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ROMA TRE UNIVERSITÀ DEGLI STUDI



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2023 IMEKO INTERNATIONAL CONFERENCE ON

METROLOGY FOR ARCHAEOLOGY AND CULTURAL HERITAGE

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CONFERENCE PROGRAM

Friday, October 20

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Room: Department of Engineering DIIEM - Sala Conferenze

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Room: Aula 2 - Department of Sciences

491 **Handheld laser-induced breakdown spectroscopy, portable energy dispersive X-ray fluorescence spectroscopy and Graph Clustering applied to the identification and inner stratigraphy of archaeological metallic artifacts**

Giorgio Saverio Senesi (CNR - Istituto per la Scienza e Tecnologia dei Plasmi (ISTP) - Sede di Bari), Sara Mattiello (CNR - Istituto per la Scienza e Tecnologia dei Plasmi (ISTP) - Sede di Bari), Vincenzo Palleschi (CNR - Istituto di Chimica dei Composti Organo-Metallici (CNR-ICCOM), U.O.S. di Pisa), Bruno Cocciaro (CNR - Istituto di Chimica dei Composti Organo-Metallici (CNR-ICCOM), U.O.S. di Pisa), Girolamo Fiorentino (Laboratory of Archeobotany and Paleoecology, Department of Cultural Heritage, University of Salento) and Olga De Pascale (CNR - Istituto per la Scienza e Tecnologia dei Plasmi (ISTP) - Sede di Bari)

496 **Digitalization of Bernini's drawing Tondo depicting St. Joseph with the baby Jesus. Increasing knowledge and monitoring surface cracks**

Beatrice Calosso (ENEA), Marialuisa Mongelli (ENEA) and Sara Pettisano (Pisa University)

502 **In situ characterization of prehistoric rock paintings: the Côa Valley (Portugal)**

Jose Santiago Pozo Antonio (Universidade de Vigo), Teresa Rivas (Universidade de Vigo), Pablo Barreiro (Universidade de Vigo), Vera Caetano (University of Coimbra), Fernando Carrera (Rock Art Conservation and Management) and Lara Bacelar Alves (University of Coimbra)

508 **Preventive conservation plan for a group of bronze sculptures from the Gori Art Collection**

Sara Croci (Department of Applied Science and Technology, Politecnico di Torino, Turin, Italy), Leila Es Sebar (Department of Applied Science and Technology, Politecnico di Torino, Turin, Italy), Caterina Gori (Collezione Gori, Fattoria di Celle, Santomato, Pistoia, Italy), Leonardo Iannucci (Department of Applied Science and Technology, Politecnico di Torino, Turin, Italy), Emma Angelini (Department of Applied Science and Technology, Politecnico di Torino, Turin, Italy) and Sabrina Grassini (Department of Applied Science and Technology, Politecnico di Torino, Turin, Italy)

514 **Processing of shaking table test data of a historic masonry structure by graph-based methods**

Vincenzo Fioriti (ENEA), Antonino Cataldo (ENEA), Alessandro Colucci (ENEA), Chiara Ormando (ENEA), Fernando Saitta (ENEA), Domenico Palumbo (ENEA) and Ivan Roselli (ENEA)

Session 4.1 - Multiscalar Approaches to Digital Documentation of Archaeology: Challenges, implications, and solutions

Room: Department of Engineering DIIEM - Sala Conferenze

520 **Phygital sculptures for archaeological dissemination: The head of Sant'Elena**

Michele Russo (History, Representation and Restauration of Architecture, Sapienza University of Rome), Luca James Senatore (History, Representation and Restauration of Architecture, Sapienza University of Rome), Raffaella Giuliani (Pontificia Commissione di Archeologia Sacra) and Rocco Bochicchio (Soprintendenza Speciale Archeologia, Belle Arti e Paesaggio di Roma)

526 **Multi-technique approach to unveil the composition, fabrication, and potential provenance of a unique pre-Roman glass collection (IV-I BC)**

Suset Barroso-Solares (University of Valladolid), Estefania Estalayo (Department of Analytical Chemistry, University of the Basque Country (UPV/EHU)), Elvira Rodriguez-Gutierrez (University of Valladolid), Violeta Hurtado-Garcia (University of Valladolid), Ricardo Vicente-Rojas (University of Valladolid), Oscar Fadon (University of Valladolid), Julene Aramendia (Department of Analytical Chemistry, University of the Basque Country (UPV/EHU),), Jose Carlos Coria-Noguera (Centro de Estudios Vacceos "Federico Wattenberg", Faculty of Philosophy and Literature, University of Valladolid), Quentin Lemasson (Centre de Recherche et de Restauration des Musées de France, C2RMF), Claire Pacheco (Centre de Recherche et de Restauration des Musées de France, C2RMF), Angel Carmelo Prieto (University of Valladolid), Carlos Sanz-Minguez (Centro de Estudios Vacceos "Federico Wattenberg", University of Valladolid, Valladolid,), Juan Manuel Madariaga (Department of Analytical Chemistry, University of the Basque Country (UPV/EHU), Bilbao, Spain) and Javier Pinto (University of Valladolid)

532 **The ancient Stone Ship. Integrated investigations on the original morphology of the Tiber Island, between legend and material consistency**

Emanuela Chiavoni (Università Sapienza di Roma), Francesca Porfiri (Università Sapienza di Roma) and Gaia Lisa Tacchi (Università Sapienza di Roma)

537 **Survey and analysis of the Fossanova Abbey**

Roberto Barni (Sapienza DIpartimento di storia disegno e restauro dell'architettura) and Carlo Inglese (Sapienza DIpartimento di storia disegno e restauro dell'architettura)

543 **Integrated survey for the modeling of complex environments.La Grotta di San Michele Arcangelo a Olevano sul Tusciano,Salerno**

Lorena Centarti (Università degli studi di Salerno), Carla Ferreyra (Università degli studi di Salerno), Caterina Gabriella Guida (Università degli studi di Salerno), Marco Limongiello (Università degli studi di Salerno) and Barbara Messina (Università degli studi di Salerno)

