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Eight Balkan Symposium in Archaeometry

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Front page: motives from Vinča culture ceramics (5,700-4,500 BC).

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CONTENTS

Preface ............................................................................................................................................. 9
Abstracts ............................................................................................................................................ 11
Macro-Raman mapping: a new step in Raman spectroscopy of art objects
P. Vandenabeele and A. Rousaki ........................................................................................................... 13
MA-XRF imaging of Greek Antiquities
A. G. Karydas, C. Caliri, E. Eleftheriou, K. Tsampa, Th. Gerodimos and D. F. Anagnostopoulos .......................................................................................................................... 15
Glass through the Adriatic: an overview
E. Gliozzo, F. Giannetti, M. Turchiano and M. Ferri ........................................................................ 17
Metallurgy of the Vinča culture: going beyond the ‘earliest’ and the ‘first’
M. Radivojević and Th. Rehren ........................................................................................................ 19
Latest analyses on Russian Byzantine frescoes from Novgorod
A. R. G. Giumlia-Mair and M. V. Vdovichenko .................................................................................. 21
Stable isotope analysis of human bone remains from the North-Thracian dava at Popești (2nd – 1st c. BC), in Southeastern Romania
N. Palincăș, V. Atudorei, C. A. Simion, M. Mihon, A. Răzvan Petre, C. Mănăilescu and C. Şendroiu ........................................................................................................................................... 23
Radiocarbon dating of animal bones from Vindija and Mujina Pećina caves – can we have an agreement?
I. Krajcar Bronić, I. Karavanić, A. Sironić, N. Vukosavljević, M. Banda and F. Smith .................. 25
Environmental and Historical Context of the King’s Road near Novi Pazar—application of GIS
I. Kajtez and V. Vidosavljević ........................................................................................................... 27
Digital mapping and 3D geovisualization in cultural heritage. The Ancient Pylos case study
G. Malaperdas and N. Zacharias ....................................................................................................... 29
A Software Tool for Egyptian-Coptic Language
A. Kontogianni, T. Ganetsos and E. C. Papakitsos .......................................................................... 31
Analysis of Panel Paintings by Clinical Multi-Slice Computed Tomography
O. Klisurić, O. Nikolić, A. Spasić, U. Molnar, V. Till and D. Korolija Crkvenjakov................. 33
Preliminary results on the presence, diversity, and dynamics of cellulolytic airborne fungi on the premises of the Archbishop’s and Kaptol’s Library, and the State

Eighth Balkan Symposium on Archaeometry, 3rd—6th October 2022, Belgrade, Serbia
Archives in Zadar
J. Lončar, M. Šimić, I. Genda and A. Mlikota ................................................................. 35

State of conservation and characteristics of constituent materials: case studies of
XVIII century Serbian National Theatre building and a Romanian industrial building
from the beginning of XX century
S. Vučetic, H. Hirsenberger, B. Miljević, J. Ranogajec, M. Ignat, R. Constantinescu
and L. Miu .......................................................................................................................... 37

Spectroscopic investigation of the pigments used for the decoration of Early-
Neolithic pottery from the region of Pernik, Western Bulgaria
A. Pirovska, V. Tankova, V. Mihailov and V. Atanassova ........................................... 41

Multidisciplinary study of Wassily Kandinsky’s reverse glass painting
M. Marić Stojanović, T. Tripković and B. Andelković .................................................. 43

Analysis of pigments palette attributes to Theophilos Chatzimichael from wall
paintings in the House of Kontos
K. Romantzi and T. Ganetsos .......................................................................................... 45

Identification of pigments on the 18th century iconostasis of St. Peter and Paul
church in Sirogojno
T. Tripković, R. Vasić, A. Lolić and R. Baošić ................................................................. 47

Pigments study of the decorative paintings of Dragutin Inkiostri Medenjak in the
Titel house by means of Raman spectroscopy
D. Korolija Crkvenjakov, T. Ganetsos and O. Klisurić .................................................. 49

HHXRF characterization of pigments on funerary paintings from the Royal Tombs at
Aigai, ancient Macedonia
H. Brecoulaki, K. Tsampa, E. Eleftheriou and A. G. Karydas ........................................ 51

Recognizing the Value of Historic Mortars: from a Database to an Exhibition

Scientific Investigations at Harappan Hinterlands of Rakhigarhi, Northwest India
A. Chowdhary .................................................................................................................. 55

A multidisciplinary study of Iron Age glass beads from the Cave Coroneia, Boeotia,
Greece
A. Oikonomou, S. Oikonomidis, K. Bataoula, N. Skoumi and A. G. Karydas .............. 57

ICP-LA-MS analysis of Archaic to Hellenistic glass from Thebes, Greece: a
contribution to glass studies
M. Kaparou, A. Oikonomou, V. S. Šelihi, J. T. van Elteren and N. Zacharias ............. 61

Roman, Late Antique and Early Byzantine glass from Serbia – overview and what
comes next
R. Balvanović .................................................................................................................. 63
Trace element and Pb-Ag isotope signatures of silver ore deposits of the central Balkans and applications for provenance studies
K. J. Westner, M. Vaxevanopoulos, J. Blichert-Toft and F. Albarède ................................. 65

Metalworking technologies in the 5th-century AD Carpathian Basin – changes in metal composition, manufacture, technology and decorating techniques
V. Mozgai, E. Horváth, A. Miháčzi-Pálfí, G. Szenthe, Zs. Hajnal, L. Schilling and B. Bajnóczı ................................................................. 67

Methodological framework for successful written heritage preservation management – operational and material aspects
I. Horvat and D. Hasenay .................................................................................................. 69

The application of non-destructive techniques to identify Mycenaean jewels from a chamber tomb in central Greece
E. Karantzali, T. Ganetsos, K. Romantzi and N. Laskaris ............................................... 71

Raman and XRF Characterization of Obsidian from Early Eneolithic site Šanac-Izba near Lipolist in Western Serbia
N. Marković, B. Tripković and D. Bajuk-Bogdanović ..................................................... 73

Stone biographies. Use-wear and residue analysis of knapped stone artifacts as direct proof of prehistoric processes of past societies
A. Petrović, S. Nunziante Cesaro and C. Lemorini .......................................................... 75

Pigments Identification: Comparative examination of materials and techniques in the Hermitage Ascension in Python of Olympus, Greece.
M. Katsantoni and T. Ganetsos ....................................................................................... 77

Use of resources in Vinča culture: a spectroscopic study of pigments for pottery decoration
V. Bogosavljević Petrović, D. Bajuk-Bogdanović, N.M. Koturović, M. Svilar, M. Marić Stojanović and Lj. Damjanović-Vasilić ................................................................. 79

Preliminary Investigations of Polychromy of the Late Roman Marble Sculpture – Head of Jupiter from the WHS Gamzigrad-Romuliana, Serbia
M. Franković, M. Živić and A. Jelikić ................................................................................. 81

12th century AD red and yellow fresco pigments from North-Eastern Russia
E. Y. Zubavichus .............................................................................................................. 85

Analyses of mortars from St. George’s cathedral, Great Novgorod
E. Ianovskaia, A. Vozniak, A. Nosova, L. Sazonova, N. Lebedeva, K. G. Erofeeva .... 87

Angular resolved XRF and XANES analysis of Attic Black Gloss ceramics
C. Caliri, A. G. Karydas, A. Migliori, and F. P. Romano ................................................... 89

Examination of painting technique and materials of Petar Lubarda’s paintings on paper support
V. Jovanović, S. Vučetić, J. M. van der Bergh and J. Ranogajec ................................. 91
Preliminary investigation of the cinnabar origin and use on archaeological findings from Early Metal Age site in Northwestern Serbia
M. Gajić-Kvaščev, V. Andrić, V. Filipović and A. Bulatović ........................................93

Ores, mines and the making of Late Bronze Age copper in the Lechkhumi district of the South Caucasus, north-west Georgia
R. Chagelishvili, N. Sulava, B. Gilmour, N. Rezesidze, T. Beridze and N. Tatuasvili... 95

Characterization of materials used in an Islamic manuscript from the 18th century
S. Ibragic, A. Alijagic, J. M. Van der Bergh, J. Ranogajec and S. Vučetić .................99

AUTHOR INDEX ..................................................................................................................101
Preface

The biannual meeting of scientist from Balkan countries in the field of Archaeometry - Balkan Symposium on Archaeometry - has matured and established itself well since its first edition held in Ohrid, N. Macedonia (2008). BSA 2 was held in Istanbul, Turkey (2010), BSA 3 in Bucurest, Romania (2012), BSA 4 in Nesebar, Bulgaria (2014), BSA 5 in Sinaia, Romania (2016), BSA 6 in Ljubaljna, Slovenia (2018) BSA 7 in Athens, Greece (2020, online meeting due to Covid-19 pandemics).

The Eight Balkan Symposium on Archaeometry (BSA 8) will be held for the first time in Serbia, from the 3rd — 6th 2022, in Belgrade. The Hall of the Rectorate of the Belgrade University, the Kapetan Mišina Mansion, will host forty-one oral and poster presentations from across the Balkans and beyond. It is our pleasure to greet not only scientist from Balkan countries, but also from Belgium, Cyprus, France, Georgia, Hungary, India, Italy, Russia, UK, fifteen countries in all. We do hope that this trend will continue in the future.

Due to its unique geographical position of bridge between Europe and Asia Minor, Balkans has often played an important role in the evolution of civilizations. The settlement of Europe by Paleolithic hunters-gatherers, then Neolithic farmers, the invention of copper metallurgy or the formation of the Europe’s first great Bronze Age societies are some of the examples. The Balkans was a birthplace of Classical Greece and Hellenism, the core of the Late Roman Empire and the long-lasting Byzantine Empire. It is a bridge over which people, culture, ideas and objects travelled from the East to Europe and vice versa. Cultural heritage of the Balkans is huge, yet not fully apprehended nor analyzed. To understand it better is to become aware of our common cultural heritage in all its diversity and beauty. To this goal, we are aiming this scientific conference.

The Symposium focuses on the major topics of Archaeometry: analytical methods, organic and inorganic materials, dating methods, computer science and imaging techniques, conservation and restoration, geophysics and Geographic Information System applications, multidisciplinary investigations, and management in cultural heritage. The focus is on the Balkans and investigation of its cultural heritage, but topics relating to other areas are also present.

Head of the Organizing Committee of the BSA 8
Roman Balvanović
Abstracts
Macro-Raman mapping: a new step in Raman spectroscopy of art objects

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Keywords: Raman spectroscopy, pigment analysis, macro-Raman mapping

Raman spectroscopy is a well appreciated technique for the analysis of art and archaeological objects. The technique allows us to identify inorganic and organic molecules in antique and modern objects. Given its excellent spatial resolution (down to 1 µm in laboratory conditions), Raman spectroscopy can be used to analyze micro samples. However, mobile (portable and handheld) instruments have also been developed, allowing for the in situ analysis of artworks.

