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*

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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)**
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Francesco Gabellone, Nanotec CNR, Lecce, Italy
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9 **A multiscalar research project, following an ancient decumanus in Montenegro**
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Joel Aldrighettoni, University of Trento, Italy
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Stefano Pagnotta, *University of Pisa, Italy*

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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
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POSTER SESSION 1

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Viviana Mollica Nardo, CNR-IPCF, Italy
Oreste Adinolfi, FARO Europe GmbH & Co., Germany
Maria Amalia Mastelloni, Parco Archeologico e Museo 'L. Bernabò Brea', Italy
Rosina Celeste Ponterio, CNR-IPCF, Italy

150 **A database for historical pigments through handheld instrumentation**
Giulia Festa, Centro Fermi, Italy
Claudia Scatigno, Centro Fermi, Italy
Maria Luisa Saladino, Università di Palermo, Italy
Francesco Armetta, Università di Palermo, Italy
Veronica Ciaramitaro, Università di Palermo, Italy
Viviana Mollica Nardo, CNR-IPCF, Italy
Rosina Celeste Ponterio, CNR-IPCF, Italy

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

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Nicola Masini, *ISPC - CNR, Italy*
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Raffaele Persico, University of Calabria, Italy
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Nicola Masini, CNR-ISPC, Italy

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Enrico Papale, ISPC CNR, Italy
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Luca Di Angelo, University of L'Aquila, Italy
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E. Guardiani, University of L'Aquila, Italy

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Athos Agapiou, Cyprus University of Technology, Eratosthenes Centre of Excellence, Cyprus
Vasiliki Lysandrou, Cyprus University of Technology, Eratosthenes Centre of Excellence, Cyprus
Diofantos Hadjimitsis, Cyprus University of Technology, Eratosthenes Centre of Excellence, Cyprus

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

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

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V. Albano, Leica Geosystems AG, Switzerland

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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

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Valeria Comite, *University of Milano, Italy*

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Marco Bertelli, A.L.M.A.G. S.p.A, Italy
Elisa Monfasani, Fondazione Enaip Lombardia, Italy

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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*

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*

SESSION 2.5 – SPECIAL SESSION ON NEUTRON TECHNIQUES IN ARCHEOMETRY

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

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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

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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
A. Brini, MIBACT Opificio delle Pietre Dure, Italy
A. Patera, MIBACT Opificio delle Pietre Dure, Italy
F. Morandini, Fondazione Brescia Musei, Italy
F. Grazzi, CNR, INFN, Italy

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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

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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
Almat M. Yergashov, Joint Institute for Nuclear Research, Russia, Institute of Nuclear Physics, Republic of Kazakhstan
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

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F. Grazzi, CNR, Istituto di Fisica Applicata 'Nello Carrara', Italy
Antonella Scherillo, ISIS Neutron Source, United Kingdom
A. Fedrigo, ISIS Neutron Source, United Kingdom
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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*

397 **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

403 **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

408 **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

413 **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

418 **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

424 **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

428 **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

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

437 **Geophysical investigations at the Cathedral of Catania**
Giovanni Leucci, CNR ISPC, Italy
Lara De Giorgi, CNR ISPC, Italy
Giovanni Fragalá, CNR, Italy
Antonino Mazzaglia, CNR, Italy
Daniele Malfitana, CNR, Italy

441 **GIS for the cataloging and enhancement of "specchie" located in the Upper Salento in Apulia Region (Southern Italy)**
Maurizio Delli Santi, ISPC-CNR, 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*

500 **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

505 **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

510 **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*

515 **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

520 **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

525 **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

531 **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

536 **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*

541 **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

547 **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

552 **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

557 **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*

563 **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

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

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

578 **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

583 **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*

587 **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

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*

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Warscapes: A "Submerged Information Basin". The Contribution of LiDaR Data to the Unveiling