Session 4.2 - Terahertz, millimeter wave and optical techniques applied to cultural heritage

Room: Aula B - Department of Mathematics and Physics

549 **Characterization of Roman Amphora Sherds Using Terahertz Time-of-Flight Tomography**

Min Zhai (International Research Lab 2958 GeorgiaTech - CNRS), Alexandre Locquet (International Research Lab 2958 GeorgiaTech - CNRS), Haolian Shi (International Research Lab 2958 GeorgiaTech - CNRS), Cesar Carreras Monfort (Universitat Atònoma de Barcelona) and D.S Citrin (International Research Lab 2958 GeorgiaTech - CNRS)

554 **Terahertz imaging super-resolution for documental heritage**

Danae Antunez Vazquez (Department of Physics, University Sapienza; ARCHMAT (EMMJD)), Laura Pilozzi (Istituto Sistemi Complessi - CNR; Research Center Enrico Fermi.), Eugenio Del Re (Department of Physics, University Sapienza), Claudio Conti (Department of Physics, University Sapienza; Istituto Sistemi Complessi - CNR; Research Center Enrico Fermi.), Silvia Sotgiu (National Central Library of Rome), Federica Delia (Recto Verso Conservation Studio; Academy of Fine Arts of Rome) and Mauro Missori (Institute for Complex Systems, National Research Council (ISC-CNR), Department of Physics, University Sapienza)

559 **Investigation of natural and synthetic pigments: terahertz continuous-waves spectroscopy (THz-CW) as a reliable high-resolution approach applied to the Cultural Heritage field**

Candida Moffa (Department of Basic and Applied Sciences for Engineering, University of Rome 'Sapienza', Rome, Italy), Fernando Jr. Piamonte Magboo (Department of Basic and Applied Sciences for Engineering, University of Rome 'Sapienza', Rome, Italy), Alessandro Curcio (National Laboratory of Frascati – LNF-INFN, Frascati (RM), Italy), Luigi Palumbo (Department of Basic and Applied Sciences for Engineering, University of Rome 'Sapienza', Rome, Italy), Anna Candida Felici (Department of Basic and Applied Sciences for Engineering, University of Rome 'Sapienza', Rome, Italy) and Massimo Petrarca (Department of Basic and Applied Sciences for Engineering, University of Rome 'Sapienza', Rome, Italy)

564 **Terahertz Identification of Characters Written in Iron-Gall Ink on Stacked Paper**

Haolian Shi (School of Electrical and Computer Engineering, Georgia Institute of Technology, Atlanta, Georgia 20223-0250 USA), Leor Jacobi (Device Spectroscopy Laboratory,Inst. for Nanotechnology and Adv. Materials,Bar-Ilan University,Ramat-Gan 5290002,Israel), Alexandre Locquet (Georgia Tech-CNS UMI2958, Georgia Tech Europe, 2 Rue Marconi, 57070 Metz, France) and David Citrin (School of Electrical and Computer Engineering, Georgia Institute of Technology, Atlanta, Georgia 20223-0250 USA)

570 **A THz Scanner to Detect Moisture on Wood Samples**

Manuel Greco (Università degli Studi "Roma Tre"), Fabio Leccese (Università degli Studi "Roma Tre"), Emilio Giovenale (ENEA, Fusion and Nuclear Dept, Frascati), Luca Senni (ENEA, Fusion and Nuclear Dept, Frascati), Andrea Taschin (ENEA, Fusion and Nuclear Dept, Frascati) and Andrea Doria (ENEA, Fusion and Nuclear Dept, Frascati)

Session 4.3 - Biodeterioration of cultural heritage: evaluation of damages and new approaches for prevention and control - General Session

Room: Aula C - Department of Mathematics and Physics

576 **IAEA fosters the development and applications of accelerator-based analytical techniques for Heritage Science**

Lena Bassel (Division of Physical and Chemical Sciences, International Atomic Energy Agency), Alessandro Migliori (Nuclear Science and Instrumentation Laboratory, International Atomic Energy Agency Laboratories), Roman Padilla Alvarez (Nuclear Science and Instrumentation Laboratory, International Atomic Energy Agency Laboratories) and Aliz Simon (Division of Physical and Chemical Sciences, International Atomic Energy Agency)

581 **Morphological Analysis of the Kheireddine Palace converted into the Museum of Tunis City**

Rym Bouhamed (Ecole Centrale Supérieure Privée Des Lettres, Des Arts Et Des Sciences De La Communication)

587 **The Role of Photogrammetry in the Conservation Management of Al Mahatta Museum, Sharjah, UAE**
Ahmad Badr Aldin Fattal (University of Sharjah), Rami Al-Ruzouq (University of Sharjah) and Eslam Nofal (University of Sharjah)

593 **LONG-LASTING METHODS TO PREVENT BIODETERIORATION OF STONE MONUMENTS: NEW SILICA NANOSYSTEM COUPLED TO NATURAL BIOCIDE**
Flavia Bartoli (Institute of Heritage Science (CNR-ISPC), Italy.), Zohreh Hosseini (Department of Sciences, University of Roma Tre, Italy.), Alma Kumbaric (Department of Sciences, University of Roma Tre, Italy.) and Giulia Caneva (Department of Sciences, University of Roma Tre, Italy.)

