



UNIVERSITÀ
DEGLI STUDI
FIRENZE



UNIVERSITÀ
DEGLI STUDI
DEL
SANNIO
Benevento

2019 IMEKO TC-4 INTERNATIONAL CONFERENCE ON
**METROLOGY FOR ARCHAEOLOGY
AND CULTURAL HERITAGE**
FLORENCE, ITALY / DECEMBER 4-6, 2019



FLORENCE 2019

PROCEEDINGS

UNIVERSITY OF FLORENCE
SAGAS DEPARTMENT
VIA S. GALLO, 10

ITALIAN GEOGRAPHIC
MILITARY INSTITUTE
VIA C. BATTISTI, 10



www.metroarcho.com

info@metroarcho.com



ISBN: 978-92-990084-5-4

2019 IMEKO TC-4 International Conference on

Metrology for Archaeology and Cultural Heritage

(MetroArcheo 2019)

PROCEEDINGS

December 4-6 2019 | Florence, Italy

© 2019 IMEKO

ISBN: 978-92-990084-5-4

All rights reserved. No part of this publication may be reproduced in any form, nor may it be stored in a retrieval system or transmitted in any form, without written permission from the copyright holders.

Welcome Message

On behalf of the Organizing Committee, we wish to welcome you to the 2019 IMEKO TC-4 International Conference on Metrology for Archaeology and Cultural Heritage - MetroArchaeo2019.

The combined use of numerical approaches and metrology in archaeology and, more generally, in the study of cultural heritage, is a firmly established reality in contemporary research, which is undergoing rapid evolution both in the scale, type and scope of applications. Metrology includes both theoretical and practical aspects with reference to measurements, whatever their uncertainties are, and in whatever fields of science or technology they occur. The characterization, valorisation and preservation of cultural heritage are therefore deeply related to metrological issues, for the collection, interpretation and validation of data, through the use of different analytical tools, physical-chemical and mechanical techniques, digital technologies, new ICT tools.

The 2019 IMEKO TC-4 International Conference on Metrology for Archaeology and Cultural Heritage - MetroArchaeo2019 aims to gather a wide range of scholars and heritage scientists working in universities and research centres, museums, galleries, libraries, archives, small and medium enterprises. MetroArchaeo2019 is conceived as an occasion to foster exchanges of ideas and information, to establish connections and collaborations, and to share innovative solutions in the field of measurements applied to cultural heritage, among material scientists, chemists, physicists, engineers, archaeologists, conservators, restorers.

Following the positive experience of the first four editions held in Benevento (2015), Turin (2016), Lecce (2017) and Cassino (2018), this year's conference has been organized in Florence, a town that houses the testimonies of a prestigious historical and cultural tradition, spanning from Roman antiquity to Middle Ages, up to modern times.

The activities aimed at the conservation, protection, enhancement and use of cultural heritage, through the development and application of innovative methods and technologies, have a consolidated academic, scientific and entrepreneurial tradition, recognized both at a national and international level, in the territory of Toscana Region. The University of Florence stands out for its commitment in this sector, with a number of initiatives involving a wide range of skills, projects, collaborations in progress with other research institutions, and industries.

Florence is therefore a perfect frame for a conference designed to encourage discussion and networking among scientists coming from all over the world, and to promote new interactions and collaborations among established scholars and new researchers working in different areas and interested in the use of measurements in the study of cultural heritage.

MetroArchaeo2019 hosts three plenary lectures and 25 oral, poster and demo sessions aiming to give a complete and multidisciplinary picture of the applications of measurements and data treatments to the characterization and safeguard of archaeological and historic heritage.

With the aim of providing a common ground for researchers to share their findings about metrology applied to archaeology and cultural heritage, MetroArchaeo2019 includes a significant number of special sessions, intended to group the different applications of metrology to

archaeology and cultural heritage into thematic strands, and to allow coherent and targeted discussions.

The program includes three keynote lectures, which will be delivered by Guido Vannini, from the University of Florence (Italy), Yuval Goren, from the Ben-Gurion University of the Negev (Israel), and Francesco Porcelli, from the University of Turin (Italy). Two Tutorials will be held on "Use of portable instruments for metallic cultural heritage assets" and "Invisible Archaeology".

Awards will be assigned to a number of outstanding papers, posters and demos.

The organisation of the conference was a very complex task, due to the large interest in the wide range of topics listed in the call for papers. A generous and tireless scientific and organising committee was involved in drafting the technical program, arranging accommodation for the speakers, managing the administrative aspects, and setting up the social programme. We are very grateful to all of them for their outstanding work, as well as to the reviewers who have contributed to guarantee the quality of the scientific program. We also wish to thank the public and private organizations which have kindly accepted to support the meeting in different ways.

The 2019 IMEKO TC-4 International Conference on Metrology for Archaeology and Cultural Heritage is about to begin. We hope you will enjoy the company of colleagues and experts as well as the natural and artistic beauties of Florence! Please, let us have your comments and remarks: we all, metrologists, archaeologists, geologists, heritage scientists, colleagues and friends, know that criticism is the best way to improve quality, and to achieve lasting excellences.

On behalf of the Organizing Committee

Marcantonio Catelani

Pasquale Daponte

Committee

GENERAL CHAIRS

Marcantonio Catelani, *University of Florence, Italy*

Pasquale Daponte, *University of Sannio, Italy*

TECHNICAL PROGRAM CO-CHAIRS

Luca Cappuccini, *University of Florence, Italy*

Lorenzo Ciani, *University of Florence, Italy*

Francesco Lamonaca, *University of Sannio, Italy*

Paolo Liverani, *University of Florence, Italy*

Paola Moscati, *CNR, Italy*

INTERNATIONAL PROGRAM COMMITTEE

Emma Angelini, *Politecnico di Torino, Italy*

Fabrizio Antonelli, *LAMA - LabCoMaC - Iuav University of Venice, Italy*

Lucio Calcagnile, *University of Salento, Italy*

Franco Cambi, *University of Siena, Italy*

Stefano Campana, *University of Siena, Italy*

Piergiulio Cappelletti, *University of Naples, Italy*

Paolo Carafa, *University of Roma La Sapienza, Italy*

Juan Antonio Quirós Castillo, *Universidad del País Vasco, Spain*

Andrea Cataldo, *University of Salento, Italy*

Cristina Corsi, *University of Cassino and Southern Lazio, Italy*

Giuseppe Cultrone, *University of Granada, Spain*

Egidio De Benedetto, *University of Salento, Italy*

Lucio Del Corso, *University of Cassino and Southern Lazio, Italy*

Zaccaria Del Prete *Sapienza University of Rome, Italy*

Maria Grazia D'Urso, *University of Bergamo, Italy*

Francesco Fontanella, *University of Cassino and Southern Lazio, Italy*

Venice Gouda, *National Research Centre, Egypt*

Sabrina Grassini, *Politecnico di Torino, Italy*

Marco Laracca, *University of Cassino and Southern Lazio, Italy*

Giovanni Leucci, *IBAM-CNR, Italy*

Carmine Lubritto, *Università degli Studi della Campania "Luigi Vanvitelli", Italy*

Marilena Maniaci, *University of Cassino and Southern Lazio, Italy*

Lara Maritan, *University of Padova, Italy*
Alessandra Pecci, *University of Barcelona, Spain*
Giacomo Pardini, *University of Salerno, Italy*
Emanuele Piuze, *Sapienza Università di Roma, Italy*
Eugenio Polito, *University of Cassino and Southern Lazio, Italy*
Gianluca Quarta, *University of Salento, Italy*
Carmen Maria Roskopf, *University of Molise, Italy*
José Antonio Barrera Vera, *University of Seville, Spain*

LOCAL ARRANGEMENTS



Keynote Speakers

Keynote Wednesday, December 4, 2019

The historical dimension of archaeological research: from the episode to the phenomenon.

Guido Vannini
University of Florence

ABSTRACT

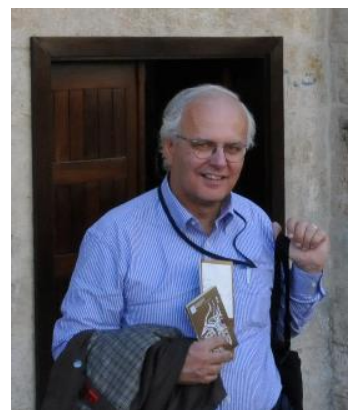
The historical dimension of archaeological research: from the episode to the phenomenon. From the experiences of a medievalist to the territorial approach of the research: we will talk about 'light' forms of archaeological approach, of public diffusion for a shared archaeology (and, also here, 'measured'), of recipients of technological processes at the service of the archaeological heritage. All this by paying attention to the risks of technicality ('poor neopositivism') and to the 'dynamic' methodology, i.e. correlated to the changing of the same quantitative and qualitative objectives of a research that at least tries to be in tune with today's society.

SHORT BIOGRAPHY

Full professor in Medieval Archaeology since 2002, Director of the Archaeology Specialization School at the University of Florence (since 2011) and member of Council of School of PhD at the University „La Sapienza“ of Rome.

Former Contrattista (1975-1980) and Researcher (1981-1990) at the University of Florence, after Associate Professor in Medieval Topography and Archaeology at the University of Calabria (1991-1996) and University of Florence (1996-2001); Dean of the Department of Arts (Un. of Calabria, 1993-1995). Cofounder of the inter-University (Universities of Aquila, Florence, Salerno, Tuscia, Milan „Cattolica“) Italian PhD in Medieval Archaeology (first in Italy, 1998); Fellows at 'The Harvard University Center for Renaissance Studies' (1976); Ministry of Culture Inspector at the Archaeological Superintendency of Tuscany (1981); honorary inspector of the Superintendency for architectural Heritage of Florence; advisor of the Europe Near East Centre (1995).

Co-director of 5 scientific series (including „Limina/Limites. Archeologies, histories, islands and frontiers in the Mediterranean (365-1556)“, BAR, Oxford; „Archeologia Pubblica“, FUP, Florence) and member of the scientific committee for other 4 series (including 'Tardoantico e Medioevo')



and „Confronti'). Guido Vannini is also a member of the scientific committees of 14 scientific journals (including "Archeologia Medievale", "Ricerche Storiche" "Archeologia Polona"; "Rivista di Scienze dell'Antichità", "Restauro Archeologico", "Schola Salernitana-Annali", "Bullettino Storico Pistoiese", "Florentia. Studi di Archeologia", "Libri Gedanenses", "Archeologia Viva") and of scientific Institutes (Deputazione di Storia Patria per la Toscana, Istituto Archeologico Italo-giordano, Centro Intern. di Studi 'La Gerusalemme di S. Vivaldo', Società Pistoiese di Storia Patria etc.); member of scientific committee of International Congress (including UNESCO Seminar Florence 2006; Archeologia dei castelli nell'Europa angioina (secoli XIII-XV), University of Salerno 2008; 'Trans-Jordan in 12th and 13th centuries and the „frontiers" of Medieval Mediterranean', University of Florence and ISU 2008). Associated to the Society of Medieval Archaeologists of Italy (SAMI) from 1995 and of I.C.O.M.O.S. (1987), Associazione di Studi storici 'Elio Conti'). Winner of the 'LUX et LAUS' medal awarded in 2018 by the Standing Committee of Polish Medievalists and of 'Father Piccirillo' award (Un. Naples 2018).

Director of some 60 national and international archaeological projects in seven Euro-Mediterranean countries - 54 archaeological areas (6 abroad) of which 22 urban and 32 rural - and organizer of 30 exhibitions, also abroad (including 'From Petra to Shawbak. Archaeology of a frontier', Florence, Pitti Palace, 2009: the first in Italy with the principles of Public Archaeology; or the permanent exposition 'Percorso archeologico attrezzato permanente nell'area archeologica dell'antico vescovado di Pistoia (secc. II. a.C.-XIX d.C.)). Major running projects include the 'Strategic Athenaeum Project' on the Mediterranean Medieval Feudal Society: archaeological profiles (with projects in Italy: Toscana, Marche, Calabria; and abroad: France, Hispania, Malta, Jordan, Syria, Lebanon) and the archaeological mission in Jordan on Medieval Petra. Archaeology of Crusader-Ayyubid in Transjordan since 1986 („Progetto Pilota" MAE, 1999 e MIUR, 'Prog. scient. d'interesse nazionale' dal 1987; 2009-2012: European Project ENPI-CIUDAD „Liason for worth": Toscana, Transgiordania, Armavir armeno); and FIRB Project (2005-2007) Dallo scavo al Museo. Metodi e tecniche avanzate di ricerca, elaborazione e fruizione condivisa del patrimonio culturale mediterraneo (responsible for Research Unit). As holder of the Chair he has therefore led the scientific supervision of a mission in Armenia ('The Silk Road in Armenia and the euro-Asian connectivity in the Middle Ages: an light archeology'), MAE-Erevan Un. and a development cooperation mission in Iraqi Kurdistan (2013-2015: MAE Cooperation project, lead partner City of Florence, 'The higher education level for the preservation and development of the tangible and intangible cultural heritage of Iraq').