Raman mapping is an approach that takes advantage of good spatial resolution while providing an overview on the distribution of the molecules. Typically, Raman mappings are performed in a research lab using a Raman microscope. These result in a detailed image of a small area of a sample. Macro-Raman mapping, on the other hand, is an approach that combines the advantages of mapping with the use of mobile instrumentation. Images of large areas (typically more than 100 cm²) are obtained directly from the artworks. Spectra are recorded in a structured way, and a large datacube (2 spatial coordinates, 1 spectral coordinate) is obtained. Using appropriate data processing techniques, this 3-dimensional datacube is transformed into a meaningful 2-dimensional image.

Therefore, a macro-mapping stage is constructed, allowing to record macro-Raman-maps of up to 50.0*50.0 cm² [1]. Our macro-mapping probe head is equipped with two cameras for visual inspection and a triangulator for distance measurements. This accounts for appropriately focusing the probe head and it avoids contact with the art object. The experimental setup will be
discussed, and examples of the data processing will be presented.

References

IL2

MA-XRF imaging of Greek Antiquities

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Keywords: MA-XRF, imaging, Greek antiquities, wall-paintings, Ancient polychromy

Macroscopic X-ray Fluorescence imaging (MA-XRF) has emerged during the last decade as an indispensable analytical tool for the non-invasive elemental imaging of historical or contemporary paintings. The ability of the technique to allow for simultaneous mapping of different chemical elements on a large-dimension pictorial surface offers through the produced elemental images an immediate visual impression of how the different elements are distributed in close conjunction with the iconographic elements, thus, unraveling their possible associations. In this way, a more comprehensive interpretation can be achieved regarding the nature of materials employed and their application techniques, the technological and artistic choices, aesthetics, the artists’ skills and likely overpainting. To date, the application of MA-XRF on archaeological artifacts is rather limited since ancient polychromy is either poorly preserved or has entirely vanished [1].

In the present contribution, recent results from the first applications of MAXRF imaging on Greek antiquities will be presented and discussed. All the measurements have been carried out in-situ at different Greek museums, using a real-time technology optimized MA-
XRF spectrometer, called LANDIS-X, developed by ISPC-CNR and INFN-LNS in Catania, Italy [2]. The obtained results have demonstrated undoubtedly the enhanced capabilities of the MA-XRF technique to analyze quite different in nature archaeological materials (gold alloy/pigments) or the same materials (pigments) on different media and highlight the perspectives and future contribution of this revolutionary technique to archaeological research and History of Art [3, 4].

References


Glass through the Adriatic: an overview

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Keywords: ancient glass, Adriatic glass trade, Levantine and Egyptian glass, trade routes

This contribution is based on the archaeometric dataset currently available for the 3rd-10th cen. AD natron-based glass found in Albania, Adriatic Italy, Serbia and Slovenia. The dataset includes over a thousand samples, mainly dated between the 4th and 7th centuries (beads and tesserae are excluded).

The main objective is to observe if, despite the significant gaps in the literature for a large part of these territories, the available data are already sufficient to trace preferential glass trade routes from the Levantine or the Egyptian coasts.

Several uncertainties undoubtedly remain regarding the provenance assignment of some samples, however, it is possible to propose some preliminary quantification.

The prevalence of the Egyptian glass groups is apparent: about 70% of the specimens included in the dataset vs 30% of Levantine-type products. Among the latter, 35% can be dated not later than the 4th century, 55% not later than the 7th and the remaining 10% not later than the 10th.

Among samples assigned to Egyptian groups, only 7% can be dated earlier than the 4th century. On the other hand, most of them (57%) are dated between the 5th and the 7th centuries, while a smaller percentage (28%) cannot be dated later than the 9th century.

So-called "fresh" glass is scarcely represented (only about 10%) by samples dated between the 4th and 7th centuries. The dominant glass groups are the Egyptians in this subset. The average of Cu and Pb calculated for the totality of the examined samples is higher than 1000.
ppm, testifying to the wide use of abundant colouring agents.

While bearing in mind that the available data may represent only a tiny percentage of the vitreous material in the investigated area, these results may already inform of some general trends that have affected the Adriatic imports between the Roman, Late Antique and Early Medieval times.
Metallurgy of the Vinča culture: going beyond the ‘earliest’ and the ‘first’

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Keywords: Vinca culture, metallurgy, slag, networks, Balkans, aesthetics

Metallurgy of the Vinca culture is currently known as the earliest in the world and dated to the beginning of the 5th millennium BC [1]. Besides the earliest documented copper and lead smelting, tin bronze making emerges at 4650 BC alongside the appearance of gold in the Balkans [2, 3]. These finds demonstrate that the technology of metal making in the Balkans evolved in a dynamic that is different from traditional models of the emergence of metallurgy based on the Near Eastern evidence and points at the necessity to revise current hypotheses on the evolution of Eurasian and global metallurgy.

We present a synthesis of all results to date that address the technology, provenance and circulation of the 5th mill BC Balkan metal with the focus on Vinca culture artifacts. Using modern analytical instruments, we reveal the recipes for metal making, the role of aesthetics as well as the patterns of cooperation between metal making communities as indicated by networks analyses [4, 5]. In this light, we suggest a novel model for the evolution of metallurgy in Eurasia and beyond.

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In this paper, we present the latest data obtained from the analyses of fragments of Russian-Byzantine wall paintings recovered from the architectural excavations carried out in the church of St. George in the Yuriev Princely Monastery built in 1119 at Veliky Novgorod, one of the oldest cities in Russia and UNESCO World site. In the last 7 years, the archaeologists of the Institute of Archaeology of the Russian Academy of Sciences in Moscow excavated the 12th-century layers and extracted a large number of fragments of frescoes, which are extremely important for the reconstruction of the history of Novgorod and the study of Russian-Byzantine art in general.

The pigments employed for the paintings and the painting techniques, with color layers, substrates, and mortars, have been studied and analyzed in the last two years in the Laboratory of the Institute of Archaeology of the Russian Academy of Sciences. The analytical methods we employed were optical microscopy (OM), X-ray Fluorescence Spectrometry (XRF) and Scanning Electron Microscope with Energy Dispersive Spectrometry (SEM-EDS). OM permits to distinguish between superficial painting method, the inclusions in the mortars, the intonaco and intonachino layers and various interesting substrates. XRF was employed to first screening of the fragments and the first pigment identification. The samples were mounted in resins and polished for analysis with SEM-EDS. The analytical data we possess up to now indicate a very classical Byzantine technique with the use of expensive pigments such as lazurite, but also green earth, various types of ochres and mixtures of pigments.
Special care was taken for the identification of the substrates.

References


Stable isotope analysis of human bone remains from the North-Thracian dava at Popești (2nd – 1st c. BC), in Southeastern Romania

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Keywords: ¹⁴C, δ¹³C, δ¹⁵N, δ³⁴S, Late La Tène human diet

The aim of this paper is to characterize five human skeleton remains from the Getic (i.e. North-Thracian) dava at Popești (South-eastern Romania; 2nd-1st c. BC) using C, N and S stable isotopes ratios for diet reconstruction coupled with ¹⁴C dating.

The 2nd c. BC is a period of deep transformations in Eastern Europe. Among others, a new repertoire of material culture was introduced and remained relatively stable over the next three centuries; a new settlement type, the dava (proto-urban fortified settlement) appeared; except in the territories of the Scordisci, the burial of the majority of the population became archaeologically untraceable. On the territory of present-day Romania, human body remains are limited to a few burial mounds with cremated bones placed outside the davae and a few human bodies or parts thereof that were inhumed in (almost) every dava. While owing to their inventory, the cremation graves found near the dava could be attributed to high-ranking warriors (for Popești, see [1]), the social status of the individuals laid in the davae is more difficult to determine. Due to the lack of associated artifacts and the irregular
positions of the skeletons or skeleton parts, some authors believed them to have been prisoners or enslaved people [2]. Still, this interpretation is debatable on several accounts among which their small number. In this paper, it is hoped that, by reconstructing the diet [3, 4, 5] and by analyzing osteologically the individuals buried in the *dava* at Popeşti, we can characterize the quality of the lives of these individuals and provide a better understanding of the social organization in the North-Thracian Late La Tène.

References


Radiocarbon dating of animal bones from Vindija and Mujina Pećina caves – can we have an agreement?

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Keywords: ¹⁴C dating, bones, Vnidiija Cave, Mujina Pećina Cave.

The project „Last Neanderthals at the Crossroads of Central Europe and the Mediterranean – NECEM“ (financed by Croatian Science Foundation, HRZZ-IP-2019-04-6649) aims to gain new data on the adaptations of late Neanderthals in today’s Croatia by interdisciplinary methods. Radiocarbon gives a chronological framework providing the samples are not older than about 50000 years.

A total of 16 bone samples from two caves, Vindija (Donja Voća, NW Croatia) and Mujina Pećina cave (Plano, near Kaštela, Dalmatia), were selected for radiocarbon AMS dating at the Ruđer Bošković Institute (RBI) laboratory. Collagen extraction yielded >1% of collagen for 10 samples. From six samples, the collagen yield was lower than 0.5 % and those bones could not have been dated since the low yield (<1%) may produce an underestimated radiocarbon age. For comparison, 12 bone samples were sent to Oxford Radiocarbon Accelerator Unit (ORAU) for radiocarbon dating with an additional step of ultrafiltration (UF) to select collagen fractions having molecules larger than 30 kDa. Four could not have been dated due to low collagen yield (<1 ‰), five were dated despite low yield, and only three were successfully dated. The ¹³C values of bone samples showed the same range in both RBI and ORAU laboratories, between -18.3 ‰ and -21.8 ‰, typical values for bone collagen. Radiocarbon conventional
ages of these limited number of bone samples were comparable. Much more radiocarbon dating results of the old bones are necessary to obtain more reliable results.

The preliminary results presented here point to the possible obstacles in radiocarbon dating of late Middle Paleolithic samples: bones are not well preserved, the yield of collagen is often low, and the age is close to the limit of the radiocarbon method.
Environmental and Historical Context of the King’s Road near Novi Pazar–application of GIS

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Keywords: King’s road, GIS, medieval Raška, archaeological landscape

One of the important routes in the history of the Balkans, used since Antiquity through the Middle Ages is known in the literature as King’s road. This communication traversed the Raška region up to Thessaloniki and Constantinople to the south, Golija Mountain to Central Serbia to the north, and the Adriatic coast to the west. Almost no historical sources mention the King’s road, but its course was indicated on 19th century military maps. Even though this road’s course leads far from the present-day main roads, many Medieval and Ottoman period archaeological sites, as well as quarries, groves, clay, mineral, and ore deposits, and springs, are located along its direction.

Since little attention was paid to this important communication by recent researchers [1], this research attempts to locate its approximate course on the section from Novi Pazar to Odvraćenica on Golija mountain. The aim of this research is to set a wider area of the route of the King’s road into a micro regional environmental and historical context through GIS. The aspect of the environmental context consists of examining natural (i.e. topographic, hypsometric, geologic, hydrographic) characteristics of the terrain and its use by the local medieval population. A historical aspect includes different types of archaeological records—settlements, necropoles, churches, forts, remains of mining and quarrying activities.