598 **Microwave transducers for moisture content characterization of cultural heritage materials**
Giovanni Gugliandolo (University of Messina), Alessio Altadonna (University of Messina), Adriana Arena (University of Messina), Marina Arena (University of Messina), Luigi Calabrese (University of Messina), Giuseppe Campobello (University of Messina), Giovanni Crupi (University of Messina), Daniela Iannazzo (University of Messina), Francesca Passalacqua (University of Messina), Fabio Todesco (University of Messina), Maria Gabriella Xibilia (University of Messina) and Nicola Donato (University of Messina)

Session 4.4 - Advancement in surface treatments and analyses in the field of conservation science
Room: Aula 1 - Department of Sciences

603 **Monitoring of protective products on Peperino stone using portable devices**
Giuseppe Capobianco (Università Sapienza Ingegneria Materiali e Materie prime), Claudia Pelosi (University of Tuscia - DEIM Dept.), Luca Lanteri (University of Tuscia - DEIM Dept.), Giuseppe Bonifazi (DICMA Sapienza - University of Rome), Oriana Trotta (DICMA Sapienza - University of Rome) and Silvia Serranti (DICMA Sapienza - University of Rome)

609 **The use of micaceous pigments for the chromatic reintegration of the gilded stuccoes in the Lante della Rovere chapel of Palazzo Orsini at Bomarzo**
Elena Testa (University of Tuscia - DIBAF Dept.), Luca Lanteri (University of Tuscia - DEIM Dept.), Giuseppe Capobianco (Sapienza - University of Rome), Giuseppe Bonifazi (Sapienza - University of Rome), Silvia Serranti (Sapienza - University of Rome), Francesca Montozzi (University of Tuscia - DIBAF Dept.), Paola Pogliani (University of Tuscia - DIBAF Dept.) and Claudia Pelosi (University of Tuscia - DEIM Dept.)

615 **Nano-hydroxyapatite for the conservation of Serena stone**
Maduka Lankani Weththimuni (Department of Chemistry, University of Pavia), Giacomo Fiocco (Arvedi Laboratory of Non-Invasive Diagnostics, CISRiC, University of Pavia), Francesca Volpi (Department of Musicology and Cultural Heritage, University of Pavia), Marco Malagodi (Department of Musicology and Cultural Heritage, University of Pavia) and Maurizio Licchelli (Department of Chemistry, University of Pavia)

620 **Unveiling Hidden Insights of Ancient Roman wall paintings in Cremona: In-Depth Knowledge Beyond the Surface with Spectroscopic Analysis**
Francesca Volpi (University of Pavia), Michela Albano (University of Pavia), Giacomo Fiocco (University of Pavia), Maduka Weththimuni (University of Pavia) and Marco Malagodi (University of Pavia)

625 **The Roman mosaic in the Nymphaeum of Villa Giulia in Rome.Characterization of the deteriogen agents and preliminary experimentation of eco-sustainable products**
Miriam Lamonaca (Museo Nazionale Etrusco di Villa Giulia)

Session 4.5 - Microclimate for Cultural Heritage: Conservation in Indoor Environments
Room: Aula 2 - Department of Sciences

631 **Indoor Climate Characterisation of the Quarantine Room of NTNU University Library**
Giulia Boccacci (Department of Earth Sciences, Sapienza University of Rome), Francesca Frasca (Department of Physics, Sapienza University of Rome), Chiara Bertolin (Department of Mechanical and Industrial Engineering, Norwegian University of Science and Technology), Claudio Chimenti (Department of Biology and Biotechnologies "Charles Darwin", Sapienza University of Rome), Erlend Lund (Library Section for Collections, Resources and Digital Services, NTNU University Library), Tonje Dahlin Sæter (Library Section for Collections, Resources and Digital Services, NTNU University Library) and Anna Maria Siani (Department of Physics, Sapienza University of Rome)

637 **Environmental tendency from the retrofit to current time: a case study in Rome, Italy**

Beatrice Bartolucci (Department of Earth Science, Sapienza University of Rome (Italy)), Francesca Frasca (Department of Physics, Sapienza University of Rome (Italy)), Chiara Bertolin (Department of Mechanical and Industrial Engineering, Norwegian University of Science and Technology (Trondheim, Norway)), Gabriele Favero (Department of Environmental Biology, Sapienza University of Rome (Italy)) and Anna Maria Siani (Department of Physics, Sapienza University of Rome (Italy))

643 **Cluster Analysis to identify Microclimate Patterns in a Multi-room Film Archive**

Lisa Vergelli (Sapienza Università di Roma), Francesca Frasca (Sapienza Università di Roma), Chiara Bertolin (Norwegian University of Science and Technology, Trondheim, Norway, Dept. of Mechanical and Industrial Engineering), Gabriele Favero (Sapienza Università di Roma) and Anna Maria Siani (Sapienza Università di Roma)

648 **The diagnostic study of the plaster casts of the Trajan's Column in the Museum of Roman Civilisation (Rome)**

Lisa Vergelli (Sapienza Università di Roma), Francesca Frasca (Sapienza Università di Roma), Chiara Bertolin (Norwegian University of Science and Technology, Trondheim, Norway, Dept. of Mechanical and Industrial Engineering), Gabriele Favero (Sapienza Università di Roma) and Anna Maria Siani (Sapienza Università di Roma)

Saturday, October 21

Session 5.1 - How do we measure scientific reliability? Semantic approaches and software solutions for 3D virtual reconstruction in archaeology

Room: Aula 1 - Department of Sciences

653 **Documentation and Evaluation of Virtual Reconstructions**

Marc Grellert (Technische Universität Darmstadt, FG Digitales Gestalten), Markus Wacker (HTW Dresden, Fakultät Informatik/Mathematik), Jonas Bruschke (HTW Dresden, Fakultät Informatik/Mathematik), Wolfgang Stille (Technische Universität Darmstadt, hessian.ai) and Daniel Beck (Technische Universität Darmstadt, hessian.ai)

659 **Reconstruction beyond Representation in Notre-Dame de Paris**

Anaïs Guillem (UMR 3495 MODÈLES ET SIMULATIONS POUR L'ARCHITECTURE ET LE PATRIMOINE CNRS), Antoine Gros (UMR 3495 MODÈLES ET SIMULATIONS POUR L'ARCHITECTURE ET LE PATRIMOINE CNRS), Abergel Violette (UMR 3495 MODÈLES ET SIMULATIONS POUR L'ARCHITECTURE ET LE PATRIMOINE CNRS) and Livio De Luca (UMR 3495 MODÈLES ET SIMULATIONS POUR L'ARCHITECTURE ET LE PATRIMOINE CNRS)

