



ROMA TRE UNIVERSITY / OCTOBER 19-21, 2023

2023 IMEKO INTERNATIONAL CONFERENCE ON

**METROLOGY FOR ARCHAEOLOGY
AND CULTURAL HERITAGE**

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ARCHAEO**

PROCEEDINGS

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CONFERENCE PROGRAM

Friday, October 20

Session 1.1 - Digital tools in Cultural Heritage: 3D modelling and metaverse

Room: Department of Engineering DIEM - Sala Conferenze

- 1 ArcheoVerso: a cultural metaverse for enhancement, technologies, communities, services**
Saverio Giulio Malatesta (Sapienza Università di Roma), Laura Leopardi (Sapienza Università di Roma), Marco Raoul Marini (Sapienza Università di Roma) and Paolo Rosati (Sapienza Università di Roma)
- 6 Realverso Lucanum: a metaverse for innovative didactic and digital tourism**
Diego Sinitò (iInformatica Srl), Giulio Setzu (iInformatica Srl), Alessandro Verderame (iInformatica Srl), Antonio Ruoto (iInformatica Srl) and Vito Santarcangelo (iInformatica Srl)
- 11 XRM imaging for non-destructive age at death estimation of the incinerated teeth from the Motya Tophet**
Martina Trocchi (Department of Earth Science, Sapienza University of Rome), Luciano Fattore (Center for Research and Services Saperi&Co, Sapienza University of Rome), Flavio Cognigni (Department of Basic and Applied Sciences for Engineering, Sapienza University of Rome), Federico Cappella (Department "Italian Institute of Oriental Studies", Sapienza University of Rome), Marco Rossi (Research Center of Nanotechnologies for Engineering, Sapienza University of Rome), Giorgio Manzi (Department of Environmental Biology, Sapienza University of Rome) and Lorenzo Nigro (Department "Italian Institute of Oriental Studies", Sapienza University of Rome)
- 17 Perceiving Ancient Landscape in Digital Simulation. Preliminary Consideration on the Case of the Missing Auser River in Pisa (Tuscany, IT)**
Alberto Caroti (Università di Roma "La Sapienza")
- 22 Finite Element analysis of Vittoriano building based on InSAR data**
Hamed Dabiri (Department of Earth Sciences, Sapienza University of Rome & CERI Research Center), Jessica Clementi (Department of Earth Sciences, Sapienza University of Rome & CERI Research Center), Roberta Marini (Natural Hazards Control and Assessment (N HAZCA srl.)), Paolo Mazzanti (Department of Earth Sciences, Sapienza University of Rome & CERI Research Center), Gabriele Scarascia Mugnozza (Department of Earth Sciences, Sapienza University of Rome & CERI Research Center), Francesca Bozzano (Department of Earth Sciences, Sapienza University of Rome & CERI Research Center) and Dan Bompà (School of Sustainability, Civil and Environmental Engineering, University of Surrey, UK)
- 27 Digital Technologies and 3D Printing for the Communication of Archaeological Discovery: The case of the early-archaic wreck of the strait of Otranto**
Vincenzo Ria (Soprintendenza Nazionale per il patrimonio culturale subacqueo) and Barbara Davide (Soprintendenza Nazionale per il patrimonio culturale subacqueo)

Session 1.2 - Diagnostic for Cultural Heritage: contribution of Raman spectroscopy and other non-destructive techniques to the investigation of art objects - Cultural heritage at synchrotrons

Room: Aula B - Department of Mathematics and Physics

33 Analytical investigations on polychrome artworks from the wooden ceiling of “ex-Ospedale San Matteo” in Pavia

Giacomo Fiocco (Arvedi Laboratory of Non-Invasive Diagnostics, CISRiC, Università di Pavia), Francesca Volpi (Arvedi Laboratory of Non-Invasive Diagnostics, CISRiC, Università di Pavia), Tommaso Rovetta (Arvedi Laboratory of Non-Invasive Diagnostics, CISRiC, Università di Pavia), Chaehoon Lee (Arvedi Laboratory of Non-Invasive Diagnostics, CISRiC, Università di Pavia), Michela Albano (Arvedi Laboratory of Non-Invasive Diagnostics, CISRiC, Università di Pavia), Chiara Delledonne (Arvedi Laboratory of Non-Invasive Diagnostics, CISRiC, Università di Pavia), Maduka L. Wehthimuni (Department of Chemistry, University of Pavia), Mario Colella (Centro Studio e Conservazione Piccolo Chioistro), Anna Letizia Magrassi Matricardi (Museo di Archeologia del Sistema Museale d’Ateneo di Pavia), Curzio Merlo (Laboratorio di Diagnostica applicata ai Beni Culturali, Scuola di Restauro Cr.Forma), Marco Malagodi (Arvedi Laboratory of Non-Invasive Diagnostics, CISRiC, Università di Pavia) and Maurizio Licchelli (Department of Chemistry, University of Pavia)

38 Raman and X-ray fluorescence spectroscopy analysis of decorative ceramic tiles manufactured by Niculoso Pisano from the church of Flores de Ávila (Ávila, Spain)

Oscar Fadon (Archaeological and Historical Materials (AHMAT), University of Valladolid (Spain)), Violeta Hurtado-Garcia (Archaeological and Historical Materials (AHMAT), University of Valladolid (Spain)), Cristian Berga-Celma (Museo de Ávila. Junta de Castilla y León en Ávila. Ávila (Spain)), Carlos Sanz-Velasco (Archaeological and Historical Materials (AHMAT), University of Valladolid (Spain)), Javier Pinto (University of Valladolid) and Suset Barroso-Solares (Archaeological and Historical Materials (AHMAT), University of Valladolid (Spain))

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Valentina Alemanno (Dept. SBAI, Sapienza University of Rome), Pierfrancesco Atanasio (Dept. SBAI, Sapienza University of Rome), Giancarlo La Penna (Dept. SBAI, Sapienza University of Rome), Chiara Mancini (Dept. SBAI, Sapienza University of Rome), Flavio Cognigni (Dept. SBAI, Sapienza University of Rome), Serena Silvestri (Dept. SBAI, Sapienza University of Rome), Anacleto Proietti (Dept. SBAI, Sapienza University of Rome), Marco Rossi (Dept. SBAI, Sapienza University of Rome), Alessandro Ciccola (Dept. of Chemistry, Sapienza University of Rome), Alessandro Nucara (Dept. of Physics, Sapienza University of Rome), Barbara Barbaro (Soprintendenza archeologia belle arti e paesaggio Viterbo e Etruria Meridionale), Paolo Binaco (Museo territoriale Lago di Bolsena) and Danilo Dini (Sapienza University of Rome, Dept. of Chemistry)

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Chiara Andrea Lombardi (Università degli Studi di Milano), Valeria Comite (Università degli Studi di Milano), Andrea Bergomi (Università degli Studi di Milano), Mattia Borelli (Università degli Studi di Milano), Gianluca Carabelli (Università degli Studi di Milano), Valentina Verzoni (Scuola di Restauro Botticino - Valore Italia), Mario Colella (Centro studio e conservazione Piccolo Chioistro) and Paola Fermo (Università degli Studi di Milano)

55 Inorganic, organic and biochemical characterization of wall paintings from a Roman domus

Leila Birolo (Dept. Chemical Sciences, University of Naples Federico II), Manuela Rossi (Dept. Earth Sciences, Environment and Resources, University of Naples Federico II), Miriam Alberico (Dipartimento di Scienze dell’Antichità, Università la Sapienza), Nunzia De Riso (Dept. Chemical Sciences, University of Naples Federico II), Georgia Ntasi (Dept. Chemical Sciences, University of Naples Federico II), Antonella Tomeo (Soprintendenza Archeologia Belle Arti e Paesaggio per le Province di Caserta e Benevento) and Alessandro Vergara (Dept. Chemical Sciences, University of Naples Federico II)

60 Synchrotron X-ray for Archaeometry: state-of-the-art and future perspectives

Ilaria Carlomagno (Elettra Sincrotrone Trieste), Giuliana Aquilanti (Elettra - Sincrotrone Trieste) and Gangadhar Das (Elettra - Sincrotrone Trieste)

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Room: Aula C - Department of Mathematics and Physics

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- 69 **Ground-penetrating Radar survey at the Basilica of Santa Caterina D’Alessandria (Galatina-Italy)**
Giancarlo De Pascalis (Università di Roma la Sapienza), Lara De Giorgi (ISPC-CNR), Ivan Ferrari (ISPC-CNR), Francesco Giuri (ISPC-CNR), Dora Francesca Barbolla (ISPC-CNR), Lucrezia Longhitano (University of Catania), Chiara Torre (University of Catania) and Giovanni Leucci (ISPC-CNR)
- 74 **Ground Penetrating Radar investigation at Roman Villas of Sabina Tiberina: the case of the villas of Montebuono and Cottanello (Rieti, Italy)**
Daniela Tarallo (National Research Council – Institute of Heritage Science, Naples), Michele Punzo (National Research Council – Institute of Heritage Science, Naples), Vincenzo Di Fiore (National Research Council – Institute of Heritage Science, Naples), Carla Sfameni (National Research Council – Institute of Heritage Science, Rome), Francesca Colosi (National Research Council – Institute of Heritage Science, Rome), Anna De Meo (National Research Council – Institute of Heritage Science, Rome), Tommaso Leti Messina (National Research Council – Institute of Heritage Science, Rome) and Daniele Verrecchia (National Research Council – Institute of Heritage Science, Rome)
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Davide Tanasi (University of South Florida), Katya Stroud (Heritage Malta), David Cardona (Heritage Malta), Dario Calderone (Ludwig Maximilians Universität), Paolo Trapani (University of Catania) and Frederick Pirone (Hillsborough Community College)
- 83 **Multiple GPR surveys in urban area. The case of S. Giovanni in Laterano and S. Croce in Gerusalemme, as part of ERC Rome Transformed Project**
Salvatore Piro (ISPC CNR Institute of Heritage Sciences, Italy), Daniela Zamuner (ISPC CNR Institute of Heritage Sciences, Italy), Daniele Verrecchia (National Research Council CNR ISPC) and Tommaso Leti Messina (ISPC CNR Institute of Heritage Sciences, Italy)
- 88 **Satellite automatic extraction and characterization of looting features in the Peruvian desert**
Alessia Brucato (Univeristy of Bari Aldo Moro, Institute of Heritage Science CNR), Rosa Lasaponara (Institute of Methodologies for Environmental Analysis CNR) and Nicola Masini (Institute of Heritage Science CNR)