The data were obtained from different sources including literature, cartographic resources, online open-source data, and the material gathered by the authors in the area along the
route. The data was translated into digital format and compatible with one another in GIS software. Several GIS analyses were conducted, such as proximity and cost analysis, viewshed analysis, and site density. These analyses attempt to show spatial relations between different types of archaeological sites with each other and the road within the landscape. This includes connections between potential and known natural resources and archaeological sites, which could clarify the character of their distribution and type within the researched microregion, and the role of the road as a means of communication between them. These relations include visual connections as well. Site density points out whether sites are clustered along the road or an important natural or cultural point of interest (quarry, marketplace, etc.).

This research points out the importance of the spatial component in archaeological research and the significance of ancient communications, which are rarely taken as research topics. It also shows the importance of using GIS tools in archaeological cases that combine a large number of different types of spatial and qualitative data, which are manipulated, visualized, related, and analyzed through GIS.

References

Digital mapping and 3D geovisualization in cultural heritage. The Ancient Pylos case study

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Keywords: GIS, 3D geo visualization, 3D modeling, digital mapping, Ancient Pylos

The purpose of this paper is to highlight digital mapping and GIS in combination with 3D geo-visualization in cases of depicting landscapes and cultural heritage sites. This methodology is not new, as Reilly has been introducing the term virtual archaeology since 1990 as the representation of sites of archaeological and historical interest, objects and landscapes through computers and 3D graphics programs.

As computers evolve in their processing capabilities (graphics card, processor, memory speed), they will produce more realistic results in faster processing time. This creates conditions for more testing, as time is minimized and modeling is constantly upgraded, for alternative renderings of monuments and landscapes, always based on the very realism of the model.

The study area chosen to be presented through the above methodology is Ancient Pylos, as there are many bibliographic references to create a cartographic approach and depiction of the area based on archaeological findings and references. The area of Ancient Pylos is not identified with either modern or Prehistoric Pylos (AnoEnglianos site) but was located on the top of Cape Coryphasium at the northern end of Navarino Bay, opposite the north end of the historic island of Sphacteria. It essentially controlled the southern tip of the Coryphasium peninsula, an extension of which is the island of Sphacteria which extends south and encloses the bay of Navarino from the west. The peninsula of Coryphasium, where Pausanias found the city of Pylos proud of its past, seems to have periods of relative prosperity from time to time.
The benefits of 3d geo-visualizations for archeology are manifold and analyzed in this project. As a general principle, visual imaging helps the scientist clarify difficult or incomplete information about a monument and the recipient user (public) in simplifying archaeological information through visualization. The use of 3D geo-visualization, to represent data and other non-photorealistic details is expected to dominate in the short term.

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References


A Software Tool for Egyptian-Coptic Language

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Keywords: Coptic, cultural heritage digitization, computer-assisted translation, cultural informatics applications

The Coptic language began in the 1st century AD with the old Coptic and extended to the 16th century AD, creating a continuum of written sources in the Egyptian language of almost 5000 years. Worldwide several museums and institutions preserve known manuscripts and artifacts of this language and art. Especially in Greece, besides a large number of Coptic corpora, there is difficulty for Greek scholars to study the language in depth and avoid various misinterpretations because of the lack of interactive computational tools. To facilitate the scholars to overcome the obstacles that someone may meet when he is engaged not only with corpora but also with artifacts, we created a software tool for semi-automated Coptic to Greek translation. The software design herein emphasizes the ability to process inscriptions on artifacts through a simple interactive interface for its usage by Greek-speaking scholars of Humanities, having just essential familiarization with computers. For this purpose, a processing model has been chosen, based on the current software tool for other ancient languages, which is currently being modified for processing Coptic scripts. It consists of three main modules, the Coptic-Greek digital dictionary, the interface (visible to the user) and the search-engine. We will also examine some difficulties that may arise and how double-based data sources will accelerate our search engine results to extract the findings about the better way familiar tools should be structured.
References


Analysis of Panel Paintings by Clinical Multi-Slice Computed Tomography

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Keywords: X-ray computed tomography, Hounsfield units, panel painting, pigment analysis, wood analysis

Panel paintings make an important part of cultural heritage, from the first Fayum portraits to modern times. Wood has been used as a naturally available material, easy to shape and prepare in the desired form. Covered with layers of preparation and color, enriched with gold and silver leaf, the simple panel was transformed into an invaluable artwork.

Even though clinical X-ray multi-slice computed tomography (MSCT) is optimized for the human body, it can be successfully used in the cultural heritage field, both for the characterization of the panel structure [1], as well as the thin layers of the polychromy [2].

In this study, MSCT was performed on the Serbian icon St. Theodor Tiron and St. George by an anonymous painter, dated 1700, from the collection of the Gallery of Matica srpska from Novi Sad.

Our experiment used a Somatom Sensation Cardiac 64 MSCT with a gantry aperture diameter of 80 cm. The acquisition was performed using chest protocol setting with the following parameters: 120 kV tube voltage, 100m As effective current, slice thickness of 0.6 mm, pitch factor of 1.4 mm, field of view (FOV) of 445 mm, matrix of 512 × 512, spatial resolution of 0.87 mm, and scan time of 14.84 s. Image reconstruction kernel B31f medium
smooth was used, followed by multi-planar (MPR) and volume rendering (VRT) post-processing techniques. Besides the precise 3D imaging of the artifact structure, the measure of Hounsfield units (HU) made the differentiation of the materials based on their density. This enabled identifying the type of wood as linden.

Moreover, three-dimensional reconstruction by VRT allowed us to investigate the panel construction's spatial geometry and the wood's morphological characteristics (ring growth, wormholes, restorator’s additions) and to detect all the foreign bodies in the panel. Visualizing the layers of high density pigments, like lead white, lead red and cinnabar were also possible. The constraints we encountered were the maximal dimension of the artifact to be analyzed and the spatial resolution concerning the layers of polychromy. Nevertheless, this method showed high potential in fast, non-destructive and precise cultural heritage documentation.

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References


OR7

Preliminary results on the presence, diversity, and dynamics of cellulolytic airborne fungi on the premises of the Archbishop's and Kaptol's Library, and the State Archives in Zadar

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Keywords: cellulolytic fungi, biodegradation, cultural heritage

Throughout the history of Zadar's cultural heritage conservation facilities as private libraries and archives, they have collected a huge amount of diverse material, among which a significant part consists of old and rare books, manuscripts, and archival documents. Cultural heritage is one of the most important components of cultural identity, which is why its preservation, research, and presentation are national priorities. Since all types of material cultural heritage are subject to biological decomposition, it is necessary to study fungal communities that can colonize and decompose them to adopt optimal prevention and conservation strategies. One of the most important causes of microbiological deterioration of book cultural property is molds. Mold spores can be found in air and dust and, under favorable conditions, begin to grow after coming into contact with the book material. They can cause significant damage by secretion of cellulolytic, ligninolytic, and proteolytic exoenzymes. Cellulolytic enzymes degrade cellulose to glucose monomers and thus cause paper degradation. To prevent mold contamination or treat already contaminated items, an integrated approach that includes (micro) climate control, material-specific cleaning, and the application of carefully selected fungicides is needed. Monitoring biological air contamination is crucial for assessing the level of contamination and the
potential risk to the preservation of cultural heritage and is the first step toward a successful prevention strategy. Moreover, the goal and purpose of the preventive approach are to prevent the biological degradation of cultural assets in case of the presence of cellulolytic molds to prevent the risk of biodegradation of cultural heritage. Therefore, within the project "KultBaMikroo", the monitoring of cellulolytic fungi in the air on the premises of the State Archives and the Archbishop's and Kaptol's Library in Zadar has begun. Air sampling was performed using the device "Air Sampler" MAS-100NT, the air was passed through sterile nutrient media in Petri dishes. At each sampling point, three types of nutrient media were used to cover a wider range of fungi living at different relative humidity. The first preliminary results of the research showed us the number of colonies, the presence, diversity, and dynamics of cellulolytic fungi in the air on the premises of the Archbishop's and Kaptol's Library and the State Archives.

References


State of conservation and characteristics of constituent materials: case studies of XVIII century Serbian National Theatre building and a Romanian industrial building from the beginning of XX century

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Keywords: architectural heritage, stone cleaning, microorganisms, self-cleaning, in situ examination

To select the most effective intervention strategies and the most suitable conservation solutions for cultural heritage buildings, it is required to characterize their constituent materials and state of conservation. Appropriate cleaning and protection procedures are required to restore and improve the mechanical, chemical, and desired functional properties of the built-in materials of historical objects and to maintain the functional properties of modern buildings over time. The main aim of our work was the detailed characterization (in situ and laboratory testing) of the Serbian National Theatre in Novi Sad, Serbia, to establish a conservation methodology for stone façade cleaning and the development of a protocol for testing materials that can improve the actual state of a Romanian industrial building that belonged to the known Romanian industrialist, Mociornita, built at the beginning of 20th century. The walls of this building have been severely affected by water infiltration, being degraded and covered with microorganisms.

The building of the Serbian National Theatre (Srpsko narodno pozorište) is located in the city of Novi Sad, the cultural and administrative center of Vojvodina, the northern Serbian province. The theatre building was built in 1981 after an intensive
adaptation of the urban environment, which included controversial demolition of some 18th and 19th-century buildings in the very heart of the city. Nevertheless, the new buildings now represent a new era in the urban development of Novi Sad, a city with a continuously growing population and economy. Today, the Serbian National Theatre building is one of the central city landmarks with a characteristic hexagonal-based structure cladded with white marble stone façade slabs.

Apart from several ad hoc interventions on the façade of the building, over 40 years, no comprehensive cleaning has been done and no consolidation or protection works on the delicate white stone. Recently, the city government has begun an ambitious project of local heritage resurgence as Novi Sad became the European Capital of Culture for 2022, together with Kaunas (Lithuania) and Esch-sur-Alzette (Luxembourg). The Laboratory for Materials in Cultural Heritage, Faculty of Technology, University of Novi Sad, is trusted with the task of performing holistic characterization of the façade stone, detecting deterioration mechanisms, and proposing an adequate conservation methodology. The Laboratory’s mobile equipment with non-destructive techniques and laboratory assessment enabled the complete analysis of the façade materials. Different types of degradation such as patina, dirt deposits, eroding surfaces, yellow layers and black crusts, large amounts of carbonaceous particles responsible for black shading of the stone surface, soluble salts, microbiological corrosion, the residue of inadequate graffiti removal, façade paints, acrylic binders, as well as mechanical damage of the stone panels were identified [1, 2].

The obtained results were subsequently used to make a comprehensive report considering the solutions for treating the identified issues. The main idea was to use traditional conservation approaches with innovative solutions such as self-cleaning photocatalytic protective coating and materials that can improve wall properties and protect against microorganisms attack [3].

