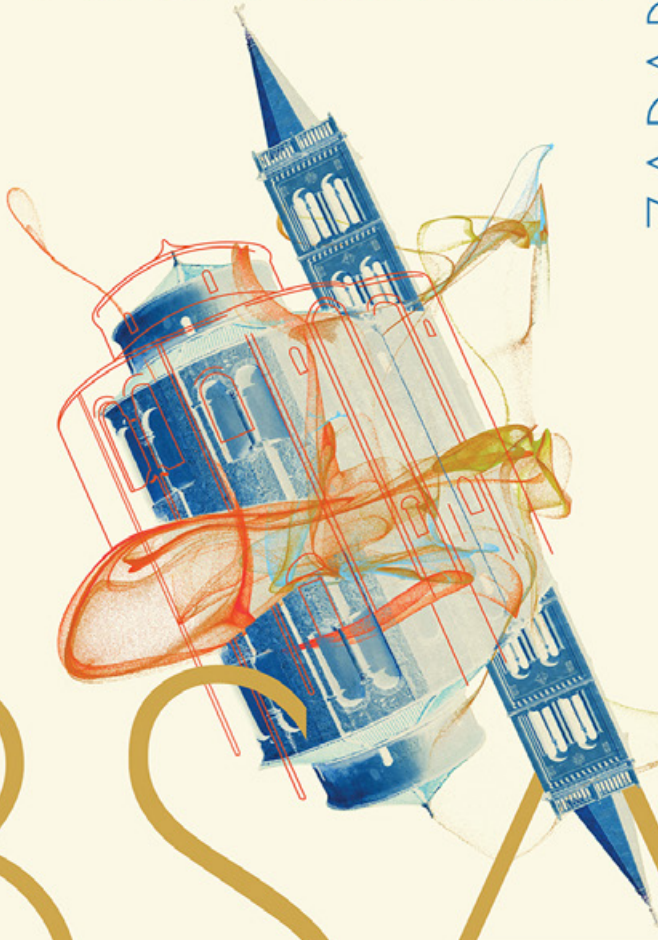
9th BALKAN SYMPOSIUM OF ARCHAEOMETRY



ZADAR

4th – 7th NOVEMBER 2024

BSA

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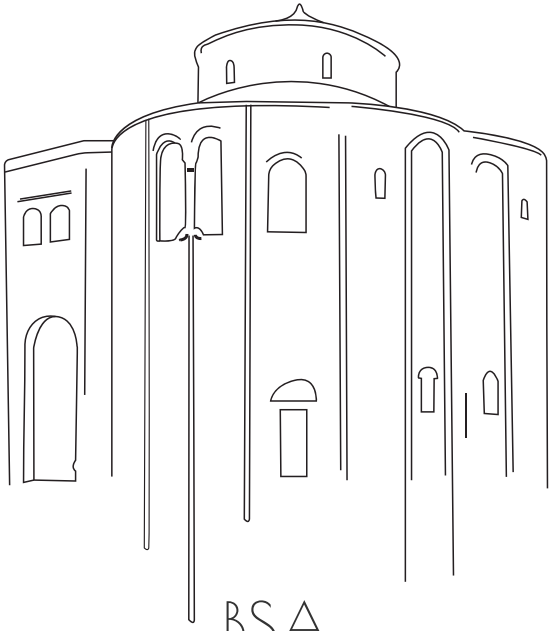

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BOOK OF ABSTRACTS
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KEYNOTE PRESENTATION

Archaeometric Potential of Underwater Archaeological Sites

Irena Radić Rossi[1]

keywords: *archaeometric analysis, radiocarbon dating, cultural heritage*

An overview of the variety of underwater archaeological sites in Croatia testifies to the importance of the underwater cultural heritage from all the periods of human past. This heritage is being researched with increasing accuracy, using sophisticated methods and techniques. Starting from radiocarbon and dendrochronological dating, through various analysis of the organic and inorganic material, present in underwater archaeological evidence, knowledge about the objects found can be expanded, and comprehensive conclusions can be reached.

The paper presents some examples of archaeometric research, which helped us to better understand some systematically researched sites. Microstructural, mineralogical and geochemical analysis of the amphorae and pottery from the 4th c. BC shipwreck site, found in the waters of the island of Žirje, greatly contributed to the interpretation of the provenance of the cargo and the inventory of the ship's galley. Analysis of the biomolecules recovered from the pitch of interior of 2nd c. AD amphorae, found at the shipwreck site near the island of Ilovik, revealed the composition of their internal coating, and the goal of future research is to determine also their content.

The radiocarbon dating has provided an average date for many underwater archaeological sites, and analysis of different types of wood has revealed what species the investigated ship hulls were made of. Multispectral imaging and various characterization analysis obtained data on the raw materials present in the cargo of the post-medieval shipwreck near the islet of Gnalić, and the glass cargo was also examined with great care. Lead isotope analysis of the lead sheeting of the post-mediaeval

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ship, sunk in the bay of Suđurađ on the island of Šipan, provides material for future research, and many other finds await future archaeometric approach.

Microbiome of Historical Wooden Churches: Strategies for Characterizing Material Preservation and Prognosticating Future Condition

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Keywords: *Swedish historical churches, wood, microbiome, fungi*

The purpose of the project is to increase knowledge about how global warming has changed indoor climate because of, for example, changes in the microbiome in and around wooden buildings over time, as well as how this, in turn, affects the lifespan of biologically degradable building materials such as wood in these buildings. The goal is to be able to increase the lifespan of both new and historic wooden constructions and their furnishings, as well as to give architects, manufacturers of wooden products, managers, and residents clear and educational advice about the impact of climate and the microbiome on building materials, furnishings, and indoor environments. The study is unique, and to build up knowledge and methodology around how the studies should be carried out, we have chosen to start by studying the wooden buildings in Sweden that have the longest documented history - the Swedish churches.

The two middle-aged Swedish churches are churches with wooden construction elements in Tångeråsa, Fjugesta, and with wooden roofs in Hammarby, Upplands Väsby, were selected from previously conducted projects that were aimed the inventory of degree of the biodeterioration

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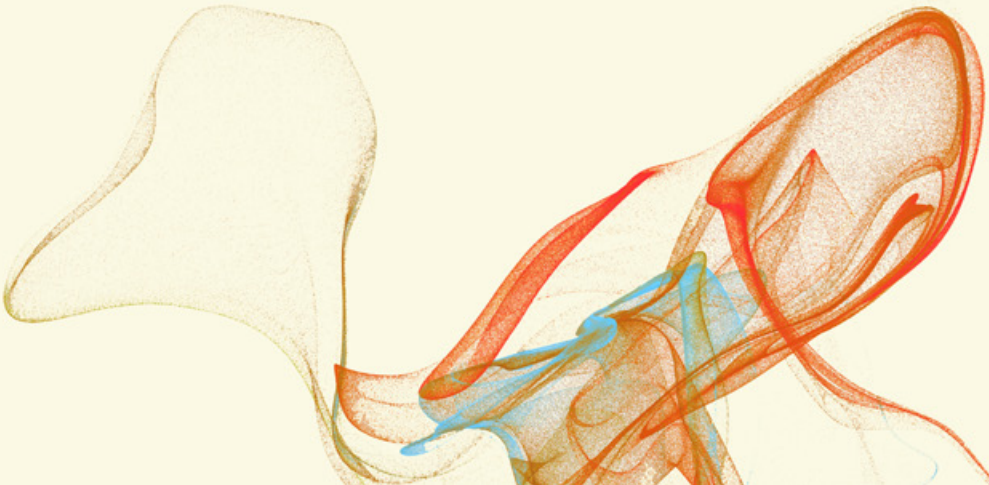
and biodegradation of wooden shingles in historical Swedish churches. Developing the degree of microbial presence assessment methods included adopting the currently existing observatory methods, which allow quantifying the microbial presence and species richness. The developed sensor system allowed non-destructive measurement of the wooden material's hygro-thermal performance and accumulation of existing microbial species inside and outside the buildings without damaging historical material. Sampling from materials and spaces inside the church houses included swabbing and cultivation using standard methods from indoor air quality assessment and washing the previously placed wooden test specimens to quantify microbial living colony forming units (CFU) and microbial species richness.