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- 93 **3D virtual restoration: from photogrammetric and 3D modeling techniques to integration with scientific documentation in a GIS environment**
Luca Lucchetti (Università degli Studi della Toscana)
- 98 **Dimensional assessment in bioarchaeology applications: a preliminary study on quality controls in 3D printing of human skulls**
Marta Cecchitelli (University of Roma Tre), Giorgia Fiori (University of Roma Tre), Gabriele Bocchetta (University of Roma Tre), Federico Filippi (University of Roma Tre), Fabio Leccese (University of Roma Tre), Jan Galo (IRCCS Children Hospital Bambino Gesù), Salvatore Andrea Sciuto (University of Roma Tre) and Andrea Scorza (University of Roma Tre)
- 104 **Dynamic 3D model for decoding archaeological complexity of funerary contexts**
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- 109 **HBIM for restoration project and data management of a religious complex**
Ilaria Trizio (Institute for Construction Technologies of Italian National Research Council), Federica Miconi (Institute for Construction Technologies of Italian National Research Council), Augusto Ciciotti (Ministry of Culture Regional Secretariat of Abruzzo) and Francesca Savini (Institute for Construction Technologies of Italian National Research Council)

- 115 Extended BIM: a proposed workflow for the integration of the HBIM and EM approaches**
Ariane Galeano (Department of Civil Engineering, University of Salerno), Anna Sanseverino (Department of Civil Engineering and Architecture, University of Pavia), Simone Berto (Institute of Heritage Science, National Research Council), Emanuel Demetrescu (Institute of Heritage Science, National Research Council) and Marco Limongiello (Department of Civil Engineering, University of Salerno)
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Augusto Palombini (CNR ISPC)

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Sara Lenzi (Università di Pisa), Marta Novello (Direzione Regionale Musei Friuli Venezia Giulia), Monica Salvadori (Università degli Studi di Padova, Dipartimento dei beni Culturali), Ivana Angelini (Università degli Studi di Padova, Dipartimento dei Beni Culturali), Alfonso Zoleo (Università degli Studi di Padova, Dipartimento di Scienze Chimiche) and Rita Deiana (Università degli Studi di Padova, Dipartimento dei Beni Culturali)
- 137 An improved methodology for extending the applicability of Reflectance Transformation Imaging to confined sites**
Federico Di Iorio (Department of Applied Science and Technology (DISAT) - Politecnico di Torino, Turin), Leila Es Sebar (Department of Applied Science and Technology (DISAT) - Politecnico di Torino, Turin), Luca Lombardo (Department of Applied Science and Technology (DISAT) - Politecnico di Torino, Turin), Amina Vietti (Department of Applied Science and Technology (DISAT) - Politecnico di Torino, Turin), Sara Aicardi (Museo Egizio, Turin), Federica Pozzi (Centro di Conservazione e Restauro Beni Culturali "La Venaria Reale", Venaria Reale) and Sabrina Grassini (Department of Applied Science and Technology (DISAT) - Politecnico di Torino, Turin)
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Andrea Massi (Department of Physics of "La Sapienza" University of Rome), Antonio Cosentino (Department of Earth Sciences, Sapienza University of Rome), Paolo Mazzanti (Department of Earth Sciences, Sapienza University of Rome), Michele Ortolani (Department of Physics of "La Sapienza" University of Rome) and Jessica Clementi (Department of Earth Sciences, Sapienza University of Rome)
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Nagmeldeen Hamza (National Museum of Ras Al Khaimah)

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Room: Aula C - Department of Mathematics and Physics

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- 177 An innovative heuristic strategy for the management of buried scenarios with strong discontinuities**
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- 181 From Space to Tree: multisensor and multiscale remote sensing based approach for monitoring monumental trees. The case of archaeological park of Colosseum in Rome. Preliminary results**
Nicola Masini (CNR-Istituto di Scienze del Patrimonio Culturale), Gabriella Strano (Ministero della Cultura - Colosseum Archaeological Park, Piazza S. Maria Nova, 53, 00186 Roma), Costanza Fiorentino (UniBas, Via Nazario Sauro 85, 85100 Potenza (PZ)), Domenico Conte (Digimat srl, Via Giovanni Agnelli, 75100 Matera (MT)), Nicodemo Abate (Consiglio Nazionale delle Ricerche - ISPC), Antonio Loperte (National Research Council – Institute of Methodologies for Environmental Analysis), Antonio Minervino Amodio (National Research Council – Institute of Heritage Science), Alfonsina Russo (Ministero della Cultura - Colosseum Archaeological Park, Piazza S. Maria Nova, 53, 00186 Roma (RM)), Angelo Donvito (Digimat srl, Via Giovanni Agnelli, 75100 Matera (MT)) and Rosa Lasaponara (CNR - IMAA)

POSTER SESSION 1

Room: Department of Engineering DIEM - Sala Conferenze

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Amira Souliman (University of Évora), Eva Leitão (Lisbon City Council), Cristina Nozes (Lisbon City Council), Patrícia Moita (Évora University | HERCULES Laboratory) and Cristina Galacho (Évora University | HERCULES Laboratory)
- 196 AI-assisted Reconstruction of Archaeological Pottery from digital 3D mesh models**
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- 201 Comparison of design formulas for torsion based catapults**
Kasper Mayntz Paasch (University of Southern Denmark) and Alexander Petersen Paasch (Aarhus University)
- 207 Study of wood samples positioning on two microwave planar coupled ring resonators for water content measurements**
Livio D'Alvia (Università Sapienza - DIMA), Ludovica Apa (Università Sapienza - DIMA), Emanuele Rizzuto (Università Sapienza - DIMA) and Zaccaria Del Prete (Università Sapienza - DIMA)
- 213 Microwave reflectometry system for non-invasive wood moisture content monitoring**
Andrea Cataldo (University of Salento), Antonio Masciullo (University of Salento), Emanuele Piuze (University of Rome Sapienza) and Raissa Schiavoni (University of Salento)
- 218 From landscape to excavation: using new smart tools for multiscale archaeological investigations**
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- 224 System design for precision weeding in secondary archaeological sites**
Mariagrazia Leccisi (Dipartimento di Scienze - Università degli Studi "Roma Tre"), Giuseppe Schirripa Spagnolo (Università Roma Tre - Dipartimento di Matematica e Fisica) and Fabio Leccese (Università degli Studi "Roma Tre")
- 230 Influence of environmental data on the degradation processes on the wall paints of the Archeological Site of Baia (Italy)**
Paola Cennamo (Department of Humanities, University of Naples Suor Orsola Benincasa), Roberta Scielzo (Department of Humanities, University of Naples Suor Orsola Benincasa), Giorgio Trojsi (Department of Humanities, University of Naples Suor Orsola Benincasa) and Elena Chianese (Department of Science and Technology, Parthenope, University of Naples,)
- 235 Protecting Archaeological Collection: The Importance of Microclimatic Monitoring and Diagnostic Investigations in the Preservation of the “Sala delle Madri”**
Antonio Spagnuolo (Energreenup srl), Carmela Vetromile (Energreenup srl), Antonio Masiello (Energreenup srl), Maria Francesca Alberghina (S.T.Art-Test di S. Schiavone & C.), Salvatore Schiavone (S.T.Art-Test di S. Schiavone & C.), Noemi Mantile (Dipartimento Scienze Ambientali Biologiche e Farmaceutiche Università Campania "L. Vanvitelli"), Giovanni Solino (Territorial planning, environment and ecology sector, local authority Province of Caserta) and Carmine Lubritto (Dipartimento Scienze Ambientali Biologiche e Farmaceutiche Università Campania "L. Vanvitelli")
- 240 A multidisciplinary investigation of an ancient kiln excavated at Costigliole Saluzzo: new archaeometric and archaeomagnetic results**
Yuri Leite Santos (Chemistry department, University of Turin), Evdokia Tema (Earth Sciences Department, University of Turin. ALP-CIMaN Alpine Palaeomagnetic Laboratory), Patrizia Davit (Chemistry department, University of Turin), Diego Elia (Historical Studies Department, University of Turin), Valeria Meirano (Historical Studies Department, University of Turin), Fulvio Fantino (TTA- Turin Thermoluminescence Analysis) and Monica Gulmini (Chemistry department, University of Turin)
- 246 Noravank Monastery in Armenia. Multidisciplinary surveying**
Marco Carpiceci (Sapienza Università di Roma, DiSDRA), Fabio Colonnese (Sapienza Università di Roma, DiSDRA), Antonio Schiavo (Sapienza Università di Roma, DiSDRA) and Rachele Zanone (Independent Researcher)
- 252 The X-ray irradiation as disinfection treatment: the state-of-the-art**
Cristina Cicero (University of Rome "Tor Vergata"), Monia Vadrucchi (Agenzia Spaziale Italiana), Claudia Mazzuca (University of Rome "Tor Vergata"), Leonardo Severini (University of Rome "Tor Vergata"), Fulvio Mercuri (University of Rome "Tor Vergata"), Ugo Zammit (University of Rome "Tor Vergata") and Noemi Orazi (University of Rome "Tor Vergata")
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- 263 Preliminary multi-spectral imaging investigation on items from the Aga Khan III necropolis, Aswan (Egypt)**
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Raffaele Martorana (Dipartimento di Scienze della Terra e del Mare, Università degli Studi di Palermo, 90123 Palermo, Italy), Patrizia Capizzi (Dipartimento di Scienze della Terra e del Mare, Università degli Studi di Palermo, 90123 Palermo, Italy), Calogero Giambrone (I.I.S.S. Archimede, Cammarata (AG), Italy), Valeria Genco (I.I.S.S. Archimede, Cammarata (AG), Italy) and Lisa Simonello (I.C. Giovanni XXIII, Cammarata (AG), Italy)