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References


Spectroscopic investigation of the pigments used for the decoration of Early-Neolithic pottery from the region of Pernik, Western Bulgaria

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Keywords: LIBS, ATR-FTIR, Raman spectroscopy, red-brown pigments, Neolithic pottery

The present study has focused on identifying the elemental and mineralogical composition of the red and brown pigments used for the decoration of Early-Neolithic pottery from the settlements of Buhovo and Galabnik located in the region of Pernik, Western Bulgaria. The material culture from a settlement mound near Galabnik represents a specific cultural phenomenon limited to the territory along the upper reaches of the Struma River during the first stage of the Early Neolithic. The analyzed ceramic shards have been excavated from several historical layers at the settlements corresponding to different generations that inhabited the area. The methods employed for this investigation were laser-induced breakdown spectroscopy (LIBS), Fourier Transformed Infrared spectroscopy in Attenuated Total Reflectance mode (ATR-FTIR), and Raman spectroscopy. The resulting spectra revealed information about the raw materials of the paints used for the pottery decoration. Conclusions on the sustainability of the production technology of the pigments in this specific region and possible trade routes between the cultures in the nearby areas during the Neolithic were drawn.

References


Multidisciplinary study of Wassily Kandinsky’s reverse glass painting

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Keywords: Kandinsky, glass painting, EDXRF, Raman spectroscopy

Here we will present a multidisciplinary approach to examining Wassily Kandinsky’s painting in the technique better known as the "Hinterglasmalerei" in German or as reverse glass painting in English. Since the painting is observed through the glass panel, the painting was performed in reverse order than usual [1]. First, the details and shadows are painted, and then the background. Backing with some dark paper or blackboard was also the part of the painting so that only the reflected light is observed.

Examining the painting with complementary techniques like UV [2] and IR [3] reflectography, optic microscopy of cross-sections and spectroscopic techniques, like energy dispersive X-ray fluorescence (EDXRF), attenuated total reflectance coupled with Fourier transform infrared (ATR-FTIR) and Raman, brought the new light on Kandinsky’s technique. It is shown, by comparing with the published data on four early reverse glass paintings of the same author [4], that author has experimented with and changed the painting technology through the years by using different pigments and different binding media. Our results show that examined painting was done after the introduction of titanium white pigment in 1920. and most probably before 1928. when there was a change in the production technology of zinc sulphide, the filler used for white pigment. Other detected pigments are well known for the assumed period and combine synthetic inorganic and organic pigments [5] and some mineral
pigments. Organic binders detected are dammar resin, proteinaceous binder, and polyvinyl acetate.

References


Analysis of pigments palette attributes to Theophilos Chatzimichael from wall paintings in the House of Kontos

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**Keywords:** Theophilos, non-destructive techniques, Raman spectroscopy, XRF, Theophilos Museum

Theophilos Kefalas Chatzimichael was the most famous folk painter of modern Greek art. He belonged to the Generation of the ‘30s, which had discovered the value of the art of folk artists. He was born in Lesbos in 1873 and came from a humble family. The painter showed an inclination for painting at a very early age. He left the island in 1883 and remained in Thessaly, specifically Volos and the villages of Pelion, where he decorated shops, cafes, and inns with paintings, but without being accepted by the area’s residents due to his eccentric behavior and appearance. In 1927, Theophilos returned to his birthplace in disappointment, where he continued to work till his death in 1934. In Theophilos’ works, wall paintings, paintings on objects or cloth, his world is caught with the ingenuousness and innocence, but also the freshness of folk painting, a world equally of gods, heroes and ordinary human beings which coexists with elements and images from familiar reality and landscape [1].

Hatzianastasi mansion, known today as the home of Kontos and Theophilos Museum, is located in Anakasia of the Municipality of Iolkos and dates back to the beginning of the 19th century. Initially, the Hatzianastasis family owned the mansion until 1905, when it was bought by the Anovolian miller Giannis Kontos. The new owner immediately proceeded with the modernization of the house and its adaptation to the neoclassical standards of the time. In 1912, according to an inscription, a program
for painting the decoration of the rooftop hall was started by the great folk painter Theophilos Chatziimichael. In 1962 the Ministry of Culture, to protect this unique monument for the region, designated it as a "historical monument" and in 1965 bought it, to use for archaeological purposes.

In this paper, the main goal is the reproduction of the painter’s palette and the identification of the pigments that he used to find out what changes occurred in his work throughout the years, as these murals belong to the second phase of Theophilos's work. Two non-destructive methods were employed for this research XRF and Raman Spectroscopy [2-4]. Several pigments have been identified, such as ultramarine, lead white, green earth and iron ochre.

References


Identification of pigments on the 18th century iconostasis of St. Peter and Paul church in Sirogojno

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Keywords: pigments, 18th century icons, Raman microscopy, XRF, optical microscopy

The Church of the Holy Apostles Peter and Paul in Sirogojno was built in 1764 on the foundations of an older medieval temple. The painting of the iconostasis was started the same year by the painter Simeon Lazović, one of the most prolific Serbian painters of the 18th century, to be finished after a break of several years. The central doors and the part above the central doors are considered to be his first signed works. They contain all the characteristics of post-Byzantine art, inspired by Serbian medieval art. The latter group of icons shows signs of the new baroque style [1].

For this manuscript, we analyzed pigments on several icons in the area of the throne icons, representing the Mother of God with the little Christ, Jesus Christ, St. John the Baptist, and icons on the central doors-the Annunciation. Tiny samples were taken and dipped in polyacrylic methacrylate resin. Their cross-sections were observed under an optical microscope and analyzed using Raman microscopy. Some samples were also analyzed using an XRF spectrometer before immersion in the resin. Applying the two analytical techniques, a variety of pigments used by the artist have been identified, such as lead white, hematite, vermilion, minium, orpiment, carbon black, indigo, Prussian blue, and chalk [2-4]. The presence of gold on the gilding of the main doors woodcarvings was also established, while silver was found on the hand-carved woodcut of the icons [5]. The multitude of different pigments points to the surprisingly rich palette of the young artist, which certainly contributed to the artistic
reach of the 18th century iconostasis in the Sirogojno church.

References


OR13

Pigments study of the decorative paintings of Dragutin Inkiostri Medenjak in the Titel house by means of Raman spectroscopy

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Keywords: pigment analysis, Dragutin Inkiostri Medenjak, Raman spectroscopy, Titel

In the decorative arts in Yugoslavia at the end of the 19th and the beginning of the 20th century, Dragutin Inkiostri Medenjak is well known. He is considered the pioneer of Yugoslav design, working in different artistic disciplines. In the early twentieth century in Serbia he certainly represented a unique artist who, with undoubted talent, created works of high quality in almost every field of applied art.

Many of Inkiostri’s works are lost or partially survived. One of his best-preserved decorated interiors was made in 1911-1912 for a private house in Titel (Serbia). It is decorated with stylized motives characteristic of Inkiostri: birds, butterflies, floral elements and stylized human heads.

The canvas with typical Inkiostri’s motives was chosen to be analyzed by Raman spectroscopy to define the pigments used.

Raman spectroscopy is well-recognized in the art conservation and archeology for identifying pigments. Through the acquisition of a vibrational spectrum of the surface of a sample, various information is gained: the type of material (inorganic or organic) present in the pigment and what weathering or environmental damage has occurred, for example. Additionally, this information helps to establish the authenticity and provenance of paint and pigment substances.
The Raman measurements discussed in this paper were made with a portable Rockhound Spectrometer with 20 mW of 785 nm laser excitation and a spectral range of 200–2000 cm⁻¹. We used the Raman spectrum from the Pigments Checker Raman database as a reference.

Various new synthetic products enriched Artist’s choice of pigments at the beginning of the 20th century in addition to the traditional ones. Results will show the artist’s palette in decorative painting, executed on large surfaces, usually based on a small number of easily available pigments. The study of the artist’s pigments is valuable both for the art historical and technological research and for the definition of the conservation strategies and preservation recommendations.

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OR14

HHXRF characterization of pigments on funerary paintings from the Royal Tombs at Aigai, ancient Macedonia

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Keywords: Ancient polychrome, Aigai, Eurydice Throne, Philip II tomb, HHXRF analysis

The Royal Tombs discovered at Aigai (modern Vergina), the necropolis of ancient Macedonians, during the 1970s and 80s by the Greek archaeologist Manolis Andronikos, are extraordinary monuments both to the history and the arts and crafts of ancient Greece[1]. Tomb II, attributed by most scholars to King Philip II of Macedon and the so-called “Tomb of Queen Eurydice” has been attracting research interest ever since its discovery. Both tombs preserve have painted artifacts of the late Classical period (second half of the 4th century BC) on their façade and interior, respectively. The large-scale hunting scene of the façade of the monumental Tomb II constitutes the largest and most renowned figural painting of Classical antiquity, encompassing a multitude of hunters and preys [2, 3]. The majestic equestrian figure occupying the middle of the frieze has been identified with Alexander the Great. In the main chamber of the so-called “Tomb of Queen Eurydice”, an unprecedented monumental marble throne preserves on its back a painted panel depicting Hades and Persephone on their divine quadriga, rendered with costly pigments and gilded decoration [3].

Analytical studies on materials and techniques of application from both tombs were carried out by handheld X-ray Fluorescence (HHXRF) spectrometry. The HHXRF results, regarding Tomb II, have pointed out the selective use of the rare green mineral pigment conichalchite, a green copper arsenate...
(CaCu(AsO₄)(OH)) that was identified for the first time on the polychromy of the chryselephantine funeral couch of Tomb II [4]. The analysis of the marble throne of the so-called “Tomb of Queen Eurydice” successfully identified the presence of more than eight different pigments, including a variety of iron-based ochres, Egyptian blue, lead white and cinnabar. Moreover, HHXRF analysis aided by Monte Carlo simulations confirmed that gold leaves of a few micrometers were superimposed on polychrome layers. Overall, this research presents the results of the in-situ HHXRF analysis of pigments and discusses their contribution to quantification approaches related to their provenance, composition and painting technique.

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References


OR15

Recognizing the Value of Historic Mortars: from a Database to an Exhibition

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Keywords: historic mortar, Danube Limes, database, exhibition, building material

A human hand is always woven into the building material, whether it only participated in the exploitation of the stone or shaped the earth into a block. However, archaeological excavations rarely detect building materials as valuable, being recorded only as unified elements that form an architectural context or mediums that carry an inscription or a trace of use [1]. Mortar Design for Conservation - Danube Roman Frontier 2000 Years After - MoDeCo2000 is a project conducted as a connection between archaeometry and conservation science, exploring the Roman mortars through the intertwining of the desire to learn about the construction activities and lives of ancient people along the Danube in today’s Serbia and the goal of preparing new materials that will preserve the built remains of these activities for the future. There are few collections of samples of historical materials worldwide, and they rarely occupy special places in museum depots or exhibitions [2]. On the other hand, databases of building materials are becoming increasingly important for conserving monuments [3, 4]. About 120 samples of lime mortars belonging to buildings dating from the 1st to the 6th century AD were collected during the MoDeCo2000 project. A database containing the results of the mortars’ characterization and proposals for the creation of compatible conservation...
mixtures was made, marking the beginning of the formation of a database of building historical materials found in Serbia, available to scientists and experts, as well as the collection exhibited for the museum public. In this way, the project tries to contribute to a wider recognition of the importance of building materials research, especially mortar, which was created in the human attempt to make a bonding material, mostly using reachable natural resources, which should be easy to use and durable, but also, in many cases, very aesthetically pleasing.

