UNIVERSITÀ DI TRENTO

IMEKO TC-4 International Conference on

METROLOGY FOR ARCHAEOLOGY AND CULTURAL HERITAGE

VIRTUAL CONFERENCE - OCTOBER 22, 24, 2020

MetroArchaeo2020

Virtual Conference

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MetroArchaeo 2020 Plenary Speakers

Thursday, October 22, 2020 – 10:00 CET

Early Pyrotechnology: Lithic Heat Treatment

Patrick Schmidt
University of Tübingen, Germany

ABSTRACT

Heat treatment of silica rocks chert and silcrete is one of the oldest transformative technologies used to alter the properties of materials. Its first use dates back to the southern African Middle Stone Age (MSA), and several examples are known from the Asian and European Upper Palaeolithic and Australia. The research questions associated with heat treatment are related to its purpose for tool manufacture, the investment in time and resources needed for it or the social and cognitive capacities it requires. Intensive research on these questions has been conducted for almost ten years now. In this presentation I will summarise the most recent progresses and discuss the methodological developments.

SPEAKERS BIOGRAPHY

Patrick Schmidt works at the interface of prehistoric archaeology and mineralogy. Research topics are the spectroscopic signature of minerals, the properties of archaeo-materials, mineralogy and crystallography of raw materials, provenance studies and stone heat treatment. His main focus lies on silica minerals like quartz, opal-CT and moganite, and siliceous rocks like flint, chert and silcrete.

Friday, October 23, 2020 – 09:30 CET

In-situ differentiation of black rock paintings in the palaeolithic caves

Ina Reiche

Research director at PCMTH team, Institut de recherche de Chimie Paris (IRCP)
Centre de recherche et de restauration des musées de France (C2RMF)

ABSTRACT

Prehistoric cave art represents a key marker for a better understanding of the evolution of mankind. Interdisciplinary approaches using methods from archaeology, geology, biology, chemistry and physics have addressed many questions about the environment of these archaeological sites, the dating and the material nature of the decorated walls. The combination of these results allowed the field to reach conclusions about the cultural and technical practices and improved our knowledge of our distant ancestors. However, cave art still remains mysterious, despite the fact that it has been the subject of many interpretations.

Physico-chemical analyses of the painted works have also been applied for thirty years to the archaeological parietal representations, such as those found in prehistoric caves. The analysis of the constituting materials of these drawings and paintings (nanosized iron oxides for the reds and yellows, nanocrystalline manganese oxides and charcoal for the blacks) ultimately reveals characteristics that provide insight into the artistic techniques and cultural practices of prehistoric humans. Analysing cultural materials also gives information on alteration processes. The knowledge acquired this way is valuable, as it provides original information that is impossible to obtain by another means.

The availability of new and advanced physicochemical techniques allowed for a renewal of the research on cave paintings. The research started with analyses carried out on samples from the paints, archaeological artefacts and raw material. They showed the existence of precise recipes of "paint pots" consisting of pigments, extender and binder. In some cases, the results allowed for an analysis of the creation sequence of the prehistoric figures. In other cases, the pigments were differentiated depending on characteristics related to their geological origin (trace elements).

Elementary analyses are used to answer questions such as the differentiation of parietal representations presenting the same mineralogical phase, the origin of raw materials, or the determination of the sequence of production.

The fragile nature of cave art has been known since its discovery. Strict conservation procedures have been applied to protect these UNESCO world heritage listed paintings. The awareness of the fragility of important cultural artefacts has led to a rapid transition from destructive studies to micro-sampling and then finally to non-invasive analyses, carried out in situ. Thus, portable X-ray diffraction, Raman spectroscopy and XRF have been used for the characterization of the paint layers directly. However, portable technologies are still not as efficient as their lab-based counterparts. Their sensitivity and precision

frequently lower than the methods available in the lab. Additionally, the differentiation of the compounds in the pigments from those in the wall is difficult because the colouring matter analysed on the cave walls is not geometrically regular nor chemically homogeneous, both laterally and in depth. Taphonomical phenomena may also contribute to the heterogeneity of the chemical composition of the paint layer and the wall substrate. Encouraging results have however been obtained in several studies, due to an active methodological research on these techniques.

In particular, p-XRF enables determining the geochemical signature of colouring matter, helping to answer archaeological questions without altering the work under study. For black pictorial layers based on manganese oxides, it was possible to develop a semi-quantitative analytical protocol that allowed the differentiation of black prehistoric figures in the case of the Rouffignac and Font-de-Gaume caves in Dordogne, France. This is all the more important in the absence of a direct dating of the figures made with three types of manganese oxides as it is the case at the Rouffignac cave. The research is carried out thanks to the combination of non-invasive chemical analyzes using X-ray fluorescence in situ as well as the stylistic study and that of the overlays of the figures. In the absence of a general organization of the panel of the Grand Ceiling of the Rouffignac cave it was possible to show that all of the figures were produced in stages in small subsets by small groups of humans. This is consistent with the creation of the friezes, in particular that of the ten mammoths present in other galleries of this cave by a small group of prehistoric artists.

SPEAKERS BIOGRAPHY

Ina Reiche: research director at PCMTH team, Institut de recherche de Chimie Paris (IRCP) - Centre de recherche et de restauration des musées de France (C2RMF) - UMR 8247 CNRS

- Degree in Chemistry and bachelor in Art history: 1997;
- PhD in Material Science: 2000;
- Researcher at the Rathgen research laboratory, National Museums in Berlin, Prussian Cultural Heritage Foundation: 2000-02;
- Researcher at French National Research Council (CNRS) from 2003;
- Habilitation in Analytical Chemistry: 2009;
- CNRS research director since 2012;
- Head of the Rathgen research laboratory (on leave from CNRS): 2014-19;
- Research fields: Archaeometry of historical and archaeological biominerals (bone, ivory, antler, corals) as well as pigments, glass and minerals. Identification and understanding of alteration processes by using analytical methods such as synchrotron methods, ion beam analysis and other laboratory and mobile equipment, especially Raman and X-ray fluorescence analysis.
- Recent studies: depth resolved chemical analysis and imaging of easel paintings; analysis of the late use of smalt in paintings; PIXE analysis of early Egyptian glass from Amarna; in situ identification of prehistoric pigments in Palaeolithic caves (Rouffignac and Font-de-Gaume, Dordogne); non-invasive ion beam analysis of Palaeolithic mammoth ivory artefacts and their origin.

Friday, October 23, 2020 – 09:30 CET

What's next in past landscapes studies? Drone-based platform a killer application in archaeological survey

Stefano Campana
Università degli Studi di Siena, Italy

ABSTRACT

In the last decade new and progressively more sophisticated aerial platforms – UAVs or drones – have become widely available for archaeological applications traditionally carried out through the use of balloons, kites or light aircraft. More recently archaeologists have been testing both the drones and their sensors for the 3D recording of excavations, monuments and historic buildings as well as for the survey of whole archaeological sites and their landscape contexts. The scale and market expansion of these platforms has been driving the rapid development of both active and passive sensors specifically designed for UAVs. Today, drones are becoming more and more versatile through the creation of multiple devices that can undertake activities traditionally treated as either airborne (LiDAR) or ground-based (geophysical prospection). Drones are now available for 3D data capture in exploratory air photography and landscape survey, capable, with the aid of semi-automation and AI, of identifying and documenting surface scatters of archaeological material. High-resolution LiDAR survey, multispectral imaging and geophysical prospection by both radar and magnetometry can now be successfully undertaken through the use of drones – a real 'life-giver' in terms of archaeological technique. These advances promise to revolutionize the practice of archaeological survey as a whole.