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***Abstract* – The impact of the Great War militarization processes has transformed most of Europe's territories, creating a meaningful warscape both in a material and cultural way. As a result of the inevitable post-war landscape transformations, the dense networks of military buildings designed for the war, as well as the "traces" of destruction, have been reabsorbed in the dynamics of landscape transformation, and today they remain almost exclusively as isolated fragments and, especially with regard to field fortifications, often barely recognizable. The need to recover a "systemic look" to give strength to the network of vestiges as a system becomes a matter of primary importance. In this sense, the interpretations of LIDAR data and some specific visualizations of the same (Hillshade and Sky-view-factor visualization) can provide very useful elaborations to facilitate the recognition of the permanence of such vestiges in today's landscape, to constitute an indispensable base of knowledge on which to set future choices in terms of conservation, selection, and transformation.**

I. A FRAGILE HERITAGE AT HIGH COMPLEXITY. ISSUES OF RECOGNIZABILITY

More than a hundred years ago the face of the whole of Europe was profoundly transformed by the long and complex militarization process of the territories connected to the Great War, which shaped different contexts through the tangible "signs" of history. Permanent fortifications, trenches, barracks, and military infrastructures represent only a part of the dense set of fortified works linked to offense and defense, conceived and designed by the different military geniuses in symbiotic relation to the morphological features of the different territories. These artifacts designed for war, in addition to the "wounds" directly imprinted by the conflict on the orography of the different territories, have permeated the pre-existing landscape to such an extent that they have become distinctive features of these warscapes, understood as "*materia signata*", that for these reasons today it is recognized as a "material witness having the value of civilization". [1].

Over time, however, the inevitable natural and anthropic transformations of the landscape led to the fragmentation of the original military systemic planting, weakening above all the intrinsic connections between permanent fortifications and the relative entrenched systems, on whose symbiotic relationship the functioning of the great "war machine" was based. Despite being designed "more to resist than to last over time" and therefore "by nature" more exposed to post-depositional processes of degradation and changes in land use, these works constituted a much more pervasive tissue than the permanent fortifications: they were the load-bearing framework of the entire warscape, the arterial system that substantiated the network. Today most of these more minute systems have been reabsorbed in the different dynamics of landscape transformation, within which they remain as isolated fragments, not clearly recognizable and often "submerged" under more recent layers that have stratified on this heritage with high witness potential but at risk of loss [2].

Also following an examination of the projects launched after the promulgation of Law no. 78/2001, a fundamental regulatory framework as it recognizes the vestiges as a heritage to be protected and safeguarded, including the started/ended projects on the occasion of the Centenary celebrations, the issue of the difficult recognition of the most fragile works as permanence remains of primary importance. This issue raises questions of knowledge and "care", implicitly highlighting the need to identify methods and analytical strategies useful to facilitate the recognition of permanences within the multilayered contemporary landscape, to avoid their loss and thus preserve our "possibility of memory" through their evocative potential.

The ongoing research presented here moves in this direction, proposing the elaboration of a methodological tool useful to decode the codes according to which the landscape is written, to build a broad spectrum knowledge base that, through a holistic and interdisciplinary approach, represents the foundation for future design choices in terms of permanence, selection and transformation of this important heritage. Moving from the deep meaning of the word *vestigia*, which refers to the physical imprint of something that is no longer tangibly present but which leaves at the same time memory of its passage through the traces imprinted in the landscape, the elaboration of the method called

"stratigraphic telescope" is part of the line of research already known as "Archaeology of the Great War", recognizing the complex palimpsest of the vestiges, visible but also "submerged", as a wide and deep information basin to be investigated and recognized. [3].

This is an interdisciplinary contribution as it integrates the study of archive documentary sources and the constructive-typological features of the artifacts with the knowledge gained from the interpretation of a series of data obtained thanks to the potential offered by high-resolution remote sensing techniques and non-destructive tests. Satellite or aerial remote sensing, through the study of orthophotos and LIDAR data, is particularly useful to investigate the development of the transformation dynamics of territories in time, comparing the impact of the war event of a hundred years ago with the current reconnaissance of the permanences. In this perspective, the use of software for the creation of Geographic Information Systems such as ArcGis and QuantumGis assumes considerable importance, as these work environments allow overall coordination of the whole knowledge-based process: from the integrated management of the different input datasets (georeferencing of historical militarisation maps and military aerial photographs) to the elaboration of the expected outputs [4].