It was found that the microbiological contamination, amount of CFU, and species richness were more than two times lower in Tangeråsa church, as the moisture content of the wooden test specimens placed for the microbiological settlement was also slightly lower. Both buildings have installed heating. The low microbiome richness phenomena of Tangeråsa church might be explained by controlled temperatures that should not go below 13 degrees Celsius.

1. ENVIRONMENTAL ARCHAEOLOGY / LANDSCAPE / GEOPHYSICS AND GEOGRAPHIC INFORMATION SYSTEM APPLICATIONS



The Silent Witnesses: Unearthing Biokovo's Burial Secrets

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Keywords: *burial mound, radiocarbon dateing, osteo analysis*

Aerial photography and field survey have demonstrated that the tumulus near the mountain hut at Lokva on Biokovo Mountain is an isolated installation. Radiocarbon dating was conducted on human bones from three different burials. The oldest burial dates back to the developed Eneolithic period, between 2410 and 2198 BCE. Thanks to the remains of a ceramic vessel, after comparing the decorations and the shape of the goblet with two opposite handles, reconstructed through 3-D scanning, it was determined that the burial belongs to the already established Cetina cultural group. The absolute date enabled an important assertion about the completion of the genesis of the Cetina culture still in the Eneolithic period and speculations about the role of Biokovo Mountain for the Cetina people. In the 14th century, two deceased individuals were successively buried in the tumulus despite the existence of a nearby sacral area, the chapel of St. Elijah at the peak that bears its name, about 1 km away in a straight line. Considering archival news about the religious historical context of that period and calculations obtained through anthropological analyses and percentages of carbon, nitrogen, and oxygen in the collagen of the bones, there is a discussion about the diet, quality of life, primary living space, and religious affiliation of the deceased.

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Predictive Modeling of Settlement Patterns in Biokovo Nature Park (Croatia) Based on Geoarchaeological Criteria

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Keywords: *Biokovo Mountain, Geoarchaeology, Predictive modelling, Multicriteria GIS decision analysis, LiDAR*

Mountain Biokovo is characterized by its rugged karst relief and harsh climate, fostering self-sustaining yet challenging living conditions since prehistoric times. The limited availability of essential resources, such as arable land and water, has historically posed significant challenges for human habitation. Given that the suitability of settlement locations on Biokovo is closely linked to various specific morphometric, environmental, archaeological, and climatic criteria, this study aims to predict the most suitable settlement patterns.

The determination of optimal settlement patterns on Mountain Biokovo is achieved through the application of multicriteria GIS decision analysis (GIS-MCDA) based predictive modeling. This approach utilizes various geoarchaeological criteria derived from high-resolution (HR) datasets. Specifically, a digital elevation model (DEM) of Biokovo, derived from LiDAR data, was used to create morphometric and climatic criteria, while PlanetScope multispectral imagery was employed to generate land cover and other environmental criteria. In addition, proximity to speleological objects, water sources, and other locations important for habitation was considered as predisposing criteria for predictive modeling.

The weighting of all criteria selected for predictive modeling of settlement

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patterns was performed through the Analytical Hierarchy Process (AHP). Determined weight coefficients and predisposing criteria were aggregated to create a final HR predictive model of settlement patterns on Mountain Biokovo. The accuracy of created final predictive model was validated with known locations of historical settlements, which were used as control points for verification of model's reliability and accuracy.

The predictive model shows that the analyzed geoarchaeological criteria had a significant influence on the suitability of certain settlement locations within Mountain Biokovo, with less than 10% of the analyzed study area being considered suitable for habitation. Furthermore, results of this research could potentially serve as a basis for extrapolating results to similar geospatial contexts, suggesting that areas with comparable characteristics could also be potential sites of historical settlements.

Detection and analysis of new archaeological sites using the methodological approach of the QField application

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Keywords: *Methodology, QField, QGIS, field surveys, pottery*

The free geographic information software, QGIS, has established itself as a standard tool in archaeology. However, the QField application, which is used for collecting and managing geospatial data, has not yet seen widespread use. This presentation will concentrate on recent archaeological field surveys conducted in the eastern part of Croatia, particularly within the municipality of Cerna. These surveys utilized the QField app to map the density of artifacts, diagnostic pottery fragments, or structures visible in airborne LiDAR-derived imagery. The paper will offer insights into the generated maps of newly discovered sites, illustrate the distribution of materials, and highlight the artifacts themselves, which played a crucial role in determining the periods to which the sites belong.

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The results of the project „KultBaMikroo“ – Protection of Zadar's Cultural Heritage from the Negative Impact of Microorganisms

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Keywords: *cultural haritage, celulolytic fungi, airborne fungi*

Airborne fungi, particularly cellulolytic species, pose a significant threat to paper-based materials, including valuable archival collections. These fungi degrade cellulose, a key component of paper, leading to the deterioration of books and documents over time. The most common genera of concern are Penicillium, Aspergillus, and Cladosporium, which are frequently found indoors due to their lightweight conidia that easily spread through the air. The KultBaMikroo project investigated the presence of airborne fungi in three heritage locations in Zadar: the State Archive, the Archbishop's Library, and the Kaptol Library. Air sampling was performed during all four seasons using an "Air Sampler" device, and during the sampling, relative humidity and temperature were also measured. The collected fungi were incubated and identified using microscopic techniques. Additionally, a test for cellulose degradation was conducted to determine the fungi's potential for damaging paper-based archival materials. The results revealed that fungal spore concentrations in the State Archive exceeded the Italian standards used as a reference. Most of the identified spores and conidia belonged to cellulolytic fungi, with the Penicillium and Aspergillus genera being the most prevalent across the locations. These fungi are known to thrive in humid conditions, contributing to their growth and spread. Cellulolytic fungi were particularly abundant in the State Archive, making up 85% of the mycoflora in the first year and 68% in the second year. In

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the Archbishop's and Kaptol Libraries, these fungi represented 66.5% of the total in the first year and 73% in the second year. Such fungi not only endanger archival materials but also pose health risks to employees and visitors, as high spore concentrations can lead to respiratory issues and skin conditions like atopic dermatitis. The goal of the project is to ensure and facilitate microbiological air monitoring and to implement preventive measures, including improved ventilation and humidity control, in order to preserve cultural heritage and protect the health of employees and visitors in these environments.