SPEAKERS BIOGRAPHY

Stefano Campana has been working for the past fifteen years at the University of Siena (Italy) and the University of Cambridge (UK). He is specializing in landscape archaeology, remote sensing and archaeological methodology for purposes of research, recording and conservation. His work is focused on the understanding of past landscapes from prehistory to the current age. The principal cultural context for his work has been Tuscany but he has also participated in and led research work in the UK, Spain, Turkey, Palestine, Iraq and Asia. Since 2006 he has been a faculty member of the University of Siena (Italy), in the Department of History and Cultural Heritage, where he has engaged in teaching and research as associate professor in Landscape Archaeology. From 2016 he has also been invited from the Department of Social, Political and Cognitive Sciences of the University of Siena to teach "Cultural Diplomacy and Archaeology" within the international master course in Cultural Diplomacy. From September 2014 to June 2016 he became Senior Research Fellow at the University of Cambridge (UK), Faculty of Classics.

He has established a sound reputation as an international authority in the field of landscape and digital archaeology. He promoted concepts such as ‘emptyscapes’ and the ‘archaeological continuum’ within rural studies and he have demonstrated their relevance to theoretical and practical approaches within Mediterranean archaeology, notably through the systematic application of large-scale geophysical survey, aerial exploration and air photography, including the use of drones and drone-based lidar.

In 2011 he was proposed and admitted as a Fellow of the Society of Antiquaries of London (FSA) and in 2012 he was invited to be a member of the General Management Board of HIST, the Governing Board of the International Centre on Space Technologies for Natural and Cultural Heritage, under the auspices of UNESCO and the Chinese Academy of Sciences. He was invited as visiting professor in 2014 at University of Lund, Department of Archaeology (Sweden), in 2016 at École Normale Supérieure (Paris), in 2017 at the Institute of Archaeology of Erbil (Erbil-Iraq) and in 20202 at the University of Bucharest, Faculty of History.

Saturday, October 24, 2020 – 09:30 CET

Long-distance timber trading in the Roman Empire

Mauro Bernabei

Università degli Studi di Siena, Italy

ABSTRACT

Throughout antiquity wood was the most important raw material and energy source. In contrast to other archaeological finds e.g. pottery, stone tools and metal, the in general poor preservation conditions for organic material make archaeological records of wood very rare. It is preserved over a long period of time only in very humid or very dry locations. Hence archaeological wooden remains are of particular interest for research: they provide insight into former environmental conditions, wood technology and ancient economic history. In addition yield annually resolved dendrochronological data that allows precise dating of archaeological features. During an archaeological excavation in the center of Rome 24 oak (Quercus sp.) planks were found as part of the foundation of a richly decorated portico, in a vast and wealthy property. Due to waterlogged conditions wood was remarkably well-preserved and the processing traces are still clearly visible. Most of the material belongs to a single lot of timber and shows no signs of reuse. Dendrochronological analyses were performed in order to date the structure. Further researches regarding the wood provenance were possible through statistical cross-dating. Our results demonstrated that the oak trees had been felled between 40 and 60 CE in the Jura Mountains of north-eastern France. It is most likely that the wood was transported to the Eternal City on the Saône and Rhône rivers and then across the Mediterranean Sea. This rare dendrochronological evidence from the capital of the Roman Empire gives fresh impetus to the ongoing debate on the likelihood of transporting timber over long distances within and between Roman provinces. This study reconstructs the administrative and logistic efforts required to transport high-quality construction timber from central Europe to Rome. It also highlights an advanced network of trade, and emphasises the enormous value of oak wood in Roman times.

SPEAKERS BIOGRAPHY

- Degree in Forestry: 1993
- PhD in Wood Science: 1997
- Researcher at the National Research Council – Institute of BioEconomy (CNR-IBE) from 1998
- Head of the Laboratory of Dendrochronology of the CNR-IBE
- Research fields: wood science and all the aspects related to wood dating, conservation, species identification in archaeology, art history and cultural heritage.
- Recent studies: wood from Pompeii; olive trees from the Gethsemane garden in Jerusalem; the roof of the Basilica of Nativity in Bethlehem; the foundations of the Rialto Bridge in Venice; the Cherubini Collection musical instruments; the timber from historical buildings in Florence (Giotto's Bell Tower, Basilica of Santa Croce, Baptistry).

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CONFERENCE PROGRAM

Technical Sessions - Thursday, October 22

SESSION 1.1 – SPECIAL SESSION ON MULTISCALE AND MULTITEMPORAL HIGH RESOLUTION REMOTE SENSING AND NON-DESTRUCTIVE TESTING FOR ARCHAEOLOGY AND MONUMENTAL HERITAGE: FROM RESEARCH TO PRESERVATION - PART 1

Room: Virtual Room #1
Chairs: Giovanni Leucci, *ISPC - CNR, Italy*
Nicola Masini, *ISPC - CNR, Italy*
Salvatore Piro, *ISPC - CNR, Italy*

1 **Integrated use of GPR and TDR for wood permittivity evaluation**
Filippo Comisi, University of Catania, Italy
Lara De Giorgi, Institute of Cultural Heritage Sciences, CNR, Italy
Giovanni Leucci, Institute of Cultural Heritage Sciences, CNR, Italy

5 **From causes to effects. Integration of heterogeneous data from non invasive imaging for the diagnosis and restoration of monuments. The case of the Church of S. Francesco della Scarpa in Lecce (Southern Italy)**
Giovanni Leucci, Institute of Cultural Heritage Sciences, CNR, Italy
Francesco Gabellone, Nanotec CNR, Lecce, Italy
Fabrizio Terenzio Gizzi, Institute of Cultural Heritage Sciences, CNR, Italy
Nicola Masini, Institute of Cultural Heritage Sciences, CNR, Italy

9 **A multiscalar research project, following an ancient decumanus in Montenegro**
Lucia Alberti, National Research Council of Italy, Italy
Francesca Colosi, National Research Council of Italy, Italy
Pasquale Merola, National Research Council of Italy, Italy

15 **Warscapes: A 'Submerged Information Basin'. The Contribution of LiDaR Data to the Unveiling**
Joel Aldrighettoni, University of Trento, Italy
Alessandra Quendolo, University of Trento, Italy

21 **Acoustic remote sensing for seabed archaeology**
Crescenzo Violante, CNR, Italy

SESSION 2.1 - SPECIAL SESSION ON GEOMATERIALS FOR CULTURAL HERITAGE - PART 1

Room: Virtual Room #2
Chairs: Marco Lezzerini, *University of Pisa, Italy*
Stefano Pagnotta, *University of Pisa, Italy*

27 **Evaluating the Effects of High Tide on Venetian Stone Buildings: A Multi Analytical Approach**
Gloria Zaccariello, Iuav University of Venice, Italy
Elena Tesser, Iuav University of Venice, Italy
Rebecca Piovesan, Iuav University of Venice, Italy
Fabrizio Antonelli, Iuav University of Venice, Italy

32 **Petro-archaeometric characterization of historical mortars in the city of Ravenna (Italy)**
Elena Marrocchino, University of Ferrara, Italy
Chiara Telloli, ENEA, Italy
Paola Novara, National Museum of Ravenna, Italy
Carmela Vaccaro, University of Ferrara, Italy

SESSION 3.1 - SPECIAL SESSION ON INTEGRATED DIGITAL SURVEY METHODOLOGIES FOR THE KNOWLEDGE AND ENHANCEMENT OF ARCHITECTURAL AND URBAN HERITAGE- PART 1

Room: Virtual Room #3

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

POSTER SESSION 1

Room: Virtual Poster Room

SESSION 1.2 – SPECIAL SESSION ON MULTISCALE AND MULTITEMPORAL HIGH RESOLUTION REMOTE SENSING AND NON-DESTRUCTIVE TESTING FOR ARCHAEOLOGY AND MONUMENTAL HERITAGE: FROM RESEARCH TO PRESERVATION - PART 2