Author of almost 300 scientific publications (including twelve monographs) - about themes articulated in specific research projects, generally connotable as historical-archeological cutting - on medieval urban settlement, Incastellamento, settlement in Mediterranean feudal territories, Production Archaeology, Landscape archaeology ('Light Archaeology') and, more recently, Public Archaeology.

Keynote Thursday, December 5, 2019

Conservation Science and Ethics in the Analytical Studies of Clay Cuneiform Tablets from Ancient Near Eastern Archives

Yuval Goren

*Department of Bible, Archaeology and Ancient Near East
Ben-Gurion University of the Negev, Israel*

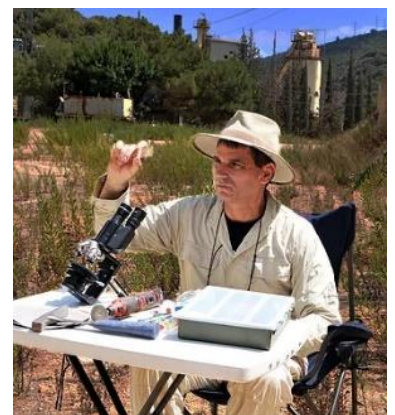
ABSTRACT

The Late Bronze Age (ca. 1500-1200 BC) constitutes the heyday of the great empires of the ancient Near East (ANE), such as Egypt, Hatti, Mitanni, Babylonia, and Assyria. Centuries of conflicts followed by peaceful relations, marked the interrelations of these superpowers. Rich literary records in the form of archives of cuneiform texts were established. These archives contain abundant tablets whose origin is unknown. Sometimes the letterhead is missing, in other cases, we may have the name of the sender and still ignore his domicile. Further, the location of many ANE countries and cities has not yet been clearly established. Hence, revealing the origin of documents has the potential of shedding new light on the history of the ANE and beyond. The paper will discuss the use of a rich array of non-destructive testing (NDT) and minimally-destructive testing (MDT) methods for studying the composition, technology and provenance of ANE cuneiform tablets. This approach opens new horizons in the interpretation of the clay documents. We applied such analyses on hundreds of tablets from el Amarna, Ras Shamra/Ugarit, Boğazköy/Hattusha, and sites in Cyprus and Israel/Palestine. made during the last decade, serves as the basis for this study. The results raise a set of ethical and practical issues concerning the study and conservation of such precious artifacts.

SHORT BIOGRAPHY

Yuval Goren is Professor of Archaeology at the Ben Gurion University of the Negev (previously at Tel Aviv University where he was faculty member for twenty years). He joined the faculty of Tel Aviv University after graduating at the Hebrew University in Jerusalem and working for several years as a petrography researcher in the Israel Antiquities Authority. He served as the Head of the Department of Archaeology and Ancient Near Eastern Cultures and as Vice Dean of the Faculty of Humanities of Tel Aviv University. Goren was the initiator and head of the graduate program in Archaeology and Archaeomaterials and the Laboratory for Comparative Microarchaeology at Tel Aviv University.

In the Ben Gurion University of the Negev he established the Trach for Archaeomaterials and



Conservation Sciences (TACS), now part of the European Erasmus and ITN ARCHMAT consortia and the formal representative of Israel in the COST-SAGA project. His research focuses on early technology and provenance of ceramics, plasters and metallurgy, using mineralogical, structural and geochemical methods. Goren co-directed the excavations of Chalcolithic sites at Nahal Sekher, Kissufim cemetery and recently the so-called shrine at Ein Gedi. He was also directing the excavation at the 1st millennium BC Tel Sochoh.

Keynote Friday, December 6, 2019

Archaeo-physics in the Valley of the Kings, Luxor

Francesco Porcelli

*Dept. of Applied Science and Technology,
Polytechnic University of Turin*

ABSTRACT

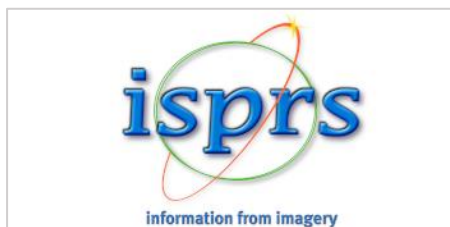
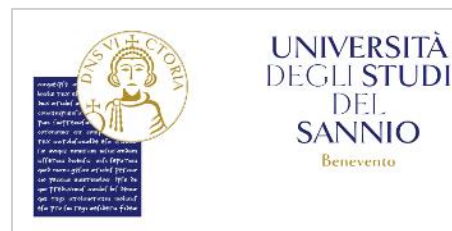
The existence of hidden chambers and corridors adjacent to Tutankhamun's tomb (code name KV62) has been long debated. In 2015 it was suggested that these chambers might host the as yet undiscovered burial of Nefertiti. In order to test this hypothesis, two Ground Penetrating Radar (GPR) surveys, conducted in 2015 and 2016 from inside KV62, were carried out, but gave contradictory results. To solve these uncertainties and obtain a more confident and conclusive response, a team led by the Politecnico di Torino in February 2018 conducted a third GPR survey. The results of this third radar scan, published in Ref. [1], are discussed in this talk. I will discuss also the first results obtained in the framework of a more extensive project, entitled "The complete geophysical survey of the Valley of the Kings", initiated in 2017 and still ongoing. This project indicates how Geophysics and Geomatics can support archaeological research within the context of a broad multidisciplinary approach.

SHORT BIOGRAPHY

Francesco Porcelli (PhD Physics, Scuola Normale Sup. di Pisa, 1985) is a full professor of Physics of Matter at the Polytechnic University of Turin. His recent research interest, developed during an eight-year long period spent in Egypt as Scientific Attaché at the Embassy of Italy, concerns the application of physics and technology to cultural heritage. In 2014-2016 he coordinated a team that established the meteoritic origin of Tutankhamen's iron dagger blade. Since 2017 he leads a project entitled "The Complete Geophysical Survey of the Valley of the Kings". Within this project, he conducted the third Ground-Penetrating-Radar (GPR) scan of Tutankhamen's tomb, searching for hidden chambers and testing the hypothesis that this tomb could be part of a larger burial place perhaps belonging to the legendary Nefertiti.



Patronages



CONFERENCE PROGRAM

Wednesday, December 4

Special Session - Data Acquisition and Processing by Integrated Geomatic Techniques, Experiences and Open Issues - PART I

Room: Great Hall, University of Florence, SAGAS Dep

Chairs: Gabriele Bitelli, University of Bologna, Italy

Maria Grazia D'Urso, DISA, University of Bergamo, Italy

- 1 An Updated Comparison on Contemporary Approaches for Digitization of Heritage Objects**
Efstathios Adamopoulos, Università degli Studi di Torino, Italy
Fulvio Rinaudo, Politecnico di Torino, Italy

- 7 A methodology for semi-automatic documentation of archaeological elements using RPAS imagery**
Eduard Angelats, Centre Tecnològic de Telecomunicacions de Catalunya, Spain
M. E. Parés, Centre Tecnològic de Telecomunicacions de Catalunya, Spain
C. Mas-Florit, Universitat de Barcelona, Spain
M.A Cau-Ontiveros, Universitat de Barcelona, ICREA, Spain

- 13 Modelling the Seventies: Image-Based Modelling to Investigate Landscape Change in a Mediterranean Mountain Area**
Manuel J.H. Peters, Politecnico di Torino, Italy, Uni. de Évora, Portugal, Uni. Leiden, The Netherlands
Tesse D. Stek, Universiteit Leiden, The Netherlands, Royal Netherlands Institute, Italy

- 19 Evaluation of the Expected Data Quality in Laser Scanning Surveying of Archaeological Sites**
Mattia Previtali, Politecnico Milano, Italy
Lucia Díaz-Vilariño, Universidade de Vigo, Spain
Marco Scaioni, Politecnico Milano, Italy
Ernesto Frías Nores, Universidade de Vigo, Spain

- 25 Rapid Mapping methods for archaeological sites**
Antonia Spanò, Politechnics of Turin, Italy

Special Session - IoT based Systems for the Structural Health Monitoring and the Analysis of Cultural Heritage Building and Archaeological Sites

Room: Parva Hall, University of Florence, SAGAS Dep

Chairs: Carmelo Scuro, University of Calabria, Italy

- 31 The Non-smooth tale of “Apennine Churches” stroked by the Central Italy Earthquakes of 2016**
Angela Ferrante, Polytechnic University of Marche, Italy
Ersilia Giordano, Polytechnic University of Marche, Italy
Francesco Clementi, Polytechnic University of Marche, Italy
Gabriele Milani, Politecnico di Milano, Italy
Antonio Formisano, University of Naples ‘Federico II’, Italy

- 37 Cultural Heritage and earthquake: the case study of San Francesco’s church in Amandola (Central Italy)**
Ersilia Giordano, Polytechnic University of Marche, Italy
Angela Ferrante, Polytechnic University of Marche, Italy
Francesco Clementi, Polytechnic University of Marche, Italy
Gabriele Milani, Politecnico di Milano,
Antonio Formisano, University of Naples ‘Federico II’, Italy

- 43 **An innovative structural health monitoring system for the preliminary study of an ancient anti-seismic construction technique.**
Carmelo Scuro, University of Calabria, Italy
Domenico Luca Carnì, University of Calabria, Italy
Francesco Lamonaca, University of Sannio, Italy
Renato Sante Olivito, University of Calabria, Italy
Gabriele Milani, University of Milan, Italy
- 48 **Automated procedure for the creation of finite element mesh: application to non-periodic historical masonry**
Simone Tiberti, University of Milan, Italy
Gabriele Milani, University of Milan, Italy
- 53 **SHM systems applied to the built heritage inventory at the territorial scale. A preliminary study based on CARTIS approach**
Renato Sante Olivito, University of Calabria, Italy
Saverio Porzio, University of Calabria, Italy
Carmelo Scuro, University of Calabria, Italy
Domenico Luca Carnì, University of Calabria, Italy
Francesco Lamonaca, University of Sannio, Italy
-

Thursday, December 5

Keynote Lecture: Conservation Science and Ethics in the Analytical Studies of Clay Cuneiform Tablets from Ancient Near Eastern Archives

Room: Great Hall, University of Florence, SAGAS Dep

Chairs: Emma Angelini, Politecnico di Torino, Italy

- 59 **Conservation Science and Ethics in the Analytical Studies of Clay Cuneiform Tablets from Ancient Near Eastern Archives**
Yuval Goren, Ben Gurion University of the Negev, Israel
Erez Ben-Yosef, Tel Aviv University, Israel
Francisco Centola, Universidade de Évora, Portugal
Cécile Fossé, Ben Gurion University of the Negev, Israel, Universidade de Évora, Portugal
Yaron Katzir, BeGorenn Gurion University of the Negev, Israel
José Mirão, Universidade de Évora, Portugal
Ron Sha'ar, The Hebrew University of Jerusalem, Israel
Yitzhak Vassal, Tel Aviv University, Israel Antiquities Authority, Israel
Nicola Schiavon, Universidade de Évora, Portugal
-

Special Session on Advanced methodologies for diagnostic and preventive conservation of stone materials in subaerial and underwater environment

Room: Great Hall, University of Florence, SAGAS Dep

Chairs: Mauro Francesco La Russa, University of Calabria, Italy

Paola Fermo, University of Milan, Italy

- 68 **SEM-EDS microanalysis in cultural heritage and archaeology: thickness effects and measurement strategy for ultrathin glass and metal fragments and particles**
Daniele Moro, Università di Bologna "Alma Mater Studiorum", Italy
Gianfranco Ulian, Università di Bologna "Alma Mater Studiorum", Italy
Giovanni Valdrè, Università di Bologna "Alma Mater Studiorum", Italy

73 Metals distributions within black crusts sampled on the facade of an historical monument: the case study of the Cathedral of Monza (Milan, Italy)

Valeria Comite, Università degli Studi di Milano, Italy
Jose Santiago Pozo-Antonio, University of Vigo, Spain
Carolina Cardell, University of Granada, Spain
Teresa Rivas, University of Vigo, Spain
Luciana Randazzo, Università della Calabria, Italy
Mauro Francesco La Russa, Università della Calabria, Italy
Paola Fermo, Università degli Studi di Milano, Italy

Special Session on Measuring Ancient Mortars and Concretes to Discover the Past

Room: Parva Hall, University of Florence, SAGAS Dep

Chairs: *Marco Lezzerini, University of Pisa, Italy*
Andrea Aquino, University of Pisa, Italy

79 Characterization of mortars of Giotto's Bell Tower for radiocarbon dating

Sara Calandra, (CNR-ICVBC), University of Florence, Italy
Serena Barone, University of Florence, INFN Florence Unit, Italy
Emma Cantisani, (CNR-ICVBC), Italy
Mariaelena Fedi, INFN Florence Unit, Italy
Carlo Alberto Garzonio, University of Florence, Italy
Lucia Liccioli, INFN Florence Unit, Italy
Barbara Salvadori, (CNR-ICVBC), Italy
Teresa Salvatici, University of Florence, Italy
Paola Ricci, University of Campania Luigi Vanvitelli, Italy