Archaeology in archives – georeferencing and geospatial connection of archival archaeological maps and documentation

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Keywords: *georeferencing, GIS, geospatial, map, documentation*

For decades, the basic documentation tools for archaeologists were paper, pencil, and tape measurers. Over time, essential surveying tools such as the leveller and total station also came into use. Documentation technology is developing rapidly, and basic tools are ALS, GIS, and photogrammetry, among others.

This situation has resulted in archives at archaeological centres having folders full of paper plans and hard drives filled with modern digital documentation. This documentation is incompatible with each other and is impossible to compare and conclude with equal value.

Therefore, for several years, we as a team have been working on methods of georeferencing archival archaeological documentation and combining them with modern geospatial documentation.

We have noticed that if there are fixed points on the old plans that can be related to some objects in the field it is possible to georeference them.

This method was applied during three projects: The survey of Bronze Age settlements, the study of an early medieval stronghold and a sunken harbour. In all cases, georeferencing archival documentation was carried out and combined with geospatial data, allowing interesting new conclusions to be reached.

The presentation aims to present the method itself, as well as its advantages and challenges in archaeological research.

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The Archaeological Photo of Poland

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Keywords: *archaeological sites, digitization, GIS systems*

The Archaeological Photo of Poland is a unique initiative, implemented in 1978 in Poland, which aims to comprehensively examine the entire area of the country to register all visible traces and occurrences of archaeological finds on the surface, and as a result, their inventory and marking on a map on an appropriate scale. To conduct a thorough prospection, a method was used to divide the entire area of Poland into rectangles of equal area, which were then examined. According to the National Heritage Institute, which collects the collected data, it results that by June 2008, 435 thousand archaeological sites had been registered in an area of 87% of Poland. Verification studies of already identified sites are being carried out to confirm the collected information. Undoubtedly, a groundbreaking assumption of the AZP is also the sharing and digitization of acquired resources, which create the virtual heritage of the Polish nation, initiated in the 2000s and still ongoing today. Access to this AZP data is available to everyone via a dedicated website. Digitalization of maps within the AZP consists of transforming analog cartographic materials, such as maps, plans, and sketches into digital form in the Geographic Information System. This process includes scanning maps, georeferencing, and vectorization of spatial data. This opens up new perspectives for archaeological research and enables effective management of cultural heritage. Digitized AZP maps and databases enable fast and effective performance of advanced archaeological queries, spatial analyses, and integration with

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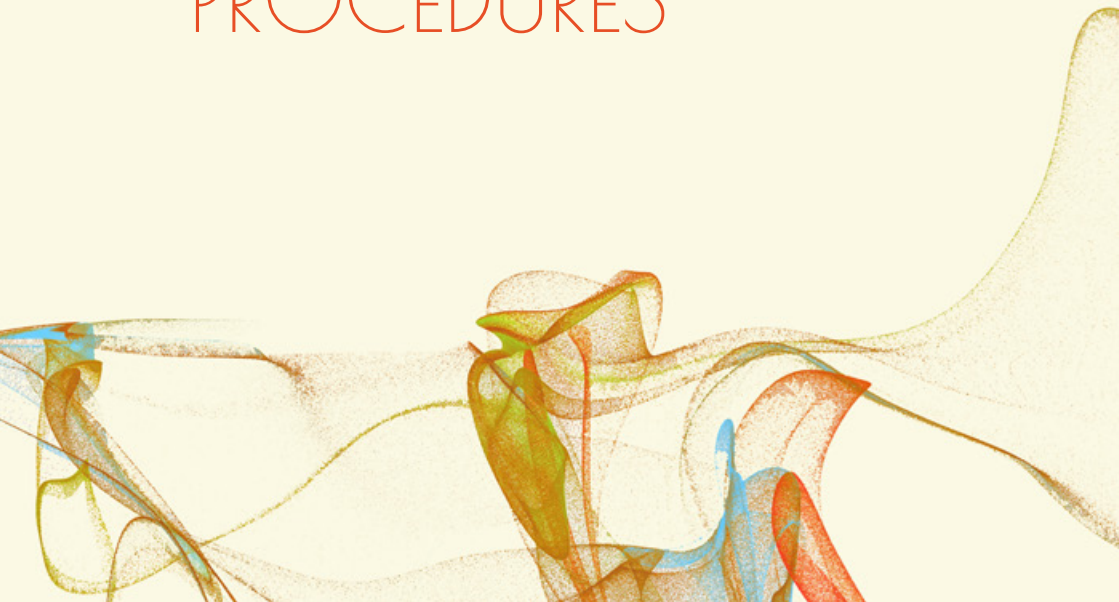
external data, which significantly increases research possibilities. Free access to archaeological data and the possibility of using them in GIS systems brings with it both benefits and certain threats. Enabling wide access to these dana promotes education and popularization of knowledge about heritage. Authorities can more effectively manage the protection of monuments, plan conservation activities, and reduce the risk of destruction of sites during construction investments. However, free access to archaeological data is also associated with serious threats. The biggest risk is that detailed information about the location of archaeological sites may be used by unauthorized persons, such as treasure hunters. This can lead to robberies, destruction of monuments, and illegal trade. In addition, free access to large amounts of dana can lead to difficulties in managing and keeping them up to date, which can result in outdated information and problems in analysis.

2. CONSERVATION SCIENCE CASE STUDIES: DECAY PROCESSES AND IMPLEMENTATION OF CONSERVATION PROCEDURES



Multifunctional TiO_2 nano-modified coatings for the protection of historic paper

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Keywords: *protective coatings, TiO_2, methylcellulose, paper conservation, starch*

Nowadays, historic paper-based cultural heritage is most threatened by climate change and environmental influences, with degradation processes that most drastically affect paper being chemical, physical, or biological in nature. To reduce the impact of deterioration factors on historic paper, various curative and preventive measures are being implemented on a daily basis. One of the main methods to mitigate degradation caused by these factors is the application of protective coatings to the paper's surface. In paper conservation, protective coatings typically consist of a polymeric coating serving as the matrix and metal oxides (i.e., TiO_2, ZnO) used as nanofillers.

In this study, paper was coated with protective coatings composed of traditional adhesive materials used in paper conservation (starch and methylcellulose), loaded with TiO_2 nanopartices in various weight concentrations. This was done to determine how each formulation affected the paper's essential physico-chemical properties (optical properties, physical variables, surface properties, mechanical properties, etc.). The study used appropriate model paper solely for ethical considerations, while working materials (starch and methylcellulose) were selected for their availability, compatibility, and extensive use in paper conservation.

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The effects of the proposed treatment were assessed before, during, and after the application, by evaluating the paper's state of preservation using FTIR spectroscopy, fluorescence spectroscopy, SEM-EDS, goniometry, and more.

The results showed that although TiO_2 can introduce multiple protective properties to the formulation, such as protecton of paper against UV radiation or microorganisms, several unpredictable occurences may arise when working with complex heterogeneous systems.