Specifically, the important contribution that interpretations of LIDAR data (through some relative visualizations of the same) can provide in the identification of areas where the vestiges of the Great War remain with different degrees of readability within the topography of today's landscape is presented below.

II. LIDAR DATA AND RELATIVE VISUALISATIONS: A CONTRIBUTION FOR THE RECOGNITION OF THE PERMANENCES

LIDAR (an acronym for Light Detection and Ranging) is an "active" remote sensing technique that performs high-resolution topographic surveys through an aerial scan of the portion of territory to be analyzed. The topographic survey is based on the measurement of the distances between the laser beam emitter and the terrain surface: what is obtained is a cloud of points to each of which is associated a data relative to the geographical coordinates (according to the WGS84 system) and the altimetric altitude calculated based on the difference in time between the emitted and reflected impulse, and the intensity of the reflected signal itself. Among the different methods of remote sensing, LIDAR has assumed strategic importance also in the study of the dynamics of archaeological transformation of the landscape because of its ability to overcome the interference caused by the presence of vegetation. In fact, in addition to a digital surface model including each detected element (the DSM, Digital Surface Model), LIDAR returns also a digital model of the "clean" orography of the ground (the DTM, Digital Terrain Model), built only with the points that belong to the ground.

As far as the research under examination is concerned, this translates into the potential possibility of identifying "remotely" the permanence of some archaeological evidence of the Great War, otherwise not visible through the analysis of current orthophotos alone. In areas where the land cover/land use of the soil has varied compared to the immediate post-war period (e.g. in newly planted woodlands), the study of the DTM, therefore, makes it easier to identify the traces imprinted in the morphology of the terrain by reducing the number of necessary field inspections and detailed reconnaissance/detection, certainly more costly in terms of time and money.

But tackling the issue of the recognisability of the permanences with an archaeological approach means analyzing the warscape in its complexity, through a look that "scans" it in-depth, relating the "emerged" heritage to the "submerged" palimpsest of more unstable evidence, often covered by post-depositional layers of degradation but not disappeared. Recognizing these "footprints" means recognizing their narrative potential, and it is precisely in this perspective that the most interesting contribution of the use of LIDAR data is manifested, in particular through various techniques of data visualization (specifically hillshade and sky-view-factor visualization) that in recent years have been developed and borrowed from other disciplines to optimize the visibility of different archaeological features [5].

The Hillshade visualization represents the most common LIDAR processing and consists of the shading calculation for each grid cell referring to established lighting values from a hypothetical light source. The possibility to artificially set the light source position according to any desired angle (even those not possible "in nature") allows highlighting also features weakly marked on the ground. At the same time, however, each specific direction of the lighting angles can be parallel to precise evidence on the ground, which in this case would not produce a shadow, and therefore would not become visible. To overcome this gap it is advisable to use a hillshading algorithm from multiple directions, able to map different hillshade with different angles on a single view, to display all the pieces of evidence on the ground at the same time.

As far as Sky-view-factor visualization is concerned, the calculation algorithm consists of simulating a diffused illumination on each pixel of the DTM coming homogeneously from all directions from above, as if, above each point, there was a uniformly illuminated hemisphere. The sky visibility factor represents the measurement of the portion of the visible sky from each specific point on the surface and returns a non-dimensional parameter between 0 (no visibility - black color) and 1 (completely free view - white color). The

goodness of this visualization depends on the good resolution of the starting digital model, the number of directions that are considered in the analysis, and the maximum radius size in which to calculate the processing. With an appropriate calibration of the parameters concerning the reference context, this type of processing can return visualizations much clearer and sharper than the classic hillshade visualization, especially concerning the detection of small topographic depressions such as bomb craters, sinkholes, trenches, etc.[6].

