08TH INTERNATIONAL SCIENTIFIC CONFERENCE

METHODOLOGY & ARCHAEOMETRY

Zagreb, 3rd – 4th December 2020

09TH INTERNATIONAL SCIENTIFIC CONFERENCE

METHODOLOGY & ARCHAEOMETRY

Zagreb, 2nd – 3rd December 2021

PROCEEDINGS

FROM THE 8TH AND 9TH SCIENTIFIC CONFERENCE METHODOLOGY AND ARCHAEOMETRY

ISSN 2718-2916

IMPRESSUM

PUBLISHER
Faculty of Humanities and Social Sciences, University of Zagreb

FOR THE PUBLISHER
Domagoj Tončinić

DESIGN & DTP
Srećko Škrinjarić

All papers were reviewed in the peer review process in which the identity of both reviewers and authors, as well as their institutions, are respectfully concealed from both parties.

DOI
https://doi.org/10.17234/METARH.2022

ISSN 2718-2916
Faculty of Humanities and Social Sciences of the University of Zagreb

URL
https://openbooks.ffzg.unizg.hr/index.php/FFpress/catalog/series/MetArh
http://www.ffzg.unizg.hr/metarh/

Publishing of this e-book is supported by
Ministry of Science and Education of the Republic of Croatia

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Content

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MetArh

Preface

Ina Miloglav

https://doi.org/10.17234/METARH.2022.01

Methodology and Archaeometry (*MetArh*) is an annual scientific conference organized since 2013 by the Department of Archaeology of the Faculty of Humanities and Social Sciences of the University of Zagreb, and the Croatian Archaeological Society.

The goal of the conference is to entice interdisciplinarity, critical thinking, new insights and approaches as well as new theoretical frameworks in contemporary archaeological science. It offers a wider perspective in observing methodology and methodological practices, also challenging traditional approaches in archaeological research, and following the creative adaptation of methods from other disciplines into archaeology. Also, it enables scholars to present their work, engage in discussion and motivate young scholars and archaeology students to pursue contemporary topics and present their research.

This edition of the conference *Proceedings* contains twelve papers from the 8th and 9th *MetArh* conference which was held at the Faculty of Humanities and Social Sciences of the University of Zagreb. The 8th *MetArh* conference was held from 3rd – 4th of December 2020, and the 9th from 2nd – 3rd of December 2021 (https://metarh.ffzg.unizg.hr/).

Due to COVID-19, both conferences were held on the online platform Hopin.to. It was very challenging to organize and realize the conference in a virtual format but, most importantly, it produced high-quality works some of which are published in this publication. Papers in this volume are focused on different aspects of archaeological methodology and archaeometry, including case studies from Croatia, Slovenia, Serbia and Ukraine.

I would like to thank all the authors, reviewers and editorial board for their contribution to this volume of the *Proceedings.*

New Considerations on Spatial Analysis in the Research of Early Medieval Landscape: the Case Study of Bale region in Istria (Croatia)

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https://doi.org/10.17234/METARH.2022.02

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The results of the archaeological research of the monastery complex of St Mary the Great near Bale in Istria (Croatia) have greatly contributed to our understanding of the Frankish expansion along the Istrian peninsula at the end of the 8th century. A quarter of a century of the research has been followed by the evolution of research and documentation methodology. In the recent period, the team has been more intensively focused on the archaeological interpretation of the surrounding region in the context of landscape archaeology, and the study of the research potential of various historical cartographic sources for future archaeological research. Although the area of the research is geographically limited, such perspective permits us to reconstruct the original features of the landscape which have persisted in the landscape and have formed a medieval spatial network of the area between the monastery of St Mary the Great and Bale settlement. The objective of this paper is to present the results of spatial analysis of this area carried out at two levels - macro and micro - through the use of geographic information systems, as well as to discuss the research possibilities offered by the ever-growing datafication of the various cartographic material.

Keywords: *historical landscape, landscape archaeology, spatial analysis, Istria, St Mary the Great, centuriation, Early Middle Ages*

Introduction

The monastery complex of Saint Mary the Great (Sveta Marija Velika, Fig. 1) near Bale in Istria is an archaeological site which has greatly contributed to our understanding of the Frankish expansion along the Istrian peninsula at the end of the 8th century (Jurković et al. 2008; Jurković and Caillet 2008; Jurković et al. 2009; Jurković and Caillet 2011). A quarter of a century of systematic research, led by the International Research Center for Late Antiquity and Middle Ages (IRCLAMA – University of Zagreb) and its director Miljenko Jurković, has been closely followed by the evolution of research and documentation methodology.

Figure 1. Monastery complex of St Mary the Great near Bale, aerial photo. (Photo: I. Kranjec).

The long-lasting and complex workflow of the research of such a significant site can be divided into three main phases. After the completion of the excavation of the early medieval church (atop of which today stands the late 18th century building) with extraordinary finds of early medieval sculpture, the team has turned its attention to the research and the immediate conservation of the quadrangular outer perimeter of the monastery complex, as well as the monastery chapel located in its southwestern part. With the second phase of the research having been almost finished, the preparations for the execution of the final stage - that is, the research of the interior of the monastery complex (the cloister and the interior of the buildings) - began in 2019. However, due to global circumstances the research team had to reorganize its research strategy, and, instead of field excavation, started a revised and more profound study of the monument's position in the context of the archaeological landscape, as well as the study of the survived surrounding spatial features which could be dated to the medieval, or even earlier periods. A more complete understanding of the spatial context of the monastery complex would most certainly expand our knowledge of the role the monastery had in the medieval period in Istria and could even contribute to the comprehension of the historical transformations of the Istrian landscape in general.

This paper will present the results of the archaeological interpretation of the surroundings of the monastery complex and the area around the historical settlement of Bale, realized primarily through the desk-based spatial analysis using geographic information system (henceforth GIS) where numerous cartographic sources (historical and contemporary) were analysed and compared with archive data and spatial data acquired in the field. The main objective of the archaeological interpretation is to examine if the selected sources are dependable enough to draw conclusions relevant for further archaeological research of the site and the surrounding area, and if it is possible to reconstruct some features of the landscape which have persisted and have formed a medieval spatial network of the area between the monastery of St Mary the Great and Bale settlement.

Theory: Approaches to the study of Istrian landscape

More than a century of extensive studies of the Istrian landscape have helped the process of a slow transition from a site-oriented approach towards a contemporary post-processual landscape-oriented approach (Novaković 2008: 39-40; Campana and Piro 2009). In the recent period, more and more scientific initiatives implement state-of-the-art technological tools which speed up the processes of documentation, analysis, and interpretation of the historical features of the landscape. Together with the contemporary practices in archaeological and spatial data organization and analysis, advanced trends in spatial data acquisition, such as the use of LiDAR data (although it could be argued that in 2022 it is far from new; for more, see Štular 2022: 111-114), are also being followed in the research of Istrian archaeological sites (Čučković 2015; Matijašić and Gerometta 2018; Bernardini and Vinci 2020; Popović et al. 2021). Such technological tools for 3D spatial data acquisition, which are yet to be implemented in the research of the area surrounding the monastery, offer us data of outstanding precision and objectivity, so much in fact that they have already transformed the field of landscape archaeology.

Aware of the fact that this is not the place to enter deeply into the explanation of each of the methods used in the field of landscape archaeology, it is our intention to mention several methods that were considered and used in our research, but also some of the methods that are to be applied in the future (more on the question of the contemporary methods and approaches see in Kluiving and Guttmann-Bond 2012; Remondino and Campana 2014; Kokalj et al. 2018; Gillings et al. 2019; Howard et al. 2019; Harvey and Wilkinson 2019; McKeague et al. 2019). The question of scale has been present in the discourse of landscape archaeology from the mid-20th century when the well-known concept of the basic levels of scale: 'macro', 'semi-micro' and 'micro' was thoroughly explained by D. L. Clarke (1977: 9-15) and then complemented in the following decades (see Campana 2009: 5-7). Each of the scale perspectives carries its own wide range of survey methods and technologies, from the aerial photography (both vertical and oblique), satellite imagery and airborne scanning (including today's almost indispensable multispectral and LiDAR data acquisition) to the more 'down to earth' methods such as the non-invasive geophysical methods and the more traditional surface collection survey but also the invasive ones, much needed when the (non)visibility conditions do not allow any other method and/or when it is necessary to better understand the studied material and its immediate spatial context. In our case, the usage of aerial photography is of exceptional value, especially when we are able to compare historical and recent datasets. Furthermore, both aerial and terrestrial photography allows us to continue with the photogrammetric processes accompanied by 3D modelling and the reconstruction of the studied materials. In the latter case (if not always) it is necessary to establish and understand the final objective, the purpose of the survey which consequently determines the scale level.

It is important to point out that in the case of the monastery of St Mary, traditional methods such as field survey could have not been fully implemented until very recently due to the fact that the majority of the surrounding terrain has been completely covered with very dense vegetation. The millennia-old forms, landscape patterns and features, which had shaped our perception of the traditional agricultural Mediterranean landscape, have been hidden by the dense vegetation during the period of the abandonment of traditional agricultural activities in the last decades of the 20th century, which is a phenomenon typical for the Adriatic and wider Mediterranean region. (Gams and Gabrovec 1999; Aničić and Perica 2003; Serra et al. 2008; Walsh 2013; Quintas-Soriano et al. 2022). Together with arable land, pastures and karstic ponds (*krške lokve* in Croatian), which served as the main agricultural resources of the area, a variety of man-made features have also been hidden under the vegetation canopy. The logical step in the continuation of the research would be the engagement of the LiDAR in order to document what is now undetectable. However (and while awaiting the results of the extensive LiDAR survey of the territory of Croatia) it is often that we tend to disregard other widely available sources which, albeit much more limited, can also be very helpful in the study of landscape and its historical transformations.

In the previous research which has been trying to define the traces of historical sites and infrastructure ramification of Northern Adriatic region, a systematic and comparative study of historical and contemporary cartographic material through the GIS platform has demonstrated its usefulness and has provided excellent results (Jurković 2019; Kranjec 2021). It is why we have decided to present the results of the implementation of a similar method here, on the case study of the Bale region, with a focus on the research potential of the use of 19th century cartographic material. While the use of contemporary base maps is obvious, as well as the use of archaeological documentation, the question if historical elements of the landscape, some of which have survived in their traces for more than two millennia, could be observed through the prism of historical cartography - and observed with a level of relevance sufficient enough for the contemporary study of archaeological landscape - may seem challenging at first. For a successful interpretation of cartographic content, it is also necessary to be able to decode meanings, methods and norms which the cartographer followed and respected in his intention to represent physical space (Hodgkiss 1981; De Silva and Pizziolo 2004). Yet the limitations of the time when such sources were made - for example, the lack of planimetric precision, insufficient scaling or a substantial lack of geographical content - often limit our possibilities to analyse smaller elements of landscape, much needed in order to understand delicate long-lasting transformations of space. The answer to this question lies in a systematic quantitative and qualitative assessment of the cartographic content.

It is important to emphasize that the novelty of such an approach does not derive from the use of the historical material itself. Numerous researchers from different disciplines have already included it in their research, even before the cartographic content was digitised and made available to the public through various online services (for example Štular 2010; Slukan Altić 2016; Zupanc 2020). Yet there is a difference which we would like to point out, generated by the omnipresent processes of digital transformation in humanities. It is the depth of analysis of the historical material, as well as the wide array of materials used (digitised sources, spatial and attribute data), which has been made possible through the use of digital tools. Furthermore, it is the relatively recent large-scale datafication of the material itself which offers new possibilities and makes the research process much more efficient.

Methodology

A significant portion of research work carried out in the period 2020-2022 was based on the archaeological interpretation (for a detailed definition see Lozić and Štular 2021) and the desk-based assessment of the available cartographic and other sources. The main difference from the study carried out during the initial stages of the research of the site in the 1990s is the sheer availability of different data, as well as the fact that the material has been digitised and is ready to be computer processed. The first step of the archaeological interpretation carried out during the most recent research period was the integration of all available data sources in GIS (QGIS 3.16-3.22). The data used for analysis was based on the assessment of the possible information it could offer for the realization of the other objective of the work, which is the valuation of the research potential for future archaeological work. The data used for the research presented here can be divided into following groups:

1) Contemporary cartographic sources: contemporary topographic map (*TK25*, scale 1:25000); Croatian base map (*HOK*, scale 1:5000);

2) Digital orthophotos of Croatia: digital orthophoto from 2018 (*DOF5*, scale 1:5000); historic orthophoto from 1950-1968, digitised by the State Geodetic Administration of the Republic of Croatia (*DOF68*, scale 1:5000);

3) Digital elevation data: STRM (NASA *Shuttle Radar Topography Mission*) v3 30m dataset; EU-DEM v1.1 digital surface model dataset;

4) Contemporary Croatian cadastral map;

5) Historical cartographic sources: topographical map of the 2nd Military Survey of the Habsburg Empire (*Franziszeische Landesaufnahme*, scale 1:28800) available through the Mapire.eu portal (Biszak et al. 2017: 204-208); cadastral map of the 2nd Military Survey (scale 1:2880, see footnote in chapter 4.3);

6) Digital orthophotos and digital elevation models of the monastery complex made from aerial and terrestrial photogrammetry in the period 2014-2022;

7) Digitised planimetry of the St Mary the Great archaeological site (1995-2019);

8) Roman centuriation schematics (after Bulić 2012; Bernardini and Vinci 2020; Popović *et al.* 2021).

The data integration served as a basis for interpretative mapping of various spatial features that could be detected from the cartographic sources from the 19th to the 21st century. This 'spatio-temporal' dimension (to cite the phrase of Eduardo Boria; see Boria 2012) spanning across two centuries must be taken into account because their comparison can demonstrate the extent of the transformations the area has survived since the beginning of the 19th century. The appearance and position of the digitised spatial features would then be compared to known historical and archaeological data so that any eventual patterns of spatial distribution could be detected and interpreted. This interpretation is the final step of our research. In order to achieve that objective, four main categories of spatial features were to be analysed: 1. built objects documented on maps (sacral and housing objects, objects for various economic purposes); 2.

communication lines (roads, pathways etc.) and linear structures (drywalls, field boundaries); 3. areas of exploitation (fields, pastures, forested areas, built areas); 4. various other points of interest (e.g. water sources).

It is important to emphasize the different scales used in the analysis. The broadest, macro perspective would focus on the entire wider southern part of the Istrian peninsula, where the general positioning of the sites in the landscape can be observed (e.g., in relation to the general morphology of the terrain, coastline, main communication lines etc.). The second scale of the study aims at the smaller area from the western surroundings of the monastery to the area east of Bale settlement. The second, micro scale, takes into account more direct relations between various spatial features, such as the relation of a single object in the landscape - in the case of this paper the monastery (with a total area of around 2500 m2) - with its immediate surroundings.

Discussion

The work will be presented through three specific research questions, all of which follow the basic premise of multi-scaled perception of space through digitised cartography.

Accuracy assessment of the 19^th^ century topographical maps

The geopolitical importance of the Istrian peninsula has secured its continuous inclusion in relevant cartographic works throughout history, from the earliest known classical sources to the later medieval, early modern and modern accomplishments (Altić 2013; Kozličić 2005). However, it was not until the second half of the 18th century when the first systematically applied topographical survey with an established mathematical basis was carried out. It is the First Military Survey of the Habsburg Empire (the *Josephine* survey) which has resulted in the production of detailed topographical maps in scale 1:28800. The scale was based on historical Austrian measurement units, *zoll* and *klafter* (1 *zoll*, or 2.63 cm : 400 Austrian *klafters*, or 758.6 m, which corresponds to the metric scale of 1:28800; Slukan Altić 2003: 144). The maps featured an unprecedented level of detail of geographical content. However, because of their mathematical deviation, a direct comparison of the historical and contemporary content is significantly limited.

Precisely because of the lack of precision, the Habsburg Empire conducted the Second Military Survey (the *Franciscan* survey) at the beginning of the 19th century, which was finished in 1869 (Slukan Altić 2003; Timar et al. 2006). It resulted in two outputs of great value for our research. New, much more precise topographical maps were created, respecting the same scale. The sheets covered all the territory of the then-Empire, and for the first time, the entire area of the Istrian peninsula has been included in the survey (Slukan Altić 2003; Timar et al. 2006). The scale let the surveyors show the majority of important housing, sacral or public structures. The road network has not only been shown, but it included the categorization of land communications. Basic categorization of vegetation has also been applied (forests, cultivated fields and grasslands, even the boundaries of agricultural parcels). The relatively precise terrain imaging was done through the method of hatching. Another useful feature is the extensive toponymic content, sometimes referring to objects which today are not known.

Because of the precision and the quality of the geographic content, a single Franciscan topographical map sheet was chosen in order to study if the geographical content documented in the 19th century could be relevant and precise enough for a contemporary spatial analysis of the area and the definition of archaeologically significant spatial features in the landscape. The chosen map sheet *Königreich Illyrien, Küstenland, Istrianer Kreis. Section N16 Colonne NIV* (as stated on the sheet) was made in the period 1821-1824 (the exact year of production has not been written). It measures 63x42 cm (24x16 *zoll*) and shows an area of around 210 km^2 in scale 1:28800. **(Fig. 2)** The fact that the settlement of Bale is positioned at the very centre of a map sheet showed to be very convenient for the research.

The first step was to assess its geographical relevance by conducting a quantitative analysis of specific features which are expected to be seen both in the landscape and to be depicted on the map. Churches were chosen as the most prominent landmarks of the 19th century rural landscape. The digitised sheet was rectified and georeferenced in the Croatian HTRS96 coordinate reference system, using the coordinates already available via map browser on the *Mapire* online platform (for an alternative approach, see Štular 2010: 88). Finally, it was inspected visually so all the symbols which depicted churches could be found, vectorized and joined with attribute data (17 categories in total, so the later classification could be carried out).

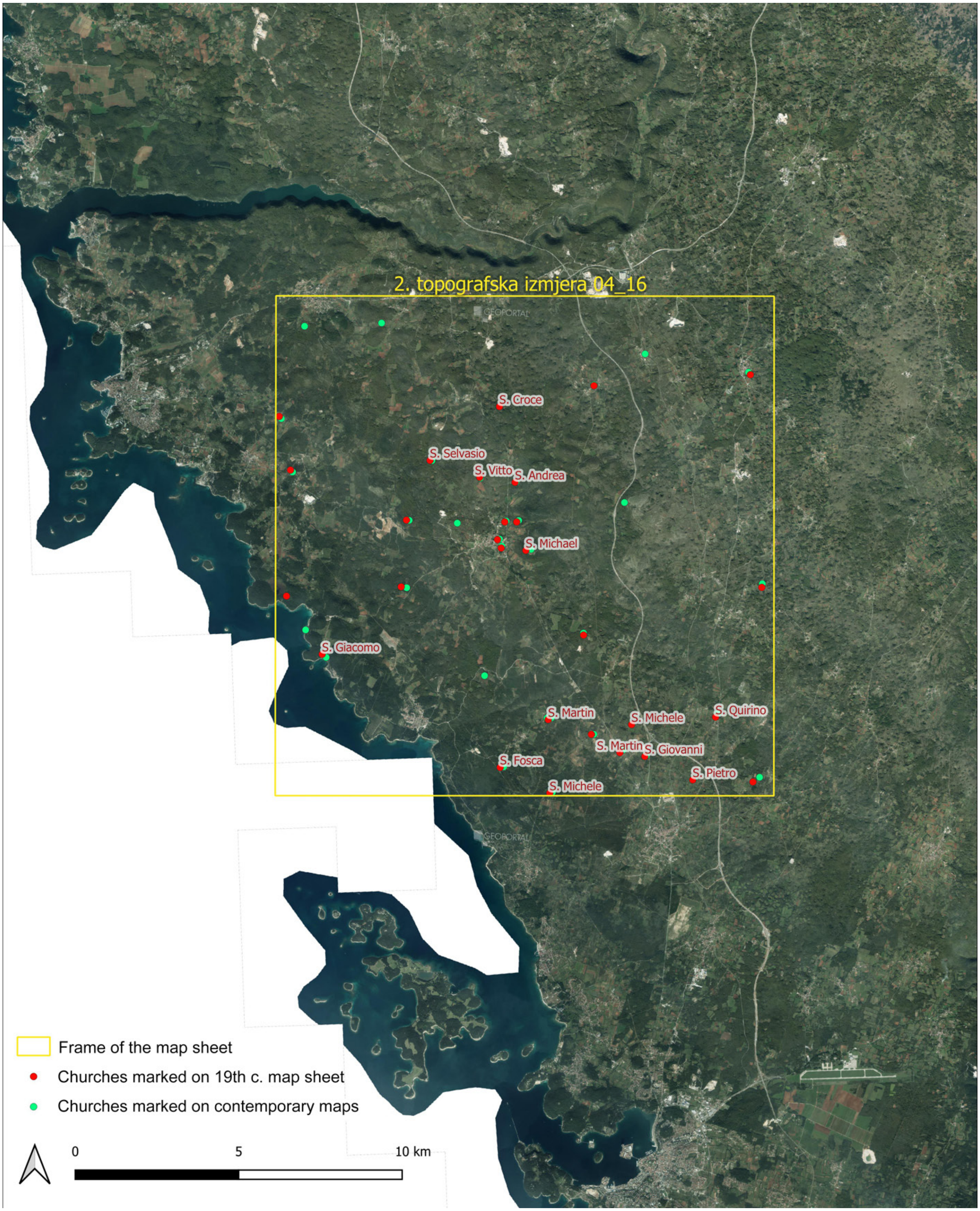

Figure 2. Area of research (step 1). Frame of digitized 19th century topographical map sheet.

Figure 3. Examples of church symbols found on 19th century topographical map sheet

This has resulted in finding 32 churches clearly documented in the 19th century on a single sheet. As opposed to the later cartographic achievements, the maps of the 2nd survey still feature a certain level of subjectivity (or a lack of uniformity?) which is shown by the heterogenous depiction of church symbols. (Fig. 3) There are different interpretations of this problem, such as the methodology of the original survey, state of preservation of built objects and their possible use, subjective interpretation of the situation in the field of specific surveyors and/or information the surveyors were given by some local informants. It is important to have in mind the key fact that the central interest of the 19th-century surveyors were features which could be useful for military purposes. Only the features which were important for the movement and the offensive or defensive actions of the army troops have been precisely surveyed and mapped, as opposed to the other contextual landscape features and subjective additions (Štular 2010: 87). Furthermore, names standing beside the positions of the church (15 of them on the map sheet) - could imply whether the church was in use or recognized by the people then as a place of cult. If we compare the documented sacral sites to the ones presented in the contemporary cartographic sources, we find that the geographic content is indeed relevant enough. The contemporary maps show only 7 more or 39 churches in total. With the presumption that all of them were in some form standing there 200 years ago, this shows that 82% of today's known sacral objects were documented by the old cartographers. Even more interesting is the precision of their accomplishment. If we simply calculate the average distance of the location of the churches documented in the 19th century from their real positions, we come to a median of 103 metres. In some cases (e.g., church of St Eliseus in Krmed), the error measures only around 30 meters which is precise enough to be able to consider these maps as a relatively reliable source for a field study.

Analysis of the road network

Having established from the analysis of the depiction of sacral objects that the information provided by the 19th century sheet indeed corresponds to the contemporary sources to a great extent, it was possible to move to the next, scaled-down and more precise step in the research. The objective here was to investigate the credibility of the land communication network and to compare the geographical content of the old maps with the contemporary ones so the rate of the transformation of the rural landscape around Bale could be established. For this purpose, a smaller rectangular area of research was established, measuring 11 km^2. (Fig. 4) As opposed to single points in the landscape from the first step (churches), the communication lines serve as both physical and symbolical links between places of activities, areas of interest, even societies (here the term "line" encompasses both roads and routes, even "corridors of movement"; for the differentiation, see e.g. van Lanen et al. 2018: 1038). The understanding of the development of such lines of movement across the landscape can be of great benefit for our understanding of the historical transformations of the society in general since they are a direct reflection of individual and communal practices and are directly related to the physical places of human activities.

Here as well the study started with the vectorization of the features of interest on the topographical map sheet (*Section N16 Colonne NIV*, see the previous chapter), i.e. the land communication lines. It was possible to digit-

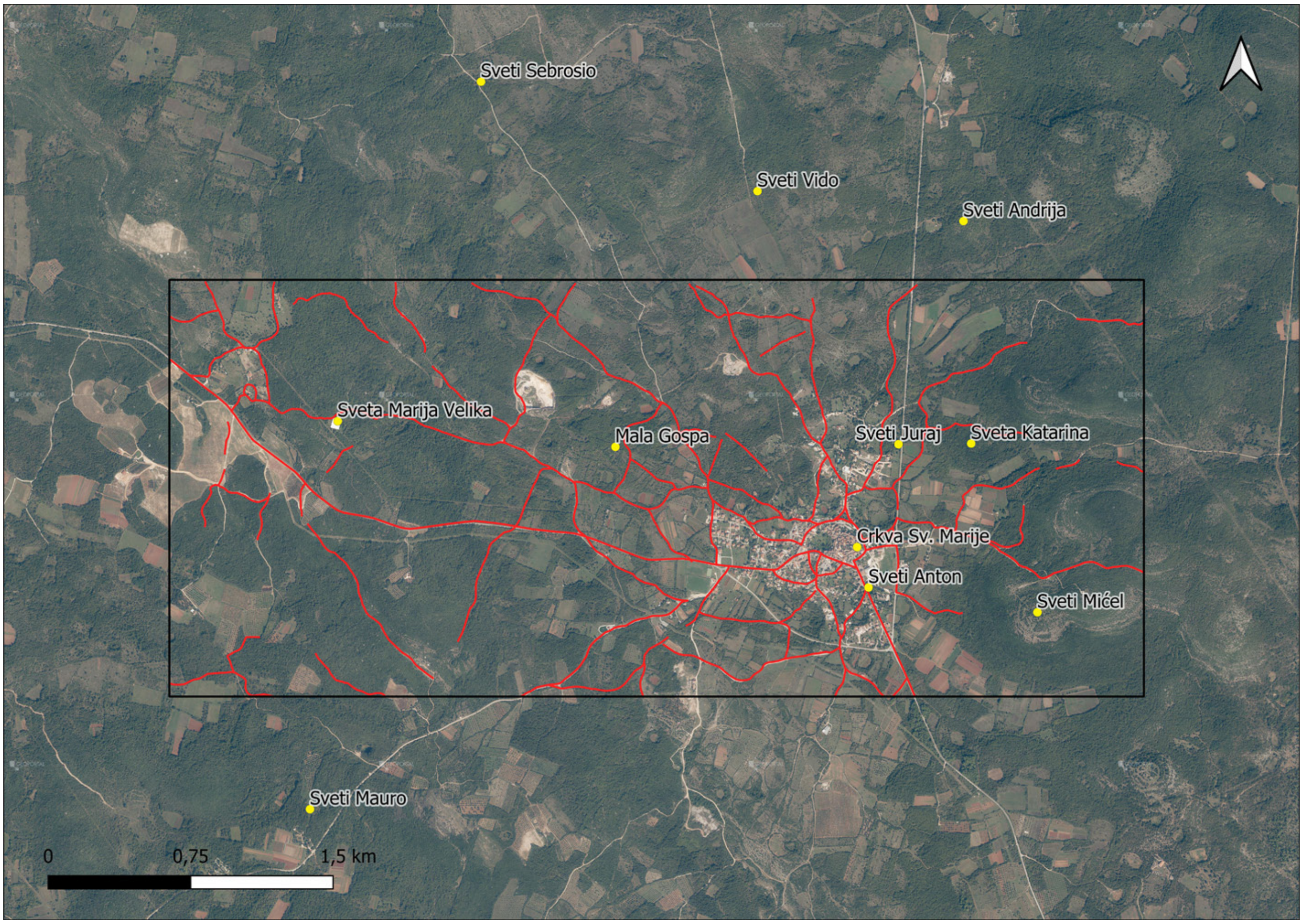

Figure 4. Area of research (step 2). Road network from 1968 ortho marked in red. Base map: ©DGU RH.

ise a total of 45.9 km of communication lines - paved roads, dirt roads, field trails etc. The depiction offers the possibility of differentiating types of roads according to their state and width. Since one of the main purposes of the topographical survey was its use in the military, such insisting on the precise depiction of possible corridors of military movement does not surprise. (Slukan Altić 2003: 181) The next step was to try and recognize the same roads, or paths, on the contemporary available map sources. However, since the flourishing vegetation is a phenomenon characteristic for the recent period of the last 50 years or so due to the abandonment of traditional agricultural activities, the orthophoto image used for the direct comparison of the land communication network was not the contemporary one (*DOF5*), but the one produced from 1950 to 1968 in scale 1:5000 (*DOF68*), which shows the state of the landscape before the transformations of the 20th century. The main objective of this step was to confirm how much of the paths documented in the 19th century could be recognized on the orthoimage from the 20th century. Digitised road network extracted from the black and white orthoimage shows almost 42 kilometres of roads and paths, which overlap with the 19th century ones rather precisely, with a medium error of some 75-100 metres. (Fig. 5) The fact that in the second half of the 20th century it was still possible to follow over 90% of the roads visible on the 19th century maps confirms the assumption about the minimal changes of the rural landscape which have occurred in that period of time. Most of the roads can be traced down easily, by following then-existing dirt roads or the modernised ones, but sometimes it is possible to track the historical road only when it is indicated by vegetation or a drywall. During the process, some distinguishable archaeological features, such as the immediately recognizable concentric structures of Istrian hillforts, could be followed to a

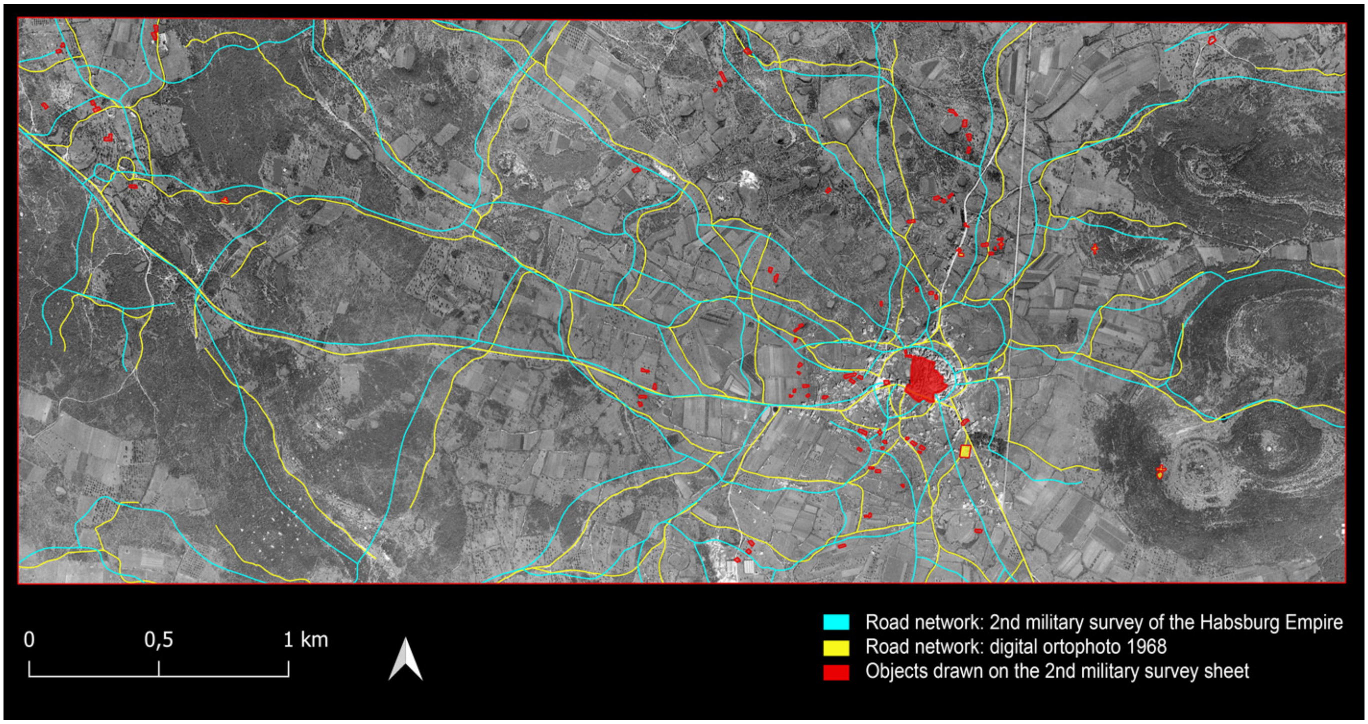

Figure 5. Comparison of digitized land communication lines. Base map: ©DGU RH.

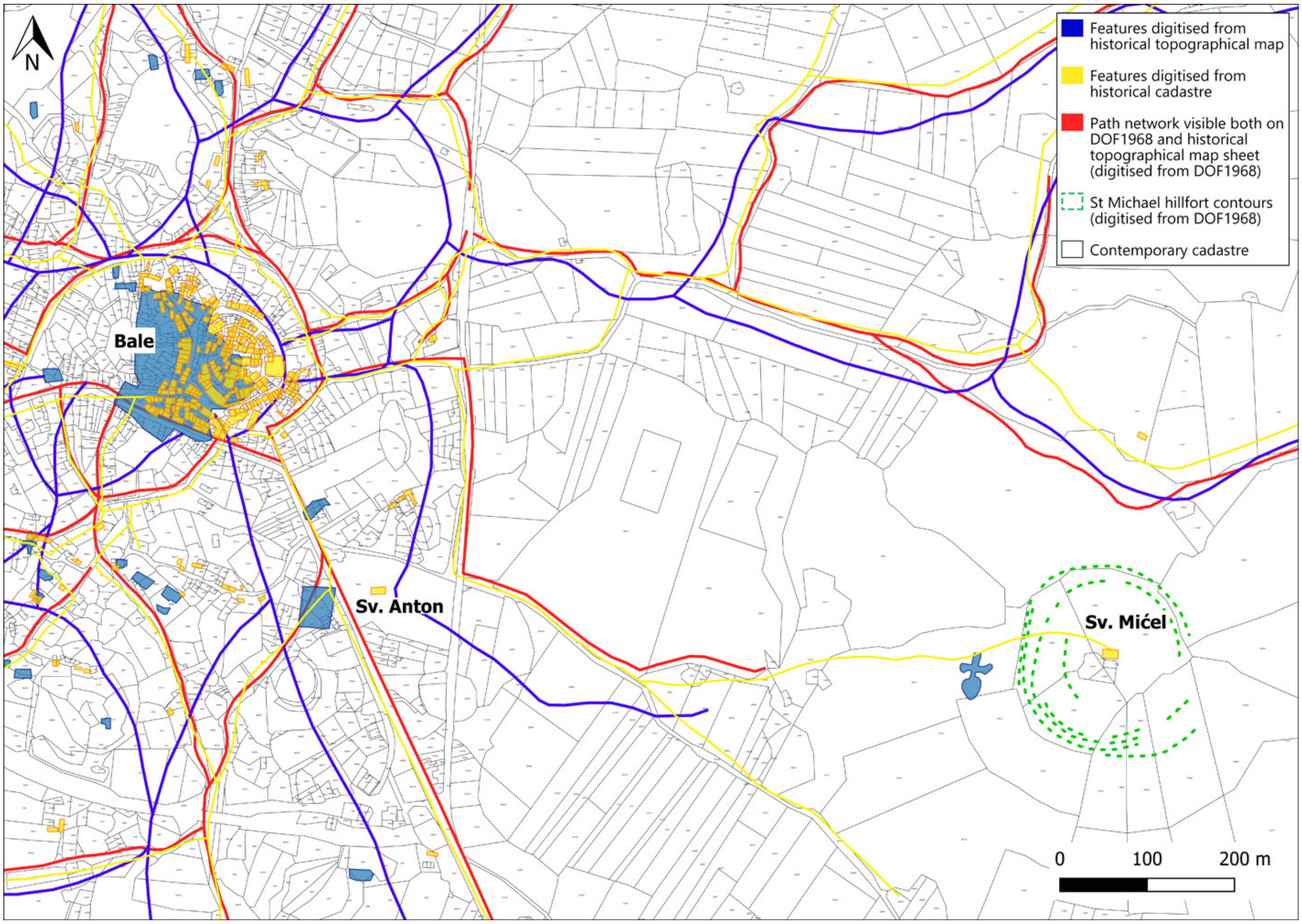

Figure 6. Comparison of road network and other digitized features east of Bale settlement.

great measure on a historical orthophoto (see the example of the St Michael/Sv. Mićel hill east of Bale, Fig. 6). However, it was possible to recognize only 65% of the same 19th-century network on the contemporary orthophotos (and only after the comparison with the 1968 orthoimages). The same applies for other Croatian base maps, such as topographical map 1:25000 where a great number of old communication lines can be followed only partially or following the basic land division (by drywalls for example). In some cases, such as in the area around St Vitus and St Andrew north of Bale, this historical network has completely disappeared in the last 50 years, as well as the original spatial context of these medieval churches.

Spatial analysis of the area surrounding Bale

The final and the most comprehensive phase included the results of the previous two steps, as well as the analysis of the additional geographic material. It is the second great accomplishment of the 2nd survey – a detailed cadastral layout in the scale 1:2880, started in 1817 (Slukan Altić 2001; Altić 2021). Although the geographical relevance of the topographical sheet has already been presented, its scale does not permit the depiction of the smallest features which hide a great potential for archaeological research. That is why cadastral sheets were used for a more detailed analysis of the spatial features in the area between the monastery of St Mary the Great, the settlement of Bale and the hill of St Michael east of Bale.[1] The preliminary comparison of the two sources shows the difference between the quantity of the geographical content which could be digitised: inside the rectangular area of research measuring 11 km^2, a total of 78 buildings outside the Bale settlement could be distinguished on the topographical sheet (the depiction of the urban raster is not adequate due to the scale). The cadastre shows a total of 384 buildings (240 in Bale, 144 outside its urban perimeter). Furthermore, a total length of land communication lines which could be digitised from the historical cadastre measures 50.55 km, and the length of the lines from the topographical sheet measures 45.9 km. This is, however, yet another confirmation that the two sources were created with different objectives in mind, and that any attempt of analysis - especially a direct comparative one – should not overlook the original context of their creation.[2]

While the previous two examples of the analysis were based on the quantitative approach, where the results served primarily for the confirmation of the quality of the sources, in this final phase a qualitative interpretation of the spatial features, their organization and distribution took place. Here the central question concerned the relation between the known archaeological sites and historical buildings (primarily churches and Bale settlement), road network, land division and the morphology of the terrain. But before such consideration could take place, it was needed to introduce another vital element into the equation – our understanding of the Roman centuriation system, which has, in many ways, formed the practices of land exploitation until today. The question of the Roman centuriation in Istria has been dealt with by a number of prominent scholars (Matijašić 1988; Starac 2000; Marchiori 2009; Bulić 2012; Bernardini and Vinci 2020; Popović et al. 2021), and we are still reconstructing the network of the land division which has transformed the previous life centred around the hillforts. Although the centuriation scheme has been partially reconstructed (Bernardini and Vinci 2020; Popović et al. 2021) (Fig. 7), the observation of all the input data from our research and the relation between the detected spatial features and the morphology of the terrain shows some interesting details which have not been interpreted so far.

The simultaneous implementation of the macro perspective (in this case, the consideration of the whole Istrian centuriation scheme) and micro perspective (the analysis of single isolated objects) offers us the possibility to reach some new conclusions, or at least to open new questions for future research. The first one is related to the position of the monastery complex of St Mary the Great. It stands on the road that connects Bale settlement with the town of Rovinj, located at about 110

[1] The sheets from the 2nd survey of the southern and central Istria are stored in the Archivio di Stato di Trieste (Trieste, Italy) and are available via the *Arianna4View* web application. The area of research was covered by a total of 8 cadastral sheets from the *Mappa catastale del Comune di Valle d'Istria* folder (names as stated in the online archive): *foglio XVIII, sezione XIX*; *foglio XIX, sezione XX*; *foglio XX, sezione XXI*; *foglio XXI, sezione XXII*; *foglio XXV, sezione XXVII*; *foglio XXVI, sezione XXVIII*; *foglio XXVII, sezione XXIX* and *foglio XXVIII, sezione XXX*.

[2] We would like to thank the reviewers for this, and all the other suggestions and comments which helped to improve the paper.

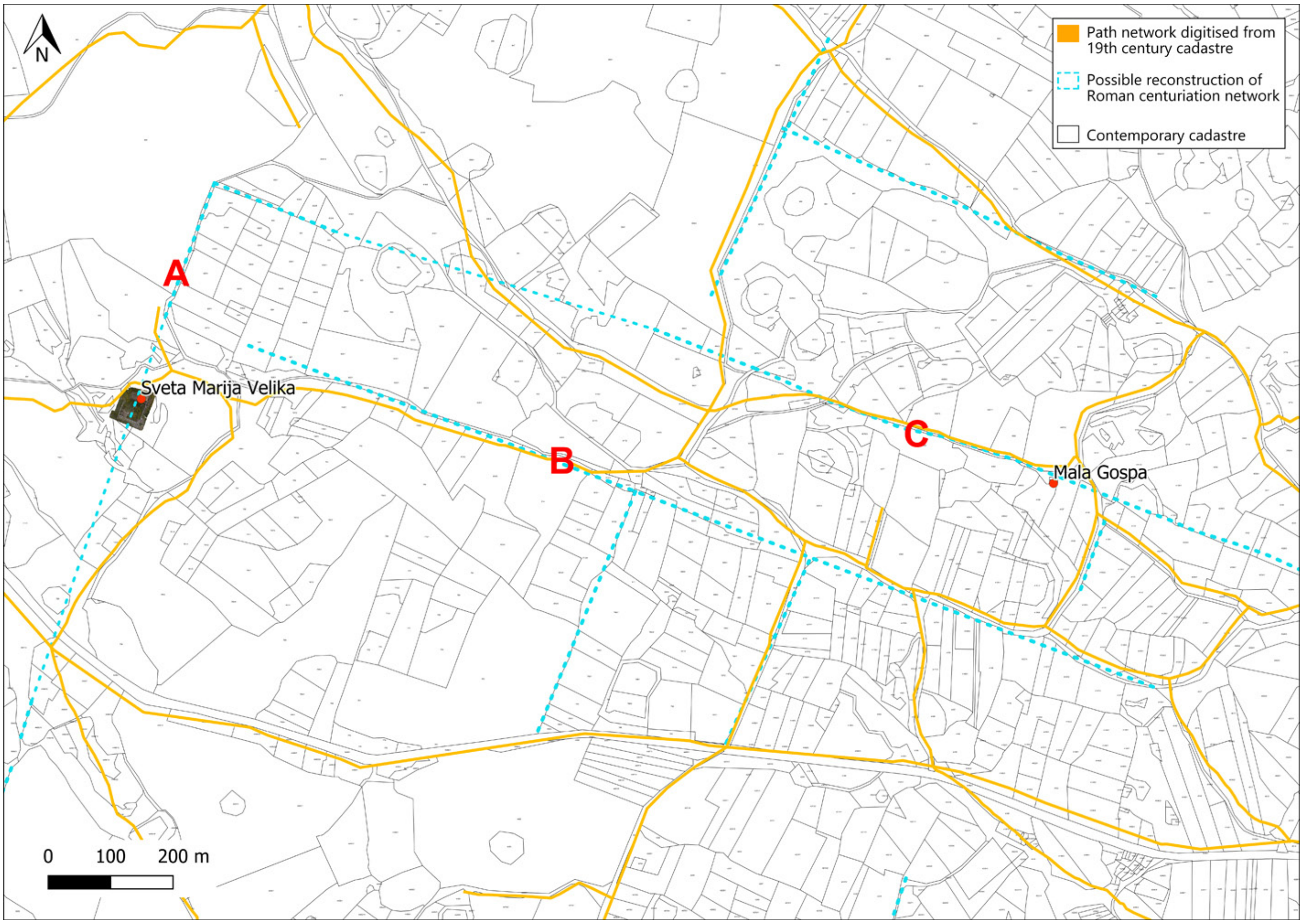

Figure 7. Possible Roman centuriation west of Bale settlement.

metres above sea level, on a gentle slope of the hill from which the view today reaches to a 4 kilometres distant coast over olive groves. The questions and the reflections that the research of this site posed in many ways marked the shift in Croatian art history from traditional notions and understandings of the profession and heritage. Since our knowledge about the early medieval monastery complexes in Istria is still very scarce, thus the greater the importance of the site of St Mary the Great actually is. There is no doubt that the control of the surrounding territory from this complex was easily achievable. Furthermore, the continuity of the site since Roman times was proved by the findings of the walls and tesserae of mosaics preceding the construction of the church and monastery. During the early medieval period, the Monastery of St Mary the Great was just one of a series of monasteries that complemented the Carolingian network of checkpoints in the area. These points, at least judging by the current state of research, consisted primarily of fortified settlements, monasteries and the estates of the newly established elites.