Fungal deteriogens of plastic: The case of a famous red Kiosk K67 from the former Yugoslavia

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Keywords: *biodeterioration, fungi, kiosk K67, plastic, polymers*

The K67 is the famous kiosk designed in 1966 in the former Yugoslavia. It has been made of laminated composite plastic polymers, which include unsaturated polyester polyurethanes reinforced with glass (Glass Fibre-Reinforced Plastic), and appeared mostly in red. Throughout history, it had various purposes, but was mostly used as parking lot booths, newspaper points of sale, fast food parlors, lottery sales, student coffee shops, cable car stations on the mountains, border police houses, etc... Its specific design enabled it to fit every open-air location, always easily approachable. Although nowadays abandoned, K67 is a good reminder of the times past and has both historical and technological significance. To get better insight into the complex fungal-plastic interactions, this study aimed to investigate the fungal infestation of the deteriorated surface of K67 deposited in the Museum of Science and Technology in Belgrade, as part of the museum's permanent collection. Deterioration signs, i.e. cracking and curling, and delamination of the polyurethane layer along with visibl growth of crustose and foliose lichenized fungi, and mosses were observed

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on the K67 surface. Surfaces characterized by these symptoms were investigated via portable and scanning electron microscopy, culture-based isolation method, and metabarcoding analysis. The isolates were identified by sequencing two selected genomic fragments: ITS region and protein coding gene BenA. Microscopy analyses showed dominance of microcolonial and lichenized fungi proliferating in the cracks and fissures. A vast number of melanized fungal spores originating from surrounding vegetation were also documented. A total of 12 species were identified: Alternaria alternata, A. longipes, A. tenuissima, Cladosporium cladosporioides, Conyothyrium telephii, Epicoccum nigrum, Fusarium asiaticum, F. equiseti, F. verticillioides, Paraphoma fimeti, Rhizopus microsporus and R. oryzae. Additional analyses are required to see if the obtained isolates could degrade plastic, with literature dana suggesting that members of the genus Paraphoma have the potential to degrade polymeric compounds, and the ability to degrade various biodegradable plastics. The metabarcoding analysis demonstrated a high diversity of lichenized and microcolonial fungi, as well as black yeasts, marking them as the main deteriogens of investigated plastic artifact.

3. MULTIDISCIPLINARY RESEARCH, DEVELOPMENTS AND MANAGEMENT IN CULTURAL HERITAGE

Written Heritage Research Challenges: Possibilities and Application of Document Image Analysis

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Keywords: *written heritage research, document image analysis, user needs, research challenges*

Technological advances have impacted the approaches to written heritage research. Previously, it was often possible to perform research only by being in immediate contact with original written heritage. Nowadays, it is possible to research digital copies and reprints which provides an opportunity to broaden research interests. Today, new technologies enable multiple research perspectives and possibilities that answer numerous research challenges. If, for example, a researcher's interest lies in analyzing the content of written heritage, areas of interest can be found in the outputs of text processing, i.e. optical character recognition (OCR). If the presentation of content is investigated, document page analysis can be used, and if the researchers are involved in digitalization of written heritage, they can perform a basic task such as skewing angles correction. The processes mentioned are a part of document image analysis (DIA), more precisely, its text processing domain. Besides this, DIA also includes graphics processing – line-based structuring and region and/or graphical symbol processing. Some of the basic tasks in this domain are image segmentation and graphics recognition. DIA, including the abovementioned processes, can be defined as an objective way to extrapolate information from document images acquired by scanning, photographing or microscopy. Acquisition types provide samples for DIA and the use of its methods

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to achieve in-depth research of text, graphics and other visual or material characteristics. Therefore, DIA is very useful and applicable for written heritage research. It improves analysis, for example examining stains or other visual elements, pre- and post-processing tasks during the digitalization process and analysis of watermarks, discolorations due to material degradation etc. Also, one of the possible areas of research is the comparison of the physical copy, original or a reprint, and the digital copy. It is presumed that digital copies represent original or physical copies faithfully regarding the content and textual, graphic, and visual elements and this has the research potential in Social Sciences and Arts and Humanities. An output of all these analyses can be a quantifiable data set which can be compared between samples as well as a qualitative analysis of various elements in a certain document image. The aim of this research was twofold – to present and investigate the possibilities and application of DIA in relation to conveying the originality of written heritage to its digital copy and to compare different document image samples considering their characteristics in relation to possible research interests. The methodological approach to this research consisted of choosing samples of written heritage – digital and physical copies, scanning physical copies, acquiring document images, selecting appropriate open-source software for DIA, and subsequent analyses. The significance of this research can be found in the approach to written heritage research challenges and finding the appropriate ways to answer them.

Connecting contexts: Challenges of the Use of Digital Technologies in Archaeological Heritage Interpretation and Presentation for Museums and Cultural Routes – a Case Study

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Keywords: *archaeological heritage, digital tools, interpretation, cultural tourism*

During recent years we are witnessing an increase of the use of digital technologies for cultural heritage reconstructions and presentations, such as virtual and augmented reality, different animation and gamification tools...etc. They are particularly convenient for creating new reconstructions and presentations of archaeological heritage, as they are often the most effective tool for reuniting elements of archaeological context (finds with sites and landscapes) for the visitors in an easy to understand, comprehensive and immersive way. Through creating new and engaging content, or new cultural tourism products, for the public, the use of digital technologies becomes a vital part of awareness-raising and heritage promotion strategies, for museums and cultural routes alike, with potentially long-term consequences of creating added value for the local communities to which the presented archaeological heritage belongs to.

However, their development is not always an easy task. As heritage reconstructions and presentations are inevitably based on (archaeological) interpretations that have to be backed by science, limitations in the use of certain types of interpretation tools or technologies may occur, which may, in turn, may influence the visitors' appeal to the final product. In

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addition, the development process involves close collaboration between experts stemming from very different backgrounds. As they are not proficient in the use of digital tools, heritage experts often lack sufficient digital and transversal skills, especially in the field of technological innovation. In this paper, we will present some of the most common challenges archaeological heritage professionals are dealing with in different stages of reconstructions and presentations development based on the experiences gathered in the Iron Age Danube and the Virtual Archaeological eLandscapes projects, as well as through our work under the aegis of the Iron Age Danube Route – Cultural Route of the Council of Europe. We will, also, show the use, role and impact such presentations and reconstructions, as new cultural products, can have in the development of sustainable cultural tourism of a region.

