and ensuring robust analysis. This approach not only supports archaeological and conservation efforts but also highlights the limitations of traditional extraction methods, underscoring the potential impacts on artifacts. By raising awareness among archaeologists, conservation scientists, and museum curators, we seek to promote refined techniques that might benefit future research and preservation practices.

References

[1] Longo et al. 2022. Coupling the beams: How controlled extraction methods and FTIR-spectroscopy, OM and SEM reveal the grinding of starchy plants in the Pontic steppe 36,000 years ago. https://doi.org/10.1016/j.jasrep.2021.103333

[2] Cagnato, Ponce, 2017. Ancient Maya manioc consumption: Starch grain evidence from late to terminal classic (8th– 9th century CE) occupation at La Corona, northwestern Petén, Guatemala. https://doi.org/10.1016/j.jasrep.2017.09.035

Acknowledgements

Progetto finanziato dall'Unione Europea – Next-GenerationEU - PNRR – M.4 C.2, INVESTIMENTO 1.1 - “SMarT4BioArCH”, Project PRIN 2022 2022XX8BRT PNRR, CUP Master B53DZ3014020006.

A multidisciplinary approach to the evaluation of the impact of the marine-coastal environment on ancient Calabrian watchtowers (Southern Italy): preliminary data

F. Giordano (*, a), N. Rovella (a, b), M.F. La Russa (a), S.A. Ruffolo (a)

(a) Department of Biology, Ecology and Earth Sciences, University of Calabria, Via P. Bucci Cubo 12 B, 87036 Arcavacata di Rende (CS), Italy
(b) Institute on Membrane Technology, CNR-ITM, Via P. Bucci 17/C, 87036, Arcavacata di Rende (CS), Italy

* Presenting author francesca.giordano.phd@unical.it

Calabria's coastal watchtowers reflect the region's cultural and architectural evolution. Initially built during the Angevin period to assert control over Southern Italy and defend against Turkish invasions, these towers gained further importance during the Viceroyalty of Charles V, who expanded their role for observation and communication purposes [1]. Currently, approximately 70 of more than 130 ancient watchtowers have survived, but the majority remain underutilized and in a state of neglect. So, this research will use modern technologies to catalogue, assess conservation, and promote these artefacts innovatively. To create a comprehensive database of coastal watchtowers, a digital map was developed using QGIS open-source software. This map includes the 70 existing watchtowers with information about their conservation status, past restorations, and construction materials, all organized in a single shapefile. Additionally, QGIS allows for the simultaneous consultation of data related to the environment, including lithological map, landslides, and coastal erosion. The study will focus on five Calabrian coastal watchtowers, namely Saracena (Palmi, RC), Ruggero (Bagnara, RC), Cavallaro (Marina di Gioiosa Ionica, RC), La Rocchetta (Briatico, VV) and Marrana (Ricadi, VV). Preliminary on-site observations have enabled the identification of their building materials. Furthermore, the alteration forms affecting the towers, including saline efflorescence, alveolisation, *flos tectorii* and biological colonization, have been also identified [2]. To characterize mineropetrographic features and conservation status of these watchtowers, building materials and degradation forms will undergo analysis such as POM (Polarized Optical Microscopy), XRD (X-Ray Diffraction), and XRF (X-Ray Fluorescence), Ion Chromatography, also SEM-EDS (Scanning Electron Microscopy coupled with Energy-Dispersive Spectroscopy). This multidisciplinary research proposes to combine traditional methods with advanced technologies, including drone-based photogrammetric surveys, to develop highly accurate 3D models implemented with data on building materials, degradation forms, and the impact of natural phenomena like earthquakes, coastal erosion, and landslides on the conservation of these structures. Moreover, by integrating Heritage Building Information Modeling (H-BIM) with 3D GIS, the research will provide detailed, multi-scale analysis, monitoring changes over time, and assessing environmental risks [3]. Finally, H-BIM and 3D GIS will be combined with augmented reality strategies to promote the knowledge and the valorization of the watchtowers to a wider range of audience, from tourists to students and researchers.

References

[1] Donato, S. (1992). La pianificazione del turismo: studi e progetti per il piano territoriale di coordinamento regionale della Calabria. Gangemi Editore.

[2] La Russa, M. F., & Ruffolo, S. A. (2021). Mortars and plasters-How to characterize mortar and plaster degradation. *Archaeological and Anthropological Sciences*, *13*(10), 165. https://doi.org/10.1007/s12520-021-01405-1

[3] Colucci, E., De Ruvo, V., Lingua, A., Matrone, F., & Rizzo, G. (2020). HBIM-GIS integration: From IFC to cityGML standard for damaged cultural heritage in a multiscale 3D GIS. *Applied Sciences*, *10*(4), 1356. https://doi.org/10.3390/app10041356

Hadrianic concrete, a Roman archetype. Archaeometric characterization of construction materials from the Mausoleum of Hadrian, Rome

A. Rekhi (*, a), M. Secco (a, b), S. Dilaria (a, b), D. Hernandez (c), G. Ricci (b, d), V. Razzante (a), P. Vitti (e), G. Artioli (b, c)

(a) University of Padova, Department of Cultural Heritage (dBC)

(b) University of Padova, Inter-Departmental Research Center for the Study of Cement Materials and Hydraulic Binders (CIRCe)

(c) University of Notre Dame, Department of Classics

(d) University of Padova, Department of Geosciences

(e) University of Notre Dame, School of Architecture

* Presenting author

aalya.rekhi@studenti.unipd.it

With a lifespan exceeding 2000 years, Roman structures remain standing even today, as enduring symbols of their glorious past. Several recent studies have attempted to understand their exceptional resilience, in some cases to inspire modern construction industry towards innovative heritage-inspired building materials, overcoming the well-known durability issues of contemporary buildings. In this paper, the authors present ongoing research promoted by the University of Notre Dame and conducted in collaboration with the University of Padova, which made possible an extensive characterization campaign of mortars and concretes in the Mausoleum of Hadrian, a monumental construction of the 2nd century CE that still dominates the Roman skyline. This robust structure, complimented for its imperial symbolism, consists of a massive concrete drum built along the Tiber River. The research is framed on a wider research project on the architecture of the imperial mausoleum, and aims to document, analyze and characterize the employed construction materials, in particular mortars and stone rubble materials for *opus caementicium* (*caementa*), to understand the construction techniques and parametrize the formulation recipes. More than 20 concrete and mortar samples were collected from different areas of the building dating back to the Roman era. Materials were subjected to an extensive characterization campaign aimed at tracking the provenance sources of raw materials and unraveling the microchemistry of the pozzolanic binders responsible for the longevity and durability of the structure. A multi-analytical approach was adopted, employing several archaeometric techniques such as Polarized Light Optical Microscopy, X-ray Powder Diffraction, Scanning Electron Microscopy combined with Energy Dispersive Spectroscopy and X-Ray Fluorescence, to characterize the petrographic, mineralogical and chemical composition of the building materials. The analyses revealed significant occurrence of amorphous calcium aluminosilicate hydrate (C-A-S-H) gels in the binding matrices, as well as long-term microcrystalline hydration products, such as strätlingite, which have played an important role in the strengthening of the structure over thousands of years. Regarding provenance, the analyses led to a well-considered selection of construction materials, primarily of local origin. This study highlighted the ambitions and risks undertaken by Roman constructors to formulate building materials that have survived through several centuries. Additionally, it provides a basis for further analysis to quantify variations in the quality of the mortar recipes among different structural and non-structural parts of the same building, aiding in identifying the level of design of mortars in this monumental construction.

Analisi Minero-Petrografiche Con Finalità Archeometriche Dei Reperti Ceramici Medievali Provenienti Dallo Scavo Di Corso Tuköry A Palermo

Alessandra Messina[1], Giuseppe Montana[2], Angelo Castrorao Barba[3], Giuseppina Battaglia[4]

[1]Libero professionista
[2]Dipartimento di Scienze della Terra e del Mare (DiSTeM), Università degli Studi di Palermo
[3]Escuela de Estudios Arabes (EEA), Consiglio Superiore delle Investigazioni Scientifiche (CSIC)
[4]Sopraintendenza BB.CC.AA di Palermo

ABSTRACT

Un set di 25 campioni ceramici è stato selezionato autopticamente tra i numerosi reperti rinvenuti in Corso Tukory (Palermo), per essere sottoposti alle analisi minero-petrografiche. Lo scavo, effettuato nel 2017 all'interno di un palazzo residenziale per la posa dell'ascensore, ha restituito abbondanti reperti in giacitura secondaria da riferire ad un arco cronologico compreso tra la seconda metà del X e inizi dell'XI secolo d.C. La metodologia applicata è stata mirata alla caratterizzazione degli impasti ceramici in termini di abbondanza relativa, distribuzione dimensionale e composizione mineralogica delle inclusioni aplastiche mediante le osservazioni microscopiche su sezioni sottili in luce polarizzata trasmessa. Nello specifico, i materiali ceramici analizzati sono appartenenti alle classi delle anfore, della ceramica da fuoco e della ceramica comune. L'analisi ha avuto lo scopo di indagare le diversità osservate macroscopicamente per determinare la provenienza, distinguere le produzioni locali dalle eventuali importazioni e, allo stesso tempo, di trarre alcune informazioni di tipo tecnologico. Appare evidente la netta predominanza dello sfruttamento delle materie prime argillose disponibili nel territorio palermitano. In particolare, i cinque frammenti di anfore, i dodici campioni di ceramica comune e la maggior parte dei campioni di ceramica da fuoco costituiscono un gruppo di impasto omogeneo che è stato associato alle Argille di Ficarazzi (materia prima). Solo per la ceramica da cucina le analisi petrografiche hanno messo in evidenza il ricorso ad importazioni o a procedure produttive specializzate.

Parole chiave: archeometria, petrografia, ceramica, periodo islamico, Palermo, Sicilia

The PITCH project: a laboratory-based phase contrast X-ray imaging system for Cultural Heritage analysis

A. Re (*,a,b), E. Di Francia (a,b), C. Garagiola (a,b), L. Guidorzi (a,b), A. Lo Giudice (a,b), R. Boano (c), R. Giustetto (d), G. Ricchiardi (e), P. Cerello (b), E. Fiorina (b), M. Magalini (b), N. Mosco (b), L. Ramello (f,b), D. Trocino (b), D. Di Martino (g), G. Marcucci (g), L. Vigorelli (g), F. Pozzi (h), C. Ricci (h)

(a) Dipartimento di Fisica, Università degli Studi di Torino, Torino, Italy

(b) INFN, sezione di Torino, Torino, Italy

(c) Dipartimento di Scienze della Vita e Biologia dei Sistemi, Università degli Studi di Torino, Torino, Italy

(d) Dipartimento di Scienze della Terra, Università degli Studi di Torino, Torino, Italy

(e) Dipartimento di Chimica, Università degli Studi di Torino, Torino, Italy

(f) Dipartimento per lo Sviluppo Sostenibile e la Transizione Ecologica, Università del Piemonte Orientale, Vercelli, Italy

(g) Dipartimento di Fisica "G. Occhialini", Università di Milano-Bicocca e INFN, sezione di Milano-Bicocca, Milano, Italy

(h) Centro per la Conservazione ed il Restauro dei Beni Culturali "La Venaria Reale", Venaria Reale (Torino), Italy

* Presenting author

alessandro.re@unito.it

Over the last few decades, X-ray imaging has improved significantly as a high-resolution, non-destructive, and non-invasive tool for radiography and tomography, solving a major challenge of detecting internal structures of samples in different applications. Furthermore, since the enhancement of synchrotron sources, extremely coherent radiation has been used for non-traditional contrast techniques [1]. The conventional absorption contrast method is particularly beneficial for characterising medium-density samples or distinguishing materials with different attenuation powers, but not for low-Z materials, which exhibit poor contrast under X-ray irradiation. Phase contrast X-ray imaging (PC) is instead an effective technique for detecting low contrast details in weakly absorbing samples. This method is based on the observation of the interference pattern between diffracted and non-diffracted waves, caused by spatial variations in the real component of the refractive index introduced by a sample placed in the wave path [2]. PC X-ray imaging has great potential in medical, material science, and cultural heritage (CH) applications since it can deliver high-quality information on microstructural characteristics. A coherent X-ray beam is an appropriate instrument for developing phase-sensitive X-ray imaging; as a result, this technology has already been deployed at synchrotron facilities [3]. Among the PC methodologies, X-ray Grating Interferometry (GI), which provides differential phase and scattering (dark-field) images in addition to the standard absorption-based image, enables the realisation of systems that can be implemented in a laboratory setting. This framework opens interesting opportunities in the CH field, including conservation, archaeology, and anthropology.

The PITCH project (funded in the framework of PRIN2022) aims at designing, developing and characterising a laboratory GI-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 analysis of various CH materials to characterise and better understand specific related issues.

References

[1] R. Fitzgerald, "Phase-Sensitive X-Ray Imaging," *Phys Today*, vol. 53, no. 7, pp. 23–26, 2000
[2] M. Endrizzi, "X-ray phase-contrast imaging" *Elsevier B.V.*, 2018
[3] R. Fitzgerald et al., "Phase objects in synchrotron radiation hard X-ray imaging," Cambridge Univ Press, 2009

Bridges still standing along the Via Appia: building materials and state of conservation

A. Lepore (*, a), S.Pagano (a), C. Germinario (b), Mariano Mercurio (b), A. Santoriello (c), Daniela Musmeci (c), Marco Limongiello (d), C. Grifa (b)

(a) Department of Ancient Sciences, University of Rome La Sapienza;

(b) Department of Science and Technology, University of Sannio.

(c) DISPAC, Department of Science of Cultural Heritage, University of Salerno, Fisciano (Sa), Italy

(d) DICIV, Department of Civil Engineering, University of Salerno, Fisciano (Sa), Italy

* Andrea Lepore

andrea.lepore@uniroma1.it

The Roman town of Benevento was an essential crossroad on ancient Appia, and two monumental bridges, *Ponte Leproso* and *Ponte Appiano* as they nowadays are named, permitted those who travelled this sector of the *Regina Viarum* to cross the watercourses.
The *Ponte Leproso* is located on the outskirts of Benevento, with the typical humpback structure, which allowed the Via Appia Antica to cross the Sabato River, about 1 km southwest of Benevento. It had and still has five spans, but only one remained original. The bridge was likely built by the censor *Appius Claudius Cieco* (350 BC - 271 BC), a Roman politician of the ancient and noble *gens* Claudia.
The *Ponte Appiano* (also named *Ponte Rotto*) spans from the 1st BCE to the 7th CE; at least four different building techniques can be identified, referable to as many historical phases; in their current state, an archway and at least three piers of the bridge and two early medieval pillars are visible, built with reused materials from funeral mausoleums from the Roman age.
Both bridges suffered heavy restoration and modification during their ages. The Ponte Leproso appears in good preservation in contrast to the Ponte Appiano, probably due to its position close to the city. To explore the building technology and the state of conservation of the two bridges included in the UNESCO site "*Appia Regina Viarum*," a multidisciplinary campaign was carried out, starting with a detailed photogrammetric survey. The identification of geomaterials showed the use of local limestones and tuffs, bricks, and reused materials on which various degradation phenomena insist, which were catalogued through the abacus provided by ICOMOS. The overlap and intensity of the forms of degradation were evaluated to estimate and quantify the damage present in the works. By the Fitzner method [1], maps of geomaterials, weathering forms and damage were produced, and finally, the damage index was calculated.

References

[1] B. Fitzner, K. Heinrichs, Evaluation of weathering state of natural stones by monument mapping, Proceedings of conference ENVIWEATH 96 "Environmental aspects of the weathering process," 1th-3th December 1996, Brno – Czech Republic, pp. 55-64.

[2] Germinario, C. et al. Conservation Science Damage Diagnosis of Ponte Rotto, a Roman Bridge. International Journal of Conservation Science (2020) 11, 277–290.

An Egyptian mummy of the Roman period with a painted shroud and gilded cartonnage: a multi-analytical study

A. Piccirillo(*, [a]), C. Ricci([a]), P. Buscaglia([a]), D. Scalarone([b]), F. Zenucchini([a]), V. Ponza([a]), R. Genta([a]), S. Aicardi ([c]), M. Borla([d])

([a]) Centro per la Conservazione ed il Restauro dei Beni Culturali "La Venaria Reale", Via XX Settembre 18, 10078 Venaria Reale, Torino
([b]) Dipartimento di Chimica, Università degli Studi di Torino, Via P. Giuria 7, 10125, Torino
([c]) Fondazione Museo delle Antichità Egizie di Torino, Via Accademia delle Scienze 6, 10123 Torino
([d]) Soprintendenza Archeologia, Belle Arti e Paesaggio per la città Metropolitana di Torino, Piazza San Giovanni, 2, 10122 Torino

* Presenting author

anna.piccirillo@ccrvenaria.it

This contribution focuses on the technical study of a rare Egyptian mummy with a painted shroud and a gilded and painted cartonnage belonging to the Museo Egizio of Torino (Provv. 0549). Stored in its warehouses, this shroud was recently studied thanks to a conservative intervention at CCR La Venaria Reale.

Multiband, non-invasive pointwise and micro-invasive analyses allowed us to distinguish between the original materials and those added on occasion of previous conservation interventions.

Morphological observation under optical microscope and a specific micro-chemical analysis were performed on samples of the fibers of the mummy bandages.

The color palette is characterized by an extensive use of Egyptian blue, as highlighted by the visible-induced luminescence (VIL), iron-based red pigment, copper-based green pigment, orpiment, carbon-based black and calcite.

The widespread presence of PVAc, used in a past conservative treatment, has prevented us from identifying the organic binders correctly; nevertheless, the identification, by FTIR analyses, of copper carboxylates suggests the use of a fatty binder, at least in relation to the green areas. In this context, scientific analysis aimed to deepen our current understanding of the artistic practices of the Roman period [1] through an in-depth study of the painting technique, while promoting an improved, science-informed preservation of the mummified human remains.

Figure 1. Front of mummy, painted shroud and gilded cartonnage

References

[1] A. Piccirillo, P. Buscaglia, C. Caliri, F.P. Romano, D.P. Pavone, E.L. Ravan, M. Botticelli, C. Conti, M. Catrambone, C. Miliani, I. Degano, A. Andreotti, F. Nardella, M. Samadelli, A. Paladin, R. Genta, M. Cardinali, F. Pozzi, D. Picchi, "Unraveling the mummy's shroud: a multi-analytical study of a rare painted textile from Roman Egypt", Journal of Cultural Heritage 68 (2024): 107-121.

Handheld digital microscopy and image analysis for examining the surface texture of patinated bronzes

C. Biondi (*,a), B. Salvadori (a), J. Vernet (b), P. Letardi (b), R. Fontana (c), A. Dal Fovo (c), E. Vannini (c), I. Lunghi (c)

(a) National Research Council, Institute of Heritage Science (CNR-ISPC), Via Madonna del Piano 10, Sesto Fiorentino (FI), Italy

(b) National Research Council, Institute of Anthropic Impacts and Sustainability in marine environment (CNR-IAS), Via De Marini 6, Genoa (GE), Italy

(c) National Research Council, National Institute of Optics (CNR-INO), Largo E. Fermi 6, Florence (FI), Italy

* Presenting author

caterinabiondi@cnr.it

Surface texture assessment in Heritage Science is key for understanding material condition and historical context. For patinated bronzes, it aids in identifying deterioration, such as corrosion or patina changes. This analysis supports restoration, informs preservation approaches and plays a key-role in evaluating the adhesion and effectiveness of protective treatments. By these textures, conservation scientists can enhance the care and management of bronze sculptures, ensuring their aesthetic and historical values are preserved. However, characterizing outdoor patinated bronze surfaces is challenging due to variability, artwork geometry, environmental factors, and portable instrument limitations. Non-contact methods are increasingly preferred to prevent surface damage. To address these challenges, efforts are focused on developing standardized non-destructive testing (NDT) methods. The Italian projects InCARE and MEDUSA are conducting extensive research on the surfaces of patinated mock-ups, including those with green Messina and sulphur liver patinas, aiming at establishing new correlations between laboratory methods and portable NDT techniques for on-site characterization. Additionally, both contact and non-contact optical roughness measurements are being carried out as part of the MOLAB access framework.

This study presents a new protocol integrating handheld digital microscopy with image analysis to investigate the surface texture of patinated samples. Its precision and variability are compared to laboratory techniques like light microscopy with raking-light illumination, optical profilometry and Optical Coherence Tomography (OCT) for surface texture and thickness measurements. The effectiveness of portable instruments for on-site roughness assessment is also evaluated.

Acknowledgements

This research was funded by Progetto di Ricerca di Interesse Nazionale PRIN 2022 “Innovative multi analytical Characterisation of the influence of pAtina-coating inteRaction on anti-corrosive propErties – InCARE” (Project code: 2022895PTX) and “MarinE outDoor bronze sUrfaceS: a methodological Approach - MEDUSA” (Project code: 2022KKKLX7), funded by MUR and the European Union – Next Generation EU.

Supply and use of limestones in the Roman architecture of the *X Regio – Venetia et Histria* (N-E Italy): methods and challenges in provenance identification

C. Girotto[a,*], C. Previato[a], E. Bridi[b], S. Dilaria[a,c], J. Bonetto[a], C. Mazzoli[c]

(a) Department of Cultural Heritage, University of Padova, Piazza Capitaniato, 7 - 35139 Padova (Italy)

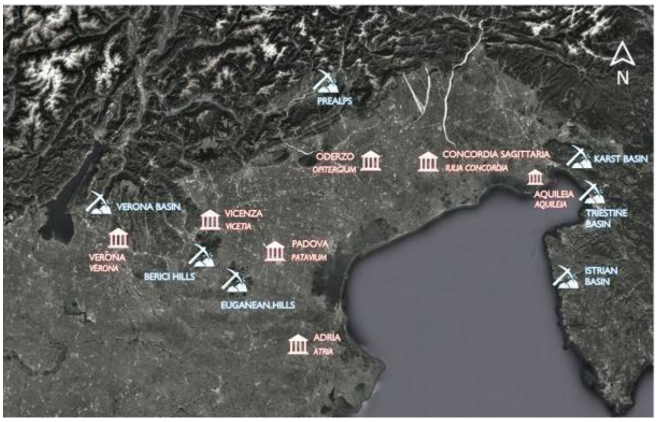
(b) Inter-Departmental Research Centre for the Study of Cement Materials and Hydraulic Binders (CIRCe)

(c) Department of Geosciences, University of Padova, Via Gradenigo, 6 - 35131 Padova PD

* Presenting author

chiara.girotto.3@phd.unipd.it

In recent years, the Department of Cultural Heritage, in collaboration with the Department of Geosciences of the University of Padova, has launched a research project aimed at investigating the stone resources used in the Roman architecture of *Regio X – Venetia et Histria* (North-Eastern Italy)[1, 2, 3]. The project aims at identifying the lithotypes used in the main urban centers of the region and their quarrying area of origin, to understand the economic and social dynamics of stone supply and trade. In doing so, a multi-disciplinary approach is applied, combining archaeological studies with archaeometric analysis of samples taken from Roman buildings and artifacts. This poster presents some of the results of this research, focusing on limestones, which are the most commonly stone materials which outcrop in the region and the most commonly used in the Roman age. Identifying the lithotypes has made it possible to reconstruct the exploitation and trade dynamics of these stone resources, revealing trends common across several cities, as well as differences in how the same lithotypes were used. The study also encountered some challenges, mainly due to difficulties in recognizing certain *petrofacies* and, in the case of geological formations outcropping in different areas of the region, identifying the exact basin of origin. Many of the analyzed samples in fact show petrographic characteristics compatible with multiple source basins, making it difficult to determine the exact extraction site of origin. Despite these limitations, the research permitted to get a deeper understanding of the use of stone in Roman architecture, paving the way for future research expansion.



Map of the main extraction basins and roman cities in the X Regio.

References

[1] C. Previato, Archeologia dell'edilizia in Aquileia romana: i materiali da costruzione e le tecniche edilizie, Padova, 2015;

[2] A. Zara, La trachite euganea: archeologia e storia di una risorsa lapidea del Veneto antico, Roma, 2018;

[3] S. Dilaria, J. Bonetto, L. Germinario, C. Previato, C. Girotto, C. Mazzoli, The stone artifacts of the National Archaeological Museum of Adria (Rovigo, Italy): a noteworthy example of heterogeneity. Archaeol Anthropol Sci (2024), 16 (14), 1-30.

Novel X-ray imaging techniques for the noninvasive investigation of European Heritage within MOLAB platform of E-RIHS

C. Caliri (*, a, b), R. Andolina (a, b), M. Botticelli (a, b), Z. Preisler (a, b), E.L. Ravan (a, c), G. Santagati (a, b), C. Miliani (a), F. P. Romano (a, b)

(a) Consiglio Nazionale delle Ricerche, Istituto di Scienze del Patrimonio Culturale (CNR- ISPC), Catania, Italy
(b) Istituto Nazionale di Fisica Nucleare, Laboratori Nazionali del Sud (INFN-LNS), Catania, Italy
(c) Sapienza University of Rome, Piazzale A. Moro 5, 00185 Rome, Italy

* Presenting author

claudia.caliri@cnr.it

The MOLAB platform of E-RIHS, the European Infrastructure for Heritage Science, provides access to advanced analytical spectroscopies for the non-invasive characterization of tangible cultural heritage on site. XRAYLab of the Institute of Heritage Science (ISPC-CNR) in Catania specializes in developing novel mobile X-ray instruments for use in MOLAB's collaborative projects. Since 2021, the laboratory has conducted more than 20 measurement campaigns to study heritage objects selected through the competitive calls of E-RIHS for access through the MOLAB.

Among the materials investigated, painted artworks represent a significant focus for the heritage science community. The analytical capabilities of advanced X-ray technologies developed by the XRAYLab have enabled deeper insights into pigment materials, creative processes and the conservation states of iconic masterpieces, such the remarkable paintings by the great Medieval and Renaissance masters, the 16-meter-long *Book of the Dead* from the funerary tomb of Kha and Merit at the Museo Egizio in Turin, and the frescoes by Masolino, Masaccio, and Lippi in the Brancacci Chapel in Florence.

In the measurement activities performed, we have combined on the same object different analytical techniques to investigate both the chemical nature of the painted materials and their layered structure. A highly sensitive MA-XRF scanner with on-the-fly imaging capabilities, a strongly focused beam and 6-SDDs detection device, provides the elemental distribution images of the paintings that are crucial to understand the nature of the pigments and the modus operandi of the artist. A novel MAXRPD based on linear Si-strip detectors covering the Bragg region is then applied for obtaining pigment specific identification and to highlight their related degradation products. Finally, we recently introduced a mobile high-resolution digital radiography equipped with a motorized frame, a flat panel covering 54x40cm^2 area with 120µm pixel pitch, and a 1kW X-ray source that allows the in-situ investigation of panels and canvas painting with dimensions up to 200x180cm^2. In this work, we present the experimental details of the device used during the MOLAB activities and some compelling results.

SEM-EDS and μ-Raman characterisation of the contents of the medieval inkwell of Palazzo Paradiso (Ferrara, Italy)

C. Ongari (*, a), C. Guarnieri (b), E. Marrocchino (c)

(a) Departement of Emvironment and Prevention Sciences, University of Ferrara, Ferrara, Italy

(b) Archaeological Heritage Office, Superintendence SABAP Bologna, Modena, Reggio Emilia and Ferrara, Bologna, Italy

(c) Department of Environmental and Prevention Sciences, University of Ferrara, Ferrara, Italy

* Presenting author: ngrcln@unife.it

The application of geochemical analysis provides valuable insights into the characteristics of soil components associated with archaeological artefacts. Such analyses of archaeological soils yield essential information regarding past human settlements, their activities and the surrounding environment. This study focused on the investigation of the contents of an inkwell discovered in an ancient throwing basin during excavations at Palazzo Paradiso, Ferrara, in the early 1980s. These vessels, commonly used during the medieval period is considered to serve as reservoirs for ink utilized in manual writing on parchment or paper. The contents of the inkwell were analysed using scanning electron microscopy with energy dispersive spectroscopy (SEM-EDS) and micro-Raman spectroscopy (μ-Raman) technique. SEM-EDS analysis revealed significant levels of sulphur and iron, while μ-Raman spectroscopy identified the presence of haematite (Fe_2O_3).

These findings align with the observations of Chireceanu C. et al., 2015 [1] and confirm the presence of iron sulphate, a key component in ancient in ancient inks. Specifically, iron-gall ink (IGI) is an iron-polyphenol complex, was produced by reacting tannins extracted from gall nuts with the Fe^{2+} derived from iron sulphate. Gum arabic was employed as the organic binder, while 'vitriol' consisting of iron (II) sulphate, was mainly used as the iron salt facilitating the formation ofa black/dark precipitate essential for ink production.

The inkwell of Palazzo Paradiso in Ferrara (FE).

Archaeometric study of fine glazed wares from Pisa (13^{th}-14^{th} century)

D. Paghi ([*,a]), H. Gao ([a]), R. Manca ([a]), M. Benvenuti ([a,b])

(a) Dipartimento di Scienze della Terra, Università degli Studi di Firenze, Via La Pira 4, 50121, Florence, Italy
(b) Istituto di Geoscienze e Georisorse (IGG), CNR, Via Giuseppe Moruzzi 1, 56124, Pisa, Italy

* Presenting author

diletta.paghi@unifi.it

Fine glazed ceramics were produced in Pisa (Italy) between the 13^{th} and the beginning of the 15^{th} century, at the same time and in the same workshops as archaic maiolica [1]. Fine glazed artifacts, however, were of lesser value compared to maiolica artifacts and, therefore, mainly intended for the table and daily life of the middle-lower social classes [2]. After being neglected in archaeological studies for many decades, they have then been thoroughly studied by Giorgio [3]. However, there is no archaeometric data on this ceramic class to date. Fifteen shards of fine glazed ceramics from Pisa, dated between the 13^{th} and 14^{th} century, with colourless or coloured (yellow, green and brown) glazes were investigated. Scanning electron microscopy (SEM-EDS) was performed to characterize the layered structure and chemical composition of the glaze. Furthermore, X-ray Fluorescence spectroscopy was used to better identify the chromophore elements responsible for the different colours of the glazes and to check possible variations in the composition in different areas of the shards. The analyses have shown that the glazes are of the high lead type, with an alkali content (Na_2O + K_2O) lower than 3 wt% in most of the samples. They are rather inhomogeneous and almost completely free of crystalline phases within the glaze. No clear difference among glazes made in different periods or from different sites was highlighted. The chromophore elements identified are copper (CuO) in the green glazes and manganese (MnO) in the brown ones. For the yellow glaze, a chromophore element was not identified. In fact, iron, the most common chromophore used to obtain yellow glazes, was found in similar concentrations in all samples; this suggests that it was not intentionally added to the glaze as a colourant, but was an impurity in the raw materials. The comparison between fine glazed shards and archaic maiolica ones from the same archaeological contexts has highlighted the compositional differences of the glazes used. Moreover, the glazes of fine glazed ceramics showed a more heterogeneous and variable composition compared to those of maiolica, whose production seems to be more standardized.
In conclusion, this first archaeometric study of fine glazed ceramics made in Pisa at the beginning of the 13^{th} century allowed us to reconstruct and increase our knowledge on one of the first productions of glazed artifacts in Tuscany.

References

[1] M. Giorgio, La città e il territorio. Circolazione e consumo di ceramica in ambito pisano tra X e XIV secolo, Atti del XLVIII Convegno Internazionale della Ceramica (2015), vol. XLVIII, p.113-128.
[2] M. Giorgio, Ceramics and Society in Pisa in Middle Ages, in GONÇALVES M.J., GÓMEZ-MARTÍNEZ S. 2016 (a cura di), Actas do X Congresso Internacional a Ceramica Medieval no Mediterraneo (Silves, 22-27 Ottobre 2012), pp. 93-105.
[3] M. Giorgio, Le ceramiche rivestite bassomedievali da mensa di produzione pisana: la maiolica arcaica e le invetriate, tesi di dottorato in Archeologia. sviluppo storico e interrelazioni culturali nell'antichità e nel medioevo, Università degli studi di Torino (2010), XXI ciclo.

Acknowledgements

The Archaeological Superintendence of Pisa and Dr. M. Giorgio are acknowledged for providing the ceramic samples involved in this study and sharing the relevant archaeological information.

The Statue of Ramesses II (Cat. 1380) at Museo Egizio, Turin: a 3D Imaging and Raman Spectroscopy Study

F. Di Iorio (*, a,b), L. Es Sebar (a), J. Auenmüller (c), F. Taverni (c), S. Aicardi (c), S. Grassini (a)

(a) Department of Applied Science and Technology, Politecnico di Torino, Corso Duca degli Abruzzi 24, 10129 Turin (TO), Italy
(b) Fondazione Centro Conservazione e Restauro dei Beni Culturali "La Venaria Reale", 10078 Venaria Reale (TO), Italy
(c) Fondazione Museo delle Antichità Egizie di Torino, 10123 Turin (TO), Italy * Presenting author federico.diiorio@polito.it

This study, a result of the collaboration between Museo Egizio, Turin, and the Politecnico di Torino, focuses on a detailed assessment of the statue of Ramesses II (Cat. 1380) through 3D imaging and Raman spectroscopy. This sculpture dates to the early years of Ramesses II's reign (New Kingdom, 19th Dynasty, ca. 1279–1254 BCE). The statue was found by Jean-Jacques Rifaud in the temple of Amun at Karnak, modern Luxor, in 1818 in a highly fragmentary state. All the fragments were, upon their arrival in Turin as part of the Drovetti collection in 1824, reassembled. A previous study has performed a petrological investigation of the rock and identified the material as tonalite from Aswan [1].

Using a multidisciplinary, non-invasive approach, the study presented here aims to gather detailed information about the statue's state of preservation and previous restoration interventions. Raman spectroscopy was employed to identify and characterize the pigments and restoration materials that are present on the statue's surface. The analyses reveal traces of synthetic pigments, including Prussian blue [2] and chrome oxide green [3], two coloring agents produced since the 18th and 19th centuries, respectively, indicating possible restoration interventions. An innovative methodology was also applied by integrating traditional 3D photogrammetry with multispectral imaging techniques to create a comprehensive digital model of the statue. This allowed for the documentation of the statue's physical dimensions, geometry, color, and surface texture, combining these features with radiometric data captured in the visible, ultraviolet, and infrared spectra. The resulting multispectral 3D model not only facilitates the visualization of the conservation state but also allows for the examination of the statue's response to various wavelengths, offering deeper insights into the materials present and revealing concealed features such as varnishes and adhesives from earlier interventions. Thanks to UV radiation, it was possible to map the adhesive and restoration materials that were employed around 1824 to reassemble the fragments of the statue. The digital models, available through platforms like Sketchfab [4], offer a novel way to engage both scholars and the public, making the findings accessible and interactive while setting a new standard for the study and preservation of ancient artifacts.

References

[1] Borghi, A., D'Amicone, E., Serra, M., Vaggelli, G., & Vigna, L. (2011). "Ramses II in Majesty": A MineroPetrographic and Provenance Rock Study. In I. Turbanti-Memmi (Ed.), Proceedings of the 37th International Symposium on Archaeometry, 13th—16th May 2008, Siena, Italy (pp. 193–198). Springer Berlin Heidelberg.
[2] Kraft, A. (2008). On the Discovery and History of Prussian Blue. Bull. Hist. Chem., 33(2).
[3] Cultural Heritage Science Open Source (CHSOS), Chrome oxide green. Retrieved November 28, 2024, from: https://chsopensource.org/chrome-green-k-44200/
[4] Sketchfab. Retrieved November 28, 2024, from: https://sketchfab.com/

Acknowledgments: This publication is part of the project PNRR-NGEU, which has received funding from the MUR – DM352/2022.