Room: Virtual Room #1

Chairs: Giovanni Leucci, *ISPC - CNR, Italy*
Nicola Masini, *ISPC - CNR, Italy*
Salvatore Piro, *ISPC - CNR, Italy*

SESSION 2.2 - SPECIAL SESSION ON GEOMATERIALS FOR CULTURAL HERITAGE - PART 1

Room: Virtual Room #2

Chairs: Marco Lezzerini, *University of Pisa, Italy*
Stefano Pagnotta, *University of Pisa, Italy*

SESSION 3.2 - SPECIAL SESSION ON INTEGRATED DIGITAL SURVEY METHODOLOGIES FOR THE KNOWLEDGE AND ENHANCEMENT OF ARCHITECTURAL AND URBAN HERITAGE- PART 2

Room: Virtual Room #3

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

SESSION 1.3 – SPECIAL SESSION ON MULTISCALE AND MULTITEMPORAL HIGH RESOLUTION REMOTE SENSING AND NON-DESTRUCTIVE TESTING FOR ARCHAEOLOGY AND MONUMENTAL HERITAGE: FROM RESEARCH TO PRESERVATION - PART 3

Room: Virtual Room #1
Chairs: Giovanni Leucci, *ISPC - CNR, Italy*
Nicola Masini, *ISPC - CNR, Italy*
Salvatore Piro, *ISPC - CNR, Italy*

SESSION 2.3 - GENERAL SESSION - PART 1

Room: Virtual Room #2
Chairs: Andrea Tavella, *LaBAAF, Università degli Studi di Trento, Italy*
Elisabetta Doria, *DICAr University of Pavia, Italy*

SESSION 3.3 - SPECIAL SESSION ON IoT BASED SYSTEMS FOR THE STRUCTURAL HEALTH MONITORING AND THE ANALYSIS OF CULTURAL HERITAGE BUILDING AND ARCHAEOLOGICAL SITES

Room: Virtual Room #3
Chairs: Carmelo Scuro, *University of Calabria, Italy*
Gabriele Milani, *Politecnico di Milano, Italy*

Technical Sessions - Friday, October 23

SESSION 1.4 – SPECIAL SESSION ON GEOMATICS AND CULTURAL HERITAGE: MODERN DIGITAL APPROACHES FOR SURVEYING AND DOCUMENTING THE PAST THROUGH GEOSPATIAL SOLUTIONS - PART 1

Room: Virtual Room #1

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

304 **Digital reconstruction of a lost heritage: the San Geminiano's church in San Marco's Square in Venice**
Caterina Balletti, Università Iuav di Venezia, Italy
Marcin Dabrowski, Università Iuav di Venezia, Italy
Francesco Guerra, Università Iuav di Venezia, Italy
Paolo Vernier, Università Iuav di Venezia, Italy

311 **Preliminary data processing on the Roman Shipwreck of Grado. Archive and legacy data to create its 3D virtual model**
Elisa Costa, Ca' Foscari University, Italy
Carlo Beltrame, Ca' Foscari University, Italy

316 **BLK2GO for DTM generation in highly vegetated area for detecting and documenting archaeological earthwork anomalies**
Marco Limongiello, University of Salerno, Italy
Diego Ronchi, Spiron Heritage and Survey, Italy
V. Albano, Leica Geosystems AG, Switzerland

322 **Fostering Etruscan heritage with effective integration of UAV, TLS and SLAM based methods**
Anna Rabbia, Politecnico di Torino, CRT - Fondazione Sviluppo e Crescita, Italy
Giulia Sammartano, Politecnico di Torino, FULL Polito, Italy
Antonia Spanò, Politecnico di Torino, FULL Polito, Italy

SESSION 2.4 – SPECIAL SESSION ON THE INTERACTION BETWEEN ENVIRONMENTAL POLLUTION AND CULTURAL HERITAGE: FROM OUTDOOR TO INDOOR ENVIRONMENT - PART 1

Room: Virtual Room #2

Chairs: Paola Fermo, *University of Milano, Italy*
Valeria Comite, *University of Milano, Italy*

328 **An experimental approach to the cleaning of a polymateric textile weave: set-up of the alternative methodology and instrumentation**
Paola Fermo, Università degli Studi di Milano, Italy
Valeria Comite, Università degli Studi di Milano, Italy
Elisabetta Boanini, Fondazione Enaip Lombardia, Italy
Roberto Bonomi, Fondazione Enaip Lombardia, Italy
Marco Bertelli, A.L.M.A.G. S.p.A, Italy
Elisa Monfasani, Fondazione Enaip Lombardia, Italy

333 **A new analytic methodology for the characterization of the carbonaceous fraction in black crusts present on stone surfaces**
Valeria Comite, Università degli Studi di Milano, Italy
Mauro Francesco La Russa, (DiBEST), Università della Calabria, Italy
Paola Fermo, Università degli Studi di Milano, Italy

338 **Air pollution, black crusts and Cairo monuments: a review**
Rovella Natalia, (DiBEST), University of Calabria, Italy

SESSION 3.4 – SPECIAL SESSION ON ARCHAEOMETRY FOR ARCHAEOLOGY: PROVENANCING AND TECHNOLOGICAL ASSESSMENT OF ARTIFACTS FROM ARCHAEOLOGICAL SITES AND MUSEUMS - PART 1

Room: Virtual Room #3

Chairs: Fabrizio Antonelli, *University of IUAV of Venice, Italy*
Lara Maritan, *University of Padova, Italy*

343 **Multi analytical study on Khol residues from the ancient Egyptian city of Assiut**
Francesco Saliu, Università Milano Bicocca, Italy
Chiara Riedo, University of Turin, Italy
Dominique Scalarone, University of Turin, Italy
Ilaria Degano, University of Pisa, Italy
Francesca Modugno, University of Pisa, Italy
Sergio Andò, Università Milano Bicocca, Italy
Marco Orlandi, Università Milano Bicocca, Italy
Oscar Chiantore, University of Turin, Italy

348 **The contribution of Archaeometric Analyses to the Multi Disciplinary Research in Hierapolis of Phrygia, Turkey**
Giulia Ricci, University of Padova, Italy
Michele Secco, University of Padova, Italy
Gilberto Artioli, University of Padova, Italy
Fabio Marzaioli, Centre for Isotopic Research on Cultural and Environmental Heritage, Italy
Isabella Passariello, Centre for Isotopic Research on Cultural and Environmental Heritage, Italy
Filippo Terrasi, Centre for Isotopic Research on Cultural and Environmental Heritage, Italy
Maria Rosa Valluzzi, University of Padova, Italy

354 **Microscopic and chemical characterization of metal slags found at the Porta Paola excavation in Ferrara**
Elena Marrocchino, University of Ferrara, Italy
Chiara Telloli, ENEA, Italy
Carmela Vaccaro, University of Ferrara, Italy

SESSION 1.5 – SPECIAL SESSION ON GEOMATICS AND CULTURAL HERITAGE: MODERN DIGITAL APPROACHES FOR SURVEYING AND DOCUMENTING THE PAST THROUGH GEOSPATIAL SOLUTIONS - PART 2

Room: Virtual Room #1
Chairs: Gabriele Bitelli, *University of Bologna, Italy*
Maria Grazia D'Urso, *University of Bergamo, Italy*

360 **Integrated geomatic methodologies to reconstruct the ancient topography of Rome**
Luca Alessandri, Groningen University, The Netherland
Valerio Baiocchi, Sapienza University of Rome, Italy
Marta Baumgartner, Soprintendenza Speciale di Roma, Italy
Diego Blanco, Archeogeos, Italy
Alessandro Bosman, CNR IGAG, Italy
Luigi Cardone, Sapienza University of Rome, Italy
Andrea Guaglianone, Italy
Matteo Onori, Sapienza University of Rome, Italy
Felicia Vatore, Sapienza University of Rome, Italy