Acknowledgments This research was supported by the Science Fund of the Republic of Serbia, PROMIS, #6067004, MoDeCo2000.

References


The plains of Northwest India are unique as it unfolds a distinct recognition of a multifaceted civilization—the Harappan Civilization. This Civilization is a culmination of three great features—sophistication, standardization, and utilitarianism. Archaeological explorations and excavations have been undertaken for several more decades in Northwest India's plains. Remarkably, several sites and site clusters are distributed over the entire region. Rakhigarhi is the largest Harappan site in Haryana, Northwest India, in the basin of Ghaggar and Saraswati. Our team reported 127 hinterland sites in Rakhigarhi. It is a fact that not every Harappan site is a city site. The rise of urban and rural centers indicates a symbiotic relationship between economic growth and human adaptation. Rakhigarhi, Banawali, Bhirrana, Kunal, Mitathal, and Dholavira are the big Harappan sites situated in Northwest India's plains. Certainly, the hinterland sites gave their undeniable contributions to the development and flourishing of major sites.

Unfortunately, the archaeologists ignore the role of small archaeological sites and hinterland sites, which creates a void in the archaeological reconstruction. It is important now to throw light on the activity of the hinterland sites like Harappan villages, Harappan ports, or manufacturing centers because unless we have data from these sites of different categories, we will not be able to understand the socioeconomic organization, a clear picture of science and technology of the Harappan culture, and so that we need to study more sites in different categories. In these circumstances, the scientific
methods, Phosphate analysis of the concerned sites have been undertaken by the researcher and considerable signatures regarding the settlement structures and connection between urban and rural sites together throughout the early, mature and late phases during the 3rd millennium BCE have been noticed. The phosphate analysis of the archaeological soils has produced evidence regarding the land use pattern over sites, food consumption and production area, how the Harappan people were creating and using their own landscapes, garbage area, etc.

The present researcher visited major parts of the study area to establish the precise location of the different hinterlands and when the Harappan people occupied them and why. To fulfill the objectives of the present studies, village to village survey, use of GPS and Phosphate analysis of archaeological soils, digital mapping of sites, collection of published literature have been attempted by the researcher. The data from the earlier Phosphate analysis revealed that the Big Harappan sites were dominantly reliant on the other local small manufacturing sites, whether metal or raw material. This paper is an inquiry into tracing the rural site Harappan archaeology and their relation with the urban centers, settlement strategy, metallurgical activity and manufacturing activity through the different scientific methods - Phosphate Analysis of the soil, SEM and EDAX analysis of a few antiquities recovered from excavations conducted by the Banaras Hindu University and the University of Cambridge, of which I was also a team member.

References


A multidisciplinary study of Iron Age glass beads from the Cave Coroneia, Boeotia, Greece

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Keywords: glass beads, Iron Age, 3D models, micro-XRF

Glass is one of the latest artificial materials. Its manufacture involves the collection of raw materials, their fusion in high temperatures and the formation of the final object. Beads are an important part of the ancient glass industry since they are the simplest form of glass object that first appeared in the archaeological record. Beads were manufactured with various techniques and served various purposes such as personal decoration (jewelry), identification of social or/and religious status and finally, they could be used as apotropaic symbols [1]. Due to their durability, small size, ease of transport and extensive use, glass beads were considered a valuable commodity of trade [2].

In the present study, we investigate an assemblage of Iron Age glass beads excavated in the Cave Coroneia, located on Mt Helikon, and in the vicinity of the village of Ayia Triada, in Boeotia [3, 4]. The Cave Coroneia acted as a well-known rural sanctuary (from Late Bronze Age to the 2nd century CE, circa), dedicated to various deities, and documented in ancient written sources such as Strabo and Pausanias [5, 6].

During the various excavation seasons in the Cave, a considerable number of glass objects were found. Among these are many glass beads of
different shapes and sizes, in their majority of the “melon shape type”, “eye type” beads, and plain beads.

The main aim of this project is to document and study a part of the beads using digital and non-destructive analytical techniques to assess the beads' technological characteristics. In particular, we have chosen 20 beads including melon, plain and eye beads. The melon and plain beads exhibit three basic translucent colors: aqua, deep blue/cobalt blue and green, naturally colored, while the eye beads have opaque yellow, blue and white colors. The beads were documented using a “Scan in a Box” 3D scanner and photogrammetry and were further analyzed non-destructively using a Bruker Artax micro-XRF. The 3D models were created with Ideal 3D scan software and Reality Capture software, while the XRF spectra were processed with PyMca software.

In this paper, we present the preliminary results regarding the full documentation of the beads to understand similar manufacturing characteristics by directly comparing the 3D models. In addition, we suggest the technological features, which are set against already published parallels, to understand the manufacturing conditions and the provenance of the glass.

References


Compositional analysis of glass finds from the Dubrovnik Cathedral

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Keywords: Dubrovnik cathedral, medieval glass, PIGE-PIXE, post-medieval glass, provenance

The paper presents the archaeometric analyses of glass fragments from Assumption Cathedral in Dubrovnik, Croatia. These were recovered during archaeological excavations in 1981–87, in the layer that remained after the extensive reconstruction of the cathedral following the 1667 earthquake. The retrieved fragments are diverse in typology, chronology, and provenance.

Sixty objects were selected for analysis, typologically characterized as various types of vessels (beakers, bottles, bowls, jars, jugs, goblets, tazza), beads, window glass (oculi), lamps, and undefined fragments. According to the typology and archaeological context, the glasses can be dated between the twelfth and eighteenth centuries. The analysis was carried out by proton-induced X-ray emission (PIXE) and proton-induced gamma-ray emission (PIGE), using an in-air proton beam of 3MeV nominal energy.

The results show that most analyzed glass was produced with flux obtained from the ash of halophytic plants. Its composition coincides with
that of Venetian and façon de Venise white glass, while on the other hand, no examples of Venetian cristallo are encountered. A few glasses are produced with a purer flux—which may be either natron or industrial soda—indicating tentative Byzantine production in the former case and eighteenth-century European glassmaking workshops in the latter. A few outliers seem to have been produced from a significantly different silica source, reflecting the range and diversity of historic Dubrovnik’s trade routes.

The findings are a small step in gradually creating a database of archaeological glass from the Dubrovnik area and the eastern Adriatic, which remain analytically underrepresented. The newly obtained chemical composition data will also allow comparisons with similar material from the rest of the world and contribute to our knowledge of medieval and post-medieval glassmaking and trade.

Reference

ICP-LA-MS analysis of Archaic to Hellenistic glass from Thebes, Greece: a contribution to glass studies

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Keywords: glass, Thebes, ICP-MS, Egypt, Levantine, Archaic to Hellenistic era

Thebes, located in Boeotia, central Greece, has been a center of the utmost importance since the Early Bronze Age. Clearly, during Mycenaen times, Thebes was a first-order center, the seat of a palatial administration. Numerous finds proved regularly sustained glass consumption in burial and settlement contexts. This consumption seems to have progressed well into later times, as archaeological research has brought a vast array of finds covering almost all later periods. With major questions remaining obscure, Thebes offers an ideal setting for attempting to address queries related to the nature of production, technology and provenance, issues falling well within the scope of this study.

In the present work, 35 samples dating from the Archaic to the Hellenistic era were studied using LA-ICP-MS analysis. The assemblage comprises 30 beads and 5 fragments of vessels, all of which are part of burial contexts, uncovered during the construction of a rough crossing under the railway lines on the Thebes-Mouriki road axis.

The analytical results offered valuable insight into the assignment of a likely provenance and technology. Glass from Thebes falls into the general soda-lime-silica category, as
expected. A set of 5 beads exhibits different compositional patterns since they show elevated values of PbO (av. PbO 26.7 wt%), suggesting other technological traditions and choices. In assessing the possible provenance of the raw glass by testing the Cr/La and Zr/Ti ratio, typically used to identify the provenance of plant ash LBA glass from Mesopotamia and Egypt [1], an Egyptian origin of the plant ash glass with varying Zr/Ti ratios is suggested, further reinforced by the high Ti/Nd ratio. A subset of low Ti/Nd ratio corresponds to Levantine provenance [2].

The evaluation of the overall results, along with the archaeological input, provides further corroboration of the glass data from the Greek mainland, enhancing our understanding of a given material charged with valuable information over cultural interconnections, trade networks and consumption.

References


OR20

Roman, Late Antique and Early Byzantine glass from Serbia – overview and what comes next

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Keywords: glass compositions, Late Antique, Early Byzantine, Serbia, provenance

The paper summarizes, discusses and contextualizes the glass compositions of the Roman, Late Antique and Early Byzantine glass assemblages from Serbia, published up until now. It suggests the goals of the next phase of investigations of archaeological glass from the Serbian context. The chemical composition of glass is reported from the 6th to early 7th century Byzantine imperial town of Caričin Grad (Justiniana Prima) [1], the 2nd – 4th-century mining settlement on Mt. Kosmaj [2], the late 3rd – late 4th-century settlement of Mala Kopašnica [3], the 4th-century site of Mediana, and the Early Byzantine settlement of Jelica [4, 5]. The latest paper reports the composition of glass assemblages from Viminacium, Diana, Pontes, and HajdučkaVodenica, all situated in the Iron Gates region of the Danube River, is underway. The 2nd – 3rd-century glass mostly belongs to the colourless glass decolourized with Sb₂O₃ and MnO, implying recycling. The 4th-century glass is mostly colourless, decolourized using Sb₂O₃ or MnO, and belonging to the Foy série 3.2 type. A small percentage belongs to the HIMT type and some to plant ash glass. Around 70% of 2nd – 4th c. glass seemingly come from Egypt and the rest from the Levant. The results hint that during the former period, raw glass was imported from the west, via road Aquileia-Sirmium, and in the latter, from the east, via the Danube. The 6th-century glass belongs predominantly to the Foy 2.1 type and a smaller extent to the Foy 3.2 type,
originating from Egypt. There seems to be a shift in raw glass trading patterns in the 6th century. The raw glass was imported almost exclusively from Egypt.

The provenance hypothesis should be verified by measuring the REE concentrations or the isotopic ratios of some of the published samples. Glass from the important Roman regional centre of Sirmium should be analyzed to get a more representative picture. The Late Antiquity to Medieval glass production transition should be probed by measuring the assemblage from the 10th – 13th-century Byzantine towns of Margum and Braničevo.

References


OR21

Trace element and Pb-Ag isotope signatures of silver ore deposits of the central Balkans and applications for provenance studies

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Keywords: ore deposits, Balkans, ancient mining, lead-silver isotopes, trace elements

The central part of the Balkan Peninsula is richly endowed with silver-bearing lead ore deposits which occur in the Dinarides, particularly the Rhodope and Serbomacedonian units [1] stretching from central Serbia southwards to northern Greece and southern Bulgaria in the east. Their importance as silver sources is well attested for the Roman Imperial [2] and medieval periods [3], with assessments, typically based on epigraphic and historical written sources. However, the beginnings of silver production in the central Balkans, possibly predating the Roman conquest of the region, are somewhat obscure. Evidence is mostly indirect, including issues of silver coinage from inland mints dating from the 5th to 3rd centuries BCE (e.g. Derrones, Damastion, Kings of Paeonia) and the presence of Greek imported goods deep in the interior, which appeared suddenly in the later 6th century BCE and were tentatively linked to precious metal trade [4]. Apart from on-site studies in mining districts which provide a direct but often a difficult-to-date record of historic metal production, data-driven approaches based on trace element and isotope signatures of local mineralizations greatly contribute to deciphering past activities and form the core of this study.