84 Calcarenite di Gravine Formation, a Raw Material for the lime production

Agnese Emanuela Bonomo, University of Basilicata, Italy
G. Rizzo, University of Basilicata, Italy
G. Prosser, University of Basilicata, Italy

90 The production of binding materials in southern Florence area: stones and their properties (Greve in Chianti, Italy)

Andrea Aquino, Università di Pisa, Italy
Elena Pecchioni, Università di Firenze, Italy
Fabio Fratini, Consiglio Nazionale delle Ricerche, Italy
Emma Cantisani, Consiglio Nazionale delle Ricerche, Italy
Sonia La Felice, Consiglio Nazionale delle Ricerche, Italy
Tsegaye Abebe, Adhana Geological Consultancy Service, Italy
Claudia Principe, Consiglio Nazionale delle Ricerche, Italy
Marco Lezzerini, Università di Pisa, Italy

95 New Strategies in Mortar Characterization and Radiocarbon Dating

Giulia Ricci, University of Padova, Italy
Michele Secco, University of Padova, Italy
Fabio Marzaioli, (CIRCE), INNOVA SCaRL, Italy
Isabella Passariello, (CIRCE), INNOVA SCaRL, Campania Uni. "Luigi Vanvitelli", Italy
Filippo Terrasi, (CIRCE), INNOVA SCaRL, Campania Uni. "Luigi Vanvitelli", Italy
Gilberto Artioli, University of Padova, Italy

Special Session on Electromagnetic methods in Archaeology and Cultural Heritage applications - PART I

Room: Italian Geographic Military Institute - De Vecchi Hall

Chairs: *Giovanni Leucci, IBAM-CNR, Italy*
Rita Deiana, University of Padova, Italy
Raffaele Martorana, University of Palermo, Italy

- 100 The watch towers in Malta: a patrimony to preserve for the future**
Raffaele Persico, IBAM-CNR, University Uninettuno UTIU, Italy
Giovanni Leucci, IBAM-CNR, Italy
Sebastiano D'Amico, University of Malta, Malta
Lara De Giorgi, IBAM-CNR, Italy
Emanuele Colica, University of Malta, Malta
Maurizio Lazzari, IBAM-CNR, Italy
- 103 Matera European Capital of Culture 2019: NDT surveys in cave churches**
Lara De Giorgi, IBAM-CNR, Italy
Maurizio Lazzari, IBAM-CNR, Italy
Giovanni Leucci, IBAM-CNR, Italy
Raffaele Persico, IBAM-CNR, Italy
- 105 Remotely controlled aerial and underwater vehicles in support to magnetic surveys**
Salvatore Scudero, INGV, Osservatorio Nazionale Terremoti, Italy
Giovanni Vitale, INGV, Osservatorio Nazionale Terremoti, Italy
Antonino Pisciotta, INGV, Sezione di Palermo, Italy
Raffaele Martorana, Università degli studi di Palermo, Italy
Patrizia Capizzi, Università degli studi di Palermo, Italy
Antonino D'Alessandro, INGV, Osservatorio Nazionale Terremoti, Italy
- 109 Recent developments on portable XRF scanner**
Sergio Augusto Barcellos Lins, La Sapienza Università di Roma, INFN Roma Tre, Italy
Giovanni Ettore Gigante, La Sapienza Università di Roma, Italy
Roberto Cesareo, Università degli Studi di Sassari, Italy
Stefano Ridolfi, Ars Mensurae, Italy

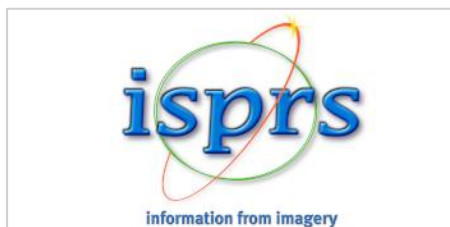
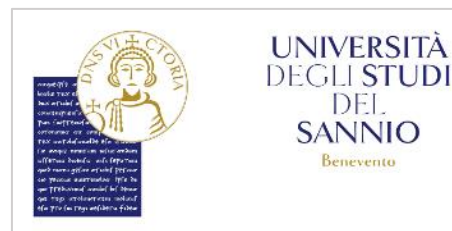
General Session - PART I

Room: Italian Geographic Military Institute - Sala del Cortile

Chairs: *Marco Carpiceci, Sapienza University of Rome, Italy*
Marcantonio Catelani, University of Florence, Italy

- 114 Managing complex Synchrotron radiation FTIR micro-spectra from historic bowed musical instruments by chemometrics**
Silvia Grassi, Università degli Studi di Milano, Italy
Giacomo Fiocco, Università degli Studi di Pavia, Università di Torino, Italy
Claudia Invernizzi, Università degli Studi di Pavia, Uni. degli Studi di Parma, Italy
Tommaso Rovetta, Università degli Studi di Pavia, Italy
Michela Albano, Università degli Studi di Pavia, Italy
Patrizia Davit, Università di Torino, Italy
Monica Gulmini, Università di Torino, Italy
Chiaromaria Stani, Elettra-Sincrotrone Trieste, Italy
Lisa Vaccari, Elettra-Sincrotrone Trieste, Italy
Maurizio Licchelli, Università degli Studi di Pavia, Italy
Marco Malagodi, Università degli Studi di Pavia, Italy
- 120 First sampling of ceramic mixtures for Valle d'Aosta: research and perspectives related to the alpine settlement of Orgères (La Thuile-AO, Italy).**
Chiara Maria Lebole, University of Torino, Italy
Marco Russo, University of Torino, Italy
Alberto Spegis, University of Torino, Italy
Giorgio Di Gangi, University of Torino, Italy
- 125 Structural degradation measurement and diagnostics of historical masonry buildings.**
Valentino Sangiorgio, Politecnico di Bari, Italy
Silvia Martiradonna, Politecnico di Bari, Italy
Fabio Fatiguso, Politecnico di Bari, Italy
Giuseppina Uva, Politecnico di Bari, Italy

Patronages



CONFERENCE PROGRAM

Wednesday, December 4

Special Session - Data Acquisition and Processing by Integrated Geomatic Techniques, Experiences and Open Issues - PART I

Room: Great Hall, University of Florence, SAGAS Dep

Chairs: *Gabriele Bitelli, University of Bologna, Italy*
Maria Grazia D'Urso, DISA, University of Bergamo, Italy

- 1 An Updated Comparison on Contemporary Approaches for Digitization of Heritage Objects**
Efstathios Adamopoulos, Università degli Studi di Torino, Italy
Fulvio Rinaudo, Politecnico di Torino, Italy

- 7 A methodology for semi-automatic documentation of archaeological elements using RPAS imagery**
Eduard Angelats, Centre Tecnològic de Telecomunicacions de Catalunya, Spain
M. E. Parés, Centre Tecnològic de Telecomunicacions de Catalunya, Spain
C. Mas-Florit, Universitat de Barcelona, Spain
M.A Cau-Ontiveros, Universitat de Barcelona, ICREA, Spain

- 13 Modelling the Seventies: Image-Based Modelling to Investigate Landscape Change in a Mediterranean Mountain Area**
Manuel J.H. Peters, Politecnico di Torino, Italy, Uni. de Évora, Portugal, Uni. Leiden, The Netherlands
Tesse D. Stek, Universiteit Leiden, The Netherlands, Royal Netherlands Institute, Italy

- 19 Evaluation of the Expected Data Quality in Laser Scanning Surveying of Archaeological Sites**
Mattia Previtali, Politecnico Milano, Italy
Lucia Díaz-Vilariño, Universidade de Vigo, Spain
Marco Scaioni, Politecnico Milano, Italy
Ernesto Frías Nores, Universidade de Vigo, Spain

- 25 Rapid Mapping methods for archaeological sites**
Antonia Spanò, Politechnics of Turin, Italy

Special Session - IoT based Systems for the Structural Health Monitoring and the Analysis of Cultural Heritage Building and Archaeological Sites

Room: Parva Hall, University of Florence, SAGAS Dep

Chairs: *Carmelo Scuro, University of Calabria, Italy*

- 31 The Non-smooth tale of “Apennine Churches” stroked by the Central Italy Earthquakes of 2016**
Angela Ferrante, Polytechnic University of Marche, Italy
Ersilia Giordano, Polytechnic University of Marche, Italy
Francesco Clementi, Polytechnic University of Marche, Italy
Gabriele Milani, Politecnico di Milano, Italy
Antonio Formisano, University of Naples ‘Federico II’, Italy

- 37 Cultural Heritage and earthquake: the case study of San Francesco’s church in Amandola (Central Italy)**
Ersilia Giordano, Polytechnic University of Marche, Italy
Angela Ferrante, Polytechnic University of Marche, Italy
Francesco Clementi, Polytechnic University of Marche, Italy
Gabriele Milani, Politecnico di Milano,
Antonio Formisano, University of Naples ‘Federico II’, Italy

- 43 **An innovative structural health monitoring system for the preliminary study of an ancient anti-seismic construction technique.**
Carmelo Scuro, University of Calabria, Italy
Domenico Luca Carnì, University of Calabria, Italy
Francesco Lamonaca, University of Sannio, Italy
Renato Sante Olivito, University of Calabria, Italy
Gabriele Milani, University of Milan, Italy
- 48 **Automated procedure for the creation of finite element mesh: application to non-periodic historical masonry**
Simone Tiberti, University of Milan, Italy
Gabriele Milani, University of Milan, Italy
- 53 **SHM systems applied to the built heritage inventory at the territorial scale. A preliminary study based on CARTIS approach**
Renato Sante Olivito, University of Calabria, Italy
Saverio Porzio, University of Calabria, Italy
Carmelo Scuro, University of Calabria, Italy
Domenico Luca Carnì, University of Calabria, Italy
Francesco Lamonaca, University of Sannio, Italy
-

Thursday, December 5

Keynote Lecture: Conservation Science and Ethics in the Analytical Studies of Clay Cuneiform Tablets from Ancient Near Eastern Archives

Room: Great Hall, University of Florence, SAGAS Dep

Chairs: *Emma Angelini, Politecnico di Torino, Italy*

- 59 **Conservation Science and Ethics in the Analytical Studies of Clay Cuneiform Tablets from Ancient Near Eastern Archives**
Yuval Goren, Ben Gurion University of the Negev, Israel
Erez Ben-Yosef, Tel Aviv University, Israel
Francisco Centola, Universidade de Évora, Portugal
Cécile Fossé, Ben Gurion University of the Negev, Israel, Universidade de Évora, Portugal
Yaron Katzir, BeGorenn Gurion University of the Negev, Israel
José Mirão, Universidade de Évora, Portugal
Ron Sha'ar, The Hebrew University of Jerusalem, Israel
Yitzhak Vassal, Tel Aviv University, Israel Antiquities Authority, Israel
Nicola Schiavon, Universidade de Évora, Portugal
-

Special Session on Advanced methodologies for diagnostic and preventive conservation of stone materials in subaerial and underwater environment

Room: Great Hall, University of Florence, SAGAS Dep

Chairs: *Mauro Francesco La Russa, University of Calabria, Italy*

Paola Fermo, University of Milan, Italy

- 68 **SEM-EDS microanalysis in cultural heritage and archaeology: thickness effects and measurement strategy for ultrathin glass and metal fragments and particles**
Daniele Moro, Università di Bologna "Alma Mater Studiorum", Italy
Gianfranco Ulian, Università di Bologna "Alma Mater Studiorum", Italy
Giovanni Valdrè, Università di Bologna "Alma Mater Studiorum", Italy

73 Metals distributions within black crusts sampled on the facade of an historical monument: the case study of the Cathedral of Monza (Milan, Italy)

Valeria Comite, Università degli Studi di Milano, Italy
Jose Santiago Pozo-Antonio, University of Vigo, Spain
Carolina Cardell, University of Granada, Spain
Teresa Rivas, University of Vigo, Spain
Luciana Randazzo, Università della Calabria, Italy
Mauro Francesco La Russa, Università della Calabria, Italy
Paola Fermo, Università degli Studi di Milano, Italy

Special Session on Measuring Ancient Mortars and Concretes to Discover the Past

Room: Parva Hall, University of Florence, SAGAS Dep

Chairs: *Marco Lezzerini, University of Pisa, Italy*
Andrea Aquino, University of Pisa, Italy

79 Characterization of mortars of Giotto's Bell Tower for radiocarbon dating

Sara Calandra, (CNR-ICVBC), University of Florence, Italy
Serena Barone, University of Florence, INFN Florence Unit, Italy
Emma Cantisani, (CNR-ICVBC), Italy
Mariaelena Fedi, INFN Florence Unit, Italy
Carlo Alberto Garzonio, University of Florence, Italy
Lucia Liccioli, INFN Florence Unit, Italy
Barbara Salvadori, (CNR-ICVBC), Italy
Teresa Salvatici, University of Florence, Italy
Paola Ricci, University of Campania Luigi Vanvitelli, Italy

84 Calcarenite di Gravine Formation, a Row Material for the lime production

Agnese Emanuela Bonomo, University of Basilicata, Italy
G. Rizzo, University of Basilicata, Italy
G. Prosser, University of Basilicata, Italy