366 **Geomatics as a knowledge base propaedeutic to the restoration of an extended fresco wall**
Gabriele Bitelli, Alma Mater Studiorum Università di Bologna, Italy
Valentina Alena Girelli, Alma Mater Studiorum Università di Bologna, Italy
Giulia Vannucci, Alma Mater Studiorum Università di Bologna, Italy
Emanuele Mandanici, Alma Mater Studiorum Università di Bologna, Italy
Marinella Pigozzi, Alma Mater Studiorum Università di Bologna, Italy

372 **Survey and preservation of an abandoned archaeological industrial site**
Maria Grazia D'Urso, University of Bergamo, Italy
Valerio Manzari, University of Cassino and Southern Lazio, Italy
Francesco Cavaliere, Italy
Barbara Marana, University of Bergamo, Italy
Francesco Marmo, University of Naples Federico II, Italy

SESSION 2.5 – SPECIAL SESSION ON NEUTRON TECHNIQUES IN ARCHEOMETRY

Room: Virtual Room #2

Chairs: Francesco Grazzi, *CNR, Italy*
Marco Zanatta, *University of Trento, Italy*

378 **Reconstruction of 3D models from microtomographic images of archeological artifacts**
Enej Gucek Puhar, University of Ljubljana, Slovenia
Lidija Korat, Slovenian National Building and Civil Engineering Institute, Slovenia
Miran Eric, Institute for the Protection of Cultural Heritage, Slovenia
Ales Jaklic, University of Ljubljana, Slovenia
Franc Solina, University of Ljubljana, Slovenia

384 **Preliminary Alloys Characterization and Technological Interpretation of the Manufacturing Process of the Vittoria Alata di Brescia by means of Neutron Diffraction**
Francesco Cantini, MIBACT Opificio delle Pietre Dure, Italy
M. Galeotti, MIBACT Opificio delle Pietre Dure, Italy
A. Cagnini, MIBACT Opificio delle Pietre Dure, Italy
S. Porcinai, MIBACT Opificio delle Pietre Dure, Italy
Antonella Scherillo, ISIS Neutron and Muon Source, United Kingdom
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A. Patera, MIBACT Opificio delle Pietre Dure, Italy
F. Morandini, Fondazione Brescia Musei, Italy
F. Grazzi, CNR, INFN, Italy

389 **Neutron-based techniques applied for non-destructive quantitative characterisation of ancient mosaic tesserae**
Giulia Marcucci, University of Milano Bicocca, INFN, Italy
Antonella Scherillo, ISIS Neutron and Muon Source, United Kingdom
Carlo Cazzaniga, ISIS Neutron and Muon Source, United Kingdom
Massimiliano Clemenza, University of Milano Bicocca, INFN, Italy
Daniela Di Martino, University of Milano Bicocca, INFN, Italy

394 **Preliminary result of investigation of element composition of Kyathos (6th-4th centuries BCE) from the necropolis Volna 1 on the Taman Peninsula by Neutron Resonance Capture Analysis**
Nina V. Simbirtseva, Joint Institute for Nuclear Research, Russia, Institute of Nuclear Physics, Republic of Kazakhstan
Pavel V. Sedyshev, Joint Institute for Nuclear Research, Russia
Saltanat T. Mazhen, Joint Institute for Nuclear Research, Russia, Institute of Nuclear Physics, Republic of Kazakhstan
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Irina A. Saprykina, Institute of Archaeology of the Russian Academy of Sciences, Russia
Roman A. Mimokhod, Institute of Archaeology of the Russian Academy of Sciences, Russia

399 **Non-invasive characterization of Nuragic bronzes through neutron based techniques**
Matteo Cataldo, Università degli Studi di Sassari, Italy
F. Grazzi, CNR, Istituto di Fisica Applicata 'Nello Carrara', Italy
Antonella Scherillo, ISIS Neutron Source, United Kingdom
A. Fedrigo, ISIS Neutron Source, United Kingdom
A. Depalmas, Università degli Studi di Sassari, Italy
A. Canu, Soprintendenza Archeologia, Belle Arti e Paesaggio per le province di Sassari e Nuoro, Italy
A. Brunetti, Università degli Studi di Sassari, Italy

SESSION 3.5 – SPECIAL SESSION ON ARCHAEOMETRY FOR ARCHAEOLOGY: PROVENANCING AND TECHNOLOGICAL ASSESSMENT OF ARTIFACTS FROM ARCHAEOLOGICAL SITES AND MUSEUMS - PART 2

Room: Virtual Room #3

Chairs: Fabrizio Antonelli, *University of IUAV of Venice, Italy*
Lara Maritan, *University of Padova, Italy*

404 **Archaeology and archaeometry of marbles in Roman central Adriatic Italy**
Devi Taelman, Ghent University, Belgium
Dimitri Van Limbergen, Ghent University, Belgium
Fabrizio Antonelli, IUAV University of Venice, Italy

410 **Analytical data on marble sculptures' polychrome traces (Palatine hill, Rome)**
Maria Cristina Caggiani, University of Catania, Italy
Alessia Coccato, University of Catania, Italy
Silvia Borghini, Museo Nazionale Romano, Italy
Paolo Mazzoleni, University of Catania, Italy
Alfonsina Russo, Parco Archeologico del Colosseo, Italy
Germana Barone, University of Catania, Italy

415 **Colorimetric Study of Ayla-Aksum amphorae from the Red Sea Coast of Eritrea**
Abraham Zerai, Università di Torino, INFN, Italy
Patrizia Davit, Università di Torino, Italy
Monica Gulmini, Università di Torino, Italy
Alessandro Re, Università di Torino, INFN, Italy
Roberto Giustetto, Università di Torino, INFN, Italy
Lara Maritan, Università di Padova, Italy
Serena Massa, Università Cattolica del Sacro Cuore, Italy
Chiara Mandelli, Università Cattolica del Sacro Cuore, Italy
Yohannes Gebreyesus, Northern Red Sea Regional Museum of Massawa, Eritrea
Alessandro Lo Giudice, Università di Torino, INFN, Italy

POSTER SESSION 2

Room: Virtual Poster Room

420 **Project of Electronic Identity of painting**
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

425 **The coloured stones and marbles decorating the Odeion of Pompeii**
Fabrizio Antonelli, Iuav University of Venice, Italy
Lorenzo Lazzarini, Iuav University of Venice, Italy
Stefano Cancelliere, Iuav University of Venice, Italy
Luigi Buffone, Applied research laboratory of the Archaeological Park of Pompeii, Italy

431 **DAMAGE assessment of cultural stone heritage in reservoir environments**
Monica Alvarez de Buergo, IGEO (CSIC, UCM), Spain
Natalia Perez Ema, IGEO (CSIC, UCM), Spain
Rafael Fort, IGEO (CSIC, UCM), Spain
Manuel Garcia Rodriguez, Universidad de Eduacion a Distancia UNED, Spain
María J. Varas, IGEO (CSIC, UCM), Spain
Mauro Francesco La Russa, Università della Calabria, Italy

435 **A preliminary study on black crusts from the Monumental Cemetery of Milan**
Valeria Comite, Università degli studi di Milano, Italy
Donatella Bonelli, Scuola di Restauro 'Arrigo Boito' Italy
Paola Fermo, Scuola di Restauro 'Arrigo Boito' Italy

440 **Coratelli Mill: micro-geophysical investigations for structural diagnostics**
Lara De Giorgi, CNR ISPC, Italy
Giovanni Leucci, CNR ISPC, Italy

SESSION 1.6 – SPECIAL SESSION ON HANDHELD AND MOBILE INSTRUMENTATION IN CULTURAL HERITAGE RESEARCH

Room: Virtual Room #1

Chairs: Rosina Celeste Ponterio, *CNR, Italy*
Giulia Festa, *Centro Fermi, Italy*
Maria Luisa Saladino, *University of Palermo, Italy*
Viviana Mollica Nardo, *CNR, Italy*