We present trace element and high-precision Pb-Ag isotope data on a suite of ore samples from precious metal deposits of the central part of the Balkan Peninsula. The samples were collected from mineralizations in Montenegro, Bosnia and Herzegovina, North Macedonia, Bulgaria, and southern Serbia (including Kosovo). These localities were selected for their documented and assumed historical significance.
Traces of ancient mining were further recorded at several of the investigated sites. Based on the new data acquired in this study and our field observations, possible applications for provenance studies are outlined.

References


Metalworking technologies in the 5th-century AD Carpathian Basin – changes in metal composition, manufacture, technology and decorating techniques

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Keywords: precious metals, niello, garnet inlays, gilding, Carpathian Basin

More than two hundred gold and silver objects from the 5th century AD Carpathian Basin and their decoration techniques (niello, gilding, garnet inlays) were analyzed in detail using non-destructive and non-invasive analytical methods (optical microscopy, handheld XRF, EPMA/SEM-EDX, µ-XRD, and µ-Raman). The comprehensive and detailed analyses have shown that no sudden changes occurred in metallic materials or decorative techniques during the period [1]. The gold objects were manufactured from high-quality gold alloys (> 90 wt% Au). Different Ag/Au and Cu/Au ratios of the gold alloy indicate the use of gold from different sources. Silver objects were manufactured from silver alloys (> 80 wt% Ag) intentionally alloyed with copper. Various amounts of gold and bismuth in the silver alloys possibly reflect the use of silver from different sources. The composition of silver objects changed towards the end of the 5th century AD containing elevated amounts of tin, zinc and lead up to several wt%, indicating remelting and alloying with bronze and brass [1, 2]. There is no sign of any standardization of alloys, but recycling was detected with increasing frequency and complexity. In the case of niello, the
objects were inlaid with various silver-copper sulfides ranging in composition from pure silver sulfide (acanthite) to pure copper sulfide (chalocite). Different gilding techniques were observed, including fire gilding and gold plating. The garnet inlays originated from different sources, including the long-used garnet sources of Sri Lanka and Southern India. Still, almandine of Northern Indian or Central Indian origin also appeared in the analyzed objects [3, 4, 5].

References


OR23

Methodological framework for successful written heritage preservation management – operational and material aspects

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Keywords: preservation management, written heritage, methodology, heritage institutions

Successful written heritage preservation management is a complex issue that can be researched from various aspects. Therefore, it is necessary to identify two main challenges – the comprehensive approach and the implementation of effective solutions. The comprehensive approach can be achieved by applying the comprehensive model, which includes five key aspects: strategic and theoretical, economic and legal, educational, operational and material, and cultural and social aspects. Each aspect considers specific issues, which, combined with other aspects, present a framework for comprehensive written heritage preservation management. The challenge of implementing effective solutions for written heritage preservation in each aspect can be achieved through specific methodological frameworks, which should result from theoretical insights into the application of specific methods, techniques and procedures and evaluating their effectiveness. This paper aims to showcase the specific thematic frameworks found in the operational and material aspects of preservation management and to elaborate on the theoretical methodological frameworks along with the prerequisites for efficient application of specific methods, techniques and procedures of written heritage preservation management into practice.

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OR24

The application of non-destructive techniques to identify Mycenaean jewels from a chamber tomb in central Greece

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Keywords: identification, semi-precious stones, XRF, Raman spectroscopy

Raman micro-spectroscopy is an ideal method for examining marketable precious, semi-precious, and gemstones because of the lack of sample preparation and the non-destructive nature of Raman analysis. The micro-Raman study of a stone also provides a unique record for identification purposes. This paper discusses the variety of Raman spectra obtained from different families of semi-precious stones, comparing and contrasting spectra from natural and artificial minerals.

The material presented in this paper comes from a very rich Mycenaean discovered in the Spercheios valley in Central Greece. The wealthy tomb XXVIII was used as a burial place from the beginning of the 14th c. B.C. until the middle of the 12th c. B.C. The architecture of the tomb, and in particular the large number of valuable personal items that accompanied the burials, demonstrate that members of an elite Mycenaean family were buried in the tomb chamber, adorned with their precious jewelers, thus indicating their high social status. Many necklaces and diadems formed from glass paste relief beads and beads from various semi-precious stones will be analyzed to determine the exact composition of the material and its origin. The analysis results will probably provide us with more evidence for further interpretation of the social position of the people buried in the grave.

Raman spectroscopy is well-recognized in the art conservation and archaeology for identifying precious and semi-precious stones.
Additionally, this information helps to establish the provenance of materials. The Raman measurements discussed in this paper were made with a portable Rockhound Spectrometer with 20 mW of 785 nm laser excitation and a spectral range of 200–2000 cm⁻¹. We used spectral data from well-characterized minerals from the ruff database as a reference.

References


OR25

Raman and XRF Characterization of Obsidian from Early Eneolithic site Šanac-Izba near Lipolist in Western Serbia

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Keywords: obsidian, Raman spectroscopy, XRF, Vinča culture, Eneolithic

This contribution presents the study of an isolated piece of obsidian from the Early Eneolithic site of Šanac-Izba [1] (Lipolist, western Serbia) with the addition of four control samples from Late Neolithic site Vinča-Belo Brdo (central Serbia). The samples from Vinča were analyzed in an earlier work by ED-XRF and the obsidian belongs to the Carpathian 1 source in modern day Slovakia [2]. Raman and pXRF analysis were used to characterize our samples. Afterwards, the spectra were deconvoluted and principal component analysis was performed on the samples. According to the measurements of both Raman and pXRF, the obsidian samples have highly similar spectra. In conclusion, despite the cultural distinction between the samples, the populations of both sites used obsidian originating from the same source. Obsidian, as a rare material, is only obtainable in a few sources. Thus, it is ideal for the research of trade, migrations, social dynamics, etc. [3]. We hope this research will be useful to other scholars whose area of interest is obsidian and cultural dynamics in the central Balkans.

References


Stone biographies. Use-wear and residue analysis of knapped stone artifacts as direct proof of prehistoric processes of past societies

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Keywords: use-wear analysis, residue analysis, knapped stone tools, Late Mesolithic, Early Neolithic

The use-wear analyses, followed by the residue studies of diverse artifacts, have been part of archaeological projects for decades since the Russian scientist S. A. Semenov established the main possibilities of the approach in the sixties. This practice, in the case of the Central Balkan region, has been applied in the last couple of years. The reason for such a gap was a lack of specialists and needed equipment. However, today the method has been gradually established in Serbian Archaeology by its implementation in large-scale studies varying from the Palaeolithic to the Early Bronze age.

This paper aims to acquaint the wider audience with the potential and impact of the use-wear and residue analysis of the archaeological materials, in this specific case, knapped stone tools. The main idea is to show how researchers today can observe human activities in the past based on the traces left on the lithic artifacts. To encourage the functional results a series of residue studies, combined with SEM-EDX and FTIR analysis was applied to the assemblages from the Iron Gates region (Serbia). The tools were found in the context of the Late Mesolithic and Early Neolithic, the so-called Transitional period. The gained results and proposed method show the ability to discover the everyday human processes in prehistory and the
difficulties or dilemmas that challenged the ancient societies.
Pigments Identification: Comparative examination of materials and techniques in the Hermitage Ascension in Python of Olympus, Greece.

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Keywords: pigments, Raman, XRF, identification, wall paintings

Python is a settlement of the municipality of Olympus in the regional unit of Larissa. It is located on the southwest side of Mount Olympus, in an amphitheater position at an altitude of about 725 meters. The word Python probably comes from the god Pythian Apollon of Greek mythology. Its oldest name was Selos.

The village remains important during the Byzantine period, a fact proven by the Post-Byzantine Hermitages that survived there. These were practiced by monks who later manned the monasteries of the area. The best-preserved hermitages are located on the hillside, where the hermitage of the Ascension at the foot and the Holy Cross is a little higher.

The hermitage of the Ascension extends into a spacious cave and includes five irregular spaces. The first two rooms are almost outdoor and served as vestibules of the nave. Access to the temple is made through an arched gate. The chapel consists of a chamber whose side walls have two arched openings that communicate with the cave's interior. The only murals that have survived are of the archangels Michael and Gabriel, which are found in the interior of the gate that leads to the temple and dates to the 14th century [1].

The present study focuses on analyzing 14th century mural pigments using spectroscopic non-destructive techniques pXRF, LIBS, FTIR and portable Raman. These measurements
will help to identify the pigments of that period and comparisons will be made with other studies concerning murals of the same period [2, 3].

References


Use of resources in Vinča culture: a spectroscopic study of pigments for pottery decoration

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Keywords: pottery, Late Neolithic, Vinča culture, bone pigments

The significance of pigments used in the long-lasting development of Vinča culture (5400/5300-4650/4600 BC), which existed in the central Balkan region, was not subjected to systematic multidisciplinary research. Two published studies encompassed 17 samples of Late Neolithic pottery from two excavation sites: Vinča Belo-Brdo and Pločnik (1, 2). In this work, 15 new pottery samples excavated at archaeological sites of Vinča Belo-Brdo, Pločnik and Drenovac are subjected to multi-technique investigation. The aim was to identify materials used by prehistoric potters to shed a light on understanding the complex social context of the Late Neolithic and Eneolithic periods. A variety of decorated pottery shards, with precisely defined motives, found at these sites indicate sophisticated preparation technology and controlled pottery firing conditions. Samples were taken from bowls, altars and figurines from all horizons, starting from the earliest phase of Vinča culture. The red and white pigments scraped from 15 pottery shards were investigated using X-Ray fluorescence (XRF), Fourier transform infrared (FTIR) and micro-Raman spectroscopy to identify the decoration techniques of prehistoric pottery. Based on preliminary results, red colored decorations of investigated samples originate from iron oxides, hematite and magnetite, as revealed by micro-Raman spectroscopy. The white colored...
decorations of investigated pottery shards were mainly made with calcium carbonate detected in FTIR and Raman spectra. The FTIR spectroscopy revealed the presence of orthophosphates, indicating that the white color on some pottery shards originates from pulverized bones. The bands characteristic for aluminosilicates have been detected in FTIR spectra probably originating from the underlying ceramic body collected during the scraping of the samples. The data obtained in this study provide an entirely new perspective on various daily, seasonal or long-term activities and trends in the Vinča community. While the exploitation of mineral resources (ochre, calcite, hematite) is unquestionably challenging, grinding animal bones for making white paste represents a significant step forward for the technology requiring in-depth knowledge of different properties of materials.