Preliminary analysis of metal artefacts from the archaeological site of Spina (VI-III sec. a.C.)

F. Chiaramonte (*, a), E.Marrocchino (b), C. Cornelio (c), L. Malnati (d), N. Eftekhari (b), C. Vaccaro (b)

(a) Dipartimento di Studi Umanistici (STUM), Via Paradiso, 12, 44121 - **Ferrara, Italy**
(b) Dipartimento di Scienze dell'Ambiente e della Prevenzione (DiSAP), Corso Ercole I° d'Este 32, 44121 – Ferrara, Italy
(c) Consorzio Futuro in Ricerca, Via Saragat 1 44122 – Ferrara, Italy
(d) Soprintendenza ABAP Bologna, Modena, Reggio Emilia e Ferrara, Italy

* Presenting author

frances.chiaramonte@stud.unife.it

The city of Spina, a fundamental commercial junction between the Etruscan and Greek worlds in the north Adriatic area, was founded around 530 B.C. [1] and remained active until the 3rd century B.C.[2,3], when changed environmental and geopolitical conditions sanctioned the decline of its function as a commercial port. The first evidence of Spina's presence in the Po Delta came to light by chance during land reclamation works in the Comacchio Valleys in 1922. During these efforts, an ancient tomb was discovered, marking the beginning of a series of finds. Continued reclamation activities subsequently led to the identification of the Valle Trebba and Valle Pega necropolises. Over the years, archaeological investigations have significantly deepened our understanding of Spina, uncovering numerous artifacts that highlight its history and its strategic importance in ancient trade networks. In 2023, the University of Ferrara, in partnership with the Consorzio Futuro in Ricerca (CFR) and under the MiC - Sabap Bologna concession, carried out an archaeological excavation led by Caterina Cornelio with Luigi Malnati, supported by the Petra Company.

The study of this material, in particular the metal slag, is of fundamental importance for understanding the technological level reached by the Etruscans and answering questions about their activities in the Po Valley [4,5,6]. In this paper, we present the preliminary results of analyses using non-destructive techniques, including portable ED-X-ray fluorescence (pXRF) and SEM-EDS, conducted on the slag and metal alloys recovered during the 2023 excavation. The pXRF analyses allowed us to obtain statistical data on the types of artefacts and metal alloys and on this basis, samples were then chosen on which to carry out in-depth observations and SEM-EDS microanalysis. This study examined approximately 120 artefacts, including metal slag, fragments of fibulae (iron and bronze), nails, and lead items, mostly under 10 cm in length and in varying states of preservation. Decorative items, like fibulae, were often heavily degraded and found only as fragments. Preliminary analysis shows most metal slag comprises ferrous alloys, with some bronze alloys primarily containing copper and lead.

References

[1] Reusser, C. (2021). Le fasi costruttive della città di Spina: risultati delle campagne di scavo condotte dall'Università di Zurigo nell'area urbana. Studi Etruschi, 84, 101-141., 84:101-141. ISBN: 03917762StEtr84
[2] Trevisanello, C. (2022). Spina 100. Dal mito alla scoperta. In Spina 100. Dal mito alla scoperta. A un secolo dal ritrovamento della città etrusca di Spina nell'antico delta del Po (pp. 66-74). Teseo Editore.
[3] De Santis, P., Govi, E., Nizzo, V., Sassatelli, G., & Trocchi, T. (Eds.). (2023). Spina etrusca: un grande porto nel Mediterraneo. ARA edizioni..
[4] Hostetter, E. (1986). Bronzes from Spina I: The Figural Classes: Tripod, Kraters, Basin, Cista, Protome, Utensil Stands, Candelabra, and Votive Statuettes. Verlag Philipp von Zabern GmbH.
[5] Hostetter, E. (2001). Bronzes from Spina II: Instrumentum Domesticum. Verlag Philipp von Zabern GmbH.
[6] Mommersteeg, P. W. (2011). Metallurgy and the development of Etruscan civilisation (Doctoral dissertation, UCL (University College London)).

PERSPECTIVE: a project dedicated to the development of innovative analytical strategies for the knowledge and preventive conservation of plastic heritage

F. Rosi[a], I. Bargagli[a], L. Cartechini[a], C. Costantino[a], A. C. Boccia[a], I. Degano[b], F Modugno[b*], J. La Nasa[b], A. Ferretti[b], D. Comelli[c], S. Samela[c], M. A. Cardinali[a,d], L. Andena[e], G. de Cesare[f], A. Botteon[g], V. di Tullio[g], D. Buti[g], L. Barchi[g], C. Miliani[g], J. Striova[h], V. Righetti Comez[i]

[a]CNR-SCITEC; [b]Dipartimento di Chimica e Chimica Industriale, Università di Pisa; [c]Dipartimento di Fisica, Politecnico di Milano; [d]Dipartimento di Chimica Biologia e Biotecnologie, Università di Perugia; [e]Dipartimento di Chimica, Materiali e Ingegneria Chimica " Giulio Natta", Politecnico di Milano; [f]Accademia delle Belle Arti dell'Aquila; [g]CNR-ISPC; [h]CNR-INO; [i]CNR-IOM

* Presenting author francesca.modugno@unipi.it

The introduction of plastics in the 19th century marked the beginning of a revolutionary era, characterized by the widespread adoption of semi-synthetic and synthetic polymers. Initially used for everyday objects, these materials quickly expanded into the domains of art and design. Today, plastic artworks and design objects constitute a significant portion of modern and contemporary museum collections. However, the short-term stability of these artifacts poses significant challenges to conservators and curators, primarily due to their heterogeneous and complex composition. The conservation of plastics is further complicated by the limited and often imprecise information available in museum catalogues.

The development of non-invasive methods, a priority in Heritage Science, becomes even more crucial for plastic artworks due to their peculiar vulnerability, heterogeneity, and material complexity. These factors hinder the standardization of effective and repeatable conservation and restoration procedures.

This poster presents the activities of the PRIN2022 interdisciplinary project PERSPECTIVE—PolymEr Research Studies for PreventivE Conservation Through non invasIVe analytical strategiEs (https://perspective.cnr.it), aimed to develop multimodal analytical approaches for the knowledge, monitoring, and preservation of plastic heritage. These approaches will deepen our understanding of ageing phenomena by combining non-invasive, in situ investigations with laboratory-based analytical techniques, eventually applicable to optimize conservation strategies for plastic artworks and design objects. In collaboration with a network of contemporary art museums across Italy and Europe, the project integrates innovative non-invasive and micro-destructive traditional methods through the contextual interpretation of results obtained from the analysis of model and reference materials, conservation materials, and case studies. By correlating compositional data with mechanical properties, the project will advance our understanding of plastic heritage in art and design museums and deepen our knowledge of the degradation processes affecting these materials.

Identifying textile fibres in Classical and Hellenistic Sicily: an archaeometry study of mineralised textile remains from burials

G. Longhitano (*, [a]), G. Quarta ([b]), M. Masieri ([b]) and M. Primavera ([a])

([a]) Dipartimento di Beni culturali, Università del Salento, Lecce.

([b]) CNR ISPC, Lecce.

* Gabriella Longhitano

gabriella.longhitano@unisalento.it

This paper presents the results of an ongoing PRIN 2022 PNRR project 'Arakne' focusing on the analysis of textiles and fibres recovered from southern Italy. The analysis has been carried out in a cross-disciplinary collaboration between archaeologists of the Department of Cultural Heritage at the University of Salento and the diagnostic team of the CNR ISPC at Lecce with the aim of characterising the techniques and the raw materials used for making the textiles found in two cemeteries in Greek Sicily. The first case study is the southern necropolis of Vassallaggi (Caltanissetta) which was excavated by D. Adamesteanu and P. Orlandini between 1950 and 1960 [1,2]. The second case study is the necropolis in *contrada Diana* at Lipari investigated by L. Bernabò Brea and M. Cavalier in the 1980s [3]. Both cemeteries yielded evidence of mineralised textiles found on metal objects in a number of burials. Recently, these textiles have been analysed using a digital portable microscope allowing for the measurement of yarn diameters and more detailed structural analysis (type of textile weaves, thread count, etc.) [4]. The goal of this paper is to present the results of further analysis carried out on the same textile remains by using scanning electronic microscopy (SEM) aiming to identify the types of fibres used to produce them. The investigation of archaeological textiles frequently poses significant challenges due to the highly perishable nature of organic materials. In this study, although the samples resulted highly mineralised, the use of SEM has proven effective as a tool to identify fibres, enabling the reconstruction of textile production and related social practice in Greek Sicily.

References

[1] Orlandini, P. (1971) Vassallaggi (S. Cataldo). Scavi 1961, I. La necropoli meridionale. *Notizie degli Scavi di Antichità, Suppl.*, 9-13.

[2] Pizzo, M. (1999) Vassallaggi (S. Cataldo, Caltanissetta). La necropoli meridionale, scavi 1956. *Notizie degli Scavi di Antichità*, 207-395.

[3] Bernabò Brea, L., Cavalier, M. and Villard, F. (2001) Meligunìs Lipàra XI, Gli scavi nella necropoli greca e romana di Lipari nell'area del terreno vescovile Parte I e Parte II, Palermo, Regione Siciliana. [4] Longhitano, G. (2024) Archeologia del tessuto in Sicilia tra l'età del Ferro e quella Ellenistica: dall'analisi delle evidenze dirette e indirette alla tradizione tessile. tesi di dottorato, Università degli Studi di Catania.

Acknowledgements *We warmly thank Rosario Vilardo, Maria Clara Martinelli, Roberto Sciarratta and Giuseppe Avenia for giving us the permission of studying the material from Lipari and Vassallaggi.*

Microorganisms Assisted Formation of Calcium Oxalate on Cultural Heritage Materials

L. Geminiani (*, a, b), C. Corti (b, c), G. Ranalli (d), E. Zanardini (a), L. Rampazzi (b, e, f)

(a) Department of Science and High Technology, Università degli Studi dell'Insubria, Via Valleggio 11, Como, Italy

(b) Centre for Cultural Heritage Studies, Università degli Studi dell'Insubria, via Valleggio 9, Como, Italy

(c) Servizio Gestione Piattaforme Di Ricerca, Università degli Studi dell'Insubria, Via Valleggio 9, Como, Italy

(d) Department of Bioscience and Territory, Università degli Studi del Molise, C.da Fonte Lappone snc, Pesche (Is), Italy;

(e) Department of Human Sciences and of Innovation for the Territory, Università degli Studi dell'Insubria, Via Valleggio, 9, Como;

(f) Istituto per le Scienze del Patrimonio Culturale, Consiglio Nazionale delle Ricerche (ISPC-CNR), via Cozzi 53, Milano, Italy

* Presenting author

lgeminiani@uninsubria.it; ludo.gemi@yahoo.it

There is still debate about the origin of calcium oxalate films, a significant contributor to the colour change of stone materials [1]. The suggested origins include the biogenic production by oxalic-acid-generating microorganisms and the chemical development of oxalic acid through the oxidative breakdown of biological coatings on stone surfaces, a consequence of previous polishing and restoration works involving natural materials such as lipids, proteins, and carbohydrates [2]. Recent research works [3] showed that oxalate salts could be also the decay product of the Japanese lacquer (urushi), which is a natural polymer obtained from the exudate of the tree Rhus Verniciflua. This lacquer is widely employed in East-Asian art for finishing wood and metallic surfaces. Historical texts and contemporary analyses also mention the incorporation of calcium carbonate powder as a filler in lacquer, providing a straightforward explanation for the presence of calcium ions. The present work aims to clarify the mechanisms leading to the formation of oxalate films due to microbial metabolic products. In literature, previous experiments investigating the biological formation of calcium oxalate revealed that various fungi, as well as bacteria, can produce organic acids, notably oxalic acid [4]. This acid reacts with carbonate substrates to yield calcium oxalate. Unlike many studies using liquid cultural media and non-environmental conditions, the experimental design which was developed in this study aimed to replicate real-world conditions as closely as possible.

Both stone and lacquered specimens were subject to microbial growth tests. Stone substrates received various organic treatments (whole egg, linseed oil, and gum arabic), both fresh and artificially aged. For Japanese lacquers, three different mixtures were employed, incorporating filler (CaCO3) and two types of additives (perilla oil and rice starch). Bacterial and fungal inocula were obtained from the microbiological sampling of a bas-relief (located at the external façade of Pisa Cathedral) and of some Japanese urushi-lacquered armors (Morigi Collection, Museo delle Culture, Lugano, Switzerland). Both the sampling contexts showed the presence of calcium oxalate. After the inoculation, the mock-up samples underwent high humidity and ambient temperature conditions. The microbial growth was assessed over time through microscopic observation (SEM), while the formation of organic acids and of oxalate salt was monitored by Fourier transform infrared spectroscopy (ATR-FTIR and external reflection-FTIR) and by X-ray diffraction (XRD).

Results on stone specimens revealed that added organic substances served as favorable microbial growth substrates, promoting chemical reactions leading to the formation of calcium oxalate and unexpected compounds, such as metal soaps, commonly found in oil paintings due to fatty acid saponification. The presence of organic substances may affect microbial production of hydrolase enzymes, potentially leading to the formation of calcium soaps. In particular, mycetes exhibited substantial growth and adaptation capabilities, hydrolyzing triglycerides from egg and linseed oil through metabolic enzymes.

This study underscores the significant influence of microbial growth on the formation of decay products like calcium oxalate and calcium soaps. It happened significantly using an experimental design which was developed to replicate real-world conditions as closely as possible. Infrared spectroscopy and X-ray diffraction proved valuable in characterizing substrates, organic substances, and inocula. In particular, portable external reflection infrared spectroscopy was able to detect bacterial and fungal growth in real time. That suggests a possible use of the technique as a mean to evaluate the presence of biological colonization on cultural materials surfaces and remnants of microbiological activity after biorestoration and biocleaning works.

References

[1] Rampazzi, Laura "Calcium oxalate films on works of art: A review." Journal of Cultural Heritage 40 (2019): 195-214.
[2] Rampazzi, Laura, et al. "Analytical investigation of calcium oxalate films on marble monuments." Talanta 63.4 (2004): 967-977.
[3] Schellmann, Nanke. "Delamination and flaking of East Asian export lacquer coatings on wood substrates." East Asian Lacquer: Material Culture, Science and Conservation". London: Archetype (2011): 107-20.
[4] Gadd, G. M., et al "Oxalate production by fungi: Significance in geomycology, biodeterioration and bioremediation" Fungal Biology Reviews 28, 2–3: 36–55 (2014)

Thermographic Diagnostics Supporting the Restoration of the Frescoes in the Abbey of San Michele Arcangelo in Badia a Passignano (Florence)

G. Di Giorgio [*, a], S. Schiavone [b], L. Randazzo [c], M. Ricca [a], F. La Russa [d], S.A. Ruffolo [a], M. F. Alberghina [a, b]

[a] Department of Biology, Ecology and Earth Sciences (DiBEST), University of Calabria, Ponte P. Bucci, Cubo 12b, II Piano 87036, Arcavacata di Rende (CS), Italy
[b] S.T.Art-Test di S. Schiavone & C sas, via Stovigliai, 88 93015 Niscemi (CL), Italy
[c] Department of Earth and Marine Sciences (DiSTeM), University of Palermo, Via Archirafi 26 90123 Palermo (PA), Italy)
[d] Conservator Scientist, Italy

* Presenting author

greta.digiorgio@icloud.com

This study focuses on the diagnostic investigations conducted on the 15th-century fresco cycle by Filippo Filippelli (1483) and created for the upper cloister of the Abbey of San Michele Arcangelo in Badia a Passignano (FI). The cycle, composed of twenty-nine scenes from the life of Saint Benedict, represents a significant example of Tuscan Renaissance painting [1], executed with a narrative and decorative technique that reflects the aesthetics and spiritual values of its time. However, the pictorial quality has been severely compromised by historical events, including the infill wall of the cloister in 1755, the “scialbatura” of the surfaces in 1734 and subsequent structural modifications made between the 18th and 19th centuries. These interventions, combined with the action of atmospheric agents before the closure of the cloister, have left evident marks on the conservation status of the frescoes. The diagnostic investigations, aimed at supporting the design of the restoration, employed non-invasive techniques such as passive mode IR thermography, cover meter surveys and hygrometric measurements. The results allowed for the identification of numerous issues, including plaster or pictorial layers detachments, infill wall of previous openings mapping, and water infiltrations or salts migrations localization. Thermography revealed anomalies that document not only the existing degradation, but also the architectural changes over the centuries. At the same time, the cover meter survey confirmed the presence of hidden metallic elements related to structural past interventions, while the surface hygrometric measurements highlighted a generally good state of dryness, with exceptions limited to specific critical areas.

a)

b)

c) *IR thermal image (a) and its corresponding picture (b) of a scene from the cycle of frescoes. (c) Capture representation of thermograms.*

The collected data constitutes an essential scientific basis for understanding of the historical and architectural context in which the pictorial cycle is situated and planning a targeted restoration, which not only aim to preserve the physical integrity but also to enhance its cultural value.

References

[1] C. Chiti, Badia a Passignano nel Quattrocento: il rinnovamento del monastero e la committenza artistica di Isidoro Del Sera, tesi Magistrale, Università degli Studi di Firenze, A.A. 2021-2022

Acknowledgements. The authors would like to thank the non-profit Committee “United by Art” which promoted the “Adopt a Panel” Campaign to support the studies and restoration of the fresco cycle of Badia a Passignano.

Study of golden filigree manufacturing technique from the Chiaravalle Cross by means of high-resolution neutron tomography

L. Vigorelli ([a,*]), Floriana Salvemini ([b]), Giulia Marcucci ([a]), Costanza Cucini ([c]), Maria Pia Riccardi ([d]), Daniela Di Martino ([a])

(a) Dipartimento di Fisica "G. Occhialini", Università degli Studi di Milano-Bicocca and INFN Sezione di Milano-Bicocca, Piazza della Scienza 3, 20126 Milan, Italy

(b) Australian Nuclear Science and Technology Organisation (ANSTO), Bragg Institute, Lucas Heights, Australia

(c) IRAMAT, UMR 7065, CNRS, Université de Technologie Belfort Montbéliard, 90010 Belfort Cedex, France

(d) Dipartimento di Scienze della Terra e dell'Ambiente and Arvedi Laboratorio– sede di Pavia, Università degli Studi di Pavia, via Ferrata 9, 27100 Pavia, Italy

* Presenting author

luisa.vigorelli@unimib.it

The Chiaravalle Cross is a medieval Italian processional cross from Chiaravalle Abbey (close to Milan, Italy). It is a beautiful and complex jewellery masterpiece from the Museo del Duomo's collection in Milan, attributed to the Venetian production, dating back to the end of the 13th century [1]. It measures 96 cm in height and 69 cm in width (with the two cross' arms) and it is realized and decorated with different types of precious materials like silver and gold laminas, combined with filigrees, crystals, gems, cameos and red jasper, thus requiring the application of varying manufacturing techniques as well as specialised expertise. During the Cross' restoration performed in 2016 within the 'Restituzioni Project' [2], a wider in-depth study of this artefact through different scientific analyses was performed [3]. During the restoration work, some filigree fragments were made available for a more in-depth study. By preliminary SEM analyses, it was suggested that the filigree was made using a silver wire with a squared section, typical of Venetian production, shaped by the "block-twisting" method and finally "amalgam" gilded (i.e. using an alloy of mercury and gold). In addition to microscope method non-invasive techniques, such as neutron Computed Tomography (CT), were employed to examine the filigree. This approach aimed to ascertain the attributed provenance and to clarify the production technique. Indeed, neutrons are a powerful probe to non-invasively survey the bulk of metallic materials and visualize their inner structures from different spatial directions at the same time. Given the tiny dimension of the sample (~1 cm), an innovative neutron imaging method was used to perform the tomographic analysis to achieve a better spatial resolution (lower than ~10 μm). The measurement was conducted at the Australian Nuclear Science and Technology Organization (ANSTO, Sydney), using a Neutron Microscope detector to achieve a sub-five μm image spatial resolution with a reasonable exposure time [4]. The performed analysis allowed to disclose the three-dimensional structure of the golden filigree, and the obtained information was integrated with two-dimensional results obtained by a previous SEM analysis getting a comprehensive understanding of the manufacturing technique. References

[1] L. Caselli, La croce di Chiaravalle Milanese e le croci veneziane in cristallo di rocca. Il Prato Ed.: Padova, Italy, 2002.

[2] C. Bertelli and G. Bonsanti, "Tesori d'Arte Restaurati," Restituzioni. 2016. Available online: http://www.restituzioni.com/opere/croce-di-chiaravalle/

[3] G. Benati and D. Di Martino, La Croce di Chiaravalle. Approfondimenti storico-scientifici in occasione del restauro. BookTime, Milano, 2017

[4] P. Trtik et al., "Improving the spatial resolution of neutron imaging at Paul Scherrer Institute–the neutron microscope project," Phys Procedia, vol. 69, pp. 169–176, 2015

Exploring biodeterioration through high throughput sequencing: a case study at Santa Maria della Grotta (Trapani, Italy)

M.A. Buccheri(*, a), R.C. Ponterio(b), D. Giuffrida(b), M.L. Saladino(b, c), C. Tuccio(c, d), G. Rappazzo(e), G. Franzò(a)

(a) CNR-IMM Sede secondaria Catania (Università), Italy

(b) CNR-IPCF, Messina, Italy

(c) STEBICEF Department, Università di Palermo, Italy

(d) Cultur and Society Department, Università di Palermo, Italy

(e) DSBGA, Università di Catania, Italy
* Presenting author, email: mariaantonietta.buccheri@cnr.it

High throughput sequencing (HTS) of both 16S rRNA and 18S rRNA gene amplicons gives insights into microbial communities' composition in diverse environments. Cultural heritage objects represent interesting ecological niches shaping unique microbial communities, which, in turn, may be held responsible for biodeterioration phenomena [1]. Therefore, investigating those communities is key to provide a clue towards biodeterioration processes. This case study focused on frescoes located in hypogea rooms of the Santa Maria della Grotta Complex in Marsala (Trapani, Italy) [2,3]. In order to explore communities possibly linked to frescoes' biodeterioration, sampling was made, by sterile swabbing, in the areas where colour differences were evident and alterations or salt concretions were identified. Main colonizers belong to the Actinomycetia class, the most represented genera being *Pseudonocardia* followed by *Mycobacterium*. Wherever Actinomycetia are less abundant, Gammaproteobacteria take over. Archaeal communities were explored too and show to include members of the Nitrososphaeria class, with a prevalence of *Nitrososphera*, a chemolithoautotroph genus, endowed with ammonia-oxidizing abilities. Interestingly, these results are in agreement with the hypogeal nature of the site. Noteworthy, in salt concretions points the genus *Rubrobacter* is overriding the sample, accompanied by low percentages of Archaea belonging to Halobacteria class. As for the 18S amplicons, the class of Saccharomycetes belonging to the Ascomycota phylum, and the class of Malasseziomycetes belonging to the phylum of Basidiomycota, are the most represented ones. The Embryophyta class is also recorded in some samples, in line with the presence of invasive vegetation in the site.

References

[1] B. Gutarowska, The use of -omics tools for assessing biodeterioration of cultural heritage: A review, Journal of Cultural Heritage, 2020, Volume 45, Pages 351-361, ISSN 1296-2074, https://doi.org/10.1016/j.culher.2020.03.006.

[2] E. Caruso, "L'abbazia basiliana di Santa Maria della Grotta", Federico e la Sicilia: dalla terra alla corona – Archeologia e Architettura (ed. by Di Stefano C. A., Cadei A.), Siracusa-Palermo, 1995, pp. 239-245.

[3] M.A. Lima, "Gli affreschi bizantini di S. Maria della Grotta", Marsala (ed. by Griffo Alabiso M. G.), Marsala, 1997, pp. 172-181.

Acknowledgements

This work has been partially funded by the European Union (NextGeneration EU), through the MUR-PNRR project SAMOTHRACE (ECS00000022). We thank Arch. A. Occhipinti and Dr. M.G. Griffo of the Archeological Park of Lilybaeum for the permission to perform the investigation

Madonna Odigitria fresco from the Palatine Chapel of the Royal Palace of Palermo (Sicily): restoration and analysis updates

M. F. Alberghina ([*, a, b]), L. Randazzo ([c]), L. Maritan ([d]), G. Bonanno ([e]), S. Bavastrelli ([e]), L. Pasta ([e]), A. Valenti ([e]), E. Passerini([e]), M. F. La Russa ([b]), S. Schiavone ([a])

([a]) S.T.Art-Test di S. Schiavone & C sas, via Stovigliai, 88 93015 Niscemi (CL), Italy

([b]) Department of Biology, Ecology and Earth Sciences (DiBEST), University of Calabria, Ponte P. Bucci, Cubo 12b, II Piano 87036, Arcavacata di Rende (CS), Italy

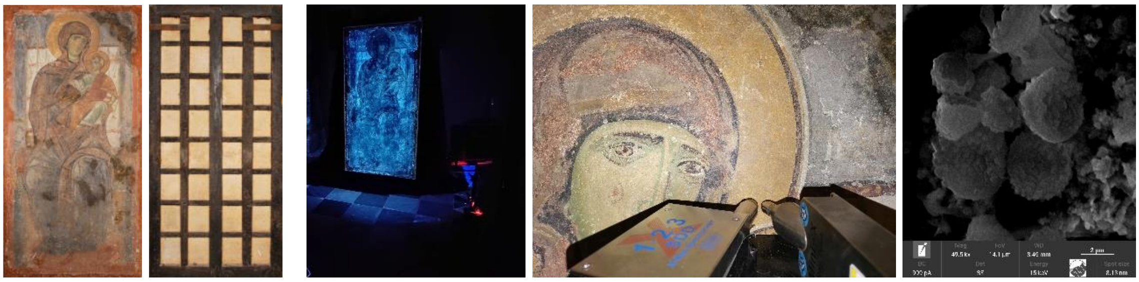
([c]) Department of Earth and Marine Sciences (DiSTeM), University of Palermo, Via Archirafi 26 90123 Palermo, Italy

([d]) Department of Geosciences, University of Padova, Via G. Gradenigo 6, 35131 Padova, Italy

([e]) Centro Regionale per la Progettazione e il Restauro (C.R.P.R.) Regione Siciliana, Assessorato dei Beni Culturali e dell'Identità Siciliana, Palermo, Italy
* Presenting author

info@start-test.it

The mural painting depicting the *Madonna Odigitria (*unknown painter Mid-12th century), displayed in the Palatine Chapel of the Royal Palace of Palermo (Sicily), is currently undergoing a delicate restoration work by the Laboratories of Centro Regionale per la Progettazione e il Restauro of Palermo. The historical data reports that in 1949 this *fresco* was detached and placed on a new support consisting of a canvas on a wooden frame, sealed with a layer of mortar and a thin pictorial layer. In order to provide targeted support for the planning of the restoration activities, a diagnostic study has been carried out through non-invasive methodologies and subsequent in-depth analyses on samples. The investigations have been aimed at characterizing the pigments and the technique, at identifying the degradation products (salts, biological attack, aged organic protective applied over time). The UV fluorescence images located the areas of pictorial and plaster integrations; the new data, the microscopic observation and macroscopic evaluation by restorers confirmed, according to the hypothesized period, that the mural painting consists of a first *fresco* layer and, subsequent lime pictorial layers applied on the plaster still wet. The selective detachment of these from the *intonachino* also confirms this hypothesis.



The XRF and FORS results and SEM-EDS and FTIR analyses allowed to fully characterize the *palette* (red and yellow ochres, green and brown earths, lime white pigment). The SEM-EDS analyses provided the vine black identification, deduced thanks to the morphology identified at high magnifications and typical K and Na content, is also characterized by poor covering power and a final bluish-grey shade that coincides well with the macroscopic characteristics observed here. The plaster based on Mg-lime is characterized by the presence of several plant fibers, denoting full awareness of the technical-executive needs of the context in which the work was produced.

Acknowledgements This project received funding from the Fondazione Federico II - Assemblea Regionale Siciliana - Palermo

Multi-analytical approach to the study of the glyptic collection of the Musei di Arte Antica of the Municipality of Ferrara (Italy)

M.V. Romagnoli ([*,a]), E. Marrocchino ([b]), N.Eftekhari ([b]), F.Acqui ([c])

([a]) Dipartimento di Studi Umanistici (STUM), Università degli Studi di Ferrara, Via Paradiso 12, 44121 Ferrara, Italy

([b]) Dipartimento di Scienze dell'Ambiente e della Prevenzione (DiSAP), Università degli Studi di Ferrara, Corso Ercole I d'Este, 32, 44121 Ferrara, Italy

([c]) Unità Operativa dei Musei d'Arte Antica, Comune di Ferrara, Palazzo Bonaccossi - via Cisterna del Follo, 5, 44121 Ferrara, Italy

* Presenting author

mariavitto.romagnoli@edu.unife.it

This research aims to analyse the evolution of gem carving (glyptic) and the historical use of precious stones in ancient Rome, with a specific focus on the collection of the Civic Museums of Ancient Art in Ferrara. Through detailed documentation and cataloguing of the exhibits, the aim is to enhance not only their material value, but also the historical and cultural context that defines them as symbols of wealth, prestige and artistic skill. These artefacts, admired for their aesthetic and symbolic value, highlight the mastery of Roman lapidaries in working quartz varieties such as chalcedony and carnelian, as well as rarer materials such as amethyst and lapis lazuli.

The study, conducted on a sample of 25 artefacts, takes an interdisciplinary approach by combining petrographic-mineralogical microanalysis, archaeology and art history to investigate the materials and techniques used in the production of carvings and cameos. The petrographic-mineralogical analyses were carried out through advanced optical microscopy observations, using a HIROX 3D Digital and Confocal Microscope, supplemented with Scanning Electron Microscopy (SEM-EDS) and µ-Raman spectroscopy techniques. These instruments made it possible to determine the chemical-mineralogical composition of the gems, to identify any artificial treatments or imitations, and to accurately characterise the quality and origin of the materials.

The result of this study is the creation of a digital archive of the analysed gems, useful for certification, conservation and future evaluation purposes. This research, focused on the provenance and sophisticated manufacture of the Ferrara collection, contributes to a deeper understanding of ancient lapidary techniques, emphasising their relevance for the conservation of cultural heritage and for the development of analytical methodologies applied to cultural assets.

Anguipes in armour with snake kegs.

Highlighting the lost: hyperspectral imaging of frescoes in the House of the Ancient Hunt (Pompeii)

M. Gulmini ([*, a]), D. Nykonenko ([a]), V. Bellacicco ([b]), M. Serino ([b]), A. Re ([c]), A. Lo Giudice ([c]) and D. Elia ([b])

([a]) Dipartimento di Chimica – Università degli Studi di Torino, Via Giuria, 7 – 10125 Torino, Italy

([b]) Dipartimento di Studi Storici - Università degli Studi di Torino, Via Sant'Ottavio, 20 – 10124 Torino, Italy

([c]) Dipartimento di Fisica - Università degli Studi di Torino and INFN Sezione di Torino, Via Pietro Giuria, 1 - 10125, Torino, Italy

* Presenting author

monica.gulmini@unito.it

The House of the Ancient Hunt (Casa della Caccia Antica) is a magnificent Roman house in Pompeii (VII, 4, 48), dating from the 2nd century BCE. It is being studied by a multidisciplinary team that is focusing both on conservative and archaeological questions, providing a better knowledge of the house itself and, through this, about Pompeii in general [1]. The house's rich wall decorations were excavated in 1833-1835. Some of them are lost, and others have deteriorated over time due to the external environment to which they are exposed. Factors such as humidity, heat, sunlight and other elements have caused the fading of the colours of the surviving frescoes and the reduction of the overall visibility of the images, with many details difficult or impossible to see with the naked eye compared with the rich documentary evidence (watercolors, photographs, etc.) available. This research explores hyperspectral imaging (HSI) as a tool to assist in the better recognition of the degraded scenes, and to highlight some hidden details that can reveal the techniques used by the painters. HSI combines spectroscopy with digital imaging and offers promising results for the analysis of painted surfaces [2]. In this work, the hyperspectral cubes obtained from the frescoes were explored in terms of spectral images and PCA images. In addition, these images were combined into false colour images to better show some hidden features (Figure 1). Fiber optic diffuse reflectance spectroscopy (FORS) was used to obtain more information about pigments, and spectra were therefore used to integrate (or confirm) the information obtained from the hyperspectral cubes.

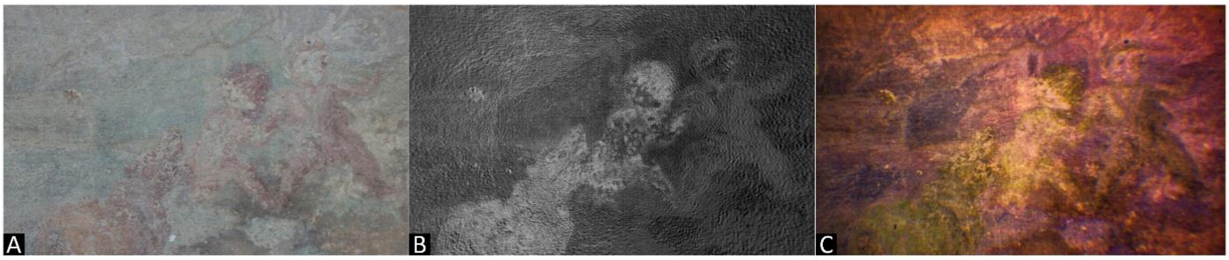


Figure 1. Images of the Nilotic scene from the tablinum of the House of the Ancient Hunt (A - visible light, B - PCA, C - false colour).

References

[1] D. Elia, V. Meirano, Pompeiana fragmenta. 2018, Hapax Editore, Torino. ISBN: 9788888000909

[2] M. Picollo, C. Cucci, A. Casini, L. Stefani, Hyper-Spectral Imaging Technique in the Cultural Heritage Field: New Possible Scenarios, Sensors (2020), 20, 2843. DOI: 10.3390/s20102843.

OCT measurements in cleaning treatments of ancient paintings

P. Buscaglia (*, a,c), C. Bellezza Prinsi (b), S. Croci (a,c), M. Olivero (b), A. Re (d), S. Grassini (a), A. Vallan (b), G. Perrone (b)

(a) Department of Applied Science and Technology, Politecnico di Torino, Torino, Italy

(b) Department of Electronics and Telecommunications, Politecnico di Torino, Torino, Italy

(c) Fondazione Centro per la Conservazione ed il Restauro dei Beni Culturali (La Venaria Reale), Venaria, Italy

(d) Physics Department, Università di Torino and Istituto Nazionale di Fisica Nucleare Torino, Italy

* Presenting author

paola.buscaglia@polito.it; paola.buscaglia@centrorestaurovenaria.it

The effectiveness of conservation procedures on painted artefacts is commonly assessed by analysing the surface before and after preliminary cleaning tests by means of chemical and morphological characterisation techniques, which sometimes also require microsampling. However, on real artefacts, irregular distribution and thicknesses of the materials to be removed make the cleaning procedure difficult to define in terms of modulation of operating parameters and the assessment of the treatment's effectiveness and safeness is almost entirely delegated to the conservator's subjective sensitivity. Moreover, it has to be taken into account that inadequate treatment leads to permanent damages with possible thinning of the original matter. Therefore, the development and validation of an analytical methodology able to discriminate the gradual removal of materials from the artefact's surface and to perform a real-time monitoring of the cleaning procedure is a need and a challenge in modern conservation.