665 **Virtual Reconstruction as a Scientific Inquiry Tool: the Late Antique Wall of Aquileia (M2) Using the Extended Matrix**

Nicola Delbarba (Università degli Studi di Verona)

671 **A new section of the Extended Matrix methodology: Transformation Stratigraphic Unit (TSU)**

Eleonora Scopinaro (Institute of Heritage Science, National Research Council of Italy (ISPC-CNR)), Simone Berto (Institute of Heritage Science, National Research Council of Italy (ISPC-CNR)) and Emanuel Demetrescu (Institute of Heritage Science, National Research Council of Italy (ISPC-CNR))

677 **A Landscape Matrix: the EM tool for the analysis of the via Appia**

Matteo Lombardi (Università degli Studi di Ferrara)

682 **"Building and reconstructing contexts". Interdisciplinary approach to the enhancement of Phoenician-Punic archaeological elements exhibited in the Museum of Cádiz (SW, Spain)**

Pablo Sicre-González (Universidad de Cádiz - Grupo de Investigación HUM509), Ana María Niveau-de-Villedary Y Mariñas (Universidad de Cádiz - Grupo de Investigación HUM509), Juan Ignacio Vallejo Sánchez (Museo Provincial de Cádiz, Junta de Andalucía – Grupo de Investigación HUM509) and María Auxiliadora Llamas Márquez (Museo Provincial de Cádiz, Junta de Andalucía, Cádiz)

688 **The Virtual Recreation of Mani's Auto de Fe (1562): Methodology and Approach to an Historical Event**
Antonio Rodríguez Alcalá (Universidad Anahuac Mayab), John F. Chuchiak IV (Missouri State University), Zoraida Raimúndez Ares (Universidad Complutense de Madrid), Maria Felicia Rega (Sapienza Università di Roma), Luis Díaz de León (Universidad Autónoma de Yucatán) and Hans B. Erikson (Missouri State University)

Session 5.2 - Nuclear Techniques for Cultural Heritage

Room: Aula 3 - Department of Sciences

694 **When a painting is a history on the rock. A methodological approach to rock art studies through the case of El Alto-Ancasti's Mountain**
Lucas Ignacio Gheco (Centro de Estudios sobre Patrimonios y Ambiente (CEPyA), EAyP-EHyS.)

699 **An innovative neutron spectroscopic imaging technique: mapping the elements distribution inside the bulk of archaeological artefacts**
Giulia Marcucci (Dipartimento di Fisica "G. Occhialini", Università degli Studi di Milano Bicocca and INFN, Sezione di Milano Bicocca), Antonella Scherillo (ISIS Neutron and Muon Source, Didcot, UK), Maria Pia Riccardi (Dip. di Scienze della Terra e dell'Ambiente and Arvedi Laboratorio, Università degli Studi di Pavia), Costanza Cucini (Laboratoire "Métallurgies et Cultures" CNRS, IRAMAT, Université de Technologie Belfort Montbéliard), Marco Tizzoni (Laboratoire "Métallurgies et Cultures" CNRS, IRAMAT, Université de Technologie Belfort Montbéliard) and Daniela Di Martino (Dipartimento di Fisica "G. Occhialini", Università degli Studi di Milano Bicocca and INFN, Sezione di Milano Bicocca)

704 **Quantitative criteria to configure and characterise portable X-ray fluorescence spectrometers**
Eleni Konstantakopoulou (Polytechnic School, Aristotle University of Thessaloniki), Annalaura Casanova Municchia (Consiglio Nazionale delle Ricerche Istituto di Scienze del Patrimonio Culturale (CNR-ISPC)), Roberto Ferretti (Department of Mathematics and Physics, Roma Tre University), Simone Porcinai (Ministero della Cultura Opificio delle Pietre Dure) and Marco Ferretti (Consiglio Nazionale delle Ricerche Istituto di Scienze del Patrimonio Culturale (CNR-ISPC))

Session 5.3 - Organic components in archaeological findings and works of art: current challenges in their identification and characterization

Room: Aula 4 - Department of Sciences

709 **Proteomics and spectroscopic analyses for the molecular characterization of collagen-based animal glues**
Georgia Ntasi (Universitty of Naples Federico II, Department of Chemical Sciences), Brunella Cipolletta (University of Naples Federico II, Department of Chemical Sciences), Carmen Aprea (University of Naples Federico II, Department of Chemical Sciences), Laura Dello Ioio (Dello Ioio Restauri, Vico Equense, Naples), Celia Duce (University of Pisa, Department of Chemistry and Industrial Chemistry), Emanuele Crisci (University of Pisa, Department of Chemistry and Industrial Chemistry), Emilia Bramanti (CNR Pisa, Institute of Chemistry of Organo Metallic Compounds), Alessandro Vergara (University of Naples Federico II, Department of Chemical Sciences), Ilaria Bonaduce (University of Pisa, Department of Chemistry and Industrial Chemistry) and Leila Birolo (University of Naples Federico II, Department of Chemical Sciences)

714 **A pre-restoration minero-petrographic, chemical and microbiological analysis of the sculpture "Real Infante Carlo Tito di Borbone"**
Piergiulio Cappelletti (Dip. di Scienze della Terra, dell'Ambiente e delle Risorse, Università degli Studi di Napoli Federico II), Francesco Izzo (Dip. di Scienze della Terra, dell'Ambiente e delle Risorse, Università degli Studi di Napoli Federico II), Concetta Rispoli (Dip. di Scienze della Terra, dell'Ambiente e delle Risorse, Università degli Studi di Napoli Federico II), Antonino Pollio (Dip. di Biologia , Università degli Studi di Napoli Federico II), Antonino De Natale (Dip. di Biologia , Università degli Studi di Napoli Federico II), Mariagioia Petraretti (Dip. di Biologia , Università degli Studi di Napoli Federico II), Andrea Carpentieri (Dip. di Scienze Chimiche, Università degli Studi di Napoli Federico II), Leila Birolo (Dip. di Scienze Chimiche, Università degli Studi di Napoli Federico II), Giarita Ferraro (Dip. di Scienze Chimiche, Università degli Studi di Napoli Federico II), Anna Manzone (Restoration Laboratory, Royal Palace of Caserta, of the Ministry of Culture) and Alessandro Vergara (Dip. di Scienze Chimiche, Università degli Studi di Napoli Federico II)