However, although its prominent role in the strategic control of the surrounding territory is well known (Jurković et al. 2008: 137-138; Behaim 2021: 110-111, 148-150), it is interesting to see how the monastery has positioned itself directly on the border between *centuriae*. (Fig. 7) This relation between the early medieval structures and the much older general land division scheme still has much to offer in the context of our understanding of how the monastery – the only early medieval monastery which has been systematically studied - functioned and what was the area it directly affected. The Roman foundations (cistern and other structures preserved only in their foundations, see Jurković and Caillet 2011: 128), as well as the Early Medieval church and the structures of the monastery also follow the basic orientation of the centuriation (at least to some extent in the case of the outer wall of the monastery). We can only presume the organization of this (for now imaginary) Roman complex, but the gentle slopes falling towards the southwest and the coastline (the terrain on the north rises gently to the hill Dorine) suggest that this would be the perfect area for cultivation. Another argument which could speak in favour of the existence of a Roman complex located next to the border of the estate is a crossroad near the church which has, until very recently, been visible only on the historical cartographic sources. Its northern section (marked 'A') could continue to follow one of the *cardo* lines to the north, and go directly towards the church named *S. Selvasio* on the 19th century topographical map. The continuation of its eastern section ('B') can be followed towards the settlement of Bale. Approximately 260 meters north of this lost path section (*decumano*?) lies a perfectly parallel line ('C'), which should be attributed to another line of Roman division. Another medieval church, St Mary the Little (Sv. Marija Mala, or Mala Gospa) is located along this line, with its rectangular layout closely following its orientation. The line C, visible either as a field path or a parcel division, stretches almost to the settlement. This western zone of the settlement hides yet another medieval church - St Elijah (Sv. Ilija) - with the easily recognizable façade bell tower. Its position also speaks in favour of the importance of the western entrance to the settlement, and the historical route towards Rovinj.

Without a proper archaeological excavation, all of these assumptions can not be confirmed. However, it is obvious that the search for the remaining traces of the system of the land division could benefit greatly from an approach presented here, even before the implementation of the latest technological marvels.

Conclusion

The outcomes of the work presented in this paper could be summed into two sets of results. The first one is related to the assessment of the relevance and reliability of the used material, primarily of the historical cartographic sources. The analysis and the results were predominantly of quantitative nature and have demonstrated their potential in the archaeological research. A high number of documented features together with the established mathematical basis offers an insight into the state of the landscape before the transformations took place in the second half of the 20th century. This is the most important characteristic of these sources, since they are the earliest, and still compatible with contemporary methodologies because of their precision. The still-existing subjectivity of the maps of the 2nd survey (after all, they were completely hand drawn and painted; see Slukan Altić 2003: 146) in some way offers new elements of personal interpretation of spatial features, whether it is the state of built objects, or the need to document a name of some site. On the other hand, contemporary methods of landscape documentation offer much more precise and completely objective, almost 'cold' results without the historical context. Therefore, the only valid strategy is to use both approaches, because they complement each other. And since the material presented here has finally become publicly available through various digitised media, we can expect more and more research projects similar to this (very limited) endeavour.

The other set of results refers to the interpretative study of the spatial organization of the area around Bale. Only after all the data and the materials have been integrated and mapped, it was possible to reach certain conclusions which have only scratched the surface of many of the problems. Unfortunately, the area in question has experienced a significant transformation, and the patterns which have shaped our perception of a typical Mediterranean landscape are slowly disappearing. That is why it is essential to continue with this work, and to apply the same research principles to other neighbouring areas.[3]

[3] This work has been supported by the "Research Cooperability" Program of the Croatian Science Foundation funded by the European Union from the European Social Fund under the Operational Programme Efficient Human Resources 2014-2020, within the project PZS-2019-02-1624 – *GLOHUM – Global Humanisms: New Perspectives on the Middle Ages (300-1600)* and by the Project of the institutional support of the Faculty of Humanities and Social Sciences, University of Zagreb, 11-931-1083 – *Valorisation of Heritage, Cultural Landscape and Spatial Transformations of Adriatic Croatia*.

References

Altić, M. 2013. Istra u srednjovjekovnim kartografskim izvorima - od prvih obrisa poluotoka do prve regionalne karte, In: I. Jurković (ed.), *Bertošin zbornik. Zbornik u čast Miroslava Bertoše. Knjiga 2*, Sveučilište Jurja Dobrile u Puli - Državni arhiv u Pazinu, 491-506.

Altić M. 2021. Preteče i uzori franciskanskog katastra Istre, *Histria*, 11, 53-72.

Aničić, B. and Perica, D. 2003. Structural features of cultural landscape in the karst area (landscape in transition), *Acta carsologica*, 32/1, 173-188.

Behaim, J. 2021. *Architectural Landscape at the Periphery of Carolingian Empire. Croatian Historical Territory and Marca Hispanica*. Doctoral dissertation (Autonomous University of Barcelona - University of Zagreb).

Bernardini, F. and Vinci, G. 2020. Archaeological landscape in central northern Istria (Croatia) revealed by airborne LiDAR: from prehistoric sites to Roman centuriation, *Archaeological and Anthropological Sciences*, 12: 133 (https://doi.org/10.1007/s12520-020-01070-w).

Biszak, E., Biszak, S., Timár, G., Nagy, D. and Molnár, G. 2017. Historical topographic and cadastral maps of Europe in spotlight – Evolution of the MAPIRE map portal, *12th ICA Conference Digital Approaches to Cartographic Heritage Proceedings*, 204- 208.

Boria, E. 2012. Mapping Time, *EspacesTemps.net* (https://www.espacestemps.net/en/articles/mapping-time-en/?output=pdf).

Bulić, D. 2012. Rimska centurijacija Istre, *Tabula*, 10, 50-74.

Campana S. 2009. Archaeological site detection and mapping: Some thoughts on differing scales of detail and archaeological 'non-visibility', In: S. Campana and S. Piro (eds.), *Seeing the Unseen Geophysics and Landscape Archaeology*, Taylor & Francis Group, London, 5-26.

Campana, S. and Piro, S. 2009. Preface, In: S. Campana and S. Piro (eds.), *Seeing the Unseen Geophysics and Landscape Archaeology*, Taylor & Francis Group, London.

Clarke, D. L. 1977. Spatial Information in Archaeology, In: D. L. Clarke (ed.), *Spatial Archeology*, New York, 1-32.

Čučković, Z. 2015. Exploring intervisibility networks: a case study from Bronze and Iron Age Istria (Croatia and Slovenia), In: F. Giligny, F. Djindjian, L. Costa, P. Moscati and S. Robert (eds.), *CAA2014. 21st Century Archaeology. Concepts, methods and tools. Proceedings of the 42nd Annual Conference on Computer Applications and Quantitative Methods in Archaeology, Paris, April 2014,* Archaeopress, Oxford, 469-478.

De Silva, M. and Pizziolo G. 2004. GIS Analysis of Historical Cadastral Maps as a Contribution in Landscape Archaeology, *2003 - Enter the Past. The E-way into the four Dimensions of Cultural Heritage. CAA 2003. Computer Applications and Quantitative Methods in Archaeology*, BAR International Series 1227, 294-298.

Gams, I. and Gabrovec, M. 1999. Land use and human impact in the Dinaric karst, *International Journal of Speleology* 28, 55-70.

Gillings, M., Hacıgüzeller, P. and Lock G. (eds.) 2019. *Re-Mapping Archaeology: Critical Perspectives, Alternative Mappings*, Taylor & Francis Group, London.

Harvey, D. and Wilkinson, T. 2019. Landscape and Heritage. Emerging Landscapes of Heritage, In: P. Howard, I. H. Thompson, E. Waterton and M. Atha (eds.), *The Routledge Companion to Landscape Studies*, Routledge, London, 176-191.

Hodgkiss, A. G. 1981. *Understanding Maps: A Systematic History of Their Use and Development,* Folkestone: Wm Dawson & Son.

Howard, P., Thompson, I., Waterton, E. and Atha, M. (eds) 2019. *The Routledge Companion to Landscape Studies,* Taylor & Francis Group, London.

Jurković, M., Milošević, A. and Basić, I. 2008. Bale, benediktinski samostan – rezultati dosadašnjih istraživanja, In: M. Jurković (ed.), *I. Porečki susret arheologa – Rezultati arheoloških istraživanja na području Istre*, 137-150.

Jurković, M. and Caillet, J.-P. 2008. *Velika Gospa près de Bale (Istrie) I. L'église Velika Gospa près de Bale, vol. I, Dissertationes et Monographiae 2,* International Research Center for Late Antiquity and Middle Ages, University of Zagreb.

Jurković, M., Matejčić, I. and Basić, I. 2009. „Barokizacija" crkve sv. Marije Velike kod Bala – primjer poštivanja ranosrednjovjekovnih starina u 18. stoljeću, In: S. Cvetnić, M. Pelc, D. Premerl (eds.), *Sic Ars Deprenditur arte, Zbornik u čast Vladimira Markovića*, Zagreb, 303-317.

Jurković, M. and Caillet, J.-P. 2011. *Velika Gospa près de Bale (Istrie) II. L'église Velika Gospa près de Bale, vol. II, Dissertationes et Monographiae 3*, International Research Center for Late Antiquity and Middle Ages, University of Zagreb.

Jurković, M. 2019. The Transformation of the Adriatic Islands from Antiquity to the Early Middle Ages, In: M. Á. C. Ontiveros and C. M. Florit (eds.), *Change and Resilience: The Occupation of Mediterranean Islands in Late Antiquity*, vol. 9, Oxbow Books, 111-138.

Kluiving, S. J. and Guttmann-Bond, E. B. (eds) 2012. *Landscape Archaeology between Art and Science: From a Multi- to an Interdisciplinary Approach*, Amsterdam University Press.

Kokalj, Ž., Hesse, R. and Mulahusić, A. (eds.) 2018. *Vizuelizacija rasterskih podataka laserskog skeniranja iz zraka*, Ljubljana: ZRC.

Kozličić, M. 2005. Povijesni razvoj kartografiranja hrvatskih zemalja, In: D. Novak, M. Lapaine and D. Mlinarić (eds.), *Pet Stoljeća geografskih i pomorskih karata Hrvatske*, Školska knjiga, Zagreb, 23-24.

Kranjec, I. 2021. Digitalne tehnologije u istraživanju materijalne kulturne baštine. Primjer recentnih istraživanja na otoku Rabu, In: P. Marković (ed.), *Zbornik radova znanstvenog skupa „Dani Cvita Fiskovića" održanog 2018. godine*, FF press, 181-191.

Lozić, E. and Štular, B. 2021. Documentation of Archaeology - Specific Workflow for Airborne LiDAR Data Processing, *Geosciences* 2021, 11, 26 (https://doi.org/10.3390/geosciences11010026).

McKeague, P., vant Veer, R., Huvila, I., Moreau, A., Verhagen, P., Bernard, L., Cooper, A., Green, C. and van Manen, N. 2019. Mapping Our Heritage: Towards a Sustainable Future for Digital Spatial Information and Technologies in European Archaeological Heritage Management, *Journal of Computer Applications in Archaeology* 2019, 2, 89-104.

Marchiori, A. 2009. Centuriazioni d'Istria: studio evolutivo delle disuguaglianze, *Agri centuriati: an International Journal of Landscape Archaeology*, 6, 71-97.

Matijašić, R. 1988. *Ageri antičkih kolonija Pola i Parentium i njihova naseljenost od I. do III. stoljeća*, Zagreb: VPA.

Matijašić, R. and Gerometta, K. 2018. Rimska centurijacija na području Vrsara, Hrvatska, In: Ž. Kokalj, R. Hesse and A. Mulahusić (eds.), *Vizuelizacija rasterskih podataka laserskog skeniranja iz zraka*, Ljubljana: ZRC, 126-129.

Novaković, P. 2008. Arheologija prostora i arheologija krajolika, In: B. Olujić (ed.), *Povijest u kršu. Zbornik radova projekta "Naselja i komunikacije u kontekstu veza između jadranskog priobalja i unutrašnjosti u prapovijesti i antici"*, Zagreb: FF press, 15-54.

Popović, S., Bulić, D., Matijašić, R., Gerometta, K. and Boschian, G. 2021. Roman land division in Istria, Croatia: historiography, LIDAR, structural survey and excavations, *Mediterranean Archaeology and Archaeometry* 21/1, 165-178.

Quintas-Soriano, C., Buerkert, A. and Plieninger, T. 2022. Effects of land abandonment on nature contributions to people and good quality of life components in the Mediterranean region: A review, *Land Use Policy*, 116 (https://doi.org/10.1016/j.landusepol.2022.106053).

Remondino, F. and Campana S. (eds.) 2014. *3D Recording and Modelling in Archaeology and Cultural Heritage*, BAR International Series 2598, Archaeopress, Oxford.

Serra, P., Pons, X. and Saurí, D. 2008. Land-cover and land-use change in a Mediterranean landscape: A spatial analysis of driving forces integrating biophysical and human factors, *Applied Geography* 28/3, 189-209.

Slukan Altić, M. 2001. *Katastar Istre 1817-1960*, Zagreb: Hrvatski državni arhiv.

Slukan Altić, M. 2003. *Povijesna kartografija, Kartografski izvori u povijesnim znanostima*, Meridijani, Samobor.

Slukan Altić, M. 2016. *Povijesna topografija otoka Krka*, Zagreb - Rijeka: HAZU, Zavod za povijesne i društvene znanosti u Rijeci.

Starac, A. 2000. *Rimsko vladanje u Histriji i Liburniji. Društveno i pravno uređenje prema literarnoj, natpisnoj i arheološkoj građi. Liburnija*, Pula: Arheološki muzej Istre.

Štular, B. 2010. Jožefinski vojaški zemljevid kot vir za preučevanje preteklih pokrajin, *Geografski vestnik* 82/1, 85-96.

Štular, B. 2022. Scientific Dissemination of Archaeological Interpretation of Airborne LiDAR-derived Data, In: K. Garstki (ed.) *Critical Archaeology in the Digital Age: Proceedings of the 12th IEMA Visiting Scholar's Conference (Vol. 2),* Cotsen Institute of Archaeology Press at UCLA, 111-122.

Timár, G., Molnár, G., Székely, B., Biszak, S., Varga, J. and Janko, A. 2006. *Digitized Maps of the Habsburg Empire. The Maps Sheets of the Second Military Survey and their Georeferenced Version*, Arcanum, Budimpešta.

Van Lanen, R.J., Groenewoudt, B.J., Spek, T. and Jansma, E. 2018. Route persistence. Modelling and quantifying historical route-network stability from the Roman period to early-modern times (AD 100–1600): a case study from the Netherlands, *Archaeological and Anthropological Sciences* 10, 1037-1052.

Walsh, K. 2013. *The Archaeology of Mediterranean Landscapes Human-Environment Interaction from the Neolithic to the Roman Period*, Cambridge University Press.

Zupanc, I. (ed.) 2020. *Franciscejski kataster v Istri: vzpostavitev, raziskave, dediščina / Il Catasto franceschino in Istria: impianto, indagini, patrimonio / Franciskanski katastar u Istri: uspostava, istraživanja, baština*, Humanističko društvo Histria, Koper.

Web sites

Croatian Base Maps (HOK) of the State Geodetic Administration of the Republic of Croatia, Web Map Service link: https://geoportal.dgu.hr/services/hok/wms (27.10.2022)

Digital orthoimage of Croatia in scale 1:5000 (DOF5, 2018) of the State Geodetic Administration of the Republic of Croatia, Web Map Service link: https://geoportal.dgu.hr/services/inspire/orthophoto_2018/wms?request=GetCapabilities&service=WMS (27.10.2022)

STRM (NASA *Shuttle Radar Topography Mission*) v3 30m elevation data dataset https://earthexplorer.usgs.gov/ (1.7.2022)

EU-DEM v1.1 elevation data dataset: https://land.copernicus.eu/imagery-in-situ/eu-dem/eu-dem-v1.1 (1.7.2022)

Topographic maps of scale 1:25 000 (TK25) of the State Geodetic Administration of the Republic of Croatia, Web Map Service link: https://geoportal.dgu.hr/services/tk/wms (27.10.2022)

Croatian cadastral plan of the State Geodetic Administration of the Republic of Croatia, Web Map Service link: https://oss.uredjenazemlja.hr/OssWebServices/inspireService/wms?service=WMS&request=GetCapabilities&version=1.3.0 (30.6.2022)

Mapire.eu online portal: https://maps.arcanum.com/en/map/europe-19century-secondsurvey/ (25.10.2022)

Arianna4view online portal of the Trieste State Archive: https://a4view.archiviodistatotrieste.it/ (2.7.2022)

Use of archaeological structural survey and the analysis of standing structures on mediaeval castles

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https://doi.org/10.17234/METARH.2022.03

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Archaeological structural survey is a non-invasive procedure that determines the existence of architectural remains and records the archaeological contents of architectural remains, or their parts visible above the ground. The archaeology of standing structures is a method that involves arranging the observed stratigraphic units in a chronological sequence, applying the so-called Harris matrix (and linking the obtained results with other sources, primarily written, legal acts, graphic historical representations, and the results of archaeological research and archaeometric analysis (samples of stone and mortar). Both methods were used in the research of the remains of medieval castles. The paper will show the results of these analyses on two case studies: the Cesargrad Castle in Hrvatsko Zagorje and Grižane Castle in the Vinodol Valley. In the case of Cesargrad different construction, phases have been identified, showing a rich architectural history of the castle, ranging from the 13th to the 17th centuries. In the case of Grižane Castle, the data suggest that the visible traces date to only one phase of construction during the 15th century, contrary to the known historical data. With the application of the structural survey, the architectural remains of the castle have been documented for the first time.

The use of these methods allows new insights into the architectural development of the archaeological remains in question, gives answers to specific research questions, especially in the field of late medieval and post-medieval archaeology, and enriches the data of individual architectural remains. The data can be used in later monuments protection programs, as the foundation for a better understanding of the architectural remains and the proper method of their preservation.

Keywords: *archaeological structural survey, archaeological documentation, archaeology of standing structures, medieval castles*

Introduction

Archaeological survey is used by archaeologist to discover sites, assess archaeological remains or damage done to archaeological sites, and a survey can range from informal exploration to very detailed strategies (Banning 2002:1). The results of any archaeological survey depends on the objectives it was designed to achieve so strategies and methods can vary depending on the goals of archaeological survey (Banning 2002: 27-38). Ever since its early days, archaeological science came upon underground historical architectural remains. Above-ground architectural remains were studied by members of similar disciplines only, such as art historians. Although the interest of contemporary archaeology goes beyond the architectural remains themselves, since the 1980s, the attention given to more detailed research of architectural remains preserved in elevation has become an inevitable part of archaeological excavations in some countries.

Structural surveys

When collecting large amounts of spatial data, archaeology implements the method of systematic field survey which is used for discovering and cataloguing archaeological remains. The systematic field survey represents a typical walking technique most commonly applied at the sites where the surface of the ground is visible, primarily in the fields with scarce vegetation. It can also yield good results in surveying visible surface structures in grasslands, forests, etc. (Mercer 1985; Fasham 1986; Čučković 2012: 247-248). Systematic field surveys can encompass the sites with architectural remains as well. Lately, the system of documenting finds began including the architectural remains which are often preserved in elevation, above the ground. Researchers ascertained that the principles of archaeological field surveys and the documentation of archaeological finds can be applied to this type of sites as well. This survey can be defined as an archaeological structural survey. The archaeological structural survey is a non-invasive procedure used for establishing the existence of archaeological finds of architectural remains and recording their position, i.e., the position of their visible, above-ground parts. This method is supplemented by structure analysis with the goal of complementing the findings and documenting certain construction interventions, elements, and construction processes, as well as collecting samples of construction materials. If necessary, the archaeological structural survey can include clearing out the surface of the ground or structures, naturally, without changing their shape or reaching deeper into the site's stratigraphy. While the surface surveys can collect data on numerous sites, systematic field surveys have the potential to collect detailed data on single sites, on their size, character or/and temporal determination. In the case of the structural survey the same can be said, but with the main goal of collecting data of architectural remains preserved above ground. Archaeological structural survey has the goal of documenting position and state of preservation of architectural remains and should be supplemented with the stratigraphic analysis of standing structures.

Gathering a large amount of data was made easy by introducing new documentation techniques in archaeology. This can also include documenting architectural

Figure 1. On site recording of the Grižane Castle. (Photo by: A. Janeš).

remains. The use of total stations at archaeological excavations enabled researchers to collect large amounts of field data faster and easier compared to the classic way of documenting in the form of drawing the finds on graph paper by hand and situating them in the environment by using a grid (Fig 1.). The use of a camera combined with a total station or a global navigation satellite system (GNSS), which has lately become more common, introduced the technique of photogrammetry in archaeology. The analysis of gathered data in CAD programmes brought the archaeological remains preserved in elevation closer to archaeologists. The introduction of a 3D laser scanner in the process of documenting sites increased the amount of gathered data exponentially (Grgurić and Novak 2018). Despite the widespread use of 3D laser scanners, photographing the site to acquire data and recording it with a total station to create a 3D model is accepted as a more cost-effective technique, especially in archaeology. The recorded data is used to create 3D models through the so-called *image based modelling* technique (Fig. 2). The combination of the images of an unmanned aerial vehicle, recordings made

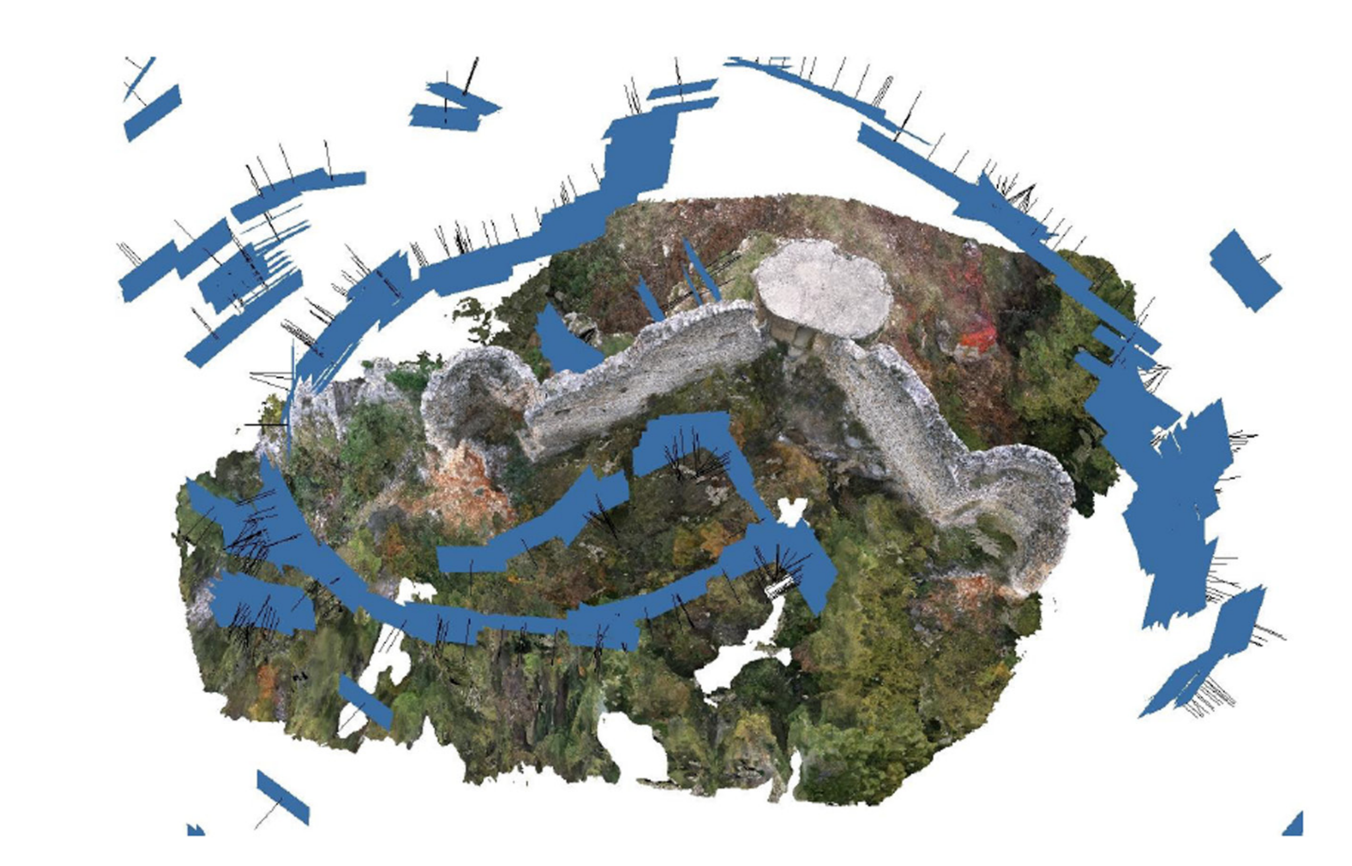

Figure 2. 3D model from UAV photos. (Made by: Vektra Ltd).

with geodetic equipment and terrestrial images yields a more cost-efficient alternative to 3D laser scans (Vuković and Mađerić 2015).

The stratigraphic analysis of standing structures

As already mentioned, archaeological structural survey is supplemented by structure analysis. Although documenting architectural remains discovered during field surveys is becoming more common, analysis of documented architectural remains is still not common practice. Data collected through an archaeological survey of any type is analysed to give comprehensive interpretation but architectural remains rarely get the same treatment from archaeologists in Croatia.

The archaeological research of architecture preserved in elevation is based on the stratigraphic analysis that enables the researchers to identify certain periods of construction and demolition as well as, the relationships of the past, present, and future. According to E. Harris, excavation is a stratigraphic procedure that can be applied to architectural remains. Unlike excavation, during which the layers are mechanically destroyed and their constituent parts revealed, the stratigraphic research of architectural remains preserved in elevation is limited to the depiction of the visible part without the possibility of breaking it up (Brogiolo and Cagnana 2017: 7). The stratigraphic method of architectural remains analysis has been used in English archaeology as well, primarily in the archaeology of churches, starting from the 1970s (Clark 2000: 17). The implementation of the stratigraphic method, which originated in the experiences of English archaeologists, was introduced to the analysis of architectural remains in Italian archaeology in the late 1970s and the first half of the 1980s, and to Spain and France a decade later (Italian: *Archeologia dell' architettura*, Spanish: *Arqueologia del architectura*, French: *L'archéologie du bâti*) (Brogiolo and Cagnana 2017: 13-14, 18).[1]

[1] The terminology in English language also nows the term analysis of standing buildings but this term is mostly used in the term of historical buildings still in use, that have a preserved roof.

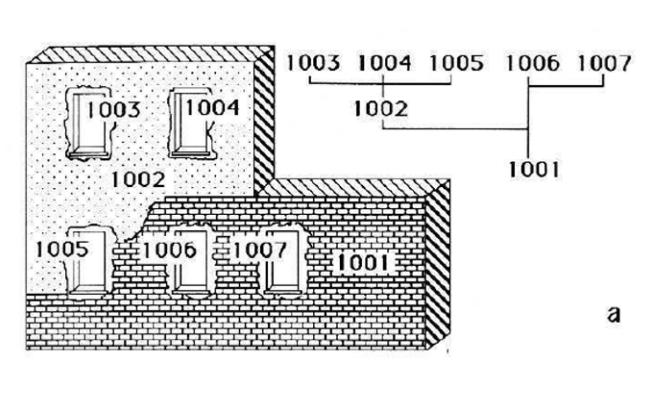

Figure 3. Stratigraphic sequencing of a standing wall (Brogiolo 1988: Fig. 16a).

In archaeology, stratigraphy includes the implementation of geologic principles in excavation techniques (Harris 1989). It is based on two concepts – the concept of space and the concept of time. It is thought that no item, structure, or object can be understood without taking its spatial and temporal context into account (Clark 2000: 20). Documenting a architectural remains depends on its degree of preservation and the documentation system can be adjusted according to it. Due to speed and cost-effectiveness, one should consider whether there is a need for the so-called total documentation of all details of a structure or a plan of specifically targeted parts should be made (Westman 2000: 108-109). Goal of structural analysis is better understanding of construction process and identification and interpretation of construction phases and architectural development through use of stratigraphic layers.

The vertical stratigraphy method can be applied in documenting architectural remains and the breakdown of their elements. It is done by identifying openings in walls, plaster remains, and different masonry techniques as new stratigraphic units. A stratigraphic unit is a basic unit in the analysis of standing architecture as well as in the research of underground structures. [2] They can be categorized as the units created during the construction and the units created during the destruction, i.e., dissolution. The first variety has a certain volume and is identified as the positive interface, while the second variety is identified as the negative interface (Brogiolo and Cagnana 2017: 25). During the analysis, architectural remains are broken down and the method of recording interface units subordinate to the stratigraphic unit of the wall is used (for instance, the wall plaster of wall SU 1003 is recorded as SU 1003.3) (Harris 2003: 11). This method implies putting the identified stratigraphic units in a chronological sequence by using the so-called Harris matrix (Harris 1989: 109-113) (Fig. 3). The use of the matrix yields a relative chronology and links the obtained results to other sources, primarily the written ones; legal acts and graphic historical sources, as well as the results of archaeological excavations and archaeometric analyses with the goal of ascertaining the absolute chronology (Brogiolo and Cagnana 2017: 25).

Examples

The high number of medieval castles in Croatia and their degree of preservation make them very good subjects for the implementation of an archaeological structural survey and stratigraphic analysis of preserved architecture. This paper presents the examples of two castles: Cesargrad in Hrvatsko zagorje and Grižane in Vinodol Valley (Fig. 4).

Cesargard

The remains of the Cesargad castle are situated on the western slope of the Cesargrad hill, above a narrow ridge of the Sutla river called Zelenjak, northwest of Klanjec. The spot was the site of a well-fortified castle core, while a moat served as additional protection. At the top, the architectural remains span east of the moat and combined with the two far-east peaks of the Cesargrad hill make up this complex castle. The whole position of this castle used to be surrounded by a defence wall which was reinforced by towers on the most protruding parts. The castle extends in the direction of southeast-northwest and is 225 m long (Janeš 2014: 197).

The site was documented with a Z+F Imager 50163D scanner[3] which resulted in a measurable 3D model in the form of a point cloud where every point is highly precisely identified in space and the coordinate system. Aside

[2] It should be pointed iut here that the researchers in certain countries, primarily in Italy, use a separate stratigraphic unit when analysing masonry structures – the stratigraphic unit of the wall (It. *Unitá stratigrafica muraria, USM*) (Brogiolo 1988: 13; Brogiolo and Cagnana 2017: 25).

[3] The technique of gathering data with the 3D laser scanner and photogrammetry has been explained in the paper by Grgurić and Novak 2018.

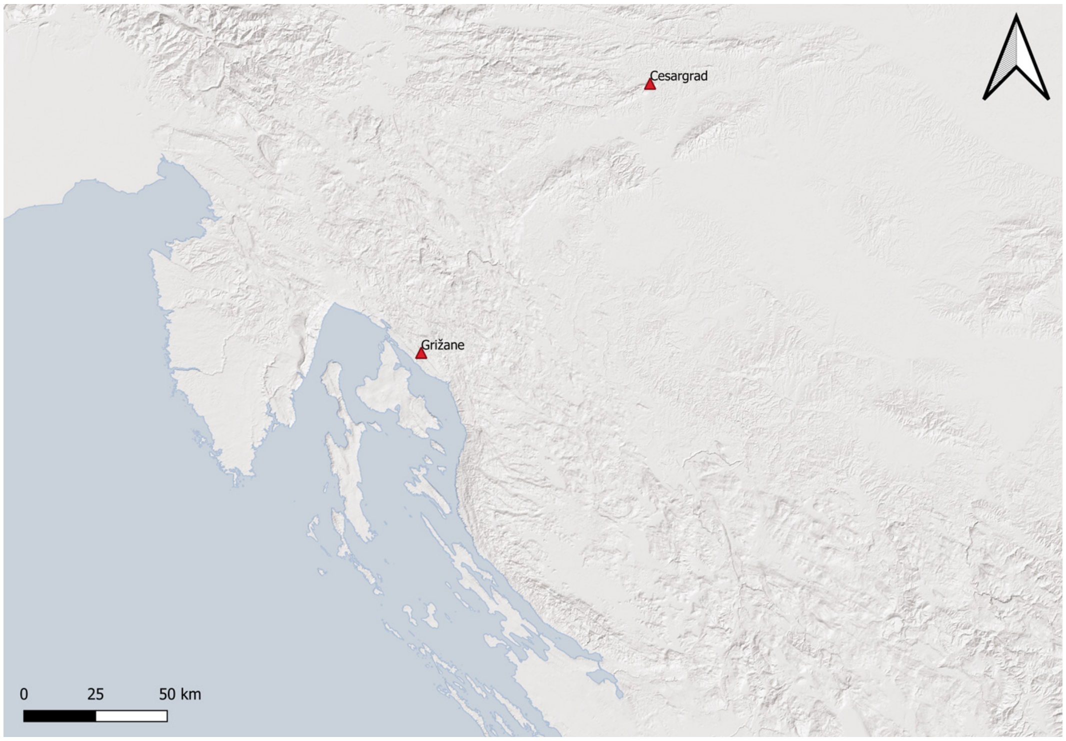

Figure 4. Locations of the sites. (Map by: A. Janeš).

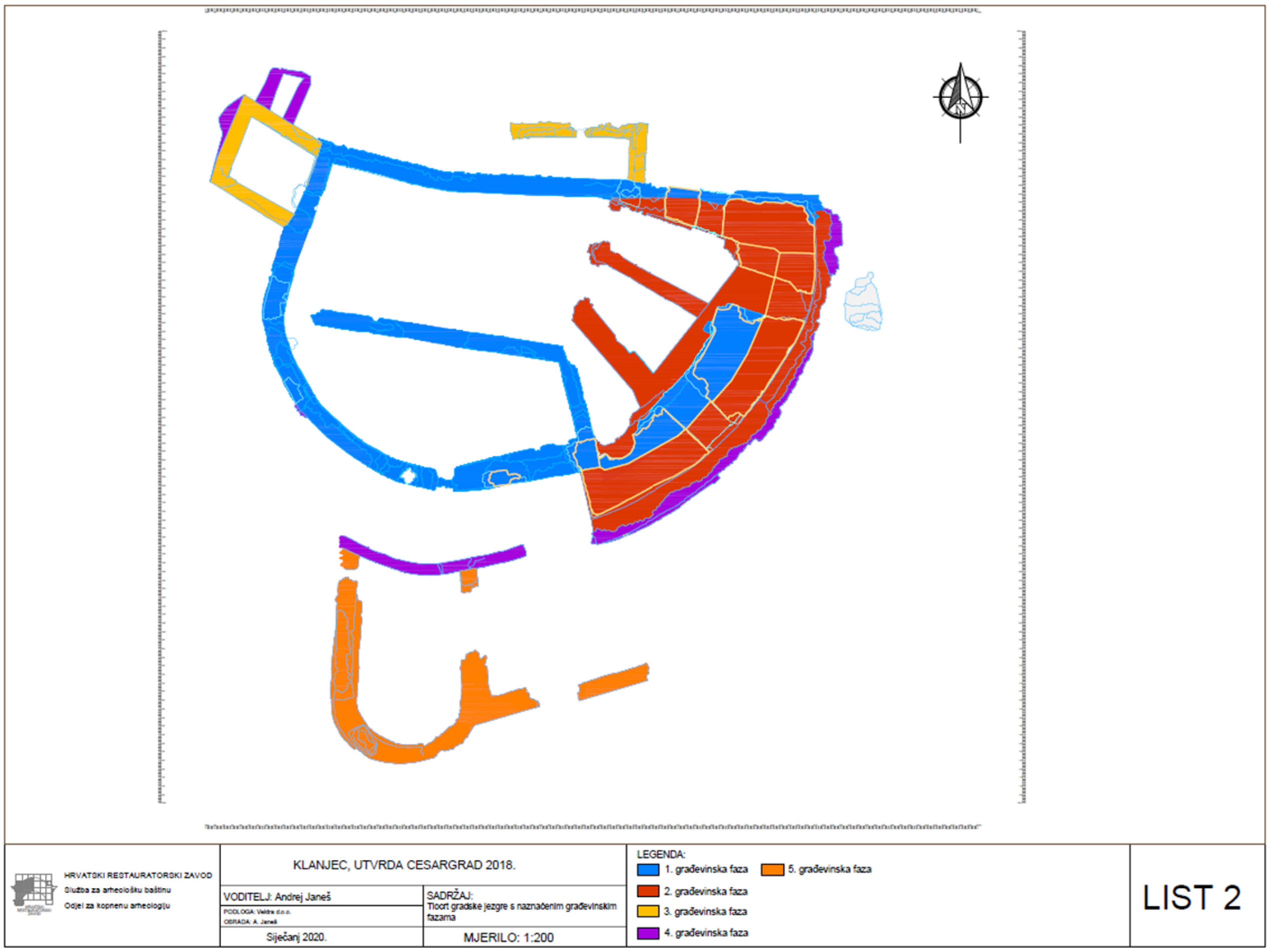

Figure 5. Cesargrad groundplan with construcion phases. (Plan by: Vektra Ltd, edited by: A. Janeš).

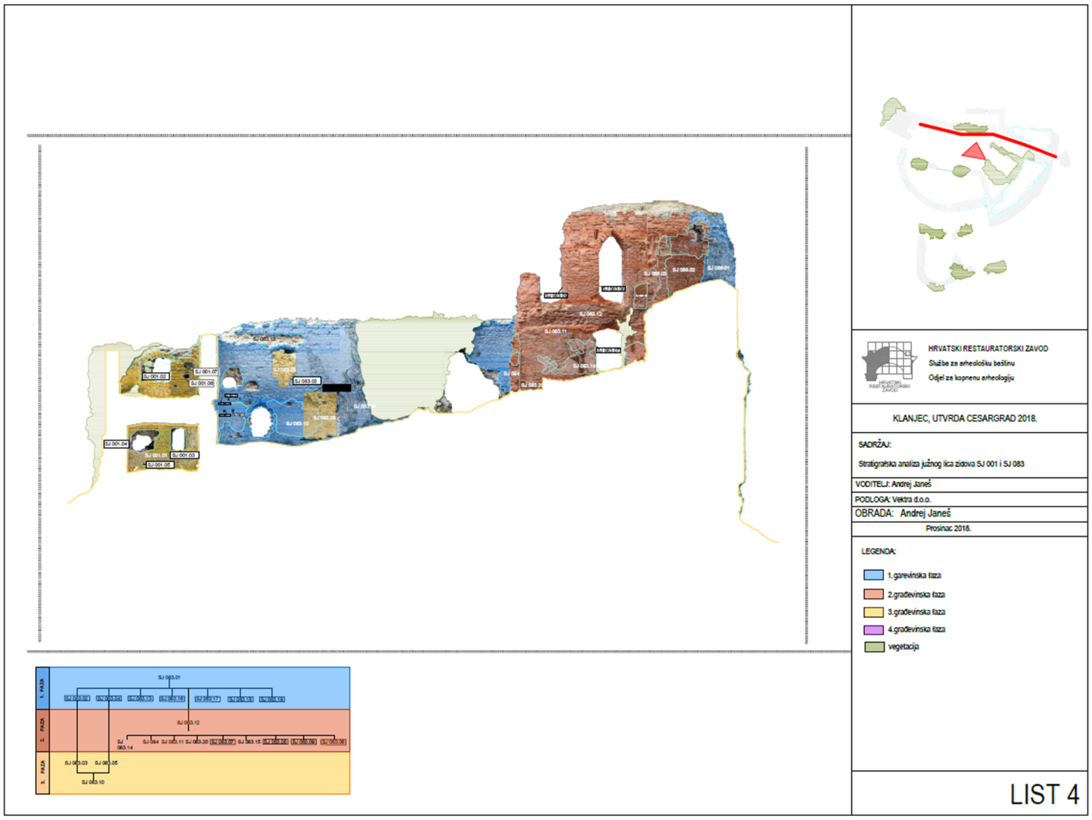

Figure 6. Stratigraphic sequencing of the northern wall of Cesargrad's centre with Harris diagram. (Plan by: Vektra Ltd., edited by: A. Janeš).

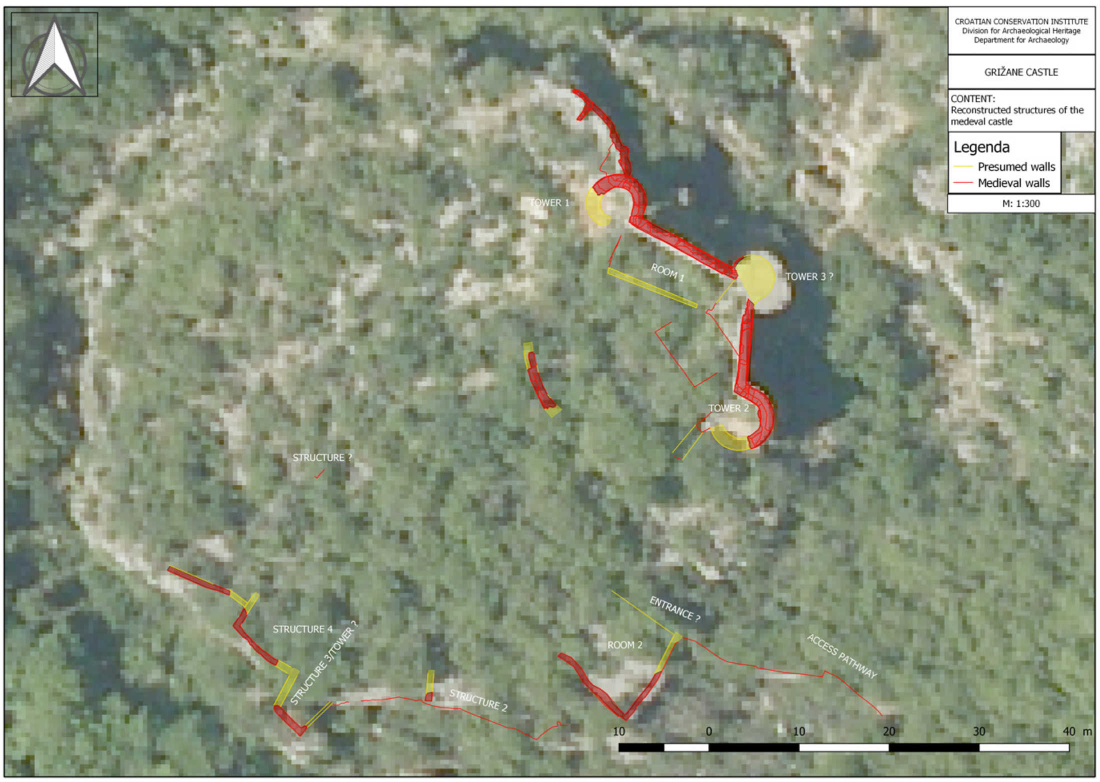

Figure 7. Grižane Castle, ground plan of the first construcion phase. (Map by: A. Janeš).

from the 3D scanner, images were acquired through the use of the Airborne Robotics XR6 unmanned aerial vehicle. The obtained 3D model was used for CAD drawings which included a layout of the site and faces of some walls preserved in elevation.

Five phases can be identified in the construction and architectural development of the castle. All of them are visible in the castle's core (Fig. 5). The first construction phase is identified by the remains of a smaller castle around the rectangular court with a room on the southern side. It was constructed during the 14th or maybe even the late 13th century. The second construction phase is said to include the reconstruction of the eastern portion of the castle. At that time, the eastern wing of the palas and the eastern defence wall were reinforced resulting in the formation of the so-called *Schildmauer* or shield wall. During the third construction phase, the entrance in the western wall was relocated eastward and reinforced (Fig. 6). A square tower was added to the north-western corner of the castle. The second and third phases can be dated to the time when the castle was owned by the Counts of Celje (1399-1456). In the fourth construction phase, the centre of the castle was reinforced in the east and the south, while the semi-circular artillery tower on the southern side of the centre was added in the fifth phase. These phases are dated after 1521 when the castle was owned by the Erdődy Family (Janeš 2020: 87-88).

Grižane

The remains of the Grižane castle are situated on a steep slope of a rock connected to the mountain massif of Podolje in the east, just above the village of the same name. Steep cliffs divide the slope from the rest of the Vinodol Valley. The terrain morphology influenced the layout of the castle; it encompasses the whole area of the circular slope. The slope is very steep, declining from east to west and south. The height difference between the highest and the lowest altitudes of the slope is 40 meters (Janeš 2021: 219).