In this context, this study deals with the assessment of the feasibility of Optical Coherence Tomography (OCT) for monitoring the removal of contaminants from painted surfaces and, in particular, measuring multilayers thicknesses in a completely non-invasive way. A set of samples, consisting of Paraloid® B72 and Egyptian blue layers deposited on glass microscope slides, were prepared (thickness in the range of 10 to 100 μm) in order to mimic the simpler stratification that can be found on real artifacts. OCT measurements were performed by means of a low-cost Lumedica instrument, employing a laser light source at 840 nm, with an optical power of 750 μW, which can be considered non perturbing even light-sensitive materials. Some sample cross-sections were also observed by a Scanning Electron Microscope (SEM) to provide a reference thickness estimation [1]. The obtained results are very promising so that the possibility of coupling OCT measurements with fluorescence spectroscopy is actually under investigation to develop an integrating approach for the monitoring of cleaning treatments.

References

[1] C. Bellezza Prinsi, P. Buscaglia, M. Olivero, S. Grassini, A. Vallan, G. Perrone, "Optical Coherence Tomography Based Measurements to Support Cleaning Treatments of Painted Ancient Artifacts," 2024 IEEE International Instrumentation and Measurement Technology Conference (I2MTC), 10.1109/I2MTC60896.2024.10560578.

Acknowledgements

This publication is part of the project PNRR-NGEU which has received funding from the MUR – DM351/2022.

Quantitative Analysis for Elemental Characterization Using Muonic Atom X-Ray Emission Spectroscopy (μXES)

S. Biswas[a], M. Cataldo[b], M. Clemenza[b,c], D. Di Martino[b,c], A.D. Hillier[a], G. Marcucci[a,b,c], **P. Monza[*,d,e]**, P. Oliva[d,e], V. Sipala[d,e]

[a] ISIS Neutron and Muon Facility STFC Rutherford Appleton Laboratory, Didcot, UK
[b] INFN, Milano-Bicocca Division, Piazza della Scienza 3, Milan, Italy
[c] Department of Physics, University of Milano-Bicocca, Piazza della Scienza 3, Milan, Italy
[d] Department of Chemical, Physical, Mathematical and Natural Sciences, University of Sassari, Piazza Università 21, Sassari, Italy
[e] INFN, Cagliari Division, S.P. per Sestu – km 0,0700, Monserrato, Italy

p.monza@studenti.uniss.it

Recent advancements in Heritage Science include the development of non-destructive techniques leveraging muon sources for the compositional analysis of archaeological artifacts. The CHNET-MAXI project, funded by the Italian National Institute for Nuclear Physics (INFN), focuses on innovating and applying a technique known as Muonic Atom X-Ray Emission Spectroscopy (μXES). This method utilizes negative muons for elemental characterization. The experimental setup used in this project is located at the RIKEN-RAL facility of the ISIS source and uses four HPGe detectors optimized for gamma and X-ray spectroscopy. The system has been enhanced with an additional detector and a hodoscope for precise muon beam monitoring (Figure 1). μXES takes advantage of the muon's greater mass compared to electrons, resulting in highly energetic muonic X-rays (0.01–6 MeV), enabling the identification of low-Z elements. This technique offers a unique capability for depth profiling, analyzing up to 1 cm in metallic samples or 2.8 cm in carbon-based materials, while avoiding post-irradiation activation. Currently, efforts are centered on the quantitative calibration of μXES to establish it as a reliable tool for the elemental analysis of archaeological metal artifacts. By providing depth-resolved elemental composition, μXES effectively addresses the challenge posed by surface alterations frequently found on archaeological objects. Calibration measurements performed on certified copper alloy standards will be presented, alongside comparative data obtained from X-Ray Fluorescence (XRF), a well-established nondestructive technique in archaeology.

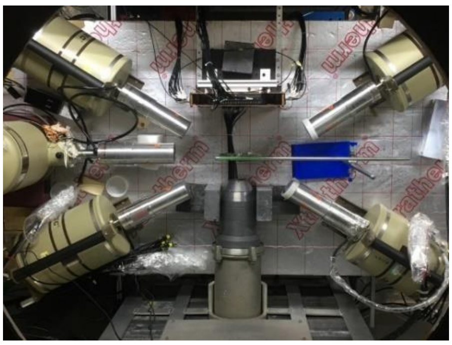


***Figure 1**: The experimental setup at ISIS neutron and muon facility (UK) composed by 5 HPGe detectors. Between the detectors is possible to see the muon beam monitor and one of the measured standard.*

References

A. D. Hillier, *et al. Microchemical Journal,* **2016**, 125, 203-207, https://doi.org/10.1016/j.microc.2015.11.031
M. Cataldo, *et al. Appl. Sci.,* **2022**, 12, 4237, https://doi.org/10.3390/app12094237
M. Cataldo, *et al. J. Phys.,* **2023**: Conf. Ser. 2462, 012003, https://doi:10.1088/1742-6596/2462/1/012003

Ultrasonic Tomography of the Diana the Huntress statue (Salinas Museum, Palermo)

P. Capizzi (*, a), A. Carollo (a), M.V. Majani (a), A. Canzoneri (a), R. Martorana (a), F. Fazzio (b)

(a) Department of Earth and Marine Sciences (DiSTeM), University of Palermo, 90123 Palermo, Italy,
(b) Restorer, Freelance Researcher
* Presenting author

Email corresponding: patrizia.capizzi@unipa.it

A geophysical study on the "Diana the Huntress" marble statue, which has to be exposed in the Salinas Museum of Palermo, was performed to solve the conservation problems of the statue, both aesthetic and structural. The statue currently has a diffuse superficial blackening, probably due to an attack of the microflora, while structurally, the weight of the bust rests entirely on the central trunk. A 3D Ultrasonic Tomography [1-2] was performed on the statue to identify any anomalies due to structural defects of the material and possible internal support elements. A total of 357 measurements were acquired following the "transparency" technique after an accurate choice of several points at which transducers were located to be used as transmitters or receivers of the ultrasonic rays (Fig. 1a). The velocity model obtained was finally constrained to the scanner survey of the statue, allowing a 3D visualization of the model. The results of the ultrasonic survey showed an average velocity of about 3000 m/s, considered adequate for the properties of the marble. However several areas with low velocity values (less than 1500 m/s) were observed, which could indicate areas with poor mechanical resistance. Thanks to ultrasonic tomography it was possible to identify the structural weaknesses that confirm what was expected; therefore, the permanent exposure will take place through the use of support elements.

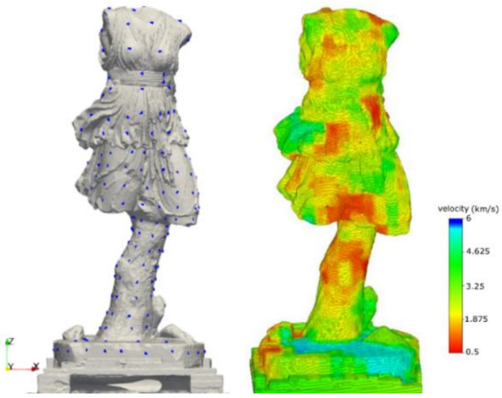


Figure 1. (a) The front view of the scanner survey of the statue, in blue the measurements; (b) 3D rendering of the velocity model.

References

[1] K.A. Dynes, R. J. Lytle, Computerized geophysical tomography, Proceeding IEEE (1979), 67, 1065-1073, DOI: 10.1109/PROC.1979.11390
[2] P. Capizzi, P. L. Cosentino, S. Schiavone, Some tests of 3D ultrasonic traveltime tomography on the Eleonora d'Aragona statue (F. Laurana, 1468), Journal of Applied Geophysics (2013), 91, 14–20, DOI: 10.1016/j.jappgeo.2013.01.012

Multianalytical investigation on a miniature *phiale*

D. Giuffrida ([a]), B. Fazzari ([b]), D. Costanzo ([b]), M. D'Onofrio ([b]), F.Armetta ([a,c]), C. Tuccio ([a]), M. L. Saladino ([a,c]), R.C. Ponterio ([a])

([a]) IPCF-CNR, Istituto per i Processi Chimico Fisici, V.le F. S. d'Alcontres 37, I- 98158 Messina, Italy

([b]) Museo Archeologico Nazionale di Reggio Calabria (MArRC), Piazza Giuseppe De Nava, 26, 89123 Reggio Calabria, Italy

([c]) Dipartimento di Scienze e Tecnologie Biologiche Chimiche e Farmaceutiche (STEBICEF) and INSTM-Palermo, Università degli studi di Palermo, Viale delle Scienze, Ed.17, I-90128 Palermo, Italy

* Presenting author

Email corresponding: ponterio@ipcf.cnr.it

The National Archaeological Museum of Reggio Calabria (MArRC) preserves a miniature pottery *phiale* (n. inv. 6223/MRC 6505; h. cm 1, diam. cm 6,6) discovered in the sanctuary of Persephone on the Mannella hill of *Lokroi Epizephyroi* (Fig. 1). This item was a votive offering found by Paolo Orsi in a large votive deposit (*favissa*) that contained an enormous number of objects, dating back from the mid-seventh to the fifth century BCE and offered to the goddess Persephone before being placed in cultic storage [1]. This miniature vessel recalls libation bowls, commonly used in religious practices of Greek and Western Greek world, as shown on figured pottery or on *pinakes*, the votive tablets found in the Mannella sanctuary. *Phialai* were typically footless and handleless, often characterized by a bulbous indentation (*omphalos*) on the underside to facilitate holding. While metal *phialai* were considered luxury offerings, ceramic versions were widespread and often imitated their metallic counterparts. The specimens preserved at MArRC will be the subject of an in-depth diagnostic study on the technique used to give their surfaces a metallic appearance. In this regard, the covering of ceramics with a tin layer, particularly in ancient Minoan and Mycenaean pottery, has been extensively studied over the years. Initially, the black coating observed on these vases was believed to be a type of varnish. However, further analysis revealed it to be a layer of tin oxide, suggesting that a tin foil had been applied to achieve the effect [2].

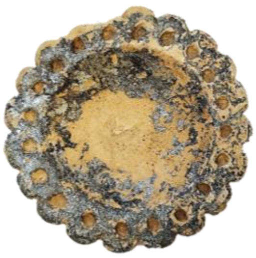


Figure 1 - phiale n. inv. 6223/MRC 6505

The different parts of the object were analyzed using X-ray fluorescence (XRF), Raman spectroscopy, and thermography in portable configuration, to determine the composition and distribution of patinas with varying colors. The results revealed the presence of tin in the grey areas, suggesting the intentional application of a special covering in those regions. Further details of the analysis and findings will be presented in the poster as preliminary results of a more complex investigation.

References

[1] M. Rubinich, *I pinakes locresi e i depositi della Mannella. Nuove considerazioni*, in *Atti e Memorie della Società Magna Grecia*, Quarta Serie, VI (2014-15), 2016, pp. 155-183.

[2] K. Holmberg, Application of Tin to Ancient Pottery, *Journal of Archaeological Science* 1983, 10, 383-384

A multi-analytical study of Chinese bronzes and gilded bronzes from the Museo delle Civiltà

S. Croci (*, a), L. Es Sebar (a), F. Di Iorio (a,b), P. Buscaglia (a,b), A. Viliani (c), M.L. Giorgi (c), D. Quadrio (d), E. Angelini (a), S. Grassini (a)

(a) Department of Applied Science and Technology, Politecnico di Torino, Corso Duca degli Abruzzi 24, 10129 Torino (TO), Italy
(b) Fondazione Centro Conservazione e Restauro dei Beni Culturali "La Venaria Reale", 10078 Venaria Reale (TO), Italy
(c) Museo delle Civiltà, Roma, Piazza Guglielmo Marconi 14, 00144 Roma (RO), Italy
(d) Museo d'Arte Orientale Via San Domenico, 11 10122 Torino (TO), Italy

* Presenting author sara.croci@polito.it

This research focuses on the characterization of a selection of Chinese votive bronze sculptures from the Museo delle Civiltà in Rome (Italy) (Fig. 1). Specifically, the study involved the analysis of ten small bronze sculptures, six of which are gilded and four are covered in brown and green surface layers. A comprehensive multi-analytical diagnostic campaign was performed to gather insights into their state of preservation and collect information on these ancient artifacts' manufacturing techniques. In particular, the elemental composition of the sculptures and the gilding technique were examined by means of X-ray fluorescence spectroscopy (XRF). In addition, Raman spectroscopy was used to identify the corrosion products on the surface. Eventually, multispectral photogrammetry was exploited to create hybrid 3D digital models of the sculptures, exploiting several spectral bands.

The alloy composition of the artifact has been studied through XRF analyses in order to highlight possible different processing practices, revealing different Cu-based compositions in the decorative parts of the sculptures. Furthermore, mercury was detected on the surface of the gilded artifacts, indicating the use of a mercury and gold amalgam on the bronze surface. By Raman spectroscopy, it was possible to identify multiple corrosion products present on the surface of the sculptures, primarily copper oxides, along with minor quantities of copper chlorides, hydroxychlorides, and nitrates, which overall indicated a good state of preservation.

The multispectral 3D models of the artifacts allowed us to document them and gather information on the distribution of varnishes and outer layers with ultraviolet radiation. The final virtual replicas integrated not only the information regarding geometry and texture and the radiometric data from multispectral imaging but also the results obtained by XRF and Raman spectroscopy. This methodology offers innovative opportunities for the study and documentation of such artifacts, facilitating more immediate access to information presented in a unique three-dimensional system.

Figure 1: Chinese votive bronze sculptures from the Museo delle Civiltà in Rome (Italy).

Acknowledgements: This publication is part of the project PNRR-NGEU which has received funding from the MUR – DM351/2022 and DM352/2022).

A precious official liturgical book of XVII century: ink, pictorial materials and artistic technique characterization

S. Schiavone ([*,a]) S. Pregagnoli ([b]), G. Bonanno ([c]), S. Bavastrelli([c]), L. Pasta([c]), A. Valenti([c]), E. Passerini([c]), M. F. Alberghina ([b])

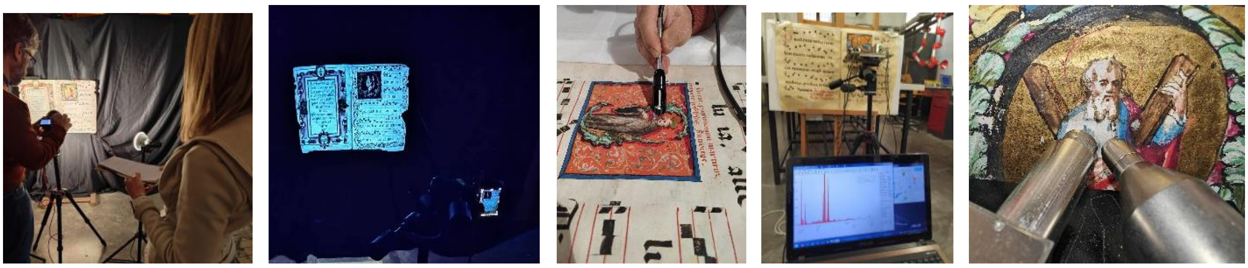
([a]) S.T.Art-Test di S. Schiavone & C sas, via Stovigliai, 88 93015 Niscemi (CL), Italy

([b]) Restauratrice di materiale archivistico-librario, Roma, Italy

([c]) Centro Regionale per la Progettazione e il Restauro (C.R.P.R.) Regione Siciliana, Assessorato dei Beni Culturali e dell'Identità Siciliana, Palermo, Italy
* Presenting author

info@start-test.it

The study describes the results of the non-invasive investigations carried out on the Gradual XIV 16 A4688 preserved at the "M. Accascina" Library of the Regional Interdisciplinary Museum of Messina (Sicily) during the recently completed restoration works. This project has been promoted within the training activity planned in the scientific collaboration agreement between the Giorgio La Pira Messinese Foundation and the Regional Center for Planning and Restoration (C.R.P.R.) of Sicily. In particular, it concerns the restoration and valorization of an official liturgical book dated 1610, coming from the Convent of *S. Maria di Gesù inferiore* in Messina. The diagnostic study was aimed at evaluating the state of conservation and at gaining in-depth knowledge of the pictorial materials and artistic technique. For these purposes, "*bifoli*" characterized by the presence of musical notations on tetragrams consisting of red lines, red inscriptions, miniatures and decorations with polychrome backgrounds representing the whole pictorial palette, have been selected.



Non-invasive investigations on gradual manuscript at the laboratories of the C.R.P.R. (Palermo)

Multispectral imaging techniques allowed to obtain a preliminary map of pigments and dyes, subsequently identified by XRF and FORS. In some cases, previous musical notations that were no longer visible have been detected thanks their yellowish fluorescence, suggesting a total reuse of the parchment or to a partial abrasion of the support. Furthermore, IR imaging also highlighted the sequence of pictorial creation of the miniatures. The integrated use of XRF and FORS techniques identified the following chromophores: lime white pigment, vermillion, minium, realgar, orpiment, copper-based green (malachite), red lake, earths, azurite and lapis lazuli. Imaging and spectroscopic analyses also provided information on the type of ink used for the musical notations, confirming the use of an iron-gall ink on all the papers and providing first information on its degradation causes.

References

[1] I. D. van der Werf, C. D. Calvano, G. Germinario, T. R.I. Cataldi, L. Sabbatini, Chemical characterization of medieval illuminated parchment scrolls, Microchemical Journal, Vol.134, 2017, doi.org/10.1016/j.microc.2017.05.018.

Acknowledgements

This project received funding from the Fondazione Giorgio La Pira messinese.

Beyond the Golden Glow: Analytical Study of Mural Paintings and Stuccoes in the Palatine Chapel of S. Anna

F. Armetta ([a]), S. Barreca ([b]), G. Arena ([b]), D. Amorello ([a]), L. Barreca ([c]), S. Orecchio ([* a]), S. Orecchio ([d])

([a]) Dipartimento di Scienze e Tecnologie Biologiche Chimiche e Farmaceutiche (STEBICEF) and INSTM-Palermo, Università degli studi di Palermo, Viale delle Scienze, Ed.17, I-90128 Palermo, Italy, IPCF-CNR, Istituto per i Processi Chimico Fisici, V.le F. S. d'Alcontres 37, I- 98158 Messina, Italy

(b) Department of Chemical Sciences, University of Catania, Viale A. Doria 6, Catania, 95125, Italy

(c) Museo civico Castelbuono, Piazza Castello, 3, 90013 Castelbuono PA, Italy

(d) Department of Physics and Chemistry Emilio Segrè, Viale delle Scienze,90100 Palermo, Italy

* Presenting author

santino.orecchio@unipa.it

This study examines the chemical composition of the wall paintings and stucco work in the Palatine Chapel of S. Anna, located within the Ventimiglia Castle in Castelbuono, Sicily. Employing non-destructive analytical techniques, such as X-ray fluorescence (XRF), Fourier transform infrared (FT-IR) spectroscopy, and X-ray diffraction (XRD), the research aims to identify the pigments and materials used in the chapel's artworks, with a particular focus on the golden yellow background often mistaken by visitors for actual gold. The analysis reveals that while small amounts of gold are present, the predominant yellow hues are derived from lead- and iron-based pigments. Further investigation of the stucco confirms a composition characteristic of the Serpotta school, with calcite and gypsum as primary components and quartz as a minor component. Environmental dust analyses also indicate significant lead levels, raising concerns about the chapel's preservation and cultural heritage degradation. These findings are crucial for guiding conservation efforts and deepening the understanding of the chapel's historical and artistic significance.

Insights into the wall painting pigments of the *Domus di Arianna* in Pompeii. Progress in the framework of the Arianna PRIN project

S. Brizzi ([*, a]), S. Vettori ([a]), I. Osticioli ([b]), B. Salvadori ([a]), L. Chiarantini ([c]), D. Magrini ([a]), C. Riminesi ([a])

([a]) National Research Council, Institute of Heritage Science (CNR-ISPC), Via Madonna del Piano 10, Sesto Fiorentino (FI), Italy

(b) National Research Council, Institute of Applied Physics (CNR-IFAC), Via Madonna del Piano 10, Sesto Fiorentino (FI), Italy

(c) Center of Electronic Microscopy and Microanalysis (MEMA), University of Florence, Via G. Capponi 3r, (FI), Italy

* Presenting author

sofiabrizzi@cnr.it

The remarkable polychromies of the wall paintings of the *Domus di Arianna* offer an example of Roman art, particularly notable for their stylistic diversity and complex color composition. The *Domus di Arianna* is one of the largest in Pompeii and it results from the union of two independent houses, which had various uses over the centuries, including wool production and the creation of aesthetic products such as perfumes and unguents [1;2]. This study provides insights into the identification of wall painting pigments (especially red, yellow and blue hues) by molecular and elemental analysis. The study was carried out on micro-samples duly taken from different rooms of the domus dating from different Roman periods, after a preliminary examination using portable and non-destructive techniques (portable digital microscope, p-XRF, ER-FTIR and FORS). The stratigraphy was examined in cross-section by optical microscopy, and characterized by micro-FTIR with FPA imaging and micro-Raman mapping. In addition, maps of the elemental distribution were obtained by scanning electron microscopy with energy dispersive X-ray spectroscopy (SEM-EDS). The results of the comparative analysis of the different wall paintings found in the domus reveal similarities and differences in the ground layers, pigment palettes, and periodic artistic techniques, which are critically discussed in relation to the literature [3-5].

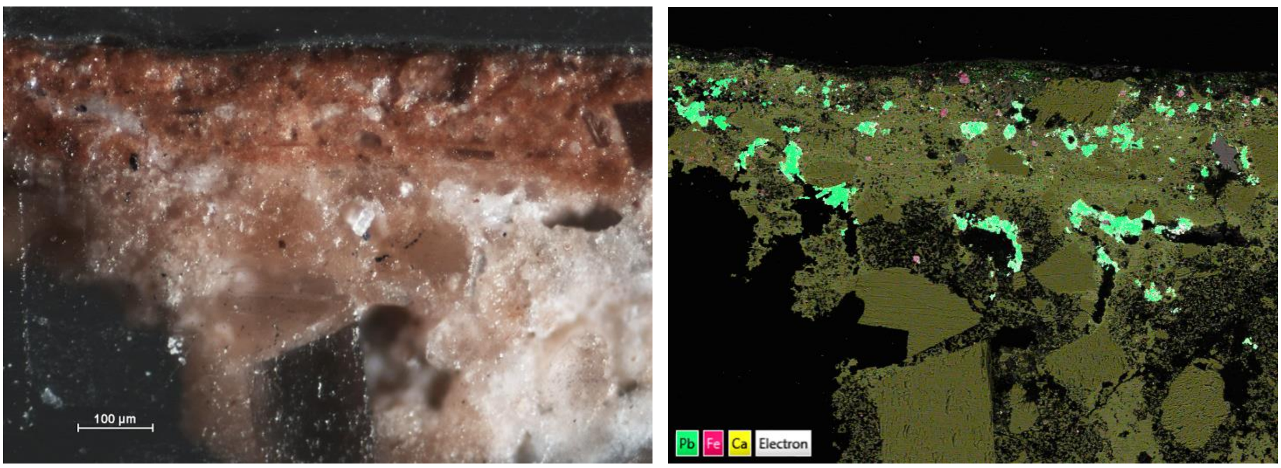


Image of a wall painting sample in cross-section observed with optical microscope (left) and distribution map of Pb, Fe, Ca obtained with SEM-EDS (right).

References:

[1] Bustamante Álvarez, M., Huguet Enguita, E., & Ribera i Lacomba, A. (2020). Un contesto ceramico chiuso nella profumeria della Casa di Arianna (VII 4, 51-31). Studi e ricerche del Parco archeologico di Pompei: 40, 2020, 267-280. DOI: 10.1400/276441

[2] Bustamante-Álvarez, M., & i Lacomba, A. R. (2020). 3. Production Moments and Areas in a Big House in Pompeii: The House of Ariadne from the 2nd Century BC to AD 79. Approaches to the Analysis of Production Activity at Archaeological Sites, 25.

[3] Cotte, M., Checroun, E., Susini, J., Dumas, P., Tchoreloff, P., Besnard, M., & Walter, P. (2006). Kinetics of oil saponification by lead salts in ancient preparations of pharmaceutical lead plasters and painting lead mediums. Talanta, 70(5), 1136-1142. 06, https://doi.org/10.1016/j.talanta.2006.03.007

[4] Cucci, C., Picollo, M., Chiarantini, L., Uda, G., Fiori, L., De Nigris, B., & Osanna, M. (2020). Remote-sensing hyperspectral imaging for applications in archaeological areas: Non-invasive investigations on wall paintings and on mural inscriptions in the Pompeii site. Microchemical Journal, 158, 105082. DOI: https://doi.org/10.1016/j.microc.2020.105082

[5] Walter, P., Martinetto, P., Tsoucaris, G., Brniaux, R., Lefebvre, M. A., Richard, G., ... & Dooryhée, E. (1999). Making make-up in Ancient Egypt. Nature, 397(6719), 483-484. https://doi.org/10.1038/17240

Acknowledgements

The research activity was conducted in the framework of the ARIANNA Project “An interoperable platform for aRchaeologIcAl sites: conservatioN, eNvironmental design and wider Accessibility after covid” of the Italian Research Program PRIN-2022 (founded by the NEXT GENERATION EU – CUP B53D23022390006, PI: Prof. R. Picone). Authors warmly thank the Archeological Park of Pompeii in Naples and in particular Eng. V. Calvanese for valuable and constant support during the organization and execution of the whole campaign.

A multidisciplinary approach to an archaeological issue

S. Bulgarini ([*, a]), L.M. Caliò ([a]), P.B. Castellino ([b]), I. Ferrara ([b]), S. Gallo ([b]), A.M. Gueli ([b]), G. Politi ([b]), G. Stella ([b])

([a]) University of Catania, Department of Humanities

([b]) University of Catania, Department of Physics and Astronomy "E. Majorana"

* Presenting author

sofia.bulgarini@phd.unict.it

During the excavations carried out in 2021 at the Greek theater of Agrigento [1], in Sicily, a large amount of plaster fragments was found in the *summa cavea* of the theater where, in recent years, some structures related to the existence of a church have been discovered. From all excavated fragments, six samples were selected: they're all monochromatic – three blue and three red. The main objective of the work was to identify the elemental structure of the colored pigments and, where possible, to obtain more information about the fresco creation technique.

The work represents an example of multidisciplinarity, blending archaeological, historical and different scientific methods to create a comprehensive understanding of the site's evolution. The research is part of the multidisciplinary PNRR project *Samothrace*. The study employed different techniques, including Raman spectroscopy with laser stimulation at 532 nm and 785 nm, spectrophotometry [2], X-ray fluorescence (XRF) [3] and observation under optical microscope in order to analyze the pigments and preparatory layers. These multidisciplinary methods provided valuable results into the composition of the plasters, revealing that the pigments used were primarily hematite and Egyptian blue.

References

[1] L.M. Caliò, A. Fino, G.M. Gerogiannis, *La* krene *nell'area del teatro di Agrigento: dati preliminari*, Thiasos (2022) 11, 417-440.
[2] G. Fioretti *et al.*, *On Devotional Artworks: A Non-Invasive Characterization of Pigments of the Madonna della Croce Wall Painting in Triggiano (Bari, Southern Italy)*, Heritage (2023), 6 (5): 4243-4281, 10.3390/heritage6050225.
[3] M.F. Alberghina *et al.*, *Byzantine wall paintings from San Marco d'Alunzio, Sicily: non-invasive diagnostics and microanalytical investigation of pigments and plasters*, Heritage Science (2024), 12(1): 184, 10.1186/s40494-024-01308z.

Acknowledgements

This research activity was funded by the European Union (NextGeneration EU), through the MUR-PNRR project SAMOTHRACE (ECS00000022) "SiciliAn Micro and nanO TecHnology Research And innovation CEnter" – Innovation Ecosystem (PNRR, Mission 4, Component 2 Investment 1.5, Call n. 3277 del 30-12-2021), Spoke 1 – University of Catania – Work Package 6 Cultural Heritage – TASK 1 "diagnostic and materials".

Multi-technique approach for the study of the carbonised papyri of Herculaneum

Sofia Ceccarelli ([*,a]), Danilo P. Pavone ([a]), Francesca Rosi ([b]), Claudia Caliri ([a]), Sabrina Samela ([a,c]), Teresa Cacace ([a]), Sveva Longo ([a]), Francesco P. Romano ([a]), Costanza Miliani ([a]) and Graziano Ranocchia ([a, d])

([a]) Istituto di Scienze del Patrimonio Culturale - Consiglio Nazionale delle Ricerche (ISPC-CNR), Italy

([b]) Istituto di Scienze e Tecnologie Chimiche – Consiglio Nazionale delle Ricerche (SCITEC-CNR), Italy

([c]) Dipartimento di Fisica, Politecnico di Milano, Italy

([d]) Dipartimento di Filologia, Letteratura e Linguistica, Università degli studi di Pisa, Italy

* Presenting author

Email corresponding: graziano.ranocchia@unipi.it

Thousands of papyrus scrolls were found during an excavation campaign commissioned by King Charles of Bourbon between 1752 and 1754, in an impressive building called *Villa dei Papiri* in the town of Herculaneum. The unique testimony of the history of ancient Greek philosophical schools, contained in these papyrus scrolls, was preserved thanks to the carbonization by the very high temperatures (300-320 °C) of pyroclastic materials deriving from the well-known eruption that destroyed Pompeii in 79 AD. While carbonization preserved the papyri, the extreme environmental conditions severely deformed them, often making them indistinguishable from pieces of burned wood. From their discovery, they underwent several mechanical and chemical treatments aimed at unrolling, unfortunately without great success, until the invention of the Piaggio machine in the mid-18th century [1]. With this tool, most of the scrolls were mechanically unrolled, were glued to pieces of cardboard and kept inside metallic frames (*cornici*). From 1925 they are preserved in the *Officina dei Papiri Ercolanesi* of the National Library "Vittorio Emanuele III" of Naples (Italy). Being a rare and unique source of information of the Greek philosophical schools, reading the texts contained in the papyri is fundamental for the knowledge of the philosophical history. Each papyrus piece, and consequently every papyrus roll to which it belongs, has its own peculiarities that involves addressing highly heterogenous morphologies, making textual reading challanging: among these are to be mentioned their complex morphology (in term of thickness, folds, planar/not planar surface), highly complex stratigraphical layering (so-called *sovrapposti* and *sottoposti* produced/due by the unrolling), varying degrees of carbonisation and the quality/preservation state of the hidden text. This contribution shows an overview of the outcomes obtained in the framework of the ERC Advanced Grant 885222-GreekSchools [2], by showing the adopted multi-technique experimental approach aimed at enhancing the text readability of unrolled papyri. The results of multi-band technical photography, high-resolution infrared digital microscopy, macro X-ray fluorescence mapping and hyperspectral imaging in the short-wave infrared (SWIR) allowed the enhancement of the papyrus readability, providing new textual progresses and a better overall knowledge of the studied papyri, with a completely non-invasive approach. Indeed, the high contrast images obtained with high resolution infrared microscopy and technical photography in the visible, near-infrared and ultraviolet ranges (VIS, VISr, NIR, UVL) provide the first systematic and high-resolution documentation of the Herculaneum collection (hundreds of pieces) and, at the same time, a preliminary reading of the texts. Legibility enhancement was then achieved with the use of SWIR hyperspectral imaging that allowed the identification of a large number of words, increasing our knowledge of the text of about 20-30% (Fig.1). Furthermore, by using macro X-ray fluorescence imaging, several metallic residuals were detected on the papyri, probably indicating the presence of impurities inside the inks or in the support preparation, and, in some cases, the writing layout of the page was detected (Fig.2).
Further studies will comprehend images processing and multivariate data analysis in order to better investigate still open issues, such as the reading of texts on the *verso.*

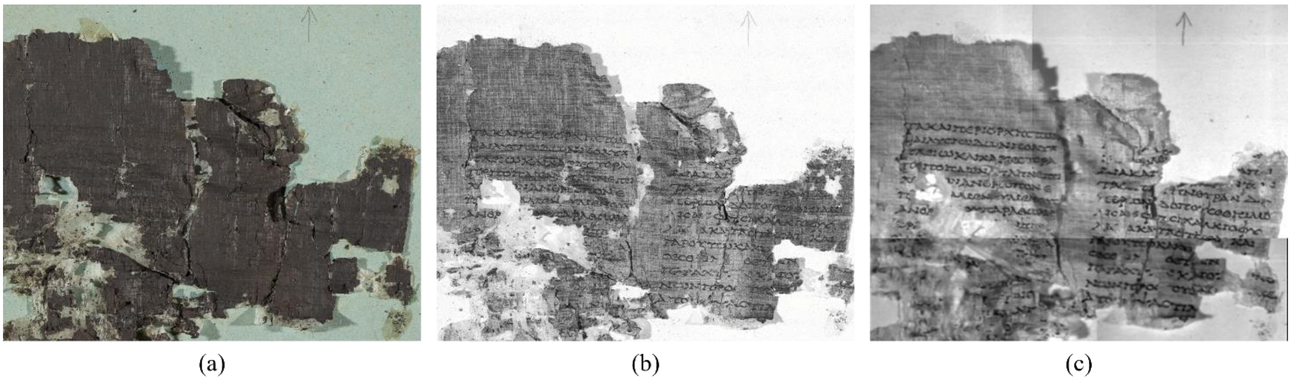


Figure 1. Papyrus Herculanensem 1018 cornice 2: (a) VIS image; (b) high resolution IR digital microscopy image detail; (c) SWIR hyperspectral image detail.

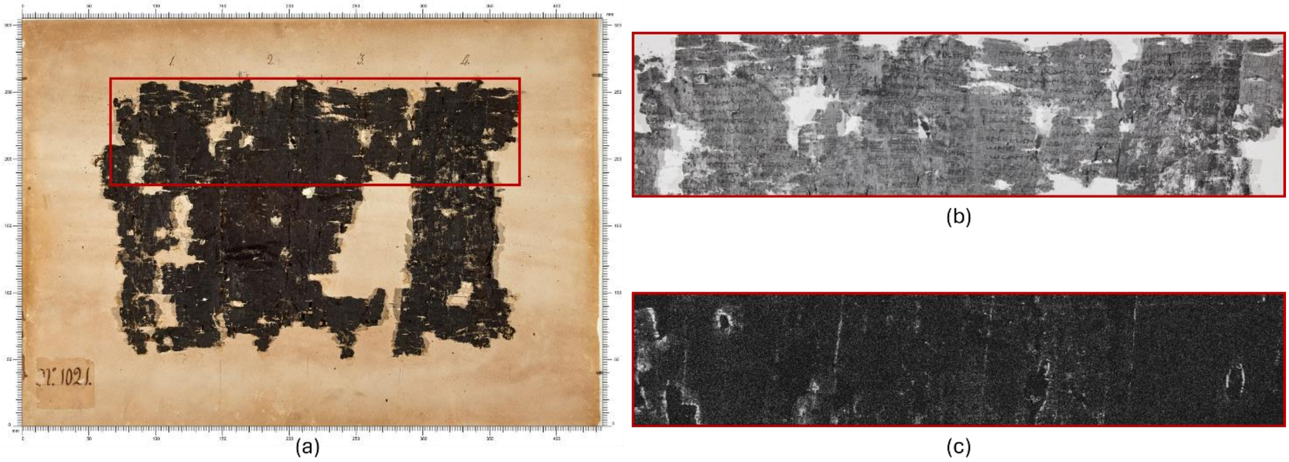


Figure 2. Papyrus Herculanensem 1021 cornice 1: (a) VIS image; (b) NIR 1000nm image detail; (c) MA-XRF Pb map; (d) SWIR hyperspectral image detail;(e) high resolution IR digital microscopy image detail.

References

[1] A. Angeli, *Papyrologica Lupiensia* **1994**, *3*, 43.
[2] C. Europea, *CORDIS - GreekSchools*.

Calcination of corals in ancient Sardinia. Early evidence from the Phoenician necropolis of Nora.