719 **Wine production and consumption in context: organic residue analysis in the so-called thermopolium V 4, 6-8 at Pompeii**

Alessandra Pecci (ERAAUB, IAUB, INSA-UB, UNIVERSITAT DE BARCELONA), Simona Mileto (ERAAUB, Universitat de Barcelona), Silvia Ritondale (Scuola Interateneo di Specializzazione in Beni Archeologici - SISBA – DISU), Valeria Amoretti (Parco Archeologico di Pompei), Luana Toniolo (Parco Archeologico di Pompei) and Daniela Cottica (Università Ca' Foscari Venezia, Dipartimento di Studi Umanistici)

725 **The challenge of extracting proteins from potteries**

Brunella Cipolletta (Department of Chemical Sciences, University of Naples Federico II, Naples, Italy), Myriam Fiore (Department of Chemical Sciences, University of Naples Federico II, Naples, Italy), Georgia Ntasi (Department of Chemical Sciences, University of Naples Federico II, Naples, Italy), Massimo Botto (National Research Council of Italy (CNR), Institute of Heritage Sciences (ISPC)), Leila Birolo (Department of Chemical Sciences, University of Naples Federico II, Naples, Italy) and Livia Tirabassi (Department of Archeaeology, Ghent University, Ghent, Belgium)

730 **INTERPRETING SOILS. ARCHAEOLOGY AND CHEMICAL ANALYSIS: ORGÉRES SITE (LA THUILE, AO - ITALY)**

Chiara Maria Lebole (Università di Torino, Dipartimento di Studi Storici), Giorgio Di Gangi (Università di Torino, Dipartimento di Studi Storici), Gabriele Sartorio (Ufficio archeologia, didattica e valorizzazione, Regione Autonoma Valle d'Aosta), Marco Ginepro (Dipartimento di Chimica, Università di Torino) and Giulia Costamagna (Dipartimento di Chimica, Università di Torino)

Session 5.4 - Building Materials and Decay Assessment for On-Land and Underwater Cultural Heritage (CH)

Room: Aula 6 - Department of Sciences

736 **Archaeometric investigations on ancient funerary stone elements from the National Archaeological Museum of Adria (Rovigo, Italy)**

Simone Dilaria (Department of Cultural Heritage, University of Padova), Luigi Germinario (Department of Geosciences, University of Padova), Chiara Girotto (Department of Cultural Heritage, University of Padova), Claudio Mazzoli (Department of Geosciences, University of Padova), Caterina Previato (Department of Cultural Heritage, University of Padova), Giovanna Falezza (Soprintendenza archeologia, belle arti e paesaggio per le province di Verona, Rovigo e Vicenza), Alberta Facchi (Museo Archeologico Nazionale di Adria (RO), Polo museale del Veneto) and Jacopo Bonetto (Department of Cultural Heritage, University of Padova)

742 **Study and restoration of the Sacra Conversazione by Lorenzo Berrettini and experimental tests to evaluate the application of diammonium phosphate as consolidant for the wall painting**

Antonio Paucecch (University of Tuscia - DIBAF Dept.), Luca Lanteri (University of Tuscia - DEIM Dept.), Francesca Montozzi (University of Tuscia - DIBAF Dept.), Paola Pogliani (University of Tuscia - DIBAF Dept.) and Claudia Pelosi (University of Tuscia - DEIM Dept.)

748 **From the context knowledge to Assessment of the Architectural Heritage decay: the case of Santa Maria di Vezzolano rectory (AT)**

Francesca Alberghina (Department of Biology, Ecology and Earth Sciences (DiBEST), University of Calabria), Valentina Barberis (Regional Directorate of Piedmont Museums, Ministry of Culture), Patrizia Capizzi (Department of Earth and Marine Sciences (DiSTeM), University of Palermo), Giulia Comello (Regional Directorate of Piedmont Museums, Ministry of Culture), Giusseppe Milazzo (Regional Directorate of Piedmont Museums, Ministry of Culture), Luciana Randazzo (Department of Earth and Marine Sciences (DiSTeM), University of Palermo) and Salvatore Schiavone (S.T.Art-Test di S. Schiavone & C sas)

753 **Surface and stratigraphic analysis of black crusts using Laser Induced Breakdown Spectroscopy**

Andrea Bergomi (University of Milan), Valeria Comite (University of Milan), Cristina Della Pina (University of Milan), Paula Maria Carmona Quiroga (Instituto de Quimica Fisica Rocasolano), Laura Maestro-Guijarro (Instituto de Quimica Fisica Rocasolano), Mohamed Oujja (Instituto de Quimica Fisica Rocasolano), Ana Crespo Ibanez (Instituto de Estructura de la Materia), Chiara Andrea Lombardi (University of Milan), Mattia Borelli (University of Milan), Marta Castillejo (Instituto de Quimica Fisica Rocasolano) and Paola Fermo (University of Milan)

758 **Promising surface-active ionic liquid coatings for underwater cultural heritage conservation**

Marika Luci (University of Messina and Stazione zoologica Anton Dohrn - Calabria Marine Centre), Filomena De Leo (University of Messina), Clara Urzì (University of Messina), Christian Galasso (Stazione zoologica Anton Dohrn - Calabria Marine Centre), Nadia Ruocco (Stazione zoologica Anton Dohrn - Calabria Marine Centre), Donatella De Pascale (Stazione zoologica Anton Dohrn), Sandra Lo Schiavo (University of Messina), Michela Ricca (University of Calabria), Silvestro Antonio Ruffolo (University of Calabria) and Mauro Francesco La Russa (University of Calabria)