90 The production of binding materials in southern Florence area: stones and their properties (Greve in Chianti, Italy)

Andrea Aquino, Università di Pisa, Italy
Elena Pecchioni, Università di Firenze, Italy
Fabio Fratini, Consiglio Nazionale delle Ricerche, Italy
Emma Cantisani, Consiglio Nazionale delle Ricerche, Italy
Sonia La Felice, Consiglio Nazionale delle Ricerche, Italy
Tsegaye Abebe, Adhana Geological Consultancy Service, Italy
Claudia Principe, Consiglio Nazionale delle Ricerche, Italy
Marco Lezzerini, Università di Pisa, Italy

95 New Strategies in Mortar Characterization and Radiocarbon Dating

Giulia Ricci, University of Padova, Italy
Michele Secco, University of Padova, Italy
Fabio Marzaioli, (CIRCE), INNOVA SCaRL, Italy
Isabella Passariello, (CIRCE), INNOVA SCaRL, Campania Uni. "Luigi Vanvitelli", Italy
Filippo Terrasi, (CIRCE), INNOVA SCaRL, Campania Uni. "Luigi Vanvitelli", Italy
Gilberto Artioli, University of Padova, Italy

Special Session on Electromagnetic methods in Archaeology and Cultural Heritage applications - PART I

Room: Italian Geographic Military Institute - De Vecchi Hall

Chairs: *Giovanni Leucci, IBAM-CNR, Italy*
Rita Deiana, University of Padova, Italy
Raffaele Martorana, University of Palermo, Italy

- 100 The watch towers in Malta: a patrimony to preserve for the future**
Raffaele Persico, IBAM-CNR, University Uninettuno UTIU, Italy
Giovanni Leucci, IBAM-CNR, Italy
Sebastiano D'Amico, University of Malta, Malta
Lara De Giorgi, IBAM-CNR, Italy
Emanuele Colica, University of Malta, Malta
Maurizio Lazzari, IBAM-CNR, Italy
- 103 Matera European Capital of Culture 2019: NDT surveys in cave churches**
Lara De Giorgi, IBAM-CNR, Italy
Maurizio Lazzari, IBAM-CNR, Italy
Giovanni Leucci, IBAM-CNR, Italy
Raffaele Persico, IBAM-CNR, Italy
- 105 Remotely controlled aerial and underwater vehicles in support to magnetic surveys**
Salvatore Scudero, INGV, Osservatorio Nazionale Terremoti, Italy
Giovanni Vitale, INGV, Osservatorio Nazionale Terremoti, Italy
Antonino Pisciotta, INGV, Sezione di Palermo, Italy
Raffaele Martorana, Università degli studi di Palermo, Italy
Patrizia Capizzi, Università degli studi di Palermo, Italy
Antonino D'Alessandro, INGV, Osservatorio Nazionale Terremoti, Italy
- 109 Recent developments on portable XRF scanner**
Sergio Augusto Barcellos Lins, La Sapienza Università di Roma, INFN Roma Tre, Italy
Giovanni Ettore Gigante, La Sapienza Università di Roma, Italy
Roberto Cesareo, Università degli Studi di Sassari, Italy
Stefano Ridolfi, Ars Mensurae, Italy

General Session - PART I

Room: Italian Geographic Military Institute - Sala del Cortile

Chairs: *Marco Carpiceci, Sapienza University of Rome, Italy*
Marcantonio Catelani, University of Florence, Italy

- 114 Managing complex Synchrotron radiation FTIR micro-spectra from historic bowed musical instruments by chemometrics**
Silvia Grassi, Università degli Studi di Milano, Italy
Giacomo Fiocco, Università degli Studi di Pavia, Università di Torino, Italy
Claudia Invernizzi, Università degli Studi di Pavia, Uni. degli Studi di Parma, Italy
Tommaso Rovetta, Università degli Studi di Pavia, Italy
Michela Albano, Università degli Studi di Pavia, Italy
Patrizia Davit, Università di Torino, Italy
Monica Gulmini, Università di Torino, Italy
Chiaromaria Stani, Elettra-Sincrotrone Trieste, Italy
Lisa Vaccari, Elettra-Sincrotrone Trieste, Italy
Maurizio Licchelli, Università degli Studi di Pavia, Italy
Marco Malagodi, Università degli Studi di Pavia, Italy
- 120 First sampling of ceramic mixtures for Valle d'Aosta: research and perspectives related to the alpine settlement of Orgères (La Thuile-AO, Italy).**
Chiara Maria Lebole, University of Torino, Italy
Marco Russo, University of Torino, Italy
Alberto Spegis, University of Torino, Italy
Giorgio Di Gangi, University of Torino, Italy
- 125 Structural degradation measurement and diagnostics of historical masonry buildings.**
Valentino Sangiorgio, Politecnico di Bari, Italy
Silvia Martiradonna, Politecnico di Bari, Italy
Fabio Fatiguso, Politecnico di Bari, Italy
Giuseppina Uva, Politecnico di Bari, Italy

Special Session on Integrated Digital Survey Methodologies for the Knowledge and Enhancement of Architectural and Urban Heritage - PART I

Room: Great Hall, University of Florence, SAGAS Dep

Chairs: *Marco Giorgio Bevilacqua, University of Pisa, Italy*

Assunta Pelliccio, University of Cassino, Italy

131 Integrated digital survey methodologies for the knowledge and enhancement of the ancient city walls. The “Curtain” of Santa Chiara in Cagliari (Italy)

Andrea Pirinu, University of Cagliari, Italy

Marco Utzeri, University of Cagliari, Italy

136 Historical data of laser scanning and photogrammetry for the knowledge and memory plan of Cultural Heritage

Gabriella Caroti, DICI, University of Pisa, Italy

Isabel Martínez-Espejo Zaragoza, DICI, University of Pisa, Italy

Andrea Piemonte, DICI, University of Pisa, Italy

142 SfM and Digital Modelling for Enhancing Architectural Archives Heritage

Roberta Spallone, Politecnico di Torino, Italy

Giulia Bertola, MODLab Arch, Italy

Francesca Ronco, MODLab Design, Italy

Special Session on Non-Invasive Systems and Techniques for "on-site" Monitoring and Diagnosis - PART I

Room: Parva Hall, University of Florence, SAGAS Dep

Chairs: *Emanuele Piuzzi, Sapienza University of Rome, Italy*

Livio d'Alvia, Sapienza University of Rome, Italy

149 A comparative evaluation of patch resonators layouts for moisture measurement in historic masonry units

Livio D'Alvia, Sapienza University of Rome, Italy

Eduardo Palermo, Sapienza University of Rome, Italy

Zaccaria Del Prete, Sapienza University of Rome, Italy

Erika Pittella, Sapienza University of Rome, Italy

Stefano Pisa, Sapienza University of Rome, Italy

Emanuele Piuzzi, Sapienza University of Rome, Italy

154 Integrated approach for non invasive diagnostic investigation at the Bishop's Palace of Frascati

Luisa Caneve, ENEA, Italy

Francesco Colao, ENEA, Italy

Massimiliano Guarneri, ENEA, Italy

Marialuisa Mongelli, ENEA, Italy

Valeria Spizzichino, ENEA, Italy

Massimo Francucci, ENEA, Italy

160 Mid-wave infrared imaging analysis of XVII century paintings on canvas of the Chigi Palace in Ariccia

Sofia Ceccarelli, Università degli Studi di Roma Tor Vergata, Italy

Noemi Orazi, Università degli Studi di Roma Tor Vergata, Italy

Fulvio Mercuri, Università degli Studi di Roma Tor Vergata, Italy

Stefano Paoloni, Università degli Studi di Roma Tor Vergata, Italy

Ugo Zammit, Università degli Studi di Roma Tor Vergata, Italy

Francesco Petrucci, Palazzo Chigi, Italy

166 Photogrammetry and structured light: comparison and integration of techniques in survey of the Corsini Throne at Corsini Gallery in Rome

Marialuisa Mongelli, ENEA, Italy

Giulia Chellini, ENEA, Italy

Silvio Migliori, ENEA, Italy

Antonio Perozziello, ENEA, Italy

Samuele Pierattini, ENEA, Italy

Marco Puccini, ENEA, Italy

Alessandro Cosma, Galleria Nazionale Corsini, Italy

Special Session on Electromagnetic methods in Archaeology and Cultural Heritage applications - PART II

Room: Italian Geographic Military Institute - De Vecchi Hall

Chairs: *Giovanni Leucci, IBAM-CNR, Italy*

Rita Deiana, University of Padova, Italy

Raffaele Martorana, University of Palermo, Italy

172 Structural detailing of buried Roman baths through GPR inspection

Luca Bianchini Ciampoli, Roma Tre University, Italy

Roberta Santarelli, Roma Tre University, Italy

Ersilia Maria Loreti, Sovrintendenza Capitolina ai Beni Culturali, Italy

Alessandra Ten, University of Roma La Sapienza, Italy

Andrea Benedetto, Roma Tre University, Italy

178 A 3D information framework for automated archaeological pottery archival

Luca Di Angelo, University of L'Aquila, Italy

Paolo Di Stefano, University of L'Aquila, Italy

Emanuele Guardiani, University of L'Aquila, Italy

Anna Eva Morabito, University of Salento, Italy

184 Hydrogeological and geotechnical modeling of the foundation soils of Maredolce Lake in Palermo, aided by geophysical surveys

Fabio Cafiso, University of Palermo, Italy

Alessandro Canzoneri, University of Palermo, Italy

Patrizia Capizzi, University of Palermo, Italy

Alessandra Carollo, University of Palermo, Italy

Raffaele Martorana, University of Palermo, Italy

Filippo Romano, University of Palermo, Italy

General Session - PART II

Room: Italian Geographic Military Institute - Sala del Cortile

Chairs: *Paolo Liverani, University of Florence, Italy*

Marcantonio Catelani, University of Florence, Italy

188 Metrological approach to the study of Central European regular cities

Maria Legut-Pintal, Wrocław University of Science and Technology, Poland

Anna Kubicka, Wrocław University of Science and Technology, Poland

193 Roman fragmentary painting: surveying technologies and methodological approaches.

Maria Legut-Pintal, Wrocław University of Science and Technology, Poland

Anna Kubicka, Wrocław University of Science and Technology, Poland

199 Thermoluminescence dating laboratory improvements tested on an archaeological rescue site in Trino, Vercelli province, Italy.

Laura Guidorzi, Università di Torino, INFN Sezione di Torino, Italy

Fulvio Fantino, TecnArt S.r.l., Italy

Elisabetta Durisi, Università di Torino, INFN Sezione di Torino, Italy

Marco Ferrero, Università di Torino, INFN Sezione di Torino, Italy

Alessandro Re, Università di Torino, INFN Sezione di Torino, Italy

Luisa Vigorelli, Università di Torino, Italy

Lorenzo Visca, Università di Torino, INFN Sezione di Torino, Italy

Monica Gulmini, Università di Torino, Italy

Giovanni Dughera, INFN Sezione di Torino, Italy

Giuseppe Giraudo, INFN Sezione di Torino, Italy

Debora Angelici, TecnArt S.r.l., Italy

Elisa Panero, Ministero per i Beni e le Attività Culturali, Italy

Alessandro Lo Giudice, Università di Torino, INFN Sezione di Torino, Italy

Special Session on Integrated Digital Survey Methodologies for the Knowledge and Enhancement of Architectural and Urban Heritage - PART II

Room: Great Hall, University of Florence, SAGAS Dep

Chairs: *Marco Giorgio Bevilacqua, University of Pisa, Italy*
Assunta Pelliccio, University of Cassino, Italy

205 Digital Survey and 3D Geometric Interpretation of Complex Vaulted Systems. Palazzo Valperga Galleani di Barbaresco in Turin

Marco Vitali, Politecnico di Torino, Italy
Fabrizio Natta, Politecnico di Torino, Italy

211 3D procedural modeling of complex vaulted systems: geometric rules vs SfM based modeling

Vincenzo Bagnolo, DICAAR, University of Cagliari, Italy
Raffaele Argiolas, DICAAR, University of Cagliari, Italy

217 Roots of 'Parametric Thinking' in Palladio's Villas. Surveying, interpreting and visual programming the plates from I quattro libri di architettura

Roberta Spallone, Politecnico di Torino, Italy
Michele Calvano, Politecnico di Torino, Italy

223 Integration and modelling of 3D data as strategy for structural diagnosis in Endangered Sites. The study case of Church of the Annunciation in Pokcha (Russia)

Sandro Parrinello, University of Pavia, Italy
Raffaella De Marco, University of Pavia, Italy

Special Session on Non-Invasive Systems and Techniques for "on-site" Monitoring and Diagnosis - PART II

Room: Parva Hall, University of Florence, SAGAS Dep

Chairs: *Emanuele Piuze, Sapienza University of Rome, Italy*
Livio d'Alvia, Sapienza University of Rome, Italy

229 Structural health monitoring of the Ninfeo Ponari by combined use of fibre optic sensors, photogrammetry and laser scanning