V.G. Prillo ([*, a]), S. Dilaria ([a,b]), A. Mazzariol ([a]), J. Bonetto ([a])

([a]) University of Padova, Department of Cultural Heritage (dBC)

([b]) University of Padova, Inter-Departmental Research Center for the Study of Cement Materials and Hydraulic Binders (CIRCe)

* Presenting author

vitogiuseppe.prillo@phd.unipd.it

Since 2013, the University of Padua has been conducting archaeological excavations in the Phoenician and Punic necropolis of the ancient settlement of Nora in Sardinia (Bonetto *et al*. 2020). In 2023, a particularly intriguing context within the necropolis was investigated, where a patch of pure slaked lime was found in stratigraphic correlation with a Phoenician tomb dating back to the end of the 7th century BCE. These findings suggest that the pit was used for lime slaking, a process triggered by the addition of water to quicklime (calcium oxide), producing hydrated lime (calcium hydroxide). Archaeometric techniques, including Polarized Light Optical Microscopy and X-ray Powder Diffraction (XRPD) analysis, were employed to characterize the materials and processes associated with lime production. The investigation revealed remnants of underburned mollusk shells (*Ostrea edulis* L. and *Murex* sp.) and, in particular, a prevalent concentration of red corals (*Corallium rubrum* Linnaeus). As these materials consist predominantly of calcite and aragonite polymorph of $CaCO_3$, it is highly probable that they served as a source of calcium carbonate for lime production. Archaeometric evidence of shell calcination is exceptionally rare in the Mediterranean, and no consistent parallels exist for coral calcination (Dilaria 2017). Beyond the distinctive use of these raw materials, the chronological context represents the earliest scientifically verified instance of calcination in Sardinia and potentially one of the oldest documented cases in the Western Mediterranean. Historically, lime has served diverse purposes, from construction materials such as mortar and plaster to applications in agriculture and water treatment. This discovery provides a valuable opportunity for further detailed comparative studies, particularly to examine the potential relationship between lime production and the funerary and ritual practices within the Phoenician funerary tradition.

The lime patch enriched under burnt remnants of corals in the Necropolis of Nora.

References

Bonetto J., Bridi E., Carraro F., Dilaria S., Mazzariol A. 2020, *La necropoli fenicio-punica di Nora (Sardegna, Italia): nuovi dati dagli scavi 2014-2018,* in *Actas del IX Congreso Internacional de Estudios Fenicios y Púnicos*, Mérida, 1047-1064.

Dilaria S., 2017, Costruire ingegnosamente riutilizzando materiali poveri. L'impiego di conchiglie a fini edilizi ad Aquileia tra età Repubblicana e Tarda Antichità, *Reudar European Journal of Roman Architecture*, 1, 25-55.

Archaeometric Analysis on Vegetal Inclusions in the Mortar Samples of Roman Aquileia

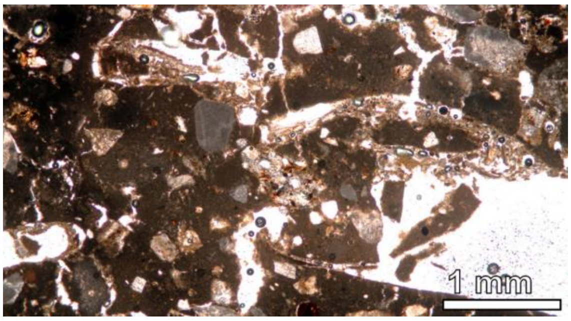
Y. Tsfoni (*, a), S. Dilaria(a,b), M. Secco (a,b), M. Gleba (a)

(a) University of Padova, Department of Cultural Heritage (dBC)
(b) University of Padova, Inter-Departmental Research Center for the Study of Cement Materials and Hydraulic Binders (CIRCe)

* Presenting author

Yardenjessica.tsfoni@studenti.unipd.it

Analytical examination of mortar samples from various sites in Roman Aquileia has revealed the presence of vegetal inclusions, raising intriguing questions about their role in ancient mortar production (Dilaria, 2024). Research specifically focused on vegetal inclusions in ancient mortars is scarce and dispersed globally. Furthermore, to date, no systematic studies have been conducted on the vegetal inclusions in ancient mortar samples from beyond mere documentation of their presence (Stefanidou et al. 2012). This gap presents a unique interdisciplinary opportunity to deepen our understanding of ancient mortar production techniques. This study addresses several key questions: 1) Were vegetal inclusions in lime mortar introduced intentionally, or were they accidental (e.g., incidental inclusion of straw in aggregate materials)? 2) What types of vegetal inclusions are present?; 3) What potential functions might these vegetal inclusions serve in mortars? 4) In which types of mortars (e.g., structural, coatings, or floor preparations) were vegetal inclusions deliberately added, and for what purposes? To explore these questions, the mortars were primarily analyzed using Polarized Light Optical Microscopy. Intentionality of vegetal inclusions was assessed by creating abundance thresholds of fiber inclusions detected through Digital Image Analysis under optical microscopy. The findings suggest that intentionally added vegetal inclusions were primarily detected in renders and plastering layers (e.g., wall-painting tectorium). In contrast, fewer instances of intentional inclusion were observed in floor and mosaic substrates or structural mortars. Additionally, Scanning Electron Microscopy coupled with Energy Dispersive Spectroscopy (SEM-EDS) analysis revealed in some cases the presence of framboids mineralization, within the vegetal inclusions. These deposits may indicate anoxic conditions that mortars experienced post-deposition, raising further questions about the relationship between mortar production practices and the environmental conditions in ancient Aquileia.



Thin section photo under cross polarized light of vegetal inclusions found in a mortar sample from the ancient site of Aquileia.

Reference

Dilaria S. 2024, Archeologia e archeometria delle miscele leganti di Aquileia romana e tardoantica (II sec. a.C. – VI sec. d.C.), Costruire nel mondo antico 8, Quasar, Rome.

Stefanidou M., Papayianni I., Pachta V. 2012, Evaluation of inclusions in mortars of different historical periods from Greek monuments, Archaeometry, 54, 4, 737-751.

A rediscovery of Macedonian artists' rich palette: the in-situ investigation of the Hunt frieze of the tomb of Philip II at Aigai (Vergina, Greece)

M. Botticelli ([*, a, b]), E. L. Ravan ([a, b]) D. P. Pavone ([a, b]) C. Caliri ([a, b]), C. Miliani ([a]) N. Kladouri ([c]), K. Tsampa ([c]), A. G. Karydas ([c]), A. Georgiadou ([d]), H. Brecoulaki ([e]), F. P. Romano ([a, b])

([a]) Consiglio Nazionale delle Ricerche, Istituto di Scienze del Patrimonio Culturale (CNR- ISPC), Catania, Italy

(b) Istituto Nazionale di Fisica Nucleare, Laboratori Nazionali del Sud (INFN-LNS), Catania, Italy

(c) Institute of Nuclear and Particle Physics, NCSR "Demokritos", Agia Paraskevi, Attiki, Greece

(d) Greek ministry of Culture, Ephorate of Antiquities of Emathia, Greece

(e) Institute of Historical Research, National Hellenic Research Foundation, Athens, Greece

* Presenting author

michela.botticelli@cnr.it

Funerary paintings on the façades and interiors of ancient Macedonian tombs made under the reign of Philip II and Alexander the Great represent the most significant examples of monumental art during the late Classical and early Hellenistic period. These unique large-scale compositions offer the opportunity to investigate the ancient painters' techniques and to explore the themes of local funerary iconography. Within the MOLAB facilities provided by the IPERION HS consortium, and as part of the research projects REVIS (funded by the Hellenic Foundation for Research and Innovation) and H2IOSC (funded by the EU), the Xray Lab of the CNR-ISPC in Catania helped the characterization of the largest and most famous Classical painting, the Hunt frieze of the façade of the Tomb of Philip II at ancient Aigai (Vergina), NE Greece.

Non-invasive mobile MA-XRF and XRD scanning were combined in-situ to infer on the spatial distribution of original inorganic materials. Results confirm the use of a rich gamut of pigments. Particularly, elemental and mineralogical data suggest the presence of unusual Cu, As-based minerals with greenish hues, possibly from local supplies. MA-XRF imaging also evidenced iconographic details, now scarcely visible due to the poor state of preservation of the pictorial layers.

MA-XRF (left), MA-XRD (centre) and technical photography (right) of the Hunt frieze

Archaeometric study Etruscan Coarse Ware from Northern Apennines (6th-4th century BCE): Preliminary Results.

L. Volpe [*, a], E. Cantisani [a], L. Cappuccini [b], A. Gaucci [c], S.M.E. Mangani [d], C. Trevisanello [c], S. Raneri [e]

[a] Istituto di Scienze del Patrimonio Culturale; CNR-Sesto Fiorentino. [b] Dipartimento di Storia, Archeologia, Geografia, Arte e Spettacolo (SAGAS), Università di Firenze. [c] Dipartimento di Storia Culture Civiltà (DISCI), Università di Bologna. [d] Istituto di Chimica dei Composti Organometallici; CNR-Pisa. [e] Dipartimento di Scienze della Terra (DST), Università di Firenze.

* Presenting author

lisa.volpe@ cnr.it

The Apennines, between the Reno valley and its tributaries (in the north) and the Bisenzio and Sieve valleys (in the south), have always been a strategic link between the Tyrrhenian and Po Valley regions, especially between the 6th and the 4th century BCE. Along these valleys, the Etruscan cities of *Kainua*-Marzabotto in the north and Gonfienti in the south where founded and thrived.

The PRIN 2022 project "APENNINESCAPE. Marginal landscapes and production processes along the Reno and the Bisenzio-Sieve valley districts during the 1st millennium BC" focuses on these Etruscan Apennine settlements and their production systems, analyzing a broad range of archaeological findings.

Within these contexts, the attention is on pottery for its well-established role in archaeology and archaeometry, particularly in the reconstruction of production processes, trade networks, and consumption.

Accordingly, an extensive collection of coarse ware sherds from both the archaeological sites of Marzabotto [1] and Gonfienti [2] was selected. The choice falls on this specific pottery because, compared to fine and black-gloss wares [3], there is a lack of systematic analyses, able to give us information on the local production processes of the vessels, especially used for storage.

These samples underwent petrographic thin-sections studies and mineralogical analyses by X-ray diffractometry (XRD) to identify their petrographic fabrics and to evaluate their technological parameters [4].

In addition, a sampling campaign of clays identified by archaeologists has provided the material for creating experimental briquettes. These have been used for comparative analysis alongside other reference groups from existing literature in order to find out local sources [5].

References

[1] G. Govi, Kainua (Marzabotto) (2023), 516, DOI: 10.7560/326626

[2] L. Donati, Gonfienti: l'insediamento etrusco e romano (2022), 2 volumes, 427 (2022), ISBN: 9788892800502. [3] M.C. Nannetti, V. Minguzzi, E. Zantedeschi, E. Esquilini, Le analisi archeometriche, in G. Govi and G. Sassatelli (eds), Marzabotto. La Casa 1 della Regio IV. Insula 2: Lo scavo-I materiali (2010), 421-437, ISBN 978-88-7849-057-4. [4] G. Montana, Ceramic raw materials: how to recognize them and locate the supply basins-mineralogy, petrography, Archaeological and Anthropological Sciences (2020), 12, 175, DOI:10.1007/s12520-020-01130-1.

[5] R, Braga, M. Tirtei, C. Trevisanello, La ceramica non tornita a Marzabotto, in L. Cappuccini and A. Gaucci (eds), Officine e artigianato ceramico nei siti dell'Appennino Tosco-Emiliano tra VII e IV secolo a.C., Atti del I Convegno Internazionale di studi sulla cultura materiale etrusca dell'Appennino (Arezzo 18 ottobre 2019 - Dicomano 19 ottobre 2019) (2022), 155-178, ISBN 978-88-7689-339-1.

Acknowledgements
We acknowledge financial support under the National Recovery and Resilience Plan (NRRP), Mission 4, Component 2, Investment 1.1, Call for tender No. 104 published on 2.2.2022 by the Italian Ministry of University and Research (MUR), funded by the European Union – NextGenerationEU– Project Title APENNINESCAPE: Marginal landscapes and production processes along the Reno and the Bisenzio-Sieve valley districts during the 1st millennium BC – CUP J53D23000300006 - Grant Assignment Decree No. D.D. n. 969 adopted on 30/06/2023 by the Italian Ministry of Ministry of University and Research (MUR).

Preserving Paper-Based Cultural Heritage: Non-Invasive Techniques and Protocols for Assessing and Restoring flooded Ancient Books

T.C. David[1] ([a]), F.A. Pisu[1] ([a]), S. Porcu[1] ([a]), P.C. Ricci[1] ([a]), C.M. Carbonaro[1] ([a]), J. Kodric[2] ([b]), D. Chiriu[1] (*,[a])

([a]) Dept. Of Physics-University Of Cagliari – Cittadella Universitaria 09042 Monserrato (CA) - Italy

(b) Alma Mater Europaea Ecm - Lubijana (Slovenia)

* Daniele Chiriu

Daniele.chiriu@dsf.unica.it

Nowadays most of the books and documents preserved in the archive's present numerous critical issues. The risks to archival assets can stem from chemical, physical, and biological phenomena, as well as from human factors such as insufficient preventive conservation-restoration measures and inadequate protection.[3][4] Additionally, in recent decades, there has been an increase in the number of extreme natural events such as torrential rains, flash floods, and other disasters due to climate change, further heightening the vulnerability of archival assets. Unfortunately, the possibility of such adverse situations recurring remains a severe reality.[5]

In this study, we examined the impact of direct immersion in various water solutions on different types of paper and how this immersion could affect their degradation. We prepared several saline solutions to replicate varying degrees of salinity associated with common hydrogeological phenomena. Our focus was particularly on investigating the effects of salt on the crystalline structure of the paper.

Typically, archival materials exposed to hydrogeological phenomena undergo processes to remove salt. Consequently, our primary objective was to determine whether these washing processes are truly essential and whether samples can be shielded from further stress.

The study was carried out using optical techniques such as luminescence, reflectivity, and Raman spectroscopy. These techniques, as well as being non-destructive, can be portable so they are suitable for carrying out in situ measurements, making them easy to apply and very useful in the field of cultural heritage.

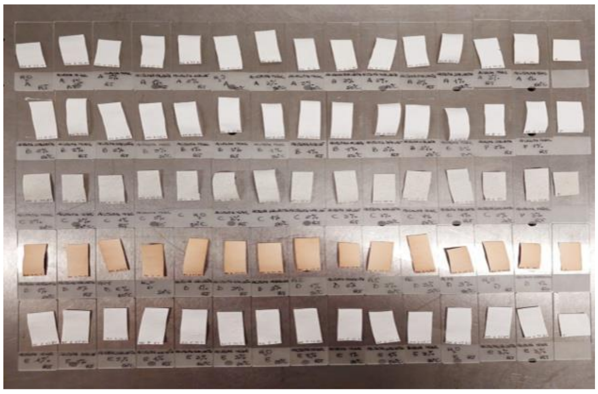


Figure 1: Analyzed samples

References

[1] D. S. Nitiu, A. C. Mallo, M. C. N. Saparrat, *Mycologia* **2020**, *112*, 859.

[2] Ministero per i beni e le attività culturali Direzione generale per gli Archivi, *Chimica e biologia applicate alla conservazione degli archivi*, Vol. 74, **2002**.
[3] M. Jablonsky, J. Šima, *Journal of Cultural Heritage* **2021**, *48*, 269.

Acknowledgements

The authors thank the precious collaboration with the State Archive of Cagliari and Fondazione di Sardegna in the framework of the project "New diagnostic techniques for ancient books restoration and conservation" FDS2022 CUP F73C23001560007

The Archaic Shipwreck of Giglio-Campese: An archaeometric contribution to the study of the geomaterials in its cargo

L. Fabrizi (a,b), R. Manca (*,a), M. Casalini (a), M. Bettuzzi (c), L. Chiarantini (d), L. Giuntini (e,f), A. Mazzinghi (e,f), M.P. Morigi (c), A. Naso (g), D. Paghi (a), C. Riccardizi (c), M. Benvenuti (a, h)

(a) Università degli Studi di Firenze, Dipartimento di Scienze della Terra
(b) Università degli Studi di Firenze, Sistema Museale di Ateneo
(c) Università di Bologna, Dipartimento di Fisica e Astronomia "Augusto Righi"
(d) Università degli Studi di Firenze, Centro di Microscopia Elettronica e Micro-Analisi (M.E.M.A.)
(e) Università degli Studi di Firenze, Dipartimento di Fisica e Astronomia
(f) Istituto Nazionale di Fisica Nucleare, Sezione di Firenze
(g) Università degli Studi di Napoli Federico II, Dipartimento di Studi Umanistici
(h) Consiglio Nazionale delle Ricerche, Istituto di Geoscienze e Georisorse

* Presenting author

rosarosa.manca@unifi.it

The archaic shipwreck of Giglio-Campese, discovered at a depth of 50 meters off the coast of Giglio Island (Tuscany, Italy), dates back to the early 6th century BCE (580-570 BCE) and represents a key piece in reconstructing trade routes across the Tyrrhenian Sea during the Archaic period.
The story of its discovery and archaeological excavation is long and complex but since its beginning in the 1960s, the origin of the ship has been debated, as both an Etruscan and Oriental/Greek origin might be invoked taking into consideration the location of the shipwreck site and the cargo composition. In this framework, a new archaeometric study of some of the geomaterials found, namely metal ingots, lithic anchors, and ferrous conglomerates, was conducted by a multidisciplinary, scientific team. Copper and lead ingots were analysed by SEM-EDS and ICP-OES to characterise their microstructural and chemical composition, and by TIMS to determine their lead isotope signature, which suggested that the most probable origin of the raw metals is the Eastern Mediterranean region. The lithotypes and possible provenances of a set of anchors were investigated by petrographic analysis, in order to test the hypothesis according to which the ship had stopped at Giglio Island to load anchors made of the local granite. Most samples resulted to be made of effusive rocks, which are not compatible with the geology of the island. Finally, a set of amorphous iron-based materials, whose original shape is not legible anymore due to the high corrosion and the presence of calcareous incrustations, were analysed by X-ray tomography in the attempt to reconstruct their original shape and function. In some cases, it was possible to identify the original profile of the iron objects, and complementary XRF analysis allowed us to determine their elemental composition.

In summary, this multidisciplinary archaeometric study of different geomaterials provided an important contribution to the currently ongoing reassessment of the shipwreck's cargo, shedding new light on the possible provenance and trade routes followed by the ship, which seems to come from the East Mediterranean. This opens new perspectives on maritime trade networks in the Archaic period.

Acknowledgements

We thank the Soprintendenza Archeologia, Belle Arti e Paesaggio per le Province di Siena, Grosseto e Arezzo for granting authorization for the analyses. Yiyang Liu and Luca Lei are thanked for their contribution to this study. Dr Antonello Scognamiglio and Prof Luigi Folco are also acknowledged.

Diagnostic analysis of the stucco fragments from the Hellenistic-Roman period at Lilybaeum. The domus of Via delle Ninfe and Via Diaz-Via Sibilla

G. Polizzi ([a]), C. Tuccio ([a,b]), M.L. Saladino ([b]), E.C. Portale ([a]), M.G. Griffo ([c])

(a) Department of Culture and Society, University of Palermo (Italy), Viale delle Scienze, Ed. 15 90128, Palermo (PA)

(b) Department of Biological, Chemical and Pharmaceutical Sciences and Technologies STEBICEF, University of Palermo (Italy), Viale delle Scienze, Ed. 17, 90128, Palermo (PA)

(c) Archaeological Park of Lilybaeum-Marsala (Italy), Lungomare Boeo, n° 30, 91025 Marsala (TP)

* giovanni.polizzi02@unipa.it

In this paper will be presented the results of diagnostic analysis carried out within the framework of the S.A.M.O.T.H.R.A.C.E. project on fragments of plaster from the *domus* of via delle Ninfe and via Diazvia Sibilla. Although we have a partial knowledge of both contexts, the richness of the decorations suggests a high status of the owners.

The aim of the analyses was to identify the execution technique and the pigments used. Diagnostic investigations were carried out in situ using portable instrumentation with non-invasive techniques. A total of 9 painted fragments were selected based on their type (fragments from ceilings and others from wall paintings) and the variety of colors present. Specifically, the analyses were conducted using multispectral imaging techniques (visible, IR reflectography, UV fluorescence, and visible light-induced luminescence) and FORS spectroscopy (Fiber Optic Reflectance Spectroscopy). The investigations allowed for defining the execution technique: it is the traditional stucco technique, involving the application of a finishing plaster made of lime and gypsum (used by the artist to delay setting time and refine sculptural details). Additionally, it was possible to reconstruct the color palette, which consisted of pigments such as Egyptian blue, red and yellow ochre, green earth, and vegetable black.

The domus of via delle Ninfe was discovered in the 1980s and is located in a state-owned area now musealized and accessible. Here, a series of rooms were discovered related to three different phases, dating from the IIIrdc. BC. to the IIndc. AD. Each phase had specific decorations of the rooms. The house in via Diaz-via Sibilla was discovered in 2006 during the renovation of the modern sewer. For the needs of the road, the excavation was buried at the end of the works, but a good part of the building was dismantled and musealized inside the Baglio Anselmi Museum. In this case, too, the documentation allows to reconstruct an elaborate decorative system, the result of the evolution of the aesthetic taste of the owners. If the comparison between the two contexts, both of them situated a short distance away from each other, allows us to reflect on the existence in Lilibeo of workshops specialized in the realization of domestic decorative systems, observations on the nature of pigments used in different eras, suggest the formulation of some working hypotheses on the procurement of raw materials.

Acknowledgements: We thank European Union (NextGeneration EU), through the MURPNRR project SAMOTHRACE — Sicilian Micro and Nano Technology Research and Innovation Center (ECS00000022).

Optical profilometry applied to quantitative use-wear analysis of percussive stone tools from Kenya

L. Germinario (*, a), I. Caricola (b,c), C. Lemorini (b), E. Finestone (d), C. Mazzoli (a), J. Oliver (e), T. Plummer (f)

(a) Department of Geosciences, University of Padova, Italy

(b) Department of Classics, Sapienza University of Rome, Italy

(c) Zinman Institute of Archaeology, Haifa University, Israel

(d) Department of Anthropology, Cleveland Museum of Natural History, USA

(e) Anthropology Section, Illinois State Museum, USA

(f) Department of Anthropology, Queens College, USA

* Presenting author

luigi.germinario@gmail.com

Nyayanga is an Early Stone Age archaeological site in Kenya reported as the oldest Oldowan site known (3.0–2.6 Ma). The site includes an assemblage of pounded and flaked artifacts made of quartzite, quartz, rhyolite, and granite used as percussive tools, together with remains of hominins (*Paranthropus* sp.) and animal fossils (hippopotamids and bovids) with cutmarks indicating butchery activities. The artifacts from Nyayanga were analyzed by 3D optical profilometry for their quantitative use-wear analysis, aided by qualitative microscopic observations of the archaeological traces and post-depositional alterations. The surface topography of the stone tools was analyzed from 3D models created by profilometry, obtaining a set of morphometric parameters (roughness, peak height, valley depth, etc.) that were then treated by multivariate statistical analysis. The findings allowed discriminating the different functions of the stone tools for processing animal tissues (bones and soft tissues) and plants (underground storage organs), providing indications on early hominin technological evolution and dietary strategies. From a methodological point of view, the pros and cons of quantification by profilometry were disclosed. Standardization of the measurements and data processing methods are much needed currently, together with more investigations focusing on archaeological materials and not just on experimental replicas.

Stone decay in coastal cultural heritage: preliminary investigation of sea salt weathering at Mykonos Castle (Greece)

L. Germinario ([*, a]), C. Mazzoli ([b])

([a]) Department of Geosciences, University of Padova, Italy

* Presenting author

luigi.germinario@gmail.com

Mykonos Castle is a coastal citadel on the homonymous island of the Aegean Sea in Greece, built and developed from the 13th century under the rule of the Republic of Venice. Nowadays, only ruins of its towers, churches, and perimetral walls survive, following the abandonment of the area begun in the 19th century. The sections of the stone walls still preserved, now a few meters away from the shore or partly underwater, offer an excellent opportunity for exploring the impact of processes of salt weathering from sea spray and seawater infiltration. This contribution presents the fieldwork and preliminary laboratory activities of a study focused on the properties and decay mechanisms of the historical building stones at Mykonos Castle, organized with the following research directions: petrographic characterization of the main building materials (gneisses, marbles, granitoids, etc.); classification of their decay patterns; analysis of the in-pore salt content constrained by wall orientation, height, and distance from the shore; monitoring and quantification of surface erosion by micro- and macro-scale 3D modelling (optical profilometry and photogrammetry) and morphometric analysis. The outcomes of this research are expected to help better comprehending the intensity and rate of salt weathering in coastal built heritage and its vulnerability, also in view of the environmental stresses brought about by climate change with increasing storms and sea level rise.

The castle structures on the W side and details of the building stones

Acknowledgements

This study is carried out within the project THETIDA, which has received funding from the European Union's Horizon Europe scheme under the program Culture, Creativity and Inclusive Society (grant agreement no. 101095253).

A preliminary investigation of Perugino's Florentine wall paintings: the *Last Supper* at the Cenacolo di Fuligno and the *Crucifixion* at Santa Maria Maddalena dei Pazzi

D. Magrini ([*, a]), S. Brizzi ([a]), E. Grifoni ([a]), C. Riminesi ([a]), O. Caruso ([b]), A. Felici ([c]), E. Manship ([d])

([a]) Italian National Research Council, Institute of Heritage Science (ISPC-CNR)

([b]) Caruso Ottaviano_Conservazione e restauro Opere d'arte

([c]) Soprintendenza Archeologia, Belle Arti e Paesaggio per la città metropolitana di Firenze e le province di Pistoia e Prato (SABAP)

([d]) University of Applied Sciences and Arts of Southern Switzerland (SUPSI)

* Presenting author

donata.magrini@cnr.it

This work presents a multi-modal investigation of the two wall paintings created by Perugino during his stay in Florence between 1487 and 1511, the *Last Supper* (circa 1486-93) at the Cenacolo di Fuligno and the *Crucifixion* (1496) at Santa Maria Maddalena dei Pazzi. The research was carried out by a multi-disciplinary team with the goal of understanding the structure and organization of the paintings, and the techniques and materials used in creating them with a particular focus on the study of pigments and how they were used by the painter in two different contexts.

The combination of direct observations and technical photography guided subsequent diagnostic investigations using non-invasive scientific techniques (thermography, XRF, FORS). The comparison of evidence coming from point-based analyses to characterize the constituent materials of the pigments used, and the observation of the surface of the paintings, have provided interesting insights into the realization of these paintings, and have helped formulate hypotheses about the operational choices employed by the painter and his collaborators. Between the two paintings, and within each individual painting, similarities and differences were noted in the painting technique and the palette, opening up interesting avenues for future research into the provenance and composition of pigments in Perugino's work.

Perugino, *Crucifixion, 1496, 812 cm x 480 cm,*
Florence, Santa Maria Maddalena dei Pazzi

Perugino, *Last Supper, 1486-1493, 794 cm x 435 cm,*
Florence, ex Convento di Sant'Onofrio

PERCEIVE Project. New technologies to preserve ancient colours of cultural heritage and digital art.

D. Magrini ([*, a]), R. Iannaccone ([a]), I. Cerato ([a]), C. Barandoni ([a]), F. Bonifazi ([a]), D. Ferdani ([b]), S. Pescarin ([d])

(a) Italian National Research Council, Institute of Heritage Science (ISPC-CNR), Florence
(b) Italian National Research Council, Institute of Heritage Science (ISPC-CNR), Rome

* Presenting author
POSTER

donata.magrini@cnr.it

Due to their fragility, polychrome collections require common methods of preservation and exhibition. Textiles, for example, can fade within 10 years, or ancient Greek and Roman statues show only tiny remnants of original polychromy. The complexity of the study, especially the attempts to reconstruct the original appearance, and the importance of proper communication to future generations are priorities for the preservation of colored cultural heritage collections.
In this context, the EU-funded project PERCEIVE (Perceptive enhanced realities of colored collections through AI and virtual experiences) is experimenting to develop a reliable method for studying, reconstructing, virtual rendering and exhibiting colored collections and digital artworks The project highlights five scenarios (Lost polychromy in Classical sculptures; color changes in paintings; fading colours in textiles; color changes in historical photos; Digital Art), focusing on specific needs and requirements, to better identify suitable solutions committed to scientific community, citizens and creative industries.
The project methodology will focus on:

- Reconstructing the original perception of the colored artworks obtaining new images, also considering the original environmental information and lighting, when possible.
- Predicting the future development of color changes.
- Using the results of the reconstruction and prediction in interactive (onsite and online) prototypes (the experience solutions) and finalising methodological guidelines for exhibiting the colored collections.

Expected outcomes include new services and tools for scientists, designers, arts professionals and educator enabling the adoption of PERCEIVE technologies beyond the project itself.

Aknowledgments
This project has received funding from the European Union’s Horizon research and innovation programme under grant agreement N. 101061157
Website: www.perceive-horizon.eu Info: info@perceive-horizon.eu

Analytical methods for the authentication of early 20th-century paintings

V. Comite ([*, a]), A. Bergomi([a]), M. Borelli ([a]), G. Galli([a]), G. Carabelli([a]), C.A. Lombardi ([a,b]), P. Fermo ([a])

([a]) Dipartimento di Chimica, Università degli Studi di Milano, Via Golgi 19, Milano, Italy

([b]) Dipartimento di Scienze dell'Antichità, Sapienza Università di Roma, Piazzale A. Moro 5, Roma, Italy

* Presenting author

Email corresponding: valeria.comite@unimi.it

The authentication of early 20th-century paintings represents a significant challenge, because of the increasing number of fakes entering the art market. During this period artists began using both innovative materials and new techniques, driven by the discovery and synthesis of new molecules by scientists [1]. This study illustrates the application of non-destructive and micro-destructive analytical techniques, including Raman spectroscopy and reflectance spectroscopy, for molecular identification, and Scanning Electron Microscopy coupled with Energy-Dispersive X-ray Spectroscopy (SEM-EDX) for the characterization of the elemental composition. The application of these analytical techniques provides a scientific basis for detecting forgeries through the identification of materials used in this specific historical period.

Several artworks dated at early the 20th-century and coming from private collections, were analyzed to verify the consistency of the materials used with those documented at the time. A key finding was the detection, primarily through Raman spectroscopy, of phthalocyanine-based pigments [2] used as green and blue pigments in some of the analyzed works. Their presence was confirmed through colorimetric measurements, comparing the spectra with those acquired from standard samples. Notably, these synthetic pigments were commercially introduced only after the 1930s, making their use incompatible with authentic early 20th-century paintings. SEM-EDX further supported this conclusion by highlighting the absence of chromophores and elements typical of inorganic pigments commonly associated with that period. Similarly, some of the analyzed works displayed pigments consistent with the first decades of the 20th-century and therefore could be deemed authentic.

In conclusion this study highlights the importance of combining analytical techniques to resolve issues related to the identification of fake works of art, which are widespread in modern and even contemporary art.

References

[1] F. Pozzi, A. van Loon, F. Casadio, A review of synthetic organic pigments in 20th-century art, Studies in Conservation (2019), 64(2), 61–78. https://doi.org/10.1080/00393630.2018.1509251

[2] N.C. Scherrer, S. Zumbuehl, F. Delavy, A. Fritsch, R. Kuehnen, Synthetic organic pigments of the 20th and 21st century relevant to artist's, Spectrochimica Acta Part A (2009), 73, 505–552. https://doi.org/10.1016/j.saa.2008.11.029.

Acknowledgments

This research was made possible thanks to funds from Cultural Heritage Active Innovation for Sustainable Society (CHANGES) Project funded by the European Union – NextGenerationEU, under the National Recovery and Resilience Plan (NRRP) Mission 4 Component 2 Investment Line 1.3. The activities were carried out in the framework of Spoke 6 (History, conservation and restoration of cultural Heritage).

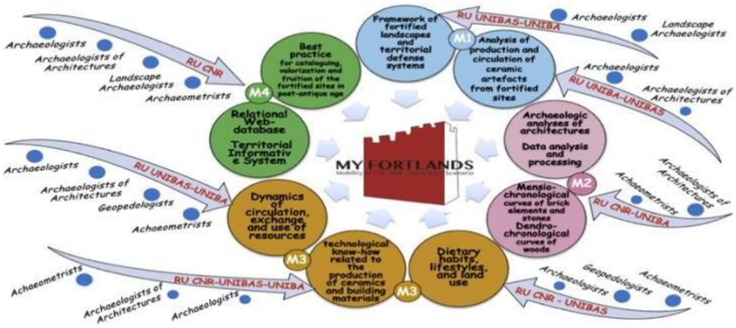
The PRIN Project MY-FORTLANDS: MobilitY of goods, men and knowledge in the FORTified LANDscape Scenario of southern Italy (Basilicata and north-central Apulia) in the Middle Age.

F. Sogliani ([a]), P. Di Leo ([*,b]), R. Giuliani ([c]), M. Campese ([a]), A. Cardone ([c]), F. Fiore ([a]), B. Gargiulo ([a]), G. Lubraco ([b]), D. Roubis ([b]), L. Scrano, ([a])

(a) UNIBAS-DIUSS Research unit, Dipartimento per l'Innovazione Umanistica, Scientifica e Sociale, 75100, Matera (Italy)
(b) CNR-IMAA/ISPC Research unit, Consiglio Nazionale delle Ricerche, 85050, Tito Scalo (PZ) (Italy)
(c) UNIBA-DIRIUM Research unit, Department of Humanistic Research and Innovation, 70121, Bari (Italy)
* Presenting author

paola.dileo@cnr.it; paola.dileo@unibas.it

MY-FORTLANDS has as its general objective the knowledge of the fortified landscapes that have marked the territories of southern Italy, with particular attention to Basilicata and central-northern Apulia, between late antiquity and the Middle Ages, both as generators of new political-demographic models and as markers of profound territorial transformation and as an ecosystem around which the mobility of goods, people and knowledge gravitated. This dimension will be explored starting from the Gothic, Byzantine and Lombard forms of defense, whose material traces are often evanescent, up to the fortified systems of the Norman-Swabian and Angevin periods. The research will be carried out in two geographical areas: a) inland areas of Basilicata (Bradano, Basento, Agri, Sinni valleys); b) central-northern Apulia (Monti Dauni district, Gargano promontory, Ofanto valley and coastal district north of Bari), as areas with key communication roles between the inland territories and the coastal areas. MY-FORTLANDS proposes to stimulate a "real" interdisciplinary dialogue, through the synergic action of research units which are diversified in their specific objectives (UNIBAS, UNIBA, CNR) and study methodologies, but which converge in the achievement of the same objectives. Fortified landscapes and their structure are the spatial representation of land occupation strategies for strategic purposes and/or territorial domination, and their understanding necessarily requires an integrated and multidisciplinary approach for the analysis of the man-environment relationship with regard to defense systems and territorial organisation, exploitation of resources, supply of materials and circulation of goods, dissemination of knowledge regarding the production of artefacts, components and building techniques and the organisation of construction sites. The need to contextualize the environmental and climatic scenario of the fortified landscapes and to define the feedback mechanisms between the physical landscape and settlement dynamics requires the study of the morphological order and the historical road network, the analysis of historical sources, intensive stratigraphic archaeological investigations on sample cases, the use of methodologies typical of landscape archaeology, analysis of land use, the study of building knowledge and the elaboration of atlases of building techniques on a sub-regional and regional scale. Privileged indicators for tracing the mobility of goods and knowledge are both building materials and ceramic products, for which the archaeometric approach based on multi-analytical experimental protocols will be used to identify places of supply of resources, their use and technological know-how. The dissemination of the research data will be entrusted to a web-database with open access levels and to a Geographical Information System (GIS).



The architecture of My-FORTLNDS project. The three milestones are depicted with different colors. For each milestone are specified the research units involved and the type of experts required.