763 **Decay assessment approach of building stones from cultural heritage in freshwater reservoirs**

Ada Saez (Instituto de Geociencias - CSIC Spanish Research Council and UCM Complutense University of Madrid), Natalia Perez-Ema (Instituto de Geociencias - CSIC Spanish Research Council and UCM Complutense University of Madrid) and Monica Alvarez de Buergo (Instituto de Geociencias - CSIC Spanish Research Council and UCM Complutense University of Madrid)

769 **Preliminary assessment of wave energy hazards in a shallow underwater water cultural heritage site**

George Alexandrakis (Coastal & Marine Research Lab, Foundation for Research and Technology - Hellas), Stelios Petrakis (Institute of Oceanography, Hellenic Centre for Marine Research (HCMR)) and Nikolaos Kampanis (Coastal & Marine Research Lab, Foundation for Research and Technology - Hellas)

Session 5.5 - The interaction between atmospheric pollution and cultural heritage: From outdoor to indoor environments - Measurement and Instrumentation for Structural Health Monitoring in Cultural Heritage Structures

Room: Aula 7 - Department of Sciences

774 **Cultural heritage safeguard through multi-parameter air quality monitoring**

Mattia Borelli (Dipartimento di Chimica, Università degli Studi di Milano, Via Golgi, 19, 20133, Milano, Italia), Andrea Bergomi (Dipartimento di Chimica, Università degli Studi di Milano, Via Golgi, 19, 20133, Milano, Italia), Valeria Comite (Dipartimento di Chimica, Università degli Studi di Milano, Via Golgi, 19, 20133, Milano, Italia), Vittoria Guglielmi (Dipartimento di Chimica, Università degli Studi di Milano, Via Golgi, 19, 20133, Milano, Italia), Chiara Andrea Lombardi (Dipartimento di Chimica, Università degli Studi di Milano, Via Golgi, 19, 20133, Milano, Italia), Maria Grazia Perrone (XEarPro Srl., Via delle Primule, 16, 20815, Cogliate (MB), Italia) and Paola Fermo (Dipartimento di Chimica, Università degli Studi di Milano, Via Golgi, 19, 20133, Milano, Italia)

779 **Air quality assessment in cultural heritage: the case study of the Amalfi Cathedral (Amalfi, Salerno, Italy)**

Daniele Sofia (DIIN-Department of Industrial Engineering, University of Salerno), Maria Ricciardi (DCB – Department of Chemistry and Biology, University of Salerno), Oriana Motta (Department of Medicine and Surgery, University of Salerno) and Antonio Proto (DCB – Department of Chemistry and Biology, University of Salerno)

785 **Protecting Art and People: Environmental Monitoring of Beata Vergine dei Miracoli Sanctuary for Health and Heritage Conservation**

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1110 **A portable and autonomous system for the diagnosis of the structural health of cultural heritage (PICUS)**

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“Building and reconstructing contexts”. An interdisciplinary approach to the enhancement of Phoenician-Punic archaeological elements exhibited in the Museum of Cádiz (SW, Spain).

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Abstract – **We present here the knowledge transfer project that we are currently developing as a result of the collaboration between the University of Cádiz and the Provincial Archaeological Museum. The main objective is the virtual reconstruction of certain archaeological contexts of a Phoenician nature documented in the city of Cádiz, with the aim of making them directly accessible to the general public. Employing an interdisciplinary approach, we begin by taking reliable reconstructive hypotheses from a historical-archaeological point of view and transforming them into scientifically cross-checked 3D environments. Within them are incorporated three-dimensional models of the most representative Phoenician-Punic archaeological pieces that are on display in the Museum's Colonisations' Room. Finally, all the information generated by the virtual reconstruction process will be included in the Museum's museography and didactic discourse.**

I. INTRODUCTION

The present-day city of Cádiz is located in the south of the Iberian Peninsula, at the tip of a small peninsula connected to the mainland by a narrow spit of land (Fig. 1). According to classical sources, the city was founded by Phoenicians from Tyre at an early date, which has not been corroborated by archaeology until recently. The most abundant archaeological remains, however, are of a funerary nature and correspond to the various necropolises of the city that have been known since the end of the 19th century, thanks to the chance discovery of the first of the anthropoid sarcophagi of the Sidonian type found in the city [1]. This and other pieces, many of uncertain origin, form part of the permanent collection

Fig. 1: The location of Cádiz and the geo-referenced position of the ritual wells.

exhibited in the Colonisations' Room of the Museum of Cádiz, which houses one of the best collections of objects of Phoenician-Punic origin in the Mediterranean. Other finds have been gradually added to these pieces as a result of the intense archaeological work carried out since

the 1980s in the city, under the protection of the new regulations on heritage matters. However, the particular conditions [2] in which many of the archaeological works were carried out during those years have meant that a large part of the original contexts and the exact origins of the materials are unknown.

Among the recent advances made in research over the last twenty years, particular attention should be made towards the study and analysis of some very abundant structures located in the funerary space, known in the scientific literature as "ritual wells" (Fig. 1) [3].

Despite the relevance that these practices had in the city's past and the extensive scientific bibliography generated around their study, the phenomenon is practically unknown to the vast majority of the population today.

With the aim of making them known to society and taking advantage of the 2022 call for Proof-of-concept projects financed with European "Next Generation" recovery funds, we proposed the project that we are now presenting.

The objectives of the scientific projects developed around the study of ritual wells were focused on the formation of the deposits and the ritual actions that created them, which ultimately explain their origin and development, thereby providing a historical contextualisation of the phenomenon [4]. However, the fundamental problem we face at this point is that, given the specificity of the subject, the discoveries of said study only reach a very limited academic and scientific circle.

To rectify this problem, one of the solutions considered was to use Virtual Archaeology to create virtual reconstructions to disseminate the structures and associated rituals. The main objective of Virtual Archaeology is the 3D representation of the historical-archaeological remains determined by means of a specific methodology and workflow.