The interpretation of the Digital Terrain Model through the types of visualization described above allows to take full advantage of the informative potential of the LIDAR data to obtain a clear and precise knowledge of the current morphology of the territory, recognizing on it also the permanence at different temperatures of the "footprints" left by the conflict on the landscape, hidden below the "one century deep archaeological deposit", but not disappeared. In this regard, the management of such visualizations in a QuantumGis environment also makes it possible to classify the different levels of visibility of the recognized permanencies expeditiously: areas with well-preserved surface features, identified as the SVF highlights clear and well-delineated edges and perimeters and the contrast in the visualization is strong; areas clearly recognizable but compromised by erosion and sedimentation; and finally areas with poor conservation, where the individual features are particularly difficult to "see".

The entrenched field that insisted around Forte Busa Verle on the Vezzena Plateau (TN) represents an interesting case to demonstrate the validity of the contribution that the different ways of interpretation of LIDAR data can provide in the recognition of the permanence of the warscape in the contemporary landscape [7].

III. THE ENTRENCHED SYSTEM AROUND BUSA VERLE FORT (TN): A STUDY-CASE

Because of its strategic position on the Vezzena/Luserna Plateau, in 1915 Forte Busa Verle was the first Austro-Hungarian fortification to be involved in the short but very intense "war of the forts". During the first year of the conflict, the fortress was repeatedly attacked by Italian troops, who bombarded it with over 8,000 artillery shots of different calibre, radically transforming the entire surrounding environment into a lunar landscape, marked by rubble, craters left by bombs and destroyed entrenches. The meaning of these "wounds" is universally recognized and it is an integral part of the complex value of the testimony of this warscape, to be protected and handed down. For this reason, the recognition of the permanencies of this palimpsest of vestiges becomes a necessary condition. Although at the wartime these vestigia were deep and well recognizable, today they have been reabsorbed in the inevitable dynamics of transformation of the landscape and therefore they are more unstable, fragmented, and often "submerged" under new layers deposited in the last hundred years.

A first examination for the recognition of what remains of these "signs" was carried out through the study of aerial photographs dating back to the years 1915-1918 kept at the Italian Historical War Museum of Rovereto (TN-Italy), and the georeferencing of them in the *QuantumGis* environment. With the observation of these photographs, it was possible to reconstruct the situation of the war landscape during the conflict, identifying not only the effects of the bombings on the fort but also on the surrounding landscape, on the fighting positions, and the trenches. The geolocation of both of the elements built for the war and of the "wounds" inflicted by the conflict itself has allowed to precisely identify the areas potentially affected today by the presence of permanencies. These areas have been studied in more detail, in the first instance through the direct survey (inspections) and the analysis of current orthophotos. In this way, the most evident "traces" of the permanencies (Visibility Class 1) have been identified, as summarized in Table 1. More than 1761 meters of reentrants clearly traceable to the original trenches around the fort and nr. 77 circular depressions or small "holes" evidently referable to the craters produced by repeated bombardments have been detected (in Fig.2 the elements referred to Visibility Class 1 are drawn in red color).

Table 1. Quantitative warscape recognition through orthophoto analysis

	Visibility Class 1
Shell traces	Nr. 77
Trenches	1761 m

However this first classification proved to be partial, as the study of the surrounding area of the fort through the analysis of the Digital Terrain Model with the different views previously described (Sun angle 315°, Hillshade from multiple directions, and Sky-view Factor) has made it possible to recognize and identify a further significant amount of vestiges less explicitly visible, but distinctly imprinted in the morphology of the ground, below the turf that indiscriminately covers everything.

As specified in Table 2, in fact, in addition to what is already recognized in the previous step, other 3849 meters of reentrants that can be traced back to trenches and nr. 1265 circular depressions of medium and small size referred to the craters produced by the bombardments have been identified (in Fig.2 the elements referred to the Visibility Class 2 are drawn in yellow color while those referred to the Visibility Class 3

in brown color).

Table 2. Quantitative warscape recognition through Hillshade from multiple directions and Sky-View Factor

	Visibility Class 2	Visibility Class 3
Shell traces	329	936
Trenches	854 m	2995 m

In conclusion, as shown in Fig.1, the potentiality of the integrated visualizations of Hillshade from multiple directions and Sky-View Factor has proved to be indispensable in the recognition of these entrenches and "footprints" of craters present in the contemporary landscape at different degrees of readability to be protected and handed down, even though they are less visible as they are probably produced by the shelling of artillery of medium and small calibre (low destructive power and consequently limited crater depth) and subjected to more consistent post-depositional layers that have compromised their direct readability (Visibility classes 2-3).