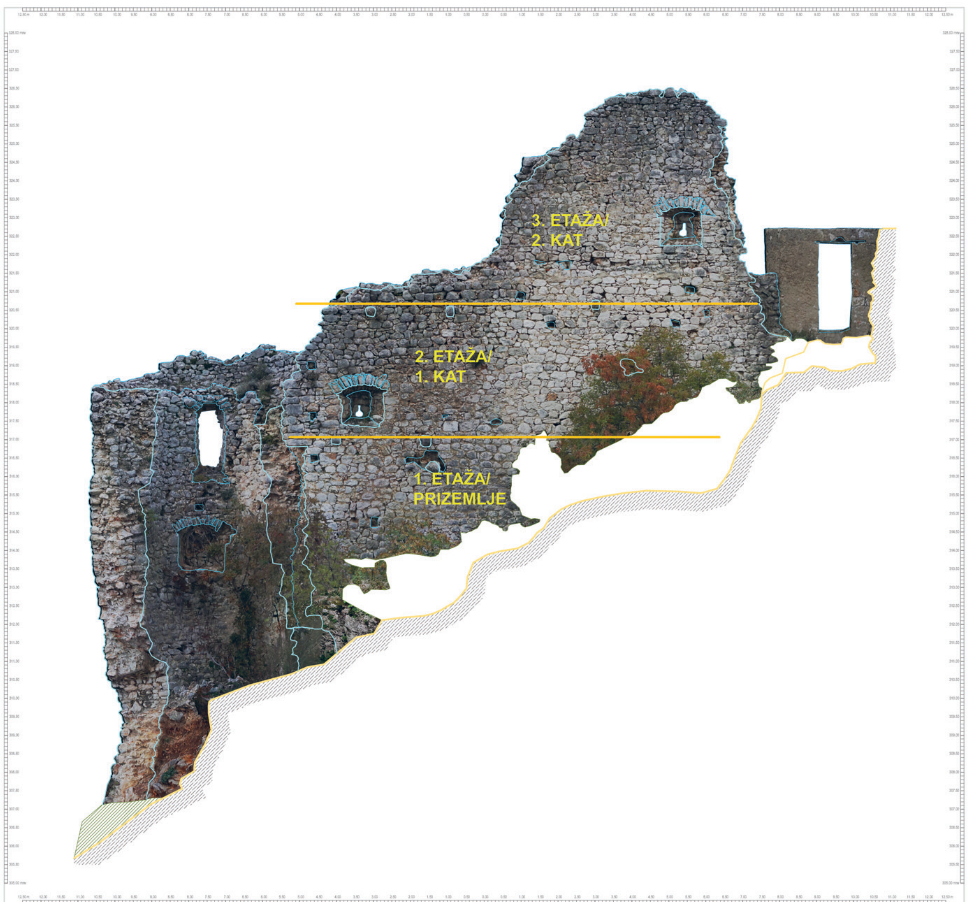

Figure 8. Grižane Castle, interpretation of the wall. (Plan by: Vektra Ltd., edited by: A. Janeš).

The Grižane castle was researched in two phases using a combination of two techniques. The remains of the central part of the castle are preserved at the highest point in the terrain (Fig. 7). The terrain is dominated by architectural remains of two eastern walls that have round towers on their western and southern borders. Two eastern walls come together at the highest point in the terrain at a 111º80“ angle. It is assumed that there was another round tower on this spot. Unfortunately, any possible traces of the tower are either completely gone or were covered by the construction of a concrete pillbox during the Second World War. In 2015, this part of the castle was documented with Z+F Imager 5010c 3D laser scanner and Airborne Robotics XR6, VEK1 unmanned aerial vehicle with Sony ILCE-6000 24 Mpx mirrorless camera. Orthomosaics were generated from the obtained 3D model and were used for CAD drawings which included top view positions and the views of the wall faces preserved in elevation (Janeš 2016: 463-465) (Fig. 8).

The remaining part of the castle spans over the slope to the west and south, to the edge of a deep cliff. In 2016, a structural survey of that part of the castle was conducted and 39 masonry structures from various periods were identified (Janeš et al. 2017). The area around the masonry structures that were documented with a camera and recorded with Leica Flexline TS06 total station was cleared out. The structural survey revealed the remains of an outer defence wall of the castle, which was constructed on the western and southern edges of the cliff. The position of the wall made it impossible to document with anything but the DJI Phantom 2 unmanned aerial vehicle (Fig. 9). The aerial survey yielded a number of images enough for the analysis in a computer programme and the production of orthomosaic. The total station recorded control points for georeferencing the obtained 3D model. The acquired orthorectified images of the view of the masonry structures of the castle were used for the production of CAD drawings of certain elements of the walls.

Figure 9. Grižane Castle, 3D model of the outer wall made from UAV photos. (Model by: A. Fundurulić).

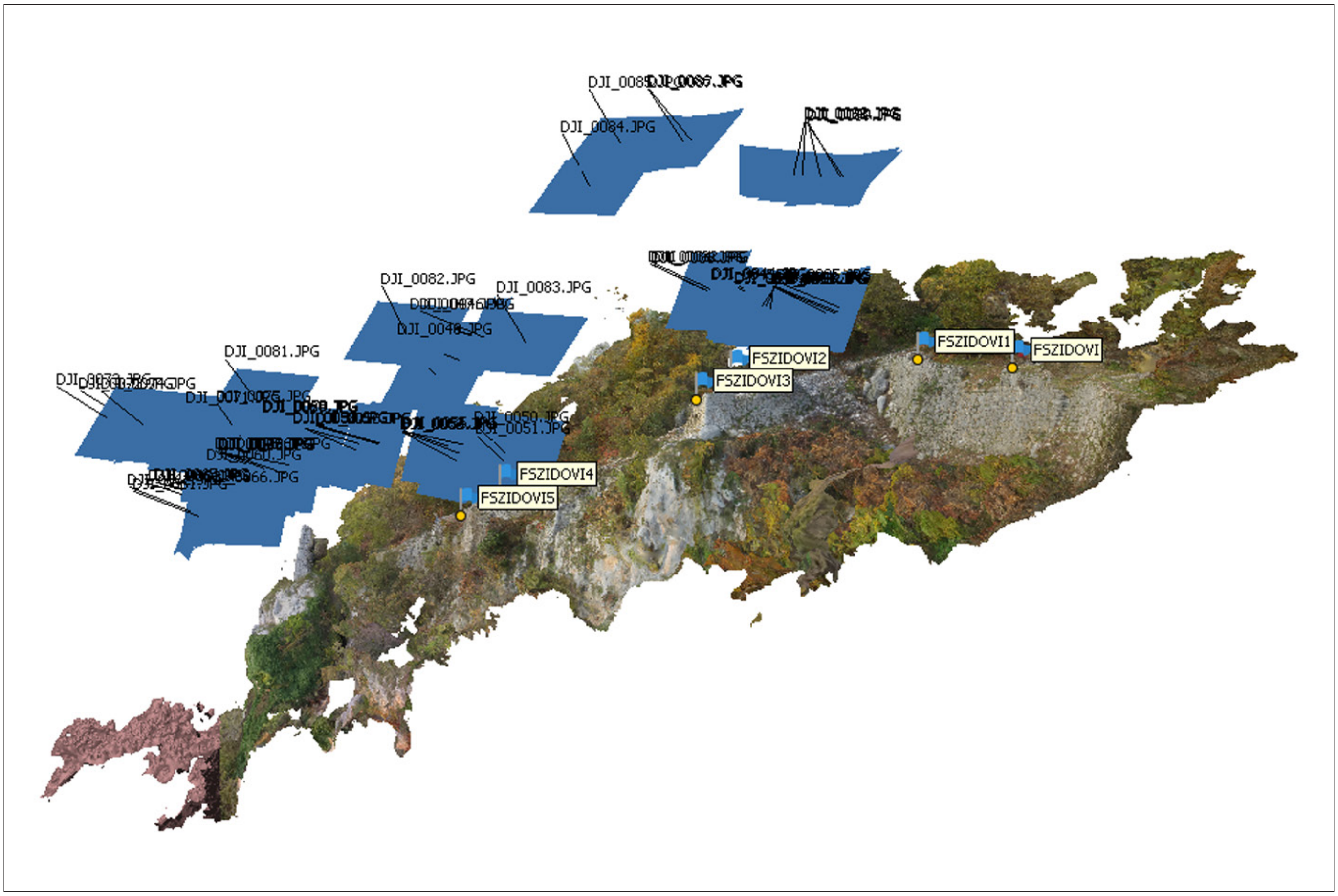

Figure 10. Osor, monastery of St. Peter, example of conservation of different construction phases. (Photo by: A. Janeš).

The analysis of the architectural remains revealed four construction phases of the Grižane castle. The first one was the most extensive and has to do with the castle's structures. The preserved architectural remains visible above ground did not reveal different structures and types of construction, leading to the conclusion that these are the remains of the original castle. The way it was built, round towers and built-in loopholes indicate that the castle can be dated to the 15th century. The second phase is represented by the walled-up openings, windows, and loopholes visible on the remains of the eastern defence walls and towers of the central fort. They can be roughly dated to the 16th or 17th century. The third construction phase is represented by the remains of the Second World War defence structures. The pillbox in question is oval and it is situated at the highest point in the terrain. There are also the remains of a square bunker in the western part of the central fort and the remains of a rectangular structure within the central part of the fort. The fourth construction phase includes all the documented dry stone structures that cannot be dated more accurately without excavation.

Conclusion

The use of the structural survey proved apt for gathering field data in the research of the architectural remains of the Grižane castle covered in thick Mediterranean vegetation. Given that the land of the site was never arable and was overgrown with thick Mediterranean vegetation, the classic systematic field survey that includes gathering movable finds was not possible. The economic and temporal limitations and the extreme terrain prevented the researchers from excavating the Grižane castle. The clearing of the terrain revealed architectural remains of the castle which were documented using the total station and the images obtained with the unmanned aerial vehicle. The aerial images were then used for the creation of an image-based 3D model, especially the remains of the outer defence walls whose data was impossible to gather via any other technique. The aim was to discover and document all architectural remains preserved above ground. Given the amount of analysed data, the use of the structural survey proved to be a cost-effective and very efficient technique for documenting the remains of a medieval castle.

The application of 3D laser scanners on architectural remains preserved in elevation proved to be a quick way of gathering large quantities of data in both aforementioned examples (Grižane and Cesargrad castles) despite being financially demanding. The analysis of various construction techniques and materials enabled the detailed analysis of all preserved remains.

The results of the structural survey and the recording of the architecture preserved in elevation were then analysed with the help of stratigraphic analysis of standing structures. They enabled a more detailed analysis of standing structures and identification of certain construction phases on the structures. The use of stratigraphic analysis of standing structures is important for a better understanding of the historical development of certain objects. The Cesargrad castle example indicates that the castle itself is older than the first mention in written sources testifies. Cesargrad was first mentioned in written sources in 1399, but the oldest structures in its core can be dated to the beginning of the 14^{th} century, or maybe even earlier (Janeš 2014: 314). Likewise, certain construction phases can be linked to specific historical events or situated to the periods when the castle was owned by people that we know of thanks to the written sources. In the Grižane case, the analysis of the architectural remains of the castle indicates that the castle was (clearly) younger than its first mention in the written sources. The famous 1288 Vinodol statute mentions notable individuals from Grižane as one of the nine medieval municipalities in Vinodol. The Grižane castle itself is mentioned only in 1449 (Janeš 2021: 221). The architectural remains visible today do not reflect a large number of construction modifications and have all the characteristics of the 15^{th}-century fortification architecture. Regarding the Grižane castle, it can be concluded that this castle was first mentioned in 1449 and has no clear link to the information from the Vinodol statute.

The stratigraphic analysis of standing structures can be just as important for making decisions about conservation works. The right use of the stratigraphic method in the analysis of standing structures shows a more systematic approach to the understanding of the building; it is an approach rooted in the concept of stratigraphy. This concept is the basic critical tool that makes a difference between archaeology and other disciplines involved in the analysis of masonry structures (Clark 2000: 20). The results of the analysis can be presented correctly on the preserved archaeological remains which would portray the historical tides of the object to all types of visitors in a better and more fitting way (Fig. 10). The understanding of the building is the first and the most important aspect of the conservation process. If we do not understand the building and its importance, we cannot evaluate any changes to it (Clark 2000: 17). The structural survey encompassed structures from all historical periods which resulted in a complete approach to the study of medieval castles from their creation to their abandoning and reusing in later periods. The georeferenced 3D models and orthographies enabled the measuring of the structures directly in the CAD, which means that they can also serve for calculating the amount of material necessary for the conservation and, consequently, the amount of financial resources needed for such works. The contemporary techniques of documenting architectural remains open the possibility of monitoring the situation of certain sites through the remains of the architecture preserved in elevation. Recording architectural remains in certain intervals can provide insight into the structure degradation which could help create conservation plans for certain sites and facilitate their proper protection.

Acknowledgements

I would like to thank my colleagues Valerija Gligora and Marin Emić for the useful comments made during the writing of this paper.

Translated by K. Deskar

References

Banning, E. B. 2002. *Archaeological survey*, Springer Science+Business Media, New York

Brogiolo, G. 1988. *Archeologia dell'edilizia storica*, Edizioni New Press, Como.

Brogiolo, G. and Cagnana, A. 2017. *Archeologia dell'architettura, metodi e interpretazioni*, All'Insegna del Giglio, Firenze.

Clark, K. 2000. Architect's Specification: Building analysis and conservation, In: S. Roskams, *Interpreting Stratigraphy. Site evaluation, recording procedure and stratigraphic analysis*, BAR International Series 910, Archaeopress, Oxford, 17-24.

Čučković, Z. 2012. Metodologija sustavnog terenskog pregleda: primjer istraživanje zapadne Bujštine (Istra), *Opuscula archaeologica* 36, 247-274.

Fasham, P. J. 1986. Approches de la prospection systematique, In A. Ferdiere and E. Zadora-Rio (eds.) *La prospection* archéologique (documents d'Archeologie francaise 3), Paris, 19-28.

Grgurić, M. and Novak, Z. 2018. Using 3D laser scanners on archaeological sites, *Opuscula archaeologica* 39/40, 107-115.

Harris, E. C. 1989. *Načela arheološke stratigrafije*, Ljubljana.

Harris E. C. 2003. The Stratigraphy of Standing Structures, *Archeologia dell' Architettura* VIII, 9-14.

Janeš, A. 2014. A View on Life in a Castle. An Analysis of the Architecture and Finds from the Castle of Cesargrad, Croatia (2008 and 2010 Excavation Campaigns), *Castrum Bene* 12: *The Castle as Social Space*, 313-324.

Janeš, A. 2016. Grižane-kaštel Grižane, *Hrvatski arheološki godišnjak* 12/2015, 463-465.

Janeš, A. 2020. *Klanjec, utvrda Cesargrad. Elaborat o provedenim dokumentacijskim radovima 2018. godine*, Arhiv Hrvatskog restauratorskog zavoda, Zagreb.

Janeš, A. 2021. The Castle Estate: A Self-sufficient or Dependant Economy – the Case Study of Grižane Castle in the Vinodol Valley, *Castrum Bene* 16: *Castle and Economy*, 219-234.

Janeš, A., Sekulić, P. and Fundurulić, A. 2017. *Izvještaj o strukturnom pregledu kaštela Grižane (Vinodolska općina) 2016. godine*, Arhiv Hrvatskog restauratorskog zavoda, Zagreb.

Mercer, R. 1985. A View of British Archaeological Survey, In: S. Macready and F. H. Thompson (eds.), *Archaeological Field Survey in Britain and Abroad*, London, 8-24.

Vuković, M. and Mađerić, M. 2015. Dokumentiranje zaštitnih iskopavanja primjenom 3D fotogrametrijskih modela, *Obavijesti Hrvatskog arheološkog društva* XLVII, 15-22.

Westman, A. 2000. The Stratigraphic Examination of Standing Buildings: problems and solutions, In: S. Roskams, *Interpreting Stratigraphy. Site evaluation, recording procedure and stratigraphic analysis*, BAR International Series 910, *Archaeopress*, Oxford, 113-123.

Archaeological surveying in karstic fields: the site of Balina Glavica

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https://doi.org/10.17234/METARH.2022.04

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This research paper explores the application of a unique field survey approach designed to deal with site detection and interpretation in karst fields. The method has its limitations, and it is predominantly focused on detecting sites from antiquity because of the nature of the material remains left in the landscape from those times. Nevertheless, the approach provides a new layer of spatial information based on objectivity in contrast to the usual practices of archaeological reconnaissance. The general goals of the wider AdriaRom Project are described and the role of this particular case study in the wider survey within the scope of the project. Finally, the results of the field survey are presented and the efficiency and the drawbacks of the utilized methodology are discussed.

Keywords: *field survey, ALS, antiquity, distribution, tegulae*

Introduction

The Department of Archaeology of the Faculty of Humanities and Social Sciences of the University of Zagreb in the scope of the Croatian Science Foundation's project IP-2018-01-4934, *Understanding Roman Borders: The Case of the Eastern Adriatic* (*AdriaRom*), explores the archaeological remnants of Roman military infrastructure in the hinterland of Iader and Salona in order to ascertain whether or not these structures were components of a defensive border. For the purpose of conducting this research, test areas were chosen (the surroundings of the Roman legionary fortresses of *Burnum* and *Tilurium*, as well as the surroundings of the presumed forts (castella of *Promona, Magnum and Andetrium*) and a seven-step

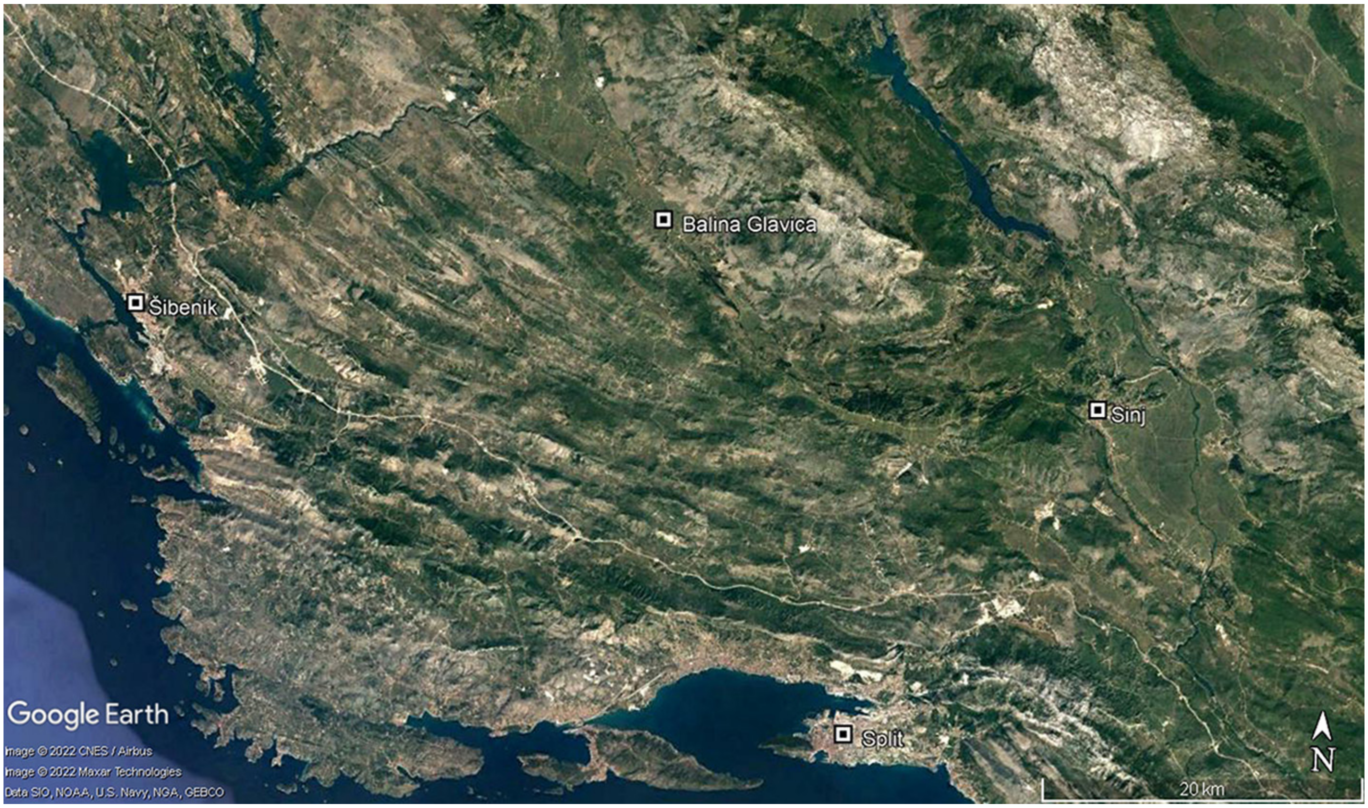

Figure 1. Balina glavica area on the wider area map.

methodological approach was adopted. The successful reconstruction of the defensive border first requires the establishment of the positions which may be assumed to have been military sites and then the formulation of structural indicators (roads, legionary fortresses, forts and sentry towers, moats, palisades, etc.). Two legionary fortresses (*Burnum* and *Tilurium*) are known in the hinterland of *Iader* and *Salona*, and the existence of several forts between them has been presumed. Even though these forts are known from Roman-era literary sources, and their existence is backed by finds of epigraphic monuments, they were never archeologically excavated and their precise locations have yet to be pinpointed. Due to this current state of research, we conducted a series of ALS surveys aiming to discover traces of roman military infrastructure (roads, forts, watchtowers, etc.). Once we identified possible targets on the ALS data the second step was to conduct a field survey to confirm the identified features on the ground.

One of the main indicators of the presence of an archaeological site are large amounts of fragmented pottery and other material from the past visible on the surface. This material is in most cases deposited on the surface as a result of agricultural activities such as ploughing and field clearance. Although the ALS data revealed a number of potential roman forts during the field survey there was no visible material on the surface.

In the case of the archaeological site near Balina glavica situated in the Petrovo polje we had a completely contrary situation to the one above. Due to intense agricultural activity there were no identifiable features visible on the ALS data in the fields below the hill of Balina glavica.. Due to the fact that the site is situated near the Čikola river, it is susceptible to seasonal flooding, and ground water is commonly found in abundance in the fields surrounding Balina glavica. This fact limits the use of geophysical prospection and other corroborating methods and approaches should be explored. The common field surveying techniques of analyzing surface pottery finds are also not possible due to the fact that agricultural activities in the region have dropped significantly in recent years, and what were once ploughed fields, have now turned to heavily overgrown grass meadows. For this reason, we were forced to come up with a field surveying method focused on analyzing drywalls and clearance mounds, which could allow us to determine the approximate boundaries of the site.

The aim of this paper is to present our approach to surveying sites in karst polje where agricultural activity has seen a significant drop in the past few decades. The area that will be presented revolves around the site of Balina glavica (Fig. 1) in Petrovo Polje next to the Čikola river. The site itself is recognized in scientific literature as the probable location of the Roman municipium of Magnum situated at an elongated narrow strip of the Petrovo polje next to the Čikola river, leading towards the south pass to Central Dalmatia. Right next to the probable remains of the Roman Magnum lies a steep hill called Balina glavica which is categorized as a prehistoric *gradina* (hillfort) site. The landscape was subjected to major changes with land divisions and terracing which have subsequently changed the micro topography, and only a small number of archaeological features are visible on the ALS data. The site could provide important information regarding the Roman military actions in the area, Roman urbanization and the extent of the prehistoric settlement. Since archaeological prospection methods have given limited results in this area, our first goal was to try to define the extent of the potential sites and the results will be presented in this paper.

Previous research

Multiple smaller excavation campaigns over the years have confirmed the existence of Roman buildings (Zaninović 2000; Glavaš 2010) at the foothills of Balina glavica. In scientific literature the site is interpreted as the remains of the Roman *municipium Magnum*, which is confirmed by multiple epigraphic inscriptions[1] and the fact that the site is shown on *Tabula Pointigueriana*[2] (Glavaš 2011: 69). Large amount of archaeological material present on the drywalls and the clearance mounds are mentioned in THE literature (Glavaš 2011: 70) The drywalls themselves are in numerous places constructed from pre-shaped stones rather than the standard irregular stones. Although the former fields have mostly turned to grasslands there are large quantities of Roman building material (*tegulae* and *imbrex*) and fragments of Roman *amphorae* strewn across the drywalls serving as land divisions. This fact provided us with an opportunity to implement a field surveying methodology initially developed for another area in the Dalmatian Hinterland with a similar geological and agricultural backdrop.[3] The goal of archaeological field surveys is to gather information about the surface distribution of archaeological artefacts and reconstruct settlement patterns of the past (Sanader et al. 2021: 120). The traditional surveying methods where the archaeologist relies on intuition and assumptions was supplanted by a field survey approach that focuses on defining a predetermined research plan (Novaković 1996), which makes it a more systematic and objective method of gathering data. The methodology of this survey is based on the assumption that most of the archaeological material deposited on the drywalls is a direct consequence of field clearing, and that the material has been removed from the subsurface layers during the ploughing process. During the numerous surveys conducted in the wider area of Dalmatian Hinterlands it was noted that the quantity of material present on the drywalls and clearance piles is not always the same. This fact could have numerous explanations but one of the possible interpretations is that the amount of material present reflects the amount of archaeological material present in the surrounding land plots and in the direct proximity of the drywalls. It should be noted that the traditional field survey methodology was already applied in Croatian karst fields, but it deliberately targeted fields that are still being worked on today to achieve the desired results (Bintlif & Gafney 1988; Slapšak 1988; Čučković 2012). This field survey approach could be defined as a subcategory of intensive field survey where circles or grid squares are treated as survey points (Van de Velde 2001: 34). The approach of documenting scatters of small finds and material was previously utilized during surveys conducted in the Starigrad field where this methodology was instrumental in expanding our knowledge of landscape use in antiquity (Slapšak 1988). Some of the reasonings used in the 1984-1985 wall survey can be directly applied to our research area, namely, the concepts that the presence of material on drywalls is indicative of a nearby structure, and that in the case of low field surface visibility (meadow, olive field, abandoned arable land) walls and stone heaps could be the only places where the material is visible (Slapšak 1988). While systematic and intensive field surveys are primarily used as a survey technique within the context of landscape archaeology, our approach is more focused on answering the questions of spatial relations within a single "site", similar to research done on the hillfort Grad at Nakovana (Forenbaher & Rajić-Šikanjić 2006).

1 CIL III, 6565 = 9798 = 14316, CIL III, 14957, CIL XIII, 6538.

2 Tab. Peut, segmentum VI.

3 The methodology applied in this project was initially developed as a part of a PhD research by Miroslav Vuković, titled: "Archaeological prospection methods in karst landscapes: case study of the Muć valley"

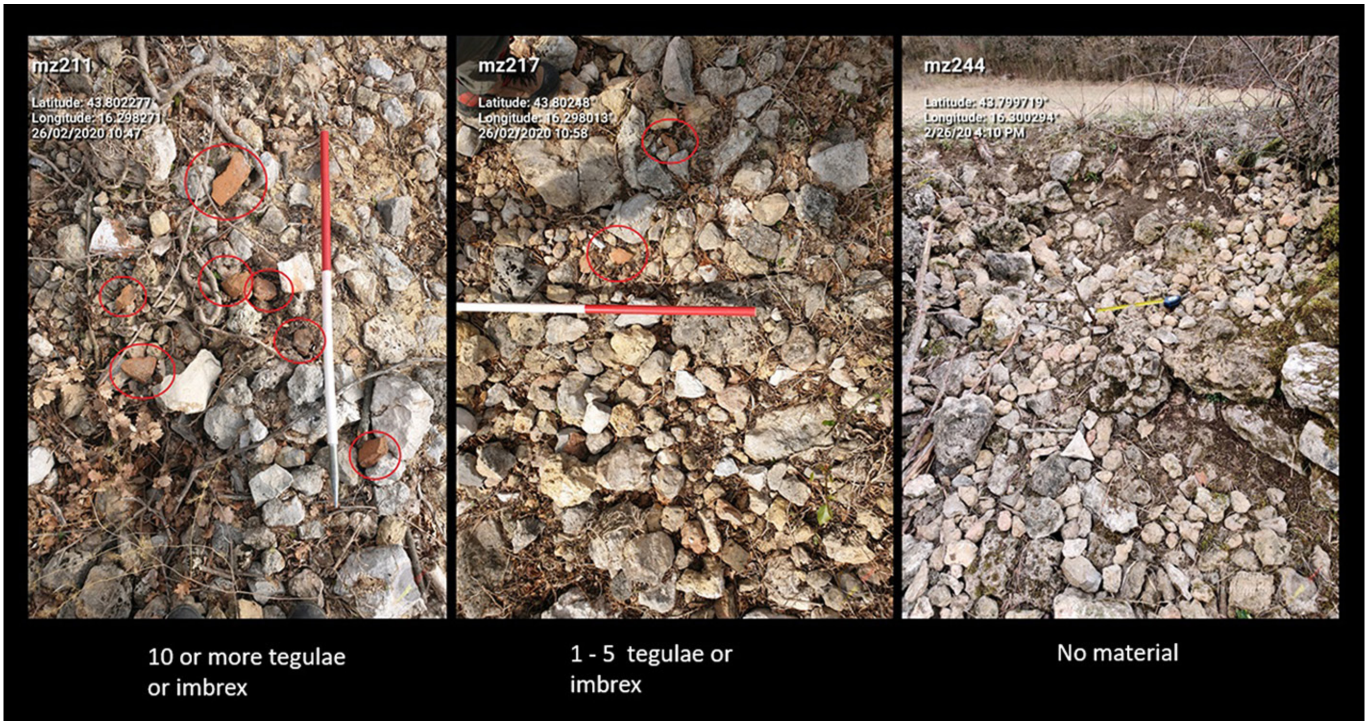

Figure 2. Different amounts of surface material present at the survey point. (Archive of the AdriaRom project).

Survey methodology

The initial research area was mapped out and it roughly amounted to the area enclosed by the modern D56 state road, Balina glavica and Čikola river measuring 0.51km^2. The project was prepared in QGIS where base maps, topographic maps of Croatia and aerial and satellite data were loaded. Additionally, we prepared a section of the Austro-Hungarian cadastral survey of Dalmatia from the 19th century for comparison of land divisions. One of the most obvious limitations of this survey method is that we are constrained by the number of drywalls and clearance mounds present in the field. Where the prevalence of drywalls stops our data also reaches its limit but this does not necessarily reflect the layout of the subsurface archaeological layers. In other words, the site could extend beyond the area where the drywalls are present but our methodology limits us from observing this in the field. By laying out a relatively even grid of survey points on the drywalls present in the field and maintaining proximally equal spacing between the survey points we got a relatively representative sample to work with. The survey points were chosen in a random selection while trying to maintain a relatively equal distance between individual points. This selection served as a guide for choosing survey points in the field which were usually removed from their original location due to the accessibility of the individual drywall section and the dense vegetation that covers most of the surfaces. Each point designated by the field survey methodology was surveyed and the amount of archaeological material in a 2m radius was counted and recorded. The section of the drywall where the survey was conducted is described and the visibility of the drywall itself is introduced as a factor because some parts of the drywalls are covered by dense vegetation.

A photograph (Fig. 2) is taken of the surveyed section as well as a control GPS point. Most of the material finds are left on site, and only a few pieces of indicative and diagnostic material are gathered for further processing (Fig. 3). The fieldwork was organized in four teams consisting of two people. Each team had a map of predetermined survey points visible on their mobile phone along with all the other necessary equipment for recording the data in the field. The fieldwork also included recording data with respect to the type of surface we were surveying (e.g. drywall, clearance pile), and a subjective as-

Figure 3. A selection of material gathered during the field surveys. (Archive of the AdriaRom project).

sessment of the visibility. The survey was conducted in winter (February) when the foliage is at its lowest. Visibility was determined on site and valued by percentages from 50% - 100% where 50% represented the worst conditions (large amounts of vegetation and dry leaves covering the surveyed section of the wall), and 100% represented the best conditions (walls and clearance piles completely free of vegetation and leaves).

Results

During the field survey, large deposits of Roman pottery and *tegulae* were found on the drywalls and stone mounds which were created as a consequence of land clearance. These factors point us to the presence of a large archaeological site dating back to Roman times. A small amount of surface finds was gathered which were all attributed to the Roman period and consisted mostly of *tegulae*, *imbrex* and some *amphorae* fragments. Most of the finds fall into the category of Roman building material (*tegulae* and *imbrex*), which is expected since that type of material is large enough to pose a problem to the farmers who probably removed it from their soil during the ploughing process. The smaller material such as pottery fragments wasn't as big of an obstacle for the farmers and their presence on the drywalls is significantly smaller than the presence of larger materials. The second limitation of our methodology becomes obvious at this point as the process itself is heavily biased toward material deposits from antiquity, and if a site is multilayered horizontally or vertically most other material remains will not show up in our surveys simply because they weren't large enough for the farmers to remove. After data processing and transcribing the field survey data to a QGIS attribute table, we were able to visualize our survey in the vicinity of Balina glavica. More than 250

Figure 4. Visualization of survey points with heatmap visualization zoomed in and individual survey points with extrapolated results are visible. (Made by: M. Vuković).

GPS points were recorded during the survey. The survey points with their attribute data reflecting the amount of material present at each location were visualized in a heatmap style (Kernel Density Estimation, QGIS 2022) overlaying the base maps for the area. The amount of material was categorized into five distinct categories:

Amount of surface material present	Heatmap intensity
0 fragments	0 (transparent)
1 – 5 fragments	1
5 – 10 fragments	2
10 – 15 fragments	3
15+ fragments	4

Table 1. Amount of surface material present divided into five categories for the heatmap visualization.

The heatmap visualization itself was tweaked to show the points where the value is zero as completely transparent and the subsequent categories with an increasing amount of material as a shifting colour from orange to red. The optimal view for the visualization is when the entire survey area is visible as a whole dataset because the detailed view provides only a small heatmap surrounding individual points where the material was detected (Fig. 4).

The final distribution of material covers an area of approximately 18 ha and it is concentrated around the eastern part of the site while the first slopes to the south and the east have shown little or no material present. The distribution also suggests that the site extends from the base of Balina glavica toward the Čikola river, but the drywalls abruptly end along the way and the only confirmation of this hypothesis comes from a single ploughed field next to the river where fragments of pottery and tegulae were found. The river also represents a natural boundary which was probably used during antiquity. The heatmap also revealed a higher concentration of archaeological material in a small radius at the center covering an area of 1 ha (Fig. 5). The higher concentration in this area could point to the possibility that the center of the Roman municipium was situated at this location.

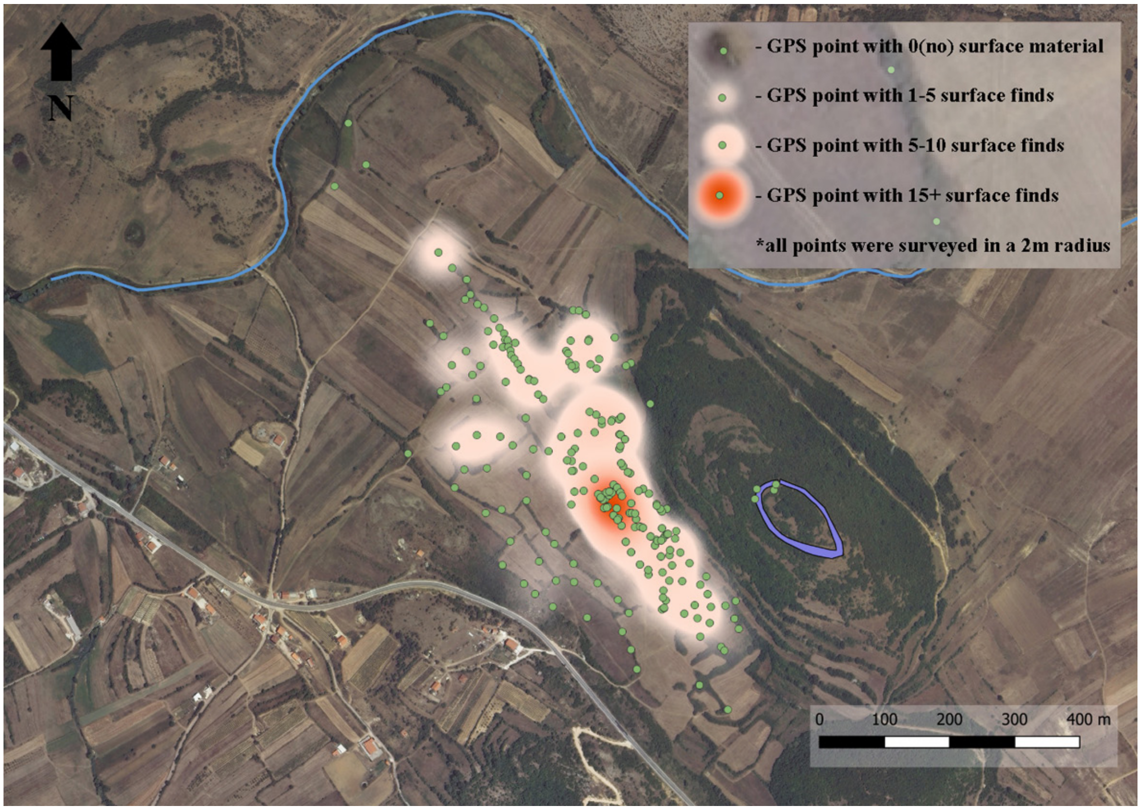

Figure 5. Final distribution overlayed with survey points represented by green dots, a quantity of surface finds within a single survey point is expressed by the strength of the heatmap colour ranging from transparent to deep orange. A possible prehistoric terrace identified on ALS data is marked in purple on the Balina glavica hill. (Made by: M. Vuković).

Additionally, a short reconnaissance was undertaken at the hill of Balina glavica as well. The site is mentioned in literature as the possible location of the Dalmatean settlement of Synodium (Kos 2002; Glavaš 2010) and in the 19th century a small hoard of Celtic coins was found on the site potentially proving the importance of the site as a place where either trade or travelers have brought the coins (Kos 2002.) The entire hill seems to be terraced with large drywalls whose exact origin is hard to place in time. The terracing could be a consequence of more recent agricultural activities or alternatively, they could represent the remains of prehistoric terracing related to the proposed prehistoric settlement situated on the hill. The fact that the modern and 19th century cadastral plans show little evidence of field divisions on the hill could point to the fact that at least some of the terracing could potentially be of prehistoric origin. If that is the case the prehistoric settlement at Balina glavica could be the location of a major prehistoric settlement with an approximate surface area of 4 ha. Besides the terracing, the most prominent feature visible on the ALS data at the site are the ditches and dug-in bunkers from the 20th century conflicts which left their trace in the area. One of the dug-in bunkers revealed the stratigraphy of the archaeological layers beneath 30cm of topsoil and numerous finds of fine, black and ornamented prehistoric pottery. The pottery was found in the northern ditches as well as the southern ditches on top of the hill. Unfortunately, besides the bunkers and the trenches, there is no other obvious way to reach the archaeological material underneath the topsoil besides digging. A magnetometer survey should be considered as a possible technique to extract as much information as possible before proceeding with actual excavations.

Discussion and conclusion

The field survey approach described above aimed to determine the possible extent of the Roman site at the foothills of Balina glavica. The data seems to show obvious boundaries in material distribution suggesting an absence of subsurface archaeological layers dated to antiquity to the east, the south and the west of the proposed settlement center. The boundary to the north reaching up to the Čikola river is less clear since it was not a consequence of a lack of material present on the drywalls but rather a consequence of an abrupt end to drywalls present in the field. The question of the correlation between the distribution of Roman building material on the surface and the actual building remains in the subsurface soil is still open. It could be argued that some of the material present on the drywalls was dispersed and that the wide distribution is a consequence of agricultural activity, but this argument would have more merit in landscapes where the division lines between fields aren't physical as is the case with drystones in karst fields. The best method for corroborating the distribution data would be to conduct a wider GPR survey of the site, but the effect and presence of the large amounts of underground water detected at the site could potentially affect the results of such a survey. This field survey approach is limited by a few factors which need to be taken into account when utilizing this method.

1/ The survey area is limited to areas in karst polje where drywalls and clearance mounds are present

2/ The method completely excludes archaeological data related to time periods older than antiquity

3/ The material distribution should be corroborated by at least one other independent archaeological prospection method

It is our opinion that this method can provide a good starting point for determining the extent of Roman sites detected in karst fields. It could serve as a base map for further research and it should ideally be combined with another archaeological prospection method. Nevertheless, the method presented in this paper did provide us with another layer of information pertaining to the extent of the Roman site at the foothills of Balina glavica despite the fact that the fields have been transformed to grasslands. This transformation of karst fields is especially evident in Dalmatian Hinterlands where an increasing number of people are leaving the rural landscapes and moving to the coastline, which leaves us with landscapes that were at one point transformed by agricultural activities but are now overgrown with dense vegetation and the land is no longer actively worked on. Since the trend of depopulation and decreased agricultural activity has only been increasing in recent years it is evident that the development of these types of methodologies could prove crucial for further archaeological research in the karst landscapes of Dalmatian Hinterlands.

References

Bintliff, J. and Gaffney, V. 1988. The Ager Pharensis/Hvar project 1987, In: J. C. Chapman, J. Bintilff, V. Gaffney and B. Slapšak (eds.), *Recent Developments in Yugoslav Archaeology*, BAR International Series 431, Oxford, 151-194.

Čučković, Z. 2012. Metodologija sustavnog terenskog pregleda: primjer istraživanja zapadne Bujštine (Istra), *Opvscvla archaeologica* 36 (1), 247-274.

Forenbaher, S. and Rajić-Šikanjić, P. 2006. The Prehistoric Hillfort at Grad (Pelješac, Dalmatia) – Preliminary Results of Intensive Surface Survey, *Collegium Anthropologicum* 3, 467-473.

Glavaš, I. 2011. Prilozi za antičku topografiju Petrovog polja. Logor rimskih pomoćnih vojnih postrojbi u Kadinoj Glavici, municipij Magnum i beneficijarijska postaja u Balinoj Glavici, *Godišnjak zaštite spomenika kulture Hrvatske* 35, 63-74.

Glavaš, I. 2010. Municipij Magnum – raskrižje rimskih cestovnih pravaca i beneficijarska postaja, *Radovi Zavoda za povijesne znanosti HAZU u Zadru* (52), 45-59.

Kos, P. 2002. A find of Celtic coins from the area of Balina Glavica (Sinotion) in Dalmatia, *Vjesnik Arheološkog muzeja u Zagrebu* 3. serija, 35, 147-158.

Novaković P. 1996. Arheologija krajine i sistematični terenski pregled, In: M. Guštin, P. Novaković, D. Grosman, B. Mušič and M. Lubišna Tušek (eds.), *Rimsko podeželje / Roman Countryside*, Ljubljana, 1-42.

Sanader M., Miloglav I., Tončinić D., Vukmanić I., Matijević V., Vuković M., Cvetko M. 2021. Field survey of Danube limes in eastern Slavonia and Baranja, In: D. Tončinić and L. Zerbini (eds.), *Traian and the Danubian provinces. The political, economic and religious life in the Danubian provinces, Proceedings of the 4th International Conference on the Roman Danubian Provinces Zagreb, 15th – 17th November 2017*, Filozofski fakultet Sveučilišta u Zagrebu, Zagreb, 117-134.

Slapšak, B. 1988. The 1982-1986 Ager Pharensis survey. Potentials and limitations of “wall survey” in karstic environments, In: J. C. Chapman, J. Bintilff, V. Gaffney and B. Slapšak (eds.), *Recent Developments in Yugoslav Archaeology*, BAR International Series 431, Oxford, 145-168.

Van de Velde, P. 2001. An Extensive Alternative To Intensive Survey: Point Sampling in the Riu Mannu Survey Project, Sardinia, *Journal of Mediterranean Archaeology* 14 (1), Sheffield, 24-52.

Zaninović J. 2000. *Arheološka istraživanja u Magnumu*, Izvještaj 2000, arhiva Ministarstva kulture i medija.

CIL – Corpus Incriptionum Latinarum, Berlin.

HD – Epigraphische Datenbank Heidelberg (Heidelberger Akademie der Wissenschaften; http://edh–www.adw.uni–heidelberg.de/home)

Source

Tab. Peut, segmentum VI.

Internet sources

QGIS 2022

QGIS Desktop user guide/Manual (QGIS3.16), group of authors, https://docs.qgis.org/3.16/en/docs/user_manual/index.html, accessed on: 12.12.2022.