507 **INFN-CHNet meets CCR La Venaria Reale: first results**
Leandro Sottili, Università degli Studi di Torino, INFN, Italy
Laura Guidorzi, Università degli Studi di Torino, INFN, Italy
Anna Mazzinghi, INFN, Università degli Studi di Firenze, Italy
Chiara Ruberto, INFN, Università degli Studi di Firenze, Italy
Lisa Castelli, INFN, Italy
Caroline Czelusniak, INFN, Italy
Lorenzo Giuntini, INFN, Università degli Studi di Firenze, Italy
Mirko Massi, INFN, Italy
Francesco Taccetti, INFN, Italy
Marco Nervo, INFN, 'La Venaria Reale', Italy
Alessandro Re, Università degli Studi di Torino, INFN, Italy
Alessandro Lo Giudice, Università degli Studi di Torino, INFN, Italy

512 **Imaging for Cultural Heritage and Archaeology**
Paolo Triolo, University of Genova and University of Urbino, Italy
Luciano Marras, Art-Test Studio di Luciano Marras, Italy
Gloria Adinolfi, Società Pegaso, Italy
Rodolfo Carmagnola, Società Pegaso, Italy
S. Legnaioli, ICCOM-CNR, Italy
Simona Raneri, ICCOM-CNR, Italy
V. Palleschi, ICCOM-CNR, Italy

517 **Santa Maria del Fiore Cupola construction tools: a non-invasive characterization using portable XRF**
Leila Es Sebar, Politecnico di Torino, Italy
Leonardo Iannucci, Politecnico di Torino, Italy
Sabrina Grassini, Politecnico di Torino, Italy
Emma Angelini, Politecnico di Torino, Italy
Marco Parvis, Politecnico di Torino, Italy
Andrea Bernardoni, Museo Galileo, Italy
Alexander Neuwahl, Artes Mechanicae, Italy
Rita Filardi, Museo dell'Opera del Duomo, Italy

SESSION 2.6 – SPECIAL SESSION ON DAMAGE ASSESSMENT: DIAGNOSIS AND MONITORING FOR THE RESTORATION, PREVENTIVE CONSERVATION AND MAINTENANCE OF CH

Room: Virtual Room #2
Chairs: Giuseppe Paladini, *University of Messina, Italy*
Luciana Randazzo, *University of Calabria, Italy*
Natalia Rovella, *University of Calabria, Italy*

522 **Ancient bricks technologies: improving the built heritage conservation at high humidity areas**
Elena Pérez Monserrat, University of Padua, Italy
Lara Maritan, University of Padua, Italy
Marie Ange Causarano, University of Padua, Italy
Alejandra Chavarría, University of Padua, Italy
Gian Pietro Brogiolo, University of Padua, Italy

527 **Polydimethylsiloxane (PDMS) /ZrO_2 doped ZnO nanocomposites as protective coatings for stone materials**
Maduka L. Weththimuni, Università di Pavia, Italy
Marwa Ben Chobba, University of Sfax, Tunisia
Ilenia Tredici, Università di Pavia, Italy
Maurizio Licchelli, Università di Pavia, Italy

532 **Digital reconstruction and scientific analysis prior the restoration of two paintings by Mattia Preti in the Church of the Immaculate Conception of Sarria (Floriana, Malta)**
Sebastiano D'Amico, University of Malta, Malta
Valentina Venuti, University of Messina, Italy
Emanuele Colica, University of Malta, Malta
Giuseppe Paladini, University of Messina, Italy
Luciano Galone, University of Malta, Malta
Vincenza Crupi, University of Messina, Italy
Domenico Majolino, University of Messina, Italy
Sante Guido, University of Trento, Italy
Giuseppe Mantella, Restauro Opere D'Arte, Italy

538 **The three polych rome mosaics of S. Aloe quarter in Vibo Valentia (Calabria , Southern Italy): chemical characterization of glass tesserae**
Natalia Rovella, University of Calabria, Italy
Elia Fiorenza, University of Calabria, Italy
Donatella Barca, University of Calabria, Italy

543 **The role of geosciences and non destructive methods in the TECTONIC project**
Michela Ricca, University of Calabria, Italy
Marco Ricci, University of Calabria, Italy
Stefano Laureti, University of Calabria, Italy
Mauro Francesco La Russa, University of Calabria, Italy

SESSION 3.6 – SPECIAL SESSION ON ARCHAEOMETRY FOR ARCHAEOLOGY: PROVENANCING AND TECHNOLOGICAL ASSESSMENT OF ARTIFACTS FROM ARCHAEOLOGICAL SITES AND MUSEUMS - PART 3

Room: Virtual Room #3
Chairs: Fabrizio Antonelli, *University of IUAV of Venice, Italy*
Lara Maritan, *University of Padova, Italy*

548 **A multi-analytical survey for the identification of the red and yellow pigments of coloured sherds discovered in the Monte d'Oro area (Rome).**
Vittoria Guglielmi, Università degli Studi di Milano, Italy
Paola Fermo, Università degli Studi di Milano, Italy
Martina Andreoli, University of Trento, Italy
Valeria Comite, Università degli Studi di Milano, Italy

554 **The pottery production at Sumhuram (Khor Rori, Sultanate of Oman): an archaeometric study**
Stefano Pagnotta, University of Pisa, Italy
Giulia Buono, University of Pisa, Italy
Marco Lezzerini, University of Pisa, Italy
Alexia Pavan, Ministry of Heritage and Tourism, Muscat Salalah, Sultanate of Oman
Carlotta Rizzo, University of Pisa, Italy

559 **Petrographic analysis to understand Etruscan architectural terracotta's technology and provenance: a study in progress.**
Maura Fugazzotto, University of Catania, Italy
Antonio Stroscio, University of Catania, Italy
Antonella Bertino, University of Catania, Italy
Germana Barone, University of Catania, Italy
Alfonsina Russo, Parco Archeologico del Colosseo, Italy
Paolo Mazzoleni, University of Catania, Italy

564 **Thermoluminescence dating and microstructural characterization of archaeological ceramic samples from Corvins'Castle area**
Rodica-Mariana Ion, ICECHIM, Group, Valahia University, Romania
Radu Setnescu, INCDIE ICPE-CA, Valahia University of Targoviste, Romania
Tanta Setnescu, Valahia University of Targoviste, Romania
Anca Irina Gheboianu, Valahia University of Targoviste, Romania
Gabriel Vasilievici, ICECHIM, Group, Romania
Sorin Tincu, Corvins' Castle, Romania

Technical Sessions - Saturday, October 24

SESSION 1.7 – GENERAL SESSION - PART 2

Room: Virtual Room #1
Chairs: Mauro Bernabei, *CNR IBE, Italy*
Nicoletta Martinelli, *Laboratorio Dendrodata, Italy*

570 **Effect of age on Pine wood microstructure studied by micro-MRI and diffusion-NMR**
Valeria Stagno, Sapienza University of Rome, National Research Council, Italy
Sveva Longo, National Research Council, University of Messina, Italy
Silvia Capuani, National Research Council, Italy

575 **Multicentennial regional oak chronologies for northern Italy: an updating**
Nicoletta Martinelli, Laboratorio Dendrodata, Italy

579 **The tree species of Po valley Logboats**
Alice Lucchini, Università Ca Foscari di Venezia, Italy
Mauro Bernabei, CNR IBE, Italy

585 **Characterization of Etruscan non vascular ceramic fragments**
Margherita Cantelli, Ca' Foscari University of Venice, Italy
Alberta Facchi, Ministry of Cultural Heritage and Activities
Francesca C. Izzo, Ca' Foscari University of Venice, Italy
Elisabetta Zendri, Ca' Foscari University of Venice, Italy