Michele Arturo Caponero, ENEA, Italy
Ernesto Grande, Univ. Guglielmo Marconi, Italy
Maura Imbimbo, Univ. of Cassino and Southern Lazio, Italy
Giuseppe Modoni, Univ. of Cassino and Southern Lazio, Italy
Marialuisa Mongelli, ENEA, Italy
Eugenio Polito, Univ. of Cassino and Southern Lazio, Italy

234 Archaeological application of centreless X-ray diffractometers for non-destructive pole figure measurements

Máté Sepsi, University of Miskolc, Hungary
Márton Benke, University of Miskolc, Hungary
Valéria Mertinger, University of Miskolc, Hungary

239 New, non-invasive texture measurement method for archaeology

Máté Sepsi, University of Miskolc, Hungary
Márton Benke, University of Miskolc, Hungary
Valéria Mertinger, University of Miskolc, Hungary

244 Diagnostic of historical vehicle's engines by acoustic emission techniques

Alejandro Roda-Buch, Haute Ecole Arc, Ecole Polytechnique Fédérale, Switzerland
Emilie Cornet, Haute Ecole Arc, Switzerland
Guillaume Rapp, Haute Ecole Arc, Switzerland
Brice Chalançon, Musée National de l'Automobile, France
Stefano Mischler, Ecole Polytechnique Fédérale, Switzerland
Laura Brambilla, Haute Ecole Arc, Switzerland

Special Session on Electromagnetic methods in Archaeology and Cultural Heritage applications - PART III

Room: Italian Geographic Military Institute - De Vecchi Hall

Chairs: *Giovanni Leucci, IBAM-CNR, Italy*

Rita Deiana, University of Padova, Italy
Raffaele Martorana, University of Palermo, Italy

- 249 **Ground Penetrating Radar investigation of the floor of Palazzo Vecchio's Great Hall**
Massimiliano Pieraccini, University of Florence, Italy
Lapo Miccinesi, University of Florence, Italy
Heidi Garcia Canizares, University of Florence, Italy
- 254 **Architectural survey and analysis of the costal tower of S. Maria dell'Alto in Nardò (Lecce, Italy).**
Francesco Gabellone, (ISPC-CNR) National Research Council, Italy
Ivan Ferrari, (ISPC-CNR) National Research Council, Italy
Alessandro Giuri, External collaborator, Italy
Francesco Giuri, (ISPC-CNR) National Research Council, Italy
- 259 **Effectiveness of electromagnetic conductivity mapping for delineating subsurface structures related to the Roman port of Emporiae**
Albert Casas, University of Barcelona, Spain
Pere Castanyer, Empúries. Museo d'Arqueologia, Spain
Mahjoub Himi, University of Barcelona, Spain
Raul Lovera, University of Barcelona, Spain
Lluís Rivero, University of Barcelona, Spain
Marta Santos, Empúries. Museo d'Arqueologia, Spain
Joaquim Tremoleda, Empúries. Museo d'Arqueologia, Spain
Rubén García, University of Barcelona, Spain
Aritz Urruela, University of Barcelona, Spain
- 265 **THE PIETRAGALLA PROJECT: FIRST RESULTS OF THE GEOPHYSICAL ACTIVITIES ON THE MONTE TORRETTA ARCHAEOLOGICAL SITE**
Luigi Capozzoli, CNR – IMAA, Italy
Vincenzo Capozzoli, Université Paris, 1 Panthéon-Sorbonne, France
Gregory De Martino, CNR – IMAA, Italy
Alain Duploux, Université Paris, 1 Panthéon-Sorbonne, France
Agnes Henning, Humboldt Universität zu Berlin, Germany
Enzo Rizzo, CNR – IMAA, Italy

Special Session on Data Acquisition and Processing by Integrated Geomatic Techniques, Experiences and Open Issues - PART II

Room: Italian Geographic Military Institute - Sala del Cortile

Chairs: Maria Grazia D'Urso, DISA, University of Bergamo, Italy
Grazia Tucci, DICEA, University of Florence, Italy

- 271 **Geomatics for Cultural Heritage conservation: integrated survey and 3D modeling**
Valeria Croce, DICI, University of Pisa, Italy
Gabriella Caroti, DICI, University of Pisa, Italy
Andrea Piemonte, DICI, University of Pisa, Italy
Marco Giorgio Bevilacqua, DESTEC, University of Pisa, Italy
- 277 **High-resolution 3D surveying in support of Cultural Heritage**
Francolini Chiara, University of Bologna, Italy
Gabriele Bitelli, University of Bologna, Italy
Beatrice Borghi, University of Bologna, Italy
Filippo Galletti, University of Bologna, Italy
- 282 **Terrestrial laser scanning points clouds for modeling masonry vaults**
Maria Grazia D'Urso, Department of Engineering and Applied Sciences, University of Bergamo, Italy
Valerio Manzari, Department of Civil and Mechanical Engineering, University of Cassino, Italy
Barbara Marana, Department of Engineering and Applied Sciences, University of Bergamo, Italy
- 288 **Additive manufacturing of marble statues: 3D replicas for the preservation of the originals**
Grazia Tucci, DICEA, University of Florence, Italy
Valentina Bonora, DICEA, University of Florence, Italy
Valerio Tesi, Soprintendenza Archeologia, Belle arti e paesaggio, Italy
Bernardo Pagnini, Freelance Architect, Italy

Special Session on Conservation and protection of natural and artificial stones used in historical buildings

Room: Great Hall, University of Florence, SAGAS Dep

Chairs: Marco Lezzerini, University of Pisa, Italy

Rosaria D'Amato, ENEA, Italy

Andrea Aquino, University of Pisa, Italy

294 Performance of consolidants in marble and sandstone from Tuscany: a comparison

Andrea Aquino, Università di Pisa, Italy

Marco Lezzerini, Università di Pisa, Italy

299 Synthesis and characterization of nanosilica products for the consolidation of stones.

Neva Maria Elisabetta Stucchi, Università Ca' Foscari di Venezia, Italy

Elena Tesser, Iuav University of Venice, Italy

Fabrizio Antonelli, Iuav University of Venice, Italy

Alvise Benedetti, Università Ca' Foscari di Venezia, Italy

305 MATERA BUILDING STONES: CHEMICAL, MINERALOGICAL AND PETROPHYSICAL CHARACTERIZATION OF THE CALCARENITE DI GRAVINA FORMATION

Agnese Emanuela Bonomo, University of Basilicata, Italy

Marco Lezzerini, University of Pisa, Italy

G. Prosser, University of Basilicata, Italy

A. Munnecke, University of Erlangen-Nuremberg, Germany

R. Koch, University of Erlangen-Nuremberg, Germany

G. Rizzo, University of Basilicata, Italy

309 Intercalibration of hyperspectral and multispectral systems for Laser Induced Fluorescence imaging

Maria Federica Caso, ENEA, Italy

Luisa Caneve, ENEA, Italy

Valeria Spizzichino, ENEA, Italy

314 ARCHAOMETRIC STUDIES AND CONSERVATION SOLUTIONS FOR CORVIN'S CASTLE CIRCULAR TOWERS

Rodica-Mariana Ion, ICECHIM, Research Group, Valahia University of Târgoviște, Romania

Sorin Tincu, Corvin's Castle, Romania

Lorena Iancu, ICECHIM, Research Group, Valahia University of Târgoviște, Romania

Ramona Marina Grigorescu, ICECHIM, Research Group, Romania

Cristiana Radulescu, University of Târgoviște - ICSTM-UVT, Romania

Sofia Teodorescu, University of Târgoviște - ICSTM-UVT, Romania

Ioana Daniela Dulama, University of Târgoviște - ICSTM-UVT, Romania

Raluca Maria Stirbescu, University of Târgoviște - ICSTM-UVT, Romania

Ioan Alin Bucurica, University of Târgoviște - ICSTM-UVT, Romania

Mihaela Lucia Ion, "Atelierul de Creatie" NGO, Romania

Anca Irina Gheboianu, University of Târgoviște - ICSTM-UVT, Romania

318 A novel fibre optic sensor of relative humidity for application in cultural heritage

Rosaria D'Amato, ENEA, Italy

Michele Arturo Caponero, ENEA, Italy

Barbara Palazzo, ENEA, Italy

Gaetano Terranova, ENEA, Italy

Andrea Polimadei, ENEA, Italy

Friday, December 6

Special Session on Pigments and palettes through the Ages: science of painting techniques

Room: Italian Geographic Military Institute - De Vecchi Hall

Chairs: Vincenza Crupi, University of Messina, Italy

Valentina Venuti, University of Messina, Italy

324 Chemical-structural analysis of wooden painted specimens by clinical multi-slice computed tomography (MSCT) and surface-enhanced Raman scattering (SERS)

Sveva Longo, University of Messina, Sapienza University of Rome, Italy

Francesca Granata, University of Messina, Italy

Silvia Capuani, Sapienza University of Rome, Italy

Fortunato Neri, University of Messina, Italy

Enza Fazio, University of Messina, Italy

330 Scientific investigation of The Conversion of St Paul painting (Mdina, Malta)

Sebastiano D'Amico, University of Malta, Malta

Valentina Venuti, University of Messina, Italy

Emanuele Colica, University of Malta, Malta

Vincenza Crupi, University of Messina, Italy

Domenico Majolino, University of Messina, Italy

Giuseppe Paladini, University of Messina, Italy

Sante Guido, University of Trento, Italy

Giuseppe Mantella, Giuseppe Mantella Restauro Opere D'Arte, Italy

Rosarianna Zumbo, St Martin's College, Malta

POSTER SESSION

Room: Italian Geographic Military Institute

Chairs: *Lorenzo Ciani, University of Florence, Italy*

335 New insights about the consolidation of archaeological mortars located in underwater environment: the case study of the apsidal fishpond of Castrum Novum (Santa Marinella, Rome, Italy)

Mauro Francesco La Russa, University of Calabria, Italy

Luciana Randazzo, University of Calabria, Italy

Michela Ricca, University of Calabria, Italy

Daniela Pellegrino, University of Calabria, Italy

Daniele La Russa, University of Calabria, Italy

Alessandro Morrone, University of Calabria, Italy

Barbara Davidde, Ministero dei Beni e delle Attività Culturali e del Turismo, Italy

Flavio Enei, Museo del Mare e della Navigazione Antica, Italy

338 A combined petrographic and geochemical metrological approach to assess the provenance of the building limestone used in the Batalha Monastery (Portugal)

Yufan Ding, University of Évora, Portugal

José Mirao, University of Évora, Portugal

Pedro Redol, Mosteiro da Batalha, Portugal

Luis Dias, University of Évora, Portugal

Patricia Moita, University of Évora, Portugal

Emma Angelini, Politecnico di Torino, Italy

Sabrina Grassini, Politecnico di Torino, Italy

Nicola Schiavon, University of Évora, Portugal

343 Ground-penetrating Radar surveys in the Lecce Cathedral

Giovanni Leucci, IBAM-CNR, Italy

Ilaria Miccoli, IBAM-CNR, Italy

Lara De Giorgi, IBAM-CNR, Italy

Immacolata Ditaranto, IBAM-CNR, Italy

Giuseppe Scardozi, IBAM-CNR, Italy

346 The Epizefiri Archaeological Site in Locri (Reggio Calabria, Italy): Geophysical surveys for excavation project

Giovanni Leucci, CNR, Italy

Daniele Malfitana, CNR, Italy

Lara De Giorgi, CNR, Italy

Antonino Mazzaglia, CNR, Italy

Giovanni Fragalá, CNR, Italy

348 Geophysical investigations for the knowledge of the buried structures in the Basilica Julia at the Roman Forum

Giovanni Leucci, IBAM-CNR, Italy
Tommaso Ismaelli, IBAM-CNR, Italy
Lara De Giorgi, IBAM-CNR, Italy
Immacolata Ditaranto, IBAM-CNR, Italy
Giuseppe Scardozzi, IBAM-CNR, Italy
Marco Galli, Sapienza Università di Roma, Italy
Carlo Inglese, Sapienza Università di Roma, Italy
Marika Griffo, Sapienza Università di Roma, Italy

351 Melite Civitas Romana Project: preliminary results from GPR survey

Robert Brown, Australian National University, Australia
David Cardona, Heritage, Malta
Lara De Giorgi, CNR, Italy
Giovanni Leucci, CNR, Italy
Ben Lowe, University of North Alabama, USA
Raffaele Persico, CNR, Italy
Davide Tanasi, University of South Florida, USA
Andrew Wilkinson, Flinders University, Australia

355 GIS to catalogue the shipment of naves lapidariae in Mediterranean Sea

Maurizio Delli Santi, CNR – ISPC, Italy

361 Geophysical surveys for the restoration of Branciforte Palace in Palermo

Patrizia Capizzi, University of Palermo, Italy
Raffaele Martorana, University of Palermo, Italy

365 A multidisciplinary non-invasive approach in geoarchaeology conducted on the archaeological area of Selinunte

Antonino Pisciotta, Istituto Nazionale di Geofisica e Vulcanologia, Italy
Raffaele Martorana, University of Palermo, Italy
Antonio Costanzo, Istituto Nazionale di Geofisica e Vulcanologia, Italy
Maria Iliara Pannaccione Apa, Istituto Nazionale di Geofisica e Vulcanologia, Italy
Simona Bongiovanni, University of Palermo, Italy
Patrizia Capizzi, University of Palermo, Italy
Antonino D'Alessandro, Istituto Nazionale di Geofisica e Vulcanologia, Italy
Sergio Falcone, Istituto Nazionale di Geofisica e Vulcanologia, Italy
Carmelo La Piana, Istituto Nazionale di Geofisica e Vulcanologia, Italy