Project MagIstra – magnetic mapping of archaeological structures in soils on flysch: case studies from Slovenian Istria

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https://doi.org/10.17234/METARH.2022.05

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The main goal of the research project "MagIstra" was to assess the potential of the magnetic method in identifying and determining the type of archaeological remains in the soil sequence on the soft carbonate rocks (Eocene flysch bedrock). For this purpose, magnetic contrast between the individual archaeological remains and the medium in which they are located was evaluated. Furthermore, all the anthropogenic and natural factors affecting the magnetic measurements in the researched environment were carefully analysed. The investigation was conducted in the late spring of 2021, on four selected case study archaeological sites from different archaeological periods in the interior of Slovenian Istria. Precise surveys with a high-resolution magnetometer were combined with the topsoil magnetic susceptibility survey. The results were supplemented and compared with the results of the earth resistance survey for a better evaluation of magnetic anomalies and to determine the possibility of the magnetometer to recognize the weakly magnetic dry-stone walls built of sandstone. The geophysical surveys were followed by ten test pits to assess the accuracy of the results and to determine the magnetic properties of the natural and archaeological materials. Research has shown that weakly magnetic soils on sandstone bedrock that are equally weakly magnetic are ideal natural conditions for detecting a variety of archaeological remains, especially those with thermoremanent magnetization (burned layers, ceramic accumulations, daub). As a result of a detailed analysis of the magnetic anomalies and the magnetic susceptibility data, we were also able to gain a better understanding of the specific conditions required to detect magnetic anomalies caused by the induced magnetization of sandstone structures. In addition to improving our knowledge of the magnetic field survey's efficiency in this environment, the study also enabled us to interpret the results of the magnetic survey in a more effective way.

Keywords: *magnetic method, Flysch, magnetic susceptibility, archaeology, archaeogeophysics, Slovenian Istria*

Introduction

Although integrated non-invasive research has been efficiently applied on archaeological sites throughout Slovenia (Slapšak and Grosman 2010; Mušič et al. 2015), Slovenian Istria remains largely unexplored when it comes to the use of geophysical methods. Geophysical research was mainly carried out as part of the protective archaeological research in the urban areas of the coastal zone (in the cities of Koper, Izola, and Piran), where ground penetrating radar was used as the most efficient geophysical method (Maselli and Monti 1994; Car 2005; Mušič 2011). Until now, only the Roman coastal villa in the Bay of San Simon has been the subject of more detailed

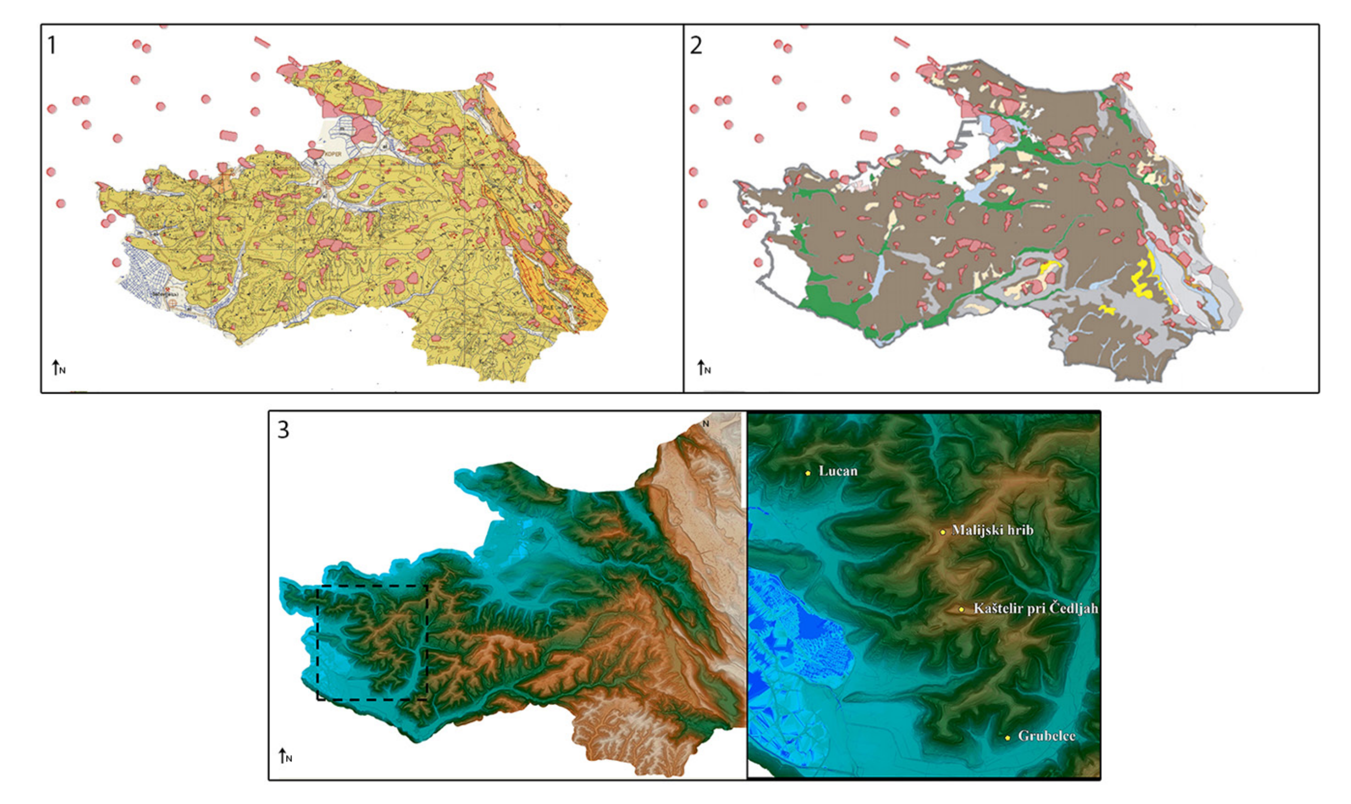

Figure 1. Slovenian Istria. Protected areas of registered archaeological sites (marked in red) on basic geological map 1: 100,000 (map adapted after Plesničar 1970 (1), and map of soils 1: 250,000 (map adapted after Grčman et. al 2015) (2). Studied archaeological sites on a digital elevation model (DEM) (map produced by the author. Raw data: https://gis.arso.gov.si/) (3).

geophysical studies in Slovenian Istria. Numerous geophysical methods have been used successfully over the past decades at the famous site, with excavations and/or chore drilling backing up the results. (Lapajne and Kelhar 1970; Mušič 2006; Groh and Sedlemayer 2017). The wider area of Izola being an exception in terms of geopedological features, since this part is a smaller outcrop of foraminifera limestone bedrock, covered with brown carbonate soil, the results in this work are not directly comparable and not so relevant to the present research. The results nevertheless contribute significantly to the archaeo-geophysical interpretation of various archaeological features and materials found on site. The interior of Slovenian Istria however, where remains of lowland and highland settlement systems are recorded, often with continuous habitation from different archaeological periods ranging from the Copper Age to the Middle Ages, remains completely un-investigated with the use of geophysical methods (Fig 1. 1 and 2). A systematic assessment of a geophysical method in a geo-pedological environment of Slovenian Istria is conducted for the first time in this study.

Each of the geophysical methods is sensitive to different physical parameters of the soil and the buried archaeological structures. A comprehensive interpretation of the archaeological sites usually requires the implementation of a multi-method approach, state-of-the-art in current archaeogeophysics (Piro et al. 2000; Piro 2009; Fassbinder 2011). Nonetheless, in this study, the magnetic method is used as the primary one among all of the geophysical methods, due to its accurate and rapid inspection capability of larger areas, and its ability to identify all types of archaeological remains under ideal conditions (Aspinall et al. 2008; Smekalova et al. 2008; Fassbinder 2015). Numerous surveys that use the magnetic method as the primary method at archaeological sites elsewhere in Slovenia show positive results in the recognition of various types of archaeological remains (Mušič 1999; Mušič et al. 2015; Medarić et al. 2016). However, solutions from one natural environment are often not directly transferable to another. For maximum survey efficiency, with a faster and more archaeologically effective interpretation of the measured data, a precise verification of the results, analysis of individual

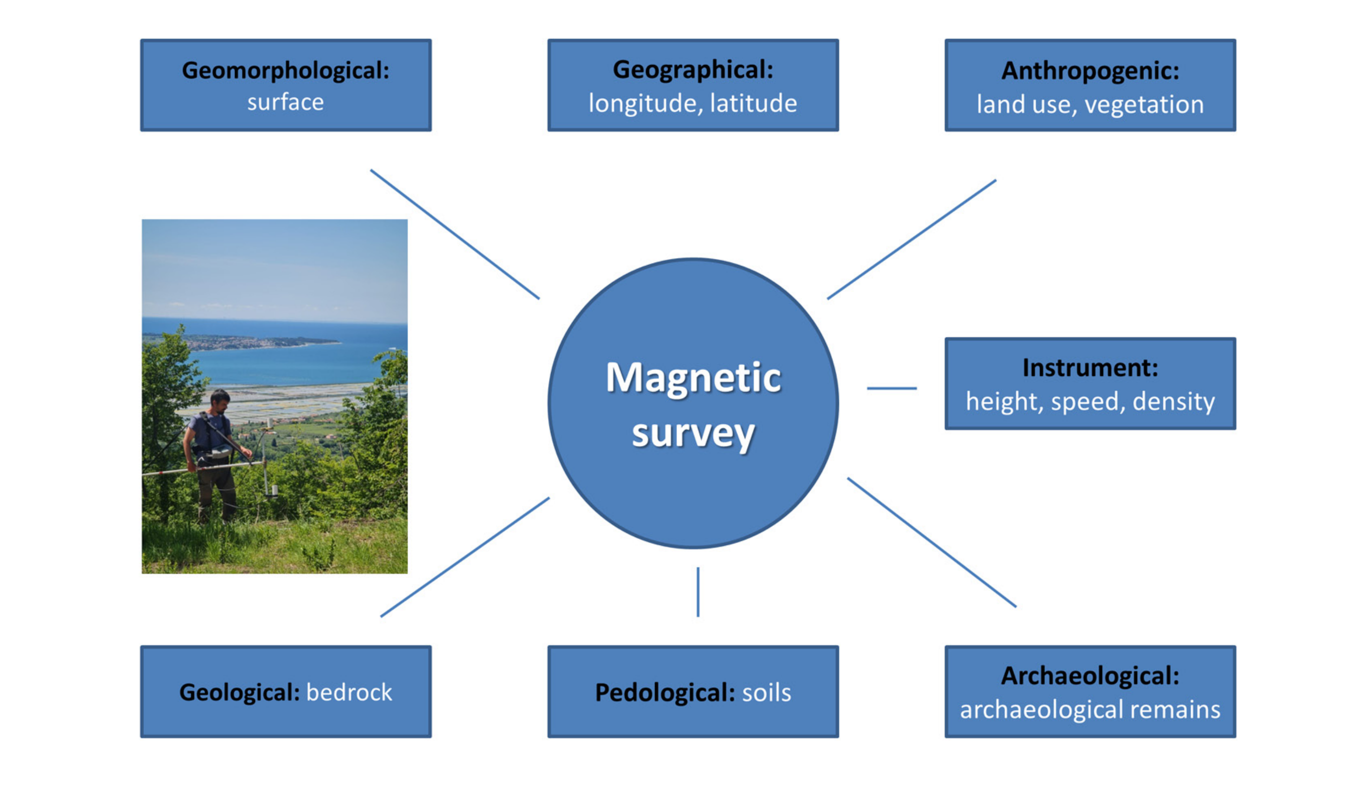

Figure 2. Factors influencing magnetometer survey evaluated in the research project (Photo by: Aleks Kunst).

factors that influence the measurements within specific natural conditions, and adaptation of the results to the goals of the research have to be conducted.

This project aimed at analysing the basic conditions specific to the geo-pedological environment of Slovenian Istria (sols on Eocene flysch bedrock). Detailed evaluation of the effectiveness of the magnetometer survey for identification and determination of the type and physical properties of archaeological remains was carried out in late spring 2021, at four typologically and chronologically different archaeological sites: multi-periodic hill-fort of Kaštelir near Čedlje (Late Bronze Age, Iron Age, Roman Age, Middle ages), hill-fort Malijski hrib (Iron Age, Early Roman period), villa rustica at Grubelce near Dragonja (Roman period) and the site of possible remains of villa rustica or a small medieval village at Lucan (Roman period, Middle Ages) (Fig. 1 and 3). The sites were selected not only for their typological and chronological diversity, but also for their geo-pedological, geographical, and anthropogenic context.

Methodology

Applied fieldwork methodology, on all the archaeological sites consisted of detailed and dense magnetic surveys with a highly sensitive optically pumped magnetometer and surveys of topsoil magnetic susceptibility, carried out at the exact same areas. Due to the limited depth reach of the susceptibility field instrument and the fact that it measures only the component produced by magnetic induction, we were able to complement the magnetic measurements by separating the properties of anomalies caused by susceptibility contrasts from those caused by magnetic remanence. A comparison of magnetic results and resistivity results was carried out on specially selected areas to determine if the magnetometer was capable of detecting the expected weak differences in magnetic properties between drywall remnants constructed from sandstone and soil.

We also analyzed the apparent magnetic susceptibility of soil and typical buried archaeological structures found on-site, or during the test pitting, to determine if there was enough magnetic contrast between them to conduct a magnetometer survey. A catalogue of individual values of apparent magnetic susceptibility measurements on samples of natural and archaeological materials was produced. Together with magnetograms of magnetic anomalies of various archaeological structures, this provided a valuable data set for assisting with future magnetometer surveys in Slovenian Istria.

Other than that, anthropogenic and natural influences, variables, and noises that were faced while conducting magnetic measurements on archaeological sites in the area were also carefully analysed. Variables that affect the identification of the individual anomalies such as the physical properties (shape and size) of the target archaeological structures, the degree of their preservation, and the depth in which they are buried were evaluated. Other influences related to the surface (relief, overgrowth, and anthropogenic influences), choice of the instrument, the way of conducting measurements (e.g. sensors height, data acquisition speed, and density of measurements), and the influence of the operator on the measurements themselves were checked (Fig. 2). The selected areas were re-measured with different densities, heights, and sensitivity levels. By carefully analysing and understanding all the unwanted information (characterized as noise), we were exploring the possibilities to reduce it, or even eliminate it completely. An efficient data capture strategy and a set of advanced processing procedures for the effective solving of specific problems which could arise in the studied environment will be developed.

Magnetometer survey

Magnetometry is one of the most widely used geophysical methods for an accurate and rapid inspection of extensive archaeological areas. Magnetometers detect small local variations in the magnetic flux density in the Earth's magnetic field, due to differences in the magnetic susceptibility of the material below the surface (Clark 1990). Under optimal conditions, sensitive instruments enable the recognition of anomalies resulting from the archaeological remains of various magnetizations (Fassbinder 2015). Magnetometers most successfully identify archaeological remains with thermoremanent magnetization (TRM), which is formed during the cooling of fired materials over its specific Curie temperature (the average Curie temperature of soil components is around 650°C). In this process, elementary particles - magnetic domains align with the external Earth's magnetic field and the burnt material becomes a strong magnet. Thermoremanent magnetisation (TRM) is characteristic mainly for fired clay, fireplaces, ceramic architectural elements, pottery kilns, metallurgical workshops, etc. Strong magnetic anomalies are also produced by larger iron objects, which, however, cannot be reliably defined as archaeological objects, as their magnetic effect is no different from pieces of modern iron.

With sensitive instruments, it is also possible to recognize extremely weak anomalies, which are the result of induced magnetization. This is the effect, when the elementary magnets of a specific matter are enhanced by external magnetic fields (e.g. the Earth's magnetic field) and, consequently, partly align with it. Induced magnetization is specific for instance, for the remains of walls and various forms of buried structures, such as ditches, pits, clusters of pits, and also simple communications and more compact floor surfaces (Le Borgne 1955; Tite and Mullins 1971).

The magnetic data were obtained with the Geometrics G-858 high-sensitivity caesium vapour magnetometer, which enables a resolution of 0, 1 – 0, 2 nT with a reading speed of 0, 2 s. For the analysis, the values of the vertical gradient of the total magnetic field, with the sensors deployed at a fixed distance of 70 cm between each other, were used. Parallel magnetic profiles were measured in a "zigzag" pattern with an interval of 50cm, and with readings along the profiles of 15 cm. The lower sensor was raised at a constant height of 30 cm from the surface.

Magnetic susceptibility survey

Magnetic susceptibility is a measure of the degree to which a substance can be magnetized and it is defined as the ratio of the induced magnetization to the inducing field. Magnetic susceptibility has been well established in geophysical prospecting in archaeology as an independent prospecting technique (Dalan and Banerjee 1998; Dalan 2007). The method has been in use on archaeological sites in Slovenia non solely as an archaeological prospection survey (Mušič 1997; Mušič 1999; Mušič et al. 2014), but also for predicting the success of magnetometer and as an aid for quantitative analysis of magnetic data with the creation of direct magnetic models (Medarić et al 2011; Medarić et al 2016).

The physical parameter expressed as a volume-specific magnetic susceptibility (SI measurement system) (k') was measured with a field instrument (Satisgeo KM-7), with

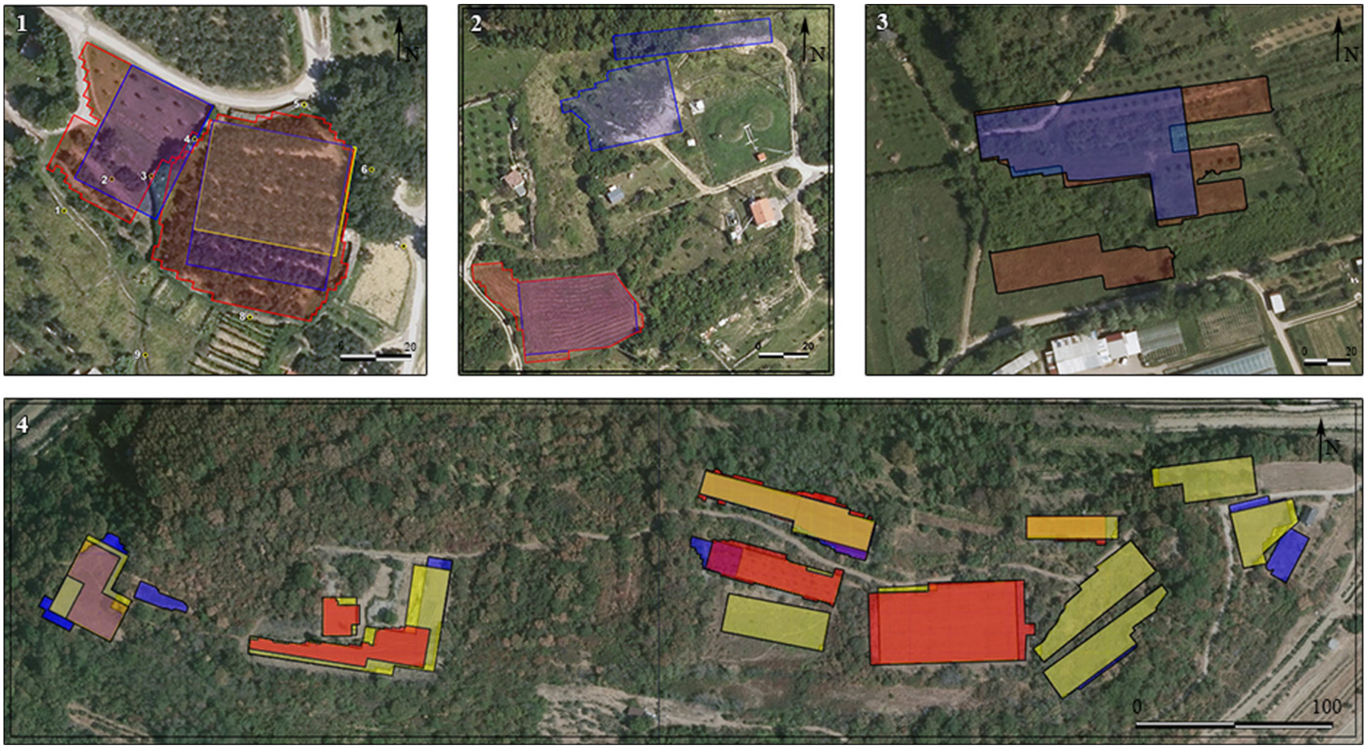

Figure 3. Location of surveyed areas (magnetometer - blue; earth resistance survey - red; topsoil magnetic susceptibility mapping - yellow). 1. Lucan. 2. Malijski hrib; 3. Grubelce near Dragonja, 4. Kaštelir near Čedlje.

a sensitivity of 0,001 x 10-3 SI units. Topsoil susceptibility surveys were performed within the grids of various sizes in a “zigzag” pattern at 2m intervals along parallel transects set 2 meters apart. Since the value of the magnetic susceptibility depends on the size and shape of the object, during the calibration, the measuring coil was applied to an absolutely smooth surface. The samples have been measured several times to obtain the mean value. To minimize the influence of environmental factors such as non-soil inclusions and moisture content, which affects the bulk density, during the measurements of the magnetic properties of the soil, it was made sure that all the samples had equal mass and were dry.

Earth resistance survey

A Geoscan RM85 earth resistance meter with a twin probe array was used for the resistivity survey - a configuration commonly used for archaeological work. For the mapping of the values of apparent electrical resistance, a pair of movable and a pair of static electrodes is used, where the depth range is determined by the distance between the mobile electrodes. The depth range at the distance of 0, 5 m between the electrodes and with the optimum humidity of the soil is 0, 75 m (Clark 1990). In addition to the distance between the moving electrodes, the depth reach is mainly affected by the moisture of the terrain. Measurements performed in the same place will not necessarily give the same results as the moisture conditions at the site change with time.

During the measurements, the static electrodes were placed at a distance of 0, 75 m. A resistivity survey was performed within the individual grids of 20 × 20 meters, by taking readings every 1m by 1m. Most of the electrical resistance measurements on each site were performed under similar conditions so that the soil moisture and thus the depth range and contrast of the results were uniform.

Results

Presented below are some results of the study of individual influences, variables, and noises encountered during the magnetic survey on archaeological sites on Eocene flysch in Slovenian Istria:

Impact of the Bedrock

The largest share (approximately 75%) of the Slovenian Istria is covered by geologically fairly uniform bedrock from the middle Eocene (Istrian Flysch), which predominantly consists of successive sequences of marl and sandstone (Pleničar 1970) (Fig. 1. 1). Magnetic susceptibility samples on the bedrock of sandstone were taken at the archaeological sites during test pitting and on exposed bedrock in their immediate vicinity (Fig. 4). The bedrock shows low mean MS values ranging from 0, 036 × 10^{-3} to 0, 130 × 10^{-3}, with only a few individual values exceeding 0, 2 × 10^{-3} (Table 1). The low and sometimes negative MS values can be attributed to high levels of Quartz (SiO2) (range: 28, 26 % - 49,1 %) and Calcite (CaO) (range: 21, 53 % – 35, 89 %) and low level (1,61 % - 2,47%) of Iron oxides Fe2O3 found in sandstones in the Triest-Koper segment of the Flysch belt (Mikes et al. 2006).

The low magnetic susceptibility of the bedrock had lesser or almost no effect on magnetic measurements in terms of “background noise” and is a favorable environment for the detection of archaeological remains with the magnetometer. No significant overlapping and concealing weaker anomalies representing archaeological structures was recognizable on the magnetograms.

Impact of soil

The relatively uniform Istrian flysch bedrock has also a rather unambiguous connection with the soil. The largest part of the region is covered with eutric brown soil (eutric cambisol). On all four investigated archaeological sites, variations of the same type of soil are present (Repe 2012) (Fig. 1. 2).

Readings on soil samples were taken in the immediate vicinity of archaeological locations on natural soils without anthropogenic disturbance, from the topsoil on the archaeological sites and especially during the test pitting (Figs 5 and 6). Mean MS values from undisturbed soil samples are similar, but slightly higher compare, to the values of sandstone bedrock, and are ranging from 0, 057 × 10^{-3} SI to 0, 138 × 10^{-3}, with individual values over 0, 2 × 10^{-3} but not exceeding 0, 3 × 10^{-3} SI. The low magnetic properties of soil sequences found on sites can be also attributed to the diamagnetic minerals. Analysis of physical and chemical properties previously done on soil samples in Slovenian Istria show that typical soil on Flysch consists of 51% quartz (SiO2), while still relatively low level of Iron oxides Fe2O3 is represented (4, 28 %) (Prus and Grčman 2019).

Since the soils on Flysch are the results of the weathering of the same low magnetic rocks, there is no sharp boundary between the physical properties and magnetic susceptibility of soil and bedrock. A predominantly uniform and isotropic medium without many rock inclusions is also a favorable environment for the detection of any type of anthropogenic contribution to the magnetic susceptibility levels in the soils. The weakly magnetic soils had low magnetic background variations and only minor irregularities, considered as surface noise (e.g. plowing). Both types of noises were easily distinguished on the magnetometer results.

Archaeological site	MS values for bedrock (sandstone) (× 10^{-3} SI units) lowest / mean / highest / standard deviation
Malijski hrib	-0, 181 / 0, 112 / 0, 276 / 0, 116
Kaštelir pri Čedljah	0, 072 / 0, 130 / 0, 207 / 0, 038
Lucan	-0, 033 / 0, 036 / 0, 130 / 0, 050
Grubelce pri Dragonji	0, 003 / 0, 094 / 0, 214 / 0, 057

Table 1. Magnetic susceptibility values of the bedrock, on researched archaeological sites.

Archaeological site	MS values for variants of eutric brown soil ($\times 10^{-3}$ SI) lowest / mean / highest / standard deviation
Malijski hrib	-0,045 / 0,086 / 0, 215/ 0, 060
Kaštelir near Čedlje	0, 029 / 0, 138 / 0, 288 / 0, 063
Grubelce near Dragonja	0, 003 / 0, 057 / 0, 205 / 0, 04
Lucan	0, 040 / 0, 113 / 0, 237 / 0, 041

Table 2. Magnetic susceptibility of the undisturbed soils, measured in the vicinity of individual archaeological site.

Figure 4. Magnetic susceptibility measurements performed on exposed bedrock, south of archaeological Kaštelir near Čedlje (left) and on Malijski hrib (right).

Magnetic properties of the archaeological remains

At surveyed sites, all architectural remains found during previous excavations were made of locally extracted sandstone. (Boltin-Tome 1967; Sakara Sućević et al. 2012.). The mean value of MS for dry-stone rubble remains taken during test pitting on Lucan and Kaštelir near Čedlje is 0, 12 × 10^{-3} (Table 1; Figs 6 and 9) (Medarić and Vinazza 2022). The values of MS do not deviate much from the values of the bedrock (Table 1) or natural soil (Table 2). Consequently, architectural remains from sandstone have a weak contrast in the magnetiza-

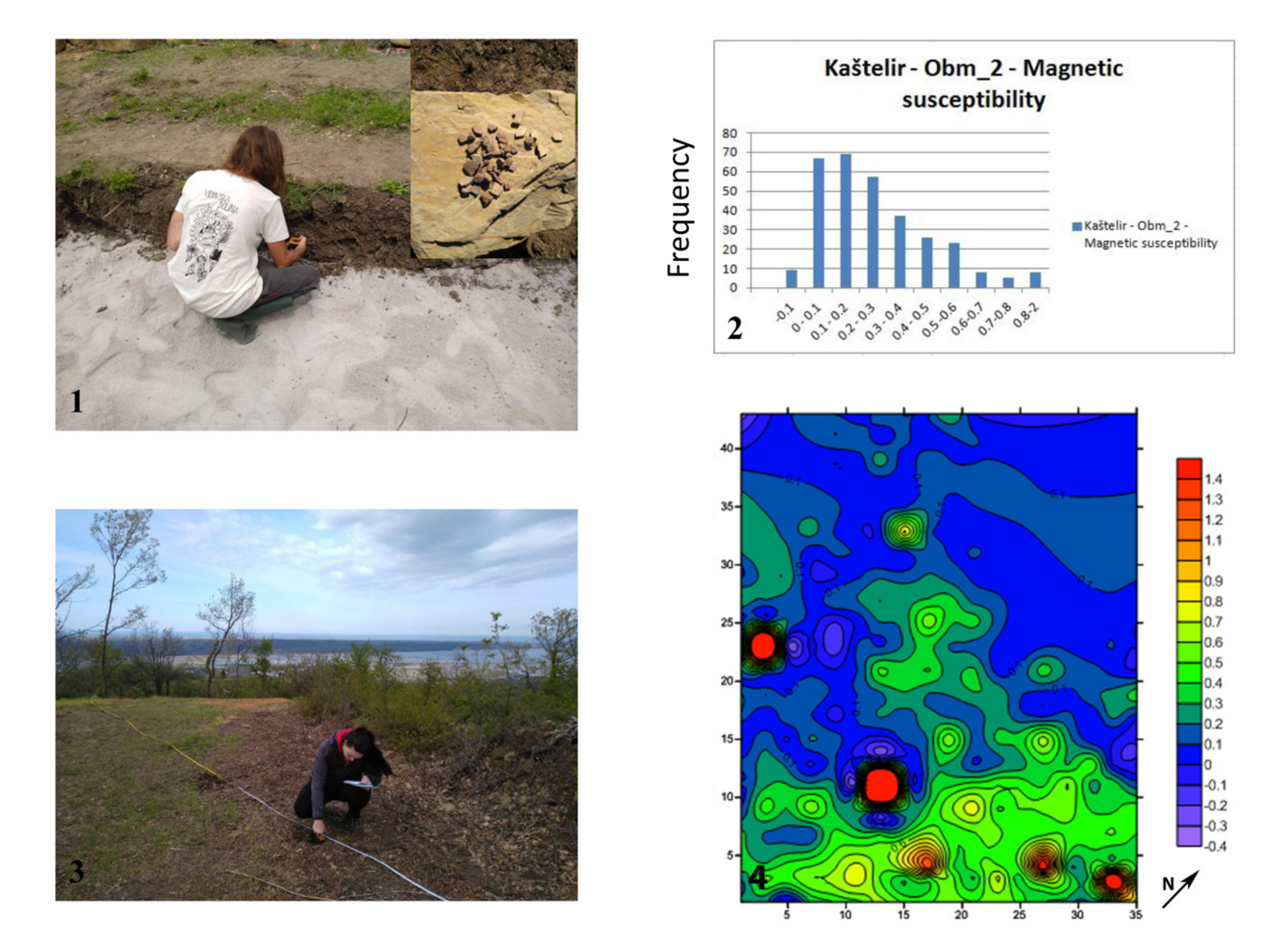

Figure 5. Kaštelir near Čedlje. Measurements of volume magnetic susceptibility conducted in a soil profile (1). Histogram of frequency distribution for collected magnetic susceptibility data (2). Topsoil magnetic susceptibility mapping (3). Magnetic susceptibility map (4). Areas of magnetically enhanced topsoil (values above $0, 3 \times 10^{-3}$ are emphasized in green and red). The accumulation of ceramic remains and daub was found here during construction work dig.

tion against the natural soils (see Tables 1 and 2) and are not easily detectable on the magnetograms. However, on all of the surveyed archaeological sites, past human activities left a permanent and considerably higher magnetic imprint on the soil, which in some cases enabled the stone walls to be more clearly identifiable on magnetic maps. The sandstone structures are more evident on the magnetic maps from the multi-periodic site of Kaštelir near Čedlje, where the accumulation of the ceramics and other burned material is considerably higher due to long occupation, burning processes and the destruction of the settlement during recent cultivation (Figs 6 and 9). On all of the researched sites, sandstone structures (bedrock, rubble, walls) are recognizable on magnetograms as negative and weakly positive anomalies ranging between -1, 5, and 1, 5 nT/m.

An example of magnetic detection of sandstone structures (bedrock or rubble) is shown in figure 6. The sandstones in this case produced negative and weakly positive gradients between -1 and 0, 7 nT. In the northern and northeastern parts, the higher magnetic gradients of 1, 7 - 2 nT well highlight the edges of the structure. In addition to supporting and contributing to the magnetometer survey results, resistance mapping helps define the shape and edges of buried sandstone structures. The resistivity values over sandstones are in this case relatively high (30 - 50 ohm/m) and are enhanced by surrounded relatively low resistivity values (20 - 28 ohm/m) caused by deeper soil and therefore higher moisture content. These deeper soil “pockets,” which are evident on both methods, can store archaeological remains that have either been undisturbed by industrial agriculture or pre-

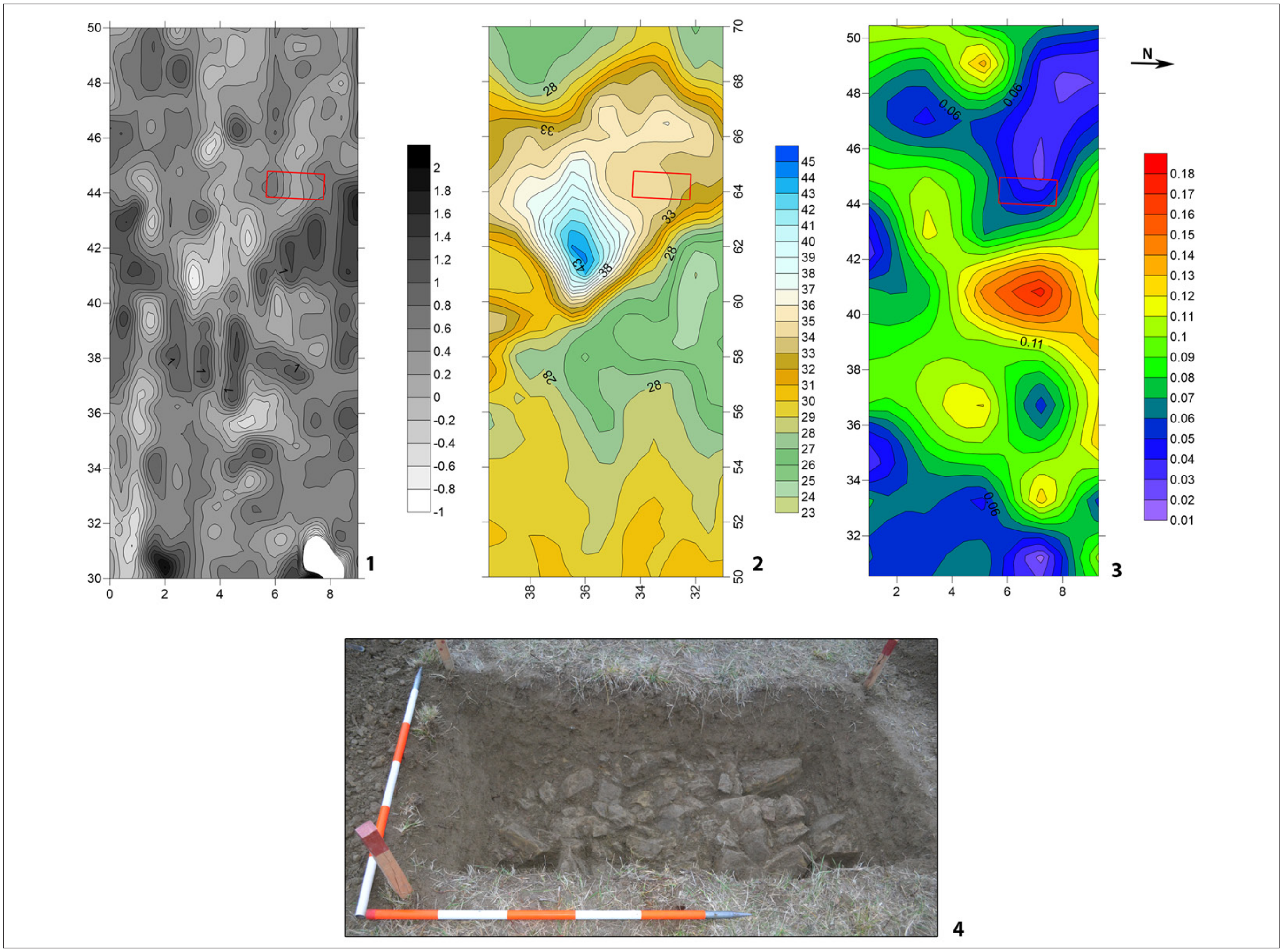

Figure 6. Kaštelir near Čedlje. The possibility of detecting sandstone structures with different geophysical methods. Researched area (10 x 20 m), with the location of test pit 1 x 2 m (marked in red): magnetometer survey (1); earth resistance survey (2), topsoil magnetic susceptibility survey (3) and test pit results (4) (photo by: M. Vinazza, 2022).

sent areas of accumulated archaeological material. This situation was commonly observed in the results in all four locations (see also results on Fig. 9). Although the susceptibility instrument cannot reach the possible in situ archaeological layers, the redisposition of remains through plowing may cause magnetic enhancement of the soil near the surface which can be detectable also with this method. On the topsoil magnetic susceptibility map (Fig. 6.3) also the edges of the sandstone structure can be sensed.

A typical soil background value for each site was estimated based on measurements taken from the surface and during the test pitting. The susceptibility measurements results from the surface and test pitting, at the site Kaštelir near Čedlje have a mean value of 0, 18 × 10^{-3} SI and a standard deviation of 0, 23 × 10^{-3} SI (Medarić and Vinazza 2022). Taking into account the variability, we can suggest that the MS of the soil higher than 0, 25 × 10^{-3} SI, can represent archaeological remains. The materials found in the filling of pits, ditches, and natural features (ceramics, burned clays, slags, and daub remains) can be detected by magnetometers of a high sensitivity. These types of structures produced positive magnetic gradients ranging from 2 to 10 nT/m (Fig. 7)

At the site Grubelce near Sečovlje (roman villa), areas of building debris with TRM such as tegulae, bricks, and imbrexes were successfully mapped with the magnetometer. The structures were well recognizable on magnetograms and produced positive magnetic gradients ranging from 5 nT/m to 20 nT/m.

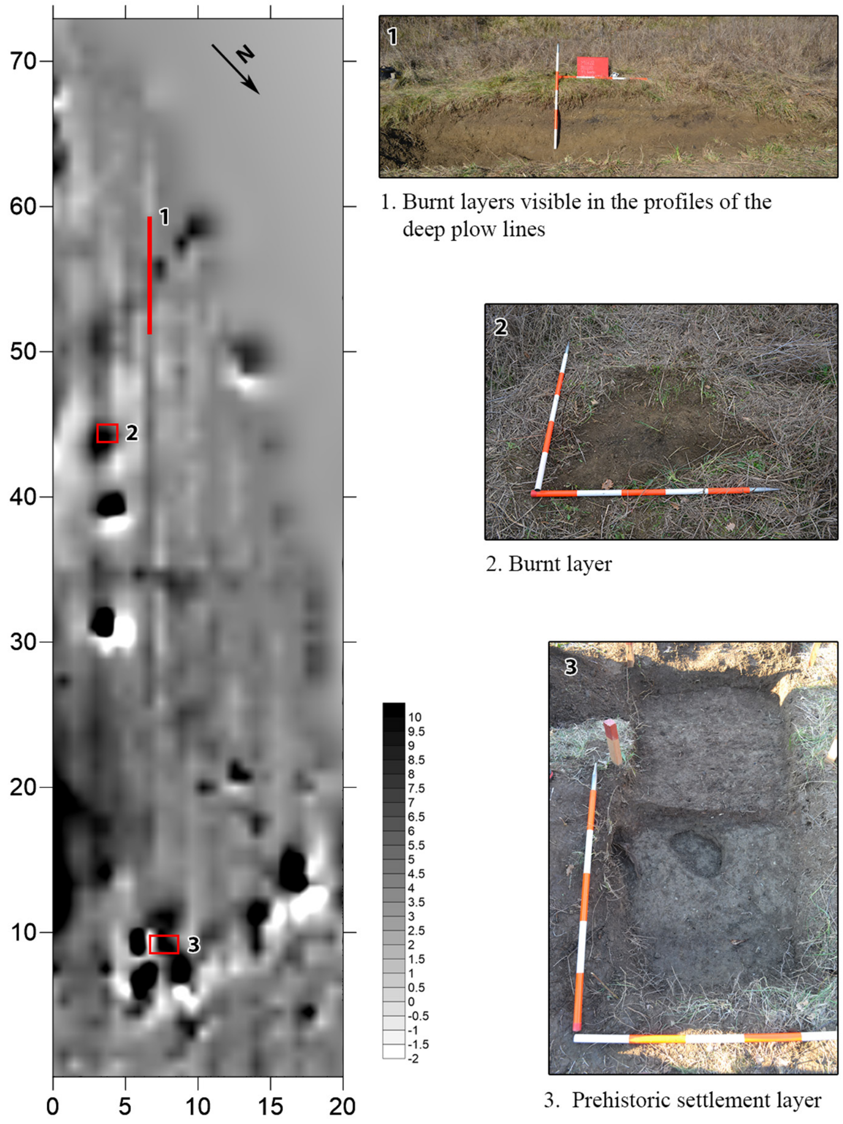

Figure 7. Kaštelir near Čedlje. Area 5. Test pits confirmed in situ archaeological remains (burnt and settlement layers). The structures are clearly visible on the magnetic map as positive gradients with values ranging from 2 to 10 nT/m (left) (photos by: M. Vinazza, 2022).

Archaeological Structure	**MS values (x 10^{-3} SI) for archaeological structures lowest / mean / highest /standard deviation**	**Assessment of recognition capabilities for ideal responses of archaeological structures in soil sequeces on flysch: poor / moderate / good / excellent**
Walls (sandstone)	-0, 169 / 0, 12 / 0, 289 /	moderate
Pits / ditches	0, 25 / 0, 34 / 0, 50 / 0, 70	good
Imbrex / Tegulae	0, 82 / 3, 29 / 1, 71 / 1, 03	Excellent
Daub	1, 16 / 7, 65 / 20, 54 / 5.95	Excellent
Roman brick	7, 83 / 9, 05 / 10, 83 /1, 83	Excellent
Slag	32 / 91, 5 / 54 / 11, 2	Excellent

Table 3. Values of magnetic susceptibility and assessment of magnetometer recognition capabilities of individual archaeological structures.

The soil thickness and the depth of the buried archaeological structures

In vertical gradient mode, with a survey height of 35 cm above ground level, the depth range of the magnetometer surveys is approximately 1 m - to the tops of buried structures (Scollar et al. 1990). Although, when estimating depth, the variation in size, shape, and magnetization of buried archaeological structures has to be considered. During the test pitting from Kaštelir near Čedlje and Lucan, archaeological structures recognized on the magnetograms were buried at shallow depths (between 20 and 50 cm) (Medarić and Vinazza 2022). The depth ranges are comparable to the results from previous excavations on the surveyed sites (Boltin-Tome 1958; 1967; Sakara Sučević et al. 2012, Tomaž and Sakara Sučević 2017).

The shallow depths, on which the archaeological remains are buried on the archaeological sites in soils on Flysch, represent another favorable condition for mapping and identifying the type of archaeological structures (Figs 6 and 7). However, the archaeological structures in shallow soil are consequently more exposed to devastating anthropogenic factors, mostly agricultural, such as plowing and terracing. Archaeological layers during vineyard plowing can be heavily mixed or in some cases completely destroyed all the way to the bedrock. Nonetheless, for the detection of the destroyed sites and defining their boundaries, a dense magnetic susceptibility survey of the topsoil was applied with great success on Kaštelir near Čedlje (Fig. 5).

External influences - geomorphic and anthropogenic factors (vegetation, land use, infrastructure)

Archaeological sites located in the area are currently used as agricultural land. The most typical commercial agricultural practices are olive groves, orchards, and vineyards. Due to the strong erosion processes, typical for Flysch in Slovenian Istria, people constructed terraces and built dry-stone boundary walls between the arable lands (see Fig. 3). Both constructions are significant obstacles to a successful implementation of the magnetic survey. On top of that, archaeological sites are mostly inaccessible due to overgrowth. Altogether they represent a limiting factor since they prevent extensive magnetic surveys, which would enable us to get a more holistic view of the researched sites.

Olive groves and orchards with densely planted trees are a demanding polygon for successful magnetic surveys. During the magnetic measurements in the olive groves on the sites of Lucan and Kaštelir near Čedlje, the trees had an impact on the position noise resulting in an error in the accuracy of acquiring the magnetic data. Moving in the direction of the set profiles was aggravated, with the trees affecting the changes in the sensor's height and survey speed. This type of small inconsistencies can significantly contribute to producing erroneous measured data and a faulty final interpretation. Measurement errors such as the positional and speed noise were reduced by placing the grids and measuring profiles parallel to the direction of the tree rows and by repeating the inappropriate measurements.

There were no recognizable anomalies of roots on the magnetograms apart from the influence of individual tree trunks. However weak enhancement of susceptibility is visible in the direction of olive tree rows supposable due to the hoeing of the olive trees. This effect of mixing the higher magnetic soil with the topsoil is even more evident in the magnetic results where the measurements were taken in profiles 1 m apart.

The effect of conducting measurements in a lavender field was also evaluated. Measurements were taken before and after the lavender field was felled – consequently on different heights (Fig. 8). The reduced quality of resolution details was expected since the strength of magnetic anomalies is decreasing inversely with the distance of the sensors from the source of anomalies. However, this small "experiment", showed that the magnetometers can be efficient in similar situations and emphasizes the importance of conducting the measurements with a sensor on a lower height (approx. 25 – 30 cm above the surface). In this way, all the weaker magnetic gradients and anomalies caused by smaller archaeological remains can be mapped more efficiency.