- 278 **Multi-spectral investigation on a sheet with dedication and drawing by Giorgio de Chirico (1929)**
Paola Fermo (Dipartimento di Chimica, Università di Milano), Paolo Baldacci (Archivio dell'Arte Metafisica), Davide Manzini (Madatec srl), Valeria Comite (Dipartimento di Chimica, Università di Milano), Chiara Andrea Lombardi (Dipartimento di Chimica, Università di Milano), Andrea Bergomi (Dipartimento di Chimica, Università di Milano), Mattia Borelli (Dipartimento di Chimica, Università di Milano) and Vittoria Guglielmi (Dipartimento di Chimica, Università degli Studi di Milano)
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Laura Fabbiano (Polytechnic of Bari, University), Alessandro De Marco (Archeo APS EPS Association), Manuela Incert (University of Ferrara), Anna Castellano (Polytechnic of Bari, University), Gaetano Vacca (Polytechnic of Bari, University) and Rosario Morello (University Mediterranea of Reggio Calabria)
- 288 **A Technique to Support the Restoration Activities of Archaeological Discoveries**
Rosario Morello (Dept. DIIES, University Mediterranea of Reggio Calabria, Italy), Claudio De Capua (Dept. DIIES, University Mediterranea of Reggio Calabria, Italy), Andrea Maria Gennaro (SABAP-RC, Archaeological Superintendence of Reggio Calabria, Italy) and Laura Fabbiano (Dept. DMMM, Politecnico di Bari, Bari, Italy)
- 294 **Electromagnetic survey to detect a section of the Messapian city walls in Ugento (Lecce)**
Dora Francesca Barbolla (ISPC-CNR), Lara De Giorgi (ISPC-CNR), Ivan Ferrari (ISPC-CNR), Francesco Giuri (ISPC-CNR), Ilaria Miccoli (ISPC-CNR), Giuseppe Scardozzi (ISPC-CNR), Chiara Torre (Università di Catania) and Giovanni Leucci (ISPC-CNR)
- 299 **A new Matrix for the Architectural Stratigraphic Diagram**
Roberto Villalobos (Sapienza University of Rome, Department of History, Restoration and Representation of Architecture)
- 305 **Significant data and information in complex analysis of the architectural heritage, the Republican Museum of Itu, Brazil**
Maisa Almeida (Postdoctoral Fellow USP), Marcela Sousa (Postdoctoral Fellow UNICAMP) and Gustavo Vanini (Faculdade de Arquitetura e Urbanismo - Universidade de São Paulo)
- 311 **Geophysical investigation at the Cathedral of Nardò (Lecce, Italy)**
Lara De Giorgi (ISPC-CNR), Ivan Ferrari (ISPC-CNR), Francesco Giuri (ISPC-CNR), Chiara Torre (University of Catania), Dora Francesca Barbolla (ISPC-CNR) and Giovanni Leucci (ISPC - CNR)
- 316 **The study of Limes Arabicus using aerial and satellite remote sensing documentation. The case of Umm ar-Rasas (Amman, Jordan)**
Francesca Di Palma (University of Bari 'Aldo Moro' / National Research Council – Institute of Heritage Science, Lecce), Roberto Gabrielli (National Research Council – Institute of Heritage Science, Rome), Ilaria Miccoli (National Research Council – Institute of Heritage Science, Lecce) and Giuseppe Scardozzi (National Research Council – Institute of Heritage Science, Lecce)
- 320 **Multitemporal analysis of remote sensing data for the study of the ancient city of Venusia (Venosa, Basilicata)**
Ilaria Miccoli (National Research Council –Institute of Heritage Science), Immacolata Ditaranto (National Research Council –Institute of Heritage Science), Pasquale Merola (National Research Council –Institute of Heritage Science) and Giuseppe Scardozzi (National Research Council –Institute of Heritage Science)
- 325 **Integrated use of aerial and ground-based close-range remote sensing techniques to support preventive archaeology: the case study of Ascoli Satriano (FG)**
Nicodemo Abate (Consiglio Nazionale delle Ricerche - ISPC), Italo Maria Muntoni (Soprintendenza Archeologia Belle Arti e Paesaggio delle province di Barletta-Andria-Trani e Foggia), Maria Sileo (CNR - ISPC), Luigi Capozzoli (CNR - IMAA), Gregory de Martino (CNR - IMAA), Rosa Lasaponara (CNR - IMAA) and Nicola Masini (CNR - ISPC)
- 330 **High resolution GPR survey to investigate the urban centres: the case of XX Settembre square of Fano (Fano, Italy)**
Salvatore Piro (ISPC CNR Institute of Heritage Sciences, Italy), Laura Cerri (Freelance archaeologist) and Oscar Mei (University of Urbino (Urbino, Italy))
- 335 **Geoarchaeological and geophysical investigation in Venusia (Basilicata, southern Italy): the test site of roman amphitheater**
Lara De Giorgi (ISPC-CNR), Ivan Ferrari (ISPC-CNR), Francesco Giuri (ISPC-CNR), Maurizio Lazzari (ISPC-CNR) and Giovanni Leucci (ISPC-CNR)

- 339 **Scientific Examination for the Investigation of the Painting Technique of Contemporary Mural Paintings: “The Angry Christ” by Alfonso Ossorio in Victorias, Negros Occidental, Philippines**
Jem Erika Nique (Alma Mater Studiorum - Università di Bologna), Emilio Catelli (Alma Mater Studiorum - Università di Bologna), Zohreh Chahardoli (Alma Mater Studiorum - Università di Bologna) and Rocco Mazzeo (Alma Mater Studiorum - Università di Bologna)
- 345 **ERT AND MAGNETIC SURVEYING: THE CASE STUDY OF KHAYRABADTEPA SATTELMENT (SOUTHERN UZBEKISTAN)**
Azamat Zakirov (Center for Advanced Technologies), Ilyas Yanbukhtin (Center for Advanced Technologies), Timur Mamarozikov (Center for Advanced Technologies), Ilkhom Alimukhamedov (Center for Advanced Technologies), Farangiz Omonova (Center for Advanced Technologies), Ulugbek Musaev (Center for Advanced Technologies) and Otabek Aripjanov (Institute of Art Studies)
- 350 **From excavation to digital use, reconstructing and returning the past to small communities: the case of the medieval fortress of Cervara di Roma**
Giulia Chellini (DigiLab Sapienza University of Rome), Saverio Giulio Malatesta (DigiLab Sapienza University of Rome), Mariflora Caruso (DigiLab Sapienza University of Rome), Paola La Torre (DigiLab Sapienza University of Rome), Paolo Rosati (DigiLab Sapienza University of Rome) and Roberta Manzollino (DigiLab Sapienza University of Rome)
- 356 **From TLS data into H-FEM model based on the quad-mesh: the case study of romanian church**
Vincenzo Saverio Alfio (Polytechnic of Bari), Domenica Costantino (Polytechnic of Bari), Sorin Herban (Politehnic University of Timisoara), Massimiliano Pepe (University G. D’Annunzio of Chieti-Pescara) and Alfredo Restuccia Garofalo (Polytechnic of Bari)

Session 3.1 - GENIUS LOCI: Methods and code for measuring historical phenomena, ancient landscape dynamics, and mechanisms through IT heritage methodologies

Room: Department of Engineering DIEM - Sala Conferenze

- 361 **Archaeological prospection methodology at Teotihuacan (Mexico): study of a neighbourhood in the centre of the city**
Alessandra Pecci (ERAAUB, IAUB, INSA-UB, UNIVERSITAT DE BARCELONA), Luis Barba (Laboratorio de Prospección Arqueológica, IIA, UNAM), Agustin Ortiz Butron (Laboratorio de Prospección Arqueológica, IIA, UNAM), Jorge Blancas (Laboratorio de Prospección Arqueológica, IIA, UNAM), Itzayana Bernal (UNAM) and Natalia Moragas (ERAAUB, IAUB, UNIVERSITAT DE BARCELONA)
- 366 **Bioclimatic study of Feng Shui principles in the ancient Chinese village of Chuandixia**
Filippo Calcerano (National Research Council), Letizia Martinelli (National Research Council), Elena Verticchio (National Research Council), Luciano Cessari (National Research Council) and Elena Gigliarelli (National Research Council)
- 371 **Archaeological data and reliability criteria. A GIS measurement proposal for the study of the Mignone Valley**
Federica Vacatello ("Sapienza" Università di Roma)
- 376 **Digital approaches to ancient metrology: new insights into methods and tools for measuring and designing marble in Late Antiquity**
Giulia Marsili (Department of History and Culture, University of Bologna, Italy) and Claudia Lamanna (University of Bologna, Department of Cultural Heritage)
- 382 **Design Analysis: Research experiences from Alexandrian manuals to Imperial Architecture**
Silvia Bertacchi (Alma Mater Studiorum University of Bologna), Francisco Juan-Vidal (Universitat Politècnica de València, Instituto Universitario de Restauración del Patrimonio) and Filippo Fantini (Alma Mater Studiorum University of Bologna)
- 388 **MirrorLAB: narrative patterns between collections of antiquities and urban landscapes**
Lorenzo Fei (Università Roma Tre), Francesco Freddolini (Sapienza Università di Roma), Federica Grigoletto (Sapienza Università di Roma), Vincenzo Maria Lacolla (Università Roma Tre), Laura Leopardi (Sapienza Università di Roma), Saverio Giulio Malatesta (Sapienza Università di Roma), Leonora Marzullo (Università Roma Tre), Maria Onori (Sapienza Università di Roma), Giorgio Ortolani (Università Roma Tre), Antonio Pugliano (Università Roma Tre) and Paolo Rosati (Sapienza Università di Roma)

Session 3.2 - Non-destructive Imaging Techniques for the Characterization of Cultural Heritage