369 The Basilica of Santa Caterina d'Alessandria in Galatina (Lecce, Italy): NDT surveys for the conservation project

Giovanni Leucci, CNR, Italy
Lara De Giorgi, CNR, Italy
Giancarlo De Pascalis, Università La sapienza Roma, Italy
Giuseppe Scardozzi, CNR, Italy

371 The Monastery of Santa Chiara in Nardó (Lecce, Italy): GPR preliminary results

Giovanni Leucci, CNR, Italy
Lara De Giorgi, CNR, Italy
Giancarlo De Pascalis, Università La sapienza Roma, Italy
Francesco Giuri, CNR, Italy

374 Preliminary results from NDT-SPR survey on wooden beams

Giovanni Leucci, CNR, Italy
Lara De Giorgi, CNR, Italy

377 Geophysical surveys in the external areas of the Basilica of St Nicholas (Bari, Italy)

Giovanni Leucci, CNR, Italy
Lara De Giorgi, CNR, Italy
Raffaele Persico, CNR, Italy

- 380 **Characterization of the decay of a wooden trunk through electrical resistivity**
Lara De Giorgi, CNR, Italy
Giovanni Leucci, CNR, Italy
- 383 **Conservation purpose material testing of corrosion products on outdoor bronze statues in Museum Park of Hungarian National Museum**
Bubonyi Tamás, University of Miskolc, Hungary
Melinda Nagy, Hungarian National Museum, Hungary
Szilvia Gyöngyösi, University of Debrecen, Hungary
Laura Juhász, University of Debrecen, Hungary
Péter Barkóczy, FUX Co. Miskolc, Hungary
György Forgács, Forgax Alkotóműhely kft, Hungary
Bakonyi Eszter Szatmáriné, University of Fine Arts Budapest, Hungary
- 389 **Non-invasive characterization of ancient Cu-based coins using Raman spectroscopy**
Leila Es Sebar, Politecnico di Torino, Italy
Leonardo Iannucci, Politecnico di Torino, Italy
Yuval Goren, Ben Gurion University of the Negev, Israel
Peter Fabian, Ben Gurion University of the Negev, Israel
Emma Angelini, Politecnico di Torino, Italy
Sabrina Grassini, Politecnico di Torino, Italy
- 395 **Characterisation of Roman copper alloy artefacts and soil from Rakafot 54 (Beer Sheva, Israel)**
Manuel J.H. Peters, Politecnico di Torino, Italy, Universidade de Évora, Portugal, Ben-Gurion University of the Negev, Israel
Yuval Goren, Ben Gurion University of the Negev, Israel
Peter Fabian, Ben Gurion University of the Negev, Israel
José Mirão, Universidade de Évora, Portugal
Sabrina Grassini, Politecnico di Torino, Italy
Emma Angelini, Politecnico di Torino, Italy
- 401 **The photogrammetric survey of Tomb II in Agios Athanasios, Thessaloniki**
Alessandra Turco, University of Salerno, Italy
- 406 **Metrological characterization of a textile temperature sensor**
Lorenzo Quartini, University of Florence, Italy
Andrea Zanobini, University of Florence, Italy
- 412 **A Machine Learning approach to aerial photointerpretation and mapping**
Ilaria Cacciari, "Nello Carrara" – CNR, Italy
Giorgio Franco Pocobelli, SAGAS, Università di Firenze, Italy
Salvatore Siano, "Nello Carrara" – CNR, Italy
- 417 **Architecture - Conceptual design in terms of the intuitive metrology method as an element of the natural development of the landscape and spatial context**
Jerzy Wojewodka, Silesian University of Technology, Poland
Julia Giżewska, Silesian University of Technology, Poland
- 423 **Measurement and analysis of visitors' trajectories in crowded museums**
Pietro Centorrino, Sapienza Università di Roma, Italy
Alessandro Corbetta, Eindhoven University of Technology, The Netherlands
Emiliano Cristiani, CNR, Italy
Elia Onofri, CNR, Italy
- 429 **A novel approach for in-situ assessment of the efficacy of biocides on building of historical interest by bioluminescence**
Eleonora Marconi, Università Roma Tre, Italy
Simonetta Tuti, Università Roma Tre, Italy
Maria Rosaria Fianza, Università Roma Tre, Italy
Fabio Leccese, Università Roma Tre, Italy
Adele Galetti, Leonardo S.r.l., Italy
Francesco Geminiani, Leonardo S.r.l., Italy

- 435 A novel approach for in-situ assessment of the efficacy of biocides on building of historical interest by bioluminescence**
Giuseppe Schirripa Spagnolo, Università degli Studi Roma Tre, Italy
Lorenzo Cozzella, Università degli Studi Roma Tre, Italy
Fabio Leccese, Università degli Studi Roma Tre, Italy
- 439 Multi-band infrared imaging for the characterization of underlying elements in the Santa Maria in Cosmedin altarpiece**
Sofia Ceccarelli, Università degli Studi di Roma Tor Vergata, Italy
Noemi Orazi, Università degli Studi di Roma Tor Vergata, Italy
Cristina Cicero, Università degli Studi di Roma Tor Vergata, Italy
Fulvio Mercuri, Università degli Studi di Roma Tor Vergata, Italy
Ugo Zammit, Università degli Studi di Roma Tor Vergata, Italy
Stefano Paoloni, Università degli Studi di Roma Tor Vergata, Italy
Anna Candida Felici, Università di Roma "La Sapienza", Italy
Francesca Matera, Private Restorer, Italy
Mariella Nuzzo, Ministero per i Beni e le attività Culturali, Italy
- 444 Using 3D scanning in the protection of industrial heritage- the example of Queen Luise Adit**
Krzysztof Herner, The Coal Mining Museum in Zabrze, Poland
- 449 Design and Implementation of a Mobile Robot for the Mechatronic Survey**
Erika Ottaviano, University of Cassino and Southern Lazio, Italy
Pierluigi Rea, University of Cassino and Southern Lazio, Italy
- 454 A new mortar from a strange ancient mortar**
Fabio Fratini, CNR, Italy
Silvia Rescic, CNR, Italy
Emma Cantisani, CNR, Italy
Elena Pecchioni, CNR, University of Firenze, Italy
Stefano Pasolini, Freelance restorer, Italy
Andrea Cagnini, OPD (Opificio delle Pietre Dure), Italy
- 459 Petrographic characteristics of the mortars from the Pisa's Cathedral apse**
Marco Lezzerini, University of Pisa, Italy
Marcello Spampinato, Freelance petrographer, Italy
Anton Sutter, Opera della Primaziale Pisana, Italy
Nadia Montevicchi, Freelance archaeologist, Italy
Andrea Aquino, University of Pisa, Italy
- 464 Quality Assurance for dosimetric measurements of mortar on polymineral fine grain fraction**
Kathya Bonilla, PH3DRA labs, Italy
Alessia D'Anna, PH3DRA labs, Italy
Sara Galvagno, PH3DRA labs, Italy
Anna Maria Gueli, PH3DRA labs, Italy
Stefania Pasquale, PH3DRA labs, Italy
Giuseppe Politi, PH3DRA labs, Italy
Giuseppe Stella, PH3DRA labs, Italy
- 469 Old anatomical models as makeshifts of measurements in medicine**
Emma Angelini, Politecnico di Torino, Italy
Andrea Gori, Museo Galileo, Italy
- 474 New insight on the 1st century BC paleo-sea level and related vertical ground movements along the Baia - Miseno coastal sector (Campi Flegrei, southern Italy)**
Pietro Aucelli, Università degli Studi di Napoli Parthenope, Italy
Claudia Caporizzo, Università degli Studi di Napoli Parthenope, Italy
Aldo Cinque, Università di Napoli 'Federico II', Italy
Gaia Mattei, Università degli Studi di Napoli Parthenope, Italy
Gerardo Pappone, Università degli Studi di Napoli Parthenope, Italy
Michele Stefanile, Università degli Studi di Napoli Parthenope, Italy

478 A petrographic study of the mortars from the Villa Reale di Marlia (NW Tuscany, Italy)

Marco Lezzerini, University of Pisa, Italy
Marcello Spampinato, Freelance Applied Petrographer, Italy
Nadia Montevicchi, Freelance Archaeologist, Italy
Luca Borgoni, Freelance Architect, Italy
Henric Grönberg, Villa Reale di Marlia, Italy
Andrea Aquino, University of Pisa, Italy

Special Session on Measuring in the past: ancient instruments between science and technology

Room: Parva Hall, University of Florence, SAGAS Dep

Chairs: *Emma Angelini, Politecnico di Torino, Italy*
Luisa Spairani, Gruppo Astrofili Eporediesi, Italy

483 A short tale of the short story of the sliding rule

Andrea Bacciotti, Politecnico di Torino, Italy

489 The sixteenth-century find “Treatise On Land Surveying Methods Using the Surveyor’s Cross”, by Francesco Paciotti, military and civil architect to the Duchy of Urbino: the technical evolution of a surveying tool.

Raffaella Marotti, Università degli Studi di Urbino "Carlo Bo", Italy

494 Measure by Measure they touched the heaven

Luisa Spairani, Gruppo Astrofili Eporediesi, Italy

499 Cleaning of historical scientific instruments: first analytical studies

Michela Albano, CISRiC, Università degli Studi di Pavia, Polytechnic of Milan, Italy
Giacomo Fiocco, CISRiC, Università degli Studi di Pavia, Università di Torino, Italy
Claudia Invernizzi, CISRiC, Uni. degli Studi di Pavia, Uni degli Studi di Parma, Italy
Maurizio Licchelli, CISRiC, Università degli Studi di Pavia, Italy
Marco Malagodi, CISRiC, Università degli Studi di Pavia, Italy
Raffaella Marotti, Università degli Studi di Urbino "Carlo Bo", Italy
Curzio Merlo, CISRiC, Università degli Studi di Pavia, Cr.Forma, Italy
Tommaso Rovetta, CISRiC, Università degli Studi di Pavia, Italy
Daniela Comelli, Polytechnic of Milan, Italy

505 Measuring instruments and protocols in Archaeomagnetic dating: Magneto-stratigraphy in Archaeology and Volcanology

Claudia Principe, CNR, Italy
Daniele Giordano, University of Turin, Italy
Sonia La Felice, CNR, Italy
Giulio Giovannetti, CNR, Italy
Marina Devidze, Tbilisi State University, Georgia

General Session - PART III

Room: Italian Geographic Military Institute - De Vecchi Hall

Chairs: *Lorenzo Ciani, University of Florence, Italy*

511 Presence and Applications of Bituminous Materials on the Ancient Vaccae Culture: a Nondestructive Spectroscopic Study

Javier Pinto, University of Valladolid, Spain
Carlos Sanz-Minguez, University of Valladolid, Spain
Carmelo Prieto, University of Valladolid, Spain

516 Computational modelling of the mechanical behaviour of the Pentelic Marble -Steel clamp system on the structures of the Athens Acropolis

Zacharias Vangelatos, University of California, USA
Michail Delagrammatikas, University of Athens, Greece
Olga Papadopoulou, University of Athens, Greece
Panayota Vassiliou, University of Athens, Greece

- 522 **Indirect Temperature Measurements for TL Signal Loss during Drilling**
Anna Maria Gueli, Università degli Studi di Catania & INFN-Sez CT, Italy
Stefania Pasquale, Università degli Studi di Catania & INFN-Sez CT, Italy
Giuseppe Politi, Università degli Studi di Catania & INFN-Sez CT, Italy
Giuseppe Stella, Università degli Studi di Catania & INFN-Sez CT, Italy
Carlo Trigona, Università degli Studi di Catania, Italy
- 527 **ERT investigation of tumuli: does the errors in locating electrodes influence the resistivity?**
Veronica Pazzi, University of Firenze, Italy
Lorenzo Ciani, University of Firenze, Italy
Luca Cappuccini, University of Firenze, Italy
Mattia Ceccatelli, University of Firenze, Italy
Gabriele Patrizi, University of Firenze, Italy
Giulia Guidi, University of Firenze, Italy
Nicola Casagli, University of Firenze, Italy
Marcantonio Catelani, University of Firenze, Italy

Special Session on Measurement and Instrumentation for the Preventive Conservation of Metallic Works of Art

Room: Great Hall, University of Florence, SAGAS Dep

Chairs: *Panayota Vassiliou, University of Athens, Greece*
Sabrina Grassini, Politecnico di Torino, Italy