The magnetic survey in the vineyards was completely inhibited as the buried weights made from concrete and metal wires supporting the vines produced unwanted noise which had a significant effect on the results. Modern features such as metal fences, pipelines, power lines, and antennas posed similar problems on the site of Malijski hrib, where most of the areas were unsuitable for the magnetic survey (see Fig. 2).

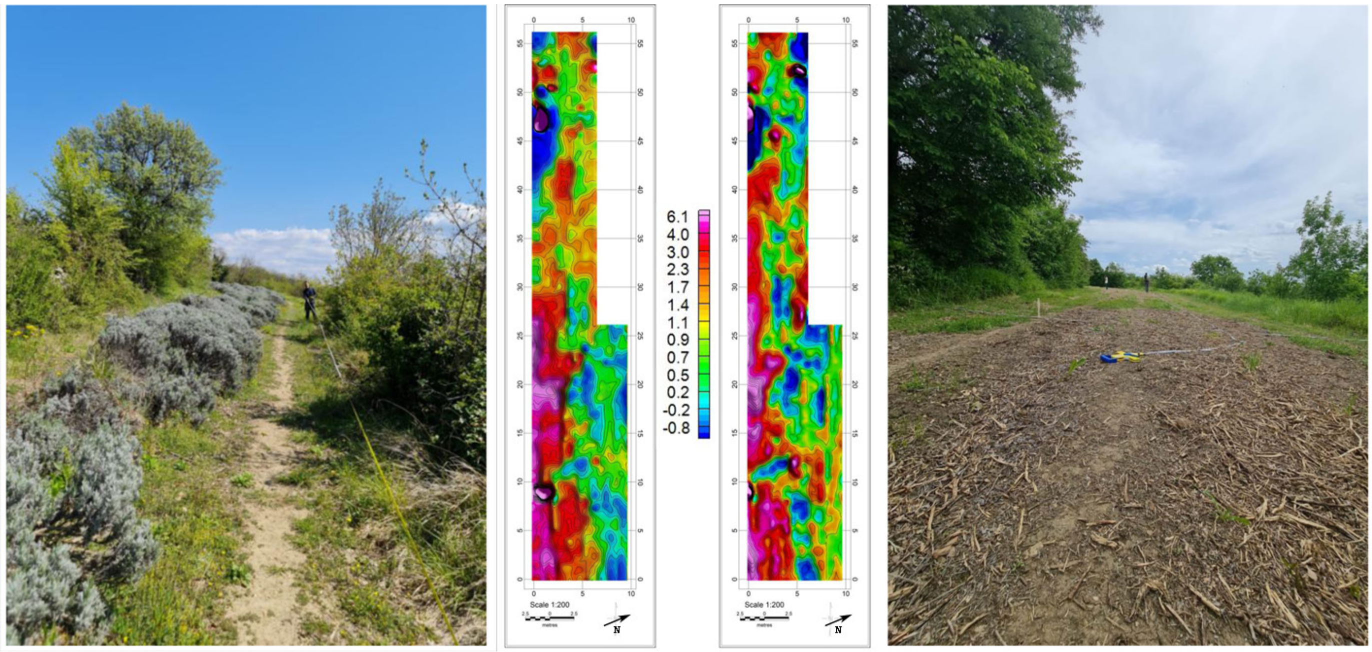

Figure 8. Kaštelir near Čedlje. The effect of vegetation on magnetometer readings. Surveyed area before (left) and after (right) the lavender was felled. Higher magnetic gradients (2 – 10 nT) seen in the southern–southeastern edge are suggesting an accumulation of archaeological material and possible in situ archaeological remains. Excavations conducted by previous researchers here support the interpretation of magnetometer data (see Sakara Sučević et al. 2012).

Influence of the instrument / conducting measurements

Due to the expected low values of magnetic susceptibility, a high-resolution magnetometer was used, which enabled the successful detection of weak anomalies of archaeological structures with induced magnetization. In such magnetically quiet environments, with extremely low magnetic contrasts, lines that run in the direction of measurements often stand out on the raw magnetic data. High-resolution sensors detected the smallest technically flawed measurement procedures, such as changes in measurement speed, differences in the position of sensors in two opposite directions, and sometimes also the magnetic effect of the operator. It became evident that the choice of the instrument is an important factor for a successful magnetic survey in this environment. In addition to the sensitivity of the instrument, instrument performance in noise correction, due to the choice of measurement direction and even using the instrument on a cart has to be considered.

The effect of conducting measurements (such as sensors height, data acquisition speed, and measurement density) was also evaluated in the study. As shown in Figure 9 an example of the magnetic gradient observed with a different spacing between the profiles 0, 5 m (Fig. 9. 1a - 1c) and 1m (Fig. 9. 1d - 1f) is presented. The total number of the readings recorded per each 15 m profile also

Factors	Bedrock	Soil	Anthropogenic	Targeted structures	Depth	Instrument/ Operator
Influence: Low/ Medium/ High	Low	Low	High	Medium / Varies	Low	High
Suitability	Favourable	Favourable	Unfavourable	Mostly favourable	Favourable	Favourable

Table 4. Influence levels of various natural and anthropogenic factors affecting magnetic surveys on soils on Flysch.

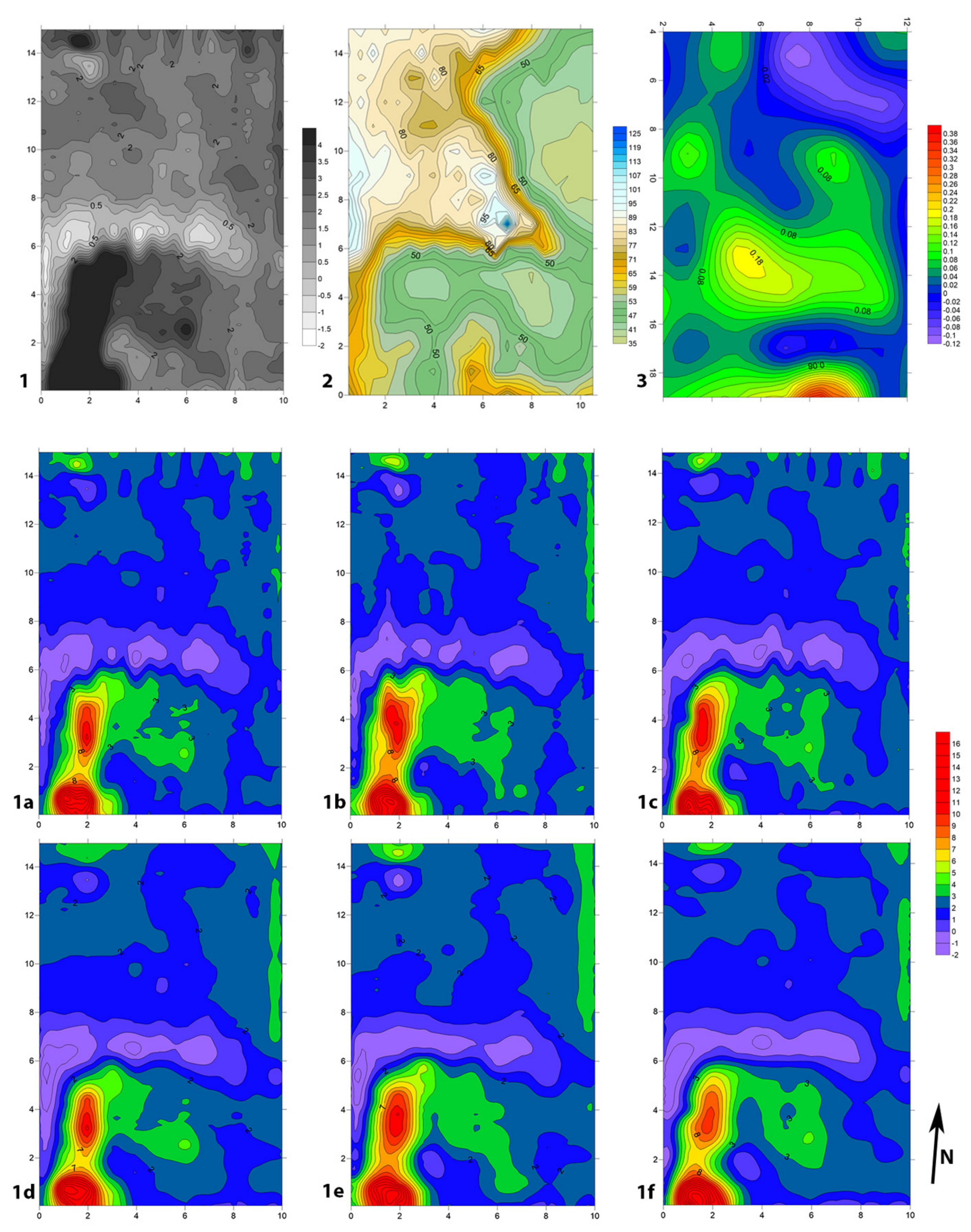

Figure 9. Kaštelir near Čedlje. The comparison of geophysical results obtained over a 10 x 15 m area: magnetometer survey (1), earth resistance survey (2), and topsoil magnetic susceptibility survey (3). Magnetometer survey results obtained with different data acquisition settings: 225 (1a), 115 (1b), and 45 (1c) readings recorded per 15 m profile, with 0, 5 m between profiles, and 225 (1d), 115 (1e), and 45 (1f) readings recorded with 1m between profiles. Although in all the magnetometer maps all three types of anomalies are well identifiable, the denser readings (higher resolution) are crucial for detecting more in details the shapes of buried structures

varied: 225 (Fig. 9. 1a and 1d), 115 (Fig. 9. 1b and 1e), and 45 (Fig. 9. 1c and 1f). Three types of anomalies can be identified in the studied area (including some that may be indicative of archaeological remains): negative and positive anomalies (-1, 5 to 1, 5 nT) marked in purple and blue are caused by weakly magnetic or non-magnetic materials (sandstone bedrock or rubble), positive anomalies from 2 to 6 nT marked in green are possibly due to accumulation of the human habitation (repeated heating of the soil as well as accumulation of organic debris, etc.) with two local high-intensive anomalies (6 – 15 nT) marked in yellow and red possibly in - situ archaeological structures due to the burning.

Conclusion

In the research, it has been demonstrated that magnetic methods can be efficiently used to identify and interpret a wide range of archaeological remains buried in the soil sequence on the Istrian flysch. Conditions related to bedrock and soil (thickness, uniformity, and low magnetic susceptibility background) are favorable since they do not significantly affect measurements. Negative impacts on magnetic research are mostly anthropogenic. Obstacles such as terraces and walls between cultivated areas, as well as overgrowth or, more often, cultivated orchards and olive groves greatly impede, and in some cases, prevent the magnetometer survey. Similarly, the measurements have been hampered by the influence of modern elements typically found in the area, such as metal fences in vineyards, but also common noise as pipes, power lines, and erected antennas. Nevertheless, under optimal conditions, in areas without external noise and major interventions or land use, the magnetometers successfully identified various types of archaeological remains, such as ditches, pits, floors, burnt houses, and walls. The identification of locally formed sandstone walls is strongly related to magnetic enhancement due to human activities in the past, as a higher magnetic background is required for their unequivocal detection. Successful distinguishing between natural and artificial sandstone structures and more effective positioning of the magnetic anomalies produced by the walls using only the magnetic method still presents a considerable challenge. However, the study gave us a much better understanding of the ranges of magnetic data values of possible sandstone remnants. Some percentage of the final result of successful magnetometer research in soils on Flysch can be attributed to the resolution of the instrument and the consistency of control over the optimal course of measurements. Therefore, magnetic data of the best possible quality should be obtained when conducting measurements. Cesium magnetometer surveys have proven to be effective in identifying subtle and low-contrast magnetic anomalies, making them a suitable choice for effective surveying. Both magnetometer surveys and especially topsoil magnetic susceptibility surveys have also proven to be very good in complementing other geophysical methods resulting in situations where there is no architecture, especially in areas where archaeological sites have been destroyed by agriculture.

Acknowledgement

Project MagIstra - *Assessment of the potential of the magnetic method for the identification of archaeological remains in soil sequence on soft carbonate rock. The case study of Slovenian Istria* (ARRS Z6-2663) is a postdoctoral research financed by Slovenian Research Agency. The author gratefully acknowledges dr. Manca Vinazza for all the help during the test pitting and dr. Maša Sakara Sučević and Snježana Karinja for allowing me to perform magnetic susceptibility measurements on archaeological finds stored in the museums. Many thanks to Alex Kunst, Luka Preložnik, Ana Tuljak, Izidor Ramšak, Katja Špec for their assistance during geophysical field surveys and excavations and also to Jurij Gorišek (GGS d. o. o.) for carrying out the geodetic survey at all listed locations.

References

Aspinall, A., Gaffney, C. and Schmidt, A. 2008. *Magnetometry for archaeologists*, Plymouth.

Boltin-Tome, E. 1958. Arheološke najdbe na Kaštelirju nad Kortami. *Arheološki vestnik* 9-10/3-4 (1958-59), 237-250.

Boltin-Tome, E. 1967. Poročilo o raziskovanjih na srednjem prečnem nasipu Kaštelirja pri Dvorih nad Izolo, *Arheološki vestnik* 18, 163-178.

Car, M. 2005. Poročilo o georadarskih preiskavah v Kopru. Lokacija Pristaniški trg. Ribiški trg, *Neobjavljeno poročilo, ZVKDS*, oe Piran / UP ZRS IDS.

Clark, A. 1990. *Seeing Beneath the Soil*, Batsford, London

Dalan, R. A. 2007. A review of the role of magnetic susceptibility in archaeogeophysical studies in the USA: recent developments and prospects, *Archaeological Prospection* 15 (1), 1-31.

Dalan, R. A. and Banerjee, S. K. 1998. Solving archaeological problems using techniques of soil magnetism, *Geoarchaeology* 13 (1), 3-36.

Le Borgne, E. 1955. Susceptibilité magnétique anormale du sol superficiel, *Annales de Géophysique*, 11, 399-419.

Fassbinder, J. W. E. 2011. Geophysical Prospection: A Powerful Non-destructive Research Method for the Detection, Mapping and Preservation of Monuments and Sites, *Proceedings of the 1st Workshop New Technologies for Aquileia* (NTA-2011), Aquileia, Italy.

Fassbinder, J. W. E. 2015. Seeing beneath the farmland, steppe and desert soil: Magnetic prospecting and soil magnetism, *Journal of Archaeological Science*, 56: 85-95, (16).

Grčman, H., Vidic, N.J., Zupan, M., Lobnik, F., Jones, A. and Montanarella, L. 2015. *Tla Slovenije s pedološko karto v merilu 1:250000 = Soils of Slovenia with soil map 1:250000* (Book, 2015)

Groh, S. and Sedlmayer, H. 2017. *Otium cum dignitate et negotium trans mare, La villa marittima di San Simone (Simonov zaliv) in Istria (Slovenia*), Ricerche series Maior 7, 16 -27, Ante Quem, Bologna.

Lapajne, J. and Kelhar, T. 1970. Simonov zaliv-Izola, *Geofizikalne raziskave*, Geološki zavod, ljubljana. Neobjavljeno poročilo, Pomorski muzej Sergej Mašera, Piran.

Maselli, G. and Monti, F. 1994. Relazione sulle indagini diagnostiche effettuale della tecno future service (TFS) nella cattedrale di santa maria di Capodistria (Slovenia), *Annales: anali za istrske in mediteranske študije = annali di Studi istriani e mediterranei = annals for Istrian and Mediterranean studies*, Series historia et sociologia. ISSN 1408-5348. - Let. 7, št. 10 (1997), 37-42

Medarić, I., Mušič, B. and Vynke K. 2011. Vrednotenje rezultatov magnetne metode z uporabo 2D magnetnega modeliranja na primeru arheološkega najdišča Duzen Tepe v Turčiji = Application of 2D magnetic modelling in evaluating the results of the magnetic method, Case study at the archaeological site at Düzen Tepe, Turkey. *Arheo* 28, 35-72.

Medarić, I., Mušič, B. and Črešnar M. 2016. Tracing flat cremation graves using integrated advanced processing of magnetometry data (case study of Poštela near Maribor, NE Slovenia). – V, In: I. Armit, H. Potrebica, M. Črešnar, P. Mason and L. Büster (eds.), *Cultural encounters in Iron Age Europe*, Archaeolingua. Series Minor 38, 67-94.

Medarić, I. and Vinazza M. 2022. Poročilo o arheoloških sondiranjih na najdiščih Lucan pri Luciji in Kaštelir pri Čedljah, *Končno strokovno poročilo o raziskavi.*

Mikes, T., Dunkl, I., Frisch, W. and von Eynatten, H. 2006. Geochemistry of Eocene flysch sandstones in the NW External Dinarides, *Acta Geol Hung* 49 (2):103-124.

Mušič, B. 1997. Magnetic susceptibility measurements in dolinas, *Annales: anali za istrske in mediteranske študije = annali di Studi istriani e mediterranei = annals for Istrian and Mediterranean studies*, Series historia et sociologia. ISSN 1408-5348. - Let. 7, št. 10 (1997), 37-42.

Mušič, B. 1999. Geophysical prospecting in Slovenia: an overview with some observatons related to the natural environment, *Arheološki vestnik* 50, 349-405.

Mušič, B. 2006. Poročilo o geofzikalni raziskavi: Izola – Simonov zaliv, Ljubljana: *neobjavljeno poročilo*. 2006.

Mušič, B. 2011. Poročilo o geofizikalni raziskavi Koper - Glavni pomol v Kopru »Sanacija glavnega pomola- valobrana v ribiškem pristanišću v Kopru, v vplivnem območju spomenika Koper-Mestno jedro /EŠD 235/ in v območju Koper-arheološko najdišče Koper/EŠD 236/«

Mušič, B., M. Črešnar and I. Medarić 2014. Možnosti geofizikalnih raziskav na Najdiščih iz starejše železne dobe. Primer Poštele pri Mariboru. *Arheo* 31, 19-47.

Mušič, B., Vinazza M., Črešnar, M. and Medarić, I. 2015. Integrirane neinvazivne raziskave in terensko preverjanje. Izkušnje s prazgodovinskih najdišč severovzhodne Slovenije, *Arheo* 32, 37-64.

Piro, S. 2009. Introduction to geophysics for archaeology, In: S. Campana and S. Piro (eds.), *Seeing the unseen. Geophysics and landscape archaeology*, CRC Press, Taylor & Francis Group, Oxon.

Piro, S., Mauirello, P. and Cammarano, F. 2000. Quantitative Integration of Geophysical Methods for Archaeological Prospection, *Archaeological Prospection* 7, 203-213.

Pleničar, M. 1970. *Tumač osnovne geološke karte SFRJ, 1:00.000,* List Trst, Savez. geol zavod, Beograd.

Prus, T. and Grčman H. 2019. Tla, In: J. Pavšič, M. Gogala, A. Seliškar and T. Bajd (eds.), *Slovenska Istra. 1, Neživi svet, rastlinstvo, živalstvo in naravovarstvo*, Slovenska matica. Ljubljana.

Sakara Sučević, M., Preložnik, A. and Ogorelec, A. 2012. *Preliminarno poročilo o zaščitnih arheoloških raziskavah na Kaštelirju nad Kortami,* parc. št. 1706, k.o. Dvori nad Izolo 2. 4. -21. 4. 2010, Koper: Univerza na Primorskem, Znanstvenoraziskovalno središče, Inštitut za dediščino Sredozemlja.

Scollar, I., Tabbagh, A., Hesse, A. and Herzog, I. 1990. *Archaeological prospecting and remote sensing*, Cambridge.

Slapšak, B. and Grosman, D. 2010. Pojem in postopki terenskega preverjanja pri neinvazivnih raziskavah v arheologiji / The notion and methods of ground-truthing in non-invasive archaeological research, *Arheo* 27, 7-13.

Smekalova, T. N., Voss, O. And Smekalov, S. 2008. *Magnetic surveying in archaeology: more than 10 years of using the Overhauser GSM-19 gradiometer,* Wormianum.

Tite, M. S. and Mullins, C. 1971. Enhancement of the magnetic susceptibility of soils on archaeological sites, *Archaeometry* 13 (2), 209-219.

Tomaž, A. and Sakara Sučević, M. 2017. *Arheološke raziskave na lokaciji Kaštelir nad Kortami v letu 2014*.

Skeletor: system for recording and analysing articulated human skeletal remains

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https://doi.org/10.17234/METARH.2022.06

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Bioarchaeological analyses have the potential to generate a large amount of various data that require an efficient system for input, storage, access and analysis. In Croatia, the recording procedure for the analysis of articulated human skeletal remains is mostly done using paper forms. As data collected during this procedure varies in type, complexity and levels of categorization, the subsequent digitization usually covers only a small part of it. This significantly slows down the analysis process, makes access and processing of data difficult, and its long-term preservation questionable. As within the discipline, well-developed and subject-specific databases are usually unavailable or unaffordable, this paper presents an easy-to-use system for recording and analysing articulated human skeletal remains in a digital environment using predesigned recording forms and tables. The main goal of this system is to improve the current recording procedure, i.e. to enable simpler and faster access to recorded data through the use of relatively simple and well-known software, to speed up and simplify the bioarchaeological analysis, and to enable compatibility with other archaeological field data within the archive.

Keywords: *human skeletal remains, bioarchaeological dataset, spreadsheet data, recording forms, report table, summary tables*

Introduction

The recording procedure for bioarchaeological analysis[1] of articulated human skeletal remains is to the great extent, a standardised procedure that follows different but well-established guidelines. These enable the collection of data on different characteristics of human skeletal material found in archaeological contexts. As this procedure has the potential to generate a large amount of various data, it requires an efficient data recording system. That is why the recording procedure is conducted using predefined recording forms intended for the collection of structured data.

[1] This work has been supported by the Croatian Science Foundation under the project “milOrd – Development and Heritage of the Military Orders in Croatia” (HRZZ, IP-2019-04-5513). In the scope of the project, which is, among other things, focused on the analysis of large amounts of human skeletal material found during archaeological excavations, a system for recording and analysing of data collected by bioarchaeological analysis has been developed.

An overview of several systems for recording data on human skeletal remains used in Croatia showed that the recording procedure for bioarchaeological analysis is mostly done using recording forms printed on paper. These are designed to include all data on the skeletal remains of one individual and represent the form in which the data is permanently stored. As bioarchaeological data considerably varies in type, complexity and levels of categorization, when subsequent digitization is carried out, it covers only a small part of it. This significantly slows down the analysis process, makes access and processing of data difficult, and its long-term preservation questionable. The situation is also accompanied by a limited level of accessibility and insufficient reuse potential. Within the discipline, well-developed and subject-specific databases are usually unavailable or unaffordable, as is their maintenance and continuous upgrade,[2] so the unavoidable question becomes the design of an appropriate system for recording articulated human skeletal remains in a digital environment which can overcome the observed issues. In this context, the system must be suitable for the digitization of existing bioarchaeological data and at the same time provide the possibility of direct input of data during bioarchaeological analysis. System setup and usage should be customised for non-expert computer users with moderate computer skills. Furthermore, such endeavour must be encompassed with the awareness of different problems caused by rapid technological development due to which digital formats or software solutions for data management very easily become obsolete (Brickley 2017: 8).

In accordance with the stated issues, under the name SKELETOR (http://milord.iarh.hr/index.php/en/activities-and-results/skeletor), an easy-to-use system for recording and analysing articulated human skeletal remains in a digital environment was designed using Microsoft Excel (© Microsoft Corporation 2022a) spreadsheet software (Appendix 1: SKELETOR_FORMS.xlsx; Appendix 2: SKELETOR_META.xlsx). This software was chosen as an environment for the system design because it is the most commonly used software for tabular data and probably the easiest input tool with powerful functions for analysing data. Although it is spreadsheet software not designed for database management, it is simple and fast and is adequate for the type and the amount of data at hand. Long-term access to data is ensured by its storage in comma-separated values (.csv) or delimited text (.txt) file formats which are preferred file formats for long-term archiving of spreadsheet data, i.e. quantitative tabular data with metadata (Niven 2011; Göldner et al. 2013; Gerth and Schäfer 2017; Trognitz 2017). At the same time, it allows the possibility to print sheets on paper for hard-copy archiving or converting the data to other file formats, e.g. .pdf or different raster formats.

The data

The initial step in the process of a system design was the review of a dataset that arises from the bioarchaeological analysis. To enable the data input process, a list of all the information that is recorded during the analysis of human skeletal remains was prepared. The final list contained 823 query fields divided into seven basic categories. Based on the number of fields in each category, in one Excel workbook, five digital recording forms were designed, which compared to the tabular entry significantly facilitate the input of data. All data entered in the recording forms are automatically transposed to the sixth worksheet in a form of a table with 823 fields arranged in an equal number of columns. To each of 823 fields, unique labels created mostly as acronyms of individual bioarchaeological categories and subcategories were assigned (Table 1). These labels serve as headers of the columns for easier navigation through data in tabular form. To understand the usage of labels and also facilitate the data input process the system is accompanied by a set of explanatory metadata (Appendix 2: SKELETOR_META-METADATA; SKELETOR_META-LABELS)

During the input process data are entered into five predesigned recording forms. In the first form (Appendix 1: SKELETOR_FORMS-I_FORM) general information on the site and archaeological context are provided. They are entered at the top of the first form and then automatically copied to all recording forms in the same work-

[2] Maybe the best known software for recording data on human skeletal remains is Osteoware® (© Smithsonian Institution 2020), a freeware developed by Smithsonian National Museum of Natural History. Although it can meet all requirements of bioarchaeological analysis and at the same time is equipped with a user-friendly interface, it demands continuous professional maintenance and upgrade. It primarily runs on Microsoft Windows OS and at the moment, it was last upgraded for Windows7™ in 2010 (see Dudar 2010: 2). The situation is somewhat different with the databases created using commercial software. The example is the database for documentation of commingled and fragmentary remains (Osterholtz 2019), which uses fragment based approach in the recording process but gives the possibility to record articulated human remains (Osterholtz 2019: 79). Built on the FileMaker software, a commercially available application that enables nonexpert users to create and modify relational databases (Osterholtz 2019: 79), it is an easy-to-use system equipped with user-friendly interface. At the same time, its long-term maintenance and support depend directly and exclusively upon the proprietor.

NO.	CATEGORY	DESCRIPTION	FORM NO.	FORM ID	LABLES CONSTRUCTION SCHEME					
					FIRST PART			SECOND PART		
					CATEGORY	SUBCATEGORY	SUFIX	PREFIX	TYPE	SUFIX
1.	GENERAL	Information on the site and archaeological context	1.	I_FORM	G	N/A	N/A	N/A	N/A	(query text or its abbreviation)
2.	INVENTORY	Inventory and completeness of individual bones			I	Cranium, Trunk, Upper limb, Lower limb	N/A	Complete, Left, Right, Single, Unsided, Any	2 letter code	Proximal, Medial, Distal, Lateral + Joint
3.	SEX	Sex determination	2.	SA_ FORM	S	Cranium, Hip	N/A	Complete, Single, Any	2 letter code	N/A
4.	AGE	Age determination			A	Cranium, Hip	N/A	Complete, Any	2 letter code	N/A
5.	MEASUREMENTS	Measurements of individual bones	3.	M_FORM	M	Cranium, Upper limb, Lower limb, Hight calculation	N/A	Left, Right, Single	3 letter code	N/A
6.	TEETH	Presence of teeth and changes in the teeth	4.	T_FORM	T	Status, caries_Occlusal, caries_Buccal, caries_Lingual, caries_Interproximal, caries_Root, caries_alveolar_ Abscess, caries_Calculus, caries_alveolar_Resorption, dental_Wear, LEH (H)	maXilla, maNdible	Left, Right	1 to 3 letter code	LEH: Crown, number 1 to 3
7.	PATHOLOGIES	Presence of pathologies	5.	P_FORM	P	Fractures, osteoArthritis, schmorls_Defect, Periostitis, Cribra_orbitalia, Ectocranial_ hypo, LEH (H), Syphilis, TBC (T), Leprosy, Rickets, scurvy (K), Other	N/A	Complete, Left, Right, Single	1 or 2 letter code	Number, Side_ Bone, Presence, Completeness, Type

Table 1. Seven categories of data divided into five different recording forms with label construction scheme for 823 query fields.

book. The main part of the first form is intended for recording the inventory and completeness of all bones of the individual skeleton: all cranial bones, trunk including vertebrae, ribs, sacrum, coccyx, sternum, manubrium, xyphoid, upper limb including scapula, clavicle, bones of the hand, humerus, radius and ulna, lower limb including pelvic bone, patella, talus, calcaneus, bones of the foot, femur, tibia and fibula. Most of the bones are separated by the side – left and right, while the long bones are further divided into epiphyses or joints (proximal and distal) and diaphyses (proximal, middle and distal third).

In the second recording form (Appendix 1: SKELETOR_FORMS-SA_FORM), the data about the sex and age of the skeleton are provided. Sex is estimated only for individuals older than 18 years of age. Based on the morphology of the cranium and pelvic bones, following criteria by Buikstra and Ubelaker (1994: 16-21), sex is estimated to be male, female, probably male, probably female or undetermined.

Age in adults is estimated by several criteria, according to changes in pubic symphysis (Brooks and Suchey 1990), auricular surface (Lovejoy et al. 1985: 21-26), and cranial suture closure (Meindl and Lovejoy 1985: 61). Adults are placed in one of the three age categories established by Buikstra and Ubelaker (1994: 36): young adults (18 to 35 years), middle adults (35 to 50 years) and old adults (50+). However, when a narrower determination is possible they are assigned to an age group of 5 or 10-year age bands. Subadults are divided into four age categories proposed by Baker et al. (2005: 10), and slightly modified: foetuses (less than full-term), infants (0 to 1 year of age), children (2 to 11 years of age), and adolescents (12 to 18 years of age). When a skeleton is not well preserved, the age category is assigned either to the adult or subadult group.

The third recording form (Appendix 1: SKELETOR_FORMS-M_FORM) contains measurements of the cranium and long bones including humerus, radius, ulna, femur, tibia and fibula. All measurements are taken according to the Martin-Saller system (Martin and Saller 1957). Skeletal height is reconstructed from measurements of the height of each long bone used in the regression equation or from a combination of measurements of the height of the femur and tibia (Trotter and Gleser 1952; 1958).[3] Since the definition of the tibia length is standard condylar-malleolar length and Trotter in her equation for stature estimation omitted the malleolus (Jantz et al. 1995: 758; Jantz et al. 2020: 2094), all calculations based on the tibia length should be taken with this consideration in mind. In the system, if certain criteria are met, that is if the age and sex of an individual are estimated, this calculation is done automatically.

Dental status is recorded in the fourth recording form (Appendix 1: SKELETOR_FORMS-T_FORM) following criteria by Buikstra and Ubelaker (1994: 49). Caries lesions are observed by their position and standards proposed by Powell (1985). Abscesses are scored using criteria established by Roberts and Manchester (2007: 70), calculus according to the Brothwell system (Brothwell 1981: 155), alveolar resorption to the DeWitte method (DeWitte 2012: 407), and dental wear by Smith scoring (Smith 1984: 45). Linear enamel hypoplasia (LEH) is documented on the maxillary first incisors and canines as well as mandibular canines. Measurements include the crown height and the measurement from the distance of the cementoenamel junction to the linear defect (Buikstra and Ubelaker 1994: 57).

The fifth and final recording form (Appendix 1: SKELETOR_FORMS-P_FORM) is intended for recording pathologies following the standards proposed by Buikstra and Ubelaker (1994: 107-123). Firstly, fractures are divided into antemortem or perimortem while possible fractures are noted as well. A total number of affected bones and their side are registered as well as a detailed description of each fracture. Degenerative osteoarthritis is noted considering the side of all major joints (shoulder, elbow, hip and knee) and vertebrae (cervical, thoracic and lumbar). Schmorl's nodes are evidenced on the thoracic and lumbar vertebrae. Nonspecific periostitis is observed as an active or healed process on both cranial and postcranial bones. Cribra orbitalia is recorded for each orbit in the form of active or healed lesions or not present at all. Ectocranial porosity of the cranial vault is simply noted as present or not. LEH is previously recorded in the fourth dental sheet so in this one its status is transferred as present or absent. Infectious diseases (syphilis, tuberculosis and leprosy) and metabolic disorders (rickets and scurvy) are registered as present or not present following criteria proposed by Ortner (2003). For a detailed description or a comment on present pathologies, an input section for free text entry is provided.

[3] The equation for stature estimation is population and age-specific and can be applied only on white population aged 18 to 35 years (Trotter and Gleser 1952). Since Trotter and Gleser (1952) noted the correlation between ageing and stature they applied a correction formula. Galloway (1988), Chandler and Bock (1991) and Giles (1991) suggested that these changes are becoming significant only after the age of 40 or 45 years. As Giles (1991) showed that only at the age of 60 a 1.2 cm for males and 0.7 cm for females must be subtracted from calculated stature, it was decided to use the Trotter-Gleser formula for all age categories without a correction formula.

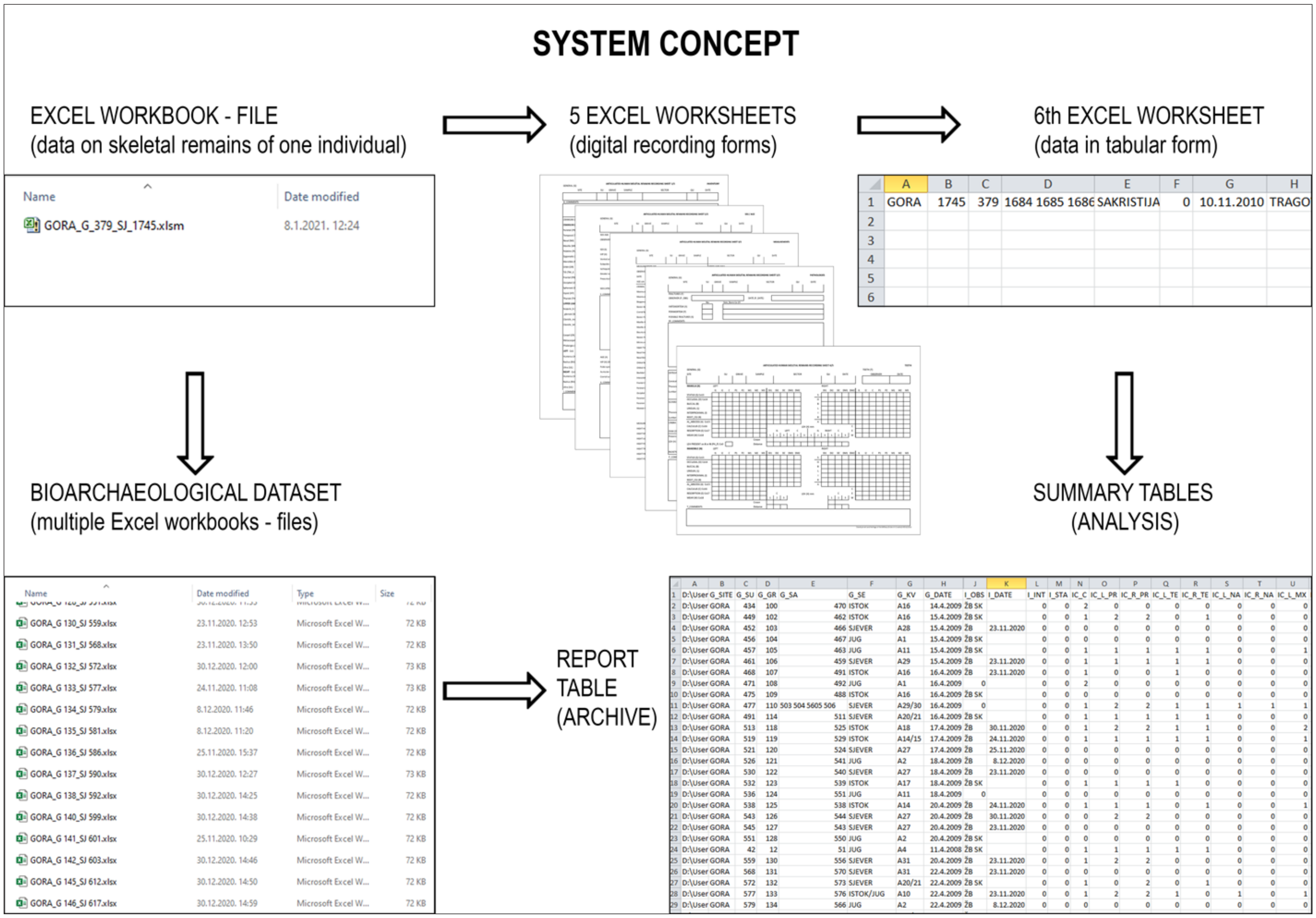

Figure 1. The scheme of a system concept.

The system

In a designed system one file, i. e. Excel workbook represents data on the skeletal remains of one individual. To facilitate the input of different types of data collected during the procedure of bioarchaeological analysis, the workbook contains five digital recording forms designed in separate Excel worksheets. During the input process, all of the data entered in the forms are automatically transposed to the sixth worksheet in a tabular form. All the worksheets in the workbook are protected which means that cells cannot be reformatted or deleted, the content in default cells cannot be edited, and the default design of the recording forms cannot be changed.[4] It is only allowed to modify input cells – which are surrounded by borders and thereby visually emphasized – and only certain predefined codes are allowed. That is why an integral part of the system is a metadata document that contains the list of allowed codes divided into 20 coding categories (Appendix 2: SKELETOR_META-CODES). Most of the codes used in the system are standardly used in bioarchaeological analysis and are taken from or modified after Brothwell 1981; Smith 1984; Lovejoy et al. 1985; Meindl and Lovejoy 1985; Powell 1985; Brooks and Suchey 1990; Buikstra and Ubelaker 1994; Roberts and Manchester 2007; De Witte 2012.

For example, in cells where the completeness of certain bones is recorded, the input of only three codes is allowed: 0 - meaning bone is not present, 1 - more than half of the bone with diagnostic features is preserved, and 2 - less than half of the bone without diagnostic

[4] To prevent accidental changes of worksheet structure, the worksheets are password-protected. Unlocking is enabled by entering a password: milOrd

features is preserved. Where the number of preserved bones is recorded, only the maximum range of the possible number of bones is allowed, so for the left side ribs, only the numbers from 0 to 12 are allowed. Blank cells are allowed, because in the worksheet with tabular data such an entry is automatically recorded as 0 - missing.[5] That is why the presence of a bone or a tooth but the absence of the observed pathology is recorded as 9 – absent, not present. The additional restriction concerns the usage of the comma. As the comma is the delimiter in the comma-separated values file, which is a future-proof archiving format intended for the long-term preservation of digital data in tabular form, its usage in the recording procedure is disabled.[6]

To maintain a proper dataset structure and to reduce the possibility of overwriting files, the file naming procedure must be defined in advance. Maybe the most appropriate are the filenames consisting of unique identifiers already used in the archaeological datasets, i.e. site, grave and stratigraphic unit IDs. After the data for every analysed individual has been entered, the result of the process is a bioarchaeological dataset for a particular site that has the form of multiple spreadsheets saved as .xlsx files and stored within one folder.

But the data stored in this manner are still not prepared for analysis. For that purpose, all data entered in five predesigned recording forms are automatically transposed to the sixth worksheet named TABLE (Appendix 1: SKELETOR_FORM-TABLE) where they are given the structure of tabular data containing all bioarchaeological data on one individual. When the data on skeletal remains of all individuals are entered, merging the automatically generated records in tabular form enables the creation of the report table with all entered data or different summary tables suitable for data analysis (Fig. 1). It is important to know that the placement of headers with column labels at the top of the report or summary tables requires the inclusion of a TABLE worksheet from the metadata document (Appendix 2: SKELETOR_META-TABLE) in the merging process.[7]

As tables from all files have the same structure, the merging procedure for multiple workbooks is not complicated and can be executed in several ways. Advanced Excel users will probably choose to use the Power Query (© Microsoft Corporation 2022b), Excel's add-in with powerful tools for merging and sorting data.[8]

For beginners, maybe the easiest method for merging data is in an open access add-in called RDB Merge (© de Bruin 2010). This user-friendly add-in is designed for merging multiple .xlsx or .csv files into a report table, at the same time enabling the selection among columns available in the original files. The result of merging the specific range of columns is a summary table suitable for problem-specific analysis. When the data are transferred to tabular form basic quantitative analysis can be done using basic Excel tools like Find and Filter, while advanced users can use Formulas or PivotTables.

Conclusion

The system for recording and analysing articulated human skeletal remains named SKELETOR is primarily designed to improve the bioarchaeological recording procedure in a digital environment through the use of relatively simple and well-known software. This makes it suitable for use by non-expert computer users with moderate computer skills. At the same time, by enabling simpler and faster access to recorded data, it is intended to speed up and simplify the bioarchaeological analysis. Also, it is designed with a basic intention to contain compatibility with archaeological field data archived in a spreadsheet form and to contain capability for long-term data archiving. Furthermore, each recording form is suitable for print on A4 paper for hard copy archiving, as well as conversion to other file formats.

Nevertheless, it is important to note that the system is not perfect nor without flaws, and these can be recognised on several points. The first concerns the structure of the final dataset which has no data connectivity between data entered in the recording forms and

5 However, entering the code 0 in the digital form is recommended because it confirms that the bone is really missing, and that, for example, the category was not accidentally skipped.

6 Usage of comma is also disabled in the cells where free text entry for analyst's descriptive remarks is allowed.

7 Equally named worksheets in workbooks placed in the same folder simplify the merging process so before merging, metadata document should be copied with bioarchaeological data.

8 To older versions of Microsoft Excel, Power Query had to be separately added but from Excel 2016 it appears in the Data tab as Get & Transform Data group of commands (© Microsoft Corporation 2022b).

the merged data in the report table or summary tables. Therefore, upon completion of data entry, it is necessary to choose in which form the data will be kept during the analysis and storage in a local repository. It is therefore important to be aware that worksheets with recoding forms designed for data entry are much more suitable for the potential entry of new or modification of old data while for digital archiving, data in tabular form is preferable. Whatever option is chosen, during the period of data usage and local data storage, constant control over the changes in the final version of the dataset is required. Another shortcoming is the lack of built-in version control which would disable the storage of multiple versions of the same document with conflicting or outdated data. Same as previous, the third flaw is also connected with the possibility of human error. It commonly occurs when coded data is used and is the result of incompletely controlled data entry. As the input of codes requires a high level of consistency, any mistake can results in problems or errors during querying and analysis (Niven 2011). At the same time, archiving coded data requires the storage of additional decoding documents whose loss can forever disable the understanding of the meaning of the codes (Niven 2011). However, the awareness of the listed problems, as well as the establishment of a clear workflow for changing, saving and overwriting documents with strict compliance to the predefined data entry instructions, can significantly reduce instances of human error and to a large extent guarantee the successful creation of a meaningful bioarchaeological dataset on human skeletal remains in a digital environment.

References

Baker, B. J., Dupras, T. L. and Tocheri, M. W. 2005. *The Osteology of Infants and Children*, Texas A&M University Press, College Station.

Brickley, M. 2017. Compiling a skeletal inventory: articulated inhumed bone, In: P. D. Mitchel and M. Brickley (eds.), *Updated Guidelines to the Standards for Recording Human Remains*, Chartered Institute for Archaeologists, British Association for Biological Anthropology and Osteoarchaeology, Reading, 7-9. https://www.babao.org.uk/assets/Uploads-to-Web/14-Updated-Guidelines-to-the-Standards-for-Recording-Human-Remains-digital.pdf (Accessed: 07. 03. 2022.)

Brooks, S. and Suchey, J. M. 1990. Skeletal age determination based on the os pubis: A comparison of the Acsádi-Nemeskéri and Suchey-Brooks methods, *Human Evolution* 5, 227-238. https://doi.org/10.1007/BF02437238

Brothwell, D. R. 1981. *Digging up bones*, Oxford University Press, Oxford.

Buikstra, J. E. and Ukelaker, D. H. 1994. *Standards for data collection from human skeletal remains*, Arkansas Archaeological Survey Research Series 44, Arkansas Archaeological Survey, Fayetteville.

Chandler, P. J. and Bock, R. D. 1991. Age changes in adult stature: trend estimation from mixed longitudinal data, *Annals of human biology* 18 (5), 433-440. https://doi.org/10.1080/03014469100001732

de Bruin, R. 2010. *RDBMerge, Excel Merge Add-in for Excel for Windows*, Version 1.3 / Version 1.4 [Computer Software]. https://www.rondebruin.nl/win/addins/rdbmerge.htm (Accessed: 07. 03. 2022.)

DeWitte, S. N. 2012. Sex differences in periodontal disease in catastrophic and attritional assemblages from medieval London, *American Journal of Physical Anthropology* 149, 405-416.