4. VARIOUS ANALYSIS / MATERIAL CHARACTERIZATION (CERAMICS, METALS, GLASS, VITREOUS MATERIALS, LITHICS, STONES, PIGMENTS, MORTARS, ORGANIC RESIDUES)

Change and Continuity in the Cucuteni Pottery Technology

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Keywords: *Cucuteni culture, Chalcolithic, pottery, technology, archaeometry*

In the eastern part of modern Europe, the Cucuteni culture (approx. 4525/4500-3350 cal BC), part of the last Chalcolithic civilisation Ariușd (Erösd, in Hungarian) – Cucuteni – Trypillia (Tripolye, in Russian), developed an enriched and diversified visual identity expanding from the forested valleys of Transylvania, in the eastern Carpathians to the plains of eastern Ukraine as far as the Dniepr valley. Two main characteristics define all three groups (Ariușd in Transylvania, Cucuteni in Eastern Romania and Moldova and Trypillia in Ukraine): the extensive presence of the long-term settlement with abundant inventories and the restrained funerary remains, as well as the dominance of the ceramic artefacts (pottery and statuettes) over all other material components (stones, metal). During the last few years, our team has conducted a comprehensive study on pottery samples from five archaeological sites in eastern Romania. We aimed to reconstruct and evaluate the production process of pottery during the

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Cucuteni A and Cucuteni B phases of the Chalcolithic Cucuteni-Trypillia civilization. We used optical microscopy (OM), X-ray diffraction (XRPD), and scanning electron microscopy coupled with energy-dispersive X-ray spectrometry (SEM-EDX) analysis to determine the mineral components, thermal transformations, and microstructural features of the pottery. Our findings revealed that the pottery was made using highly processed raw materials and fired in complex kiln structures that produced mostly uniform light reddish hues. The formation of new mineral phases in a large number of the pottery samples suggests a controlled atmosphere and temperature during the firing process, possibly indicating a change in the social and economic strategy of pottery production from household needs to more complex production facilities during the Cucuteni B phase combined with more restricted vessel types. The pottery samples provided valuable insights into the daily life and artistic handicrafts of the Chalcolithic Cucuteni-Trypillia civilization.

Nondestructive SEM-EDS analysis of the silver and gold hair-rings from the Early Bronze Age from the Lower and Middle course of the Tundzha River, Bulgaria

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Keywords: *Early Bronze Age, Yamnaya culture, silver hair-rings, gold hair-rings, Tundzha River*

The second half of the 4th millennium BC marks one of the most dynamic and interesting periods in Balkan history – the Bronze Age. This is a time of migrations of people, transfer of technological know-how, exchange of ideas and innovations, and cultural influences.

Around 3100 BC, large groups of migrants of the so-called Yamnaya culture appeared on the Balkan Peninsula. These people were nomads who originally lived in the North Black Sea area. The communities of the Yamnaya culture crossed the Stara Planina Mountain and reached the valley of the Tundzha River. The terrain in the Tundzha River watershed is level to rolling. Abundant water and mild climate offered optimal natural conditions for the newcomers. With the bringers of Yamnaya culture also appeared the first silver jewels.

The aim of this report is to present results from the nondestructive SEM-EDS analysis of the 3 golden and 21 silver spiral hair-rings from the Early Bronze Age. They jewels are found in the main and secondary graves of 13 burial mounds in Lower and Middle course of Tundzha River.

Spiral hair-rings were worn on the most visible places in the human body – the face. They are symbols of the prestige and presented the social position of their owner in ancient society.

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Tracing Tradition: White and Red Pigments in Chalcolithic Balkan Incrustation

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Keywords: *White and Red pigments, Chalcolithic, Balkans*

The 5th millennium BC witnessed the emergence of extensive cultural complexes spanning from the Aegean Sea to the Carpathian Mountains, including Kodzadermen-Gumelnitsa-Karanovo VI, Krivodol-Salcutsa-Bubani, and Varna-Bolgrad-Aldeni. Within the Chalcolithic period, according to Bulgarian periodization (4900/4850–4200/4100 BC), a prevalent decorative practice involved the incrustation of white or red pigments. This technique was employed by artisans from diverse cultural backgrounds dispersed throughout the Balkans. This study aims to trace and present the recognized minerals involved in the composition of pigments used in this era, shedding light on the materials and techniques employed by ancient artisans.

Archaeometric analyses examining the mineralogical composition of pigments reveal a standardized use of hematite for red coloring. However, variations in other ingredients suggest diverse recipes. While calcite is commonly employed in white paste, the presence of additional minerals such as dolomite, gypsum, diatomite, clinochlore, apatite, and aragonite indicates a quest for novelty among potters. These innovations reflect the spirit of exploration and cultural advancement prevalent in Chalcolithic pottery production, showcasing artisans' ingenuity and the evolving

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landscape of ancient craftsmanship. By identifying the minerals used in pigments, we gain insight into the technological and artistic capabilities of prehistoric communities, as well as their interaction with the natural environment and each other. The study highlights the complexity and sophistication of ceramic decoration in Southeast Europe during the 5th millennium BC.

New archaeometric results on late Roman lead glazed pottery from Pannonia

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Keywords: *lead glazed pottery, Pannonia, petrography, XRD, SEM-EDX*

Roman glazed ware, especially Late Roman glazed ceramics (mid-3rd–5th centuries AD), received little attention in the archaeological research of Pannonia recently. Although there have been numerous archaeological studies and sporadic archaeometric investigations on Pannonian artefacts, no systematic archaeological research combined with detailed archaeometric analysis of Pannonian glazed ceramics has been carried out. *Aquincum* has a prominent role in Pannonia, and although no traces of

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late Roman pottery production have yet been excavated, the processing of the huge amount of glazed ceramic finds is an important task for contemporary research. This study aims at analysing late Roman pottery from twenty-one archaeological sites in *Aquincum* in order to reconstruct the material usage and the production technology, with special attention to the preparation technique of lead glaze. Similar research is performed on some early Roman lead-glazed pottery from *Aquincum*, as well as late Roman glazed ceramics from the Barbaricum (sites Ecser 7, Üllő 5 and Üllő 9), and the results are compared to reveal any differences in time and space.

Fabric, clay type and the non-plastic components of ceramic bodies was studied by thin section petrography, whereas the phase and chemical composition of the bodies was determined by X-ray diffraction, ICP-OES and ICP-MS analyses, respectively. The microtexture, inclusions and chemistry of the glazes were analysed by SEM-EDX.

A wide variety of petrographic groups (raw material types) was identified in the ceramic bodies analysed (22 groups for 100 ceramics from *Aquincum*, 8 groups for 12 ceramics from Ecser 7 site, 5 groups for 9 ceramics from Üllő 5 site). However, most of the ceramic bodies are made of clay pastes with low Ca and high Fe content. Similar raw material types appear in the ceramics from the *Aquincum*, Ecser and Üllő sites, similar type of sand probably of local origin was used for tempering.

XRD analysis indicates high-temperature Ca-silicate phases in one quarter of the ceramic bodies indicating an apparent firing temperature of 750-800°C, whereas the rest of the ceramics were fired at lower temperatures.

Based on the SEM-EDX analysis carried out so far on artefacts from the Ecser 7 site, the preparation technique for high and very high lead glazes of yellow and green colours was similar: application of lead oxide directly to the raw body, colouring with iron derived from assimilation of the Fe-rich body, and intentional addition of iron only in a case of a brown glaze.

Some issues regarding provenance of the 11th – 12th c. CE glass bracelets from Braničevo and Morava (Margum), Serbia

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Keywords: *glass bracelets, Islamic glass, provenance, NAA, trace elements*

Glass bracelets from the 11th c. CE Byzantine sites of Morava (Margum) and the 11th - 12th c. CE Braničevo, mostly of dark blue, almost black appearing colour, have an elemental composition that shows general similarities with the contemporaneous glass objects of the wider Levant region. The elemental composition was determined using simultaneous PIXE-PIGE measurements. Majority of these bracelets were produced using plant-ash flux, and the rest using natron flux. This find correlates well with the general picture of the epoch that is characterized by the domination of plant-ash glass with some natron-based glass still in circulation. The flux of the majority of plant-ash glasses corresponds well to the plant-ash glasses reported from the early 11th c. CE Serçe Limani shipwreck, indicating that the Braničevo and Morava raw glass was perhaps imported from the Levantine ports over the same coastal waterways of Asia Minor.