SENSORIA: Redefining Cultural Heritage Through Innovation and Accessibility

A. Spagnuolo ([*, a]), C. Vetromile ([a]), A. Masiello ([a]), G. De Santo([a]), C. Lubritto ([b])

([a]) Energreenup srl, via Parata, 3 Pietramelara (CE), Italy

([b]) Department of Environmental, Biological and Pharmaceutical Sciences and Technologies and MAReA Centre, University of Campania "Luigi Vanvitelli", Via Vivaldi 43, 81100, Caserta, Italy

* Presenting author

a.spagnuolo@energreenup.it

The SENSORIA project ("Innovative Systems for Accessibility and Extended Enjoyment of Cultural Heritage") represents a multidisciplinary initiative aimed at integrating scientific, technological, and humanistic expertise to address the challenges associated with the conservation, enhancement, and enjoyment of cultural heritage. This project stands out for its innovative approach, based on the dynamic interaction between humans and the exhibition environment, with particular attention to museums and street art. Energreenup, the promoter of this initiative, aims to develop advanced technological solutions that are both inclusive and accessible, capable of meeting the needs of the most vulnerable groups and ensuring a comprehensive experience for all visitors.

At the core of SENSORIA lies the ambition to develop innovative tools and methodologies for monitoring environmental parameters and assessing the conservation conditions of cultural assets, while simultaneously ensuring unprecedented physical and sensory accessibility. The complexity of the challenges in this field is addressed through an integrated approach, combining the use of advanced analytical technologies with the adoption of inclusive dissemination systems. The project includes the creation of an integrated environmental monitoring and diagnostic system that not only collects essential data for preventive conservation but also optimizes the environmental comfort for both the exhibits and the visitors. The collected information will be processed and made available through a digital platform, thereby promoting dynamic and informed heritage management.

A significant example of application is the experimental monitoring at the Archaeological Museum of Ancient Capua and the Mithraeum, where a network of small, visually unobtrusive sensors will be installed. These devices will measure, in real time, parameters such as temperature, humidity, and gas concentrations (PM, SO_x, NO_x, VOC, CO_2,…) providing critical data for assessing the conservation status of the exhibited works. In parallel, SENSORIA also deals with street art, a contemporary art form that requires specific monitoring interventions to assess the effects of air pollutants and climate change. Studies conducted highlight how chemical and physical agents can accelerate degradation processes, making timely and targeted actions indispensable for preserving these works. Comparative analysis of the collected data will help identify temporal variations and plan conservation interventions based on scientific evidence.

Another crucial aspect of the project concerns inclusivity and dissemination. SENSORIA aims to make cultural heritage accessible to an increasingly broad and diverse audience through the creation of inclusive pathways and interactive digital platforms. The technologies developed include applications for mobile devices, 3D projections, and data representation systems that facilitate the understanding of scientific processes related to conservation. At the Archaeological Museum of Ancient Capua and the Mithraeum, an audio-video guided tour accessible to people with disabilities will be created, featuring content designed with an inclusive perspective. This initiative seeks to combine art and science, offering a new perspective on the application of technologies to cultural heritage and fostering a constructive dialogue between different disciplines.

Thus, the SENSORIA project represents a model of excellence in the sustainable and innovative management of cultural heritage. Its implementation will not only contribute to the preservation of works of great historical and artistic value but will also promote greater awareness and participation among the public. Through collaboration among experts in archaeometry, environmental science, and the humanities, SENSORIA lays the foundations for a new era of accessibility and enhancement of cultural heritage, underpinned by sustainability and innovation.

References

[1] D. Camuffo, Microclimate for Cultural Heritage -3rd Edition. Elsevier, 2019, ISBN 9780444641069
[2] A. Hinostroza, J. Tarrillo, Wireless sensor network for environmental monitoring of cultural heritage, Proc. of the 11th Int. Conf. on Sensor Networks SENSORNETS 2022, Online, 7- 8 February 2022, vol. 1, pp. 171–175. DOI: 10.5220/0010916700003118
[3] S. Ferrarese, D. Bertoni, V. Dentis, L. Gena, M. Leone, M. Rinaudo, Microclimatic analysis in the Museum of Physics, University of Turin, Italy: A case-study⋆, Eur. Phys. J. Plus, vol. 133 (2018), pp. 1-11. DOI: 10.1140/epjp/i2018-12367-4

Acknowledgements

PNRR-funded project,
Mission 1 - Digitalisation, Innovation, Competitiveness and Culture,
Component 3 - CUP: C27J23001990008, COR: 15911872

Public Engagement and Empowerment in Heritage

Ilaria Filonzi (*, a, b), Wladimiro Carlo Patatu (b), Andrea Patti (b)

(a) Università di Genova, Dipartimento di lingue e culture moderne, Piazza S. Sabina, 2, Genova, Italy

(b) EHT S.C.p.A. – Viale Africa, 31, 95129 Catania, Italy

* Presenting author

ilaria.filonzi@edu.unige.it, andrea.patti@eht.eu, vladimiro.patatu@eht.eu

Introduction: The museum is recognized as a public institution responsible for creating opportunities for democratic and participatory culture. In museum practice, participation is applied in a variety of settings: it can be used simultaneously or exclusively for social activism, as a method of audience development or a tool of empowerment. Museum's goal is to achieve and develop a way to improve empowerment in socially exercised and develop how museum experiences can contribute to the active training and education of visitors. Concepts such as cultural citizenship, participation and engagement, are rooted in the theoretical and ideological frameworks that define the museum as a communicative and social institution, within the democratic society.

State of the art: Currently, museums are encouraging integration with technologies to increase engagement and active participation. However, it is not easy and, in this perspective, the use of a Web App based on the Bring Your Own Device (BYOD) methodology favors active learning by visitors.Simon (2010) identifies four models of participation: contributory, collaborative, co-creative and hosted where the collaborative relationship in which people become active partners of institutions. Dahlgren (2006) describes the concept of engagement as subjective states, indicating a mobilized, focused attention on some object. Based on these theories, Lotina (2016) integrates museum and audience perspectives and defines engagement as a two-way process combining the performance of both the museum and the active audience by responding to the stimulus of engaged parties and initiating new actions with the aim to improve museum work, enhance the experience or make a difference on a larger scale in society.

Methodology: The methodology that will be used will be oriented towards the use of new technologies and psychological evaluation. A Web App, based on the Bring Your Own Device (BYOD) methodology, will be proposed where the user can choose a specific type of storytelling based on the profile chosen by the user. This will allow for an immersive experience and co-creation of the museum experience with the aim of promoting engagement and emotional resonance. This methodology is based on four main theoretical aspects: active visitor involvement, positive emotions, psychological well-being and educational potential.As regards psychological evaluation, psychometric tests will be used to evaluate emotional resonance, engagement and the skills and knowledge learned during the visit.

Conclusion: In the museum context, immersive storytelling uses engaging and multisensory narratives to connect visitors with the works, spaces and stories of the museum with the aim of stimulating and involving the visitor in an active and emotional way.According to experiential learning, sensory and narrative immersion allows visitors to learn through actions. In this perspective, emotional and personal connections to stories in museums on personal, universal and socially relevant themes can foster resilience and active citizenship in visitors, promoting engagement in the museum experience and the common well-being of society.

Promoting Sustainable Management and Enhancement of Cultural Heritage in Coastal Areas: Insights from the TECTONIC Project

M.A. De Pascali ([a]), A. Lavitola ([b]), M.F. La Russa ([*, c]),

([a]) Conservator Scientist and experienced diver, Vibo Valentia, Italy

([b]) Biologist, Cosenza, Italy

([c]) University of Calabria, Department of Biology, Ecology and Earth Sciences, Italy

* Presenting author

mlarussa@unical.it

The conservation and documentation of coastal regions and underwater cultural heritage (UCH) are essential to protect history, maintain tangible traces of previous human existence, and ensure sustainable access for future generations. The TECTONIC project (Technological Consortium for the Development of Sustainability in Underwater Cultural Heritage) fosters collaboration among professionals from various sectors, including academia and industry, such as conservators, archaeologists, geologists, biologists, engineers, experts in underwater activities, etc. This multidisciplinary approach addresses existing challenges in the marine field with a focus on UCHs to devise sustainable and innovative solutions [1]. The main objective is to facilitate the exchange of knowledge to improve and evaluate innovative practices, techniques, and materials for the effective documentation, conservation, and management of underwater resources. TECTONIC's activities include: (1) researching, documenting, and mapping selected UCHs; (2) developing decision-support tools for assessing UCHs risks in changing environments; (3) establishing conservation study protocols; (4) creating accessible robotic technologies for the UCH inspection; and (5) increasing public awareness and understanding of UCHs. Each of these objectives is designed to promote sustainable practices, fostering growth in cultural tourism and coastal development by leveraging research outcomes. This work aims to present the results achieved at one of the underwater pilot sites studied within the TECTONIC project.

References

[1] M. Ricca, G. Alexandrakis, A. Bonazza, F. Bruno, B. Davidde Petriaggi, D. Elkin, A. Lagudi, S. Nicolas, M. Novák, G. Papatheodorou, et al. A Sustainable Approach for the Management and Valorization of Underwater Cultural Heritage: New Perspectives from the TECTONIC Project. *Sustainability*. 2020; 12(12):5000. https://doi.org/10.3390/su12125000

Acknowledgements

This project has received funding from the European Union's Horizon 2020 Research and Innovation program under the Marie Skłodowska-Curie Grant Agreement No. 873132. CUP H24G20000000006.

Preservation of Submerged Cultural Heritage: insights from the SOUTH Project and preliminary results

M. Ricca (*, a), M.F. Alberghina (a), F. Sfravara (b), M.F La Russa. (a), G. Montana (c), V. Catania (c) L. Randazzo (c)

(a) University of Calabria, Department of Biology, Ecology and Earth Sciences, Cosenza, Italy

(b) University of Messina, Department of Industrial Engineering, Messina, Italy

(c) University of Palermo, Department of Earth and Marine Sciences, Palermo, Italy

* Presenting author

michela.ricca@unical.it

The SOUTH project is designed to carry out a comparative study on the degradation of stone materials typically found in submerged historical and archaeological sites. This research focuses on testing innovative formulations aimed at protecting these materials from biofouling by monitoring the growth and progression of damage over time. The monitoring phase will be automated through the use of advanced image acquisition methods, processing techniques and machine learning algorithms, which will help to minimize the noise of images captured underwater and facilitate the analysis of microbial growth based on data collected from both laboratory and in situ tests. This automated approach will enhance monitoring efficiency, allowing for the assessment of materials without the need to extract samples from the aquatic environment at specific times. The primary objective is to analyze and compare damage to various stone materials exposed to seawater over an extended period while assessing the efficacy of new protective formulations against biofouling. Initial pilot tests will be conducted in the laboratory, followed by validation at an ideal submerged site located in Southern Italy, within the Mediterranean region. The solutions developed and tested within this framework could potentially be applied to other historical and archaeological sites across the Mediterranean facing similar conservation challenges. This document outlines the initial phase of the project's experimentation, commencing with a comprehensive review of existing literature [1-3], also showing preliminary laboratory results.

References

[1] UNESCO. The entry into force of the 2001 UNESCO Convention on the Protection of the Underwater Cultural Heritage. In Proceedings of the Convention on the Protection of the Underwater Cultural Heritage, Paris, France, 2 November 2001.
[2] S.A. Ruffolo, M. Ricca, A. Macchia, M.F. La Russa, Antifouling coatings for underwater archaeological stone materials. Prog. Org. Coat. 2017, 104, 64–71.
[3] L. Randazzo, M. Ricca, D. Pellegrino, D. La Russa, A. Marrone, A. Macchia, L. Rivaroli, F. Enei, M.F. La Russa, Antifouling additives for the consolidation of archaeological mortars in underwater environment: Efficacy tests performed on the apsidal fishpond of Castrum Novum (Rome, Italy). IJCS 2020, 11, 243–250.

Acknowledgements

This study received funding from the European Union - Next-Generation EU - National Recovery and Resilience Plan (NRRP) – MISSION 4 COMPONENT 2, INVESTIMENT N. 1.1, CALL PRIN 2022 PNRR D.D. 1409 14-09-2022 – (SOUTH) CUP N. H53D23010210001.

Ànchors of the Soprintendenza del Mare-Regione Siciliana. The value of a collection that is too often underestimated

Valentina Purpura (Ricercatrice indipendente); valentina.purpura80@gmail.com
Daniel Becerra Fernández (Universidad de Málaga, España); dbecerra@uma.es

---

The new study, presented here, on the anchors in the possession of the Soprintendenza del Mare was possible through an extensive census, cataloguing and documentation activity which made it possible to understand the numerical consistency of the possession and understand its value, also going back, through the archive material and not only, the places of discovery. These data were then merged into a digital mapping through the G.I.S. system. which with its specific applications allows you to view, organize, analyze and represent the spatial data known about the findings which have allowed more detailed research on ancient Sicilian navigation, routes and ports. All this has brought out how anchors, often underestimated material, can become a "significant part" of the museum itinerary of the "“Museo del Mare e della Navigazione della Sicilia" which is soon to open.

Figura 1- Àncora litica

Figura 2-Ceppo di ancora plumbea

References:

G.M. Columba, *I porti della Sicilia*, 1906 (rist. 1991).
G. Kapitän, *Ancient Anchors – Tecnology and Classification*, in *International Journal of Nautical Archaeology*, 1984, 13, 1, pp. 33-44, https://doi.org/10.1111/j.1095-9270.1984.tb01175.x.
D.E. McCaslin, *Stone Anchors in Antiquity: Coastal Settlements and Maritime Trade-Routes in the Eastern Mediterranean ca. 1600-1050 B.C.*, 1980.
A. Papò, *Ancore di pietra viaggio alle radici della storia*, 2004.
G. Purpura, *Porti e scali della Sicilia Occidentale*, on-line: <https://www.academia.edu/10960125/Porti_e_scali_della_Sicilia_occidentale_VII_Rassegna_di_Archeologia_subacquea_Giardini_1992> (viewed 29 October2024)

I thank the Soprintendente del Mare Dr. Ferdinando Maurici who allowed me, with the support of Dr. Fabrizio Sgroi, to study without any limitation all the anchors currently available from the Soprintendenza del Mare. All staff of the Soprintendenza del Mare of the decentralized offices. All the staff of the Biblioteca di Antichistica of the University of Palermo for supporting and supporting me in the bibliographic research and acquisition of the writings preserved in it.

A non-invasive methodological approach to identify wreck wood chemical elements contamination

G. Gallello ([*, a,b]), C. de Juan Fuerte ([a]), L. López Fernández ([a]), Desiré Rico Navarro ([a]), Y. Carrión Marco ([a]), Ángel Morales Rubio ([c]), J.L. Sierra ([d]), A. Diez Castillo ([a])

(a) Department of Prehistory, Archaeology and Ancient History, University of Valencia.

(b) University Institute of Materials Science (ICMUV), University of Valencia.

(c) Department of Analytical Chemistry, University of Valencia.

(d) Arquatec laboratory, Ministry of the Culture-Spain.

* Presenting author

gianni.gallello@uv.es

Mazarrón II is a shipwreck found in Mazarrón, a town located in the south-east of Murcia region (Spain) that was excavated in 1999-2001 by the National Museum of Underwater Archaeology (ARQVA) [1]. The wreck was dated to the Phoenician period being the length 8.15 m and the beam 2.25 m with a main cargo of 2.8 t of litharge lead and just an amphorae [2]. In the following years a cage was built to protect the ship *in situ* from both natural and anthropic activities, while the archaeological findings were stored at the ARQVA (Cartagena, Murcia). However recent conservation studies alerted about the multiples degradation processes that were impacting the defensive cage and also the shipwreck [3]. Consequently, an extraction plan was developed and it has taken action during the 2024 being now a day the total of Mazarrón II remains deposited in ARQVAtec Laboratory under desalination treatment. A methodological approach using non-invasive analyses to identify wreck wood chemical elements contamination for the best evaluation of the conservation actions was developed. Different parts of the boat, including wood and resin, were analysed using a portable X-ray fluorescence device. The obtained data were statistically processed to assess similarities and differences between the analysed wreck parts. The results show high heavy metals concentrations in some pieces that will need special care during the restoration process. The reported procedure may be useful for specialists working on conservation for underwater archaeology.

Portable X-ray fluorescence analyses carried out in Mazarrón II.

References

[1] A.Villa, The Mazarrón II Wreck (Murcia, Spain). Management of human and natural threats, Internet Archaeology (2023), 62, https://doi.org/10.11141/ia.62.3

[2] I. Negueruela, Hacia la comprensión de la construcción naval fenicia según el barco de "Mazarrón-2" del siglo VII a.C. En Peña, Mederos y Wagner (eds.), La navegación fenicia. Tecnología naval y derroteros (2004), 227-278, Madrid: Centro de Estudios Fenicio Púnicos.

[3] C. De Juan, El Pecio de Mazarrón 2 (Murcia) y la arquitectura naval venida del Levante. Actas de la Reunión Internacional de Expertos sobre la extracción y conservación del pecio Mazarrón 2 (2023), 15-28.

Crystallinity Index to Assess Thermal Alteration of Minerals in Manure: A Case Study from *Riparo Gaban*

A. Santiglia (*, a), A.L. Tassi (a), Martina Sciortino(b), L. Santagostini(a), V. Guglielmi(a)

(a) Department of Chemistry, Università degli Studi di Milano, Via Golgi 19, Milano, Italy
(b) Department of Humanities, Università di Trento, Trento, Italy

* Presenting author

alessia.santiglia@unimi.it

Fumiers are long and complex sequences of intentional accumulations rich in organic sediments. They are typically found in many caves and rock shelters used for pastoral activities since the Neolithic period in the Mediterranean basin. These deposits mainly consist of burnt animal dung and plant remains, interpreted as the result of domestic livestock occupation and stabling activities. The repetitive and systematic combustion processes carried out to clean these spaces generate multiple layers with distinct archaeo-sedimentary characteristics, referred to as facies [1].

This study highlights the changes occurring in the mineral components of ceramics included in different facies, as well as in the mineralogical phases of sediments from the stratigraphic layers of the fumiers at *Riparo Gaban*, located in Piazzina di Martignano, Trento. The primary analytical technique employed in this research is Fourier Transform Infrared Spectroscopy (FTIR). The analysis was conducted on 11 sediment samples, each corresponding to a distinct facies from archaeological levels datable to the Early Neolithic (using as a reference the section adjacent to the walls at the center of the shelter) [2].

Anthropic calcite is a form of calcium carbonate produced through pyrotechnological activities and is used in ceramic production. This type of calcite is characterized by a significantly lower degree of crystallinity compared to geogenic calcite, as a result of different formation processes. Its crystallinity can be assessed using transmission infrared spectroscopy, which decouples the effects of particle size from atomic order, effectively distinguishing between anthropic and geogenic calcites [3]. The use of the crystallinity index aims to differentiate geogenic from anthropic calcite within the various samples.

To support the FTIR results, X-ray powder diffraction (XRPD) analysis was also conducted. This technique enables the identification of secondary phases or structural differences within the calcite fraction of the sample. In conclusion, by comparing the results from FTIR and XRPD analyses, it was demonstrated that spectroscopic methods can effectively trace structural differences in materials caused by thermal alteration. Additionally, a future development of this work involves utilizing FTIR not only for qualitative analysis but also for quantitative analysis to determine the proportions of different calcite phases present in the sediments. This goal can be achieved using artificial intelligence and machine learning techniques, as reported in the literature [4].

References

[1] H. Del Valle, I. Cáceres, C. Tornero, A. Burguet-Coca, A. Moclán, J. M. Vergès, ATR-FTIR to distinguish Holocene fumier facies. A perspective from bone diagenesis at El Mirador cave (Sierra de Atapuerca, Spain), Journal of Archaeological Science, Volume 141, 2022, 105582, ISSN 0305-4403, doi: 10.1016/j.jas.2022.105582.

[2] Angelucci, D. E. *et al.* (2009) 'Shepherds and karst: the use of caves and rock-shelters in the Mediterranean region during the Neolithic', *World Archaeology*, 41(2), pp. 191–214. doi: 10.1080/00438240902843659.
[3] Toffolo, M.B., Pinkas, I., Gallo, A.Á. *et al.* Crystallinity assessment of anthropogenic calcites using Raman micro- spectroscopy. *Sci Rep* **13**, 12971 (2023). doi:10.1038/s41598-023-39842-8
[4] T.J.U. Thompson, M. Islam, and M. Bonniere, "A new statistical approach for determining the crystallinity of heat- altered bone mineral from FTIR spectra," Journal of Archaeological Science 40, 2013, pp.416-422.

Acknowledgements

This research is part of the project Pyro-Transitions: prehistoric cultural changes in the use of fire from foraging to the earliest farming societies, funded by MUR - PRIN 2022 (project code 2022PWY2YS, CUP Master no. E53D23000300006, CUP G53D23000310006).

How Melamine-Formaldehyde Treatment Changes Waterlogged Archaeological Wood: Challenges for Preservation

J. Łucejko ([*, a]), Maria Vlata ([b]), Stavroula Rapti ([b]), Stamatis Boyatzis ([b]), Michel Bardet ([c]), Anastasia Pournou ([b])

([a]) Department of Chemistry and Industrial Chemistry, University of Pisa, via Moruzzi 13, I-56124 Pisa, Italy;

([b]) Department of Conservation of Antiquities & Works of Art, University of West Attica, Ag. Spyridonos Str. Aegaleo, 12243 Athens, Greece;

([c]) IRIG/DEPHY/MEM/LRM, CEA-Grenoble, 17 rue des Martyrs, 38054 Grenoble, Cedex 9 – France;

* Presenting author

jeannette.lucejko@unipi.it

This study focused on a Roman waterlogged *Abies cephalonica* trunk to evaluate the effects of melamine-formaldehyde (MF) resin treatment on archaeological wood and its implications for heritage preservation [1].

Analytical techniques, including FTIR, solid-state ^{13}C NMR, Py(HMDS)-GC/MS, and EGA-MS, were used to investigate changes in the wood's chemistry. FTIR revealed that MF treatment caused the formation of amide bonds, significant lignin modification, and further degradation of the already deteriorated cellulose. Solid-state ^{13}C NMR confirmed the deep penetration of the resin into the wood and strong chemical interactions between the MF resin and lignin, with retention levels increasing with the degree of wood degradation. Py(HMDS)-GC/MS analysis showed that the lignocellulosic matrix had transformed into a new biopolymer, with almost no detectable lignin or cellulose pyrolysis products. EGA-MS indicated an increase in thermal stability of the treated wood, but its chemical composition was entirely altered compared to fresh or untreated archaeological wood.

These findings demonstrate that MF treatment irreversibly modifies the chemical structure of waterlogged archaeological wood, compromising its authenticity and long-term preservation. As such, the treatment is deemed unsuitable for the conservation of cultural heritage objects.

References

[1] Vlata et al, Melamine-formaldehyde in the conservation of waterlogged archaeological wood: Investigating the effect of the treatment on wood residual chemistry with FTIR, 13C NMR, Py(HMDS)-GC/MS and EGA-MS, Wood Science and Technology, *accepted for publication (2024)*

Decoding Molecular Degradation in Ancient Waterlogged Wood: Insights from FTIR and Pyrolysis-GC-MS Analysis

J. Łucejko ([*, a]), F. Paolino ([a]), A. Martínez Cortizas ([b]), O. López-Costas ([c]), M. Traoré ([d])

([a]) Department of Chemistry and Industrial Chemistry, University of Pisa, via Moruzzi 13, I-56124 Pisa, Italy;

([b]) CRETUS, EcoPast (GI-1553), Departamento de Edafoloxía e Química Agrícola, Universidade de Santiago de Compostela, Santiago de Compostela, Spain; and Bolin Centre for Climate Research, Stockholm University, Stockholm, Sweden;

([c]) CRETUS, EcoPast (GI-1553), Área de Arqueoloxía, Departamento de Historia, Universidade de Santiago de Compostela, Santiago de Compostela, Spain; and Archaeological Research Laboratory, Wallenberg Laboratoriet, Stockholm University, 10691, Stockholm, Sweden;

([d]) Fundación Centro Tecnológico de Investigación Multisectorial (CETIM), Parque empresarial de Alvedro, Rúa H, 20, 15180 Culleredo, A Coruña, Spain.

* Presenting author

jeannette.lucejko@unipi.it

This research examines the molecular degradation of 8000-year-old waterlogged cherry (*Prunus* sp.) and oak (*Quercus* sp.) woods samples retrieved below the O Areal archaeological site in Vigo, Spain [1], by applying FTIR spectroscopy [2] and analytical pyrolysis-GC-MS [3]. This aimed to understand changes that arise from prolonged acidic, waterlogged burial in marsh environments.

FTIR spectroscopy enabled to identify significant changes in lignin and polysaccharides, showing that cherry wood experienced more severe polysaccharide degradation, while oak wood showed changes in both lignin and polysaccharides. These results were confirmed with Pyrolysis-GC-MS, detecting depletion of polysaccharides and altered lignin structures in the ancient and waterlogged woods, with each species showing different degradation patterns.

By combining both techniques, we gained a clearer understanding of how lignin and hemicellulose degrade over time, particularly through oxidation and breakdown of key structural components. This approach demonstrates the effectiveness of FTIR and pyrolysis-GC-MS in detecting wood degradation, offering critical insights for archaeologists and conservators into the preservation and analysis of waterlogged wood artefacts and ecofacts.

References

[1] L. López-Merino, R. Tallón-Armada, M. Costa-Casais, N. Silva-Sánchez, J.A. López-Sáez, A. Martínez Cortizas, Palaeoenvironmental Framing of the O Areal Roman Saltworks and Related Anthropogenic Activities in North-western Iberia, Environmental Archaeology (2023), 1-25, https://doi.org/10.1080/14614103.2023.2206199

[2] Traoré M., A. Martínez Cortizas, Comparative study of four timber wood species in southern Mali (West Africa) by combining FTIR spectroscopy and multivariate analysis, European Journal of Wood and Wood Products (2023), 81(6): 1513-1524, https://doi.org/10.1007/s00107-023-01979-8

[3] M. Fejfer, J.J. Łucejko, B. Miazga, E. Cantisani, M. Zborowska, Gold mine wooden artefacts: multianalytical investigations for the selection of appropriate consolidation treatments, Molecules (2022), 27(16): 1-15, https://doi.org/10.3390/molecules27165228.

Quantifying Stone Ornament Deterioration for Heritage Preservation

Chiara Coletti (*, [a]), Anna Arizzi ([b]), Giuseppe Cultrone ([b]), Gianmario Guidarelli ([c]), Claudio Mazzoli ([a])

([a]) Department of Geosciences, University of Padova, Italy

([b]) Department of Mineralogy and Petrology, Faculty of Sciences, University of Granada, Spain

([c]) Department of Civil, Environmental and Architectural Engineering – ICEA, University of Padova, Italy

* Presenting author

chiara.coletti@unipd.it

Climate change's impact on stone heritage is a critical concern for scientists in cultural heritage preservation. Despite efforts to establish accurate recession rates [1,2], this field requires further research. Stone deterioration studies have primarily focused on physicochemical processes, neglecting crucial geometric and morphometric aspects of surfaces. However, these aspects are vital for preserving the cultural significance embedded in the three-dimensional forms of monuments, which have implications for cultural legacies and the sustainable management of heritage sites [1]. o advance knowledge on these aspects, laboratory tests simulating environmental conditions are being conducted on samples that replicate traditional architectural elements from Vignola's 16th-century treatise '*Regola delli cinque ordini d'architettura*'. The study examines five carbonate rock types commonly used in Mediterranean cultural heritage: Carrara and Sivec marbles, red Verona marble, Nanto stone, and Istria stone. Surfaces are monitored before, during, and after climate simulations using a multi-analytical approach, including spectrophotometry, scanning electron microscopy, non-contact profilometry, 3D digital reconstructions, and water-surface interaction analysis.
This methodology aims to provide detailed insights into degradation rate processes across diverse stone types, surface geometries, and climatic conditions, enabling the development of degradation models applicable to various cultural assets and geographical zones. This research is crucial for identifying vulnerable cultural heritage elements, facilitating the planning of priority conservation measures and mitigating deterioration processes. Managing historical areas demands new approaches that consider decorations and ornaments as integral parts of the urban environment.

This research is conducted within the framework of the M3DEA project, funded by the Marie Skłodowska-Curie Actions postdoctoral programme. The project's outcomes aim to provide valuable insights for developing targeted conservation strategies and enhancing public awareness of long-term preservation challenges in managing cultural heritage legacies amidst climate change.

References

[1] Coletti C., Climate Change Threats to Stone Cultural Heritage: State of the Art of Quantitative Damage Functions and New Challenges for a Sustainable Future, Heritage, 2024, Volume 7, Issue 6, Pages 3276 – 3290, doi:10.3390/heritage7060154.
[2] Salvini S., Bertoncello R., Coletti C., Germinario L., Maritan L., Massironi M., Pozzobon R., Mazzoli C., Recession rate of carbonate rocks used in cultural heritage: textural control assessed by accelerated ageing tests, J Cult Herit, 2022, 57(6):154-164. doi: 10.1016/j.culher.2022.08.010.

Acknowledgements
The authors thank *Arte 2000 - Italian Marble Temptation* for providing and preparing the samples for this study.

Conservation methods for 19th century plaster replicas: understanding gypsum compositions and protective treatments

F. Bubola ([*, a]), E. Balliana ([b]), C. Coletti ([a]), T. De Kock ([c]), C. Mazzoli ([a])

([a]) University of Padua, Geosciences, Padua, Italy

([b]) Ca' Foscari University, Environmental Sciences, Informatics and Statistics, Venice, Italy ([c])
University of Antwerp, Design Science, Antwerp, Belgium

* Presenting author federica.bubola@phd.unipd.it

In the 19th century, academic institutions and museums assembled extensive collections of gypsumbased replicas, primarily reproducing ancient sculptures for educational, documentary and artistic training purposes. These gypsum-based casts have been essential in preserving the intricate details of classical monuments, many of which have since deteriorated or been lost. However, maintaining the durability of these replicas has proven difficult, as their soft, porous nature makes gypsum highly susceptible to environmental fluctuations. Prolonged exposure to uncontrolled temperature and humidity variations, common in many historical buildings lacking modern climate control, accelerates their deterioration. The environmental instability in these historical spaces, stresses the replicas, causing cracking, surface detachment and other material degradation. Managing microclimate conditions in museums and heritage buildings is, therefore, crucial for preserving such vulnerable collections. Rapid changes in temperature and humidity, can induce internal stress and exacerbate damage. For historic collections, maintaining a "historic climate" – the stable microclimate to which artifacts have adjusted over decades – is essential to their conservation. In response to these conservation challenges, this study investigates the traditional gypsum mixtures and additives typical of 19th century recipes used in plaster casting. 72 gypsum-based mock-ups according to the historical recipes were produced. These mixtures included alabaster and Paris gypsum, with the addition of various additives such as marble powder, Arabic gum, kaolin and wood powder. By studying properties of these materials, the research seeks to determine how various combinations of gypsum and additives influence the physical and chemical stability of the casts. Moreover, in order to explore the effectiveness of both historical and modern protective coatings like a mixture of kaolin and water, polyvinyl alcohol and Acryl-EM 33. Mock-up samples undergo accelerated ageing tests, simulating the effects of environmental factors such as humidity and temperature fluctuations. These tests examine the coatings' capacity to prevent plaster deterioration, ensuring the preservation of its original appearance and texture. By combining material analysis, protective testing and environmental assessment, this research aims to develop sustainable, cost-effective methods for conserving plaster replicas, ensuring their continued role as cultural and educational resources. These strategies provide a foundation for preserving and displaying plaster casts in significant historic buildings where modern climate control may be insufficient or lacking, thereby safeguarding their durability and cultural value.

References

[1] E. M. Payne, The conservation of plaster casts in the Nineteenth Century, Stud. Conserv. (2022), vol. 65, pp. 37-58, DOI: 10.1080/00393630.2019.1610845

[2] E. Salavessa, S. Jalali, L. M. O. Sousa, L. Fernandes, A. M. Duarte, Historical plasterwork techniques inspire new formulations, Constr. Build. Mater. (2013), vol. 48, pp. 858-867, DOI: 10.1016/j.conbuildmat.2013.07.064
[3] C. Arcolao, Le ricette del Restauro: Malte, intonaci, Stucchi dal XV al XIX secolo, Saggi Marsilio, Venezia, 1998
[4] T. Turco, Il gesso lavorazione – trasformazione – impieghi, Ulrico Hoepli, Milano, 1861
[5] A. Zornoza-Indart, P. López-Arce, L. López-Polín, Durability of traditional and new nanoparticle base consolidating products for the treatment of archaeological stone tools: Chert artifacts from Atapuerca sites (Burgos, Spain), J. Cult. Herit. (2017), vol. 24, pp. 9-21, DOI: 10.1016/j.culher.2016.10.019
[6] V. Risdonne, C. Hubbard, V. H. López Borges, C. Theodorakopoulos, Materials and Techniques for the Coating of Nineteenth-century Plaster Casts: A Review of Historical Sources, Stud. Conserv. (2022), vol. 67, pp. 186-208, DOI: 10.1080/00393630.2020.1864896

Evaluation of indoor and outdoor microclimatic conditions using indexes: a case study in an ancient church

S. Ferrarese ([*, a]), E. Racca ([a]), D. Bertoni ([a]),

([a]) Department of Physics, University of Turin, Italy

* Presenting author

silvia.ferrarese@unito.it

The conservation of works of art depends on the surrounding environmental conditions, in particular, the objects that are hosted inside buildings usually experience more favorable conditions than objects in outdoor environments as a consequence of the physical characteristics of the building itself, such as its thermal capacity and absorbing power, which can mitigate the fluctuations in temperature and relative humidity.
In this work, we consider the indoor and outdoor microclimatic conditions at the church of San Panfilo in Tornimparte (AQ) where an archaeometric study was conducted in 2020-2021 by the Italian Association of Archaeometry (AIAr) members to study the conservative conditions of the frescoes in the apse depicted by the Renaissance painter Saturnino Gatti [1] and a microclimatic measurement campaign was performed [2].
The microclimatic conditions were measured at several sites in the church and at two sites outside: one in a near-building position and one in an open-air site. The present work aims to characterize the indoor and outdoor microclimatic conditions, using some statistical indexes [3]. The applied indexes are: a) the Performance Index (PI), b) the Index of Microclimatic Excursion (IME), c) the Index of Microclimatic Variability (IMV), d) the Normalized Diurnal Range (NDR), e) the Relative Humidity ratio (RH_{ratio}), and f) the minimum radius of never-filled micropores.
The results show that all the indexes can distinguish between indoor and outdoor conditions.
However, the IME, IMV, and NDR are also sensitive to the different conditions inside the church. Among the indexes, the IMV seems to describe better the microclimatic conditions, as it is defined using both temperature and relative humidity and does not depend on the thresholds based on the standards or the curators' experience. The indexes proved to be a useful tool in comparing different microclimatic conditions and they could be included in microclimatic records.

References

[1] A. Galli, A., M.F. Alberghina, A. Re, D. Magrini, C. Grifa, R.C. Ponterio, M.F. La Russa, Special Issue: Results of the II National Research Project of AIAr: Archaeometric Study of the Frescoes by Saturnino Gatti and Workshop at the Church of San Panfilo in Tornimparte (AQ, Italy), Appl. Sci. (2023), 13, 8924-1 – 8924-13, https://doi.org/10.3390/app13158924

[2] S. Ferrarese, D. Bertoni, A. Golzio, L. Lanteri, C. Pelosi, A. Re, Indoor Microclimate Analysis of the San Panfilo Church in Tornimparte, Italy, Appl. Sci (2023), 13, 6770-1 – 6770-17, https://doi.org/10.3390/app13116770

[3] E. Racca, D. Bertoni, S. Ferrarese, Indexes for Estimating Outdoor and Indoor Microclimates: A Case Study at the San Panfilo Church in Tornimparte, Italy, Heritage (2024), 7, 6729 - 6748, https://doi.org/10.3390/heritage7120311

Acknowledgements

The authors thank the AIAr for the organization of the measurement campaign, and the Centro Funzionale and Ufficio Idrografico of Regione Abruzzo for the availability of meteorological data.