Room: Aula B - Department of Mathematics and Physics

- 393 The Application of Reflectance Transformation Imaging (RTI) and Multispectral analysis on Ancient Egyptian Coffin-lids at the Israel Museum, Jerusalem: a New Analytic Approach to Workshop Identification**
Daniela Galazzo (University of Haifa), Shirly Ben Dor (University of Haifa) and Assaf Yasur-Landau (University of Haifa)
- 398 Active infrared thermography for the analysis of ancient books**
Giovanni Caruso (ISPC-CNR), Noemi Orazi (Università di Roma Tor Vergata), Stefano Paoloni (University of Rome "Tor Vergata"), Ugo Zammit (University of Rome "Tor Vergata") and Fulvio Mercuri (University of Rome "Tor Vergata")
- 403 Optical NDT supporting the restoration of a marble sculpture on the facade of the Gesù Nuovo church in Naples**
Massimo Ripa (ISASI-CNR), Vito Pagliarulo (ISASI-CNR), Chiara Saltarelli (University Suor Orsola Benincasa), Maria Rosaria Vigorito (University Suor Orsola Benincasa), Gianluca Coda (ISASI-CNR), Pasquale Mormile (ISASI-CNR), Andrea Carpentieri (University Suor Orsola Benincasa, UNINA) and Melania Paturzo (ISASI-CNR)
- 408 Development of a Quantitative Multimodal Imaging Technique for In-situ Study of Iron Archaeological Artefacts**
Elodie Granget (Haute Ecole Arc Conservation-Restauration Neuchâtel, HES-SO), Ocson Reginald Cocen (Haute Ecole Arc Conservation-Restauration Neuchâtel, HES-SO), Mahdieh Shakoorioskooie (Laboratory for Neutron Scattering and Imaging at the Paul Scherrer Institute), Zhan Qianru (Laboratory for Neutron Scattering and Imaging at the Paul Scherrer Institute), Marian Nida Lumongsod-Thompson (Tribology and Interfacial Chemistry (TIC) Group, SCI-STI-SM, Institute of Materials, EPFL), Anders Kaestner (Laboratory for Neutron Scattering and Imaging at the Paul Scherrer Institute), David Mannes (Laboratory for Neutron Scattering and Imaging at the Paul Scherrer Institute) and Laura Brambilla (Haute Ecole Arc Conservation-Restauration Neuchâtel, HES-SO)
- 414 Gellan gum hydrogels as such and ionic-liquid doped as modulable micro-invasive tools for cultural heritage studies**
Rocco Cancelliere (Department of Chemical Science and Technologies, University of Rome "Tor Vergata"), Leonardo Severini (Department of Chemical Science and Technologies, University of Rome "Tor Vergata"), Eleonora Kratter Thaler (Department of Chemistry, University of Milan), Claudia Mazzuca (Department of Chemical Science and Technologies, University of Rome "Tor Vergata"), Vittoria Guglielmi (Department of Chemistry, University of Milan), Patrizia Mussini (Patrizia Mussini) and Laura Micheli (Department of Chemical Science and Technologies, University of Rome "Tor Vergata")
- 419 Thermal texturing for ancient codes 4D exploration**
Noemi Orazi (Dip. Ingegneria Industriale, Università di Roma Tor Vergata), Eva Pietroni (ISPC-CNR), Fulvio Mercuri (Dip. Ingegneria Industriale, Università di Roma Tor Vergata), Daniele Ferdani (ISPC-CNR), Enzo D'Annibale (ISPC-CNR), Giovanni Caruso (ISPC-CNR), Diego Ronchi (ISPC-CNR), Stefano Paoloni (Dip. Ingegneria Industriale, Università di Roma Tor Vergata) and Ugo Zammit (Dip. Ingegneria Industriale, Università di Roma Tor Vergata)
- 424 Absolute dating of three ancient kilns excavated at Canosa di Puglia through archaeomagnetism**
Evdokia Tema (Dipartimento di Scienze della Terra) and Italo Maria Muntoni (Soprintendenza archeologia, belle arti e paesaggio per le province di Barletta-Andria-Trani e Foggia)

Session 3.3 - Geomatics for Cultural Heritage by integrating multi-source and multi-scale data

Room: Aula C - Department of Mathematics and Physics

- 429 3D metric Survey of the Mezzagnone Arab bath. From point clouds to 2D drawings and parametric model**
Alessandro Spadaro (Postgraduate School of Architectural Heritage and Landscape, Politecnico di Torino), Filiberto Chiabrando (Dep. Architecture and Design, Politecnico di Torino) and Lorenzo Teppati Losé (Dep. Architecture and Design, Politecnico di Torino)

- 435 **Comparison of two technologies in 3D surveying of Real Estate Assets and Cultural Heritage**
Giulia Fiorini (DICAM Alma Mater Studiorum University of Bologna – Department of Classic Sapienza University of Rome), Maria Alessandra Tini (DICAM Alma Mater Studiorum University of Bologna), Francesco Montelli (Operai dell'Arte APS) and Gabriele Bitelli (DICAM Alma Mater Studiorum University of Bologna)
- 441 **War-scapes testimonial gradient: a multi-criteria approach as a proactive tool for choosing future practices of enhancement**
Joel Aldrighettoni (Engineer, Architect, PhD), Barbara Marana (University of Bergamo) and Maria Grazia D'Urso (Department of Engineering and Applied Sciences, University of Bergamo)
- 447 **Unveiling the Hidden Past: exploring the historical evolution of Borbona (Rieti, Italy) through archaeological surveys and geophysical prospections**
Cecilia Giorgi (CNR ISPC), Marilena Cozzolino (Università del Molise), Vincenzo Gentile (Università del Molise) and Paolo Mauriello (Università del Molise)
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Session 3.4 - Inorganic, organic, and hybrid materials for the conservation and consolidation of cultural heritage

Room: Aula 1 - Department of Sciences

- 452 **Recycled bacterial nanocellulose membranes as novel green gels for the cleaning of cultural heritage surfaces**
Erica Sonaglia (Department of Chemical Engineering Materials and Environment, Sapienza University of Rome, Rome, Italy), Maria Paola Bracciale (Department of Chemical Engineering Materials and Environment, Sapienza University of Rome, Rome, Italy) and Maria Laura Santarelli (Department of Chemical Engineering Materials and Environment, Sapienza University of Rome, Rome, Italy)
- 457 **Cellulose ethers and nanoconsolidants: preliminary observations on the suitability of the use of cellulose derivatives in the synthesis of nanolime particles**
Penka Girginova (HERCULES Laboratory, University of Évora) and Cristina Galacho (HERCULES Laboratory & Chemistry and Biochemistry Department of School of Sciences and Technology, University of Évora)
- 462 **Electrochemistry and vibrational spectroscopy in investigation of protective coatings for bronze artworks**
Angelja Kjara Surca (National Institute of Chemistry, Hajdrihova 19, 1000 Ljubljana, Slovenia) and Mohor Mihelčič (National Institute of Chemistry, Hajdrihova 19, 1000 Ljubljana, Slovenia)
- 468 **Analysis of materials of wax Christ-children from the Monastery of Santa Rosa in Viterbo**
Arianna Ceci (University of Tuscia - DIBAF Dept.), Luca Lanteri (University of Tuscia - DEIM Dept.), Claudia Pelosi (University of Tuscia - DEIM Dept.), Paola Pogliani (University of Tuscia - DIBAF Dept.) and Sabrina Sottile (University of Tuscia - DIBAF Dept.)
- 474 **Novel, effective and safe coatings for the protection of copper-based artefacts**
Gabriella Di Carlo (CNR-ISMN)
- 479 **Synthesis of titania nanoparticles in W/O microemulsion: moving the production toward a green approach**
Eleonora Marconi (Istituto Nazionale di Fisica Nucleare) and Luca Tortora (Università Roma Tre)
- 485 **Monoazo and Isoindoline Yellow reactivity in presence of Pb, Ti, Zn-based white substrates**
Agnese De Carlo (Department of Science, Roma Tre University; National Institute for Nuclear Physics INFN.), Valerio Graziani (National Institute for Nuclear Physics INFN), Paolo Branchini (National Institute for Nuclear Physics INFN) and Luca Tortora (Department of Science, Roma Tre University; National Institute for Nuclear Physics INFN.)
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Session 3.5 - Non-Invasive Systems and Techniques for "On-Site" Monitoring and Diagnosis

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 DIEM - Sala Conferenze

- 520 **Phyigital 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 Pillozzi (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 BIOCIDES**
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 deteriorogen 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)**
Federica Bubola (Department of Geosciences, University of Padua), Chiara Coletti (Department of Geosciences, University of Padua), Eleonora Balliana (Department of Environmental Sciences, Informatics and Statistics, Ca' Foscari University), Claudia Cecamore (Sovrintendenza Capitolina ai Beni Culturali, Rome), Claudio Parisi Presicce (Sovrintendenza Capitolina ai Beni Culturali, Rome) and Claudio Mazzoli (Department of Geosciences, University of Padua)

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 Brusckhe (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)
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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))
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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 (University 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 Archaeology, Ghent University, Ghent, Belgium)

730 INTERPRETING SOILS. ARCHAEOLOGY AND CHEMICAL ANALYSIS: ORGÈRES 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 Giroto (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), Giuseppe 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 Química Física Rocasolano), Laura Maestro-Guijarro (Instituto de Química Física Rocasolano), Mohamed Oujja (Instituto de Química Física 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 Química Física 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**
Antonio Spagnuolo (Energreenup srl), Andrea Bergomi (Department of Chemistry, University of Milan), Carmela Vetromile (Energreenup srl), Antonio Masiello (Energreenup srl), Noemi Mantile (Department of Environmental, Biological and Pharmaceutical Sciences and Technologies, University of Campania), Mattia Borelli (Department of Chemistry, University of Milan), Chiara Andrea Lombardi (Department of Chemistry, University of Milan), Valeria Comite (Department of Chemistry, University of Milan), Paola Fermo (Department of Chemistry, University of Milan) and Carmine Lubritto (Department of Environmental, Biological and Pharmaceutical Sciences and Technologies, University of Campania)
- 790 Preventive conservation of the pictorial evidence in the church of Sotterra (Paola, Italy): a microclimatic investigation in a hypogean environment**
Maria Antonietta Zicarelli (Department of Biology, Ecology and Earth Sciences (DiBEST), University of Calabria), Michela Ricca (Department of Biology, Ecology and Earth Sciences (DiBEST), University of Calabria), Silvestro Antonio Ruffolo (Department of Biology, Ecology and Earth Sciences (DiBEST), University of Calabria), Raffaella Greca (Department of Biology, Ecology and Earth Sciences (DiBEST), University of Calabria) and Mauro Francesco La Russa (Department of Biology, Ecology and Earth Sciences (DiBEST), University of Calabria)