Dudar, C. 2010. *Installation Instructions for Osteoware Beta*, Smithsonian Institution, Washington D. C. https://naturalhistory.si.edu/research/anthropology/programs/repatriation-office/osteoware (Accessed: 07. 03. 2022.)

Galloway, A. 1988. Estimating actual height in the older individual, *Journal of forensic sciences* 33, 126-136. https://doi.org/10.1520/JFS12443J

Gerth, P. and Schäfer, F. 2017. Datenbanken, In: M. Heinrich, F. Schäfer and M. Trognitz (eds.), *IT-Empfehlungen für den nachhaltigen Umgang mit digitalen Daten in den Altertumswissenschaften: Version 1.0.1.0*, IANUS, Deutsches Archäologisches Institut, Berlin, 143-177. https://www.ianus-fdz.de/it-empfehlungen/sites/default/files/ianus-Files/IT-Empfehlungen_v101.pdf; https://ianus-fdz.de/datenbanken (Accessed: 07. 03. 2022.)

Giles, E. 1991. Corrections for age in estimating older adults' stature from long bones, *Journal of forensic sciences* 36 (3), 898-901. https://doi.org/10.1520/JFS13100J

Göldner, R., Bibby, D., Brunn, A., Fitting, S., Posluschny, A. and Stoll-Tucker, B. 2013. Kleiner Ratgeber zur Archivierung digitaler Daten, In: S. Winghart (ed.), *Archäologie und Informationssysteme: Vom Umgang mit archäologischen Fachdaten in Denkmalpflege und Forschung*, Arbeitshefte zur Denkmalpflege in Niedersachsen 42, Niedersächsisches Landesamt für Denkmalpflege, Hannover, 86-104. https://denkmalpflege.niedersachsen.de/download/83452/Arbeitshefte_zur_Denkmalpflege_in_Niedersachsen_Band_42._Archaeologie_und_Informationssysteme.pdf (Accessed: 07. 03. 2022.)

Jantz, R. L., Hunt, D. R., Meadows, L. 1995. The measure and mismeasure of the tibia: implications for stature estimation, *Journal of Forensic Sciences* 40 (5), 758-761. https://doi.org/10.1520/JFS15379J

Jantz, R. L., Meadows Jantz, L., Ousley, S. D. 2020. Measuring the Tibia: Trotter's Error Revisited, *Journal of Forensic Sciences* 65, 2094-2097. https://doi.org/10.1111/1556-4029.14550

Lovejoy, C. O., Meindl, R. S., Pryzbeck, T. R. and Mensforth, R. P. 1985. Chronological metamorphosis of the auricular surface of the ilium: A new method for the determination of adult skeletal age at death, *American Journal of Physical Anthropology* 68, 15-28. https://doi.org/10.1002/ajpa.1330680103

Martin, R. and Saller, K. 1957. *Lehrbuch der Anthropologie: In systematischer Darstellung*, Fischer, Stuttgart.

Meindl, R. S. and Lovejoy, C. O. 1985. Ectocranial suture closure: A revised method for the determination of skeletal age at death based on the lateral-anterior sutures, *American Journal of Physical Anthropology* 68, 57-66. https://doi.org/10.1002/ajpa.1330680106

Microsoft Corporation 2022a. *Microsoft Excel* [Computer Software].

https://www.microsoft.com/en-us/microsoft-365/excel (Accessed: 07. 03. 2022.)

Microsoft Corporation 2022b. *Power Query* [Computer Software Add-in].

https://powerquery.microsoft.com/en-us/excel/ (Accessed: 07. 03. 2022.)

milOrd 2022. *SKELETOR* [Spreadsheet System]. http://milord.iarh.hr (Accessed: Forthcoming)

Niven, K. J. 2011. Databases and Spreadsheets: A Guide to Good Practice, In: K. J. Niven and F. P. McManamon (eds.), *Guides to Good Practice*, Archaeology Data Service, Digital Antiquity, York, Tempe. https://guides.archaeologydataservice.ac.uk/g2gp/DbSht_Toc (Accessed: 07. 03. 2022.)

Ortner, D. J. 2003. *Identification of Pathological Conditions in Human Skeletal Remains*, Academic Press, New York.

Osterholtz, A. J. 2019. Advances in Documentation of Commingled and Fragmentary Remains, Advances in Archaeological Practice 7 (1), 77-86. https://doi.org/10.1017/aap.2018.35

Powell, M. L. 1985. Analysis of dental wear and caries for dietary reconstruction, In: Gilbert R. I. and Mielke J. H. (eds.), *The analysis of prehistoric diets*, Academic Press, Orlando, 307-338.

Roberts, C. A. and Manchester, K. 2007. *The archaeology of disease*, Cornell University Press, New York.

Smith, B. H. 1984. Patterns of molar wear in hunter-gatherers and agriculturalists, *American Journal of Physical Anthropology* 63, 39–56. https://doi.org/10.1002/ajpa.1330630107

Smithsonian Institution 2020. *Osteoware®* [Computer Software]. https://naturalhistory.si.edu/research/anthropology/programs/repatriation-office/osteoware (Accessed: 07. 03. 2022.)

Trognitz, M. 2017. Tabellen, In: M. Heinrich, F. Schäfer and M. Trognitz (eds.), *IT-Empfehlungen für den nachhaltigen Umgang mit digitalen Daten in den Altertumswissenschaften: Version 1.0.1.0*, IANUS, Deutsches Archäologisches Institut, Berlin, 131-142. https://www.ianus-fdz.de/it-empfehlungen/sites/default/files/ianusFiles/IT-Empfehlungen_v101.pdf; https://ianus-fdz.de/it-empfehlungen/tabellen (Accessed: 07. 03. 2022.)

Trotter, M. and Gleser, G. 1952. Estimation of stature from long limb bones of American whites and Negroes, *American Journal of Physical Anthropology* 10, 463-514. https://doi.org/10.1002/ajpa.1330100407

Trotter, M. and Gleser, G. 1958. A re-evaluation of stature based on measurements taken during life and of long bones after death, *American Journal of Physical Anthropology* 16, 79-123. https://doi.org/10.1002/ajpa.1330160106

http://milord.iarh.hr/index.php/en/activities-and-results/skeletor (Accessed: 07. 10. 2022.)

Regional Absolute Chronologies of the Late Neolithic in Serbia. The case study of At near Vršac

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https://doi.org/10.17234/METARH.2022.07

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The paper presents the concept, methodology and preliminary results of the project Regional Absolute Chronologies of the Late Neolithic in Serbia that started in 2020 using a case study from the site of At near Vršac in northeast Serbia. The aim of the project is to create multiple new regional chronological strands consisting of Bayesian modelled radiocarbon dates from sites with material culture belonging to the tradition of the Late Neolithic period Vinča culture. Combining statistical seriation of pottery assemblages and the Bayesian statistical modelling framework of several case studies from various regions of Serbia, new regional chronological anchor points will be created, thus avoiding constant comparison with the assemblage and dating of the eponymous site of Belo Brdo in Vinča. This approach will overcome the effects of the regionalization of material culture evident in most ceramic assemblages located further than 100 kilometres away from the type site. Using archival archaeological records from previous excavations will enable an establishment of a geography of chronological reference points which would then provide new insights into the dynamics of the evolution of the Late Neolithic Vinča societies and changes that occurred throughout its territory during the late sixth and the larger part of the fifth millennia BCE.

Keywords: *Late Neolithic, Vinča Culture, Correspondence analysis, Bayesian modelling, Radiocarbon dating*

Introduction

The Late Neolithic Vinča phenomenon of the central Balkans area is well-known in archaeological literature not only in the region where it manifests, but also well beyond. The question of the chronological placement of Vinča material has been debated almost since the first excavations of the late nineteenth century and early twentieth century (e.g. Jovanović 1892; Vassits 1902; Vasić 1906). The work of Miloje Vasić on the site of Belo

Brdo in the village of Vinča, located on the right bank of Danube, 13 kilometres downstream of Belgrade, Serbia would become essential towards solving this problem. Starting in 1908 (Vasić 1910), upon receiving multiple surface finds from the inhabitants of the village in the previous years, Vasić undertook a series of excavations that would eventually span four decades, with interruptions caused by the first World war and the lack of funds following it. These excavations, still largest in size until modern period, revealed the existence of 10 meters thick archaeological evidence of continued occupation on the site of Belo Brdo, from the period of the Early Neolithic until the Late Medieval period. However, despite such abundant evidence of prolonged human occupation on this location, just one particular section would bring this site world fame; the fabled eight meters thick deposits of the Late Neolithic period, that was to become known as the period of Vinča culture.

Vasić, after decades of diligent work on the excavation of the site, duly published his findings in the four volume *Preistoriska Vinča* (Vasić 1932; 1936a; 1936b; 1936c), and explored multiple subjects including the chronology of the site. Although his relative dating of the Vinča chronology with respect to the Bronze Age of the Aegean presented in the first part of his chronology chapter did not stand the test of time, prophetically, at the end of the chapter, Vasić stated 'Cultural layer in Vinča will, in this aspect, be a chronological ladder for dating culture occurrences in settlements and areas, with whom Vinča was in connection and communication' (Vasić 1932: 97).

Although Vasić published a detailed account of the type site inventory he never attempted to analyse it in detail, even stating in his monograph that the sheer numbers of the finds prevented him from publishing and analysing it in detail (Vasić 1936c: 1). Thus, he made no attempt at phasing the Vinča phenomenon he diligently toiled on for more than three decades. However, very soon after the publication of the finds, other authors attempted to phase the material (Holste 1939) and to present a relative chronology of the period. This early, basic phasing, although re-examined and refined over time by other authors, remains the backbone of most later periodisations, like the one of Milojčić (1949) who was the first to incorporate the Vinča relative chronological scheme into the wider central Balkans one.

The seminal work came with Milutin Garašanin (1951), the first author to publish the entire inventory of the Vasić excavations in Vinča, systematised and divided into major and sub phases named Vinča-Tordoš and Vinča-Pločnik respectively. Over the decades, on several occasions (Garašanin 1979; 1993) he further fine-tuned the relative chronology of the Vinča period. This included the important Gradac phase, the turning point in the use of copper metallurgy on Vinča settlements, defined in further detail by Borislav Jovanović (Jovanović 1971; 1978; 1980; Jovanović and Ottaway 1976). Garašanin's chronological periodisation also influenced authors from the fringe areas of Vinča distribution, like Dumitru Berciu (Berciu 1961), Stojan Dimitrijević (1968) and Gheorghe Lazarovici (Lazarovici 1979; 1981) who also tried to incorporate the Vinča material into the relationships and correlations with neighbouring societies of different pottery traditions. In their attempts the authors always referenced pottery sequences to Belo Brdo finds, some disregarding the distance and possible local variations that may not always have been present on the type site, with others (Lazarovici 1979) including detailed accounts for it. The chronological sequencing continued in the 1990's both on pure relative chronology phasing based on pottery finds (Parzinger 1993; Jovanović 1994) or on the combination of relative and absolute chronologies (Schier 1996). The availability of larger quantities of radiocarbon dates, combined with the developments in computer use of statistical seriation methods, made it possible to investigate chronological relations to a greater detail, giving rise to new studies that suggested the existence of more phases than originally thought (Schier 1996; 2000). At the end of the first decade of the 21st century, one paper (Borić 2009) provided a host of new radiocarbon dates for Vinča period from sites found throughout Serbia. However, it was focused on the emergence of metallic Vinča, a rather narrow period within the Late Neolithic chronology of the region, and it did not particularly concern the entirely of this period or the broader periodisation. The past few years saw another surge of interest in the further refinement of existing chronologies, this time heavily relying on robust statistical models backed by numerous radiocarbon dates of both secure contexts and excavation layers (e.g. Jakucs et al. 2016; Tasić et al. 2016a; Tasić et al. 2016b; Whittle et al. 2016). However, there is still plenty unknowns in the realm of the chronology of the Late Neolithic of the Central Balkans area, and more studies in the coming years will surely try to fill these gaps with new data and interpretations.

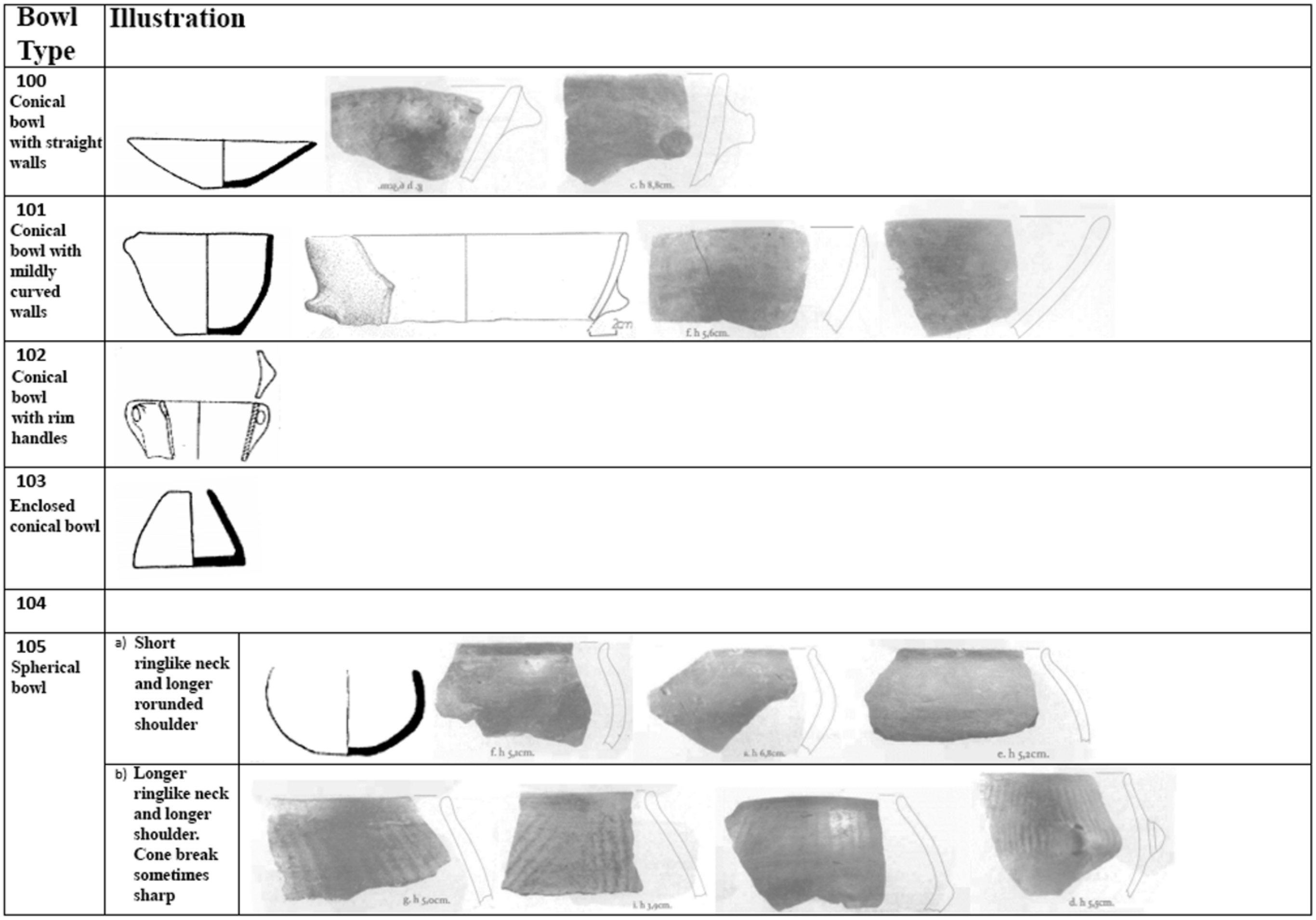


Figure 1. Illustration of the first five types of bowls in the pottery typology used for Correspondence Analysis. (Made by: M. Marić).

Material and Methods

The paper presented, containing first Bayesian modelling of radiocarbon dates from the site of At near Vršac, is a part of a larger project, started in late 2020, called *Regional Chronologies of the Late Neolithic in Serbia.* The project launched, amidst the ongoing COVID-19 pandemic, a two-year odyssey of examining Vinča period collections from different museum collections in Serbia. It sought good pottery sequences and adequate organic remains to date and produce chronological sequences in under researched areas occupied by this Late Neolithic phenomenon. The project was envisaged as an attempt to create precise regional chronologies through the use of radiocarbon dating of the selected Late Neolithic period sites in Serbia, combined with statistical seriation of pottery inventory using correspondence analysis (CA) from chosen sites. A series of case studies from various regions would result in a number of relative chronological sequences that could be merged with absolute chronological measurements into a Bayesian statistical framework to produce a strict chronological scale of higher precision. This approach would rely strictly on archival records in existence, created during archaeological excavations, in order to provide a notion of early-late relationships between excavated features.

In order to have comparable results, the pottery sequencing had to be based on a unique pottery typology, one applicable to both the core and the fringe areas of the Vinča period ceramics. Over the years, multiple typological attempts on site assemblages were made by numerous authors (e.g. Garašanin 1951; Madas 1988; Vukmanović and Radojčić 1990; Jovanović 1994; Nikolić

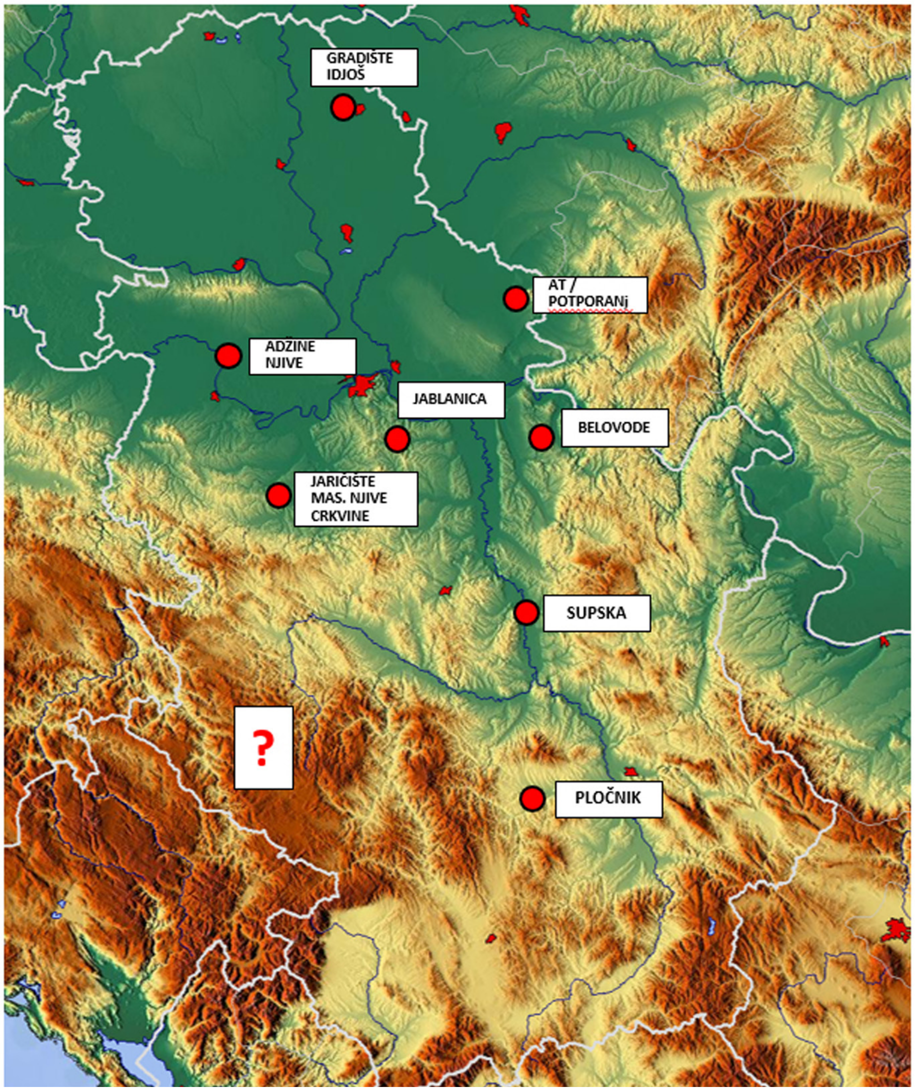


Figure 2. Vinča period sites to be analysed in the project. (Made by: M. Marić).

2004), but usually none proved completely useful beyond a certain distance from the published site. This issue had been identified by earlier authors as well (Chapman 1981: 22-31, Figs. 12-13), indicating a need for the creation of a more complete typology, that would include both the type site (i.e. Vinča Belo Brdo site) vessel forms as well as local variations from the vast area inhabited by communities of Vinča tradition pottery and influences from contemporary neighbouring communities of different pottery traditions. Drawing from the experience of recent archaeological research on the sites of Belovode and Pločnik (Mirković-Marić et al. 2021a; 2021b) and in concord with the proposed universal Vinča style pottery typology of Garašanin and Stanković (1985), a new typology was created for the purpose of the project with ten principle categories of vessels, each consisting of multiple subtype entries (Fig. 1). Within the principal category, each vessel type was defined according to its function (or proposed function) and then within that type, further sub-divided according to variations in vessel morphology. For instance, the most commonly referred vessel type in the study of Vinča tradition pottery, the bowl, in our typology consists of 24 principal types, many including multiple sub-type varieties based on the variation of individual morphological characteristics on a certain part of the vessel profile. The bowls range from simple conical and spherical bowls to more complex types - carinated, biconical, funnel shape, everted rim type and others derived solely from the morphology of the vessel profile. It must be noted that the finite number of bowl types is not set and can be easily amended if new, regional variants occur in site inventories by the simple addition of a new vessel type or sub-type to the list. Because we used the whole of the vessel profile as its morphological characteristic in defining the type, simple reverse engineering is also possible on previous typologies to make the material universally comparable. The more intricate details of the typology go beyond the scope of this paper and will be discussed elsewhere.

Having defined the typology to be used, the statistical analysis is the next step in the process. Correspondence analysis (CA) of pottery types was chosen, as it already showed great potential on Vinča style pottery for determining evolutionary phases and trends (Schier 1996; Diaconescu et al. 2020), both on the type site and in the peripheral areas. Correspondence analysis of archaeological material is not a novelty, it has been around for the better part of a half a century already (Baxter 1994: 101), but its popularity grew with the rapid development of personal computing in the 1990's. In principle, it is a 'technique for displaying rows and columns of a two-way contingency table as points in corresponding low-dimensional vector spaces' (Greenacre 1981: 119). Correspondence analysis is most appropriately used in analysing tables containing counted data, such as the number (or frequency) of pot types per stratigraphical unit, context or site. It's most positive feature for archaeologists is the ability to simultaneously represent both rows and columns of a data matrix as points of a single plot (Baxter 1994: 100). Superimposition of row and column data can then identify clustering (if one exists) of analysed data to reveal a pattern of unusual values in the data that stand out from the *average* data profile.

One of the most common uses of CA is seriation, to test whether certain types of finds can identify relative chronology of contexts or entire archaeological sites (Baxter 1994: 118). The hope is that for instance row orders reflect the relative chronology of contexts and the column reflects the chronological development of material type being examined. However, since archaeological data is rarely perfect, the *outliers* will often introduce noise in this ordering, so the need to identify them is the first step in the process of CA. When done properly, the CA will produce a 'horseshoe' pattern of the plot, also known as the 'Guttman' effect (Schier 1996: Fig. 2). This demonstrates that the contexts or sites at the end of the horseshoe shape will have nothing in common and the data in-between will have shared similarities indicating that the finds examined come in and out of fashion, and are, based on their abundance, more or less popular through time or are shorter or longer lived. However, CA is not guaranteed to seriate an abundance matrix correctly. Thus, it is sometimes complemented with the radiocarbon data to confirm or question the seriation.

The choice of sites to be included in the study presented a different set of problems. The geographical position of the site was one of the primary factors to be taken into account, as having sites grouped too close to one another could lead to decreased regionality in the site inventory. Being forced to rely on archival excavation data made the choice even more difficult, especially for older excavations, where often the pre-selection of finds to be kept in the inventory was made immediately on-site during excavations, thus robbing us of the true quantities and qualities involved. Furthermore, up until recently, animal remains were commonly not collected and stored permanently. Rather, if collected in the first place, they were processed on site and returned to backfill of the excavated trenches or disposed of in the years after the excavation to free up space in museum storage. A similar story can be told for macrobotanical samples, the collection of which has only recently become a standard practice on archaeological excavations in Serbia, thus older excavations are void of such potential short-lived material for radiocarbon sampling. The team had to also look for sites with the longest possible occupation on record, in order to illustrate the extent of the Vinča period to its fullest potential in the area being examined. This realisation led to the need of having to select more than one site in several regions, as there were no excavated multi-phase Vinča sites available, even though they must exist in almost every region occupied in Vinča period. The selection of sites was thus born out of many necessities and is less than ideal (Fig. 2), with certain regions, like southwest Serbia, being underrepresented, due to the lack of excavated sites or preserved organic material for radiocarbon analyses. It is our belief that future research will alter this image and present more options for regional chronological assessment projects like ours.

In choosing adequate samples for radiocarbon dating, the entirety of the existent archaeozoological collection was examined and processed to the level of identification of individual species (where possible). The sampling strategy of animal remains followed vertical (and/or horizontal) stratigraphy in order to obtain the absolute chronology duration in each Late Neolithic settlement. An identical protocol was applied to all faunal assemblages from archaeological sites included in the project. At least two samples (main and control) belonging to different animals were taken from each archaeological context. The main criteria for selecting and sampling of animal remains for radiocarbon dating were the following: good surface preservation and skeletal elements without any traces of taphonomic changes such as burning and weathering. Small fragments from the selected specimens, approximately 10g in weight, were cut using a small circular diamond saw. Before cutting, each specimen was analysed in detail and photographed. Data were recorded in the RACOLNS faunal database. The following information was recorded: taxon, element, element party, symmetry, diagnostic zones (Dobney and Reilly 1988), epiphyseal fusion, tooth eruption and wear, sex, surface condition, taphonomic and pathological changes. For specimens with butchery marks and pathological changes, the location and description were provided. Taxonomic identification was carried out using standard guides of morphological criteria and comparative animal anatomy (Boessneck 1969; Schmid 1972; Prummel 1988; Helmer and Rocheteau 1994). Measurements were taken following Driesh (1976). It must be stated that, due to the lack of adequate documentation, often it was not possible to establish whether a total collection of zooarchaeological material was implemented during the excavations. The examined collection suggests that this was not the practice during excavations, so the samples had to be chosen from the available material.

The radiocarbon dating for creation of sequences was, from the outset, envisioned within the framework of the Bayesian chronological modelling (Buck et al. 1996). This approach was chosen in order to date the succession of Neolithic phases from the complete sequence of the sites being examined, using primarily depth and the ceramic seriation of finds combined with series of AMS radiocarbon dates made on zooarchaeological samples gathered during these excavations. Our sampling strategy aimed at obtaining multiple measurements on finds at specific vertical spacings (spits or relative depths depending on the site). In order to cover the complete sequence of the excavated trenches all spits were covered if enough samples survived. However, occasionally it was not possible to retrieve quality bone for sampling, leaving us with underrepresented sampling. All measurements are given in conventional radiocarbon ages, corrected for fractionation (Stuiver and Polach 1977).

Selected samples for radiocarbon dating were analysed in two separate laboratories, The BRAMS facility of the University of Bristol, UK and the HEKAL AMS laboratory in Debrecen, Hungary where they were prepared in concordance with the procedures described in Knowles et al. (2019) and Molnar et al. (2013) respectively. These particular laboratories were chosen because of the identical equipment in use, the MIDACAS (MIni CArbon DAting System) AMS developed and built by the Laboratory of Ion Beam Physics at the ETH in Zürich. This decision made it possible to compare directly measurements provided replicate measurement data are statistically consistent using the method of Ward and Wilson (1978).

In our modelling approach, which consisted of several steps and which is summarily presented here, we applied the R statistical software, because of its open software license and the fact that it contains multiple pre-made packages for various statistical analysis, including CA, which was applicable for the particular needs of the project. We choose to implement one of the relatively more common packages; the Factoshiny statistical package (https://cran.r-project.org/web/packages/Factoshiny/index.html) which, through a web browser graphical interface, facilitates the analysis and reduces the need for complex coding sequences, typically entered manually in the R Studio software (or similar GUI software). However, other possibilities exist, like the CAinterprTools package developed by Gianmarco Alberti (2015) or one can even manually enter the command lines (Baxter and Cool 2010; Carlson 2017: Chapter 13) or use scripts with commands listed in order of execution.

The chronological part of the modelling which will be described in detail in the next section has been undertaken using OxCal v4.4 (Bronk Ramsey 1995; 2009a; 2009b). The models described in images are defined by OxCal CQL2 keywords. The calibrated ^{14}C date spans are represented in grey outlines, whilst the posterior density estimates created through the Bayesian chronological modelling are given in solid dark grey colour overlaid over the light grey outlines of the posterior density estimates (see Fig. 6).

In conclusion, we must once again stress that our study is based on the combined use of relative chronological data as supplied by the excavator during the research and the statistical sequencing using CA on pottery types found, to produce the relative chronological sequence of the site. This is then paired with the ^{14}C measurement data to create a strong absolute chronological sequence that can reduce measured probability distributions of individual samples significantly, thus facilitating a more precise chronological estimate of site/context duration.

The archaeological site of At

The Late Neolithic site of At is located near Vršac, in south Banat (Fig. 3). It is nested on an elevated loess plateau squeezed between Mali and Veliki Rit, marshy areas

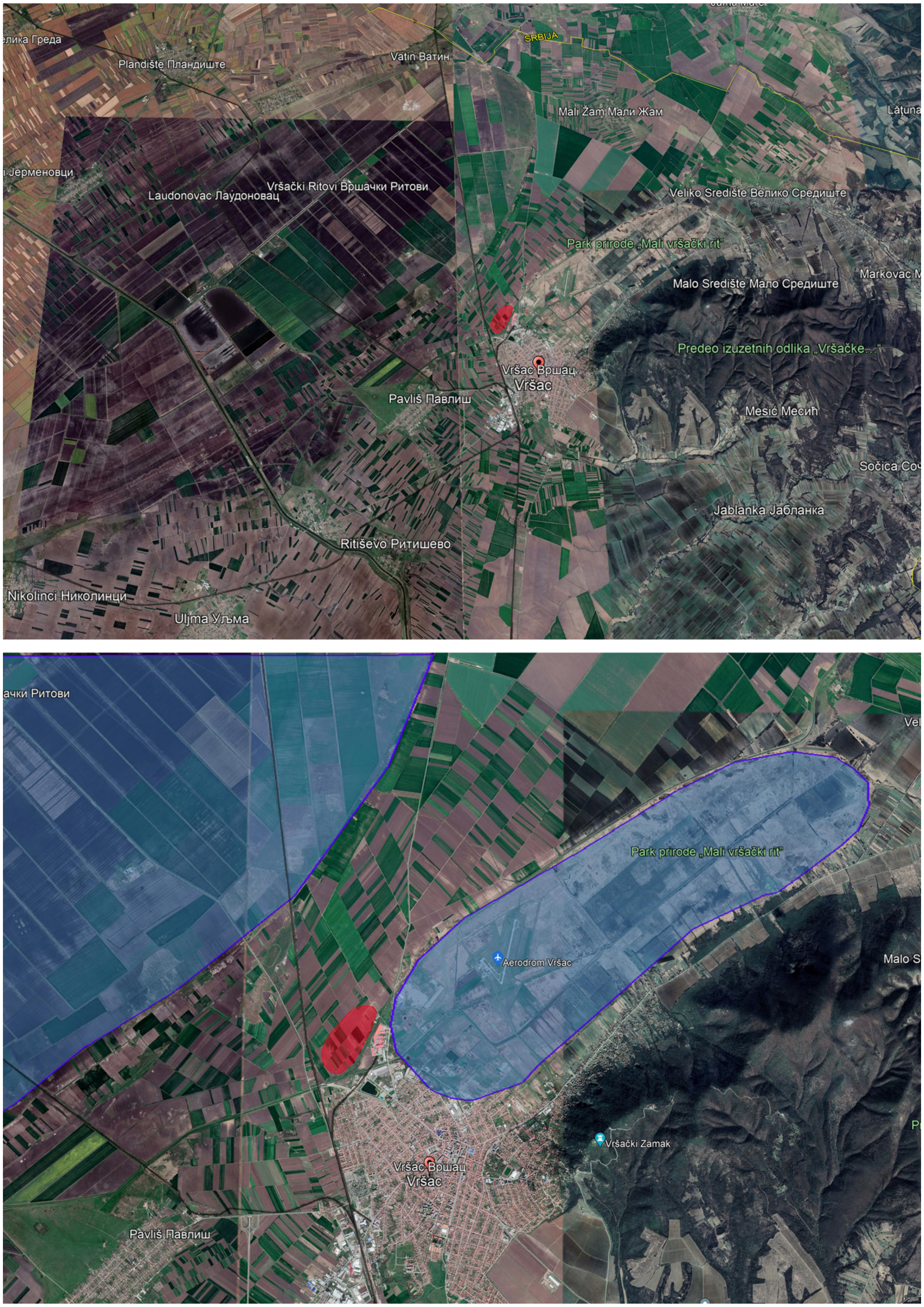


Figure 3. Location of the site of At-Vršac; regional context (up), detail (down). Approximate site area given in red, transparent blue major geological formations Mali and Veliki Rit.
(Made by: M. Marić).

(even possibly shallow lakes) formed in early Pleistocene, against the backdrop of the Vršac mountains. The site is located opposite another Early Vinča period settlement, the site of Kanal Mesić, known only from small-scale rescue excavations undertaken during the construction of an artificial lake in 1954 (Prikić and Joanovič 1978: 24). At was discovered at the end of the 19th century by Felix Mileker, the first archaeological custodian of the Vršac City Museum (Rašajski 1976). It was first excavated in 1959 when sand quarrying started on the location. The

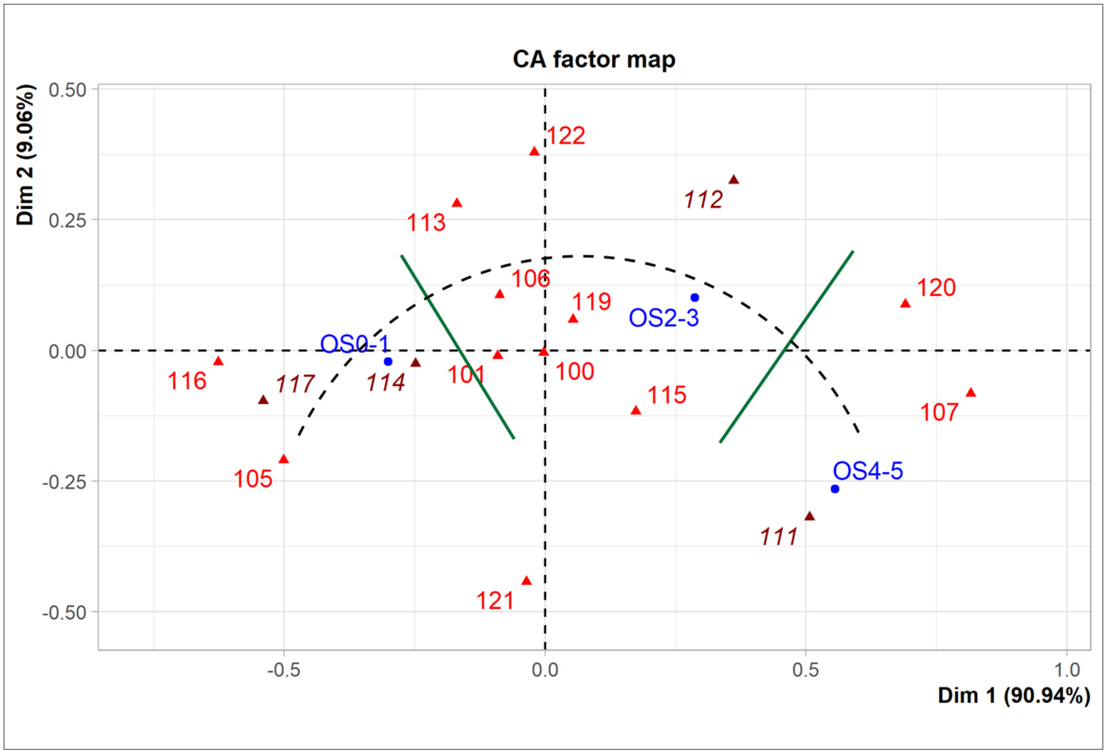


Figure 4. Factor map of Correspondence Analysis performed on 16 bowl types found on At. (Made by: M. Marić).

excavations were always associated with the opening of new sand pits and lasted several decades with pauses between individual campaigns. The recovered archaeological finds and a few available radiocarbon dates put the Late Neolithic site at the end of the Vinča period, in the Vinča D phase (Chu et al. 2016), but the limited amount of radiocarbon dates prevented us from a more detailed phasing. Here we present the Bayesian model created from excavation results of trenches 4 and 5, excavated in early October 1976, consisting of a total area of 200 m^2. The trenches were located in the eastern part of the site, where two different sand quarrying pits were made and exploited over the years. The surviving excavation documentation suggests that the archaeological layers were not deep, only about 1-1.2 meters, indicating a relatively short occupation period. Even though spaced apart by some distance, the characteristics of excavated layers in the trenches suggest a similar stratigraphic sequence. Both trenches were excavated using the same excavation methodology and system of documentation, using arbitrary mechanical spits of 20 cm, unless a structure or feature was detected in the process. Although there is no direct contact between the trenches, available surviving evidence shows no major differences between the two. A coarse overview of the material retrieved from trenches 4 and 5 suggested that the relative dating can be placed in the latter part of the Vinča period, namely Vinča D, easily identifiable by lack of specific pottery types (e.g. pedestal bowls) and decorations (incised encrusted bands and figures with pricks, black topped vessels and similar).

Results and Discussion

In total, slightly over 2000 identifiable fragments of pottery were available for the CA analysis from the ceramic fragments' assemblage of the excavations covering all pot types of the Vinča style production present in the assemblage. Their morphological features were recorded according to the typology created for the project in a database file. For this occasion, we selected only the most typical pot type in the Vinča ceramic production; the bowls (Plates 1-3). The raw data used in the analysis is presented in Table 1.

Bowls in the Vinča ceramic typology are a core vessel type when establishing relative chronology and phasing of period sites. All existing divisions (e.g. Garašanin 1951; Schier 2000) are heavily influenced by the morphological characteristics and frequencies of bowls found on Vinča sites. In our analysis we focused on 695 individual fragments of bowls divided among 16 bowl types, spread

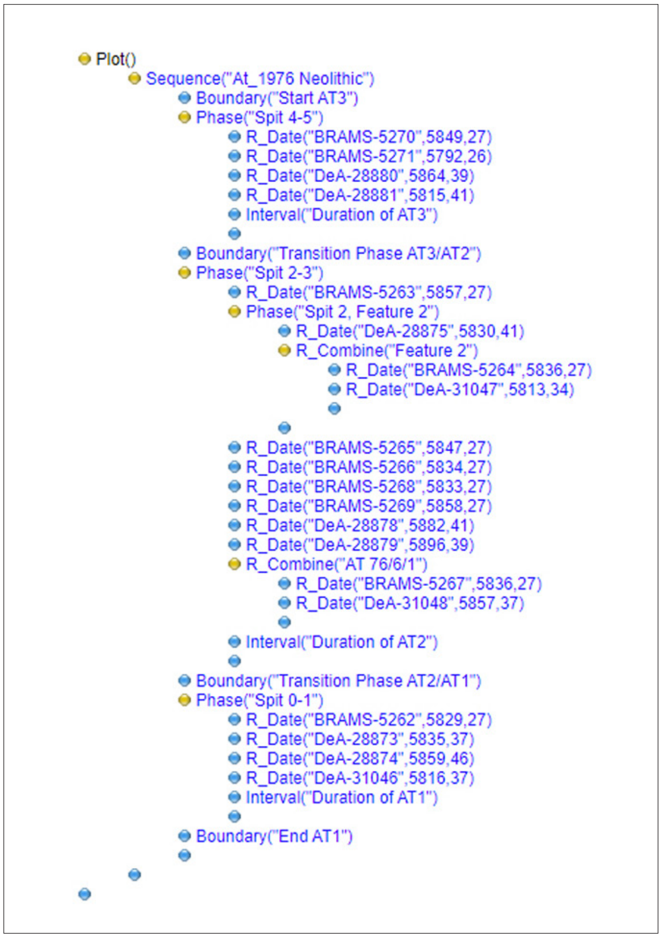


Figure 5. Structure of the Oxcal model used for the Bayesian chronological modelling.

across five excavation spits. The spits (marked in the CA as OS, standing for *otkopni sloj*, i.e. *excavation layer*) contained an uneven number of sherds with excavation layers closer to the bottom of the trenches having a significantly smaller number of fragments than the upper layers. Aside from the partially excavated burnt wattle and daub structures (features 1 and 2) in the second and third spits of both trenches no other Neolithic structures such as pits were found, so the majority of finds were solely examined as a part of the spits they were found in. The results of the CA (Fig. 4) illustrate spits 0 and 1 (the surface layer was marked sometimes 0) representing a single phase, while spits 2 and 3 (the ones containing burnt wattle and daub structure) were a separate, second phase. Spits 4 and 5 (OS4-5) can also be bundled together into a single phase, the earliest recorded on the site. The Factor map clearly identifies a horseshoe effect between the spits, thus allowing for a correct chronological sequencing of layers. The pottery types are given in red numbers with triangular points, whilst the spits are given in blue lettering with a round point next to them. Green lines present the break lines between individual groups of pots typical for each phase.

If we examine the results of the analysis, the χ^2 value of 99.8898 (p-value=1.932682e-09) indicates a significant relationship between analysed variables (Drennan 2009: 182-188). Eigen values of 90.94% for dimension 1 and 9.06% for dimension 2 show that the variance of data is completely explained in two dimensions.

Looking further (Table 2, rows section) we can easily see that OS0-1 contributes (ctr) with 45.856% to the construction of the first dimension, and is adequately represented (cos2=0.994 on a scale of 0 to 1). It is similar for OS2-3 which contributes with 30.312% (cos2=0.846) and OS4-5 (contribution=23.832%, cos2=0.676) to the same dimension. The second dimension of data analysed shows clearly that OS2-3 (ctr=31.99%, cos2=0.154) and OS4-5(ctr=66.384%, cos2=0.324) are the only contributors to its construction.

The same can be applied for the column (i.e. bowl type) data (Table 2, columns section). Not all bowl types are equally involved in the construction of dimensions that explain variance. Types 105, 107, 116 and 117 contribute 68.73% to dimension 1, whilst types 105, 111, 112 and 122 contribute the most (73.136%) to dimension 2. Other types are involved as well, but these are the most influential bowl types that explain the largest percentage of variation between spits.

Having established the stratigraphic connections between spits and their relative chronological relations with respect to the bowl type variation within them, we can now add the absolute chronological aspect to produce the Bayesian chronological model of the site. During the course of the project 26 samples of animal bones from all spits of trenches 4 and 5 were sent for radiocarbon dating analysis (Table 3). Only one sample yielded <1% collagen and could not produce measurements, whilst 25 samples produced a range of radiocarbon dates. Of the 26 samples, 3 pairs of samples were pre-selected as replicate measurement data, to ensure statistical consistency for the direct comparison of measurements. The majority (2 of 3) pairs proved statistically consistent, whilst the third pair failed (DeA-31045 and BRAMS-5261) and was not used as it suggests that the bone was most likely insufficiently calcined to provide reliable dating. One further radiocarbon sample (DeA-31046) was eliminated from the modelling, as its exact

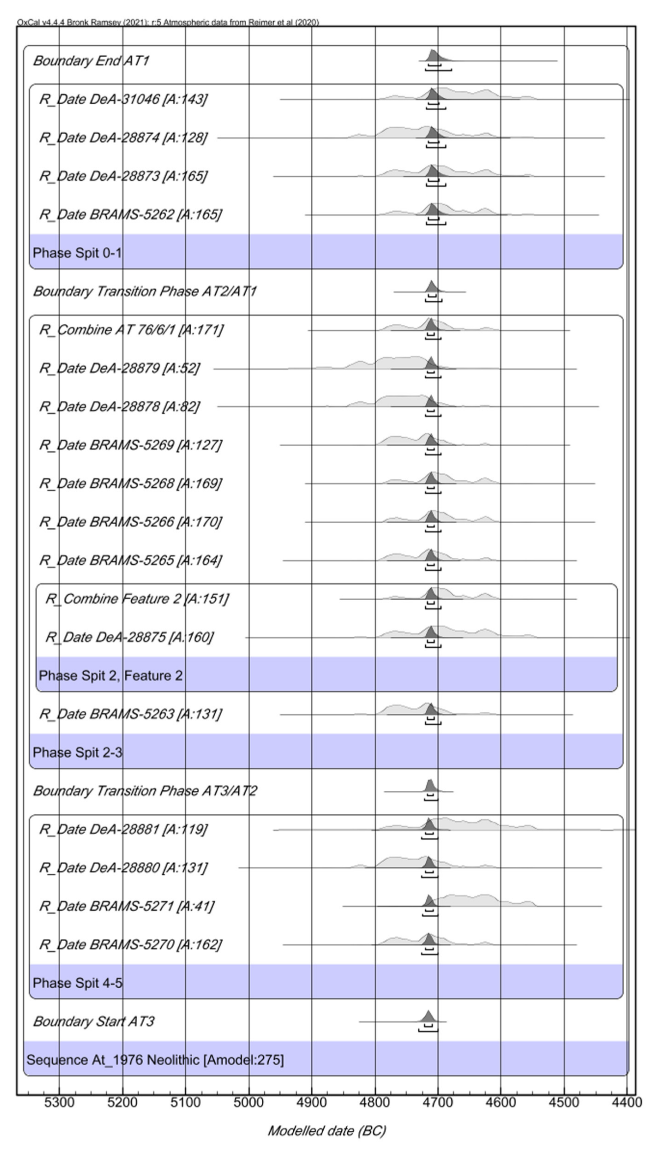


Figure 6. Final appearance of the Oxcal model for the site of At-Vršac.