In a bid to provide more specific details of actual the provenance of the glass, we performed a Nuclear Activation Analysis (NAA) of the selected subset of bracelets, obtaining concentration of trace elements Sc, Cr, Co,

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Zn, Fe, As, Se, Br, Rb, Ag, Sb, Cs, Ba, Au, Hf, Ta, Th, U, La, Ce, Nd, Sm, Eu, Gd, Tb, Tm, Yb, and Lu. The comparison of these results with the published data hinted that a majority of bracelets have provenance related to the several regions of primary production - Lebanon, Syria, Anatolia, but also to Mesopotamia and in some cases perhaps to Iran. Nevertheless, some compositional ambiguities do remain, and they will be addressed in the future by additional isotopic measurements of the selected subset of samples.

On the problem of early medieval metal resources in East-Central-Europe based on the analysis of late Avar copper alloy objects

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Keywords: *copper alloys, late Avar, provenance, Carpathian Basin, hXRF, lead isotopes*

Our case study addresses the questions of the accessibility and redistribution of copper in the early medieval Carpathian Basin, located on the eastern periphery of the zone influenced by European early medieval processes. The issue also provides answers to the question of how the region was linked to the European continental economic network, which is until recently an unresolved problem. Our research also seeks answers to the questions of material resources, and the local, regional and interregional redistributive networks.

Ore extraction and the production of various non-ferrous metals (copper, silver, gold) had important centres in the Carpathian Mountains throughout the Middle Ages until the Modern Era. Concerning the Avar period, our study is based on 'Late Avar' (c. 8th century AD) copper alloy artefacts that are predominant in the period.

In order to get better knowledge about possible differences and changes in the know-how of metal use, more than 800 copper-based alloy objects from 33 localities were analysed on cleaned surfaces by using handheld X-ray fluorescence spectrometry in order to determine their chemical composition. Based on the results, a wide range of copper alloys were used by the Avars, the majority is leaded bronze, but leaded copper, bronze, brass,

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leaded brass, unalloyed copper, gunmetal and leaded gunmetal are also represented. This metal use indicates an extensive reuse/recycling during this period as well.

Unalloyed copper rivets, used for fastening copper alloy artefacts, could represent fresh, primary metal. Their chemical and lead isotope composition was determined by using MC ICP-MS and ICP-OES to determine their raw material provenance. As samples were selected from the entire Avar cultural area, results are representative of the entire region and allow the identification of copper resources accessed by the inhabitants of the Carpathian Basin. If fresh copper metal was used for manufacturing the rivets, their raw material most probably derived from a northern ore source (possibly Slovakia).

Fresco Painting of St. George monastery in Old Ras, Serbia

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Keywords: *The monastery St. George, Fresco fragments, spectroscopy, petrography*

The monastery St. George, in the center of Old Ras (Serbia), founded by Stefan Nemanja, the Serbian Grand, was fresco painted until the end of 1175. This church is considered to be the prototype of a stylistic group in the architecture of medieval Serbia called the "Raška school". The exonarthex is attributed to the time of King Dragutin (1276-1282), Nemanja's great-grandson and the second founder of the monastery. Fresco fragments are collected on several occasions of restauration and archaeological excavations of the church during 20th century. About thirty fragments were analysed by means of energy dispersive x-ray spectroscopy, scanning electron microscopy with energy dispersive x-ray spectroscopy, optical microscopy, Raman spectroscopy and petrography.

Most of the mortars are composed of two layers, the lower one - made of lime with the addition of minimal amount of sand and straw or some other organic material and upper - made of lime. On optical microscopy of cross sections, it can be seen the boundary line between mortar and the

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pigment and the fable appearance of the dissolved lime under the pigment layer, indicating lime painting technique. Identified pigments, habitual for this period, comprise earth pigments like ochre, burnt ochre, and hematite used for different nuances from yellow to red and brown, with addition or not of red cinnabar. Green pigment was also identified as an earth pigment, while black is made of charcoal. Lime was used for the white colour. Two kinds of blue pigments, lapis lazuli and azurite were identified by Raman spectroscopy.

By combining different instrumental methods, the painter's technique and pigments used for the frescoes were revealed.

Looking through the *ballotina di laccha*: characterization analyses of red lake pigment from the cargo of the 16th-century Venetian ship *Gagliana grossa* (Gnalić shipwreck)

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Keywords: *red lake pigment, Venice, Renaissance, shipwreck*

In late October or early November of 1583, the ship *Gagliana grossa* headed from the port of Venice, loaded with various goods from European and Venetian workshops. Instead of reaching Constantinople, she sank near the island of Gnalić, in the Adriatic Sea. Today, the Gnalić shipwreck site is one of the most prominent underwater site for studying the late Renaissance period, due to the well-preserved construction of the ship, a rich collection of artefacts, and precise identification and dating based on archival documents.

Among the colouring materials discovered at the site, the discovery of the red lake pigment is particularly important. Unlike dyes, which are made solely from organic materials (although a metal is often needed to bind the dye to the textile), lake pigments are a mixture of organic materials extracted from plants and insects precipitated on an inorganic substrate, such as alum.

In Venetian historical documents, red lake pigments are referred to by different names, including *grana*, *laccha*, *verzino*, and *cremese*, depending on the type and quality of the colorant used for their production. Although they were often a byproduct of the dyeing industries, the more expensive