590 **May metagenomics disclose the hidden secrets of the ancient damaged parchments?**
Luciana Migliore, Tor Vergata University, Italy
Nicoletta Perini, Tor Vergata University, Italy
Annamaria Alabiso, Tor Vergata University, Italy

SESSION 2.7 – GENERAL SESSION - PART 3

Room: Virtual Room #2
Chairs: Ilaria Patania, *University of Haifa, Israel*
Omar Larentis, *University of Insubria, Italy*
Fabio Santaniello, *University of Trento, Italy*

594 **Distinguishing colour alteration processes occurred in Late Pleistocene animal remains**
Andrea Perez, University of Trento, Italy
Fabio Santaniello, University of Trento, Italy
Stefano Grimaldi, University of Trento, Italy
Stefano Gialanella, University of Trento, Italy

600 **Differences between archaeological and forensic burned samples using powder X-ray diffraction (XRD) and ATR-IR spectrometry**
Giampaolo Piga, University of Coimbra, Portugal
Fabio Cavalli, Julian-Isontine Universitary Integrated Health Enterprise (ASUGI),Italy
Dario Innocenti, Julian-Isontine Universitary Integrated Health Enterprise (ASUGI),Italy
Eugénia Cunha, University of Coimbra, Portugal
Stefano Enzo, University of Sassari, Italy
David Gonçalves, University of Coimbra, Portugal, Archaeosciences Laboratory, Spain

605 **The Roman bridge of Canosa di Puglia: a metrological approach**
Germano Germanò, Polytechnic University of Bari, Italy

611 **Optical micro-profilometry for surface analysis and 3D printed replica of archeological artefacts**
Sara Mazzocato, University of Verona, Italy
Giacomo Marchioro, University of Verona, Italy
Alessandra Menegazzi, University of Padua, Italy
Claudia Daffara, University of Verona, Italy

617 **Operational methodology for a historical, critical and virtual reconstruction of Baroque ephemeral apparatuses**
Margherita Antolini

623 **Upgrade of the x-ray imaging set-up at CCR "La Venaria Reale": the case study of an Egyptian wooden statuette**
Luisa Vigorelli, Politecnico di Torino, Università degli Studi di Torino, INFN, Italy
Alessandro Lo Giudice, Università degli Studi di Torino, INFN, Italy
Tiziana Cavaleri, Centro Conservazione e Restauro 'La Venaria Reale', Italy
Paola Buscaglia, Centro Conservazione e Restauro 'La Venaria Reale', Italy
Marco Nervo, INFN, Centro Conservazione e Restauro 'La Venaria Reale', Italy
Paolo Del Vesco, Fondazione Museo delle Antichità Egizie di Torino, Italy
Matilde Borla, Soprintendenza ABAP-TO, Italy
Sabrina Grassini, Politecnico di Torino, Italy
Alessandro Re, Università degli Studi di Torino, INFN, Italy

SESSION 3.7 – SPECIAL SESSION ON THE INTERACTION BETWEEN ENVIRONMENTAL POLLUTION AND CULTURAL HERITAGE: FROM OUTDOOR TO INDOOR ENVIRONMENT - PART 2

Room: Virtual Room #3
Chairs: Paola Fermo, *University of Milano, Italy*
Valeria Comite, *University of Milano, Italy*

629 **An Innovative Fluorinated Polyacrylic Coating for the Protection of the Cultural Heritage**
Eleonora Pargoletti, Università degli Studi di Milano, Consorzio INSTM, Italy
Valeria Comite, Università degli Studi di Milano, Consorzio INSTM, Italy
Valentina Sabatini, Università degli Studi di Milano, Italy
Paola Fermo, Università degli Studi di Milano, Consorzio INSTM, Italy
Marco Aldo Ortenzi, Università degli Studi di Milano, Italy
Hermes Farina, Università degli Studi di Milano, Italy
Giuseppe Cappelletti, Università degli Studi di Milano, Consorzio INSTM, Italy

635 **Correlation of indoor air quality and stable carbon isotope ratio of CO_2 in historical monuments of Italy: a case study**
Concetta Pironti, University of Salerno, Italy
Maria Ricciardi, University of Salerno, Italy
Antonio Proto, University of Salerno, Italy
Raffaele Cucciniello, University of Salerno, Italy
Antonino Fiorentino, University of Salerno, Italy
Oriana Motta, University of Salerno, Italy

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Trento, Italy, October 22-24, 2020

Integrated digital survey for the knowledge and enhancement of the IIWW heritage. The Natural Park *Molentargius-Saline* (Cagliari, Italy)

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***Abstract* –The essay illustrates the choices aimed at building a digital database of military architectures made in Sardinia during the Second World War.**
It is an historical cultural heritage characterized by an interesting landscape value, composed by more than 1.500 artifacts positioned along the coast of the island and designed to protect the urban centers and areas of strategic interest.
The small bunkers built adapting the models designed by the Italian and German Military Genius gave rise to an interesting repertoire.
The need for mimesis of these 'sentries' has in fact required an adaptation to the places of the typological solutions indicated in the archive documents.
A possible recovery and enhancement of this heritage necessarily passes through an activity of knowledge and cataloging entrusted to integrated digital survey methods.

I. TOWARDS A DIGITAL DATABASE OF II WW SARDINIAN MILITARY ARCHITECTURES

The Sardinian coastal landscape is characterized by the presence of towers, built between the sixteenth and eighteenth centuries by the Spanish and Piedmontese Kingdom, in activity until the first half of the nineteenth century.

Designed to control the coasts, these architectures 'mark' the rhythm of a landscape shaped by high cliffs, coves, lagoon and sandy coasts. During the Second World War the same positions will be re-occupied by small reinforced concrete bunkers built in a very short time by the Italian and German Military Engineers to thwart an announced allied landing on the island.

This heritage, composed of "industrial pieces", today is mostly abandoned and lack of specific a protection and safeguard rules. In fact, no official cataloging activity [1] or specific regulation guarantees their protection or directs a possible reuse within historical and cultural itineraries. The only regulatory reference remains the PPR (Sardinian Landscape Plan) of Sardinia which identifies "refuges, bunkers and caves" [2] among the 'identity assets' subject to protection pursuant to art. 143 of Legislative Decree no. 42/2004.

However, the historical and cultural value of bunkers, representative architectures of a (recent) past not to be forgotten [3], is evident as well as the landscape value linked to their original position; in the past, sentries to control the sky, seas and cities and today, 'windows' to look and appreciate the landscape. Placed in different areas they make it difficult -but not impossible- to coordinate the intervention strategies. Abandoned along the sandy or rocky coasts, immersed in the rural or urban landscape of the major centers of the island, they coexist with the recent stratifications that have welcomed them.

The organization of a digital database projected to manage two-dimensional and three-dimensional models is the first step to reorganize the knowledge and plan a reuse of this built heritage.

To this aim digital survey methodologies support the recording of scientific data and information computer technologies allow the design of interoperable digital models.

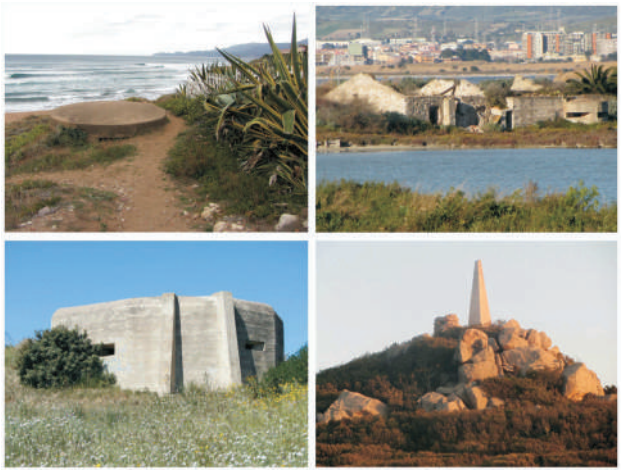

Fig. 1. Tresnuraghes (OR), Natural Park "Molentargius-Saline" (Cagliari), Quartu Sant'Elena (CA), Santa Teresa Gallura (OT)

II. BUILT A DIGITAL DATABASE OF II WW HERITAGE

The development of information technologies and tools for architectural and environmental survey and representation has facilitated the development of interesting initiatives aimed at cataloging the existing built heritage and at the creation of digital archives for their protection, recovery and enhancement.