- 533 **Micro-Raman investigation of dangerous corrosion products of archaeological bronzes from Tharros (Sardinia/Italy)**
Tilde de Caro, ISMN–CNR Rome, Italy
Leila Es Sebar, Politecnico di Torino, Italy
Emma Angelini, Politecnico di Torino, Italy
- 538 **MA-XRF measurement for corrosion assessment on bronze artefacts**
Sergio Augusto Barcellos Lins, La Sapienza Università di Roma, INFN Roma Tre, Italy
Elisabetta Di Francia, INFN Roma Tre, Italy
Sabrina Grassini, Politecnico di Torino, Italy
Giovanni Ettore Gigante, La Sapienza Università di Roma, Italy
Stefano Ridolfi, Ars Mensurae, Italy
- 543 **Measurement Setup for the Development of PreCorroded Sensors for Metal Artwork Monitoring**
Marco Faifer, DEIB, Politecnico di Milano, Italy
Sara Goidanich, Chemistry “Giulio Natta” Politecnico di Milano, Italy
Christian Laurano, DEIB, Politecnico di Milano, Italy
Chiara Petiti, Chemistry “Giulio Natta” Politecnico di Milano, Italy
Sergio Toscani, DEIB, Politecnico di Milano, Italy
Michele Zanoni, DEIB, Politecnico di Milano, Italy
- 549 **A long-term corrosion investigation of bronze sculptures exposed outdoor**
Leila Es Sebar, Politecnico di Torino, Italy
Alessandro Re, Università di Torino and INFN, Italy
Marco Parvis, Politecnico di Torino, Italy
Emma Angelini, Politecnico di Torino, Italy
Sabrina Grassini, Politecnico di Torino, Italy
- 554 **Provenance, manufacturing and corrosion behavior of Ancient Hellenistic coins from Egypt**
Panayota Vassiliou, School of Chemical Engineering, NTUA, Athens, Greece
Olga Papadopolou, School of Chemical Engineering, NTUA, Athens, Greece
Sabrina Grassini, Politecnico di Torino, Italy
Emma Angelini, Politecnico di Torino, Italy

Special Session on Metrology for taphonomy: quantifying the alterations of skeletal remains in archaeology

Room: Parva Hall, University of Florence, SAGAS Dep

Chairs: *Francesco Boschini, Università degli Studi di Siena, Italy*
Simona Arrighi, Università di Bologna, Italy

560 A new geometric morphometrics-based shape and size analysis discriminating anthropogenic and non-anthropogenic bone surface modifications of an experimental data set

Antoine Souron, Université de Bordeaux, France
Alexandre Napias, Université de Bordeaux, France
Thomas Lavidalie, Université de Bordeaux, France
Frédéric Santos, Université de Bordeaux, France
Ronan Ledevin, Université de Bordeaux, France
Jean-Christophe Castel, Muséum d'histoire naturelle, Switzerland
Sandrine Costamagno, Université de Toulouse Jean Jaurès, France
Daniel Cusimano, Diablo Valley College, USA
Stephanie Drumheller, The University of Tennessee, USA
Jennifer Parkinson, University of San Diego, USA
Lee Rozada, Muséum national d'Histoire naturelle, France
David Cochard, Université de Bordeaux, France

566 The cut runs deep: linking the cut marks to the cutting tools

Francesco Boschini, Università degli Studi di Siena, Italy
Erika Moretti
Daniele Aureli, Université Paris Ouest Nanterre La Défense, France
Jacopo Crezzini, Università degli Studi di Siena, Italy
Simona Arrighi, Università di Bologna, Italy

571 Detection of sexual dimorphism in the human neurocranium at local scale

Antonieta Del Bove, IPHES, Universitat Rovira i Virgili (URV), Spain
Antonio Profico, University of York, UK
Carlos Lorenzo, IPHES, Universitat Rovira i Virgili (URV), Spain

577 Index of Authors

Integration and modelling of 3D data as strategy for structural diagnosis in Endangered Sites. The study case of Church of the Annunciation in Pokcha (Russia)

Sandro Parrinello¹, Raffaella De Marco¹

¹ *University of Pavia, via Ferrata 3 27100 Pavia (Italy), sandro.parrinello@unipv.it,
raffaella.demarco@unipv.it*

Abstract – Cultural Heritage and its variety of Built Heritage is increasing a scientific cognitive approach from European Committees, related to the difficulties of its protection and management. This is primarily due to the lack of emergency protocols of structural knowledge and documentation on architecture and ruins, for the protection and intervention on an Endangered Heritage that is going to disappear. The consideration of structural documentation applied to Historical Built Heritage, as in the case study of Pokcha Church (Russia), reviews the declination of integrated products of 3D survey into Reality-Based Models, with the possibility of systematizing data through methodological phases and controlling the quality of numerical components into 3D polygonal models, in different levels of details and integration of survey data. These models are intended in the capacity of their shape to conserve morphological qualities about structural behaviour, and to fit into computational platforms of analysis, for information on tensional behaviour and emergency risks.

I. ENDANGERED SITES: TOPICS AND EMERGENCY FOR DOCUMENTATION

The analysis of Cultural Heritage, in parallel to the development of communitarian guidelines for its protection [1], is determining a growing scientific cognitive approach to European and Worldwide sites [2]. The variety of Built Heritage, including from localized historical buildings and monuments to extensive targets of historical centers, sites and territorial landscapes, intends a wider field of knowledge and intervention in terms of both structure, policy and extension. This justifies the difficulty of its protection and preservation, assisting to a fragmented reality of separated protocols of documentation, directly derived into computation and administrative actions. Thus, the difficulties in the sharing of information and data integration are influencing and slowing the entire approach in particular regarding the so-called “Endangered Heritage”, that class of heritage particularly affected by

proven or potential threats that define a high level of risk for its preservation [3].

Actually, the revision of those sites officially recognized highlights the coexistence of a double type of cognitive emergency on Built Heritage: on the one hand the classification of the site in its double meaning of physical container and cultural visualizer, on the other the growing request for parameters and specific analysis frameworks for the definition of the emergency value of the building, conditioning the relative useful time for intervention.

Thus, it follows a growing demand in the identification of these sites [4], both geographical and typological, expanding the dissemination and application of proportionate monitoring and knowledge practices, preliminary to intervention on territory [5], with the aim of triggering a growing process of safeguard policies [6].

The attention to safeguarding methodologies for existing heritage is receiving an awareness-raising improvement of research, able to develop new generations of digital products combining a Survey-based phase of digital documentation of Cultural Heritage, necessary for a correct and complete understanding of the characteristics and parameters of units and contexts of Built Heritage, to a Compute-based action of cognitive and interactive models, with the elaboration of 3D digital products for investigations and simulations on shapes and structures.

New representation systems produce new expectations related to digital communication, changing the objectives and constantly renewing the demand in analytical terms of cognitive requirements, also in response to necessities more linked to the computational nature of interaction within the models themselves, now capable of providing quantitative as well as qualitative answers. The difficulties on the development of reliable diagnosis of historical structures can be reconducted to the need of new methods of analysis, that can exploit computation through methodologies and cognitive practices experimented on the visual and graphic aspects of the documentation of architecture [7], in its present configuration as linked to its constructive and safeguarding rules.



Fig. 1. Examples of Endangered sites along Upper Kama Route (Russia): Bondjug, Uzhginskay, Usolye, Parakseva

II. HISTORICAL STRUCTURES AND THEIR CONNECTION TO ARCHITECTURAL DOCUMENTATION

The consideration of structural diagnosis applied to Historical Built Heritage, as capacity of knowledge of stress behaviours and prevision of damage mechanisms, has a central part in the development of documentation protocols for the safeguarding of heritage. The review on risks and priorities of endangered buildings [8] highlights the focus on the character of *Robustness*, as strength of architecture and its elements to withstand a level of stress derived from the combined action of degradation and function alteration of both materials and environments [9].

In this way, the theme of 3D models configures as a way of deriving and indexing information from investigation on historical structures, and as a possibility of interconnecting metadata and databases among them, moving to systematized data through methodological phases and 3D products. The model, whose numerical component determines and characterizes every aspect of its reliability, can become a tool for the management of the asset in terms of computing and planning interventions both in the short, medium and long term, and also for its enhancement.

These considerations are encouraging, both methodologically and contextually, the structuring of project ideas aimed at defining strategies of integration of data for the development and promotion of Structural Reality-Based Models on architectural heritage. On a scientific level, the experimentation of Reality-Based models for structural diagnosis will develop a multidisciplinary and implementable methodology, capable of preparing a standardized product, the polygonal model, in different levels of details and integration for the management of the existing Built Heritage. This species of model is intended for the intervention both in "emergency" and in "long term", in the calibration of his procedural computing, and in a both aware-scientific and a practical-operational direction, in the capacity of its shape to decline into morphological and computational platforms of analysis. The methodological process aims to be as far as possible fast, extendable and replicable, to facilitate interchange and make possible a complete knowledge and management capacity through 3D models of built assets in a state of emergency.

III. AN EXPERIMENTAL CASE STUDY: THE CHURCH OF THE ANNUNCIATION IN POKCHA (RUSSIA)

The case of Blagoveshchenskaya Church, or Church of the Annunciation in the village of Pokcha, within the Cultural Heritage Route of Upper Kama in Russia, consolidates a central historical-architectural phase characteristic of Cherdyn district, synthesizing the value of historical evolutionary urban events in the stratification of its structures and walls, today abandoned in a state of ruin.

The original wooden complex was replaced in 1785 with a new one in stone and brick masonry, subdivided in multiple environments: the main body, with a quadrilateral planimetry, constituting a nucleus for the refectory, the chapels of St. George (southern) and St. Nicholas (northern), the bell tower and the entrance narthex. In 1910, a reconstruction intervention modified structurally and morphologically large portions, in particular the bell tower, entirely replaced, and the eastern section of the central vault and the altar, reconstructed with the insertion of a 5-headed chapter; the interiors in plastered stone, with paintings and ornaments from 1870, are preserved instead. The general coat of the building with an additional red brick facing contributes to the strengthening of the external envelope and gives the possibility of inserting additional devices of tension resistance into the stratified walls.

The history of the site goes through restoration works attempted starting from 1920, until the complete abandonment in 1940 and the re-conversion into a power central: the energy issues linked to the new function led in the 90s to the partial collapse of the main pavilion vault and of the bell tower roof, after repeated flashes attracted by the electrical system. As result of the extensive damage, the church was excluded from the list of architectural

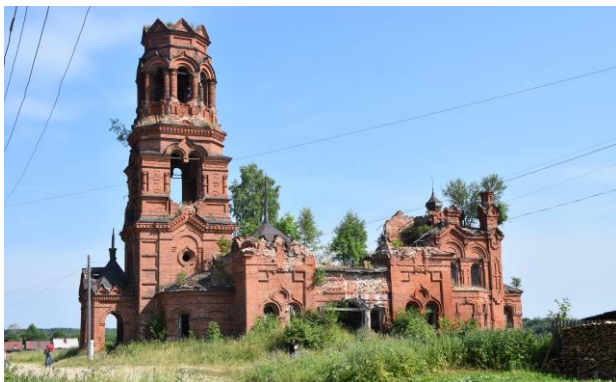


Fig. 2. Blagoveshchenskaya Church, or Church of the Annunciation in the village of Pokcha: historical documentation (before 1917) and conservation in 2018.

monuments of interest, precluding any new intervention and restoration initiative, and leaving the site to collapse.

In 2018 the architectural complex is in an obvious state of neglect. The rubble of the roofing systems of the main span, wooden and vaulted, have collapsed occupying the environment of the central nave: over time they have been covered by earth and vegetation creating a natural ridge, which reduces the access to the church only to the portions of narthex and apse. The connection to the bell tower, once permitted by the central nave through the gallery and the refectory, has been demolished and it prevents documenting the state of conservation of the elevated rooms, externally still conserved. The complex is also totally devoid of control and regulation services for the presence of people and animals, often occupying the narthex environments that, consequently, are deteriorated by the presence of herds in transhumance during the summer season.

IV. STRATEGIES OF ANALYSIS FOR THE DIGITIZATION OF THE RUINED SHAPE

The documentation of the current state of Blagoveshchenskaya Church has highlighted the need to experiment integrated approaches of acquiring the survived "shape" to understand the preservation of the architectural "ruin", centring the analysis on the main structures of the building and on their security for the recovery intervention [10].

The morphological analysis of masonry structures was organized and simplified during the digital measurement and acquisition processes, organizing a decomposition of the spatial constructive units that semantized the architectural apparatuses of environments, linking them to the global volumetric macrosystem at the end of the digitization process. Furthermore, the internal inspection of the masonry sections, in their fracture or collapsed portions, has allowed the cognitive integration of the structural envelope, reliably reconstructed in the shape of its architectural "skin", to which materials and constructive information can be referred.

The documentation approach thus highlights the need for a renewed attention to the methodologies of acquisition and representation of the formal properties of the complex itself, in particular in terms of their correspondence and integration, and encourages the possibilities offered by digital transposition as an enhanced opportunity for reconstruction and use of archaeological and architectural data. The adoption of a double level of acquisition, static from the ground with Terrestrial Laser Scanner (TLS) and mobile aerial with drones for photogrammetry (UAV), ensures total coverage and, despite of different instruments, defines a compatible procedure of integration of these data in the common format of point clouds.