796 A metrological approach to the study of ancient architecture. The cases of the Grotta dell'Arsenale and the villas of Gradola and Damecuta in Capri

Cecilia Giorgi (CNR ISPC) and Giovanni Caratelli (CNR ISPC)

802 Investigation on a prototype integrated system for strengthening and monitoring architectural heritage

Stefano De Santis (Roma Tre University, Dept of Civil, Computer and Aeronautical Engineering), Giovanni Moretti (Roma Tre University, Dept of Civil, Computer and Aeronautical Engineering), Michele Arturo Caponero (ENEA, Frascati Research Centre), Sara Fares (Roma Tre University, Dept of Civil, Computer and Aeronautical Engineering), Cristina Mazzotta (ENEA, Frascati Research Centre) and Diego Dell'Erba (Ingegneria Integrata srl)

Session 6.1 - Size matters. High-resolution survey of small artifacts: acquisition strategies and methodologies, level of detail, dissemination - Artificial Intelligence for Cultural Heritage: Tools and applications

Room: Aula 1 - Department of Sciences

808 The Dynamic Collections project: providing structured online access to digital replicas

Åsa Berggren (Department of Archaeology and Ancient History, Lund University), Marco Callieri (Visual Computing Laboratory, ISTI-CNR), Nicolò Dell'Unto (Department of Archaeology and Ancient History, Lund University), Paola Derudas (Department of Archaeology and Ancient History, Lund University), Domenica Dinunno (ISPC-CNR, Lund University), Fredrik Ekengren (Department of Archaeology and Ancient History, Lund University) and Giuseppe Naponiello (Lund University)

813 The survey of the "precious one of Constance". Tools and techniques for three-dimensional restitution of complex surfaces at sub-millimetre resolution

Francesco Di Paola (Università degli Studi di Palermo), Sara Morena (Università degli Studi di Palermo) and Sara Antinozzi (Università degli Studi di Salerno)

819 Ponte San Lorenzo, a case study for the comparison of image-based survey tools. NeRF as an alternative to photogrammetry

Maurizio Perticarini (Università degli Studi di Padova) and Andrea Giordano (Università degli Studi di Padova)

824 A deep learning experiment for semantic segmentation of overlapping characters in palimpsests

Michela Perino (Sapienza Università di Roma), Michele Ginolfi (Università degli studi di Firenze), Anna Candida Felici (Sapienza Università di Roma) and Michela Rosellini (Sapienza Università di Roma)

Session 6.2 - Nuclear Techniques for Cultural Heritage - Organic components in archaeological findings and works of art: current challenges in their identification and characterization - Multi-analytical approaches for the study of written archaeological artefacts

Room: Aula 3 - Department of Sciences

829 Revealing and unveiling the polychromy of the Camponeschi Monument in L'Aquila

Elena De Panfilis (Gran Sasso Science Institute, L'Aquila)

835 A natural resins reference collection to identify organic compounds in archaeological samples

Marc Valls Mompó (University of Valencia), Gianni Gallelo (University of Valencia), Irene Sáez Giménez (University of Valencia), Agustín Pastor Garcia (University of Valencia) and María Oreto Garcia Puchol (University of Valencia)

840 Alpine archaeology and everyday life at high altitudes: from the excavation to the laboratory (Orgères-La Thuile, AO, Italy)

Giorgio Di Gangi (Department of Historical Studies (University of Torino)), Chiara Maria Lebole (Department of Historical Studies (University of Torino)), Sergio Enrico Favero Longo (Department of Life Sciences and Systems Biology (University of Torino)), Laura Guglielmone (Department of Life Sciences and Systems Biology (University of Torino)), Gabriele Sartorio (Ufficio archeologia, didattica e valorizzazione, Regione Autonoma Valle d'Aosta) and Samuele Voyron (Department of Life Sciences and Systems Biology (University of Torino))

845 Scribes and Writing Practices in Egypt's Ala Veterana Gallica: A Preliminary Study of Inks from a Military Roll

Olivier Bonnerot (Cluster of Excellence "Understanding Written Artefacts", University of Hamburg) and Leah Mascia (Cluster of Excellence "Understanding Written Artefacts", University of Hamburg)

851 Leafing through time: Ink Analysis of the longest Qur'ān on Papyrus

Sowmeya Sathiyamani (Universität Hamburg), Mathieu Tillier (Sorbonne Université, Paris (France)), Naïm Vanthieghem (Institut de recherche et d'histoire du texte, CNRS, Paris (France)) and Claudia Colini (Universität Hamburg)

Session 6.3 - Damage and Radiological Risk Assessment: Diagnosis and Monitoring for the Restoration, Preventive Conservation, Usability and Maintenance of Cultural Heritage

Room: Aula 4 - Department of Sciences

856 XRF investigation of the Monument to the Fallen of the Great War by Francesco Jerace in San Ferdinando (Reggio Calabria, Italy)

Francesco Caridi (University of Messina), Simona Mancini (University of Salerno), Giuseppe Paladini (University of Catania), Pasquale Faenza (G. Rohlfs Museum of the Calabrian Greek Language, Bova (RC)), Vincenza Crupi (University of Messina), Valentina Venuti (University of Messina) and Domenico Majolino (University of Messina)

861 X-ray fluorescence analysis of bronze sculptures by Giuseppe Renda

Francesco Caridi (University of Messina), Giuseppe Paladini (University of Catania), Pasquale Faenza (G. Rohlfs Museum of the Calabrian Greek Language), Vincenza Crupi (University of Messina), Domenico Majolino (University of Messina) and Valentina Venuti (University of Messina)

866 Assessment of the natural radioactivity content in typical building materials employed in the Italian cultural heritage

Serpil Akozcan (Kirkklareli University), Simona Mancini (university of Salerno), Natasa Todorovic (University of Novi Sad), Selin Ozden (Kirkklareli university) and Michele Guida (university of salerno)

871 Monitoring of indoor Radon in historical heritage buildings by means of passive and active methods. A case study

Simona Mancini (university of Salerno), Natasa Todorovic (university of Novi sad), Serpil Akozcan (Kirkklareli University), Domenico Guida (university of Salerno), Albina Cuomo (university of salerno) and Michele Guida (university of salerno)

876 Radioactivity content in construction materials of assets of particular historical-artistic interest

Francesco Caridi (University of Messina), Giuseppe Paladini (University of Catania), Santina Marguccio (Agenzia Regionale Protezione Ambientale Calabria (ARPACal), Dipartimento di Reggio Calabria), Maurizio D'Agostino (Agenzia Regionale Protezione Ambientale Calabria (ARPACal), Dipartimento di Reggio Calabria), Alberto Belvedere (Agenzia Regionale Protezione Ambientale Calabria (ARPACal), Dipartimento di Reggio Calabria), Vincenza Crupi (University of Messina), Domenico Majolino (University of Messina) and Valentina Venuti (University of Messina)

881 Thermoluminescence dating of historical buildings as a tool for assessing natural radioactivity risk

Rosaria Galvagno (Department of Physics and Astronomy "E. Majorana", University of Catania, Via S. Sofia 64, 95123 Catania, Italy), Alessia D'Anna (Department of Physics and Astronomy "E. Majorana", University of Catania, Via S. Sofia 64, 95123 Catania, Italy), Anna Maria Gueli (Department of Physics and Astronomy "E. Majorana", University of Catania, Via S. Sofia 64, 95123 Catania, Italy), Giuseppe Politi (Department of Physics and Astronomy "E. Majorana", University of Catania, Via S. Sofia 64, 95123 Catania, Italy) and Giuseppe Stella (Department of Physics and Astronomy "E. Majorana", University of Catania, Via S. Sofia 64, 95123 Catania, Italy)

Session 6.4 - Remote sensing methods and approaches for Underwater Cultural Heritage research and management

Room: Aula 6 - Department of Sciences

- 886 Geophysical and geoarchaeological investigations in the Submerged Archaeological Park of Baia (south Italy)**
Crescenzo Violante (Institute of Cultural Heritage ISPC-CNR), Enrico Gallochio (Phlegraeen Fields Archaeological Park (PAFLEG), Palazzo de Fraja - Pozzuoli (NA)), Fabio Pagano (Phlegraeen Fields Archaeological Park (PAFLEG), Palazzo de Fraja - Pozzuoli (NA)) and Nikos Papadopoulos (Institute for Mediterranean Studies, Foundation for Research and Technology, Nikiforou Foka 130, Rethymno)
- 892 iblueCulture – An Innovative Underwater Cultural Heritage Real-Time Streaming System In A Virtual Reality Environment**
Apostolos Vlachos (Information Technologies Institute Centre for Research and Technology Hellas), Stelios Krinidis (Information Technologies Institute Centre for Research and Technology Hellas), Kimon Papadimitriou (Aristotle University of Thessaloniki), Aggelos Manglis (Skopelos Dive Centre, Atlantis Consulting S.A.), Anastasia Fourkiotou (Atlantis Consulting S.A.) and Dimitrios Tzovaras (Information Technologies Institute Centre for Research and Technology Hellas)
- 897 Marine remote sensing and photogrammetric survey of an UCH site: A cluster of cannons in the SW Gulf of Patras, Greece**
Alexandros Labrianidis (Laboratory of Marine Geology and Physical Oceanography, Dept. Geology, University of Patras), Elias Fakiris (Laboratory of Marine Geology and Physical Oceanography, Dept. Geology, University of Patras), Georgiou Nikos (Laboratory of Marine Geology and Physical Oceanography, Dept. Geology, University of Patras), Dimitris Christodoulou (Laboratory of Marine Geology and Physical Oceanography, Dept. Geology, University of Patras), Xenophon Dimas (Laboratory of Marine Geology and Physical Oceanography, Dept. Geology, University of Patras), Maria Geraga (Laboratory of Marine Geology and Physical Oceanography, Dept. Geology, University of Patras), Nikos Mavrommatis (Intelligent Machines P.C., Ag. Paraskevis, 26504, Patras, Greece) and George Papatheodorou (Laboratory of Marine Geology and Physical Oceanography, Dept. Geology, University of Patras)
- 903 A low cost Unmanned Surface Vehicle for mapping shallow-water UCH sites: Ancient and historical shipwrecks in Methoni bay, Greece**
Vasileios Giannakopoulos (Laboratory of Marine Geology and Physical Oceanography, Dept. Geology, University of Patras), George Papatheodorou (Laboratory of Marine Geology and Physical Oceanography, Dept. Geology, University of Patras), Dimitris Christodoulou (Laboratory of Marine Geology and Physical Oceanography, Dept. Geology, University of Patras), Elias Fakiris (Laboratory of Marine Geology and Physical Oceanography, Dept. Geology, University of Patras), Maria Geraga (Laboratory of Marine Geology and Physical Oceanography, Dept. Geology, University of Patras), Panagiotis Gkionis (Laboratory of Marine Geology and Physical Oceanography, Dept. Geology, University of Patras), Nikos Mavrommatis (Intelligent Machines P.C., Ag. Paraskevis, 26504, Patras, Greece) and Thomas Levy (Center for Cyber-Archaeology and Sustainability, Qualcomm Institute, University of California)
- 908 Coastal and shallow marine geophysical investigations in the Roman site of Baia in Naples, Italy**
Nikos Papadopoulos (GeoSat Lab, IMS-FORTH), Crescenzo Violante (Institute of Heritage Science), Dimitrios Oikonomou (GeoSat Lab, IMS-FORTH) and George Kritikakis (Technical University of Crete, School)
- 913 Archaeological predictive modelling in underwater contexts. Utility and challenges**
Manuela Ritondale (University of Groningen)
- 918 Combining acoustic and optical cameras onboard an ROV as a detection and expertise tool for underwater preventive archaeology: a case study off Marseilles (France)**
Souen Fontaine (Institut National de Recherches Archéologiques Préventives), Alex Sabastia (Institut National de Recherches Archéologiques Préventives), Jérôme Sialelli (Copetech SM), Denis Dégez (Département des Recherches Archéologiques Subaquatiques et Sous-Marines), Alexis Rochat (Département des Recherches Archéologiques Subaquatiques et Sous-Marines) and Marine Sadania (Département des Recherches Archéologiques Subaquatiques et Sous-Marines)