References


Preliminary Investigations of Polychromy of the Late Roman Marble Sculpture – Head of Jupiter from the WHS Gamzigrad-Romuliana, Serbia

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Keywords: Felix Romuliana, polychromy, marble statue, late Roman period, gilding

The paper presents the results of a preliminary study of polychromy on the sculpture Head of Jupiter, found at WHS Gamzigrad-Romuliana: a fortified palace with a sacral-memorial complex on Magura, commissioned by Emperor Gaius Valerius Galerius Maximianus in the late 3rd and early 4th centuries.

The head of Jupiter’s statue, once adorning Jupiter’s Temple, was found in 1986 during archaeological excavations in the sector east of the Temple. Part of the right eye, nose and lower lip were damaged. It is made of white coarse-grained marble, most likely from Greece or Asia Minor. It is dated around 310 AD [1]. The statue was close to colossal—the head measures 47 cm in height.

Recently undertaken conservation restoration presented an opportunity to examine traces of original polychromy using non-invasive techniques. Macroscopic observations were made in visible and UV light, followed by optical microscopy with a portable digital microscope. To determine the chemical composition of the applied polychromy, XRF spectra were obtained in situ using a handheld Thermo Scientific Niton XL3t Gold x-ray fluorescence (XRF) analyzer with a 50kV x-ray tube, large area drift detector and automatic voltage and current optimization. A CCD camera was used to isolate colored spots of interest. Spots were analyzed in All Geo calibration mode without helium or vacuum purging. Filters for main,
high, low and light elements were all used in a total time of 90 sec per sample. This technique analyzed six points.

By macroscopic observations, prominent traces of red coloring are visible in the hair locks framing the face, the beard and the undamaged upper lip. Yellowish traces are noted in the neck area. Remains of black outlining the inner corners of the eyes, left eyelid and eyebrow are similar to those indicated by other authors [2, 3, 4]. Detailed examination of the beard area with a portable digital microscope revealed traces of gilding on top of a red layer. It is best preserved on the lower left side of the sculpture in the beard area, semi-covered by incrustations.

The XRF spectra of red coloring demonstrate that pigment mainly consists of Ca, Si, Al, P, S and Fe, as well as the surprising presence of small amounts of Au, indicating that the red pigment is probably hydrated iron oxide (hematite). Traces of gold are detected in three succeeding red colored analyzed points on the beard. Measured concentrations were 101±9 ppm, 33±6 ppm and 322±19 ppm. In the other areas of the sculpture with yellow and black coloration, the concentration of gold is out of the limit of instrument detection. This suggests red bolus was used underneath the gilding of the statue’s beard and possibly hair. The gilding of Roman portraits is not unknown, but is rarely documented [4].

Analyses of yellowish deposits in the neck area are not conclusive. It is of similar elemental composition as red surfaces, but with less iron, leading to the conclusion that the paint carrier could be one of the iron oxides mixed with different amounts of clay or deposited traces of iron oxides present in the soil during burial. This requires further study. The composition of surfaces with black traces equally corresponds to the matrix of marble sculpture, referring to carbon black which, the other analytical techniques should verify.

The outstanding findings of this preliminary study give rise to a detailed study of polychromy in the sculptural repertoire of Felix Romuliana, which by all means represents masterpieces of late antique art.

References


PO4

12th century AD red and yellow fresco pigments from North-Eastern Russia

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Keywords: wall painting, medieval pigments, the church of Boris and Gleb, ochre, cinnabar

The paper presents the results of the study of wall painting fragments from the church of Boris and Gleb in Kideksha (mid-12th century AD). We used the following methods: optical microscopy, SEM-EDS and X-ray diffraction. In comparison, we used materials from the cathedral in Suzdal (turn of the XI-XII centuries AD), the Transfiguration Cathedral in Pereslavl-Zalessky (mid-12th century AD) and materials from the 12th-century cathedral of St. Georg at Novgorod.

In the church of Boris and Gleb, pigments such as red ochre, cinnabar and yellow ochre were used. The wall paintings of the cathedral in Pereslavl-Zalessky were made with similar pigments, but they contained more sand in the intonaco. The same red and yellow pigments were also used in the Suzdal Cathedral, but a large number of ceramic fragments were found in the intonaco. The main difference between northeastern Russian and Novgorod frescoes is the use of minium, which was used in Novgorod frescoes of the 12th century AD.

References


PO5

Analyses of mortars from St. George’s cathedral, Great Novgorod

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Keywords: mortars, Yuriev Monastery, petrography, masonry

The St. George cathedral of Yuriev Monastery—one of the largest churches in Great Novgorod – was built at the beginning of the XII century by Prince Vsevolod Mstislavich. Now the Yuriev Monastery is a UNESCO World Heritage Site.

During the archaeological excavations in 2013-2021, carried out by the Department of Archaeology-and-Architecture of the Institute of Archaeology, Russian Academy of Sciences (Moscow), samples of limestone mortars of the different building periods were taken. The samples' analyses were carried out using optical microscopy, petrography and SEM-EDS to determine the compositions of mortars in the different constructions and the development of building techniques.

The poster presents the first data of the material analyses.

The 17 samples of the lime mortars were investigated in this study. Analysis showed that lime was used as a binder. It consists of a cryptocrystalline sintered carbonate material with an admixture of very small (hundredths and tenths of mm) quartz particles. The fillers are brown and grayish-brown small fragments of brick with various compositions. Some fragments are burnt clays and some of the brick fragments consist of quartz and clay in different ratios.

We could highlight several different construction periods-two pre-Mongolian stages (12 century)
and the rebuilding of the monastery by the Metropolitan Photius (first quarter of 19 century).

References


Angular resolved XRF and XANES analysis of Attic Black Gloss ceramics

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Keywords: synchrotron XRF, XANES, angular resolved, Attic black gloss, Fe-K edge

The requirement for depth sensitive non-destructive analysis is often imposed when archaeological and historical materials with stratified structures, for example, presenting a surface layer of a few tens of micrometers, need to be characterized. These materials might be the intentional result of a particular manufactured process or simply the consequence of the alteration of the original surface due to surface enrichment phenomena or environmental factors. A characteristic example of stratified material is the Attic black gloss decorative layer on ceramics. It was introduced during the classical period in Athens (VI-IV century BC) by applying a three stages oxidation-reduction-oxidation firing process of an illitic clay enriched in iron [1]. Through time, the black gloss manufacturing technology was finely imitated in Sicily and Southern Italy workshops.

Using synchrotron confocal geometry set-ups is a proven analytical methodology for investigating with enhanced depth resolution surface layers of a few micrometers [2]. Alternatively, angular resolved X-ray measurements at grazing incidence conditions also present a promising methodology. The Nuclear Science and Instrumentation Laboratory (NSIL) of the IAEA in collaboration with Elettra Sincrotrone Trieste, have developed a multipurpose end-station facility at the XRF beam line that offers the
required degrees of freedom for precise angular resolved measurements [3]. Several original black gloss and imitation pottery fragments manufactured in Sicily and South Italy with well-documented archaeological references were examined using synchrotron XRF analysis at three different excitation energies and with X-ray absorption near-edge structure spectroscopy (XANES) across the iron K-edge. The results offer new insights into the provenance and black gloss manufacturing technology across the Mediterranean during the classical period.

References


Examination of painting technique and materials of Petar Lubarda’s paintings on paper support

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Keywords: Petar Lubarda, paintings on paper support, synthetic media-based paintings, non-invasive analytical techniques, preventive conservation

Paintings authored by Serbian painter Petar Lubarda between 1953 and 1974 demonstrate the author’s knowledge of the new materials used in international high modernism. His dedication to constantly exploring different aspects of various synthetic materials and their manipulation on paintings to obtain a variety of visual effects, testifies intensely to the importance of the visual in Lubarda’s aesthetics. Although there are numerous publications about Petar Lubarda’s life and work, not a single information about his painting technique's characteristics was found during the literature research.

As part of a longtime project (2018-2020) dealing with the analysis and conservation of Petar Lubarda’s paintings on paper support, which belongs to the “Kragujevac 1941” period, alkyd-based painting medium (used alone or in combination with polyvinyl-acetate) was identified, and acrylic-based medium was additionally identified on two paintings. In 1969 the author left his handwritten will by which he donated his paintings to the Memorial Park in Kragujevac¹, which had a very peculiar and explicit request in it—the paintings were not to be removed from Kragujevac and the Memorial Park under any circumstances whatsoever. This fact, in addition to virtually no data about the materials Lubarda used, made the analysis and conservation of these artworks even a greater

¹City in Serbia, famous for the atrocities committed by the Nazi occupation forces on the civilians (including pupils) during the WW2.

Vinča Institute of Nuclear Sciences
challenge that was successfully overcome using portable non-invasive analytical techniques (Fourier transformed infrared spectroscopy–FTIR, X-ray fluorescent spectroscopy–XRF, and portable optical microscopy) coupled with the extensive laboratory database and expertise.

Determination of the technological characteristics of the artworks enabled the conservators to apply adequate techniques and compatible materials without jeopardising any paint layers. The final goals were making sure that only the appropriate conservation methods that are in accordance with the obtained results would be used, and making recommendations for preventive conservation of these delicate synthetic media-based paintings.

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References


Preliminary investigation of the cinnabar origin and use on archaeological findings from Early Metal Age site in Northwestern Serbia

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Keywords: cinnabar, EDXRF, XRD, copper and mercury deposits, Early Metal Age

Mercury is considered one of the ancient seven metals due to its naturally occurring mineral cinnabar usage as a red pigment for coloring and burial ceremonies which has been confirmed since prehistory. Several publications have already indicated the use of cinnabar in the Neolithic Balkans [1, 2], especially in the context of its origin. During the Early and Late Eneolithic, the use of cinnabar for drawing woman figurines was confirmed on a ceramic vessel from the Velika Humska Čuka site near Niš. Still, cinnabar remains were also found in a ceramic vessel from the Pločnik site. Surprisingly, the findings from the Vinča site are not colored with cinnabar but with red ochre. However, for a hundred years, there has been an assumption that the Vinča culture was the first to mine cinnabar at the well-known Šuplja stena mine on the nearby Avala mountain.

This work focused on investigating cinnabar use in archaeological findings from a recently discovered site in Northwestern Serbia attributed to the Early Metal Age. Attention has also been drawn to copper and mercury ore deposits in the vicinity of the archaeological site. Portable milli-beam EDXRF spectroscopy and powder XRD were used to identify mercury on the selected excavated artifacts and ore samples and for elemental and crystallographic analysis. The results will gain new knowledge or confirm existing ones regarding trading and cultural routes in prehistoric Central Balkans.
Acknowledgements

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References


Ores, mines and the making of Late Bronze Age copper in the Lechkhumi district of the South Caucasus, north-west Georgia

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Keywords: copper ore, archaeometallurgy, mountainous Colchis, mining, smelting

For more than 3,000 years, the South Caucasus region, east of the Black Sea, has been recognized as an important center for prehistoric metallurgy, mainly known for its Colchian Bronze Age culture. A recent survey in modern Lechkhumi—the mountain region of ancient Colchis—has shown the existence of Late Bronze Age Copper smelting which can be linked to earlier discoveries of hoards of copper ingots, cakes and associated metalwork found by the accidental discovery of a series of hoards buried in this area [1].