A number of 73 TLS scans have been realized to collect all external surfaces and to spatially connect the complex distribution of internal environments. The quality of scans



Fig. 3. Vectorial and metric sections of Blagoveshchenskaya Church and of the main ruin vaulted central environment

has been performed at almost 2 mm of laser spot spacing till 5m height, and of almost 5 mm in the upper surfaces. The quality of TLS acquisition for the bell tower and the central dome has been favoured by the presence of the inner natural hill over the ruins of the roof, permitting a higher level of instrument position from the ground.

The UAV photogrammetric campaign has been organized with a flight plan mission set from the central top of the complex at a level of 50 m from the ground in the mode “point of interest”. Within this procedure, a photogrammetric campaign has been conducted through the aerial camera with a conical acquisition around the monumental complex, descending to a height of 15 meters above ground and developing 329 shots in 20 minutes of flight. This has given the opportunity to conceive a wide area of overlapping between TLS and UAV resulting point clouds, both on vertical and horizontal built surfaces, in order to optimize their referencing in an integrated sparse database of morpho-metric characters.

V. OPPORTUNITIES OF 3D INTEGRATED MODELLING FOR SHAPE AND STRUCTURE

The integration of the products of digital survey protocols applied on the site [11], from both terrestrial and aerial metric and image acquisition tools, was complementary completed through the differentiated visual stations, able to guarantee information on basement, exterior and interior parameters, as well as monitoring data on the roof components and elevation units. Focusing on the central pavilion vault, half-destroyed during the electrical accident, the documentation, finalized to the restitution of a complete structural shape, has involved the detection both of the vault from the intrados, visible also in its constructive thickness, and also of the extrados levels, occupied by the ruins of the octagonal masonry tholobate at the base of the wooden roof.

The finalization of the integrated database of Pokcha complex has defined a virtual system of the preserved form, directing the attention on the metric-spatial correspondence of information obtained from TLS database and UAV photogrammetry, calibrated at the different reliability of space reconstruction characteristic of the instruments. In particular, a morphological reference and registration has been developed on the scale of each structural unit of the built complex: for the pavilion vault, the two type of data have been aligned on perimetrical boundaries and façades, considering the deviation accuracy of discrete surfaces and target control points. Then, a segmentation of the overlapped point cloud has been provided, deleting the overlapped areas of points and maintaining the TLS quality of data on the intrados surfaces and both TLS and UAV on the coverage surfaces.

The subsequent modelling action has followed the integration of instrumental point clouds experimenting an overall mesh triangulation strategy, finalized to the generation of a Reality-Based model capable of preserving the structural irregularity through the mediation of numerical polygonal surfaces.

Particular methodological considerations have been developed for the mesh triangulation of the integrated TLS and UAV sparse database. In order to perform an HD Mesh Construction, a correct correspondence of points normal was necessary, and it required the processing of UAV point cloud in order to support the optimization of poly-faces orientation in the mesh. Other processes of filtering of the point cloud, in particular regarding the presence of openings’ grids and extensive vegetation, have been implemented to better expose the surface of the structural domain under the decay and nature levels of the ruin site.

The triangulation phase of the final integrated database has highlighted some portions of missing morphological information, due to building masonry areas covered by vegetation during the survey campaign (removed in the point cloud with the filtering process). These parts have been integrated with a fitting of mesh holes according the geometric primitives derived from the mesh model.

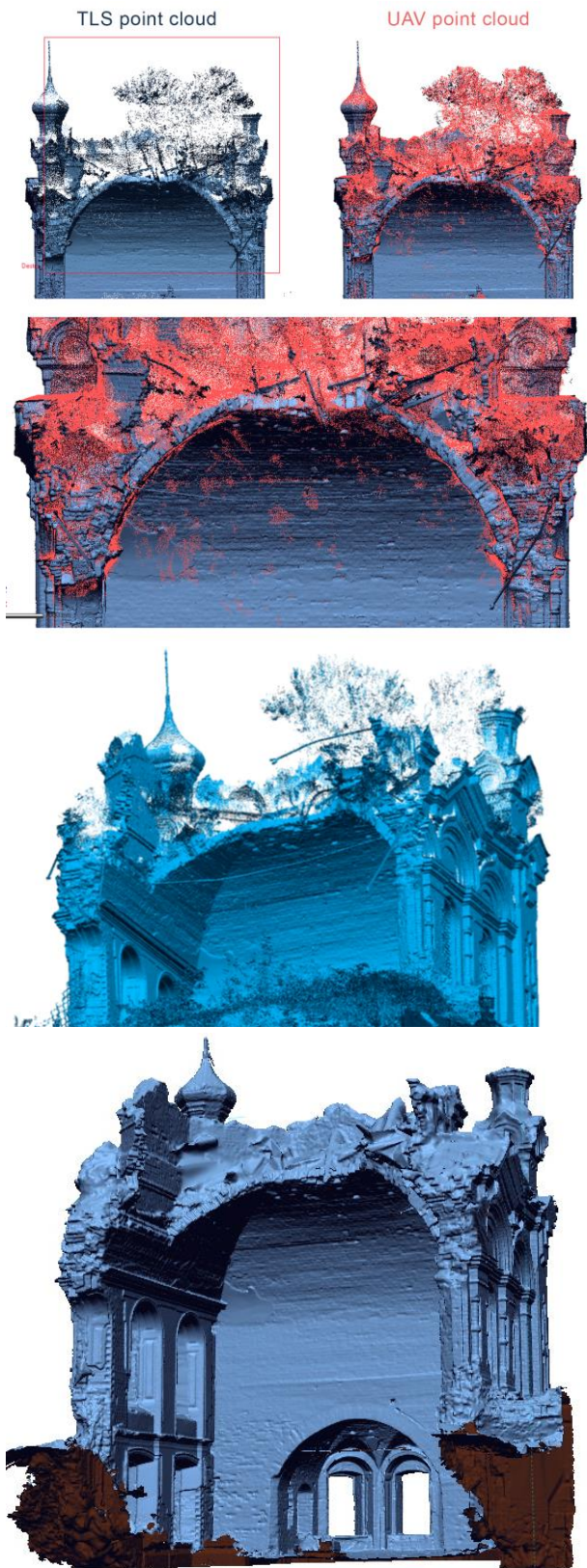


Fig. 4. Integration between TLS and UAV point cloud and management of alignment reliability, optimizing the final integrated database to derive the HD mesh model.

VI. CONCLUSIONS

The need for a formal approach to the re-drawing analysis and intervention on Endangered Historical Sites directs the operational experimentation of morphological-structural representation on two research targets [12]:

- The planning of a documentary strategy able to acquire the totality and particularity of the architectural detail, in all its typological variants (masonry, metal parts, wall coverings) and collocation (main environments, underground, in elevation, coverage levels).
- The convenience of transferring these detailed systems into suitable morpho-metric products, capable of experiencing information and analytical opportunities of historical masonries through graphic representation.

This objective directs methodologies and products to prefer a three-dimensional approach to documentation and visualization of the building, directly from data of digital survey. The interactive orbital approach and the parametric comparison thus become the means dedicated to qualitative and quantitative structural assessments, aware of the interactions that the historical architecture can establish between its individual preserved components and, referring to restoration, with its intervention design.

The presented study case defines a primary phase of research directed to the generation of an overall model of Blagoveshchenskaya Church. Thus, this strategy will support the decomposition and meshing for "structural cells" of the entire complex, defined for minimal spatially identifiable and statically defined units in which the architectural system of the ruin can be subdivided.

In this way, the semantized structure will permit an easier management in the possibility of analysis of his deformed shape and considering the direction of computing of reliable mesh models into structural simulation platforms for the monitoring of evolving damages in endangered heritage. [13]

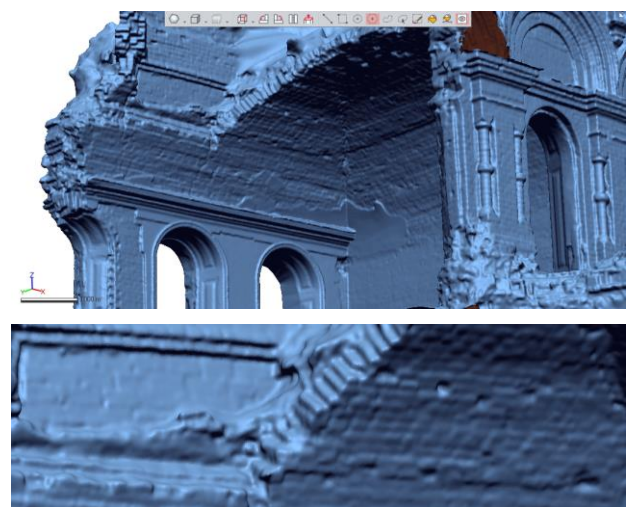


Fig. 5. Details of the shape quality in the HD mesh of Blagoveshchenskaya Church structural model.

ACKNOWLEDGMENTS

The documentation of Upper Kama Region is part of a wider program of activities carried out, since 2013, by DAda-LAB - University of Pavia (coordinator prof. S. Parrinello) and Perm National Research Polytechnic University (coordinator prof. S. Maximova). The digital survey campaigns in 2018 and 2019 have been conducted by Parrinello S., Picchio F., De Marco R., Dell'Amico A. Part of the graphic elaborates of the contribution were developed inside the course of "Architectural survey & restoration" (prof. S. Parrinello, prof. G. Minutoli) of the Double Degree Italian Chinese course in Building Engineering and Architecture of University of Pavia.

PROMETHEUS project is funded by the EU program Horizon 2020-R&I-RISE-Research & Innovation Staff Exchange Marie Skłodowska-Curie. It sees the collaboration between three Universities (University of Pavia, Italy, Polytechnic University of Valencia, Spain, Perm National Research Polytechnic University Perm National Polytechnic University Research, Russia) and two companies (EBIME, Spain, SISMA, Italy).

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 821870.

The editorial responsibility of the paragraphs is recognized to: S. Parrinello for paragraphs 1 and 6, R. De Marco for paragraph 2, 3, 4, and 5.

REFERENCES

- [1] JP – EU, "Guidelines on Cultural Heritage. Technical tools for Heritage Conservation and Management" September 2012, JP - EU/CoE Support to the Promotion of Cultural Diversity (PCDK).
- [2] United Nations Educational, Scientific and Cultural Organization, "Operational Guidelines for the Implementation of the World Heritage Convention", WHC.17/01, UNESCO World Heritage Centre, Paris, France, 2017.
- [3] UNESCO, "Recueil de décisions importantes sur la conservation des biens du patrimoine culturel inscrits sur la Liste du patrimoine mondial en péril de l'UNESCO", WHC-09/33.COM/9, Paris, 2009.
- [4] K. Rao, "A new paradigm for the identification, nomination and inscription of properties on the World Heritage List", *International Journal of Heritage Studies*, 16:3, 2010, pp. 161-172.
- [5] L. Toniolo, M. Boriani, G. Guidi (eds), "Built Heritage: Monitoring Conservation Management", Springer, Cham, Switzerland, 2015.
- [6] E. Psychogiopoulou, "Cultural Heritage and the EU: Legal Competences, Instrumental Policies, and the Search for a European Dimension", in: A. Jakubowski, K. Hausler, F. Fiorentini (eds) "Cultural Heritage in the European Union. A Critical Inquiry into Law and Policy", Brill Nijhoff, Netherlands, 2019, pp. 57-78.
- [7] S. Parrinello, R. De Marco, "From the city to the stone: digital survey for the establishment of structural behaviours in historical architecture", in: R. Salerno, "Drawing as (in)tangible representation", Gangemi Editore, Roma, Italy, 2018, pp. 747-754.
- [8] B. M. Feilden, J. Jokilehto, "Management Guidelines for World Cultural Heritage Sites", ICCROM, Rome, Italy, 1998.
- [9] M. Bruneau, S. E. Chang, R. T. Eguchi, G. C. Lee, T. D. O'Rourke, A. M. Reinhorn, M. Shinozuka, K. Tierney, W. A. Wallace, D. von Winterfeldt, "A Framework to Quantitatively Assess and Enhance the Seismic Resilience of Communities", *Earthquake Spectra*, Vol. 19, No. 4, 2003, pp. 733-752.
- [10] A. Guarnieri, F. Pirotti, M. Pontin, A. Vettore, "Combined 3D Surveying Techniques for Structural Analysis Applications", *Proc. of International Symposium on Photogrammetry and Remote Sensing (ISPRS)*, 2005, vol. XXXVI-5/W1, pp. 22-24.
- [11] L. De Luca, P. Veron, M. Florenzano, Michele. "Reverse-engineering of architectural buildings based on a hybrid modeling approach". *Computers & Graphics*, Volume 30, Issue 2, 2006, pp. 160–176.
- [12] R. De Marco. "Shapes and Models: the Survey for the study of Structures in Historical Buildings". In: K. Williams, M. G. Bevilacqua. "Nexus 2018 Architecture and Mathematics - Conference Book". Kim Williams Books, Pisa, Italy, 2018, pp. 289-292.
- [13] S. Parrinello, R. De Marco. "Dal rilievo al modello: la trasposizione grafica dell'evento sismico." *Disegnare Idee Immagini*, 2018, vol. 57, pp. 70-81.