Session 6.5 - Historical gardens and archaeological landscape: knowledge and valorization

Room: Aula 7 - Department of Sciences

- 923 **Garden heritage and tourism: present and future of Madeira Island as a garden destination**
Susana Silva (University of Coimbra, CEGOT – Centre of Studies in Geography and Spatial Planning, Faculty of Arts and Humanities) and Paulo Carvalho (University of Coimbra, CEGOT – Centre of Studies in Geography and Spatial Planning, Faculty of Arts and Humanities)
- 928 **Preserving and valuing historic gardens: an analysis of projects under the Portugal 2020 investment framework (2014-2020)**
Susana Silva (University of Coimbra, CEGOT – Centre of Studies in Geography and Spatial Planning, Faculty of Arts and Humanities) and Paulo Carvalho (University of Coimbra, CEGOT – Centre of Studies in Geography and Spatial Planning, Faculty of Arts and Humanities)
- 934 **Identification of plant elements represented in the suburban Villa della Piscina di Centocelle (Rome, Italy) as a source of reconstruction of the ancient gardens**
Alma Kumbaric (Roma Tre University), Flavia Bartoli (ISPC-CNR), Zohreh Hosseini (Roma Tre University) and Giulia Caneva (Roma Tre University)
- 940 **The Fathers' cell gardens of the Charterhouse of Calci-Pisa in Tuscany (Central Italy): pollen and multidisciplinary reconstruction**
Eleonora Clò (Università degli Studi di Modena e Reggio Emilia), Gabriele Gattiglia (Università di Pisa), Eleonora Rattighieri (Università degli Studi di Modena e Reggio Emilia), Francesca Anichini (Università di Pisa), Antonio Campus (Università di Pisa), Marta Rossi (Università degli Studi di Siena), Mauro Buonincontri (Università degli Studi di Siena) and Anna Maria Mercuri (Università degli Studi di Modena e Reggio Emilia)

POSTER SESSION 2

Room: Department of Sciences

- 946 **Acoustic characteristics and defects of adhesion of ancient construction materials using the PICUS system**
Francesca Mariani (Università della Tuscia), Giosuè Caliano (Università Roma Tre), Stefano De Angeli (Università della Tuscia) and Pogliani Paola (Università della Tuscia)
- 951 **The Via Severiana and its Representation in the Tabula Peutingeriana**
Enrico Petritoli (Dipartimento di Scienze - Università degli Studi "Roma Tre") and Fabio Leccese (Dipartimento di Scienze - Università degli Studi "Roma Tre")
- 956 **First results of plant processing on ground stone tools: phytolith evidence and GC-MS from archaic Messapian settlements - San Vito dei Normanni and Cavallino (Puglia, Italy)**
Gaia Sabetta (Università del Salento), Grazia Semeraro (Università del Salento), Florinda Notarstefano (Università del Salento) and Marta Portillo (Archaeology of Social Dynamics (2021SGR 501), IMF - CSIC)
- 962 **Isotopic analysis of black crust samples from the Monza Cathedral (Italy): a preliminary study**
Maria Ricciardi (Department of Chemistry and Biology, University of Salerno), Valeria Comite (Department of Chemistry, University of Milan), Andrea Bergomi (Department of Chemistry, University of Milan), Chiara Andrea Lombardi (Department of Chemistry, University of Milan), Paola Fermo (Department of Chemistry, University of Milan), Antonio Faggiano (Department of Chemistry and Biology, University of Salerno), Antonino Fiorentino (Department of Chemistry and Biology, University of Salerno), Concetta Pironti (Department of Medicine and Surgery, University of Salerno), Luana Bontempo (Fondazione Edmund Mach, Research and Innovation Center, Food Quality and Nutrition Department), Federica Camin (Fondazione Edmund Mach, Research and Innovation Center, Food Quality and Nutrition Department), Oriana Motta (Department of Medicine and Surgery, University of Salerno) and Antonio Proto (Department of Chemistry and Biology, University of Salerno)
- 967 **Diagnostic study and efficiency evaluation of treatments against rising damp and salts crystallization in ornamental stones: the case of the green stone sacristy washbasin in the Church of San Domenico in Cosenza (Calabria, Italy)**
Michela Ricca (University of Calabria)
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Giosue Caliano (Dip. DICITA, Università Roma Tre), Francesca Mariani (DIBAF - Università della Tuscia) and Alessandro Salvini (Dip. DICITA - Università Roma Tre)

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

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Abstract – This contribution presents the analysis of environmental data collected over the 2016-2022 period in the Hall of the historic building of Villa Blanc in Rome, Italy, with ceiling and walls hardwood paneling. Data related to three different sub-periods (during the retrofit, after 1 and 5 years from the retrofit) were analyzed in detail. Based on the ASHRAE 2019 Guidelines, it was found that thermo-hygrometric data differ among the sub-periods (specifically in the years 2016-2017, data are outside the limits of the 5th-95th multi-year band), however there is no marked risk of mechanical damage and mold germination in the prestigious wood. Finally, water vapour mixing ratio and carbon dioxide concentrations were studied as indoor tracers. Since the water vapor mixing ratio remains fairly constant while carbon dioxide concentrations have more variability, e.g., it can be assumed that people (as CO₂ source) may have a more visible effect than indoor/outdoor air exchanges.

I. INTRODUCTION

In the field of cultural heritage, the knowledge of the environmental conditions affecting a cultural asset is relevant since the environment (the ensemble of the climatic conditions and air pollution surrounding the object of interest) can induce some types of deterioration (mechanical, biological, and chemical) [1,2]. The ASHRAE 2019 Handbook [3] defines six Types of Climate Control together with information on risk of degradation and benefits for the collections preserved in a building. The present contribution aims at analyzing microclimate (i.e., indoor temperature and relative humidity) and carbon dioxide data collected over the period 2016-2022 inside the Hall of Villa Blanc, a historic building located in Rome, Italy. Major focus is given to study the tendency of environmental time series

from 2016 until 2022 and comparing three sub-periods (June 2016-May 2017, during the retrofit; June 2017-May 2018, after the retrofit; June 2021-May 2022, 5 years from the retrofit) since the Hall has ceiling and the walls hardwood paneling which is sensitive to microclimate changes. Indeed, indoor climate is strictly connected with wood conservation.

II. MATERIALS AND METHODS

A. Case study and environmental monitoring

Villa Blanc, as it appears nowadays, is the result of the transformation and expansion, wanted by Baron Alberto Blanc, of a building from the second half of the 19th century belonging to the *Lezzani*'s family (Figure 1a). In 1893 Blanc, bought the property formed by a small rustic building and a vineyard of about four hectares in the area surrounding the *Basilica of Sant'Agnese Fuori Le Mura*. He transformed the property into a particularly refined residence, representing a rare example of the eclectic art at the end of the 19th century in Rome, especially concerning the pictorial and the sculptural decorations. The architectural project was carried out by the architect Giacomo Boni while the structural aspects were designed by the engineer Francesco Mora. In carrying out the radical transformation of Villa Blanc, the architect Giacomo Boni experimented new techniques for working with traditional materials such as iron, cast iron, wood, ceramic, marble, granite, and leather. The decorative aspects were entrusted to the meticulousness and care of Alessandro Morani and Adolfo de Carolis, also helped by the painters Giuseppe Cellini and Guido Calori. Innovative techniques were mixed with traditional ones resulting in ceramics and painted glass and mosaics. After years in a state of disrepair, in 1997 the LUISS University of Rome bought Villa Blanc and the surrounding park in a public auction. Only in 2011 it was possible for the

LUISS to start a long and meticulous conservative restoration for the functional adaptation and redevelopment, bringing the Villa back to its former prestige [4]. Since 2017 Villa Blanc is the headquarters of the LUISS Business School. The complex includes a main villa, six dependencies and greenhouses immersed in a park where typically Mediterranean precious species are preserved. It is under architectural protection and cultural heritage constraints since 1922.



Fig. 1. Villa Blanc, a) outdoor view and b) indoor Hall
Source: photo by Bartolucci B., 2018.