A historical architectural heritage to be ride for: Sicily's abandoned railway lines and their annexes.

S. Pennisi (*, a), A. Russell (b)

(a) Dipartimento di Ingegneria, Università di Palermo

(b) Department of History, University of Malta
* Presenting author

silvia.pennisi@unipa.it sandrorussell@gmail.com

The history of local communities and their areas runs along many roads dotted with anecdotes worth reading again and again and, in some instances even rewriting so that their memory may be preserved.

Over the course of two centuries, on the edges of the lines that steadily filled the rural corners of Europe and the world, a vast heritage accumulated. This consisted of mobile resources, such as travelling materials (locomotives and wagons), immovable heritage such as railways and industrial buildings (stations, booths, workshops, factories of various kinds) and immaterial heritage made up of the on-site experience enjoyed by individuals and groups who contributed to radically redefining the founding elements of human geography, people and landscape. In Sicily, the decommissioning resulting from the mass motorization and deindustrialization of the territory (1950-1980) led to the abandonment of railway complexes in a more widespread fashion than elsewhere. In fact, although it persists in holding the record for the island with the largest railway endowment in the Mediterranean (1,370 km), it is also the first Italian region in terms of abandoned linear kilometres (approx. 1,500 km). The contribution proposes a hypothesis of revaluation and redevelopment in line with objectives 7 (clean and accessible energy), 8 (decent work and economic growth), 10 (reducing inequalities), 11 (sustainable cities and communities) and 13 (fight against climate change) of the UN's 2030 Agenda for Sustainable Development Finally, the project relies on a transnational partnership made up by scientific and non-profit organisations based in the UK, Brazil, Spain, Malta and Cyprus.

The Contessa Entellina's (Pa) station

References

[1] S. Amoroso, La linea di Vallelunga: la tormentata genesi del collegamento ferroviario fra Palermo e Catania, Aracne, Roma, 1987.
[2] D. Pirrone, Archeologia industriale in Sicilia: la linea a scartamento ridotto Palermo S. Erasmo-San Carlo, Guida, Palermo, 1993.
[3] G. Tesoriere, Le strade e le ferrovie in Sicilia : le tappe del loro sviluppo dopo l'unificazione, Zedi Italia, Palermo, 1995.
[4] E. Godoli, M. Cozzi (a cura di), L'architettura ferroviaria in Italia, Ottocento, Atti del Convegno di Studi, 14-15 novembre 2023, Palermo.

Diagnostic investigations on corbles of Pietra Serena sandstone

T. Salvatici (*, [a]), E. Segabinazzi ([a]) , S. Calandra ([a]), I. Centauro ([a]), C. Azil ([a]), C.A. Garzonio ([a]), E. Intrieri ([a])

(a) Department of Earth Sciences, University of Florence, Florence, Italy * Teresa Salvatici teresa.salvatici@unifi.it

Diagnostic investigations are essential for the conservation and safeguarding of buildings belonging to the historical-artistic heritage, particularly in the case of the Florentine Pietra Serena, a sandstone widely used in Renaissance and XIX century constructions. This stone is a symbol of Florence's cultural heritage and constitutes a significant part of the city's historic center, which was designated a UNESCO World Heritage Site in 1982. However, environmental factors have contributed to the deterioration of Pietra Serena, increasing the risk of falling fragments, which not only leads to the loss of cultural heritage but also poses a danger to citizens and tourists.

In response to these issues, it has been developed a new diagnostic approach combining various techniques to monitor the decay of Pietra Serena and ensure both the safety of the cultural heritage and the public. Over the last eight years, there have been incidents in the Florence area where corbels placed beneath balconies and eaves fell, including a fatal accident in October 2017 at the Santa Croce Basilica, caused by the detachment of a stone corbel. To prevent such events, non-destructive techniques (NDTs) like ultrasonic and Schmidt hammer tests have been adopted to assess the state of conservation of the stone elements.

This approach has been applied to several historical buildings in Florence, such as Pucci-Sansedoni Palace, Rimbotti Palace, Salone delle Feste Palace, Badia Fiesolana Monastery, and others. These techniques, supported by laboratory studies like mineralogical and petrographic analyses, allow for a detailed investigation of the stone materials and their decay state. The ultrasonic and rebound measurements obtained are inserted into a reference database, enabling the rapid identification of weak points and unstable elements in the stone. Furthermore, by correlating NDT results with the mineralogical, petrographic, chemical, and physical properties of the stone, the study allows for a comprehensive understanding of the material's condition.

The collected data were organized in an application useful for data analysis and in situ data gathering (localization, mapping, description of degradation phenomena and photographic documentation).

References

[1] Salvatici, T., Calandra, S., Centauro, I., Pecchioni, E., Intrieri, E., & Garzonio, C. A. (2020). Monitoring and evaluation of sandstone decay adopting non-destructive techniques: On-site application on building stones. Heritage, 3(4), 1287-1301. https://doi.org/10.3390/heritage3040071

[2] Salvatici, T., Centauro, I., Calandra, S., Segabinazzi, E., Intrieri, E., & Garzonio, C. A. (2023). Non-destructive methods applied for in situ mechanical diagnosis: Florentine historical buildings in Pietra Serena. Heritage Science, 11(1), 116. https://doi.org/10.1186/s40494-023-00959-8

[3] Calandra, S., Centauro, I., Salvatici, T., Pecchioni, E., & Garzonio, C. A. (2022, May). Monitoring and evaluation of Pietra Serena decay adopting NDT techniques: Application on building stones in situ. In International Conference Florence Heri-Tech: the Future of Heritage Science and Technologies (pp. 292-304). Cham: Springer International Publishing. https://doi.org/10.1007/978-3-031- 17594-7_22

[4] Segabinazzi E., Centauro I., Salvatici T., Calandra S., Intrieri E., Garzonio C.A. (2025, in press). Architectural Heritage monitoring: implementing data-driven preservation for stone corbels with low-code app tools and reporting. In International Conference Florence Heri-Tech: the Future of Heritage Science and Technologies.

New Application Scenarios of Reaction Path Modelling for the Study of Weathering Processes in the Field of Cultural Heritage: Preliminary Presentation of a Novel Research Project and first data

A. Pantuso ([*, a]), C. Apollaro ([a]), I. Fuoco ([a, b]), M. F. La Russa ([a]), M. Ricca ([a])

(a) University of Calabria, Department of Biology, Ecology and Earth Science, Via P. Bucci, 87036 Arcavacata di Rende (CS), Italy
(b) Institute on Membrane Technology (CNR-ITM), Via P. Bucci 17/C, 87036 Arcavacata di Rende (CS), Italy

* Presenting author

alessia.pantuso@unical.it

Climate change poses a significant threat to Cultural Heritage, accelerating degradation processes that impact the structure and composition of stone materials, thus increasing the need for preventive interventions [1]. It is therefore essential to apply innovative methods to monitor and predict the effects of this phenomenon on Cultural Heritage. For instance, *Reaction Path Modelling* represents a high-potential geochemical tool, based on the use of software to study different geochemical processes [2], including weathering, which can be applied to Cultural Heritage. In this work, *Reaction Path Modelling* will be applied to study the weathering processes affecting stone materials with an emphasis on carbonate and granitoid materials from cultural heritage sites under coastal and urban environmental conditions, both exposed to pollutants and meteorological agents. Indeed, water and CO_2, act as aggressive agents of deterioration of building materials. Furthermore, the research aims to achieve its objective by combining the innovative application of *Reaction Path Modelling* with a traditional diagnostic protocol, to identify forms of alteration and degradation of stone materials of cultural interest. Four pilot sites were selected in the Calabrian territory: the Roman Villa of Casignana (Reggio Calabria) and the Chapel of the Madonna dell'Itria in Gerace (Reggio Calabria) for studies on carbonate stones; while the Castle of Squillace (Catanzaro) and the granite structures at the MuTerr of Soriano Calabro (Vibo Valentia) for the granitoid materials. Diagnostic analyses will characterize the stone materials and their degradation forms while providing data for weathering simulations. Environmental studies have also been conducted to support these analyses. Time series data (2003-2023) on monthly average precipitation and temperature were processed from local monitoring stations situated near each pilot site [3]. Additional data on atmospheric pCO_2 and rainfall composition are being analyzed to refine the geochemical model and support future projections. These inputs enable weathering simulations using EQ3/6 [4] and PhreeqC [5] under kinetic conditions. The expected results of this research will provide enhance understanding of the weathering processes in Cultural Heritage stones and predict their evolution under current and future climate scenarios.

References

[1] E. Sesana, A.S. Gagnon, C. Ciantelli, J. Cassar, J.J. Hughes, Climate change impacts on cultural heritage: A literature review, Wiley Interdisciplinary Reviews: Climate Change (2021), 12 (4), e710, https://doi.org/10.1002/wcc.710. [2] H. Helgeson, C. Brown, T.H. Nigrini, T.A. Jones, Calculation of mass transfer in geochemical processes involving aqueous solutions, Geochim. Cosmochim. Acta (1970), 34 (5), 569-592, https://doi.org/10.1016/0016-7037(70)90017-7. [3] CFM (Centro Funzionale Multirischi della Calabria) – Arpacal Available online: https://www.cfd.calabria.it/index.php/dati-stazioni/dati-storici (accessed on 07 November 2024). [4] T.W. Wolery, R.L. Jarek, Software User's Manual. EQ3/6, Version 8.0 (2003), Sandia National Laboratories. U.S. Dept. of Energy Report, 376. [5] S.R. Charlton, D.L. Parkhurst, PhreeqcI-A graphical user interface to the geochemical model PHREEQC (2002), US Geological Survey, No. 031-02.
[5] S.R. Charlton, D.L. Parkhurst, PhreeqcI-A graphical user interface to the geochemical model PHREEQC (2002), US Geological Survey, No. 031-02.

Porosimetry inspection of Mesoporous Molecular Sieves combined with Tea Tree Essential Oil for Microbial Reduction in Cultural Heritage Spaces

A.L. Tassi ([*, a]), A. Santiglia ([a]), L. Santagostini ([a]), V. Guglielmi ([a])

([a]) Department of Chemistry, Università degli studi di Milano, Milan, Italy

* Presenting author

Annalaura.tassi@unimi.it

MCM-41, part of the M41S family of mesoporous silica materials, boasts a high surface area often exceeding 1000 m^2/g, making it highly effective for adsorption applications [1]. In this study, MCM41 microparticles were treated with Tea Tree Essential oil to develop an antimicrobial air-cleaning device. The oil was both encapsulated and covalently bonded to the material's surface via a tailored post-crafting reaction, enhancing its biocidal properties and longevity [2]. These functionalized microparticles will be used in air filtration systems to sanitize the air, reducing bacterial and fungal presence through the oil's biocidal power.

MCM-41's hexagonal, uniform mesopores make it ideal for porosimetr [3], and in particolar for gas adsorption porosimetry, which uses nitrogen or argon at cryogenic temperatures to provide nondestructive, detailed analysis of pore size, volume, and surface area, using BET theory and the BJH method. These techniques are crucial for optimizing material performance in filtration and other applications.

In this research, gas adsorption porosimetry was employed to examine MCM-41 before and after functionalization, revealing changes in pore distribution, volume, and structural integrity. These insights enhance MCM-41's filtration efficiency and provide a deeper understanding of its novel postcrafting reaction with tea tree oil, conducted here for the first time.

References

[1] Y. Liu *et al.*, Mesoporous MCM-41 derived from natural Opoka and its application for organic vapors removal', J. Hazard. Mater (2021), vol. 408, p. 124911, DOI: 10.1016/j.jhazmat.2020.124911.

[2] A. L. Tassi *et al.*, NIR spectroscopic profiling of a progressive air purification system for indoor Cultural Heritage spaces, Book of Abstracts, Chimica Sotto L'albero, 19-20 Bari 2024.

[3] J. R. Dodson *et al.*, 'Alkali silicates and structured mesoporous silicas from biomass power station wastes: the emergence of bio-MCMs', Green Chem. (2013), vol. 15, no. 5, pp. 1203–1210, DOI: 10.1039/C3GC40324F.

An integrated approach to the conservation of two Mariano Rossi paintings (18th) in Palazzo Alliata di Villafranca, Palermo

C. Pellerito ([*, a]), M.Sebastianelli ([b]), G.Zaffora ([c])

(a) Dipartimento di Fisica e Chimica ''E.Segrè'', Università degli Studi di Palermo

(b) Soprintendenza per i Beni Culturali e Ambientali di Palermo

(c) Restauratore di beni culturali

* C. Pellerito

claudia.pellerito@unipa.it

Objects of this study are two Mariano Rossi paintings, dating from the 18th century, representing Adoration of the Magi and Nativity of Jesus (Figure) and belonging to Palazzo Alliata di Villafranca of Palermo. The scientific investigation of the techniques employed by the artist, such as composition of the paints, color palette, and painting style represents a fundamental pre-requisite in order to develop proper conservation and restoration strategies. In this context, the combined use of nondestructive, non-invasive (multispectral investigations) and micro-invasive techniques (SEM-EDS and FT-IR Spectroscopy) was here successfully employed for the investigation of the XVIII century paintings. From the results, details of the artwork useful for restoration and conservation procedures were revealed. The identification of most of the artist's palette was also achieved, as well the composition of different preparatory substrates. The obtained results, other than constituting a crucial step for future restoration works, can be at the same time useful for characterizing and comparing with all Mariano Rossi production. Eventually all data obtained in this study, coupled with a full photographic and graphic documentation of all the frames, have been entered in a properly designed technical data file. This record acts both as the starting (the cognitive tool) and ending (the recording method) point of the research work.

Adoration of the Magi and Nativity of Jesus – oil on canvas, (1764-1768) Mariano Rossi

References

[1] N. Bevilacqua, L. Borgioli, I. Adrover Garcia, I pigmenti nell'arte, dalla preistoria alla rivoluzione industriale, Padova 2010; ISBN: 9788863360905

[2] C. Falcucci, Le metodiche della diagnostica, in: M. Cardinali, M. B. De Ruggieri, C. Falcucci, Diagnostica artistica. Tracce materiali per la storia dell'arte e per la conservazione, Palombi Editori, Roma, 2007, pp. 112-116; ISBN: 887621263-9

[3] M. R. Derrick, Methods in scientific examination of art: infrared microspectroscopy, The Getty Conservation Institute, Los Angeles, 1998.

Microscopic techniques and analytical approach to characterize constitutive materials and techniques of Mariano Rossi paintings

C. Pellerito ([*, a]), M. Sebastianelli ([b]), G.Zaffora ([c]), M.Vitella ([d])

(a) Dipartimento di Fisica e Chimica ''E.Segrè'', Università degli Studi di Palermo
(b) Soprintendenza per i Beni Culturali e Ambientali di Palermo
(c) Restauratore di Beni Culturali
(d) Dipartimento Culture e Società, Università degli Studi di Palermo

* C. Pellerito

claudia.pellerito@unipa.it

The study of academies of art in Europe has always turned on current perceptions of the role of such institutions in the training and support of artists. Roman Accademia di San Luca (founded c. 1593) where the first official art academy in Europe.
Mariano Rossi (7 December 1731 - 24 October 1807) was a San Luca academic Italian painter, born to poor parents in Sciacca, Sicily. He trained first in Palermo, then in Naples, and finally in Rome. He is considered one of the greatest exponents of the art of painting in the second half of the eighteenth century, working mainly in Sicily, Campania and Lazio.
The present study is probably the first attempt to record the Mariano Rossi painting production: the aim has been pursued by studying at least nine paintings made in the second half of XVIII century by Mariano Rossi, in order to give a proper insight on the evolution of its painting technique and to find out possible correlations between his work and the cultural artistic environment in South of Italy. Micro samples (c. 500 µg) of small and big Mariano Rossi paintings production were analysed with a multi-analytical approach. The micro-morphological characterisation of the pigments and the paint stratigraphy was assessed using light (LM) and scanning electron microscopes (SEM). X-ray microanalysis (EDX) coupled with SEM and Fourier transform infrared spectroscopy.
The multimethod and historical approach were confirmed to be extremely useful for establishing the authenticity of the analyzed paintings through the identification of the constitutive materials and their methods of application.

Drawing of the painting competition announced by the Accademia di San Luca-Mariano Rossi

References

[1] Accademia di San Luca in Roma, Libro dè decreti delle congregazioni, Tomo 52.
[2] C. Falcucci, Le metodiche della diagnostica, in: M. Cardinali, M. B. De Ruggieri, C. Falcucci, Diagnostica artistica. Tracce materiali per la storia dell'arte e per la conservazione, Palombi Editori, Roma, 2007, pp. 112-116; ISBN: 88-7621263-9

A Sustainable Approach to Self-Healing Mortars

A. Sammaritano (*, a), J. Bidoggia (a), A. Guolo (a), C. de Nardi (b), D. Herrera-Avellanosa, (c), A. Vavasori (a), L. Ronchin (a).

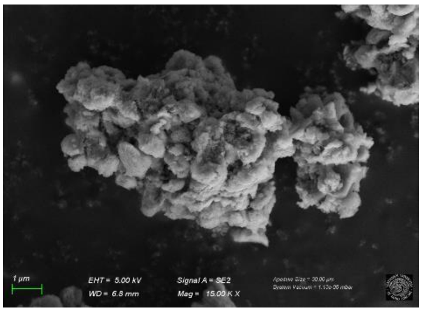
(a) Ca' Foscari University of Venice, Dep. of Molecular Science and Nanosystems, 30170 via Torino 155 Venezia

(b) Resilient Structures and Construction Materials (RESCOM) Research Group, School of Engineering, Cardiff University, Queen's Buildings, The Parade, Cardiff, CF243AA Wales, United Kingdom (c) Eurac Research, Bolzano, Italy

* Presenting author

alex.sammaritano@unive.it

In the field of historic buildings, the durability of Roman mortars and their self-healing properties are a highly relevant topic [1]. Self-healing refers to the mortar's capability to fill cracks with newly formed calcium carbonate following damage [2]. This process can be categorised into two types: autonomous and autogenous self-healing. Autonomous self-healing involves the use of materials intentionally incorporated into the mortar to promote repair, including both chemical and biological mechanisms [3, 4]. In contrast, autogenous healing refers to the natural self-healing processes inherent to the material [3]. This project, adopting a sustainable and ecological approach, focuses on studying the autonomous self-healing properties achieved through the addition of additives such as rice husk (RH) and natural hydraulic lime (NHL) coated with organic polymers. To evaluate the effectiveness of these additives, two environmental conditions – high humidity and water immersion – were employed to simulate self-healing scenarios. Mechanical compression tests, microscopic, and hygrothermal analyses were conducted to assess the recovery of structural integrity. Preliminary results demonstrate that organic encapsulation and rice husks significantly facilitate selfhealing. Organic encapsulation achieves this by releasing repair agents upon crack activation, with water immersion providing the most effective recovery conditions. Rice husks enhance the self-repair and crack filling due to their silicate composition, and the slow release of water thanks to its fibrous structure.



SEM image of NHL with organic coating

References

[1] L. M. Seymour, J. Maragh, P. Sabatini, M. Di Tommaso, J. C. Weaver, A. Masic, Hot mixing: Mechanistic insights into the durability of ancient Roman concrete, Science Advances, 2023, V. 9, DOI: 10.1126/sciadv.add1602

[2] C. De Nardi, A. Cecchi, L. Ferrara, A. Benedetti, D. Cristofori, Effect of age and level of damage on the autogenous healing of lime mortars, Composites Part B: Engineering, 2017, V. 124, PP. 144-157, DOI: 10.1016/j.compositesb.2017.05.041.

[3] S. Deeba, A. K. Ammasi, State-of-the-art review on self-healing in mortar, concrete, and composites, Case Studies in Construction Materials, 2024, V. 20, DOI: 10.1016/j.cscm.2024.e03298.

[4] R. Roy, E. Rossi, J. Silfwerbrand, H. Jonkers, Self-healing capacity of mortars with added-in bio-plastic bacteriabased agents: Characterization and quantification through micro-scale techniques, Construction and Building Materials (2021), V,297, DOI: 10.1016/j.conbuildmat.2021.123793.

Biotechnological restoration potential of the bacterial communities of three distinctively damaged mosaics from the coastal Calabrian area.

C. Diliberto Cascio ([*, a]), S. A. Ruffolo ([a]), A. Macchia ([a]), M. F. La Russa ([a]), P. Quatrini ([b]), V. Catania ([b,c])

([a]) University of Calabria, CS, Italy, ([b]) University of Palermo, PA, Italy, ([c]) National Biodiversity Future Center, PA, Italy

* Presenting author

Email corresponding: costanza.diliberto@gmail.com

Mosaics are complex structures where the *tesserae* are usually obtained from sedimentary stones, mainly limestone. Stone deteriorates through time, by the means of natural weathering and anthropic influence, causing physical, chemical and aesthetic damage to the Cultural Heritage (CH). The biodeterioration of mosaics refers to undesirable changes in a material caused by the activity of (micro)organisms, but the expression of specific microbial metabolic patterns can determine the biodeteriogen or bioprotectant condition of a given microorganism [1,2]. Biodeterioration control as so far been limited to the use of chemical biocides, that cause negative impacts on the environment, human health and mosaics, hence, the use of natural products derived from microorganisms such as biosurfactants as eco-friendly alternatives is encouraged for their specificity, effectiveness, biodegradability and low toxicity towards people and the wildlife [3]. The bacterial communities of three distinctively damaged mosaics from the Villa Romana Palazzi of Casignana (RC, Italy) were characterized to establish the correlations between bacterial community distribution and damage category, and evaluate the CH restorative potential of selected bacterial strains. Next-Generation Sequencing was deployed to assess microbial community structure and diversity, culture-dependent techniques were used to isolate biosurfactant-producing bacterial strains. Oil spreading tests, drop collapse tests and microplate assays were used to determine the biosurfactant production and emulsification ability of isolated strains [4,5]. The three mosaic communities shared a common base of stone-growing, coastal and biosurfactant-producing strains adapted to the climate of the site and their differences could be dictated by damage categories in terms of microclimate variation. 128 bacterial strains were isolated, and 56 were sequenced and affiliated to the Bacillota (75%), Actinomycetota (17%) and Pseudomonadota (8%) phyla. 50% of the strains displayed biosurfactant production and emulsification activity. New green and innovative product for restoration may be obtained from the isolated strains' biosurfactants as alternative to chemical biocides.

References

[1] Chlouveraki, S. (2018). Deterioration of Mosaics. *The Encyclopedia of Archaeological Sciences*, 1-4.

[2] Liu, X., Qian, Y., Wu, F., Wang, Y., Wang, W., & Gu, J. D. (2022). Biofilms on stone monuments: biodeterioration or bioprotection?. *Trends in Microbiology*.

[3] Manga, E. B., Celik, P. A., Cabuk, A., & Banat, I. M. (2021). Biosurfactants: Opportunities for the development of a sustainable future. *Current Opinion in Colloid & Interface Sci-ence*, *56*, 101514.

[4] Marvasi, M., Cavalieri, D., Mastromei, G., Casaccia, A., & Perito, B. (2019). Omics technologies for an in-depth investigation of biodeterioration of cultural heritage. *International Biodeterioration & Biodegradation*, *144*, 104736.

[5] Djahnit, N., Chernai, S., Catania, V., Hamdi, B., China, B., Cappello, S., & Quatrini, P. (2019). Isolation, characterization and determination of biotechnological potential of oil-degrading bacteria from Algerian centre coast. *Journal of applied microbiology*, *126*(3), 780–795.

Acknowledgements: This research was supported by PNRR TECH4YOU – TECHNOLOGIES FOR CLIMATE CHANGE ADAPTATION AND QUALITY OF LIFE IMPROVEMENT, CUP H23C22000370006, Project Code ECS_00000009

The Challenge of Archaeological Wood Restoration: Traditional Methods and Scientific Innovations

E. Dell'Aglio (*, a, b, c), S. Slimani (a, c), S. Laureti (c), F. Locardi (a), I.B. Perticucci (b), D. Peddis (a, c)

(a) University of Genova, Department of Chemistry and Industrial Chemistry (DCIC), Genova, 16131, Italy
(b) Ilaria Bianca Perticucci – Conservazione e restauro, Milano, 20122, Italy
(c) CNR, Institute of Structure of Matter, nM2-Lab, Monterotondo Scalo (Roma), 00015, Italy

* Presenting author

emanuele.dellaglio@edu.unige.it

Since ancient times, wood has been used for all kinds of purposes, from the manufacture of everyday tools to the construction of buildings, dwellings, and means of transport such as carts and ships. Archaeological wooden artefacts preserve ancient traces of the evolution of past societies, making it essential to undertake appropriate recovery, restoration, and conservation activities to enable their study and accessibility.

Upon discovery, waterlogged archaeological wooden artefacts are generally physically fragile, highly porous, and chemically altered. The goal is to stabilise the artefact and make it suitable for display in museums. To achieve this, a consolidant is used, typically an aqueous solution of polyethylene glycol (PEG). This method is robust, reversible, non-toxic, and relatively economical. However, over the decades, some disadvantages of using PEG have been identified, revealing it to be an imperfect agent for the preservation of wood.

This presentation will showcase case studies on the use of PEG in the consolidation of ancient ships, evaluating its advantages and disadvantages. Additionally, it will explore new treatment options currently under investigation by the scientific community, including the use of functionalised halloysite nanotubes.

Long-term PEG mobilisation and recrystallisation.

References

[1] M. Broda, C. Hill, Conservation of waterlogged wood—past, present and future perspectives, Forests (2021) 12(9), 1-55, DOI 10.3390/f12091193
[2] K.E. High, K.E. Penkman, A review of analytical methods for assessing preservation in waterlogged archaeological wood and their application in practice, Heritage Science (2020), 8(1), 1-33, DOI 10.1186/s40494-020-00422-y
[3] Y. Fors, F. Jalilehvand, M. Sandstrom, Analytical Aspects of Waterlogged Wood in Historical Shipwrecks, Analytical Sciences (2011), 27, 785-792, DOI 10.2116/analsci.27.785

Documenting ancient stone quarries: a multi-scale geometric survey for the study of the extraction site of Le Grotte (Populonia, Italy)

C. Previato (*, a), E. Faresin (a), A. Mazzariol (a)

(a) University of Padova, Department of Cultural Heritage

* Presenting author

caterina.previato@unipd.it

Since 2024 the Department of Cultural Heritage of the University of Padua has undertaken a multidisciplinary research project aimed at the study of an ancient stone quarry sited in the locality of Le Grotte, in the suburbs of the Etruscan-Roman site of Populonia (Piombino, Italy). The site is of extreme interest considering the significant extension of the extraction area (the quarry fronts extend for approximately 5 hectares) and the excellent state of preservation of the traces of ancient quarrying activity, such as pick and wedge marks, separation trenches between blocks, semiextracted blocks, etc. [1, 2]. The project aims to analyze the quarry in detail, to reconstruct the dynamics of its exploitation and the tools and techniques used by the quarrymen, and to quantify the material extracted from it. The first step of the project involves the realization of a detailed 2D and 3D geometric survey of the entire extraction area. The site poses several challenges for survey activity: in fact, the quarry is currently located in the middle of a forest, so some sectors are totally or partially covered by vegetation. In addition, the quarry fronts have a considerable height development, and the upper parts are not visible and reachable from the ground. Furthermore, some fronts are strongly inclined. To overcome these difficulties, the survey is carried out with a multi-scale approach by combining several techniques: total station survey, field and aerial photogrammetry, laser-scanning and manual survey. The final aim is to obtain not only a 3D model of the entire quarry, but also detailed plans and sections of the different sectors useful to map and study ancient extraction traces. To date, this multiscale approach has been applied in the survey of the central sector of the quarry, revealing its efficiency in fulfilling the project's goals.

Orthophoto of the central sector of the quarry extrapolated from the 3D model realized in 2024.

References

[1] A. Romualdi, Le cave di pietra e la necropoli delle Grotte a Populonia, in Falchetti F., Romualdi A. (eds.), Etruschi. Le scoperte più recenti, 2000, 183-202.
[2] A. Romualdi, R. Settesoldi, Populonia. La necropoli delle Grotte. Lo scavo nell'area della cava, Pisa 2009.

Acknowledgements

The research is authorised by the Soprintendenza Archeologia, Belle Arti e Paesaggio per le Province di Pisa e Livorno and is funded by the University of Padova under the World Class Research Infrastructures (WCRI) programme - SYCURI (*Synergic Strategies for Cultural Heritage at Risk*).

3D scanning, microscopic and radiographic analysis to study the Ripatransone treasure: the largest European hoard of daggers from the ancient Bronze Age.

M. Montecchiari [a], A. Blasetti[a], G. Roselli [b], S. Campanelli [b,*], G. Piccioni [b]

([a]) Science Museum of the University of Camerino, Piazza dei Costanti, 7 - 62032 Camerino

([b]) Diagnostic for the conservation and restoration Laboratory, University of Camerino, Via Pacifici Mazzoni 2, 63100, Ascoli Piceno, Italy

([c]) Innovative technologies for cultural heritage, University of Camerino, Lungo Castellano 36 , 63100, Ascoli Piceno, Italy

graziella.roselli@unicam.it

The Treasure of Ripatransone is the largest European treasure of daggers from the ancient Bronze Age, discovered in 1888 in Contrada Castellano di Ripatransone (AP). These bronzes document the existence of a craftsmanship of considerable technical complexity and intense trade. Given the importance of the discovery, it is essential to provide the tools and the opportunity for anyone to admire the finds, even if only virtually. 3D scanning is currently the fastest technology for three-dimensional reconstruction and is increasingly used for the protection and restoration of historical and archaeological finds. The digitization of cultural heritage offers the possibility of preserving physical finds through a virtual copy, protecting them from damage, deterioration or loss over time. It also ensures that the valuable information contained in the finds is acquired and archived. Digital scanning ensures that even in the event of damage, deterioration or catastrophes, digital versions of objects survive, thus preserving the historical and cultural heritage for future generations. Digital replicas also offer the possibility of easily sharing and making the finds accessible worldwide through online platforms and digital resources. In this work, we therefore decided to exploit 3D scanning technologies to create accurate digital models of the objects. Once digital models were created, it was possible to use 3D printing to produce physical replicas of these objects for use in exhibitions, but also for study and conservation purposes. The scanning was carried out with the high-resolution structured light scanner EinScan Pro HD, which allowed an accuracy of up to 2 tenths in the reproduction of surface details. In addition to 3D scanning, the daggers were subjected to both radiographic investigations, which allowed to better highlight the casting defects such as dripping and porosity, and to optical microscopy, thanks to which the corrosion patinas, decorations, traces of use and reworking were better highlighted.References

[1] Nora Lucentini. (2022). Osservazioni preliminari sul ripostiglio di Ripatransone (AP). Ipogei. La Vita, La Morte ,i Culti Nei Mondi Sotterranei , Preistoria e Protostoria in Etruria, Atti XV.

[2] Kantaros, A.; Ganetsos, T.; Petrescu, F.I.T. Three-Dimensional Printing and 3D Scanning: Emerging Technologies Exhibiting High Potential in the Field of Cultural Heritage. *Appl. Sci.* 2023, *13*, 4777. https://doi.org/10.3390/app13084777

[3] Li, R., Luo, T., Zha, H. (2010). 3D Digitization and Its Applications in Cultural Heritage. In: Ioannides, M., Fellner, D., Georgopoulos, A., Hadjimitsis, D.G. (eds) Digital Heritage. EuroMed 2010. Lecture Notes in Computer Science, vol 6436. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-16873-4_29

[4] Massimiliano Pieraccini, Gabriele Guidi, Carlo Atzeni, 3D digitizing of cultural heritage, Journal of Cultural Heritage, Volume 2, Issue 1, 2001, Pages 63-70, ISSN 1296-2074, https://doi.org/10.1016/S1296-2074(01)01108-6.

[5] Wachowiak, M. J., & Karas, B. V. (2009). 3d Scanning and Replication for Museum and Cultural Heritage Applications. Journal of the American Institute for Conservation, 48(2), 141–158. https://doi.org/10.1179/019713609804516992

[6] F. Fazzini, L'Archeologia Sperimentale e la metallurgia del bronzo in Italia: storia degli studi e problematiche, Archeologie sperimentali. Temi, metodi, ricerche Journal (2020), 01, 100-107, ISSN 2724-2501

First results on 3D documentation of the architectural/archeological complex of the Church of San Nicolò Regale in Mazara del Vallo (Italy)

M. Lo Brutto1 (*, a), M. Aricò (a), M. La Guardia (b), G. Mineo (a)

(a) Department of Engineering, University of Palermo, Viale delle Scienze, Ed. 8, 90128 Palermo, Italy
(b) Department of Engineering, University of Messina, Contrada di Dio, 98158 Sant'Agata, Messina, Italy
* Presenting author

mauro.lobrutto@unipa.it

Recent survey technologies for 3D digitisation now allow accurate and highly detailed 3D geometric information of archaeological sites and monumental contexts with ease of use and reduced acquisition times. In particular, recent advances in the field of 3D surveying based on laser scanning technologies have allowed the development of mobile systems that allow real-time acquisition of 3D data for the documentation of architectural and archaeological heritage [1,2]. These systems are based on SLAM (Simultaneous Localisation and Mapping) technology and are usually divided into handheld and backpack wearable laser scanners. The work describes the first complete 3D survey of the architectural/archaeological complex of the Church of San Nicolò Regale in Mazara del Vallo (Italy). The survey was carried out using the new Leica Geosystems BLK2GO handheld mobile laser scanner and was an important experimental test for the use of these systems. The complex is composed of the Church of San Nicolò Regale, a typical Arab-Norman church built in 1124, and of the hidden underground archaeological remains below. The church has undergone several alterations and only from 1947 restoring operations allowed it to recover its original architectural asset. The archaeological area was discovered in recent times (around 1932); the archaeological excavations have brought to light some environments that probably belong to a Roman domus. This interpretation is supported by the presence of some mosaics with geometric and polychrome decorations. At present, there is no complete and detailed geometric documentation of the entire complex. The survey work has involved the implementation of different acquisition paths, with the aim of obtaining a complete 3D documentation of the entire complex.

Figure 1. Image of the complex and of the point clouds of San Nicolò Regale.

References

[1] A. Conti, G. Pagliaricci, V. Bonora, G. Tucci, A Comparison Between Terrestrial Laser Scanning and Hand-Held Mobile Mapping for the Documentation of Built Heritage, Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci. (2024), XLVIII-2/W4-2024, 141–147, https://doi.org/10.5194/isprs-archives-XLVIII-2-W4-2024-141-2024.

[2] M. Aricò, M. La Guardia, M. Lo Brutto, E.M. Rappa, C. Vinci, Mobile Mapping for Cultural Heritage: the Survey of the Complex of St. John of the Hermits in Palermo (Italy), Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci. (2023), XLVIII-1/W1-2023, 25–32, https://doi.org/10.5194/isprs-archives-XLVIII-1-W1-2023-25-2023.