IV. CONCLUSION

In light of the above considerations, it is clear that the LIDAR data constitute an informative dataset of considerable importance for the integrated study of the dynamics of landscape transformation. The different visualization modes available define some "privileged looks" through which to investigate in depth the Digital Terrain Models to recognize the complex stratification.

Specifically, concerning the surroundings of Forte Busa Verle, the interpretation of the Sky-view-factor has allowed identifying with greater ease the permanence of even minute and fragile fortified tissue, often "submerged" under other layers deposited over time but still meaningful and full of identity values (Fig.2).

Table 3. Quantitative shell craters recognition with/without DTM analysis

	Nr.	%
Total	> 5000	100
without DTM analysis	77	1,54
with Hillshade +SVF Analysis	1342	26,84

Only by way of example, a simple comparison between the number of "craters" recognized exclusively through the observation of the orthophotos (nr. 77) compared to those identified also with the integrated analysis of the DTM (nr. 1342) shows how these visualizations have allowed the recognition of about 1265 "wounds" (about 25% of the total), unstable but still present in the contemporary landscape, that otherwise would have remained unidentified (Table 3).

The potentialities of this analytical-archaeological approach have been operationally manifested and constitute one of the founding aspects of the "stratigraphic telescope" method elaborated within the in-progress research at UniTN-DICAM, to explore the processes of construction/transformation of warscapes at different scales. The recognition of the permanence of the remains in the current state of the places can take full meaning through the comparison with the maps of the impacts of the conflict referred to as the original wartime. This comparison will allow identifying the different gradients of permanence within the contemporary landscape, whose recognition becomes the necessary condition to understand how to 'take care' of this complex set of signs within the future transformations of the landscape.

REFERENCES

[1] D.Ravenna, G.Severini, “Il patrimonio storico della Grande Guerra. Commento alla legge 7 marzo 2001 n.78”, Gaspari, Udine, 2001.

[2] A.Quendolo (a cura di), “Paesaggi di Guerra. Memoria e progetto”, Gaspari, Udine, 2014.

[3] A.De Guio, A.Betto, P. Kirschner, V.Manzon, D.Zambon, “Tracking the warscape”: fronti, frontiere e confini sugli altipiani trentini dall’età del Bronzo al 1915-18”, Proc. of “Laser Scanner e GPS. Paesaggi archeologici e tecnologie digitali 1”, Università di Siena, Siena, 2006, vol.1, pp. 227-272.

[4] H.Can den Berghe, W.Gheyle, N.Note, B.Stichelbaut, M.Van Meirvenne, J.Bouorgeois, V.Van Eetvelde, “Revealing the preservation of First World War shell hole landscapes based on a landscape change study and LiDAR”, in Geografisk Tidsskrift-Danish Journal of Geography, 2019, pp.38-51.

[5] W.Gheyle, B.Stichelbaut, T.Saey, N.Note, H.Van den Berghe, V.Van Eetvelde, M.Van Meirvenne, J.Bourgeois, “Scratching the surface of war. Airborne laser scans of the Great War conflict landscape in Flanders (Belgium), in Applied Geography 90, 2018, pp. 55-68.

[6] Z.Kokalj, K.Zaksek, K.Ostir, “Application of sky-view factor for the visualisation of historica landscape features in Lidar-derived relief models”, in Antiquity 85 (327), pp. 263-273.

[7] A.Quendolo, J.Aldrighettoni, “La “cura” dei paesaggi di guerra. La conoscenza come metodo per conservare e valorizzare stratificazioni di segni, tracce, ferite.”, Proc. of “Boundary landscapes”, Brescia, 2020, pp. 331-342.