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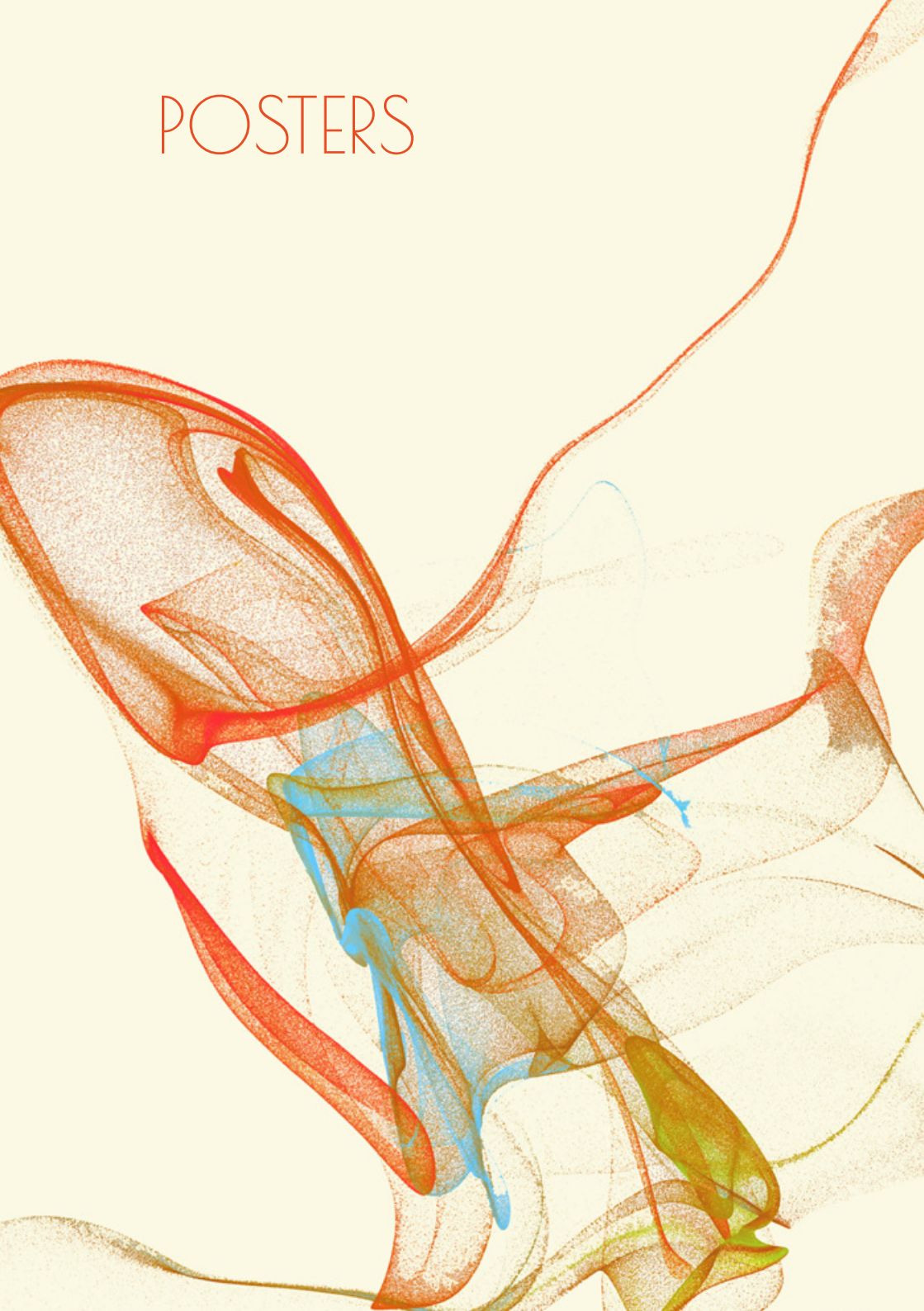
red lake pigments were extracted from textile clippings [3] and were extensively exported to the Islamic world. While red lake pigments have been mentioned in various historical documents, including inventories of the Venetian colour seller shops, painting treatises, and documents of maritime insurance, and have been identified in particles of shiny red glaze on Renaissance paintings, they have never been found in complete, raw form at an archaeological site.

This talk presents the results of analyses, conducted to explore the complex composition of this remarkable and unique find. The analyses include optical microscopic observations (optical microscope, SEM and microtomography), as well as elemental, molecular and structural analyses (SEM-EDS, Raman Spectroscopy, FTIR, HPLC, and XRD). The results are discussed in the context of the sixteenth-century Venetian dyeing and painting industries.

POSTERS



Belts between different cultures such as metallurgical technological differences

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Keywords: *Belt, Iron Age, North Italy, craftsman*

My research is based on the analytical study of the different techniques of artisanal production of belts and hooks in Northern Italy during the Iron Age. On a metal object can be identified the chaîne operatoire, which consists of a series of technical operations in the manufacturing process. It is essential to understand the morphological characteristics that a metal object has between the time of its design and that of its burial depending on the place where it was produced and used. The method used in this case is simple observation by eye, with which it will be possible to identify traces of use and repairs carried out. It will be possible to study the traces of artisanal manufacturing in some cases, with a binocular glass. In the case of belts, their flattened shape corresponds to the multiaxial deformation process undergone. The methods and techniques used by the craftsman modify the structure, surface and shape of the object, understanding this series of processes up to the manufacturing of the finished object will be the objective of this work. Finally, the usefulness of this work consists in identifying the regional technical peculiarities, characteristic of northern Italy, the result of different cultures: Ligurian, Golasecca, Ligurian, Venetian, Villanovan.

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Weapons and warriors between ceramics and metal, through iconography

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Keywords: *Puglia, iconography, warrious, waepons*

This research aims to analyze two armor complexes from northern Puglia, under two profiles, the first the real one in metal, the second through the iconography of warriors and weapons represented on amphorae and red-painted craters. The two complexes were found in northern Puglia and date back to the 4th century BC. They are currently preserved at the Antikemuseum in Basel and show a refinement typical of the goldsmiths of Magna Graecia. The vases also preserved at the Archaeological Museum in Basel are functional as containers of food products, they represent the ideals of the aristocracy and are characterized by the relief of one or more characters, represented inside a small temple (naiskos), in white like statues, surrounded by two or four visitors. They are typical figures and scenes: the warrior (foot soldier or knight), a son with his father, a girl. "Portraits" that correspond to social roles, characterized by shapes, clothes and objects that express the qualities of the Greek world: the splendor of yellow weapons (helmet, breastplate, shield, spear, sword) and the harmony of the proportions of young and muscular bodies, like heroes. This scenario can only enrich the social role of weapons in communities, helping us to reconstruct their value relative to their historical period. The relationship between the relations of Magna Graecia with Greece in artisanal production and in the choice of themes to be displayed will also be taken into consideration, how much influence and exchanges were there between them? The final objective of this analysis is to provide us with more informa-

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tion on the figure of the warrior and on the funerary contexts for ritual or non-ritual purposes in which they are deposited. The proposed methods on which this research is based consist of archaeometallurgical analysis and archaeometric analysis of the physical-chemical composition (Raman x-ray).

Cultural landscape dynamics - detecting landscape change in the area of high-altitude pastures of Jezera, northern Velebit mountain

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Keywords: *Velebit, dry-stone walls, cultural landscape, karst, landscape dynamics*

The Jezera meadows in northern Velebit Mountain are high-altitude pastures located at elevations between 1400 and 1480 meters above sea level, spanning an area of 2.5 square kilometers. The area of Jezera is named after the ponds found there, which were a valuable water source for seasonal herders in the dry karst landscape in the past. Jezera has never been permanently inhabited. However, the seasonal habitation of this area is confirmed by numerous dry-stone wall remains of shepherds' dwellings.
This poster presents the research results on the dynamics of changes in the cultural landscape in the Jezera area, conducted as part of the PREVENT IP-UNIZD-2023 project. Historical cadasters and historical aerial photographs were analyzed in order to interpret the dynamics of landscape change, thus providing insight into the state of the landscape over time. To determine the dynamics of landscape change, natural and cultural elements of the Jezera landscape were mapped. The dynamics of changes in these elements were determined for the period from the 19th century to the present day. The analysis of changes in the elements revealed a certain stability in the landscape and a strong connection between natural and cultural elements.