Terravecchia of Caltavuturo: Digital Techniques from Excavation Documentation to University Teaching

F. Meli ([a, e]), S. Ficarra ([*, a, b]), G. Lauria ([a]), S. Cesare ([a]), V. Cunzolo ([a]), G. Minà ([a]), R. Basile ([a]), E.O. Cangialosi ([a]), F. Iannì ([c]), R.M. Cucco ([d]), L. Sineo ([a])

([a]) Università degli Studi di Palermo – Laboratorio di Antropologia

(b) Università di Bologna Alma Mater Studiorum - CeSIA

(c) Archeologo Soprintendenza per i BB.CC.AA. di Palermo

(d) Funzionario Archeologo Soprintendenza per i BB.CC.AA. di Palermo

(e) Università del Salento – Laboratorio di analisi chimiche per l'ambiente e I beni culturali / LAMPEA - Aix-en-Provence Marseille Université - CNRS - Ministère de la Culture

* Presenting author

franzinemeli@gmail.com – salvatore.ficarra@gmail.com

The funerary area of Saint Bartholomew's Church in Terravecchia of Caltavuturo was the focus of an extensive excavation campaign conducted by the Soprintendenza per i BB.CC.AA. di Palermo between 2017 and 2019. The campaign was directed by Dr. Rosa Maria Cucco. The archaeological investigation was enhanced by a comprehensive anthropological study, executed in partnership with the Anthropology Laboratory of the University of Palermo, under the scientific leadership of Prof. Luca Sineo.

Through the course of this project, cutting-edge digital documenting strategies that are founded on photogrammetry were implemented. This technology allowed three-dimensional modeling of burial structures, stratigraphic units, and excavation phases. Topographic surveys and DEMs were created from the 3D models, providing a detailed and accurate archeological context.

The digitalization of data enabled the development of comprehensive and current excavation documentation and also increased the value of the archaeological site by the online publication of 3D models on the Sketchfab platform. This method of dissemination rendered the research findings available to a broad audience and introduced new perspectives for the virtual musealization.

The virtualization method was likewise applied to anthropological studies. Skeletal remains of specific interest underwent photogrammetric scanning to produce high-resolution 3D models. These models were employed to examine the preservation condition of the bones and to provide a digital archive for subsequent research. Additionally, the 3D models were incorporated into the curriculum of the Funerary Archaeology course (2024, Luca Sineo and Francesca Meli) providing students with a distinctive opportunity to examine and understand the archaeological material using digital technologies.

References

[1] R.M. Cucco, A. Mammato – L'insediamento medievale di Terravecchia di Caltavuturo: la storia della ricerca archeologica e la documentazione, in Studi in onore di Stefano Vassallo a cura di M. Chiovaro e R. Sapia, (2020), volume, 91-94.
[2] F. Iannì – Terravecchia di Caltavuturo: indagini archeologiche 2017-2019, in Studi in onore di Stefano Vassallo a cura di M. Chiovaro e R. Sapia, (2020), volume, 121-127.
[3] G. Lauria, L. Sineo, S. Ficarra - A detailed method for creating digital 3D models of human crania: an example of close-range photogrammetry based on the use of Structure-from-Motion (SfM) in virtual anthropology, Archaeological and Anthropological Sciences (2022), Volume 14, article number 42, https://doi.org/10.1007/s12520-022-01502-9.

Vanished Tarquinia: 3D Virtualization and a Virtual Museum Experience

V. Zanoni ([a]), S. Ficarra ([*, b])

([a]) Ph.D Università degli Studi di Pavia

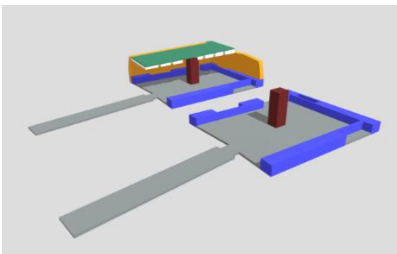
(b) Università di Bologna Alma Mater Studiorum CeSIA
* Presenting author

v.zanoni@cesaris.edu.it - salvatore.ficarra@gmail.com

The archaeological record often hinges on the interplay between visible and invisible. A third category, the "no longer visible," regards archaeological evidence obscured by the passage of time. Calvario site, within the Monterozzi necropolis of Tarquinia (Viterbo, Italy), is an example of this kind of contexts. Excavated extensively by Ing. Carlo Maurilio Lerici Foundation since 1950s, the site reveals multiple occupation phases, from the Final Bronze Age settlement to the Hellenistic-Roman period: during the last frequentation phase, the area was characterized by semi-subterranean tombs. Because of the absence of paintings and peculiar features, those “standardized” graves were excavated and numbered, but archaeological data remain almost unpublished and the tombs are now invisible and no more accessible.

By leveraging digital technology, we bridged the gap between the "no longer visible" and the documented evidence, reviving a forgotten context. Through meticulous archival analysis of cartographic sources, their vectorization, and structural and architectural analysis using historical photographs from the Lerici Foundation, we reconstructed a three-dimensional environment that allows for the rediscovery of this lost site, as showed in the picture below.

To share this discovery effectively, we employed modern museological techniques and social media platforms like Sketchfab and Google Earth. These tools, when used in conjunction, provide viewers with the opportunity to explore and understand these vanished contexts and their historical significance. Furthermore, 3D printing technology has enabled us to create tangible representations of the virtual reconstructions. These physical models offer a tactile experience for museum visitors, particularly children, fostering engagement and learning through hands-on exploration.



Tomb’s Structure Captation

References

[1] S. Ficarra, P. Gioia, Tecnologia 3D e Beni Culturali: la sezione archeologica del Museo Santo Naselli (Gangi), 2019, Roma, Sapienza Università di Roma.
[2] V. Zanoni, Istantanea di uno scavo: osservazioni sulla documentazione d’archivio della Fondazione “Ing. Carlo Maurilio Lerici”, necropoli del Calvario (località Monterozzi, Tarquinia, Viterbo), 2022, in Sibrium, 36, 56-79.

In situ physico-chemical investigations on instruments for electrical measurements of the Politecnico di Torino scientific collections

E. Angelini ([*, a]), M. Bongiovanni ([b]), L. Es Sebar ([a]), S. Grassini ([a]), F. Di Iorio ([a,c]), F. Pozzi ([c]), M. Morita([d])

([a]) Department of Applied Science and Technology, Politecnico di Torino, Torino, Italy

(b) ARIA, Affari Generali, Relazioni Istituzionali, Archivi e Biblioteche, Politecnico di Torino, Torino, Italy

(c) Fondazione Centro per la Conservazione ed il restauro dei Beni Culturali (La Venaria Reale), Venaria, Italy

(d) CONICET, Centro de Investigaciones Opticas, Gonnet, Buenos Aires, Argentina

* Presenting author

emma.angelini@polito.it

A preservation campaign is underway at Politecnico di Torino on a collection of instruments for didactic purposes and research from 1920 to 1960, including electrometers, voltmeters, amperometers, galvanometers, and more, by means of in situ non-invasive analytical techniques.

X-ray fluorescence (XRF) spectroscopy allowed to identify the multimateric composition meanwhile the identification of the corrosion products was performed by Raman spectroscopy, in areas with different exposure to atmospheric corrosion. The photogrammetry was employed to create three-dimensional models representing the instruments that integrate data from UV luminescence and visible light into a single 3D representation. In order to enhance the accuracy of the models of such shiny and reflective objects, the reproduction technique employed polarised light, thus reducing errors due to three-dimensional reconstruction and obtaining a more realistic effect when sharing [1].

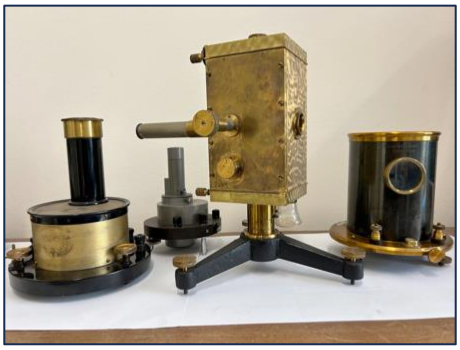


Figure 1- Instruments for electrical measurements, object of the preservation campaign

References

[1]. F. Di Iorio, L. Es Sebar, S. Croci, F. Taverni, J. Auenmüller, F. Pozzi, S. Grassini, “The Use of Virtual Reflectance Transformation Imaging (V-RTI) in the Field of Cultural Heritage: Approaching the Materiality of an Ancient Egyptian Rock-Cut Chapel”, Appl. Sci. (2024) vol. 14(11), 4768, DOI: 10.3390/app14114768

Acknowledgements

This publication is part of the project PNRR-NGEU funded by MUR –DM352/2022

A Neuro-Symbolic Approach for Archaeoceramological Analysis

A. Patti (*, a), Wladimiro Carlo Patatu (a), S. Iiritano (b)

(a) EHT S.C.p.A. – Viale Africa 31, 95129 Catania, Italy

(b) Revelis Srl - V. della Resistenza 19/C, Rende (CS), Italy

* Presenting author

andrea.patti@eht.eu, salvatore.iiritano@revelis.eu, vladimiro.patatu@eht.eu

Introduction: Archaeologists aim to provide systemic descriptions and confirm hypotheses about past social structures by analyzing selected material remains. This examination often involves experts from various disciplines, including anthropology, social sciences, and physical sciences. This paper proposes a methodological and architectural approach for analyzing archaeoceramological data to aid archaeologists and diagnostic professionals during excavations.

State of the art: Artificial intelligence, particularly Expert Systems, has been successfully used in archaeology for decades, alongside statistical techniques. While statistical data analysis constantly evolves with new techniques (including image analysis), the use of Expert Systems remains prevalent. Recently, hybrid methodologies have emerged, combining deductive approaches based on statistical analysis with inductive approaches and uncertainty management, characteristic of Expert Systems.

Proposed methods: This research will utilize a neuro-symbolic approach for archaeoceramological analysis. This approach incorporates both a bottom-up deductive approach based on scientific data and a top-down inductive approach that infers new knowledge based on archaeological expertise. A methodological schema will be developed, integrating symbolic reasoning with machine learning and neural networks, combining the ability to understand abstract concepts with efficient data analysis.

Architecture: DLV, a deductive database system based on disjunctive logic programming, will be employed. Additionally, a formal codification of the archaeological excavation as an open dynamic system is proposed.

Conclusion: This approach facilitates incremental innovations by merging different statistical analyses and formalizing the system schema's components and interrelationships. A solution for updating the expert system with new knowledge bases is also proposed.

We would like to thank the MML-ARCH project, funded by the European Union (NextGeneration EU), CHANGES – “Cultural Heritage Active Innovation for Sustainable Society” (PE_00000020) Spoke 5 (B53C22003890006), for its support in the realization of this work.

The European Project “ChemiNova”: protecting cultural heritage in a changing climate by remote and non-invasive monitoring

A. Sardella (a), F. Prestileo (*,b), B. Megna (c), P. Dorninger (d), N. Molochkova (e), A. Ostapchuk (e), F. Palla (c), H. Polsterer (f), Á. Solbes (g), C. Portalés (g), A. Bonazza (a)

(a) National Research Council of Italy, Institute of Atmospheric Sciences and Climate, Bologna, Italy
(b) National Research Council of Italy, Institute of Atmospheric Sciences and Climate, Rome, Italy
(c) University of Palermo, Italy
(d) 4D-IT GmbH, Vienna, Austria
(e) National Conservation Area “St. Sophia of Kyiv”, Ukraine
(f) Schönbrunn Palace Culture and Operating Company, Vienna, Austria
(g) University of Valencia, Spain
* Presenting author

fernanda.prestileo@cnr.it

As highlighted in 2022 in the report “Strengthening cultural heritage resilience for climate change”, of the EU Open Method of Coordination (OMC) expert group of Member States, cultural heritage continues to be at threat due to the increase of intensity and frequency of the impacts of climate change [1]. This reports evidences also the still existing lack of a coherent and EU standardized methodology for the acquisition of quantitative data on the decay and loss of cultural heritage, that would be a fundamental prerequisite for supporting the adoption of joint strategies and creation of effective policies addressed to safeguarding cultural heritage at risk.

Within this framework the HORIZON EU project ‘ChemiNova - Novel technologies for on-site and remote collaborative enriched monitoring to detect structural and chemical damages in cultural heritage assets’ aims to develop an intelligent computational system that outperforms current technologies, improving the conservation, analysis and monitoring of European cultural heritage [2]. By focusing on the three scales of monitoring (artefacts, buildings and monuments) and by investigating structural and chemical damage on heritage materials, ChemiNova tackles the impacts on cultural heritage caused by two specific human-induced threats: climate change and civil conflict. Using artificial intelligence, the project aims to develop innovative and cost-effective ways of remote and in-situ monitoring of cultural heritage by re-using existing technologies, based on a user driven approach and the consultation with stakeholders. The finalization of the system will be based on its testing and performance evaluation at four pilot sites: Saint Sophia Cathedral - Kyiv, Ukraine; Human Anatomy Section “Emerico Luna” Collection of the University of Palermo, Italy; Schloß Schönbrunn - Vienna, Austria; Collection of the University of Valencia, Spain.

The present contribution will highlight the results achieved so far for the creation of the know-how in relation to the decay of the heritage materials at the case studies caused by pollution and slow variations of climate parameters that will constitute the basis for the development of the system for remote and non-invasive monitoring.

References

[1] European Commission Directorate-General for Education, Youth, Sport and Culture. Strengthening Cultural Heritage Resilience for Climate Change: Where the European Green Deal Meets Cultural Heritage; Publications Office of the European Union: Luxembourg, 2022; Available online: https://data.europa.eu/doi/10.2766/44688;
[2] https://cheminova.eu/

Acknowledgements
ChemiNova has received funding from the European Union’s Horizon Europe Framework Programme under grant agreement 101132442.

X-Ray Fluorescence and Machine Learning to reveals the origin of bronze arrowheads

F.Armetta ([*, a, c]), P.Sconzo ([b]), F. Ferraro ([a]),R.C. Ponterio ([c]), D. Giuffrida ([c]), S. Orecchio ([a]), F. Lo Celso ([a]), M. L. Saladino ([a,c])

([a]) Dipartimento di Scienze e Tecnologie Biologiche Chimiche e Farmaceutiche (STEBICEF) and INSTM-Palermo, Università degli studi di Palermo, Viale delle Scienze, Ed.17, I-90128 Palermo, Italy

(b) Dipartimento Cultura e Società, Università degli studi di Palermo, Viale delle Scienze, Ed.15, I-90128 Palermo, Italy

(c) IPCF-CNR, Istituto per i Processi Chimico Fisici, V.le F. S. d'Alcontres 37, I- 98158 Messina, Italy

* Presenting author

francesco.armetta01@unipa.it

This study introduces a novel methodology for analyzing X-ray fluorescence (XRF) data by leveraging machine learning algorithms to accurately determine the provenance of copper-based arrowheads discovered in Motya, an ancient Carthaginian stronghold in western Sicily. Established by Phoenician settlers in the 8th century BCE, Motya became a key center of Carthaginian influence until its destruction by the Greeks from Syracuse in 397 BCE. The site's rich archaeological record, particularly the abundance of weaponry found amidst its ruins, offers a unique opportunity to explore the technological and material networks of the Mediterranean warfare industry.

The research employs a multiscalar and interdisciplinary approach, innovatively combining traditional archaeological methods with advanced computational analysis. Machine learning techniques are applied to the elemental composition data, facilitating the identification of distinct geochemical signatures associated with different metal sources. This method aims to enhance our understanding of ancient metallurgical practices and trade routes, with a specific focus on pinpointing the geographic origins of the raw materials used in the arrowheads.

The robustness of the machine learning models is further validated through the determination of lead isotopic ratios, providing a complementary isotopic fingerprint that reinforces the provenance analysis. This comprehensive approach underscores the efficacy of combining archaeometry with data science, paving the way for future research in archaeological provenance studies.

References

[1] A. Termini, Le punte di freccia in bronzo nella Sicilia punica. In A. Spanò Giammellaro (ed.), Atti del V Congresso Internazionale di Studi Fenici e Punici, (2005) 653-665.N.
G. Falsone, - P. Sconzo New Investigations in The North-East Quarter at Motya. The Archaic Cemetery and Building J. In M. Guirguis (ed.), From the Mediterranean to the Atlantic: people, goods and ideas between East and West. I, Pholia Phoenicia (2017) 1: 62-69

Acknowledgements

Progetto Eurostart "Armi puniche o greche? la risposta nell'invisibile", Finanziamenti da bandi Ministeriali e altri EEPP "MUR FONDI PNR D.M. 737/2021" CUP: B79J21038330001 and Project MML-ARCH - "Metodologie di machine learning applicate all'archeometria: una nuova frontiera per l'interpretazione materica dei Beni Culturali", Programma "CHANGES Cultural Heritage Active iNnovation for Sustainable Society" CUP B53C22003890006 - Codice Identificativo PE_00000020, finanziato dall'Unione Europea – Next Generation EU sui fondi PNRR MUR – M4C2 – Investimento 1.3 "Partenariati estesi a Università, centri di ricerca, imprese e finanziamento progetti di ricerca" Avviso pubblico per la presentazione di Proposte di intervento per la creazione di "Partenariati estesi alle università, ai centri di ricerca, alle aziende per il finanziamento di progetti di ricerca di base".

MML-ARCH Project: Machine Learning for prediction in archaeometry

F. Armetta([a]), F. Lo Celso([b]), M. L. Saladino ([a,c])

([a]) Dipartimento di Scienze e Tecnologie Biologiche Chimiche e Farmaceutiche (STEBICEF) and INSTM-Palermo, Università degli studi di Palermo, Viale delle Scienze, Ed.17, I-90128 Palermo, Italy

(b) Dipartimento di Fisica e Chimica E. Segrè, Università degli studi di Palermo, Viale delle Scienze, Ed.17, I-90128 Palermo, Italy

([c]) IPCF-CNR, Istituto per i Processi Chimico Fisici, V.le F. S. d'Alcontres 37, I- 98158 Messina, Italy

* Presenting author

marialuisa.saladino@unipa.it

Recently, the application of machine learning and artificial intelligence has demonstrated the powerful impact of data analysis in evaluating the most significant variables that allow for the classification of objects or the prediction of results. The field of cultural heritage has also benefited from these advancements [1-2] and the MML-ARCH project aims to develop predictive and classification models using machine learning algorithms to analyze archaeological and physico-chemical data, presenting itself as an innovative solution for sustainable diagnostics of cultural heritage. The data will be collected through advanced non-invasive diagnostic techniques in order to maximize the preservation of manufact. The algorithms will be developed to identify correlations between archaeological and material data, defining new knowledge and predictive models useful for future studies. Considering the aim, the project combines archaeology, chemistry, and computer science, promoting an interdisciplinary approach through collaboration between universities, companies, and cultural heritage management institutes. The objects of study include ancient paintings on stone substrates, coins, and arrowheads, artifacts from sites in Western Sicily (Lilibeo/Marsala, Selinunte/Castelvetrano, S. Pantaleo/Mozia, Pantelleria), the Palermo hinterland (Caltavuturo), and the central-eastern part of the island (Centuripe), held in museums managed by the Department of Cultural Heritage and Sicilian Identity of the Regional Sicilian Government. Taking into consideration different categories of substrates and characterization techniques, the training of the algorithms will analyze a wide range of variables. The preparation of mock-ups with known and systematic differences will aid in designing a model for the rapid analysis of new objects and potentially uncover new features for their valorisation.

References

[1] F. Armetta, M. Baublytė, M. Lucia, R.C. Ponterio, D. Giuffrida, M. L. Saladino, S. Orecchio, J. Am. Chem. Soc. 2024, https://doi.org/10.1021/jacs.4c12611
[2] S. Wang, Z. Wu, S. Dai, D. Jiang, Angewandte Chemie International Edition, 2021, 60(22), 12289-12292. https://doi.org/10.1002/ange.202100407

Acknowledgements

Project MML-ARCH - "Metodologie di machine learning applicate all'archeometria: una nuova frontiera per l'interpretazione materica dei Beni Culturali", Programma "CHANGES Cultural Heritage Active iNnovation for Sustainable Society" CUP B53C22003890006 - Codice Identificativo PE_00000020, finanziato dall'Unione Europea – Next Generation EU sui fondi PNRR MUR – M4C2 – Investimento 1.3 "Partenariati estesi a Università, centri di ricerca, imprese e finanziamento progetti di ricerca" Avviso pubblico per la presentazione di Proposte di intervento per la creazione di "Partenariati estesi alle università, ai centri di ricerca, alle aziende per il finanziamento di progetti di ricerca di base".

Nanoscience and Conservation: New Strategies for Cultural Preservation

C. Tuccio ([a]), F. Armetta ([b]), M.L. Saladino ([b])

([a]) Department of Culture and Society, University of Palermo (Italy), Viale delle Scienze, Ed. 15
90128, Palermo (PA)

([b]) Department of Biological, Chemical and Pharmaceutical Sciences and Technologies STEBICEF, University of Palermo (Italy), Viale delle Scienze, Ed. 17, 90128, Palermo (PA)

* chiara.tuccio@unipa.it

The conservation of cultural heritage in critical environments, such as archaeological sites, poses significant challenges due to unstable thermo-hygrometric conditions that accelerate degradation processes [1]. Phenomena such as material disintegration, wind erosion, and rainwater washing compromise the structural integrity of constructions and stone surfaces. This study presents an innovative approach based on the use of eco-friendly nanomaterials specifically designed to improve substrate cohesion without altering their aesthetic or breathable properties [2,3]. Specifically, the synthesis of strontium hydroxide and magnesium hydroxide nanoparticles for the consolidation of mud bricks is presented. A Sicilian case study, the mud bricks (fig. 1) of the Hellenistic-Roman constructions in the city of Solunto (Palermo), was selected to evaluate the effectiveness of nanostructured dispersions of strontium and magnesium hydroxide. The adopted methodology included an analysis of the site's thermo-hygrometric conditions, a diagnostic characterization of degradation phenomena, and the synthesis of nanomaterials tailored to the identified issues. The developed formulations were tested in the laboratory on mock-ups, testing of chemical-physical properties according to standards. These results highlight the potential of nanotechnologies as versatile and sustainable tools for the conservation of cultural heritage in critical contexts.

Fig. 1 Archaeological area of Solunto

References

[1] Baglioni, P., & Chelazzi, D. (2013). Nanoscience for the Conservation of Works of Art. The Royal Society of Chemistry.
[2] Giorgi, R., Dei, L., & Baglioni, P. (2000). A New Method for Consolidating Wall Paintings Based on Lime Dispersions in Alcohol. Studies in Conservation, 45(3), 154-161.
[3] Ruffolo, S. A., La Russa, M. F., & Macchia, A. (2019). Innovative Approaches to Stone Conservation: The Use of Nanomaterials. Heritage Science, 7, 1-10.

Acknowledgements

This work has been funded by European Union (NextGeneration EU), through the MUR MUR-PNRR project SAMOTHRACE (ECS00000022)

Geopolymers: An Innovative Resource for Cultural Heritage Conservation

A. Lo Bianco ([*, a]), M. M. Calvino ([a]), G. Lazzara ([a]), M. Broda ([b]), G. Cavallaro ([a]), S. Milioto ([a])

([a]) *Department of Physics and Chemistry "E. Segrè", University of Palermo, Viale delle Scienze, Ed.17, Palermo 90128, Italy.*

([b]) *Department of Wood Science and Thermal Techniques, Faculty of Forestry and Wood Technology, Poznan University of Life Sciences, ul. Wojska Polskiego 38/42, 60- 637 Poznan, Poland.*

* Presenting author

alessandro.lobianco02@unipa.it

The conservation of Cultural Heritage presents a complex challenge that demands innovative materials capable of addressing diverse needs, including structural consolidation, resistance to extreme environmental conditions, and moisture control. Geopolymers, a class of inorganic materials formed through the alkaline polymerization of aluminosilicates, are emerging as a promising solution in this field[1]. This work explores the potential of geopolymers for applications in archaeometry and Cultural Heritage preservation, focusing on their unique properties and versatility. Their high mechanical strength makes them suitable for reinforcing degraded materials such as natural stones, ancient bricks, or historic plasters. In addition to their structural capabilities, geopolymers demonstrate exceptional resistance to fire and heat[2]. Their inherent thermal stability allows them to maintain structural integrity even under prolonged exposure to temperatures exceeding 1000 °C, providing an effective barrier against thermal degradation. This characteristic makes them particularly valuable for safeguarding historic structures in fire-prone or high-temperature environments. Geopolymers also offer significant potential for moisture control, thanks to their controlled microporosity, which enables selective moisture adsorption. This property can help stabilize humidity conditions in museum environments or preventive conservation contexts, mitigating the impact of relative humidity on the deterioration of sensitive artifacts. The analysis presented is supported by experimental tests, including mechanical, thermal, and chemical characterizations such as FT-IR spectroscopy, thermogravimetric analysis (TGA), and scanning electron microscopy (SEM). Preliminary results indicate that geopolymers, beyond their broad applicability, can be tailored to meet the specific requirements of conservation projects. This work aims to demonstrate how the introduction of geopolymers into the field of Cultural Heritage conservation can open new perspectives, combining scientific innovation with respect for the authenticity of historical artifacts.

References

[1] F. Giacobello, I. Ielo, H. Belhamdi, M. R. Plutino, *Materials* **2022**, *15*, 1725.
[2] A. Lo Bianco, M. M. Calvino, G. Cavallaro, L. Lisuzzo, P. Pasbakhsh, S. Milioto, G. Lazzara, Y. Lvov, *Small n/a*, 2406812.

Acknowledgments

This work was financially supported by Project MML-ARCH - "Metodologie di machine learning applicate all'archeometria: una nuova frontiera per l'interpretazione materica dei Beni Culturali", Programma "CHANGES Cultural Heritage Active iNnovation for Sustainable Society" CUP B53C22003890006 - Codice Identificativo PE_00000020, finanziato dall'Unione Europea – Next Generation EU sui fondi PNRR MUR – M4C2 – Investimento 1.3 "Partenariati estesi a Università, centri di ricerca, imprese e finanziamento progetti di ricerca and "SiciliAn MicronanOTecH Research And Innovation CEnter– SAMOTHRACE" (MUR, PNRR-M4C2, ECS0000002), spoke 3, Università degli Studi di Palermo, "S2-COMMs Micro and Nanotechnologies for Smart & Sustainable Communities"

Biohybrid Xerogels Incorporating Halloysite Nanoclay for Sustainable Removal of Pollutants

M.M. Calvino (*, a), M.R. Caruso(a), Lisuzzo L. (a), Cavallaro G. (a), Milioto S. (a), Lazzara G. (a)

(a) Dipartimento di Fisica e Chimica, Università Degli Studi di Palermo, Viale delle Scienze, pad. 17, Palermo, 90128, Italy

* Presenting author

martinamaria.calvino@unipa.it

Here we propose a scalable and systematic protocol for the development of biohybrid xerogel using sustainable and low-cost materials, specifically halloysite nanoclay and chitosan. Halloysite nanotubes (HNTs) are naturally occurring aluminosilicates with a hollow nanotubular morphology and peculiar physico chemical properties, while chitosan is a biopolymer derived from chitin, known for its biocompatibility and sustainable applications. Starting from colloidal dispersions, rheological studies reveal the formation of hydrogels with zero-shear viscosities enhanced by approximately nine orders of magnitude and significantly higher storage moduli. Self-standing xerogels are subsequently obtained using a simple solvent casting method, with properties, including thermal stability and mechanical performance, depending on halloysite concentration.
The resulting xerogel can be exploited for environmental remediation since it was proved to efficiently absorb organic pollutants. Specifically, good removal efficiencies were reached for the capture of CO_2 from the atmosphere and organic molecules from aqueous media. Moreover, the presence of an inorganic skeleton within the xerogels prevents structural collapse during drying, enabling precise control over their morphology and shape to suit specific conservation needs.

These xerogels hold significant potential for the cultural heritage field, particularly in the preservation of artifacts and historical structures.

References

[1] M.R. Caruso, M.M. Calvino, P. Šiler, L. Càba, S. Milioto, L. Lisuzzo, G. Lazzara, G. Cavallaro, Self-Standing Biohybrid Xerogels Incorporating Nanotubular Clays for Sustainable Removal of Pollutants, Small (2024), 2405215, https://doi.org/10.1002/smll.202405215

Acknowledgements

This work was supported by "SiciliAn MicronanOTecH Research And innovation CEnter - SAMOTHRACE" (MUR, PNRR-M4C2, ECS0000002), spoke 3, Università degli Studi di Palermo.

Sustainable conservation of bronzes by supramolecular silica nanoparticles releasing corrosion inhibitors

A. Privitera (*, a), A. Sodo (a)

(a) Dipartimento di Scienze, Università degli Studi Roma Tre, via della Vasca Navale, 84, 00146 Roma (RM), Italy

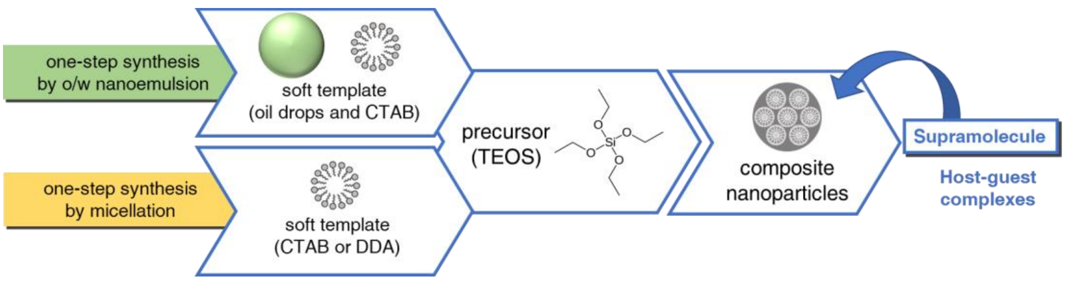
* Presenting author

antonella.privitera@uniroma3.it

Bronze protection against corrosion is a widespread research topic of significant importance in the conservation of cultural heritage, requiring the hart task of efficiently prevent corrosion minimizing risks for the environment and for the restorers at the meantime. To meet the requirement of sustainability for the environment and for the health, application methods and chemical compounds must be safe and effective at much lower concentrations with respect to common corrosion inhibitors. Azole compounds form stable organo-metal complexes and therefore, are expected to have the best corrosion inhibition properties [1,2]. 1H-benzotriazole (BTA) is currently the compound most used by restorer against copper corrosion, although classified as a suspected human carcinogenic substance and hazardous for the environment, due to its traditional application methods.

In this work, innovative eco-friendly, low-toxicity and long-lasting effective materials and solutions have been adopted, exploiting the potential of nanoscience and supramolecular chemistry. First, a new molecule has been identified and tested, on a standard bronze alloy subjected to corrosion, as a possible non-toxic substitute inhibitor of BTA: namely 5-Phenyl-1H-tetrazole (PT). Subsequently, BTA and PT were encapsulated in nanocontainers, via one-step synthesis of supramolecular systems based on mesoporous silica, then subjected to chemical-physical characterization by electrochemical (EIS/PP) and surface techniques (XPS, AFM and micro-Raman spectroscopy), by electron microscopy techniques (SEM and TEM), nitrogen physisorption porosimetry (BET, BJH), UVVisible spectroscopy and thermal analysis.

An inhibition efficiency of PT (IE=94.7-96.1%) comparable to BTA (IE=99.5-99.9%) was obtained, but at a much lower concentration (1 mM compared to 10 mM). The *in-situ* inhibition mechanism of PT was investigated [3]. The supramolecular systems, containing BTA or PT, in the form of coreshell nanocapsules and mesoporous channel-structured nanoparticles, were obtained with a high loading capacity, higher than loaded systems by impregnation [4,5]. These supramolecular silica systems are also eco-friendly, since they are soluble in water and are compatible with the surfaces of Cultural Heritage, being transparent and inert, therefore, they can be tested in a subsequent step within smart coatings.



Sketch of the adopted one-step syntheses procedures to obtain supramolecular silica systems

References

[1] H. Wei, Y. Wang, J. Guo et al, Advanced micro/nanocapsules for self-healing smart anticorrosion coatings, Journal of Materials Chemistry A (2015), 3, 469–480. https://doi.org/10.1039/C4TA04791E

[2] A. Fateh, M. Aliofkhazraei, A.R. Rezvanian, Review of corrosive environments for copper and its corrosion inhibitors, Arabian journal of Chemistry (2020), 13, 481–544. https://doi.org/10.1016/J.ARABJC.2017.05.021

[3] A. Privitera, F. Porcelli, et al, Chemical-physical characterisation of 5-Phenyl-1H-tetrazole inhibitive behaviour: a new non-toxic compound for a sustainable protection of Cu-alloys, Journal of Applied Electrochemistry (2023), 53(12), 2375-2395, https://doi.org/10.1007/s10800-023-01936-6

[4] A. Privitera, L. Ruggiero et al, One step nanoencapsulation of corrosion inhibitors for gradual release application. Materials Today Chemistry (2022), 24, 100851, https://doi.org/10.1016/j.mtchem.2022.100851

[5] A. Privitera, S. Tuti et al, One-stage synthesis and characterisation of supramolecular silica systems incorporating corrosion inhibitors for gradual release applications, Journal of Materials Science (2024), 59(6), 2497-2521, https://doi.org/10.1007/s10853-023-09306-5

Acknowledgements

This communication is an excerpt of the PhD Thesis in Sciences of matter, Nanotechnologies and Complex Systems (XXXV) cycle at the Roma Tre University, awarded with the first prize “Centro d’Eccellenza DTC Lazio Award 2024 – first edition” in the topic “*Protection and conservation of cultural heritage against climate change and natural and anthropogenic risks*” of CHANGES project.

Sustainable materials for the protection of steel in concrete heritage: green corrosion inhibitors and smart nanocarriers

C. Fratello,[a,b](*) E. Messina,[a] F. Boccaccini,[a] C. Riccucci,[a] M. Pascucci,[a] M. L. Santarelli[b] and G. Di Carlo[a]

[a] Institute for the Study of Nanostructured Materials (ISMN), National Research Council (CNR), SP35d, 9, 00010 Montelibretti, Rome

[b] Department of Chemical Engineering Materials Environment, Sapienza University of Rome, Via Eudossiana, 18, 00184, Rome

* Presenting author

chiarafratello@cnr.it

The corrosion of steel reinforcing bars in concrete structures strongly impacts their stability, causing the formation of rust and other products that lead to mechanical stress and structural damages, with consequences both on safety and economics [1]. The main triggering factor of this process can be identified in the loss of the passivating oxide layer that is usually present in fresh concrete, due to the high pH values. This layer becomes less stable while the carbonation proceeds lowering the pH and is often also worsened by environmentally degrading species such as chlorides.

Corrosion, if in an advanced state, may require invasive restoration interventions but, when dealing with concrete heritage, this is obviously not advisable. It is, therefore, demanding to preserve the integrity of the steel rebars ensuring the preservation of the cultural asset over time [2].

Commercially available corrosion inhibitors can help reduce or drastically slow down these processes, but most of them are whether not able to satisfactorily reach the rebar by migrating into the concrete porosity, like amines, that are usually volatile, or contain heterocyclic compounds (i.e. benzotriazole), that are harmful to operators and toxic to the environment.

Moreover, as in the field of cultural heritage the inhibitor can only be applied on the surface of concrete and can’t cause any visual change, an ideal product has to be able to migrate into the innermost pores until it reaches the rebars. Therefore, this research not only aims to seek increasingly green solutions that are effective and safe to use, by identifying new inhibitors for steel in concrete heritage, but is also focused on the synthesis and validation of carrier systems that can deliver these inhibitors through the concrete matrix and release them upon environmental stimuli (pH change, presence of chlorides) [3].

The current research began with validating some corrosion inhibitors after 5 years of treatments, a particularly relevant analysis as these tests are usually conducted over shorter timescales. To evaluate their efficacy, corrosion products on the surface were analyzed using a multi-analytical approach. The testing of protective molecules is also being carried out by means of electrochemical tests.

References

[1] Poursaee, A.; Hansson, C. M. Potential Pitfalls in Assessing Chloride-Induced Corrosion of Steel in Concrete. Cem. Concr. Res.2009, 39 (5), 391–400.