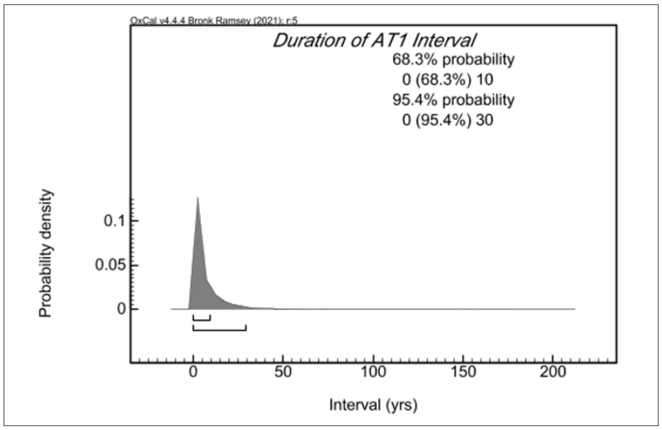


Figure 7. Duration period of AT 1 phase derived from At 1976 Oxcal model.

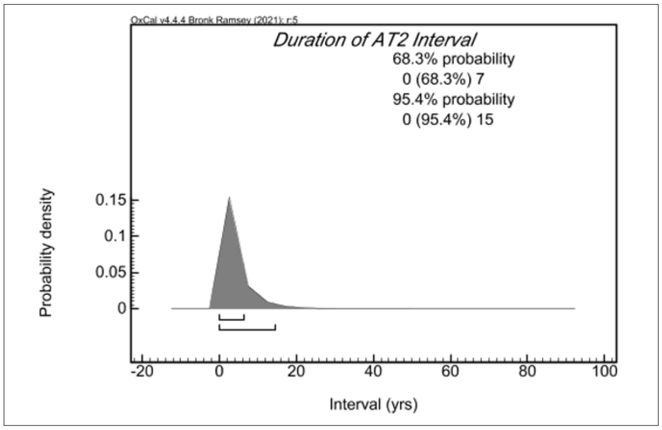


Figure 8. Duration period of AT 2 phase derived from At 1976 Oxcal model.

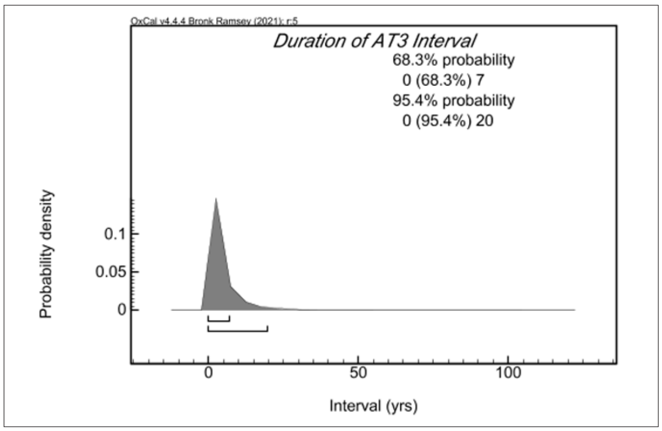


Figure 9. Duration period of AT 3 phase derived from At 1976 Oxcal model.

relative stratigraphy could not be established. An interesting physical marking on the bone, indicative of certain pathologies, led to it being chosen for radiocarbon dating (Marković et al. in prep) despite this shortcoming. The remaining radiocarbon measurements were used to construct a Bayesian model given in Figure 5. The model, shown in Figure 6 interprets the sequence from trenches 4 and 5 as continuous habitation of this part of the site, as suggested by excavation documentation, showing no signs of temporary abandonment of the site. The probability distribution of one sample (DeA-28876) in relation to its stratigraphic position identifies it as a *terminus post quem* for that context and this sample was omitted from the final model. However, other samples from the same context provided enough data for a secure determination.

The model has excellent overall agreement (Amodel: 273.6, Fig. 6), which firmly corroborates the interpretation of relative phasing of the site based on the CA results of bowl types found in trenches. It suggests that the occupation of the site in this area occurred 4732–4701 cal BC (*95% probability; Start AT3;* Fig. 6*),* probably

4722–4710 cal BC (*68.3% probability*). The first phase of occupation did not last long - up to 20 years (*95.4% probability*), but likely just 7 (68.3% probability) which can be seen using the *Interval* command in Oxcal (Fig 7.)

The second phase of At occupation (*Transition phase AT3/AT2;* Fig. 6) started at 4723–4701 cal BC (*95.4% probability*), possibly 4718–4709 cal BC (68.3%), and again lasted a relatively short period of time – 15 years (*95.4% probability;* Fig. 8), and possibly just 6 (*68.3% probability;* Fig. 8). This puts it well within one generation's life span. The final phase of the Late Neolithic occupation of At in trenches 4 and 5 (*Transition phase AT2/AT1)* began at around 4721–4695 cal BC (*95.4% probability*; Fig. 6), possibly 4716–4705 cal BC (*68.3% prob.*), lasted up to 30 years (*95.4% prob.*), and possibly just 9 (*68.3% prob.* Fig. 9). According to the model, the end of late Neolithic occupation in the area of the site where trenches 4 and 5 were located is modelled at 4720–4679 cal BC (*95.4% prob.;* Fig. 6), possibly 4716–4696 cal BC (*68.3% prob.*).

In terms of relative chronology, the Late Neolithic Vinča occupation of trenches 4 and 5 at At coincides with the early period of Vinča D phase (Whittle et al. 2016: 31), which can be somewhat corroborated by the typology of bowls found in the trenches. Some of the very typical finds, like the biconical bowl with inverted rim (type 117 in our typology), a very typical Vinča D phase bowl in central Serbia (Mirković-Marić et al. 2021a, 2021b), only appears in limited numbers in trenches 4 and 5 (31 examples in total, most from spit 1) and is not as prevalent as this type is in the later part of Vinča D phase (e.g. Garašanin and Garašanin 1979: TI/1, TIII/3, TIV/4, TVI/2).

Conclusion

The first results of the *Regional Absolute Chronologies in Late Neolithic Serbia* presented in this volume are just a hint of what carefully constructed Bayesian model combining relative and absolute chronological data can yield even from partially preserved archival data from an excavation undertaken almost over half a century ago. The creation of regional chronological *beacons* based on such an approach can greatly improve our knowledge of locally occurring phenomena, and need not be directly linked with the remainder of the vast territory covered by identical or similar material culture. It can also provide us with new insights into developments that may have, gradually, over time, led to bigger events that triggered large scale transformations. The approach presented illustrates the need to access and evaluate the existing corpus of archaeological data sitting in the storage rooms of regional museums often for decades on end. Combing the data mined from dusty old boxes, long forgotten on shelves, can indeed present new data and open new areas of research in what otherwise appears to be a limited opportunity for modern archaeological research.

Finally, the At Late Neolithic Bayesian chronological model presented, demonstrates a rather dynamic set of events taking place in the extremely short time span of just one generation. It confirms that the site was created and abandoned possibly very quickly, but also leaves us with a question of causalities that led to such events. From the available corpus of archaeological records in the Vršac area, there are no later Vinča period sites known, with one possible site, Cerovica being of a similar period. However, this latter site is dated from material gathered solely during surface prospection (the site is only partially published in the form of short reports, e.g. Joanovič 1976). The quantity of known sites in the Vršac area (over 40 sites are currently on register) indicates the importance of the region during the Late Neolithic Vinča period. However, the rather early abandonment of sites in respect to the span of the Vinča period, as shown on the At examples presented in this paper, especially in comparison to the type site of Belo Brdo located mere 70 kilometres southwest of the region may be an indication of the onset of a larger phenomenon would engulf the Danubian Vinča a century and a half later. This phenomenon would bring about its fiery demise around 4545–4480 cal BC (95% probability) when Belo Brdo was abandoned for good (Borić 2009; Tasić et al. 2015).

It is our hope, that in the immediate future, we start seeing more Bayesian chronological models appearing in the region, making it possible to study Late Neolithic period transformation on a generation or even a household level, contributing more to the many still unanswered questions of the period.

Acknowledgments

This research presented in this paper was supported by the Science Fund of the Republic of Serbia, PROMIS grant #6062361, project RACOLNS.

References

Alberti, G. 2015. CAinterprTools: An R package to help interpreting Correspondence Analysis' results, *SoftwareX*, 1-2, 26-31.

Baxter, M. J. 1994. *Exploratory Multivariate Analysis in Archaeology*. Edinburgh: Edinburgh University Press.

Baxter, M. J. and Cool, H. E. M. 2010. Correspondence Analysis in R for archaeologists: an educational account, *Archeologia e Calcolatori*, 21, 211-228.

Berciu, D. 1961. *Contribui la problemele neoliticului in Romînia în lumina noilor cercetări*, Bucarest.

Boessneck, J. 1969. Osteological differences between sheep (Ovis aries Linn.) and goat (Capra hircus Linn.), In: D. R. Brothwell and E. Higgs (eds.), *Science in Archaeology: A survey of Progress and Research*, London: Thames and Hudson, 331-358.

Borić, D. 2009. Absolute dating of metallurgical innovations in the Vinča culture of the Balkans, In: T. L. Kienlin and B. W. Roberts (eds.), *Metals and Societies. Studies in honour of Barbara S. Ottaway*, Bonn: Verlag Dr. Rudolf Habelt GmbH, 191-245.

Bronk Ramsey, C. 1995. Radiocarbon calibration and analysis of stratigraphy: the OxCal program, *Radiocarbon*, 37 (2), 425-430.

Bronk Ramsey, C. 2009a. Bayesian analysis of radiocarbon dates, *Radiocarbon*, 51 (1), 337-360.

Bronk Ramsey, C. 2009b. Dealing with outliers and offsets in radiocarbon dating, *Radiocarbon*, 51 (3), 1032-1045.

Buck, C. E., Cavanagh, W. G., and Litton, C. D. 1996. *Bayesian Approach to Intrepreting Archaeological Data*, Chichester: John Wiley & Sons.

Carlson, D. L. 2017. *Quantative Methods in Archaeology Using R*, Cambridge: Cambridge University Press.

Chapman, J. 1981. *Vinča Culture of South-East Europe: Studies in Chronology, Economy and Society*, Oxford: British Archaeological Reports, BAR International Series 117.

Chu, W., Mihailović, D., Pantović, I., Zeeden, C., Hauck, T. and Lehmkuhl, F. 2016. Archaeological excavations at the site of At (Vršac, Serbia), *Antiquity*, 90 (352).

Diaconescu, D., Niţu, F.M. and Cosmin Ioan Suciu, 2020. The early Vinča culture in Transylvania: Considerations regarding its chronological position using correspondence analysis, *Quaternary International*, 560-561 (Formation and Transformation of Early Neolithic Lifestyles in Europe), 65-77.

Dimitrijević, S. 1968. *Sopotsko-Lenđelska kultura*, Zagreb: Arheološki Institut, Filozofski Fakultet Sveučilišta u Zagrebu.

Drennan, R. D. 2009. *Statistics for Archaeologists. A Common Sense Approach*, New York: Springer.

Driesh, A. 1976. *A Guide to the Measurement of Animal Bones from Archaeological Sites,* Cambridge: Harvard University Peabody Museum.

Garašanin, D. and Garašanin, M. 1979. *Supska. 'Stublina' - praistorijsko naselje vinčanske grupe*, Beograd: Narodni muzej.

Garašanin, M., 1951. *Hronologija vinčanske grupe*. Arheološki seminar. Ljubljana: Univerza v Ljubljani.

Garašanin, M. 1979. Centralnobalkanska zona, In: A. Benac (ed.), *Praistorija Jugoslavenskih Zemalja, Tom II*, Sarajevo: Svjetlost, 79-212.

Garašanin, M. 1993. Zu den Problemen der Vinča-Gruppe in Rumaenien, *Balcanica*, 24, 7-20.

Garašanin, M. and Stanković, S. 1985. Razrada tipologije vinčanske grupe. Prilog jedinstvenoj arheološkoj dokumentaciji, *Glasnik Srpskog Arheološkog Društva*, 2, 10-30.

Greenacre, M. J. 1981. Practical correspondence analysis. In: V. Barnett (ed.), *Interpreting Multivariate Data*, Chichester: John Wiley & Sons, 119-146.

Helmer, D. and Rocheteau, M. 1994. *Atlas du Squelette Appendiculaire des Principaux Genres Holocenes de Petits Rumiant du Nord de la Méditerranée et du Proche-Orient (Capra, Ovis, Rupicapra, Capreolus, Gazella)*, Juan-les-Pins: APDCA.

Holste, F. 1939. Zur chronologische Stellung der Vinča-Keramik, *Wiener Prähistorische Zeitschrift*, 26, 1-21.

Jakucs, J., Bánffy, E., Oross, K., Voicsek, V., Bronk Ramsey, C., Dunbar, E., Kromer, B., Bayliss, A., Hofmann, D., Marshall, P., and Whittle, A. 2016. Between the Vinča and Linearbandkeramik Worlds: The Diversity of Practices and Identities in the 54th–53rd Centuries cal BC in Southwest Hungary and Beyond, *Journal of World Prehistory*, 29 (3), 267-336.

Joanovič, Š. 1976. Banatska Subotica, Cerovica - neolitski lokalitet, *Arheološki pregled*, 18, 17-20.

Jovanović, B. 1971. *Metallurgy in the Eneolithic Period in Yugoslavia*, Belgrade: Archaeological Institute.

Jovanović, B. 1978. The oldest copper metallurgy in the Balkans, *Expedition*, 21 (1), 9-17.

Jovanović, B. 1980. The origins of copper mining in Europe, *Scientific American*, 242 (5), 152-167.

Jovanović, B. 1994. Gradac Phase in the relative chronology of the late Vinča culture, *Starinar (new series)*, 43-44, 1-12.

Jovanović, B. and Ottaway, B. S. 1976. Copper mining and metallurgy in the Vinča group, *Antiquity*, 50, 104-113.

Jovanović, Đ. P. 1892. Petnička pećina. Preistorijsko selište iz neolitskog doba, *Starinar Srpskog arheološkog društva*, 9 (2), 41-45.

Knowles, T. D. J., Monaghan, P. S. and Evershed, R. P. 2019. Radiocarbon Sample Preparation Procedures and the First status Report from the Bristol Radiocarbon AMS (BRAMS) Facility, *Radiocarbon*, 61 (5), 1541-1550.

Lazarovici, G. 1979. *Neoliticul Banatului,* Cluj-Napoca: Bibliotheca Musei Napocensis IV.

Lazarovici, G. 1981. Die Periodisierung der Vinča-Kultur in Rumänien, *Prähistorische Zeitschrift*, 56, 169-196.

Madas, D. 1988. Ceramic Vessels from the Divostin II House Floors. In: A. McPherron and D. Srejović (eds.), *Divostin and the Neolithic of Central Serbia*, Kragujevac, Pittsburgh: Narodni muzej Kragujevac, Department of Anthropology, University of Pittsburgh, 143-173.

Marković, N., Bulatović, J., Krstić, N., Marinković, D., Pantović, I., Russel, N., Rothschild, B. and Marić, M., Wild vs. domestic: Severe traumatic lesions in the Late Neolithic cattle from the site of At-Vršac, Serbia, *International Journal of Paleopathology*, *in press.*

Milojčić, V. 1949. *Chronologie der Jüngeren Steinzeit Mittel- und Südosteuropas*, Berlin: Gebr. Mann.

Mirković-Marić, N., Savić, M. and Rajičić, M. 2021a. Pottery from Trench 18 at Belovode. In: M. Radivojević, B. W. Roberts, M. Marić, J. Kuzmanović Cvetković and T. Rehren (eds.), *The Rise of Metallurgy in Eurasia. Evolution, Organisatiojn and Consumption of Early Metal in the Balkans*, Oxford: Archaeopress Publishing LTS, 152-169.

Mirković-Marić, N., Savić, M. and Rajičić, M. 2021b. Pottery from Trench 24 at Pločnik. In: M. Radivojević, B. W. Roberts, M. Marić, J. Kuzmanović Cvetković and T. Rehren (eds.), *The Rise of Metallurgy in Eurasia. Evolution, Organisatiojn and Consumption of Early Metal in the Balkans*, Oxford: Archaeopress Publishing LTS, 317-344.

Molnar, M., Janovics, R., Major, I., Orsovszki, J., Gönczi, R., Veres, M., Leonard, A., Castle, S. M., Lange, T., Wacker, L., Hajdas, I. and Jull, A. J. T. 2013. Status report of the new AMS 14C sample preparation lab of the Hertelendi laboratory of environmental studies (Debrecen, Hungary), *Radiocarbon*, 55 (2-3), 656-676.

Nikolić, D. 2004. Keramičko posuđe. In: M. Bogdanović (ed.), *Grivac. Naselja protostarčevačke i vinčanske kulture*, Kragujevac: Centar za naučna istraživanja Srpske akademije nauka i umetnosti i Univerziteta u Kragujevcu, Narodni muzej Kragujevac, 205-318.

Parzinger, H. 1993. *Studien zur Chronologie und Kulturgeschichte der Jungstein-, Kupfer- und Frühbronzezeit zwischen Karpaten und Mittlerem Taurus*, Mainz: Philipp von Zabern.

Prikić, M. and Joanovič, Š. 1978. *Neolit južnog Banata sa pregledom neolitskih nalazišta*, Pančevo: Narodni muzej u Pančevu, Narodni muzej u Vršcu.

Prummel, W. 1988. Distinguishing features of postcranial skeletal elements of cattle, Bos primigenius f. taurus, and red deer, Cervus elaphus, *Schriften aus der Archäologisch-Zoologischen Arbeitsgruppe Schleswig-Kiel*, 12, 1-52.

Rašajski, R. 1976. At, Vršac - neolitsko naselje i nekropola bronzanog doba, *Arheološki pregled*, 17, 14-16.

Schier, W. 1996. The relative and absolute chronology of Vinča: new evidence from the type site. In: F. Draşovean (ed.), *The Vinča Culture, its Role and Cultural Connections*, Timişoara: National Museum, 141-162.

Schier, W. 2000. Measuring change: the Neolithic pottery sequence of Vinča-Belo Brdo, *Documenta Praehistorica*, 27, 187-197.

Schmid, E. 1972. *Atlas of Animal Bones: for Prehistorians, Archaeologists and Quaternary Geologists*, New York: Elsevier.

Stuiver, M. and Polach, H. A. 1977. Reporting of 14C data, *Radiocarbon*, 19 (3), 355-363.

Tasić, N. N., Marić, M., Bronk Ramsey, C., Kromer, B., Barclay, A. J., Bayliss, A., Beavan, N., Gaydarska, B. and Whittle, A. 2016a. Vinča-Belo Brdo, Serbia: the times of a tell, *Germania*, 93, 1-75.

Tasić, N. N., Marić, M., Filipović, D., Penezić, K., Dunbar, E., Reimer, P., Barclay, A., Bayliss, A., Gaydarska, B. and Whittle, A. 2016b. Interwoven Strands for Refining the Chronology of the Neolithic Tell of Vinča-Belo Brdo, Serbia, *Radiocarbon*, 58 (4), 795-831.

Tasić, N. N., Marić, M., Penezić, K., Filipović, D., Borojević, K., Russell, N., Reimer, P., Barclay, A., Bayliss, A., Borić, D., Gaydarska, B. and Whittle, A. 2015. The end of the affair: formal chronological modelling for the top of the Neolithic tell of Vinča-Belo Brdo, *Antiquity*, 89 (347), 1064-1082.

Vasić, M. 1910. Die Hauptergebnisse der prähistorischen Ausgrabung in Vinča im Jahre 1908, *Prähistorische Zeitschrift*, 2 (1), 23-39.

Vasić, M. 1932. *Preistoriska Vinča*, Beograd: Državna štamparija Kraljevine Jugoslavije.

Vasić, M. 1936a. *Preistoriska Vinča*, Beograd: Državna štamparija Kraljevine Jugoslavije.

Vasić, M. 1936b. *Preistoriska Vinča*, Beograd: Državna štamparija Kraljevine Jugoslavije.

Vasić, M. 1936c. *Preistoriska Vinča*, Beograd: Državna štamparija Kraljevine Jugoslavije.

Vasić, M. M. 1906. Nekoliki preistorijski nalasci iz Vinče, *Starinar druga serija*, 1 (2), 89-140.

Vassits, M. 1902. Die Neolithische Station Jablanica bei Medjulužje in Serbien, *Archiv für Anthropologie*, 27 (4), 1-66.

Vukmanović, M. and Radojčić, N. 1990. Quantative Analysis of Pottery. In: R. E. Tringham and D. Krstić (eds.), *Selevac: A Neolithic Village in Yugoslavia*, Los Angeles: University of California Press, 289-321.

Ward, G. K. and Wilson, S. R. 1978. Procedures for comparing and combining radiocarbon age deter-minations: a critique, *Archaeometry*, 20 (1), 19-31.

Whittle, A., Bayliss, A., Barclay, A., Gaydarksa, B., Bánffy, E., Borić, D., Draşovean, F., Jakucs, J., Marić, M., Orton, D., Pantović, I., Schier, W., Tasić, N. and Vander Linden, M. 2016. A Vinča potscape: formal chronological models for the use and development of Vinča ceramics in south-east Europe, *Documenta Praehistorica*, 43, 1-60.

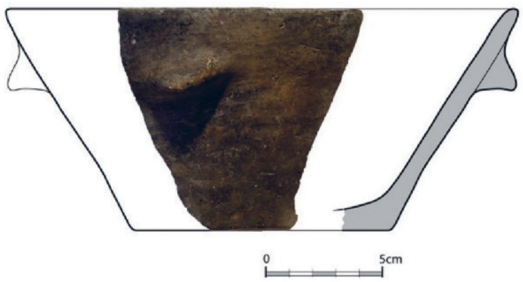
Plate 1.

17
Ro=22cm
Rd=x

AP 8012
Ro=26cm
Rd=x

43
Ro=28cm
Rd=x

39
Ro=22cm
Rd=x



AP 546
Ro=21cm
Rd=x

bb
Ro=29cm
Rd=10cm

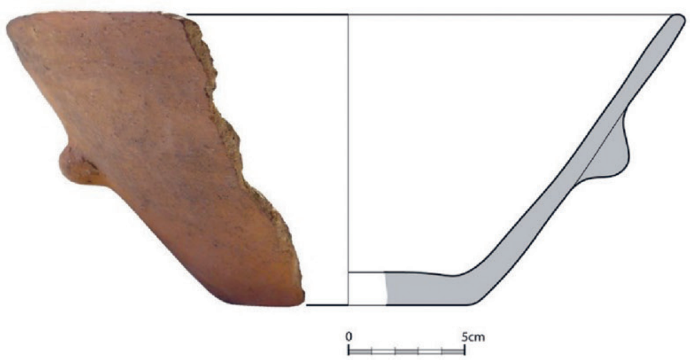
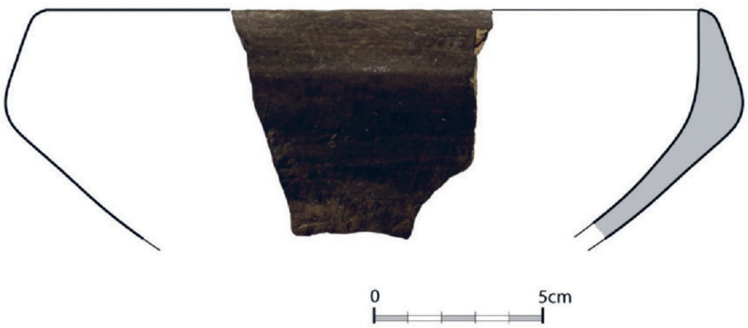


Plate 2.

AP 8031
Ro=20cm
Rd=x

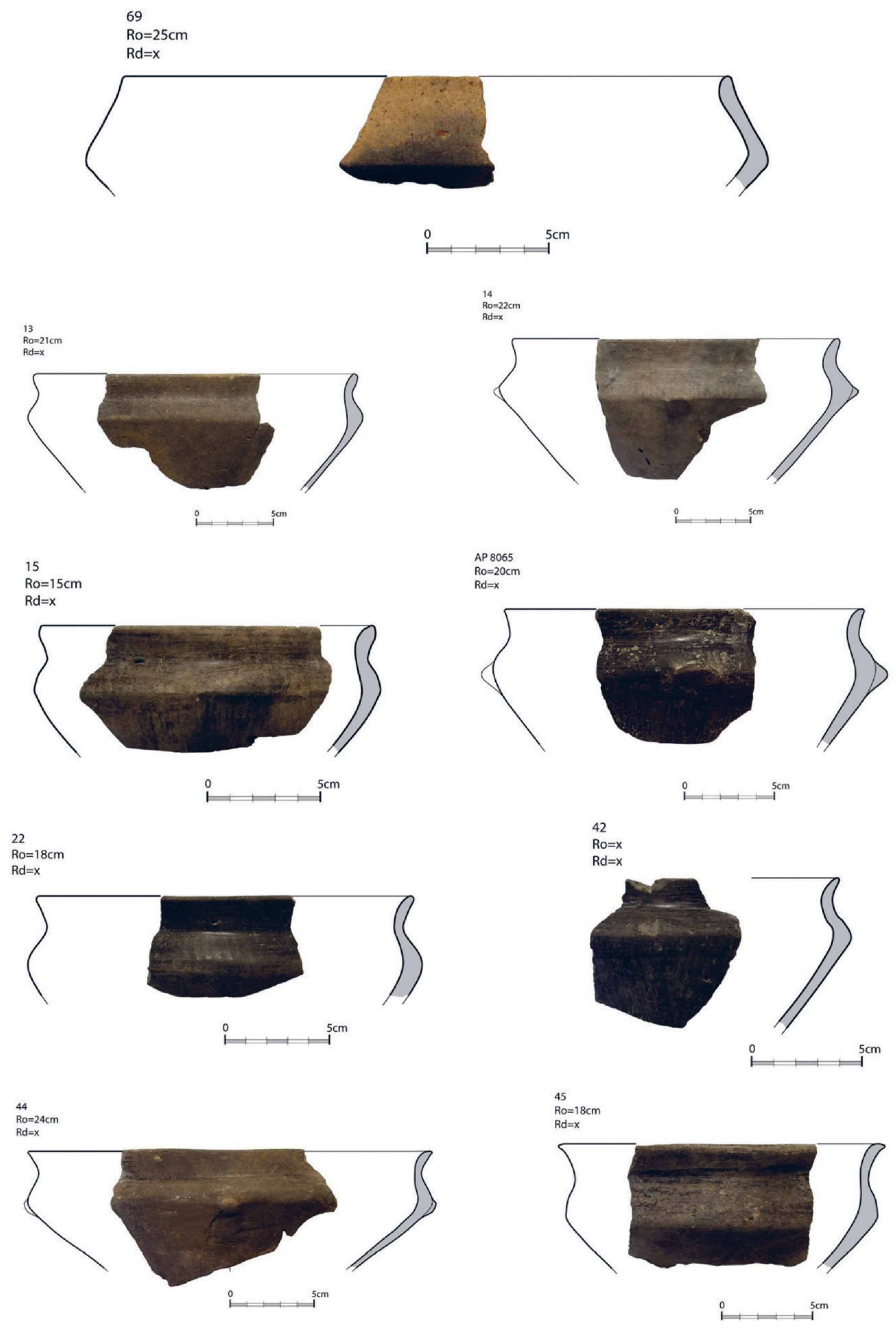
T 1337
Ro=23cm
Rd=x

AP 8027
Ro=20cm
Rd=x



56
Ro=17cm
Rd=x

Plate 3.


69
Ro=25cm
Rd=x
0
5cm
13
Ro=21cm
Rd=x
0
5cm
14
Ro=22cm
Rd=x
0
5cm
15
Ro=15cm
Rd=x
0
5cm
AP 8065
Ro=20cm
Rd=x
0
5cm
22
Ro=18cm
Rd=x
0
5cm
42
Ro=x
Rd=x
0
5cm
44
Ro=24cm
Rd=x
0
5cm
45
Ro=18cm
Rd=x
0
5cm

The Late Neolithic human burials from Kotlina – Szuzai Hegy, Baranja: the first results of the anthropological analysis

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https://doi.org/10.17234/METARH.2022.08

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Human burials with skeletal remains of four individuals were discovered during the systematic archaeological excavation conducted between 2018 and 2021 at Kotlina - Szuzai Hegy site. Movable archaeological finds and direct radiocarbon dates show that the site can be attributed to the Lengyel culture.

The skeletons were laid in shallow pits, in the contracted position, only 30 cm below the surface, which contributed to their bad preservation. Conventional bioarchaeological analysis revealed the sex and age-at-death of the studied individuals as well their health status. Their demographic profile was somewhat unusual: Grave 1 (G 1) contained the remains of a young female (17-22 years) while the other three burials contained the remains of subadults (Grave 2 an adolescent 11-13 years old; Grave 4 a small child 2-3 years old; Grave 5 an infant 6-9 months old). The samples from all four skeletons were taken for the purposes of ancient DNA and stable isotope analyses that will tell us more about the ancestry, kinship and diet of these individuals. The burials show evidence of complex funerary practice: ceramic vessels, polished stone tools, and mollusc shell bead. The human remains from Kotlina provide an excellent opportunity to reconstruct the biological profiles of the studied individuals, while recovered grave-goods allow a comprehensive archaeological analysis of mortuary practices in this Late Neolithic community, but also the analysis of the long-distance networks and exchange activities.

Keywords: *Neolithic, Baranja, burials, Lengyel culture, human remains, grave-goods*

Introduction

Systematic archaeological excavation of the site of Kotlina, situated in the Baranja region, in eastern Croatia, was initiated in 2018 and is still ongoing (Fig.1). The project "Kotlina, the prehistoric site" encompassed a non-invasive field survey and the excavations of two trenches. During that time the area of 130 m² was excavated, revealing different archaeological structures: graves, post holes, and rubbish pits[1]. Archaeological finds belong to the classical phase of the Lengyel

[1] Archaeological excavations are led by the Archaeological Museum Osijek.

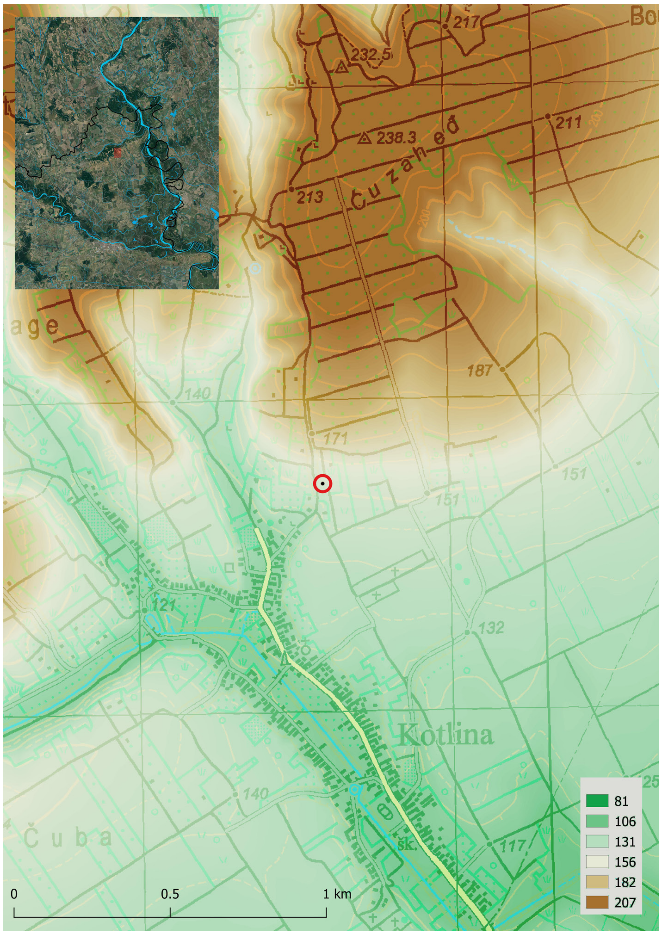

Figure 1. The location of the site of Kotlina and the location of Szuzai Hegy (1:10000) (made by: M. Mađerić)

Site	Lab number	Sample	C 14-Age (BP)	Calibrated Age
Kotlina	Beta-494071	Cattle bone/ SU 8	5770 +/- 30 BP	4709-4542 cal BC
Kotlina	Beta-548562	Cattle bone/ SU 15	5730 +/- 30 BP	4681-4492 cal BC
Kotlina	DeA-28493	Human bone-Grave 1	5792 +/- 30 BP	4720-4550 cal BC
Kotlina	DeA-31813	Human bone-Grave 2	5804 +/- 32 BP	4780-4540 cal BC
Kotlina	DeA-31814	Human bone-Grave 4	5796 +/- 34 BP	4730-4540 cal BC
Kotlina	DeA-31815	Human bone-Grave 5	5881 +/- 37 BP	4850-4620 cal BC

Table 1. Table 1. Dates of the Lengyel culture from the Kotlina-Szuzai Hegy site:

culture. Absolute dates were obtained from six samples. The first sample that was taken from a cattle bone from excavation pit 8 places this site to the period of 4709-4542 cal BCE.[2] The second sample, also obtained from a cattle bone, provided the date 4681-4492 cal BCE.[3] Four other direct radiocarbon dates have been obtained from human bone samples from graves 1, 2, 4 and 5 and all four provide very similar dates (Table 1, Fig. 17).

The Lengyel culture was very widely distributed in central Europe in the first half of the fifth millennium cal BC. At its great extent, its settlements are found in western and north-east Hungary, south-west Slovakia, eastern Austria and Czech Republic. Its distribution reached Slovenia and Croatia in the south, and Poland in the north (Osztás et al. 2013: 180). The existing radiocarbon dates from Lengyel context suggest duration of approximately more than half a millennium, estimated roughly as falling between 4900 and 4300 cal BC. Some estimates place the culture's end at the turn of the 4th millennium (Bánffy 1997: 7; Bickle 2014: 78). Based on pottery four main phases have been identified: Protolengyel, Lengyel I, II and III. The earliest formations of this archaeological culture are found in the northern Croatia and Slovenia (Bickle 2014: 75-76). On its primary territory, the Lengyel culture emerged on the basis of the early Sopot culture south of the Balaton Lake, and the Želiezovce group north of it. Protolengyel groups (Sopot-Bicske, Bíňa-Bicske, Lužianky, Sé) are formed in this area and the early classical Lengyel culture emerged on the same territory (Lengyel IA). From there it spread through Austria and Moravia towards the north and west. During this early phase, it spread from western Hungary to eastern Austria. During the IB phase, the Lengyel culture moved

[2] 6652-6494 cal BP (Beta-494071).

[3] 6573-6445 cal BP (Beta 548562).

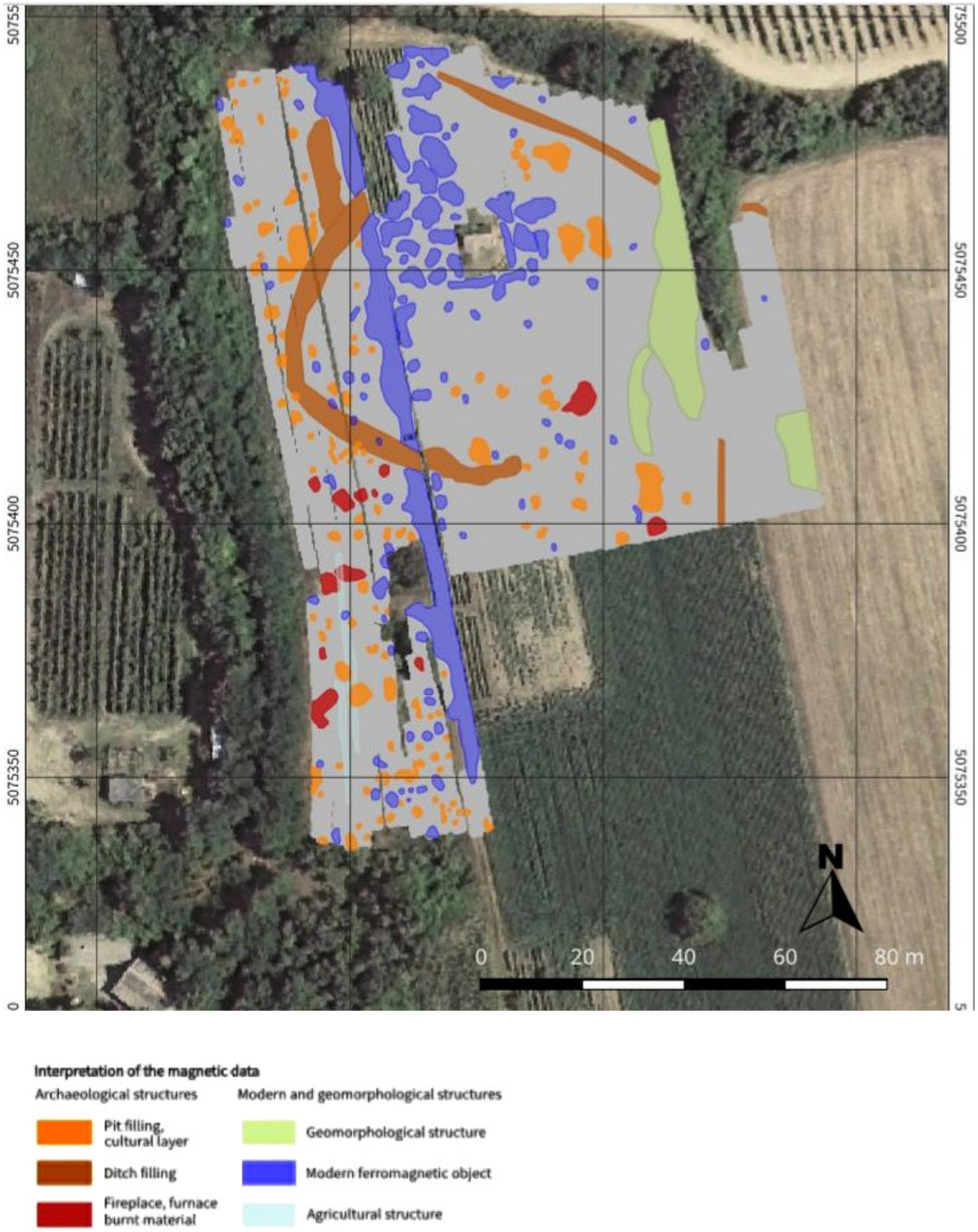

Figure 2. Magnetic measurements and archaeological interpretation (made by: Eastern Atlas GmbH & Co. KG); Figure 2_2 Interpretation of the data

further to southern Moravia into the vicinity of Brno. In the Lengyel II stage, it appeared in Central Moravia and Upper Silesia. During the Lengyel III stage, it reached Little Poland replacing there the Malice culture. The Lengyel culture reached its maximum spread within the Epilengyel/ Lengyel IV stage with autonomous regional groups (Pavúk 2007: 11). During the classical phase, the Lengyel culture was also present in the area north of the Drava River in Baranja, eastern Croatia (Los 2020; Rajković et al. *in press*).

Materials and Methods

The systematic archaeological excavations at the location of Szuzai Hegy were carried out in two phases, the first one (carried out in 2018 and 2019) included a magnetic field survey while the second phase included the actual field excavations (started in 2018, on-going) (Fig. 2). During the excavation different archaeological structures were recovered: post holes (parts of habitation units), rubbish pits, and four graves (burials) (Graves 1, 2, 4 and 5)[4] (Fig. 3). It should be noted that the burials

[4] Grave 3 was labelled on the basis of the outline of the pit. However, during the excavation of the feature it was concluded that there is no actual grave, only the pit, without any finds.

Figure 3. The position of graves 1, 2, 4, 5. (Made by: M. Mađerić)

occurred at a very shallow depth, just below the surface; they were without visible grave-pits, and were recovered only because of careful search. The graves were not visible at all because the colour of their fill was exactly the same as the topsoil, and only skeletal remains and grave-goods indicated the position of graves 1, 2 and 4. The deceased were laid in a contracted position on their left side (graves 1 and 2), and skeleton of the grave 5 was laid on the right side. The form of grave 1 was oval-shaped pit, and in other cases, the shape of pit was not detectable. The overall level of furnishing of the burials is also highly variable: graves 1 and 2 include pots (2-4) and bone/stone tools while graves 4 and 5 do not contain any grave-goods.

The skeletal remains were analysed at the Centre for Applied Bioanthropology of the Institute for Anthropological Research in Zagreb, Croatia. The sex (where possible) and the age-at-death of the analysed individuals were established using methods described by Buikstra and Ubelaker (1994), and Klales (2020). The stature estimation was calculated for an adult individual by using formulae proposed by Trotter (1970). All individuals were analysed for the possible presence of various pathological changes usually seen in archaeological samples. All observed conditions were documented according to criteria described by Ortner (2003), and Aufderheide and Rodríguez-Martín (1998). The samples from all four individuals were taken for ancient DNA as well as carbon and nitrogen stable isotope analysis.

Results

Grave 1 (Figs 4, 5) was recovered during the 2020 excavation campaign. It was discovered to the east of the posts of the above-ground structure, only 30 cm below the present-day surface, on the border between the humus layer and layer of the Unit 45.[5] The burial pit contained the skeletal remains of one individual placed in the contracted position, on its left side, oriented to the east-west, facing south. The arms were flexed at elbows, placed along the torso, hands were next to the head, while the legs were bent at the knees. Within the grave, four items were discovered: one ceramic vessel placed near the head (PN 108) (Fig. 6), one vessel below the skull (PN 112), one vessel near the legs (PN 109), and decorative elements on the cranium (PN 105) (Figs 14,

[5] Unit 45 is described as a archaeological layer under the humus, which consists a brownish soil with archaeological structures and material.

Figure 4. Grave 1. (Photo by: D. Rajković).

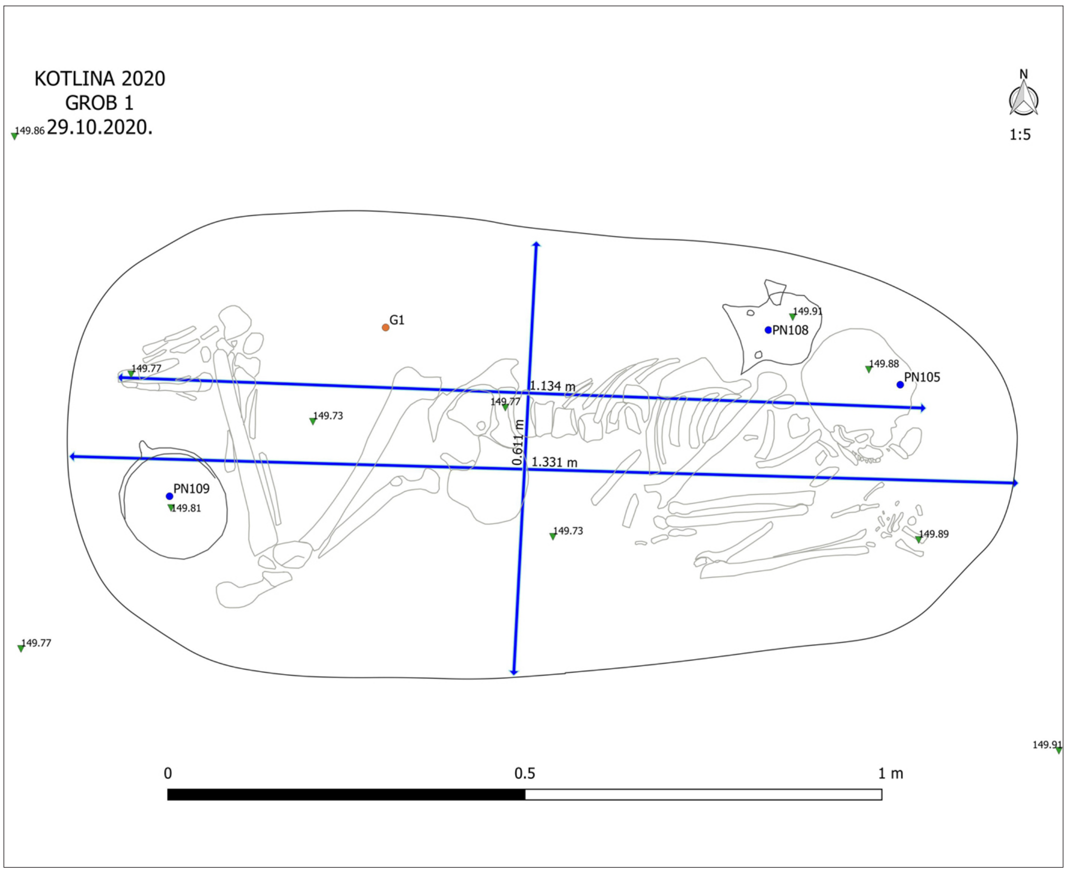

Figure 5. Grave 1. (Made by: M. Mađerić).