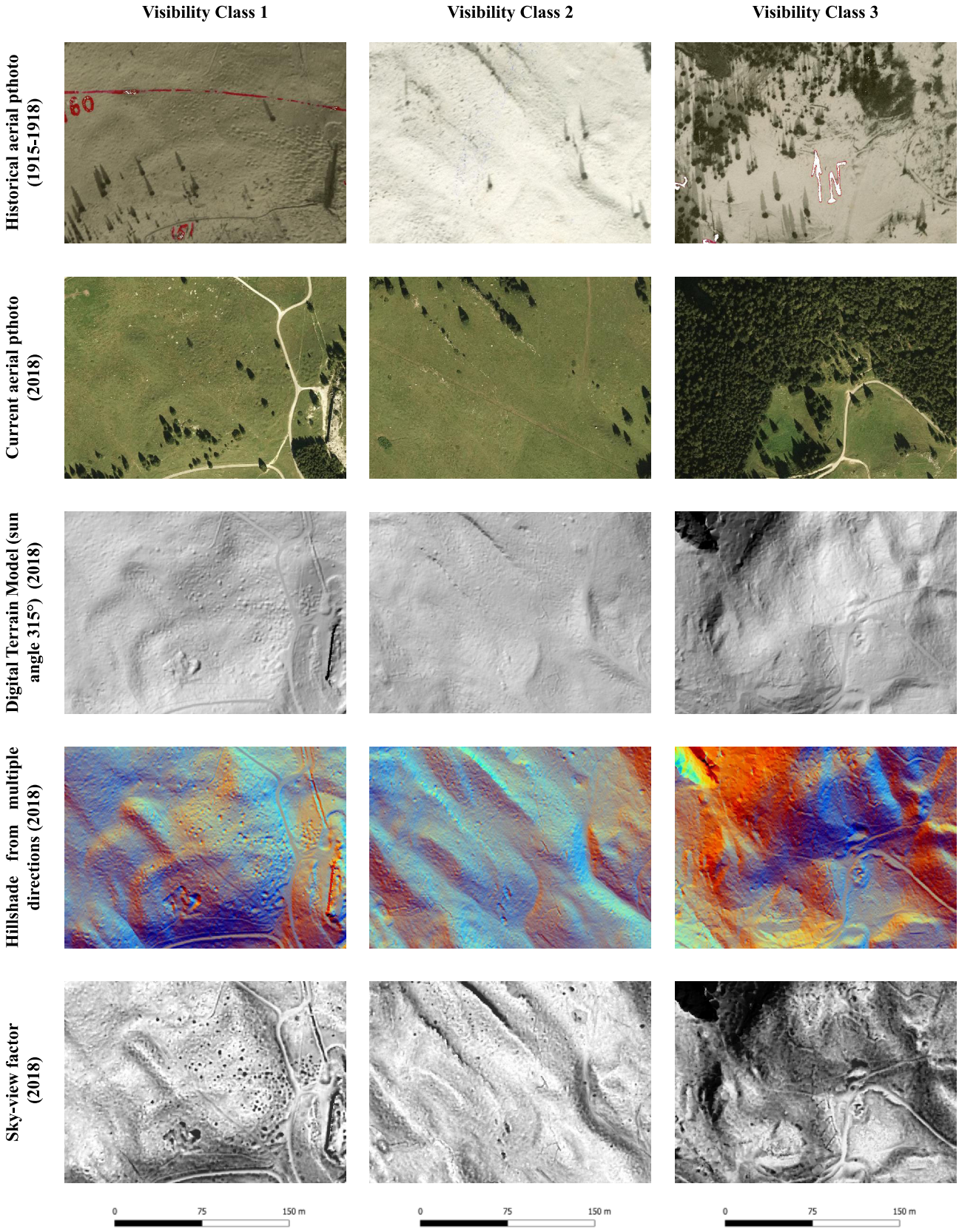

Fig. 1. Different degrees of visibility of the entrenched system around Forte Busa Verle (Altopiano di Vezzena - Trento - Italy). Analysis conducted by comparing historical photographs, current orthophotos and different views of DTM data, that are freely provided by the Autonomous Province of Trento: Digital Terrain model with sun inclination angle 315°, Hillshading from multiple directions, Sky-view Factor (radius 32).