[2] Bertolini, L.; Carsana, M.; Gastaldi, M.; Lollini, F.; Redaelli, E. Corrosion Assessment and Restoration Strategies of Reinforced Concrete Buildings of the Cultural Heritage. Mater Corros 2011, 62 (2), 146–154.

[3] Giuliani, C.; Messina, E.; Staccioli, M. P.; Pascucci, M.; Riccucci, C.; Liotta, L. F.; Tortora, L.; Ingo, G. M.; Di Carlo, G. On-Demand Release of Protective Agents Triggered by Environmental Stimuli. Front. Chem. 2020, 8, 304.

Acknowledgements

This activity is carried out within the MUR PRIN2022 ECOforCONCRETE project (2022M4KCKP) which is kindly acknowledged for financial support.

Sustainable sensing for Cultural Heritage: development of SERS-active devices based on cellulose and Ag nanostructured surfaces (SAMOTHRACE project)

D. Giuffrida ([*, a]), D. Spadaro ([a]), V. Strano ([b]), S. Trusso ([a]), M.L. Saladino ([c,a]), F. Armetta ([c, a]), R.C. Ponterio ([a])

([a]) Istituto per I Processi Chimico-Fisici (IPCF), Consiglio Nazionale delle Ricerche, V.le F. S. d'Alcontres 37, 98158, Messina, Italy

([b]) Istituto per la Microelettronica e Microsistemi (IMM), Consiglio Nazionale delle Ricerche, Via S. Sofia 64, 95123, Catania, Italy

([c]) Dipartimento Scienze e Tecnologie Biologiche, Chimiche e Farmaceutiche (STEBICEF) and INSTM UdR - Palermo, Università di Palermo, Viale delle Scienze pad. 17, Palermo, 90128, Italy

* Presenting author

dario.giuffrida@ipcf.cnr.it

Within the framework of the SAMOTHRACE ecosystem (https://samothrace.eu/), the IPCF is developing flexible and eco-sustainable devices based on Surface-Enhanced Raman Spectroscopy (SERS) for non-invasive sensing of pigments, dyes and alteration products in Cultural Heritage materials [1]. These devices are based on cellulose substrates derived from biomass waste, which are transformed into flexible sensors by depositing Ag nanostructured thin films onto their surface. Pulsed laser deposition process was optimized for this kind of substrate, while alternative solutions employing Ag colloid nanoparticles (NPs) are under investigation. Key parameters influencing SERS efficiency, such as NPs size, substrate morphology and roughness, were investigated using SEM, UV-VIS spectroscopy and micro-profilometry to assess optimal conditions. The SERS activity was evaluated using Rhodamine 6G (Rh6G) solutions at different concentrations against different types of paper, revealing a lower detection limit of 10^{-10} M. While Rh6G is a standard probe molecule for SERS device calibration, alternative non-toxic and natural molecules were also explored: among these, violacein, a colorant derived from bacterial sources, showed a satisfying result of 10^{-7} M under identical conditions.

Following this step, a sensor holder prototype was designed to integrate with various Raman spectrometers, including both portable and benchtop configurations. The system (sensor + sample holder) was then validated through extensive laboratory testing. During this phase, mock-up samples simulating real-world conditions were prepared to evaluate the sensors' sampling capabilities on different background layers such as wood, canvas, and plaster. The system successfully allowed to collect SERS spectra for a range of pigments and dyes, including ochres, brazilwood, methylene blue, and indigo carmine, among others, demonstrating its potential for on-site and non-invasive applications. By extending their use to real-world artifacts, we aim to gain a more comprehensive understanding of the system's capabilities and limitations. The research marks a step toward full sustainability which includes multiple aspects, such as the use of eco-friendly materials (from the substrate to the probe molecule), manufacturing processes, portability, and non-invasiveness.

References

[1] D. Giuffrida, D. Spadaro, V. Strano, S. Trusso, M.L. Saladino, F. Armetta, R.C. Ponterio, Eco-sustainable and flexible SERS platform based on waste cellulose decorated by Ag nanoparticles, *Materials Chemistry and Physics* (2025), *329*, 130061, https://doi.org/10.1016/j.matchemphys.2024.130061.

Acknowledgements*: We thank European Union (NextGeneration EU), through the MURPNRR project SAMOTHRACE — Sicilian Micro and Nano Technology Research and Innovation Center (ECS00000022).*

PVA-Borax Hydrogels in Restoration

E. Barberi, A. Tumminello, F. Palla*

University of Palermo, Master Degree in Conservation and Restoration of Cultural Heritage, and Laboratoriy of Biology and Biotechnology for Cultural Heritage – STEBICEF via Archirafi 38, 90123 Palermo Italy
* Presenting author

franco.palla@unipa.it

In this study the removal of undesired not original and altered layers have been performed by an highly elastic gel whose removal from the surface occurs by peeling, therefore through a mechanical action and without the need od further component.These gels fall into the category of responsive gels, and due to their mechanical properties, no residues remain on the artwork surface after removal.

The PVA-borax gels have characteristics that have made them a valid alternative to traditional cleaning methods, since they:
- have high viscosity - allowing that the action of the gel is limited to the desired areas and therefore to carry out precise and, if necessary, differentiated cleaning;
- are transparent and colourless - the cleaning action can be visually checked during the restoration so as to verify the response of the materials and have the possibility of promptly removing the gel in the event of unwanted reactions with the substrate;
- have low adhesive power- the risk in damaging the surface is minimised in the case of particularly fragile surfaces;
- are malleable and viscoelastic - under specific condition they can form very thin films that are able of adapting to the roughness of the surfaces;
- are highly retentive - they reduce the penetration of the solvent into the constituent layers of the artwork and also reduce its volatility, decreasing its potential toxicity
- have chemical versatility - several polar and apolar solvents can be dissolved as co-solvents inside, as well as chelating agents and surfactants, therefore, they allow the removal of a very large number of substances [1].

The aim of this case-study was the removing of an oily layer, with different degree of ageing, from a papier-mache artwork. To achieve this goal, various solvents and application times have been assayed preliminary on *ad hoc* assembled laboratory specimens, undergoing specific aging cycles, evaluating possible changes on color surfaces by colorimetric analysis. After having indentified the best gel composition, (containing green solvent) [2], it was tested on papier-mache artwork. The define gel acted only on the layer to be removed, without damaging the underlying one. Furthermore, the elasticity of the gel was found to be adequate for application on a three-dimensional surface, and no change in surface color was detected.

References

[1] Banger, A., Srivastava, A., Yadav, A.,Sharma, R., & Srivastava, M. *Application of Green Solvent in GreenChemistry: An overview*. GreenChemistry & Technology Letters, 9(1),01 14, 2023;
[2] Altobelli, A. et al., Experimentation of a PVA-Borax hydrogel for the removal of Paraloid B72® from artifacts of archaeological interest from the National Archaeological Museum in Naples, Italy , In: ACTA IMEKO, 12, pp. 1-8, 2023

Acknowledgements

Results on PVA borex Hydrogelare are part of E. Barberi’s final exam of the Master’s degree in Conservation and Restoration of Cultural Heritage at the University of Palermo (Italy), graduated cum laude and qualified as an Italian Restorer of Cultural Heritage (MiC, Italian Ministry of Culture).

Innovation, sustainability and compatibility for on-site consolidation of natural stones and historic mortars by new nanolimes in water

G. Taglieri ([*, a]), O. Spadaro ([b]), L. Arrizza ([c]), M. Spadaro ([d]), V. Maurizio ([d]), A. Ministeri ([e]), V. Daniele ([a])

([a]) Dept. of Industrial and Information Engineering and Economics, University of L'Aquila, 67100 L'Aquila (Italy)

([b]) SPADAROCALCE1886 SRL, Via dell'Industria 2, 67100 L'Aquila (Italy)

([c]) Microscopy Centre, University of L'Aquila, 67100 L'Aquila, Italy

([d]) SNAPTECH SRL, Piazzale Pontieri 1 - Monteluco di Roio, 67100 L'Aquila, Italy

([e]) Soprintendenza per i Beni Culturali e Ambientali di Siracusa, Italy

* Presenting author: giuliana.taglieri@univaq.it

Nanolimes have been introduced in Cultural Heritage to match the crucial request of compatible treatments of carbonatic surfaces, thanks to their assumed high reactivity in the carbonatation process. Nevertheless, nanolimes have frequently been dispersed in short-chain aliphatic alcohols, which limit the particles' sedimentation but negatively affect the carbonatation process and penetration ability, resulting in a low treatment efficacy. On extensive surfaces and in indoor uses, in addition, alcoholic nanolimes would release large volumes of VOCs, causing environmental pollution and human health risks. By SNAPTECH technologies, new nanolimes in water (NANOLAQ) have been recently produced, by a sustainable and innovative method (European Patent EP 2880101B1), operating in water, at room temperature and ambient pressure, starting from cheap or renewable reagents, with low energy consumption and low waste. NANOLAQ sustainability is attributed not only to the synthetic process but also to the presence of water as dispersing medium, which assures the completeness of the carbonatation process and an exceptional penetration depth, leading to good consolidating efficacies without polluting substances. Not lastly, NANOLAQ can be produced in large volumes, (up to 40 l/hour), to satisfy on-site applications, for extensive and wide uses on Cultural Heritage surfaces.

In this work, we present two case studies, aimed at the on-site superficial consolidation of: a) the stone facade of a historic Church in Ortigia b) the historic mortar of the graffiti, Carceri dello Steri Palermo. The effectiveness of NANOLAQ treatments is evaluated in terms of penetration depth, surface cohesion (STT), mechanical resistance (DRMS) and SEM microscopic studies.

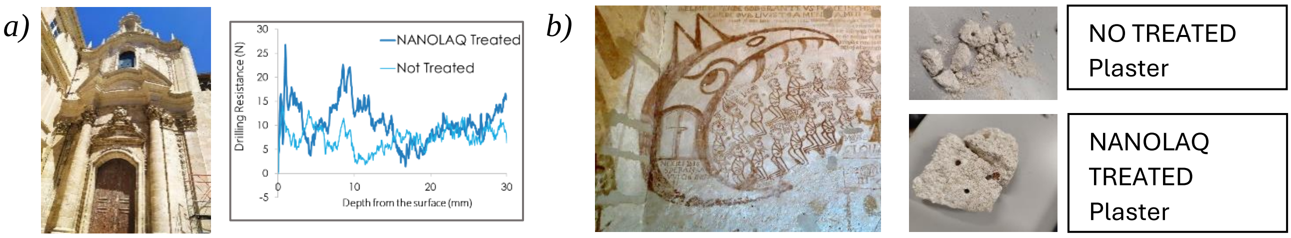


Figure. a) The façade of the Church in the historical center of Ortigia, and DRMS test on NANOLAQ treated stone surfaces; b) the Graffiti in Carceri dello Steri, Palermo and the original plaster, before ad after NANOLAQ treatments

References

[1] B. Salvadori, and L. Dei, "Synthesis of $Ca(OH)_2$ nanoparticles from diol", Langmuir, (2001), 17, 2371–2374, DOI 10.1021/la0015967

[2] G. Taglieri, V. Daniele, L. Macera, C. Mondelli, "Nano $Ca(OH)_2$ synthesis using a cost-effective and innovative method: Reactivity Study", Journal of American Ceramic Society, (2017), 100, 5766–5778, DOI 10.1111/jace.15112

Eco-sustainable nanostructured materials for the protection of bronze artworks: a surface science perspective

M.P. Casaletto [*, a], F. Scaglione [a], P. Letardi [b], J. Vernet[b], G. Pellis[c], D. Scalarone[c]

[a] *Consiglio Nazionale delle Ricerche – Istituto per lo Studio dei Materiali Nanostrutturati, Palermo, Italy*

[b] *Consiglio Nazionale delle Ricerche – Istituto per lo Studio degli Impatti Antropici e Sostenibilità in Ambiente Marino, Genova, Italy*

[c] *Università di Torino, Dipartimento di Chimica, Torino, Italy*

* Presenting author

mariapia.casaletto@cnr.it

X-ray Photoemission Spectroscopy (XPS) is a surface-sensitive analytical technique commonly used in the field of materials science. Due to its ability of probing the surface reactivity at the nanoscale level, XPS can be very fruitfully used also in the field of Conservation of Cultural Heritage for the assessment and validation of new eco-compatible conservation products, and for the choice of suitable conservation and restoration protocols. In this work, the surface properties of smart nanocontainer-based products selected for a sustainable conservation of metallic artworks are reported. In order to reduce the toxicity of the commercial corrosion inhibitor (Benzotriazole, BTA), and also to increase the durability of protective treatments, β-cyclodextrins (β-CD) were used as nanocontainers for a sustained release of the active agents [1-3]. Pure β-cyclodextrins were used to prepare a β-CD/BTA (1:1) inclusion complex and its methyl derivative (Meβ-CD) was studied as nanocarrier of 5-ethyl-1,3,4-thiadiazol-2-amine (AEDTA), a recently studied ecofriendly alternative to benzotriazole [4]. The incorporation of these nanostructured systems into commercial microcrystalline wax (R21) was made to produce an active multifunctional coating with a passive action as a protection barrier and a rapid feedback activity in response to changes in the local environment or in the coating integrity. The stimuli-responsive activity of these innovative coatings on quaternary bronze substrates was tested by XPS, both before and after corrosion in a NaCl 3% wt. solution, simulating a marine corrosion attack.

References

[1] M.P. Casaletto, V. Basilissi, Sustainable Conservation of Bronze Artworks: Advanced Research in Materials Science, in Artistry in Bronze: The Greeks and Their Legacy, edited by Jens M. Daehner, Kenneth Lapatin, Ambra Spinelli, J. Paul Getty Museum and Getty Conservation Institute (2017), 371-378

[2] E. Berdimurodov, I. Eliboyev, K. Berdimuradov, A. Kholikov, K. Akbarov, O. Dagdag, M. Rbaa, B. El Ibrahimi, D. K. Verma, R. Haldhar, N. Arrousse. Green β-cyclodextrin-based corrosion inhibitors: Recent developments, innovations and future opportunities. Carbohydr. Polym. (2022), 292, 119719. https://doi.org/10.1016/j.carbpol.2022.119719

[3] B. Cheirsilp, J. Rakmai. Inclusion complex formation of cyclodextrin with its guest and their applications. Biol. Eng. Med. (2016), 2(1), 1-6. doi: 10.15761/BEM.1000108

[4] G. Pellis, B. Giussani, P. Letardi, T. Poli, P. Rizzi, B. Salvadori, A. Sansonetti, D. Scalarone. Improvement in the sustainability and stability of acrylic protective coatings for outdoor bronze artworks. Polym. Degrad. Stab. (2023), 218, 110575.https://doi.org/10.1016/j.polymdegradstab.2023.110575

Acknowledgements

Financial support by European Union – NextGenerationEU for the PRIN 2022KKKLX7 “*MarinE outDoor bronze sUrfaceS: a methodological Approach”* MEDUSA Project and for the PRIN 2022895PTX “*Innovative multi analytical Characterisation of the influence of pAtina-coating inteRaction on anti-corrosive propErties*” InCARE Project is gratefully acknowledged.

Potential use of agricultural wastes to develop sustainable Hydraulic Lime Mortars for the Conservation of Cultural Heritage

Maria Antonietta Zicarelli ([*, a]), Mauro Francesco La Russa ([a]), Silvestro Antonio Ruffolo ([a])

([a]) Department of Biology, Ecology and Earth Sciences, University of Calabria

* Maria Antonietta Zicarelli

mariaantonietta.zicarelli@unical.it

At the beginning of the 20th century the world agricultural waste production was estimated to be about 4.000 billion tons [1]. Since waste recovery is often hindered by management, transport and processing costs, the disposal of such residue represents an environmental issue [2]. Applying circular economy principles to agricultural waste management holds significant potential for minimizing waste generation and enhancing sustainability. In the last years, the research in the field of building construction has moved in this direction, gaining attention in valorizing industrial and agricultural wastes. So far, their application is limited to the formulation of cement-based concrete. However, there is little information about the use of such wastes in lime mortars. This research shows preliminary results about the potential use of agricultural by-products such as rice husk ash (RHA) in lime-based mortars for the conservation of cultural heritage. In order to obtain a high-reactive ash, the first step was aimed at investigating the influence of burning temperature on the characteristics of RHA. Calcination was performed at different temperatures up to 800°C and then XRD, XRF, LOI and SEM-EDS analysis have been carried out on the obtained ashes. The results demonstrate that RHA remains amorphous for temperatures of up to 700 °C. The ashes were then grinded and subsequently mixed with hydrated lime to assess the portlandite consumption and the consequent formation of the CSH phases. Thus, TGA, FT-IR and SEM-EDS investigations were conducted. The peculiar CSH honeycomb morphologies were detected by SEM-EDS in all the samples. The FT-IR spectra, on the other hand, evidenced an intense peak at ~966 cm^{-1} in pastes with RHA calcinated at 500°C. Furthermore, almost all the free $Ca(OH)_2$ in 500°C RHA pastes is consumed after just 7 days. The higher reactivity of the 500°C RHA seems to be due to its higher specific surface area measured by BET. As a result, 500°C RHA was chosen as the optimum calcination temperature. The second phase is still ongoing and focuses on the production and the testing of mortars with the addition of 500°C ashes, hydrated lime and standard siliceous sand. The properties of the new formulated mortars will be evaluated through both mechanical and physical tests.

References

[1] Z. Mengqi, A. Shi, M. Ajmal, L. Ye, M. Awais. Comprehensive review on agricultural waste utilization and high-temperature fermentation and composting. Biomass Conv. Bioref. (2023), 13, 5445–5468, https://doi.org/10.1007/s13399-021-01438-5

[2] S. A. Memon, U. Javed, R. A. Khushnood. Eco-friendly utilization of corncob ash as partial replacement of sand in concrete. Construction and Building Materials (2019), 195, 165-177, https://doi.org/10.1016/j.conbuildmat.2018.11.063

Acknowledgements

This research is funded by PNRR, TECH4YOU - “Technologies for Climate Change Adaptation and Quality of Life Improvement”, CUP H23C22000370006, Project Code: ECS_00000009.

Innovative coatings and Non-destructive Techniques protocols for the investigation and the protection of marine outdoor bronzes: first insights of the MEDUSA project.

J. Vernet (*, a), P. Letardi (a), G. Sciutto (b), S. Prati (b), E. Catelli (b), D. Spaleta (b), R. Mazzeo (b), R. Stifanese (a), S. Aronica (c), F. Scaglione (d), M.P. Casaletto (d)

[a] *Consiglio Nazionale delle Ricerche – Istituto per lo Studio degli Impatti Antropici e Sostenibilità in Ambiente Marino, Via dei Marini 6, 16149 Genova, Italy* [b] *Università di Bologna – Campus di Ravenna, Via A. Baccarini, 27, 48121 Ravenna, Italy* [c] *Consiglio Nazionale delle Ricerche – Istituto per lo Studio degli Impatti Antropici e Sostenibilità in Ambiente Marino, Via del Mare 3, 91021 Torretta Granitola (TP), Italy*
[d] *Consiglio Nazionale delle Ricerche - Istituto per lo Studio dei Materiali Nanostrutturati, Via U. La Malfa 153, 90146 Palermo, Italy*

* Presenting author justine.vernet@ias.cnr.it

The MEDUSA project: "*MarinE outDoor bronze sUrfaceS: a methodological Approach*" aims to bridge the gap between scientific research on marine outdoor bronze artworks and the technological transfer of products and treatments to conservation professionals. It focuses on:

1. **developing and testing new sustainable treatments** that improve conservation and restoration practices based on a solid scientific foundation. New sustainable products, such as smart nanostructured coatings based on suitable nanocarriers capable of a gradually release of active agents (corrosion inhibitors) onto bronze surfaces, have been selected as protective treatments.
2. **investigating the physicochemical and morphological properties** of three different foundry surface finishes of quaternary bronze alloy mock-ups (i.e. non-patinated, foundry "*liver of sulfur*" or "*Messina green*" patinated samples). This study includes an assessment of their range of variability and their time evolution upon treatment and natural weathering in aggressive marine environments. The results will provide a deeper understanding of the role of the foundry patina layers and the weathering environments on the behavior of protective treatments (inhibitors, coatings).
3. **realizing reliable protocols for data acquisition** using both laboratory and portable nondestructive techniques (NdT) to enhance the quality of *in-situ* measurements on outdoor bronzes. Special attention has been given to the experimental design to identify through chemometric analysis the relevant parameters affecting the system's performance and the acceptable variability range.

This presentation aims to highlight the initial results of the surface characterization of mockups, including colour, roughness, thickness, Electrochemical Impedance Spectroscopy, Infra-Red and Raman Spectroscopies, conducted before (S0) and after the application (S1) of three protective treatments. The coatings were produced by adding three different corrosion inhibitors (Benzotriazole BTA, beta-cyclodextrin β-CD/BTA and methyl-betacyclodextrin Meβ-CD/AEDTA) to a commercial microcrystalline wax (R21 Antares srl). The natural weathering of the mock-ups treated with the selected coatings is currently underway in both urban and rural marine areas (Genoa Harbour and Capo Granitola, respectively).

Acknowledgements.
The PRIN 2022KKKLX7 MEDUSA Project: "*MarinE outDoor bronze sUrfaceS: a methodological Approach*" is financially supported by European Union – NextGenerationEU. The contribution of Prof. D. Scalarone and Dr. G. Pellis (Department of Chemistry, University of Turin) is gratefully acknowledged.

Refining Ceramic Rehydroxylation Dating Through Controlled Preheating and Hydroxyl Content Analysis

Maspero F. ([a]), Uccheddu G. ([a]), Panzeri L. ([a]), Martini M. ([a]) , Galli A. ([a])

(a) Dipartimento di Scienza dei Materiali, Università degli Studi di Milano-Bicocca

francesco.maspero@unimib.it

Rehydroxylation (RHX) dating of ceramic materials has turned out to be promising for age determination of ceramic materials (Wilson et al. 2012; Barrett 2015); however, results have not been consistently reliable across all samples. This study explores the impact of preheating temperature on dating accuracy, focusing on mineralogical and chemical differences between samples that align with expected dates and those that do not. Experimentally, samples that failed to yield accurate dates when preheated at 100°C provided correct results when preheated at 300°C(Maspero et al. 2022). To investigate this phenomenon, ceramic and brick samples of varying ages were characterized using X-ray diffraction (XRD) for mineralogical analysis and Fourier-transform infrared spectroscopy (FTIR) for relative assessment of water and hydroxyl ion content at different preheating temperatures(Shoval 2003; Shoval et al. 2011). The latter revealed a correlation between residual water content at various temperatures and dating reliability. Ongoing comparisons with thermogravimetric analysis (TGA) are being conducted to establish a link between TGA curve and water and OH content determined by FTIR. These findings, if confirmed, may enable a preliminary method for selecting optimal preheating temperatures, enhancing the reliability of RHX dating of ceramics.

References

Barrett GT (2015) Rehydroxylation Dating: Assessment for Archaeological Application

Maspero F, Galli A, Panzeri L, Martini M (2022) Rehydroxylation: A promising technique for ceramic dating. In: Journal of Physics: Conference Series. Institute of Physics

Shoval S (2003) Using FT-IR spectroscopy for study of calcareous ancient ceramics. In: Optical Materials. Elsevier, pp 117–122

Shoval S, Yadin E, Panczer G (2011) Analysis of thermal phases in calcareous Iron Age pottery using FT-IR and Raman spectroscopy. J Therm Anal Calorim 104:515–525. https://doi.org/10.1007/s10973-011-1518-5

Wilson MA, Hamilton A, Ince C, et al (2012) Rehydroxylation (RHX) dating of archaeological pottery. Proceedings of the Royal Society a-Mathematical Physical and Engineering Sciences 468:3476–3493. https://doi.org/10.1098/rspa.2012.0109

The Cala Tramontana hoard in Pantelleria: archaeometric study for the production of the Sardinian-Punic coins

L. Sole (* [a]), F.Armetta ([b,c]), M. L. Saladino ([b,c])

([a]) Dipartimento Cultura e Società, Università degli studi di Palermo, Viale delle Scienze, Ed.15, I-90128 Palermo, Italy

(b) Dipartimento di Scienze e Tecnologie Biologiche Chimiche e Farmaceutiche (STEBICEF) and INSTM-Palermo, Università degli studi di Palermo, Viale delle Scienze, Ed.17, I-90128 Palermo, Italy

(c) IPCF-CNR, Istituto per i Processi Chimico Fisici, V.le F. S. d'Alcontres 37, I- 98158 Messina, Italy

* Presenting author

lavinia.sole@unipa.it

The application of efficient methods to determine the provenance of metals remains a continuous challenge, particularly when employing techniques that minimize the impact on the object. This is especially valued in numismatic studies, where researchers deal with the small size of coins and the need to preserve them. However, non-destructive analysis is often considered insufficient in numismatic literature, as it is limited to investigating the surface of the coin. As a result, invasive techniques, which clearly compromise the integrity of the artifact due to its very small size, are often preferred. In this context, lead isotope analysis is widely recognized as the most reliable technique for tracing the provenance of metals. However, it requires sampling, making the process invasive. In this study, we compare the results of analyses conducted using both non-destructive and invasive techniques. In the first case, we propose a method that combines non-invasive XRF spectroscopy for elemental composition analysis with data interpretation using chemometric tools such as Principal Component Analysis (PCA) and Cluster Analysis (CA) to identify key features and compositional differences. Specifically, 74 Sardo-Punic coins from the hoard, belonging to the 1A series described by Forteleoni in 1964, were analyzed, and their compositions were compared with existing literature on coins from the same series, other Sardo-Punic series (1B series), and other mints. The combined analysis revealed not only a common origin of the metal used for the 1A series coins from the hoard but also suggested a similarity with the metal of other Sardo-Punic series and a difference from coins of other mints. To validate these results, lead isotopic ratios were determined for two representative coins from the hoard. These measurements confirmed a Sardinian origin for the metal of the 1A series coins from the hoard, specifically linked to the mines of Bosa. This study demonstrates the feasibility of a non-invasive archaeometric approach while providing essential information about the hoard and the production area of the coins it contains.

References

[1] S. Frey-Kupper – J.N. Barrandon, Analisi Metallurgiche di monete antiche in bronzo circolanti nella Sicilia Occidentale, *Quarte giornate internazionali di studi sull'area Elima* (2022) ISBN 88-7642-122-X

Acknowledgements

This work was supported by Project MML-ARCH - "Metodologie di machine learning applicate all'archeometria: una nuova frontiera per l'interpretazione materica dei Beni Culturali", Programma "CHANGES Cultural Heritage Active iNnovation for Sustainable Society" CUP B53C22003890006 - Codice Identificativo PE_00000020, finanziato dall'Unione Europea – Next Generation EU sui fondi PNRR MUR – M4C2 – Investimento 1.3 "Partenariati estesi a Università, centri di ricerca, imprese e finanziamento progetti di ricerca" Avviso pubblico per la presentazione di Proposte di intervento per la creazione di "Partenariati estesi alle università, ai centri di ricerca, alle aziende per il finanziamento di progetti di ricerca di base".

Terracottas from the Athenaion in Castro (Apulia, Italy): further insight into the provenancing

M.M.N. Franceschini (*, a, b), E. Cantisani (b), S. Vettori (b), L. Chelazzi (c), F. Di Benedetto (b, d), C. Grifa (e), T. Ismaelli (b)

(a) Department of Science of Antiquities, Sapienza University of Rome, Piazzale Aldo Moro 5, 00185 Rome, Italy

(b) Institute of Heritage Science, National Research Council of Italy (ISPC-CNR), via Madonna del Piano 10, Sesto Fiorentino, 50019 Florence, Italy

(c) Centro di Servizi di Cristallografia Strutturale (CRIST), University of Florence, Via della Lastruccia 3, 50019 Sesto Fiorentino Florence, Italy

(d) Department of Physics and Earth Science, University of Ferrara, via Saragat 1, 44122 Ferrara, Italy

(e) Department of Science and Technology (DST), University of Sannio, via de Sanctis, 82100 Benevento, Italy

* Presenting author

matteomaria.franceschini@uniroma1.it

Systematic archaeological research carried out since 2000 has brought to light the ancient sanctuary of Athena in the indigenous settlement of Castro (Lecce) on the Adriatic coast of the ancient region of Messapia (southern Apulia). Between the 7th and 2nd centuries BC, local groups, the Greek inhabitants of Taranto and the Greeks from Macedonia, Epirus and the Corinthian colonies on the Adriatic met here. From the late 6th century BC, temples and other sacred buildings were erected and decorated with colourful terracotta roofs. Many roof types have been identified on the basis of their morphological and stylistic characteristics and assigned to the Tarentine workshops, while other groups cannot be clearly determined on the basis of morphological and stylistic characteristics alone [1].

A selection of 20 samples, representative of the different roof types from the Archaic and Classical periods, have been identified during the archaeological study. So, a multi-analytical approach, using Optical microscopy (OM), semi-quantitative X-ray powder diffraction (XRPD), X-ray fluorescence (XRF) and SEM-EDS analyses, were applied for petrographic and geochemical characterization of the minerals.

Both the crystalline and amorphous fractions were calculated using the internal standard method applying the Rietveld method. Four groups with different contents of volcanic and carbonate inclusions were identified by cluster analysis of the petrographic and mineralogical data. EDS microanalysis of volcanic inclusions, mainly clinopyroxenes, was also performed and effectively used to address the origin of the raw materials.

References

[1] T. Ismaelli, Riflessi dell'architettura tarantina a Castro (2023). In: D'Andria F., Degl'Innocenti E., Caggia M.P., Ismaelli T., Mancini L. (Eds), Athenaion - Tarantini, Messapi e altri nel Santuario di Atena a Castro, Catalogo della mostra, MArTA - Museo Archeologico Nazionale di Taranto, MAR di Castro - Museo Archeologico "Antonio Lazzari" di Castro, Bari, 125-131.

Project Prin 2020 The Time of Castles: the raw materials for the production of castle mortars

S. Calandra ([*, a]), E. Pecchioni ([a]), T. Salvatici ([a]), A. Arrighetti ([b]), C. Lubritto ([c]), A. Fiore ([d]), C.A. Garzonio ([a]), G. Bianchi ([b])

(a) Department of Earth Science, University of Florence, Via G. La Pira, 4, 50121, Florence, Italy

(b) Department of History and Cultural Heritage, University of Siena, Via Roma, 56, 53100, Siena, Italy

(c) Department of Environmental, Biological and Pharmaceutical Sciences and Technologies, MAREa Centre Via Vivaldi, 43, 81100 Caserta, Italy

(d) Department of Historical Studies, University of Turin, Palazzo Nuovo, Via S. Ottavio, 20, 10124 Turin, Italy

* Presenting author

sara.calandra@unifi.it

Archaeometric analyses were essential as part of the PRIN 2020 CASTLES project, which investigates mediaeval castles in central and north-eastern Italy, in order to determine their chronology. The mineralogical-petrographic and chemical investigations carried out (including XRDP, PLM, SEM-EDS and PLM-CL) focused on the raw materials used to produce the castle mortars at the various archaeological sites. This analysis was crucial for the characterization of the mortars and the selection of the most suitable samples for dating. The composition and properties of the binder and aggregates in the mortars depend on the region from which the raw materials originate and the location of the buildings. The mortars of the castles in Tuscany, Piedmont and Liguria differ due to the different geology and areas, leading to variations in the aggregates and carbonate rock used to produce binders in the three regions.

Based on the results obtained, we were able to select the most suitable mortars for dating: airhardening lime mortars are the most suitable, while air-hardening magnesium lime mortars and natural hydraulic lime can cause problems. The aggregate composition data provided information about the supply area. It is important to emphasise that the source areas have shifted over the centuries due to the expansion of settlements. The type of lithologies used may or may not confirm the local production of artefacts (as in the castles studied), which is helpful in the 'relative dating' of constructions.

Acknowledgements

Research within the PRIN Project - MIUR protocol: 20203YX58R "Il tempo dei castelli: Ricerche multidisciplinari per una nuova cronologia dei cantieri di incastellamento (XI-XII secolo)," CUP: B53C2100029000, in collaboration between University of Siena (Prof. G. Bianchi PI, DSSBC), University of Campania "Luigi Vanvitelli" (coordinator Prof. C. Lubritto, DISTABiF), University of Turin (coordinator Prof. A. Fiore, Dept. of Historical Studies) and University of Florence (coordinator Prof. C.A. Garzonio, DST). More information: https://castles.unisi.it/

True or false? Archaeometric study on the authenticity of a sculpture found in 1991 during archaeological excavations in Ustica (PA)

A. Russolillo [a, e], G. Montana [b], L. Randazzo[b], S.de Vita [c], P. Talamo [d], D. Targia [a], F. Foresta Martin [c,f*]

[a] Parco archeologico di Himera Solunto e Iato (Regione Siciliana)
(b) Dipartimento di Scienze della Terra e del Mare (DiSTeM), Università degli Studi di Palermo
(c) Istituto Nazionale di Geofisica e Vulcanologia (INGV)
(d) Direzione Regionale Musei Campania, Ministero della Cultura (MiC)
(e) Università degli Studi Suor Orsola Benincasa di Napoli
(f) Laboratorio Museo di Scienze della Terra Isola di Ustica (LABMUST) * Presenting author

franco.forestamartin@ingv.it

On the morning of May 21, 1991, during archaeological excavations at the Faraglioni Village (Middle Bronze Age) on the island of Ustica, under the direction of the American archaeologist Robert Ross Holloway, a small tuff sculpture depicting a stylized female figure was discovered. Holloway himself reported this as the first example of a Middle Bronze Age sculpture found in Sicily [1,2]. Two years later, on March 11, 1993, a letter sent to various parties claimed that the sculpture was fake, furtively placed in the excavation as a prank. This sparked a bitter controversy between Holloway, who defended the authenticity of the artefact and considered the prank an attempt to discredit his discovery, and Giovanni Mannino, who had carried out excavations at the Faraglioni site before Holloway and maintained that the find was indeed a forgery [3,4]. The dilemma has remained unresolved for over thirty years, with no scientific initiative to provide an answer.

With this study, we announce the start of a multidisciplinary scientific investigation aimed at detecting clues of the authenticity or falsity of the artifact. Preliminary results from non-destructive elemental analysis using portable X-ray fluorescence (pXRF) indicate:

The sculpture in tuff

1. The tuff of the sculpture has the same geochemical fingerprint (Naalkaline hawaiite) as the tuffs of Mt. Falconiera, a volcano located about 1 km east of the Villaggio dei Faraglioni, inactive for over 100 kyr; 2. Some samples of tuff from Mt. Falconiera, slightly engraved by us using modern metal tools, show clear contamination of the trace elements contained in the alloys of those tools; 3. The search for similar contamination on the Holloway artifact has yielded negative results.

A first provisional conclusion to draw is that the Holloway sculpture shows no evidence of having been worked with modern tools.

Further studies are underway to verify the concentration of Cu (copper) in the surface of the artifact beyond that naturally present in the volcanic tuffs, which could indicate it was worked with a Bronze Age tool. Additional investigations are planned to compare the morphological and stylistic features of the sculpture with those of similar contemporary artifacts.

References

[1] R.R. Holloway, Rinvenimento di una scultura della media età del bronzo, Sicilia Archeologica (1991), 24, 81 – 5.
[2] R.R. Holloway &, S.S. Lukesh, Ustica I, Archaeologia Transatlantica (1995), XIV.
[3] S.S. Lukesh & R.R. Holloway, The non-fraud of the Middle Bronze Age stone goddess from Ustica: a reverse Piltdown hoax, Antiquity (2002), 76, 974-9.
[4] R.R. Holloway &, G. Mannino, Ustica: la polemica. Confronto tra R.R. Holloway e G. Mannino. Sicilia Archeologica (1997), 30, 13 – 8.