The workflow of this discipline begins by carrying out extensive research into the historical-archaeological data necessary to establish the reconstructive hypotheses that are essential for the reconstruction or virtual recreation. In addition to bibliographical research and the search for parallels with which to make comparative hypotheses, if the work requires it, we can obtain information directly from the object or space in question thanks to the use of new technologies.

To reinforce the discourse, it was decided to include many of the pieces exhibited in the Museum of Cádiz in the infographics. Finally, in order to give them context, it was decided to recreate the settings and environments in which the pieces themselves were used during their lifespan, before being discarded as part of the rituals practised in the wells.

II. ARCHAEOLOGICAL CONTEXT OF THE FINDS

Ritual wells are scattered throughout the Phoenician-Punic funerary space of the city of Cádiz, the former Gadir. The wells found in the necropolis of Cádiz are associated with the rituals that took place in the vicinity. These wells are found in the archaeological record clogged with the remains of libation and commensality rituals. Thanks to this, we have been able to discern the different steps that would have taken place in the ritual, as well as the particularities and characteristics of the ritual, such as the sacrifice of canids and their subsequent placement inside the structures [5].

In the last count carried out, more than 80 structures were counted; however, 80% of them have been excavated with obsolete methodologies and were not correctly documented, meaning we only have reliable documentary data on the process of construction, use and closure of the remaining 20% [6].

However, due to the physicochemical qualities of the geological substrates of the city of Cádiz, as well as the particularities of urban and emergency archaeology, the wells documented, following this classification criterion, do not present reliable information on the stratigraphic relationship of these structures and their spatial context in the necropolis itself.

These handicaps have not been a problem when planning this project for the transfer and dissemination of the knowledge generated by our research, but rather a challenge to be overcome through the application of Virtual Archaeology.

By virtue of the existence of protocols and tools associated with this discipline, such as the Extended Matrix [7], it is possible to generate virtual reconstruction contexts from which we can obtain data in relation to the original contexts of the pieces, as well as a graphic expression of the rituals associated with the structures.

With this information, optimised qualitatively and quantitatively, we will be able to depict aspects related to the morphology of the wells themselves, their immediate spatial environment, as well as the ritual processes associated with their closure as functional structures.

A. Chosen archaeological context

The ritual pit we have chosen for this project is one of the best documented. It is located at number 10 of the current Avda. San Severiano (Cádiz, Spain), and was excavated between 2012-2014. In its interior, it has been possible to document different deposits formed from the different ritual actions performed both in the structure itself and in its immediate surroundings (Fig. 2b). Notable among them, for the remarkable nature of the ritual, is the sacrifice of canids and their ritual deposit inside the wells as offerings. This ritual action is repeated in most of the wells and is only known so far in the Phoenician-Punic city of Cádiz (Fig. 2c) [8].

Fig. 2: a. Section of well 4 at Avda. San Severiano nº10. b. Deposits found inside the pit, c. Canid sacrificed and deposited inside the well.

III. METHODOLOGY OF VIRTUAL RECONSTRUCTION – IMPLEMENTATION OF EXTENDED MATRIX VERSION 1.4

The application that we want to carry out based on the Extended Matrix tool, and on the other protocols already mentioned, will result in the creation of reconstructive hypotheses on which we will base the 3D work. These reconstructive hypotheses, and the decision-making developed during the process of creating them, will be shaped depending on the different tools implemented.

We are not starting from scratch; prior to this work, we had the opportunity to apply Virtual Archaeology in a practical way to the analysis and dissemination of other structures from the Phoenician-Punic period in the Bay of Cádiz, namely the construction process of the wall of the Phoenician settlement of Cerro del Castillo, in Chiclana de la Frontera, a town close to Cádiz [9]. In this work, the main tool used in the virtual archaeological record was the Extended Matrix [10]. However, to develop specific workflows that overlapped different protocols for recording and presenting the results of the 3D work, other protocols were included, such as the Scale of Historical-Archaeological Evidence [11] and the Reconstructive Units [12]. The first of these consists of the graphic representation, using a colour scale, of the level of historical-archaeological evidence with which the reconstruction or virtual recreation has been carried out. The second of the tools, the Reconstructive Units, consists of the creation of stratigraphic data sheets, similar to those used in the field of common archaeology, in order to document the virtual reconstruction process in the best possible way. As for the final product, although we were generally satisfied with the results of the workflow, we would like to implement some improvements in its practical application for the current project.

A. Project particularities

The project of virtual reconstruction of the ritual wells of the necropolis of Cádiz has some particular characteristics that version 1.0-1.1-1.2 of the Extended Matrix do not solve. In order to resolve the record problems generated, we will use the version currently under development, version 1.4. We want to materialise our work of generating reconstructive hypotheses in this new version, as it includes new aspects that are very well adjusted to the needs and particularities of the project we are presenting, two of which are of vital importance.

The first is that, in the current case, we want to reconstruct a specific time and solar orientation, with a specific climatology. Moreover, we do not have a photogrammetric model of the space or geographical context, only an overall spatial approximation developed thanks to LiDAR technology and the most recent topographic data from the Phoenician-Punic period [13].

The second particularity of this project is the insertion, almost as protagonists, of characters participating in the ritual process. This complicates the proposed reconstructive hypotheses, as they are not only limited to archaeological structures but also to actions that are not archaeologically recorded (gestures, postures, body physiognomy), a whole intangible heritage related to the ritual aspects intended to be represented. This means that the virtual reconstruction is not linked to a particular period but to a moment captured in the form of a photographic snapshot.

B. Methodology and approach

The process of integral reconstruction of the space and the insertion of the museum pieces from the Phoenician-Punic period has three distinct phases.

The first of these focuses on the creation of the 3D reconstructive hypotheses by gathering as much information as possible. This data should not only be limited to the archaeological aspects of the intervention but also to the immaterial aspects of the intervention. In this phase, collaborative work between the heritage virtualisers and the team of specialist archaeologists is of vital importance.