Laser scanning technology and photogrammetric methods (and an increasingly use of drones, particularly useful in limited accessibility contexts) makes it possible to have a thorough knowledge of the architectural and material characteristics of historical centers, as well as monumental complexes, achieve three-dimensional representations of the landscape and create virtual tours and cultural heritage routes [4].

However, the bunkers of the Second World War only recently have been the subject of interest and studies aimed at an in-depth knowledge although a first cataloging (survey and classification) of the Atlantic Wall is dated 1985 and is due to the scholar Rolf Rudi [5].

A first investigation have highlighted an interesting affinity between the Spanish and Sardinian coasts, "Mediterranean" areas that share historical and architectural events since the Middle Ages and with particular intensity in the modern era. This research [6,7] has interested the design solutions adopted along the Spanish coast between Cadiz and Girona -specifically in the province of Alicante- and has defined a repertoire divided into categories (fig. 2).

The study was subsequently the subject of some insights, related to the disciplinary field of history of architecture and landscape representation [8], with particular attention to the relationship between the identified models and the watchtowers built from the second half of the sixteenth century along the coasts of Spain and Sardinia [9].

The design of a digital database of Sardinian architectures needs a geo-referenced cartographic base; for this purpose it is been identified the Regional Technical Map (C.T.R.) dated 1998 on a numerical scale of 1:10.000, modified to become GIS oriented, integrated by aerial surveys dated from 1954 to 2013 and by the maps prepared by the Italian Military Engineer on a numerical scale of 1:25.000 in the years 1941-42.

The compatibility between the selected documents allows an easy identification of the bunkers and the subsequent inspection aimed at verifying the site conditions and planning the survey operations.

The distribution of the architectures in different landscape contexts of the island requires a territorial planning of the surveys and a choice of some case studies on which to deepen the knowledge of the design characteristics and evaluate the landscape value.

To this end, field operations are conducted on different scales of investigation - architecture and landscape.

Through the use of integrated survey methodologies is possible to acquiring information on the architectural, geometric, material characteristics of single bunkers and landscape qualities of the contexts that host them; all of these data make up the scientific database (fig.3) and are aimed at cataloging and studying the military heritage.

Comparison with the archival models, examination of the state of degradation, analysis of the landscape value, also aimed at the construction of cultural itineraries, are just some of the possible uses of this catalog.

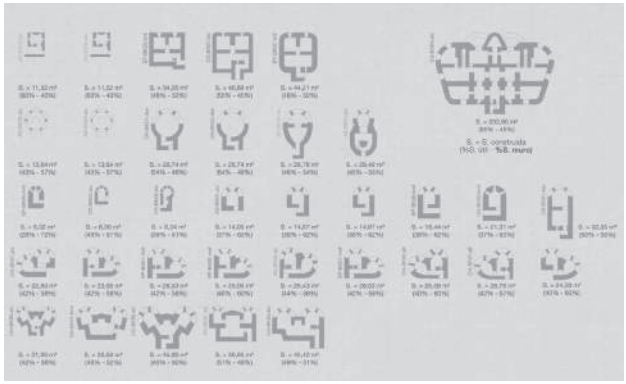

Fig. 2. Catalog of bunker built during the Spanish Civil War (1936-39) in the territory of Alicante (Martínez-Medina 2016)

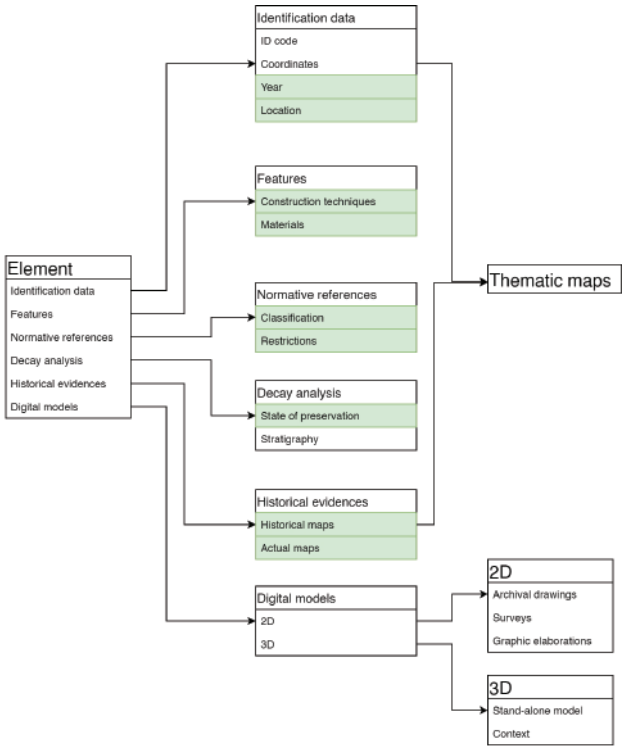

Fig. 3. Main structure of Sardinian IIW heritage database (design by A.Pirinu & R.Argiolas)

III. SURVEY, REPRESENTATION AND CATALOGING IN THE "NATURAL PARK MOLENTARGIUS-SALINE" (CAGLIARI)

The interventions planned in Sardinia during the 1940s was carried out especially in the coastal area.

The projects are well described in the archival documentation kept in the Military Archive of Cagliari (*Archivio Documentale del XIV Reparto Infrastrutture Esercito*) and at the Historical Archive in Rome (*Archivio dell'Ufficio Storico Stato Maggiore Esercito*).

The bunkers location is identified on a IGM maps elaborated by the Military Engineers (fig. 4); it allows an easy recognition of works carried out.

Starting from an analysis of these documents a territorial survey has been realized; this first step as highlighted an interesting repertoire of design solutions that show the presence of models, that take up shapes (circle and square as in figg. 6-7-8) and dimensions indicated in the military catalog, sometime integrated with existing buildings (coastal towers, civil/industrial dwellings) in order to achieve a complete mimesis with the landscape.

One of the case studies investigated is the *Molentargius-Saline* compendium in Cagliari in which 11 bunkers are identified and cataloged; placed in 4 strategic points (sector 1,2,3,4) and visually connected to each other, they was built to control crossroads and canals. Some of them have been modified to disguise themselves by acquiring the shape of cisterns (figg. 9-10) or becoming part of some buildings built in the nineteenth century to support salt works activities (figg. 12-13).