Temperature, relative humidity, and carbon dioxide have been monitored in the Hall of Villa Blanc (Figure 1b) since December 2015. In this indoor space, internal walls are covered with boiserie of acacia and cedar wood, which have been known as durable and precious woods since ancient times. The room, as the whole Villa, has windows and impressive stained glass, which are peculiar from a decorative point of view even if they could favor air exchanges with the outside and making the environment sensitive to the external climate. The indoor monitoring campaign of thermo-hygrometric parameters and carbon dioxide at Villa Blanc has been conducted to track environmental conditions during and after the retrofitting and to study whether the environment may be favorable to wooden materials deterioration. The monitoring system consists of two sensors for measuring temperature (T , $^{\circ}\text{C}$) and relative humidity (RH , %) installed at a height of 2.5 m and 4 m, and a carbon dioxide sensor for the measure of indoor concentration (CO_2 , ppm). Technical specifications of the monitoring system are listed in Table 1. The instruments are connected to an acquisition system. Data sampling takes place every 5 minutes, and an average is processed every 30 minutes. Furthermore, to trace the air masses, from the thermo-hygrometric values the mixing ratio (MR , g/kg) is calculated considering the atmospheric pressure equals to 1013 hPa, according to EN 16242:2012 [5].

Before carrying out an exploratory statistical analysis, a data quality analysis was carried out, by determining completeness (CoI) and continuity (CI) indices at the annual level [6] on the entire dataset (from 2016 to 2022). Values outside measurement range of the instruments

were discarded. For completeness of information, this contribution will focus on the analysis of data related to the sensor at 2.5m being the stability of the air (analyzing data of the sensors at 2.5m and 4m) out of scope.

Table 1. Technical specifications (name of sensor, type of transducer, measuring range, and accuracy) are provided for thermo-hygrometric (T , RH) and for carbon dioxide (CO_2) sensors, from the Rotronic and Vaisala manufacturers, respectively.

	T ($^{\circ}\text{C}$)	RH (%)	CO_2 (ppm)
Name	Thermo-hygrometer “TTU 600”		
Transducer	Pt100 thermo-resistance	Thin film capacitor	CARBOCAP
Range	- 40 $^{\circ}\text{C}$ + 60 $^{\circ}\text{C}$	0 - 100%	0 - 2000 ppm
Accuracy	$\pm 0.3^{\circ}\text{C}$	$\pm 1.5\%$	± 30 ppm

B. Identification of environmental reference band

Hourly data of temperature, relative humidity, and carbon dioxide were analyzed for the entire period. For each variable the band between the 95th and 5th percentiles related to the long-term period (2017-2022) was determined as the reference excluding both the 2016 (i.e., during the retrofit) and the three months of COVID lockdown (i.e., March, April, and May 2020). The percentiles were computed for each of the i^{th} day based on hourly data collected for each of i^{th} day of the year and smoothed out by the 30-days moving average centered on the i^{th} day under investigation. The same procedure was applied to CO_2 , but excluding the entire year 2020, as during the pandemic condition the lectures and activities were largely carried out on-line.

Then the daily average of each variable was compared with respect to the reference band to evaluate the occurrences of the departures from the percentiles (e.g., too warm, or too cool).

C. ASHRAE 2019 Guidelines

ASHRAE Guidelines 2019 were applied to the thermo-hygrometric data of the three sub-periods, i.e., during the retrofit (June 2016 - May 2017), after the retrofit (June 2017 - May 2018), and 5 years from the retrofit (June 2021 - May 2022). The Type of Climate Control B was chosen as the reference target conditions based on the type of building and on the material preserved (details are reported in Table 2). Thermo-hygrometric data and the guidelines’ limits related to the climate-induced risk for wooden ceilings and boiserie are displayed on the psychrometric chart. On this chart it is plotted the long-term outer limits (i.e., the boundaries beyond which the risk increases unacceptably for hygroscopic materials such as wood), the annual average (historic for permanent

collection, i.e., the average to which the material has acclimatized to minimize the risk of mechanic degradation), the seasonal adjustments (i.e., the limits drawn from the annual averages and reported in Table 2), the short-term fluctuations (i.e., limits allowed beyond the long-term outer limits).

Table 2. ASHRAE 2019 Guidelines limits for wooden materials kept inside a building with Type of Climate Control B.

Type of Collection and Building	Museums, galleries, archives, and libraries needing to reduce stress on their building (e.g., historic house museums), depending on climate zone
Type of Control	B: limited control, seasonal changes in RH and large seasonal changes in T
Long-Term Outer Limits	$30\% \leq RH \leq 70\%$ $T \leq 30^\circ\text{C}$
Annual Averages	For permanent collection: historic annual average of RH and T.
Seasonal Adjustments from Annual Average	$\pm 10\%$ (RH) $+ 10^\circ\text{C}, - 20^\circ\text{C}$ (T)
Short-Term Fluctuations	$\pm 10\%$ (RH) $\pm 5^\circ\text{C}$ (T)

D. MR and CO₂ as indoor tracers

The water vapor mixing ratio (MR, g/kg) and the indoor carbon dioxide (CO₂, ppm) concentrations can provide information about the indoor/outdoor air exchanges, and the presence of people respectively and for this reason can be used as “indoor tracers”. In this contribution, MR data and CO₂ concentrations were analyzed by considering the average hourly data over the four seasons (spring, summer, autumn, and winter), with their respective standard deviations, over the three selected periods.

III. RESULTS AND DISCUSSIONS

A. Data quality analysis

The determination of CoI and CI of the data series revealed that the completeness is close to 100% (i.e., indexes are close to the unity) for the entire dataset and for each year, both for T and RH data, and it is above 70% (i.e., index > 0.7) for CO₂ data. Before computing the 5th and 95th percentiles, the level of completeness of the dataset within each day of the years was verified, resulting in the data coverage always above 72%.

B. Analysis of environmental data with respect to the reference band

Figures 2 and 3 shows the time series of daily averages

of T and RH for each year over the period 2016-2022 with respect to the 5th and 95th percentiles band calculated with respect to the reference period, i.e., 2017-2022.

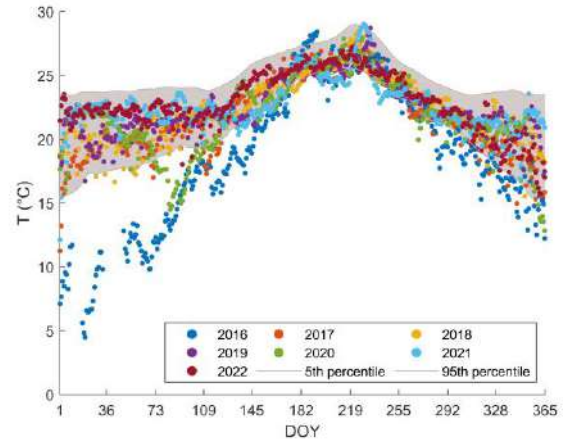


Fig. 2. Time series of T daily averages for each year over the period 2016-2022 with respect to the 5th and 95th percentiles of a reference period 2017-2022 (grey band), excluding the three months of lockdown (March, April, and May 2020).

As it can be noticed from both graphs, the daily average data of 2016, and part of 2017 (specifically from January to April 2017) are outside the limits of the reference band (the grey band determined by the 5th and 95th percentiles). This could be justified by the fact that during the year 2016 and part of 2017 (characterized by the end of the retrofit interventions) the Hall of Villa Blanc perhaps had the indoor air conditioning system not in operation and hence a higher air exchange rate because of the windows and doors maintained open during the retrofit intervention, thus highlighting the effect of external climate.

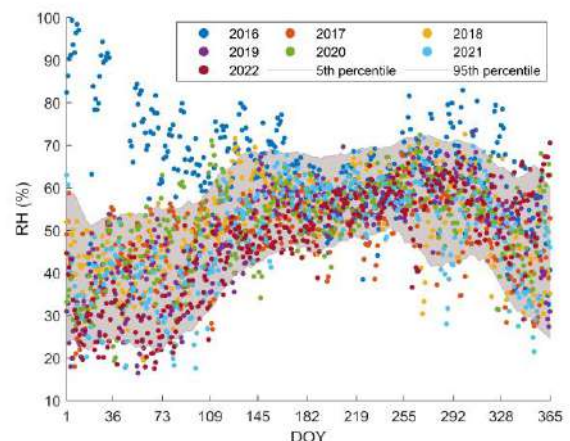


Fig. 3. Time series of RH daily averages for each year over the period 2016-2022 with respect to the 5th and 95th percentiles of a reference period 2017-2022 (grey band), excluding the three months of lockdown (March, April, and May 2020).

In addition, focusing on 2020, i.e., the year of COVID lockdown, the daily averages are distributed within the band limits, except for the months of March and April which have data below the 5th percentile (specifically for temperature) and few data above the 95th percentile (for relative humidity), highlighting a colder and wetter environment than the reference, probably for the indoor conditioning system switched off due to restrictions imposed by the COVID period.

Figure 4 shows the behaviour of carbon dioxide with respect to the reference band.

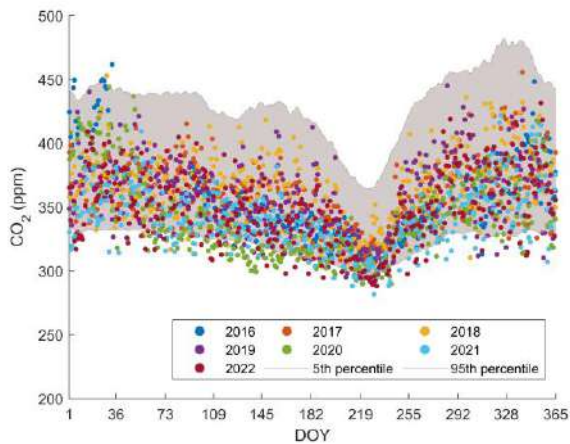


Fig. 4. Time series of CO₂ daily averages for each year over the period 2016-2022 with respect to the 5th and 95th percentiles of a reference period 2017-2022 (grey band), excluding the entire year 2020

From this graph we can notice that 2020, 2021, and 2022 have data below the 5th percentile. Therefore, we can assume that after 2020, the COVID period, the access to the Hall and to Villa Blanc was regulated by the limitations and restrictions that the post-Covid imposed.