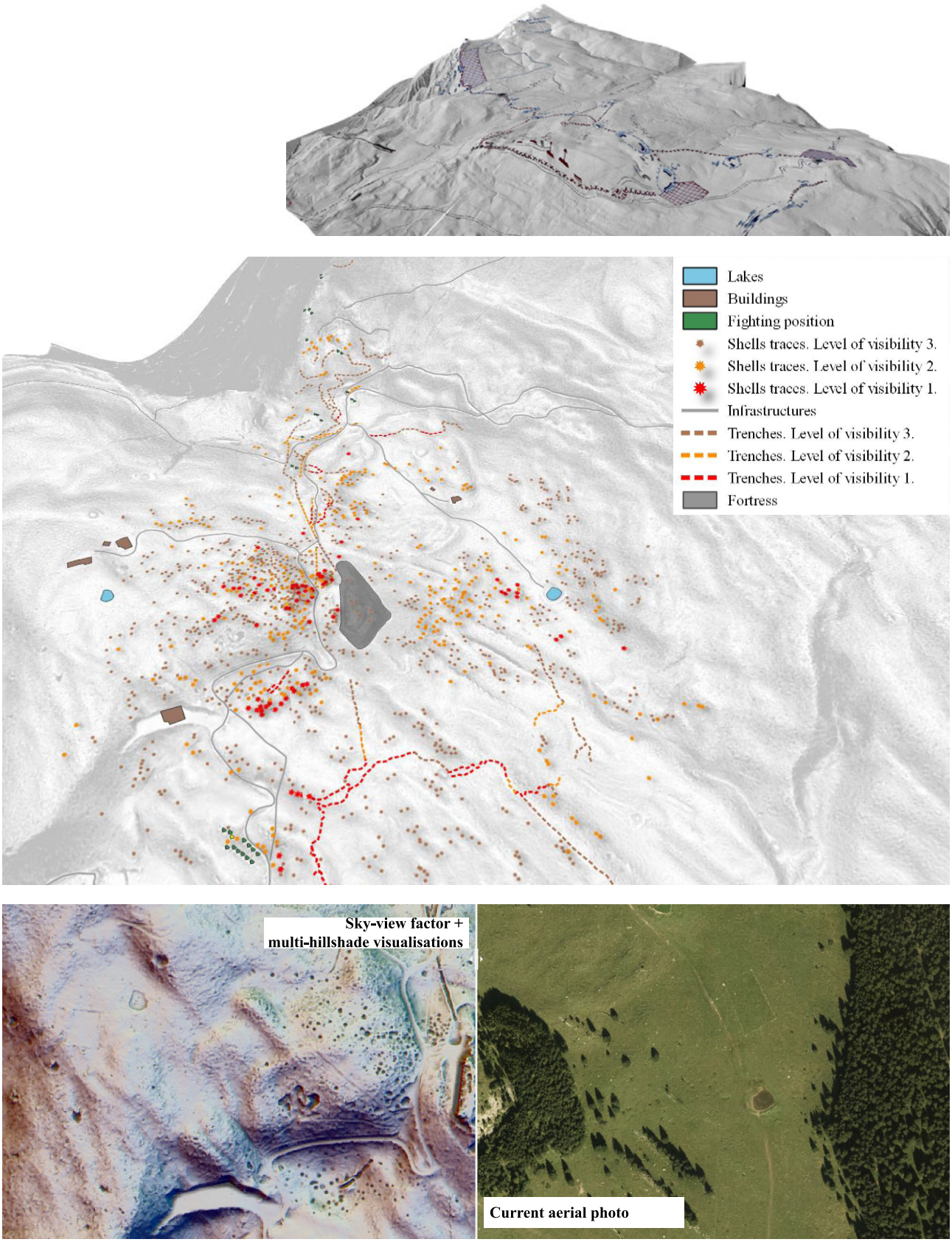

Fig. 2. Warscapes: a "Submerged Informative Basin". Historical photo 1915 - Museo Storico Italiano della Guerra di Rovereto (1). Overlapping of original Austro-Ungarian militarization projects on the current DTM to identify the permanencies (2). Traces of the Great War unveiled through the Hillshade from multiple directions and Sky-view Factor visualizations (3). Comparison between Sky-View Factor visualization and current orthophoto (4).