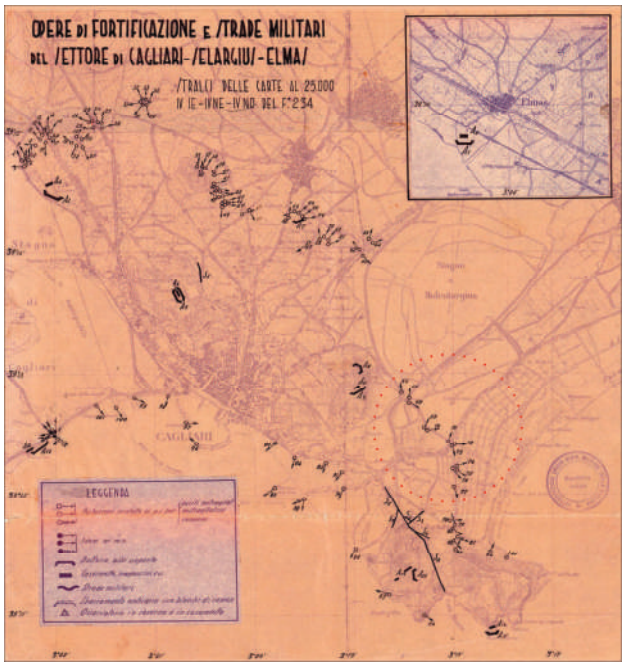

Fig. 4. Military works planned in the sector of Cagliari. The red dotted line identified the survey area

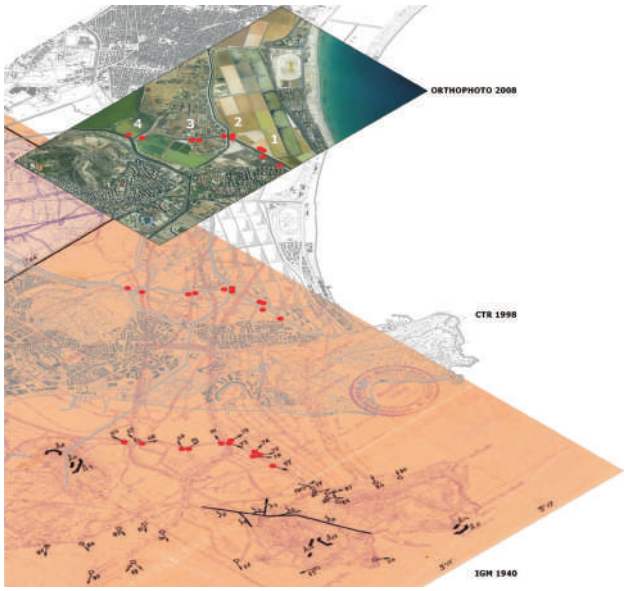

Fig. 5. Military works realized in the Natural Park of Molentargius-Saline (drawing and C.G.I.by A.Pirinu).

Fig. 6. Design model: circle + square in the sector 1

Fig. 7. Design model: circle + square - sector 2

Fig. 8. Design model: circle + square - sector 3

Fig.11. Bunker positioned along the canal - sector 4

Fig.9. Bunker as a cylindrical water tank - sector 3

Fig.12. Bunker incorporated in a building - sector 1

Fig.10. Circle + rectangle (as a water tank) - sector 2

Fig.13. Bunker incorporated in a nineteenth century building to control waterways and road that connected in the 1940s Quartu Sant'Elena to Cagliari - sector 4

In the area of the *Molentargius* (fig.14) the survey operations were entrusted to the photogrammetric method preceded and supported by a direct measurement of the internal and external dimension, useful to scale the model.

This procedure made it possible to record the architectural and dimensional characteristics of all the bunkers identified and to produce a digital representation, of which the sequence of images in figure 17 is an example.

Regarding the operational aspect, during the "design" of the survey, the use of drone was evaluated.

However, from an analysis of the ENAV (the company that manages civil air traffic in Italy) cartography, it is been verified that the airspace related to the site falls within the Natural Park *Molentargius-Saline* area, where flight is prohibited.

Consequently, it was not possible to make a wide view of the landscape context and survey operation were mainly conducted on the architectural scale.

The small size of the bunkers leads the choice for the use of an inexpensive Action Cam (20MegaPixel camera resolution) installed on a telescopic support (maximum capacity of 8 meters).

Despite the good technical characteristics, the files processed by the camera highlight a limit in terms of dynamic range and image sharpness; for this reason it was decided to make up for the poor quality of the image with a high number of shots.

This expedient has made it possible to achieve the intended purposes, that is the documentation of the bunkers (made with the use of simple construction models and regular surfaces in reinforced concrete of excellent quality) on the architectural scale.

The data processing was performed with Agisoft Metashape Professional v.1.5.3 in which the internal and external images were processed separately.

Once the point clouds were acquired, the "chunks" were joined with the "point based" method to obtain a complete and perfectly aligned "Dense Cloud".

Finally, the dense cloud was managed within the software Cloud Compare v.2.10.2 and used to process 2D and 3D digital representation.

All of this scientific information gives a further contribution to the construction of IIW Sardinian military architecture database and -together with the case studies already examined in the area of Bosa (OR) and Quartu Sant'Elena (CA) and to those still in progress in the north of the island in the territories of Santa Teresa Gallura (OT) and La Maddalena (OT)- to the recovery and enhancement of this important historical cultural heritage.

Fig. 14. Strategic points to control roads and waterways

Fig. 15. Bunker located in the sector 2

Fig.16. Photographic survey– sector2

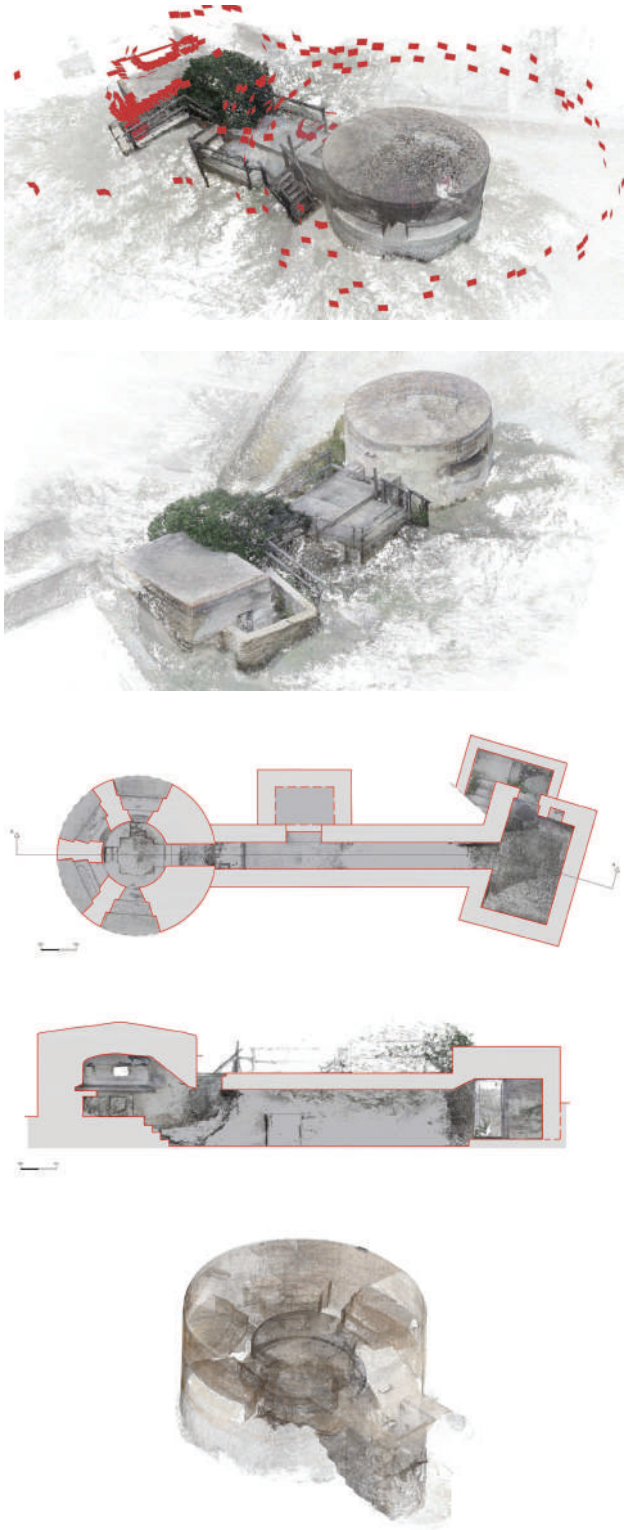

Fig.17. Digital models of surveyed bunker (drawing and C.G.I. by N.Paba, scientific coordinator A.Pirinu)

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Index of Authors