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Ancient Artistry: Exploring the Mineral Diversity in White Paste Encrusted on Chalcolithic Pottery

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Keywords: *White decoration, Chalcolithic pottery, white mineral pigments, Bulgaria, ATR-FTIR*

During the Chalcolithic period in present-day Bulgaria, one way for artisans to adorn pottery with white-colored ornamentations was to apply materials as encrustations. This study focuses on identifying the variety of minerals used to enrich and diversify the recipes of prehistoric white pigments. The mineralogical composition of 50 ceramic sherds dated to the Chalcolithic (5th mill. BC according to Bulgarian periodization) was analyzed using Fourier-transform infrared spectroscopy in attenuated total reflection mode (ATR-FTIR).

The findings reveal that calcite, enriched with various fillers and carriers, including quartz, clays, feldspars, and metal oxides, was the primary raw material used for white decoration throughout the period. The use of additional minerals such as aragonite, dolomite, gypsum, clinochlore, and hydroxyapatite shows significant innovation in decoration techniques. These materials reflect a broad understanding of their properties and a desire to experiment with new local deposits or multiple fillers.

The findings highlight the complexity and richness of Chalcolithic pottery, showcasing the artisans' expertise and their role in cultural and technological advancements. This study deepens our understanding of prehis-

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toric craftsmanship and provides insights into the social and economic interactions that facilitated the exchange of materials and ideas during this period.

Tracing Tradition: White and Red Pigments in Chalcolithic Balkan Incrustation

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Keywords: *White and Red pigments, Chalcolithic, Balkans*

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Archaeometric analyses examining the mineralogical composition of pigments reveal a standardized use of hematite for red coloring. However, variations in other ingredients suggest diverse recipes. While calcite is commonly employed in white paste, the presence of additional minerals such as dolomite, gypsum, diatomite, clinochlore, apatite, and aragonite indicates a quest for novelty among potters. These innovations reflect the spirit of exploration and cultural advancement prevalent in Chalcolithic pottery production, showcasing artisans' ingenuity and the evolving

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landscape of ancient craftsmanship. By identifying the minerals used in pigments, we gain insight into the technological and artistic capabilities of prehistoric communities, as well as their interaction with the natural environment and each other. The study highlights the complexity and sophistication of ceramic decoration in Southeast Europe during the 5th millennium BC.

Non-destructive testing application methodologies and approach on two paintings by G. Gounaropoulos

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Keywords: *paintings, ndt, Gounaropoulos, in situ*

An ongoing research is focused into the work of Greek modernist painter Giorgos Gounaropoulos (1889-1977) involving two paintings from the G. Gounaropoulos Museum collection (1), namely *Woman with fish*, 1933 (oil on hardboard, 101x82 cm) and *Vase with flowers*, 1965 (oil on canvas, 82x66 cm). The two paintings span a period of thirty years. *Woman with fish* dates from the first decade during which the artist formulated his personal style, while *Vase with flowers* belongs to his later period, when flowers and their symbolic interpretations became one of his favorite themes (2).

Gounaropoulos used to make many preparatory drawings before proceeding with oil painting, so that he had a quite clear idea about what he wanted to do. However, the current research reveals that even after all the preparatory sketches, he sometimes changed his compositions while working with oil paint on canvas or board.

The aim is to employ novel non-destructive approaches (3) to acquire information *in situ* from the paintings, without moving them from their display position inside the museum (4, 5). Postprocessing and analysis of the acquired data is expected to reveal information regarding their current condition, as also to examine them for any possible hidden information

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like changes in preparatory sketches or in the materials used. The overall effort to achieve this goal is also considered, to understand the real benefit of using non-destructive techniques in everyday practice.
Results presented reveal the outcome of the study in comparison with the effort and user-friendliness of the non-destructive techniques.

Elemental analysis of red and brown pigments in the decoration of Neolithic and Chalcolithic pottery from Bulgaria

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Keywords: *LIBS, PCA, Neolithic and Chalcolithic, decorated pottery, red and brown pigments*

At the end of the Early Neolithic, dark-colored paints—ranging from various shades of red to brown—were commonly used to decorate ceramic vessels. However, during the Chalcolithic period, the use of this painting technology declined, and red pigment inlay became the preferred decorative technique. The aim of this research is to identify the elements responsible for the various colors of the decorations. To achieve this, 35 pottery fragments from nine archaeological sites across different geographical and cultural regions of present-day Bulgaria were analyzed using Laser-Induced Breakdown Spectroscopy (LIBS) combined with the multivariate chemometric method Principal Component Analysis (PCA). This approach allows materials to be classified based on their elementary similarities and differences.

The results revealed that all the decorations contain iron, silicon, calcium, aluminum, magnesium, manganese, sodium, potassium, titanium, strontium, barium, chromium, and copper at various relative concentrations. The statistical processing of LIBS data using PCA primarily separates the fragments based on the presence of iron and manganese. This indicates that red pigments primarily consist of iron-bearing minerals, while brown

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pigments are predominantly composed of manganese-bearing minerals. However, in some fragments, the brown pigment is also derived from iron-bearing minerals, suggesting the existence of two distinct technologies for producing brown pigment.

The findings of this study offer significant benefits to archaeologists by shedding light on production techniques, origins, trade routes, and interactions between cultures during the Neolithic and Chalcolithic periods.

Whispers of the Palace: The Journey of Split's Hotels from Heart to Horizon

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Keywords: *Split, hotels, radial architecture expansion, center-periphery, GIS*

The location, design, and planning of hotel and resort architecture have been influenced by the advent of organized tourism and the creation of an urban habitus. New lifestyles, demographic structures, and cultural and social conditions in the Split area have reciprocally impacted the style, form, and function of architecture, with changes traceable from the late 19th century through modernization and up to the emergence and growth of mass tourism after the 1990s.

The connection of Dalmatia, including Split, to Central Europe by sea in the 19th century accelerated the exchange of goods and ideas, laying the groundwork for the influx of visitors. Additionally, archaeological research conducted in Diocletian's Palace was presented to the world by Robert Adam through his publication, thereby capturing the interest of both the professional and cultural public. Besides foreign researchers, local scholars like Vicko Andrić, Don Frane Bulić, and Ljubo Karaman played crucial roles in the conservation field and influenced the life within and around the palace.

In this early tourism atmosphere, necessary accommodation facilities, hotels and resorts, emerged within the cultural monument itself, in the heart of Diocletian's Palace. This integration allowed new tourists to immerse themselves in the historical and cultural heritage of the city and its surroundings. Subsequent urbanization, sociocultural developments, changes in legislation, and shifts in conservation perspectives led to the

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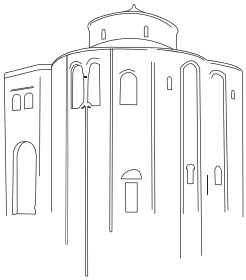
relocation of hotel and resort units to the city's periphery after the mid-20th century. By hypothesizing a connection between the time of construction and the architectural location with specific architectural expressions, it is possible to identify various programs, types, design determinants, and relationships with the built environment within the given spatial and temporal framework.

Using a Geographic Information System (GIS), a detailed spatial database was created, encompassing the temporal and spatial dynamics of tourist construction in the narrower and broader Split area. Spatial analyses delineated different construction zones, confirming the hypothesis of a radial expansion pattern of architecture from the center to the periphery. The applied methodology enabled precise tracking of the development of Split's tourist infrastructure and established a foundation for future research.



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