C. Analysis of environmental data with respect to the Type of Climate Control B of the ASHRAE 2019 Guidelines

Hourly data (small colored dots) and monthly averages (bigger color dots) are plotted in the psychrometric chart for the three selected sub-periods (Figures 5, a, b, c). Moreover, hourly data and the monthly averages are colored according to the season: red for summer, orange for autumn, blue for winter, and green for spring. Climate specifications from ASHRAE 2019 are also reported: the black full line represents the long-term outer limits, the dashed line is the seasonal adjustments from the annual averages reported in Table 3, and the dotted line represents the short-term fluctuations.

In all three psychrometric charts (Figure 5), T is never above 30°C, i.e., the long-term outer limit. Comparing the period “during” and the periods “after” (1 and 5 years), it can be noted the increase in the minimum

temperature value, while the maximum temperature always remains stable around 29°C.

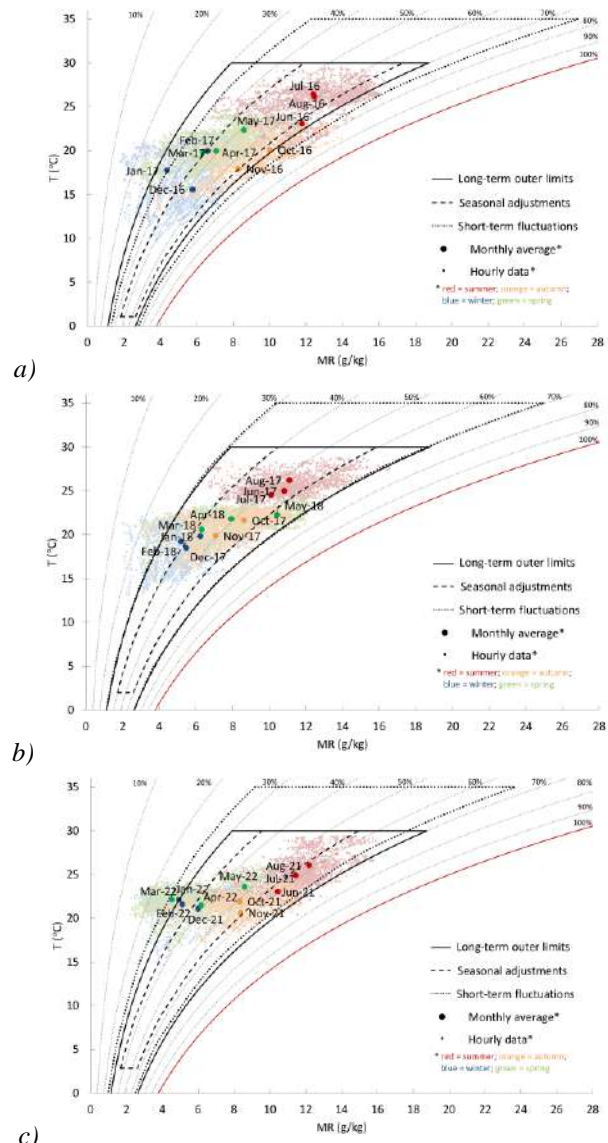


Fig. 5. Psychrometric chart representing the a) During retrofit (first period, 2016-17), b) 1 year after the retrofit (second period, 2017-18), and c) 5 years after the retrofit (third period, 2021-22).

The comparison among the three different sub-periods highlights the passage between the “during” and “after” retrofitting, as the data in figures 5b and 5c are distributed in an increasingly smaller cloud of points, highlighting a reduction in the indoor climate variability. Despite this, some relative humidity values exceed the long-term outer limits of 30% and 70% in winter and spring, especially 5 years after the retrofit (Figure 5c). RH data below 30% during the spring, could be attributed to the rise of the average monthly temperatures, as visible from the three psychrometric charts. This slight increase is also visible

at annual level, and, at the same time, it is also characterized by a decrease in RH (Table 3). The decay effect of the lowering of RH on a hygroscopic material (such as wood) could be visible in the long term, but since most data are within the annual limits and short-term fluctuations allowed by the Type of Control B, and being the monthly averages within the aforementioned limits, sudden damages could not occur.

Table 3. Annual averages of Temperature (T , °C) and Relative Humidity (RH, %) for each period.

Annual average	T (°C)	RH (%)
2016-17	21.1	55.0
2017-18	22.0	49.6
2021-22	22.8	46.2

D. MR and CO_2 as indoor tracers

Hourly average data of MR are displayed in Figure 6 on seasonal basis over the three sub-periods. It can be seen that the average values always remain stable within each season within each sub-period except in summer. Furthermore, in the winter and autumn seasons, data are distributed with a slight decrease in the morning hours, to then increase from the early afternoon, while in the spring and summer data seem to decrease in the middle of day. It is worth noticing that in summer 2017-18 MR values reached the minimum. It can be observed that during the retrofit the MR was generally higher (except in winter and spring); while 5 years after the retrofit the MR values decreased with respect to the retrofit period especially during the winter season and also in the spring months.

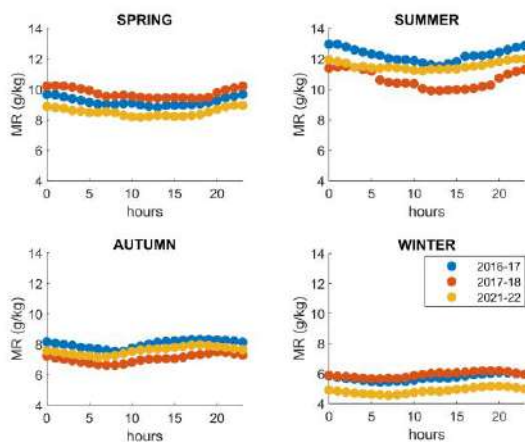


Fig. 6. Hourly data of water vapor mixing ratio (MR, g/kg), during the retrofit (2016-17, blue dots), 1 year after the retrofit (2017-18, orange dots), 5 years after the retrofit (2021-22, yellow dots) for the four seasons

Carbon dioxide was also studied in the same way. The hourly averages of carbon dioxide related to the three sub-periods by season are displayed in Figure 7. Specifically, the three sub-periods have consistent decrease in CO_2 in the summer season, and in part also in

the afternoon hours of the spring season, that can be assumed as both a shorter use of the Hall, and/or a continuous opening of the windows with a consequent CO_2 sink effect caused by the presence of vegetation in proximity of the building [7]. This can also explain the CO_2 decrease during the hours 9-20 in summer or during the afternoon hours in late spring.

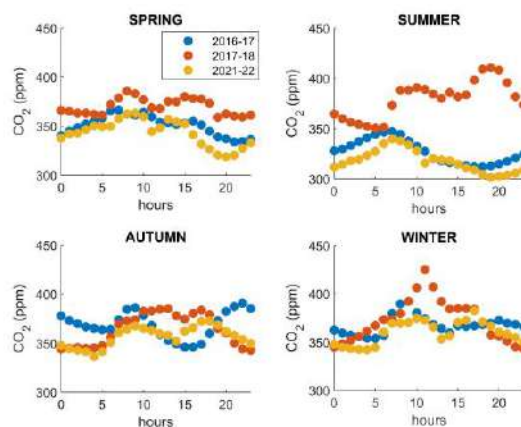


Fig. 7. Hourly data of carbon dioxide (CO_2 , ppm), during the retrofit (2016-17, blue dots), 1 year after the retrofit (2017-18, orange dots), 5 years after the retrofit (2021-22, yellow dots) for the four seasons.

IV. CONCLUSIONS

This contribution presents the analysis of the environmental data collected in the Hall of the historic building of Villa Blanc. Conclusions can be outlined on the preliminary analysis of environmental data of T , RH and CO_2 , based on the ASHRAE 2019 Guidelines to reduce the risk of climate-induced decay for wooden material. In addition, the analysis of the MR and CO_2 used as indoor tracers allow to highlight the use of opening of the Hall and the presence of visitors.

The daily average data of the 7 years considered in the analysis (2016-2022) show that T and RH data for the year 2016 and part of 2017 were outside the reference band of the 5th-95th percentiles, and this can be attributed that the Hall was kept open during the retrofit interventions, as expected. As for CO_2 , the years 2020, 2021 and 2022 partially fall outside the limit of the fifth percentile, assuming that during the lockdown and subsequent years the restrictions to limit the COVID spread have caused the minimum access of visitors and staff to the Hall.

Furthermore, ASHRAE 2019 Guidelines have been applied on three different sub-periods to verify the differences among the "during the retrofit", "1 year after the retrofit", and "5 years from the retrofit". By using the psychrometric chart, it was possible to extract information on conservation benefit and risks associated to the Type of Climate Control. In this case study, the Type of Climate Control B has taken as the reference,

with the category of the material to be preserved being hardwood present on the ceilings and boiserie of the Hall. Within the climate specifications suggested by Type of Climate Control B for this type of hygroscopic material, we can conclude that the mold germination or proliferation is avoided. Moreover, there is no risk of mechanical degradation, and, as visible from psychrometric charts, the retrofit carried out seems to limit and/or eliminate sudden drops in temperature which could damage the prestigious wooden materials. However, with respect to relative humidity, a very small part of data is detected outside the lower limit in all three sub-periods and the annual average RH value is detected to be lower of about 9% with respect to the “during retrofit period”. Therefore, it is necessary to monitor these data in order not to incur into risky situations of dryness for the conservation of wooden materials.

As regards the indoor tracers, both MR and CO₂ can give information on the influences of the external climate and of the close vegetation of the park of Villa Blanc on the internal environment and/or on the presence of users inside the building Hall. Analyzing the data, the carbon dioxide seems to have a major variability with respect to the mixing ratio during the summer season, and this may suggest a closer connection with the presence of people and the opening of the Hall kept open thus enhancing the air exchange between inside and outside.

Finally, the present contribution has as final aim to present the environmental tendency of Villa Blanc, considering the data of the entrance Hall, from the time of the retrofit until today. This approach highlights the importance of monitoring the microclimate and carbon dioxide, especially in historic buildings in order to evaluate whether the microclimate conditions depart from the historic climate to which the wooden materials is acclimatized. This is also important when the building has undergone (or is undergoing) a retrofit and restoration process, as the case study here presented. The results obtained through the methodological approach of this study could be better supported by information, such as

opening and closing times to the public, switching on and off times of the indoor conditioning system, number of users per hour per day.

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