The second phase consists of the photogrammetric documentation of the selected pieces from the Museum of Cádiz, as well as the generation of the final models for their insertion into the 3D scene. This photogrammetric intervention on the pieces must be carried out jointly with the museum's curatorial-restoration staff. In addition, in this phase, the 3D terrain modelling or DTM is also developed, based on the LiDAR data and the topographical relationship of the chosen geographical

framework in the Phoenician-Punic period, in order to configure the physical space in which the recreations will take place.

Finally, the 3D work itself is carried out, based on the modeling of the scene, its animation, and the export of the results that are deemed appropriate for their correct dissemination (2D infographics, 360º images, etc.). The results obtained will be integrated into the museography discourse following a didactic plan that is developed simultaneously with the professionals in charge during the first two phases of the project.

IV. VIRTUAL ARCHAEOLOGY APPLIED TO TANGIBLE HERITAGE: NECROPOLIS AND WELLS

With regard to the approach of the current work being carried out with a view to generating specific reconstructive hypotheses for the particular case study in question, the following steps have been taken so far.

A. Compilation of archaeological contextual documentation

We have a large amount of information on the structure chosen for its reconstruction, both on the immediate spatial environment and on the process of deposition of the materials: planimetric information, archaeological drawings, photographs, measurements, etc. Once all the available primary archaeological documentation has been gathered, the second step is to complete the relative data on the instruments and objects used and the (possible) food eaten or used as offerings, in order to obtain an overall view of the ritual processes carried out in the necropolis of Cádiz around these structures.

This "secondary" information is the product of intensive research and years of work on these structures, which has made it possible to gather an extensive corpus of documents and document numerous examples of ritual wells and ritual variants.

Once all of the aforementioned information has been gathered, it is now time to propose the appropriate reconstructive hypotheses. The main tool used is, as we have already specified, the Extended Matrix 1.4dev. All the data and documentary sources from which data have been extracted or which have provided information, either directly or indirectly, are collected in it. This is done with the intention of being as transparent as possible both in the decision-making process and in its subsequent publication.

B. The pieces exhibited in the Museum of Cádiz

Simultaneously the first phase of the project is being carried out by the team of archaeologists specialising in the Phoenician-Punic period and the heritage virtualisers, while work is underway to virtualise the objects on display in the "colonisations' room" of the Museum of Cádiz. This work, of vital importance for the achievement of the project's objectives, is being carried out using digital photogrammetry. The pieces chosen are directly related to the well structures, or indirectly to the associated rituals.

Before starting the virtualisation process of the pieces themselves, it is necessary to make a selection of those that are to be included in the virtual reconstruction. This selection of pieces is made following the technical criteria of both the archaeologists specialising in the field and the conservation and restoration staff of the Museum of Cádiz itself.

This work requires careful planning of the data capture, whether due to complications derived from the morphology of the piece, the particular characteristics of the material in which it is made (the shine, for example), or the condition of the piece itself, the deterioration and its state of conservation. Some pieces, such as terracottas or bronzes, pose a real challenge in terms of gloss management, while others, such as sculptures, require specific planning to capture all the details of their morphology.

After the photogrammetry process, the resulting models are being post-processed in all cases (Fig. 3).

Firstly, a photogrammetric optimisation is carried out, with an intensive re-topology of the models. After this intervention, in some cases, various virtual restoration interventions are carried out in conjunction with the restoration and conservation professionals.

In this way, the pieces can be understood volumetrically and functionally, since in some cases, due to post-depositional deterioration, they cannot be correctly interpreted with the naked eye. This work is concluded with a reprojection of textures and their post-processing to improve the optimisation of the model, with the aim of inserting them into the 3D scene.

Fig. 3: On the left optimised and post-processed photogrammetric model. On the right, original photogrammetric model

V. VIRTUAL ARCHAEOLOGY APPLIED TO INTANGIBLE HERITAGE: ACTIONS AND

CHARACTERS

Meanwhile, the intervention of characters as protagonists of the scene to be virtually reconstructed is planned and documented. This is also a key moment, as it requires the participation and collaboration of both the heritage virtualiser and the team of archaeologists and historians, as well as those responsible for the insertion of the virtual products in the museum's museographic and didactic discourse. The choice of the number of people, gender, age, social status or physical characteristics involves complex historical-archaeological and even anthropological research in order to represent the rituals as faithfully as possible as they must have been in reality, many aspects of which escape us. This decision-making has a direct influence on the discourse to be disseminated, as well as on the development of the 3D works themselves. The 3D work of recreating characters, postures and social contexts will be represented as a hypothesis in the Extended Matrix, using the tools implemented in the new version.

Once this research, decision-making and 3D development have been undertaken, the reconstruction work itself can be completed and the results can be exported (Fig. 4). In this scene, carried out as an example of the work we are carrying out, we can see the historical-archaeological reconstruction of the ritual well, as well as the recreation of its immediate geographical context. In this scene, we can also see the insertion of a character, by way of a recreation context, in which the characters acquire a major importance for the correct interpretation of the archaeological remains. Furthermore, in this scene we can appreciate the insertion of two photogrammetric models, the instrumental shell being used by the character, and the perfume burner at the top of the well. Thanks to the generation of this virtual recreation, these pieces acquire meaning and can be seen in their original context.

Fig. 4: Example of virtual reconstruction presented for the project.

VI. CONCLUSIONS

The philosophy of the project, as it is conceived, has a clear vocation towards the dissemination and transfer of the knowledge generated by the research, but it is also (perhaps for this very reason) complex in its execution. A complexity that requires the participation and involvement of an interdisciplinary team made up of professionals from different areas of knowledge and which poses a scenario in which decision-making is key to success and which, at the same time, entails a high degree of responsibility on the part of all the specialists involved to ensure the veracity of the reconstructions, which will be attested and recorded in the tools and protocols of Virtual Archaeology.

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The project team is composed of historians and archaeologists who are experts in the Phoenician world, specialists in heritage virtualisation, professionals from the Museum of Cádiz, educators, and experts in museography, forming a plural and interdisciplinary work team.

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