In Lechkhumi, systematic exploration, analysis and dating studies have been focused on a series of prehistoric copper smelting sites—especially three related sites at Dogurashi (in the northern part of the survey area) as well as the study of related artifacts and ore deposits. This has been conducted during the last ten years, focusing mainly on the northern part of this district (the Dogurashi group of sites). Across the Lechkhumi region, more than 20 prehistoric copper smelting sites, together with associated waste material (slag, coarse crucibles, tuyères, destroyed remains of smelting furnaces and ore roasting pits/trenches), have so far been located [2].

An integrated framework of archaeological, archaeometallurgical and geological studies has now been
carried out. From this, it has been established that these sites were operating in the 13th-9th centuries B.C. and were part of a much wider prehistoric copper smelting industry [3].

Since 2016 more archaeological and geological exploration has been focused on two main areas of ore mineralization: the Dogurashi area of the northern part of Lechkhumi and then the area further south covering the village areas of Okureshi-Opitara. Base metal mineralization (lead, zinc and copper) was previously located here during exploratory visits to this area in the early 20th century by exploratory mining geologists [4]. Early prospection records also mention the existence of much earlier smelting debris—for instance, in the village areas of Okureshi and Opitara—although the significance of these descriptions was not realized until much more recently.

Three mine workings now have been found in the narrow gorge of the river Rtkhmelebis gele, also in the vicinity of the village of Opitara. Various scientific analytical methods have been used to establish a link between the Opitara-Okureshi archaeometallurgical sites, Late Bronze Age settlement, and mines. These include the analytical investigation of the petrography of mineralized rock and slag and the additional application of atomic absorption spectrophotometry (AAS) and X-ray fluorescence (XRF). Key samples from ores, slags and metal artifacts (ingots and finished objects) also have been submitted for lead isotope analysis.

The results obtained through the petrochemical and petrographic studies of mineralized rock samples from the Opitara mines and prehistoric slag from elsewhere in this region are in complete correlation with each other, establishing the direct link between copper mining and smelting within the study area.

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References


Characterization of materials used in an Islamic manuscript from the 18th century

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Keywords: Islamic manuscript, spot tests, pH, foxing, FTIR

The oriental manuscript titled Eṭ-Ṭarîḳatü’l-Muḥammediyye’s-sireṭü’l-Aḥmediyye from the year 1760 (Hijri year 1181) belongs to the most read works of Sufi origin. It was written by the famous scholar Birgivi Mehmed Efendi’nin in Ottoman Turkish and Arabic script (Nesih calligraphy). The original text dates from the 16th century and was written in Arabic. The manuscript is still preserved and housed at the Masudi Library in Bosnia and Herzegovina. Its current state required conservation and restoration treatments, before which an analytical characterization of materials was performed.

The examination methodology ranged from preliminary tests to FTIR analyses of the paper support. The acidity status of the paper was investigated using the TAPPI method modified by Kocar [1] and revealed a neutral pH value. Hence it was concluded that no neutralization was necessary. Using microchemical tests accompanied by optical microscopy, the presence of proteins and alum was confirmed, two components that are part of traditional recipes for paper preparation. Using the same method, lignin and starch were found to be absent on the paper surface. The FTIR-ATR analysis confirmed the presence of proteins and revealed a higher level of cellulose crystallinity. The paper support was made of hemp fibers, identified based on optical microscopy and staining with Herzberg and Graff C reagents [2]. Some pages contained foxing stains.
that were further observed under UV fluorescence and an optical microscope. The foxing stains had the typical bullseye appearance - a distinct dark center within a lighter ring on paper. This type of foxing is usually associated with metal ions in the core. However, recent findings [3] also emphasize the role of preferential cellulose oxidation and moisture condensation.

The obtained results have allowed a deeper understanding of the manuscript making process and identification of the causes of its deterioration over the centuries. The presented approach is an example of a responsible conservation strategy of the valuable 16th century oriental manuscripts.

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References
AUTHOR INDEX

Albarède, F. 65
Alijagic, A. 99
Anagnostopoulos, D. F. 15
Andelković, B. 43
Andrić, V. 93
Atanassova V. 41
Atudorei, V. 23
Bajnóczi, B. 67
Bajuk-Bogdanović, D. 73, 79
Balvanović, R. 63
Banda, M. 25
Baošić, R. 47
Bataoula, K. 57
Beridze, T. 95
Blichert-Toft, J. 65
Bogosavljević Petrović, V. 79
Brecoulaki, H. 51
Bulatović, A. 93
Caliri, C.15, 89
Chagelishvili, R. 95
Chowdhary, A. 55
Constantinescu, R. 37
Damjanović-Vasilić, Lj. 79
Delić-Nikolić, I. 53
E. Eleftheriou 15. 51
Erofeeva, K. G. 87
Ferri, M. 17
Filipović, V. 93
Franjić, A. 59
Franković, M. 81
Gajić-Kvaščev, M. 93
Ganetsos, T. 31, 45, 49, 71,77
Genda, I. 35
Gerodimos, Th. 15
Giannetti, F. 17
Gilmour, B. 95
Giumlia-Mair, A. R. G. 21
Gliozzo, E. 17
Hajnal, Zs. 67
Hasenay, D. 69
Hirsenberger, H. 37
Horvat, I. 69
Horváth, E. 67
Ianovskaia, E. 87
Ibragic, S. 99
Ignat, M. 37
Jelikić, A. 81
Jovanović, V. 91
Jovičić, M. 53
Kajtez, I. 27
Kaparou, M. 61
Karantzali, E. 71
Karavanić, I. 25
Karydas, A. G. 15, 51, 57, 89
Katsantoni, M. 77
Klisurić, O. 33, 49
<table>
<thead>
<tr>
<th>Name</th>
<th>Page Numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kontogianni, A.</td>
<td>31</td>
</tr>
<tr>
<td>Korolija Crkvenjakov, D.</td>
<td>33, 49</td>
</tr>
<tr>
<td>Koturović, N. M.</td>
<td>79</td>
</tr>
<tr>
<td>Krajcar Bronić, I.</td>
<td>25</td>
</tr>
<tr>
<td>Laskaris, N.</td>
<td>71</td>
</tr>
<tr>
<td>Lebedeva, N.</td>
<td>87</td>
</tr>
<tr>
<td>Lemorini, C.</td>
<td>75</td>
</tr>
<tr>
<td>Lolić, A.</td>
<td>47</td>
</tr>
<tr>
<td>Lončar, J.</td>
<td>35</td>
</tr>
<tr>
<td>Malaperdas, G.</td>
<td>29</td>
</tr>
<tr>
<td>Mănăilescu, C.</td>
<td>23</td>
</tr>
<tr>
<td>Marić Stojanović, M.</td>
<td>43, 79</td>
</tr>
<tr>
<td>Marković, N.</td>
<td>73</td>
</tr>
<tr>
<td>Migliori, A.</td>
<td>89</td>
</tr>
<tr>
<td>Mihácsi-Pálfi, A.</td>
<td>67</td>
</tr>
<tr>
<td>Mihailov V.</td>
<td>41</td>
</tr>
<tr>
<td>Mihon, M.</td>
<td>23</td>
</tr>
<tr>
<td>Miličić, Lj.</td>
<td>53</td>
</tr>
<tr>
<td>Miljević, B.</td>
<td>37</td>
</tr>
<tr>
<td>Miu, L.</td>
<td>37</td>
</tr>
<tr>
<td>Mlikota, A.</td>
<td>35</td>
</tr>
<tr>
<td>Molnar, U.</td>
<td>33</td>
</tr>
<tr>
<td>Mozgai, V.</td>
<td>67</td>
</tr>
<tr>
<td>Nikolić, E.</td>
<td>53</td>
</tr>
<tr>
<td>Nikolić, O.</td>
<td>33</td>
</tr>
<tr>
<td>Nosova, A.</td>
<td>87</td>
</tr>
<tr>
<td>Nunziante Cesaro, S.</td>
<td>75</td>
</tr>
<tr>
<td>Oikonomidis, S.</td>
<td>57</td>
</tr>
<tr>
<td>Oikonomou, A.</td>
<td>57, 61</td>
</tr>
<tr>
<td>Palincaş, N.</td>
<td>23</td>
</tr>
<tr>
<td>Papakitsos, E. C.</td>
<td>31</td>
</tr>
<tr>
<td>Petrović, A.</td>
<td>75</td>
</tr>
<tr>
<td>Pirovska, A.</td>
<td>41</td>
</tr>
<tr>
<td>Rađivojević, M.</td>
<td>19</td>
</tr>
<tr>
<td>Ranogajec, J.</td>
<td>37, 53, 91, 99</td>
</tr>
<tr>
<td>Razvan Petre, A.</td>
<td>23</td>
</tr>
<tr>
<td>Rehren, Th.</td>
<td>19</td>
</tr>
<tr>
<td>Rezesidze, N.</td>
<td>95</td>
</tr>
<tr>
<td>Romano, F. P.</td>
<td>15, 89</td>
</tr>
<tr>
<td>Romantzi, K.</td>
<td>45, 71</td>
</tr>
<tr>
<td>Rousaki, A.</td>
<td>13</td>
</tr>
<tr>
<td>Sazonova, L.</td>
<td>87</td>
</tr>
<tr>
<td>Schilling, L.</td>
<td>67</td>
</tr>
<tr>
<td>Ėndroiu, C.</td>
<td>23</td>
</tr>
<tr>
<td>Simion, C. A.</td>
<td>23</td>
</tr>
<tr>
<td>Sironić, A.</td>
<td>25</td>
</tr>
<tr>
<td>Skoumi, N.</td>
<td>57</td>
</tr>
<tr>
<td>Smith, F.</td>
<td>25</td>
</tr>
<tr>
<td>Spasić, A.</td>
<td>33</td>
</tr>
<tr>
<td>Sulava, N.</td>
<td>95</td>
</tr>
<tr>
<td>Svilar, M.</td>
<td>79</td>
</tr>
<tr>
<td>Szenthe, G.</td>
<td>67</td>
</tr>
<tr>
<td>Šelih, V. S.</td>
<td>61</td>
</tr>
<tr>
<td>Šimić, M.</td>
<td>35</td>
</tr>
<tr>
<td>Šmit, Ž.</td>
<td>59</td>
</tr>
<tr>
<td>Tankova, V.</td>
<td>41</td>
</tr>
<tr>
<td>Tatuasvili, N.</td>
<td>95</td>
</tr>
<tr>
<td>Till, V.</td>
<td>33</td>
</tr>
</tbody>
</table>
Topić, N. 59
Tripković, B. 73
Tripković, T 43,47
Tsampa, K. 15, 51
Turchiano, M. 17
Van der Bergh, J. M. 91, 99
Van Elteren, J. T. 61
Vandenabeele, P. 13
Vasić, R. 47
Vaxevanopoulos, M. 65
Vdovichenko, M. V. 21
Vidosavljević, V. 27
Vozniak, A. 87
Vučetić, S. 37, 53, 91, 99
Vukosavljević, N. 25
Westner, K. J. 65
Zacharias, N. 29, 61
Zubavichus, E. Y. 85
Živić, M. 81
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