Figure 6. Grave 1. (detail of grave pot PN 108). (Photo by: D. Rajković).

Figure 7. Grave 2 (Photo by: D. Rajković).

15). Additionally, one bead made from *Spondylus* shell was discovered later, within the skull (PN 127). We may assume this bead was part of a large ornament, but due to taphonomic reasons (in particular soil erosion, since the grave was discovered close to the present-day surface layer) only this one bead was recovered. Grave 1 contained the remains of a young female (17-22 years of age). Based on the maximum length of the right humerus (280 mm) the stature of this individual was about 156.7 cm. Linear enamel hypoplasia was observed on all present anterior teeth.

Figure 8. Grave 2. (Photo by: D. Rajković).

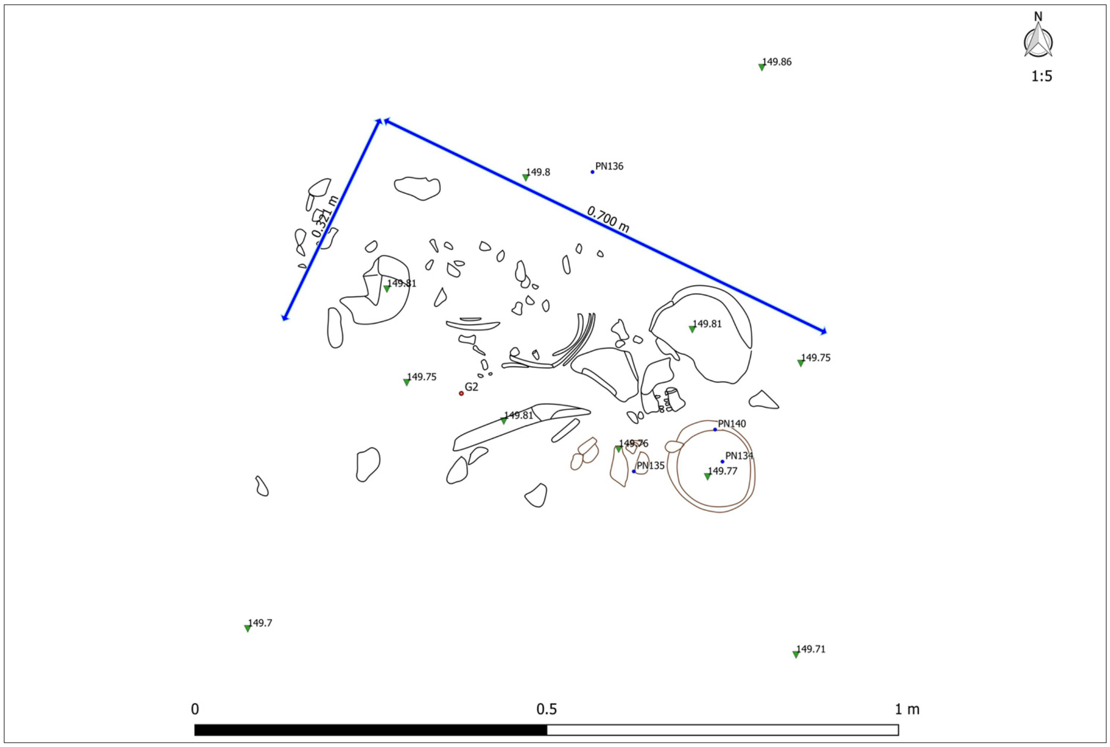

Figure 9. Grave 2. (Made by: M. Mađerić).

Grave 2 (Figs 7, 8, 9) was discovered in the southern part of trench 2. The cranium is well-preserved and laid on the left side, facing south. The arms were flexed at the elbows, and the hands were placed next to the face. Of the other bones, the ribs and pelvis have been preserved, the hand bones are quite damaged and fragmented while the legs are completely missing. Next to the head, there were two ceramic vessels (PN 134, 135), very damaged, and a trace of pottery in the ground (PN 136). A greenish stone adze (PN 140) was subsequently spotted below the vessel (PN 135), in front of the face (Figs 8, 16). During the anthropological analysis an ani-

Figure 10. Grave 4.
(Photo by: D. Rajković).

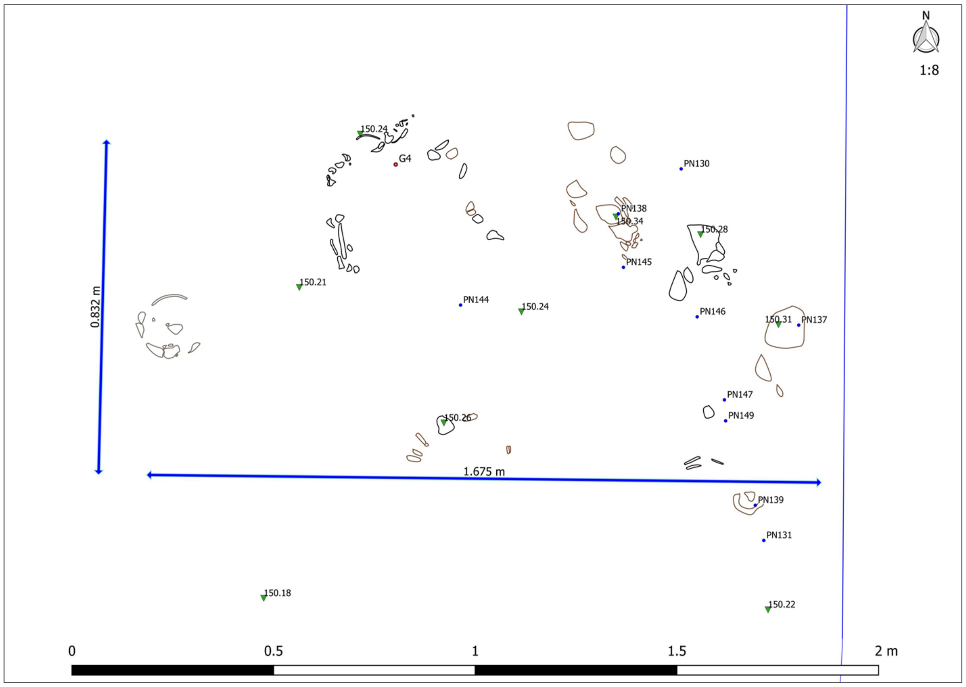

Figure 11. Grave 4.
(Made by: M. Mađerić).

mal bone (perforated rib) was found (PN 217) (Fig. 16). Due to the damage, it is difficult to determine the typological affiliation. Grave 2 contained the remains of an adolescent (11-13 years of age) whose sex could not be estimated with certainty. Linear enamel hypoplasia was observed on all present anterior teeth.[6] Microdontia is present on the right maxillary I2.[7]

[6] Linear enamel hypoplasia occurs in a form of transversal lines on the surface of tooth crowns. Such deformities are defects in dental development (White and Folkens 2005) and as such are good indicators of subadult stress (long-term metabolic stress, and/or a stressful event that caused it) (Aufderheide and Rodriguez-Martin 1998).

[7] The common definition of microdontia is when teeth are smaller than normal. This condition is associated with a number of congenital morbid conditions, including heart disease, Down's syndrome, and cleft palate. Often the shape in microdontia will be abnormal as well (Ortner 2003).

Figure 12. Grave 5.
(Photo by: D. Rajković).

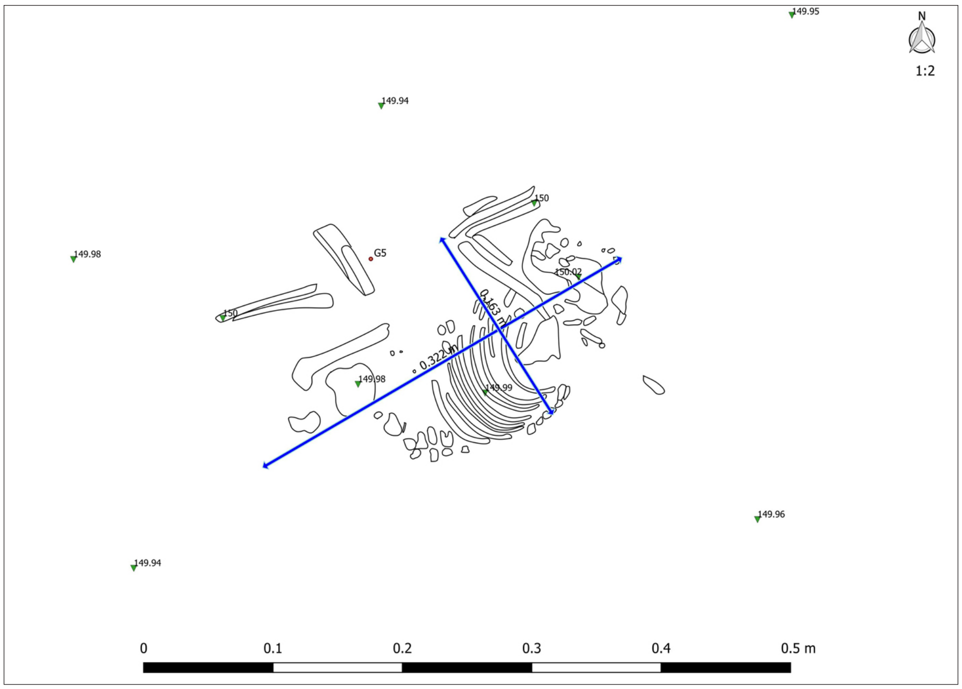

Figure 13. Grave 5.
(Made by: M. Mađerić).

Grave 4 (Figs 10, 11) contained dislocated bones of a very young individual, and only the bones of the skull, ribs and legs were collected. Additionally, the burial of this individual was placed into the fill of a pit (SU 164/165) and contains debris from the settlement (pottery fragments). Grave 4 contained the remains of a small child (2-3 years of age).

Grave 5 (Figs 12, 13) contained a partially preserved skeleton of a small child, laid on the right side, and oriented northeast-southwest. The hands were placed next to the skull, and the legs were bent at the knees. The skull is very badly preserved, probably laid on the right side. The grave did not contain any archaeological finds. Grave 5 contained the remains of an infant (6-9 months of age).

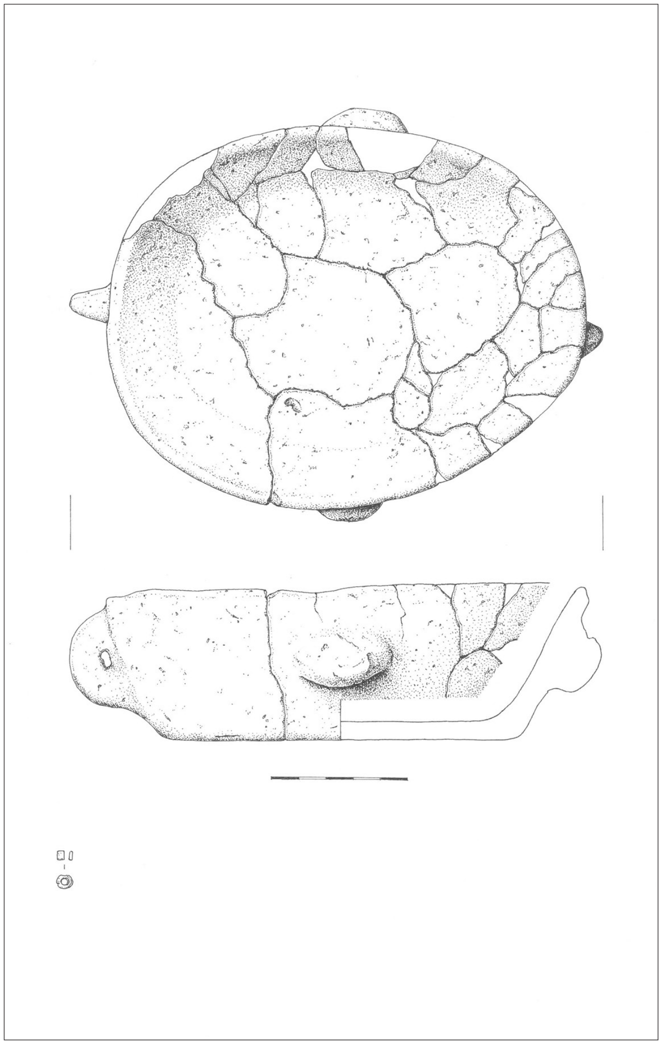

Figure 14. Grave 1 - Illustration of the grave-goods - bowl (PN 109) and *Spondylus* bead (PN 127). (Drawing by: M. Marijanović).

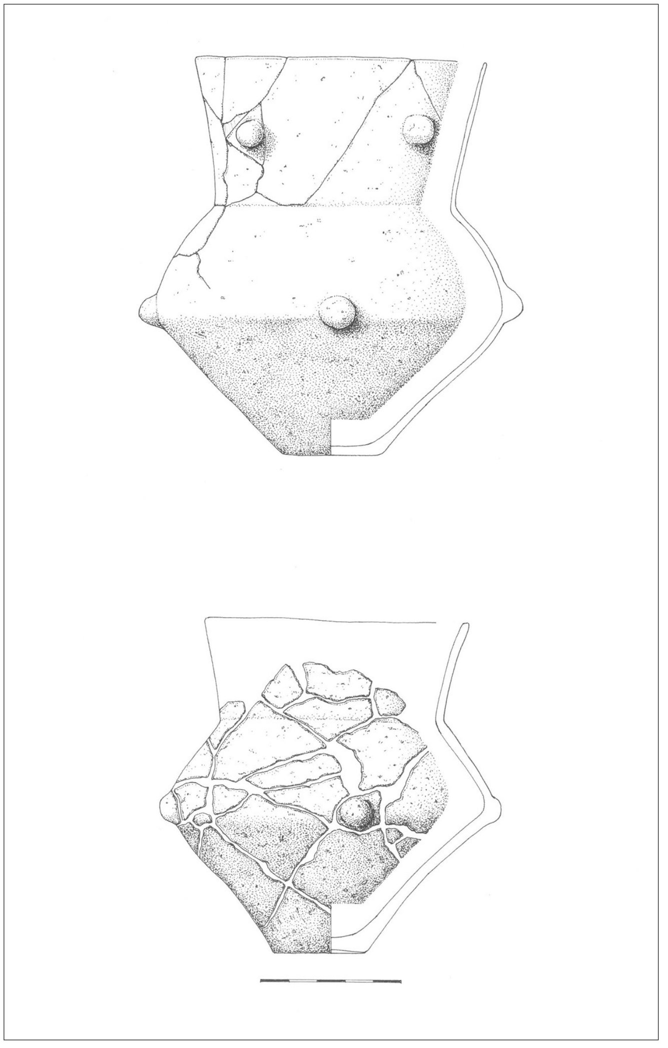

Figure 15. Grave 1 - Illustration of grave-goods (vessel PN 108 and vessel 112). (Drawing by: M. Marijanović).

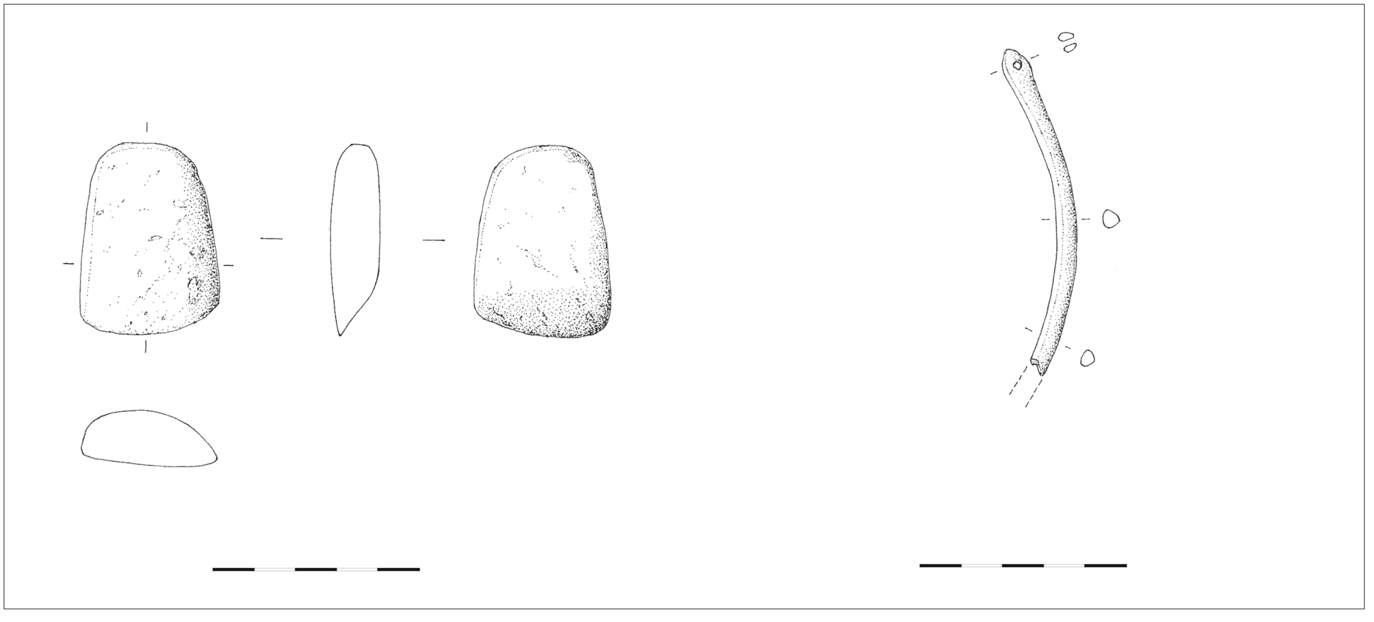

Figure 16. Grave 2 - Illustration of grave-goods - adze (PN 140) and perforated bone (PN 217). (Drawing by: M. Marijanović).

Discussion

According to the position of the recovered graves at the site of Kotlina, it seems that there was no difference between the space for the dead and the space for the living. The graves were positioned individually within the settlement, east of the post holes, The burial of a young adult female (G1) and the burial of an adolescent (G2) contained numerous grave-goods, while the graves of small children (G4 and G5) did not contain any grave-goods. The objects found in the burials are subdivided into two main groups. Some of them are pieces of attire on the cranium (bead made from *Spondylus* shell, decorative elements, perforated rib) and others were placed into the burials as a grave-goods (working tools, ceramic findings). The pottery types are fairly varied in shape and size and do not differ markedly from the ceramic material of other south-eastern Transdanubian Lengyel burials (Osztás et al. 2013: 186-187).

In eastern Transdanubia which represents the eastern area of the Lengyel culture, many burials were found, mostly in smaller or larger groupings, within the perimeter or close to the settlement (Regenye et al. 2016: 7). For example, at the site of Alsónyék - Bátaszék graves containing the remains of over 2000 individuals were discovered (Osztás et al. 2012; 2013). Analogies between Kotlina and Alsónyék may be noted in chronology, in terms of the treatment of the body (contracted position, orientation), as well as in the presence and choice of burial equipment. For example, polished stone tools are present and in seem to be a characteristic of grave goods in male burials (Zalai-Gaál et al. 2011: 71). *Spondylus* shell bead found in Grave 1 can be observed as a prestige item. Among the graves of the Lengyel culture in general, pieces of attire and jewellery made of *Spondylus* shell tend to be more common in the burials of women, but may be found in the burials of both genders (Anders and Nagy 2007: 84). The perforated rib from Grave 2 can be observed as a personal ornament. A characteristic feature of the Lengyel culture burials is that they usually contained ceramic vessel that were associated with some kind of a ritual (Regenye et al. 2016: 11). Usually between one and three pots were placed in the graves, and this practice is also seen at the Kotlina site.

It is interesting to note that at the site of Beli Manastir - Popova zemlja (excavated in 2014/2015, located about 15 km from Kotlina), several graves associated with the Lengyel culture community were recovered (among a total of 36 inhumation burials). Similarities are visible in the absolute dates of these two localities and in the grave-goods, where ceramic vessels are placed next to the body (Los 2020: 96, fig. 8.).

When talking about the demography and health of the recovered individuals from Kotlina one can notice that out of the four skeletons, only one belonged to an adult (although very young) and the other three skeletons belonged to subadults (one adolescent and two small children). Obviously, this is not a representative demographic profile for the whole community from Kotlina because the analysed sample is very small and erratic. Nevertheless, such sex and age distribution (however small and subject to errors) might indicate a high subadult mortality and a relatively short life-span that was characteristic for most Neolithic/Eneolithic communities from the region. For example, at the already mentioned Beli Manastir - Popova zemlja site more than one third of all studied individuals were subadults (especially those below five years of age) (Novak et al. 2018) and most of the adults belonged to the youngest adult age group (18-35 years). An almost identical situation was also registered at the catastrophic skeletal assemblage from Potočani (Eneolithic Lasinja culture) representing the victims of a massacre (Janković and Novak 2018; Janković et al. 2021) where half of the individuals were children under the 18 years of age and most of the adults belonged to the youngest age group. Also, the reconstructed height of a young female from G1 of about 157 cm might seem very low by modern standards, but similar heights were recorded for most females from the nearby site of Beli Manastir - Popova zemlja (average height of 156 cm) (Novak et al. 2018; Jovanović et al. 2021). Due to the fact that most of the skeletons from Kotlina were either partially preserved and/or dislocated (in other words, poorly preserved) only two pathological conditions were recorded. Linear enamel hypoplasia is present in all anterior teeth of the young female from Grave 2 suggesting systematic physiological stress during early childhood. Obviously, the individual in question managed to recover from this episode of stress and lived to the young adulthood. Unfortunately, we cannot tell what the cause of death of this individual was and if the causative agent of linear enamel hypoplasia had any (non-direct) relations to her premature death. Otherwise, linear enamel hypoplasia is a frequent occurrence in prehistoric communities. For example, at Beli Manastir three individuals were affected by this condition (Novak et al. 2018; Jovanović et al. 2021), while in Potočani numerous individuals showed signs of enamel hypoplasia in their permanent dentition (Janković and Novak 2018), again suggesting systematic and frequent episodes of physiological stress during childhood. And finally, microdontia of the right maxillary second incisor recorded in a skeleton of an adolescent from G2 represents a unique case in prehistoric assemblages from continental Croatia. So far, at least to our knowledge, such a case has not been reported. Unfortunately, at the moment we cannot tell with certainty what could have caused such a change in the dentition of this individual.

Conclusion

The excavation results at the site Kotlina - Szuzai Hegy show that it is an exceptionally interesting and rich site of the classical phase of Lengyel culture in the region of Baranja. The most significant finds at the site are human remains from four burials placed near the post holes of above ground object.

The demographic profile of the studied individuals is somewhat unusual – a young female and three subadults – suggesting high subadult mortality and a relatively short life-span in this community. Also, linear enamel hypoplasia was registered in one skeleton suggesting systematic physiological stress. The samples from all four skeletons were taken for the purposes of ancient DNA and stable isotope analyses that will tell us more on the ancestry, kinship and diet of these individuals.

The site is located in a region where different cultural elements of the Sopot and Vinča cultures are mixed and represent a very important element in cultural and chronological relations. Recent studies demonstrated that the southern borders of the Lengyel culture need to be pushed further, since several sites were discovered in the Baranja region that display differences in the material culture and burial rites in comparison to those encountered within the Sopot culture.

Acknowledgements

We would like to thank the Ministry of Culture of the Republic of Croatia for the financial support of the excavation.

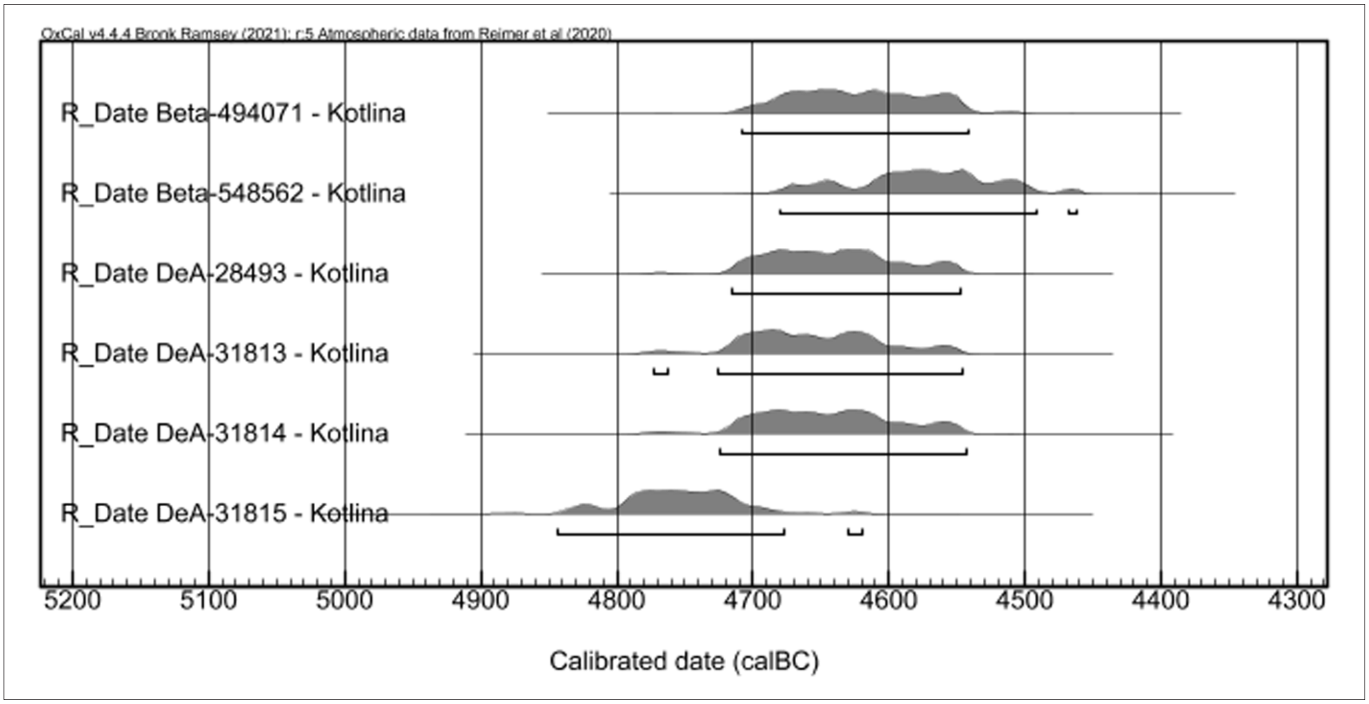

Figure 17. Time range of calibrated radiocarbon dates for the Kotlina- Szuzai Hegy site (program OxCal v.4.4.4).

References

Anders, A. and Nagy, E. G. 2007. Late Neolithic burial rites at the site of Polgár-Csőszhalom-Dűlő, In: J. K. Kozłowski and P. Raczky (eds.), *The Lengyel, Polgár and related cultures in the Middle/ Late Noelithic in Central Europe,* The Polish Academy of Arts and Sciences / Institute of Archaeological Sciences, Eötvös Loránd University, Krakow / Budapest, 83-96.

Aufderheide, A. C. and Rodríguez-Martín, C. 1998. *The Cambridge encyclopedia of human paleopathology*, Cambridge University Press, Cambridge.

Bánffy, E. 1997. *Cult objects of the Neolithic Lengyel culture: connections and interpretations*, Archaeolingua, Budapest.

Bickle, P. 2014. Lenđelska kultura / The Lengyel Culture, In: J. Balen, T. Hršak and R. Šošić Klindžić (eds.), *Darovi zemlje. Neolitik između Save, Drave i Dunava /Gifts of Earth. The Neolithic between the Sava, Drava and Danube*, Archaeological Museum in Zagreb / Museum of Slavonia / Faculty of Humanities and Social Sciences, University of Zagreb, Zagreb / Osijek, 74-87.

Buikstra, J. E. and Ubelaker, D. H. 1994. *Standards for data collection from human skeletal remains*, Arkansas Archaeological Survey, Fayetteville.

Janković, I. and Novak, M. 2018. Bioarchaeology of Copper Age populations in continental Croatia, In: J. Balen, I. Miloglav and D. Rajković (eds.), *Back to the past. Copper Age in northern Croatia*, Archaeological Museum in Zagreb / Faculty of Humanities and Social Sciences, University of Zagreb / Archaeological Museum Osijek, Zagreb / Osijek, 211-223.

Janković, I., Balen, J., Potrebica, H., Ahern, J. C. M. and Novak, M. 2021. Mass violence in Copper Age Europe: The massacre burial site from Potočani, Croatia, *American Journal of Biological Anthropology* 176, 474-485.

Jovanović, J., Blagojević, T., Marković, J., Novak, M., Bedić, Ž., Naumov, G., Stojanova Kanzurova, E., Los, Dž., Hutinec, M., Fidanoski, L., Skelac, G., Šlaus, M. and Stefanović, S. 2021. New radiocarbon dates, stable isotope, and anthropological analysis of prehistoric human bones from the Balkans and Southwestern Carpathian Basin, *Documenta Praehistorica* 48, 224-251.

Klales, A. R. 2020. *Sex estimation of the human skeleton. History, methods, and emerging techniques*, Academic Press, London.

Los, Dž. 2020. Rezultati arheoloških istraživanja lokaliteta AN 2 Beli Manastir - Popova zemlja, *Annales Instituti Archaeologici* XVI/2020, 90-102.

Novak, M., Los, Dž. and Janković, I. 2018. Život i smrt tijekom neolitika na jugu Panonske nizine: preliminarni rezultati bioarheološke i molekularne analize ljudskih ostataka s nalazišta Beli Manastir-Popova zemlja, In: A. Crnobrnja and V. Filipović (eds.), *Srpsko arheološko društvo, XLI Skupština i godišnji skup - program, izveštaji i apstrakti*, Serbian Archaeological Society, Beograd / Pančevo, 85-86.

Ortner, D. J. 2003. *Identification of pathological conditions in human skeletal remains*, Academic Press, London.

Osztás, A., Zalai-Gaál, I. and Bánffy, E. 2012. Alsónyék-Bátaszék: A new chapter in the research of the Lengyel culture, *Documenta Praehistorica* 39, 377-396.

Osztás, A., Zalai-Gaál, I., Bánffy, E., Marton, T., Nyerges, E. A., Köhler, K., Somogyi, K., Gallina, Z., Ramsey, C. B., Dunbar, E., Kromer, B., Bayliss, Hamilton, D., Marshall, P. and Whittle, A. 2013. Coalescent community at the Alsónyék: The timing and duration of Lengyel burials and settlement, *Bericht der Römisch-Germanischen Kommision* 94, 179-361.

Pavúk, J. 2007. Zur frage der Entstehung und Verbreitung der Lengyel-Kultur, In: J. K. Kozłowski and P. Raczky (eds.), *The Lengyel, Polgár and related cultures in the Middle/ Late Neolithic in Central Europe*, The Polish Academy of Arts and Sciences / Institute of Archaeological Sciences, Eötvös Loránd University, Krakow / Budapest, 11-28.

Rajković, D., Vitezović, S. and Hršak, T. *in press.* Prehistoric site of Kotlina in Baranja: Systematic archaeological researches (preliminary report of seasons 2018-2020), In: T. Hršak and M. Dizdar (eds.), *Prehistoric communities along the Danube*, Archaeological Museum Osijek / Institute of Archaeology, Osijek.

Regenye, J., Bánffy, E., Demján, P., Ebert, J., Osztás, A., Bronk Ramsey, C., Dunbar, E., Friedrich, R., Bayliss, A., Beavan, N., Gaydarska, B. and Whittle, A. 2016. Narratives for Lengyel funerary practice, *Bericht der Römisch-Germanischen Kommission*, 97, 5-80.

Trotter, M. L., 1970. Estimation of stature from intact limb bones, In: T. D. Stewart (ed.), *Personal identification in mass disasters*, Smithsonian Institution, National Museum of Natural History, Washington DC, 71-83.

Zalai-Gaál, I., Gál, E., Köhler, K. and Osztás, A. 2011. Das Steingerätedepot aus dem Häuptlingsgrab 3060 der Lengyel-Kultur von Alsónyék, Südtransdanubien, In: H.-J. Beier, R. Einicke and E. Biermann (eds.), *Beiträge zur Ur- und Frühgeschichte Mitteleuropas 63, Varia neolithica VII*, Beier & Beran - Archäologische Fachliteratur, Langenweissbach, 65-83.

White, T. D. and Folkens, P. A. 2005. *The human bone manual*, Academic Press, San Diego.

"If its quacks like a duck" – interpretation of Late Neolithic site Gorjani Kremenjača, Eastern Croatia

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https://doi.org/10.17234/METARH.2022.09

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This paper examines the role of perception and traditional knowledge in archaeology, using the site of Gorjani Kremenjača in Eastern Croatia as an example. It is argued that traditional typologies are deeply rooted in the production of archaeological knowledge, leaving little room for unbiased site evaluation. The focus is on two main elements that are under a strong influence of perception and traditional knowledge: size and shape, age and "cultural" affiliation. Recent research using satellite imagery and cyclical aerial photography has shown that large late Neolithic settlements are much more frequent than previously thought, changing our understanding of average Neolithic settlements. Another focus of the text is the classification of the post-Starčevo period in the area between the Sava and Drava rivers, traditionally referred to as the Sopot culture. The classification is based on the presence of black burnished pottery, biconical shapes and footed vessels at a site, and the division is conveniently placed along the Danube, following the borders of Croatia and Serbia. The authors argue that the division between the Sopot and Vinča cultures is based on convenience and the dominant scientific narrative of the period and region. The text also notes that the origin and demise of the Sopot culture are closely intertwined with Vinča culture and the overall proportion of ornamented pottery is very low, making it difficult to define specific site affiliation. I will argue that the process of creating and transforming archaeological knowledge is slow and static, and the site of Gorjani Kremenjača was attributed to the Sopot culture without much reconsideration. Overall, the paper highlights the importance of reflection and challenging traditional knowledge in archaeology.

Keywords: *Late Neolithic, Sopot, Vinča, settlement layout, pottery ornaments, production of archaeological knowledge, interpretation*

Introduction & background

In archaeology, perception plays a vital role in any segment of research. However, when it comes to a particular site or research question, we researchers often do not take that aspects into account, and the need for reflection becomes a neglected and overlooked factor. That is why we often dwell on old knowledge and interpretation without proper reflection, and rather fit our data within existing frames. In this paper, the site of Gorjani Kremenjača will be used (Fig.1) as an example of the "logical" interpretation based on existing traditional knowledge. We will try to show how traditional typologies are deeply rooted in the production of archaeological knowledge, leaving little space for unbiased site evaluation. The site in question is situated in Eastern

Figure 1. Position of the sites of Gorjani Kremenjača on a satellite image of Croatia and surrounding areas. Satellite image of Croatia in September 2003. Cropped image, original taken from NASA's Visible Earth. Obtained from Wikimedia Commons (Modified by the author).

Croatia, between the rivers of Sava, Drava and Danube. Being part of SE Europe and the Balkans, this area is in particular up to this day very closely related in the local perception as the crucial one in the great division between East and West, which influence stretches to Stone Age as well.

With regards to this site, there are several basic elements that are under the strong influence of perception and traditional knowledge:

- Size and shape
- Age and affiliation

Size and shape

Late Neolithic settlement sites are generally divided between tells and flat settlements. The most important criteria when it comes to defining a site as a tell is a thickness of "cultural layers". Those sites are often observed only as more distinctly elevated areas, while other surrounding areas, if containing any archaeological finds, are explained as a "periphery", or can even be overlooked. If a site extends over an area considered "average" for sites of the respective period (10 ha, or even 5ha), it is often declared as a "special site" and consequently falls into the category above "normal" settlements and becomes a subject of global debate regarding the organization of life in the Neolithic (for example Hodder 2006; Tripković 2014; Bernardini and Schachner 2018).

In the Croatian publications, ditches and palisades are associated with tells, while other sites are described as flat and open (Balen and Čataj 2014: 65). At the local level, tells are dated to the middle phase of the Sopot culture (Balen and Čataj 2014: 65 and references). The size of a Sopot tell is between 80 and 150 m in diameter in general, with a thickness between 2-4 m, and sometimes up to 15 m (Balen and Čataj 2014: 65). Not much attention is paid to areas around tells, and finds in the vicinity can be attributed to "other sites".

The work by H. Kalafatić and B. Šiljeg (Šiljeg and Kalafatić 2015; 2016; 2017; Kalafatić and Šiljeg 2016; 2018) using satellite imagery and cyclical aerial photography showed without a doubt that large late Neolithic settlements are much more frequent than traditional archaeological knowledge is ready to accept, and is changing our knowledge about the Late Neolithic settlements. Most of the sites consist of several enclosure and ditch systems. Already around 50 large enclosed sites of the Sopot culture have been published in the area between Sava and Drava (Kalafatić and Šiljeg 2016; 2018; Šiljeg and Kalafatić 2015; 2016; 2017; Šošić Klindžić et al. 2019). New sites have been confirmed by field survey and collections of late Neolithic pottery. This research changes the perception of average (late) Neolithic settlements being small and compact.

Gorjani Kremenjača site was not visible from air, but fits into the pattern of large multi-component late Neolithic settlements' layout provided by Kalafatić and Šiljeg based on the results of magnetic survey and excavations (Šošić Klindžić et al. 2019; Kalafatić et al. 2020).

Age and Affiliation

Traditionally, the post-Starčevo in the area between Sava and Drava is called the Sopot culture (Dimitrijević 1968; 1979: Balen and Čataj 2014 etc.). If black burnished pottery, biconical shapes and footed vessels are found at a site, it is attributed to the Sopot culture. Only a few sites in a narrow and localized stretch along the Danube between Vukovar and Bapska and possibly Baranja have been recognized as Vinča sites (Botić 2020b; Burić 2014). V. Milojčić distinguished Sopot as a separate entity in 1949, naming it the "Slavonian-Syrmian culture", which was later confirmed by S. Dimitrijević, subsequently renaming it the Sopot culture (Dimitrijević 1968; 1979). The division was conveniently placed along the Danube and followed the borders of Croatia and Serbia, that at that time were both parts of the Socialist Federation Republic of Yugoslavia. Even in the synthesis of Yugoslavian prehistory, the Croatian-Serbian border is declared as the dividing line between the Sopot and Vinča cultures (Dimitrijević 1979: 266) It seems very convenient that the two late Neolithic cultures were divided exactly by the lines (federation borders) initially separating the realms of scholars from Croatian and Serbian universities and their respective territories.

The idea of Vinča world stopping somewhere in Srijem is very strongly embedded in the archaeological narrative of the region. The presence of Vinča here is still described as problematic or enigmatic, and more often explained as import (Ervenica, Samatovci) or influence (Sopot) and imitation (Samatovci, Bapska), or coexistence of the two populations (Bršadin) (e.g. Dimitrijević 1979; Botić, 2020a). Parts of Slavonia where Vinča has not been detected are perceived as very far, completely out of the Vinča reach, even though sometimes the distances are less than 100 km. Nevertheless, both origin and demise of the Sopot culture is the subject of relations to Vinča and closely intertwined with it. Another major obstacle in defining specific site affiliation is very low overall proportion of ornamented pottery and big scale of fragmentation. The pottery assemblages from various sites in the region, the most important, if not only factor of site attribution to specific culture were not the subject of comparative analysis to establish key similarities and differences. Each new assemblage was rather assigned to specific culture and sub-type by incorporating it according to eminent publications by esteemed scholars. All of this is the result of scholarly work based on available material and common practices in accordance with a dominant scientific narrative of a period and region. All these divisions of prehistoric assemblages were also very convenient on a larger global scale considering contemporary trends and assumptions about the role of Eastern Croatia in time, space, and relations to neighbouring areas.

The site of Gorjani Kremenjača was also attributed to the Sopot culture in old and recent publications without much reconsideration (Dimitrijević 1968; Minichreiter 1992; Šošić Klindžić et al. 2019). It reflects how the process of creating and transforming archaeological knowledge is rather slow and static. To explain the main characteristic of the Sopot culture I present here quote from its founder, Stojan Dimitrijević:

"The ceramic production of the Sopot culture, deprived of the Vinča imports and fashionable Vinča trends, is in itself an immensely simple and static production category. The Sopot culture, although a member of a group of cultures comprising the Balkan-Anatolian culture complex and consequently a close relative of the Vinča culture, almost completely lacks that Vinča decorative sheen – with the exception of brilliantly polished external surface of its simple pottery vessels. In terms of fine pottery assortment, the culture expresses itself with unvarying biconical designs from its beginning to its end, with only an occasional occurrence of a modest novelty. The decoration is represented in a small percentage range; it is,

however, authentic (deep incising and notching), but it is too simple to be attractive, let alone fascinating – unlike objects from Vinča, Danilo and Butmir cultures. There is no attractive plasticity, nothing which would stimulate the mind of an art historian. Nevertheless, this modest simplicity, the smooth lines of biconical bowls and pots, the fine profile curves of cups on foot speak to the fact that this ceramography is not a result of a lack of imagination, but of a certain will.

In a number of previous texts, it has been stated that the Sopot culture originated from the Starčevo substrate; that it is, summarily speaking, a result of the Vinča-Starčevo cultural symbiosis, but the new culture's basic direction, its spirit comes from Starčevo. The Starčevo culture gave the Sopot successor its sense of simplicity, its adherence to traditional accomplishments. If the Starčevo culture is stripped of painted ornamentation, if it is monochromised, it becomes a very basic ceramographic creation. Its development line moves slowly from the beginning to the end. One should constantly be aware that towards the end the Starčevo culture almost completely lost the category of painted pottery – it fell from ca. 20 % to 2,36 % and 1 % (Vinkovci-Tržnica, Gornja Tuzla VI-a); therefore, it was monochromised. During that time, when painted ceramics lost its meaning, when it became fully outdated, the Sopot culture arose from the Starčevo substrate.

Hence, the Starčevo culture, from which the Sopot culture emerged, was no longer exclusively traditional Starčevo manifestation, because it too experienced the impacts and tremors brought by Vinča population, not only in socio-political but also cultural sense. The Vinča culture was an unusually vital and penetrative cultural factor, as all new cultures are – new under local conditions, naturally. The vitality of Vinča population is already attested by the act of the great migration itself: only the vigorous and powerful organisms, when absolutely threatened in a physical sense (i.e. biologically and culturally), venture into the unknown, in order to preserve their cultural and ethnical integrity at all costs. Less vital populations remain where they are and surrender to destiny. The Starčevo population was only partially affected by the Vinča migration, and outside of Šumadija it could continue to exist on its own terms. But the presence of something new and powerful has an enchanting effect and this conservative Starčevo population nevertheless adopts some innovations – what we can observe today from the preserved legacy are only the fine pottery biconisation and the decline of painted decoration. But even that is sufficient. The transformed Starčevo ceramography in itself represents an introduction into the Sopot culture – it possesses an indisputably proto-Sopot spirit, because the Sopot culture would take over all those Starčevo biconical forms. However, it should not be forgotten that such biconical modelling is a result of the Vinča pressure. Following the chronological sequence of events, the spiraloid B horizon of the transformed Starčevo culture should be determined as consequential to the initial Vinča thrust. This form of Starčevo culture, regardless of the vast area on which it existed, was nonetheless doomed to extinction. It was biologically worn out and did not possess enough power to resist the impending changes. The recurrent Vinča pressure which followed at the transition from phase A-2 to phase B-1, i.e. the enormous Vinča expansion commencing at that time and aimed in every possible direction, with starting point in Vinča's primary territorial core, reached Srijem as well. But the Vinča invasion was halted approximately at the line Ilok – Sremska Rača, though its presence in the interfluve had a much stronger impact than the plain physical manifestation. This second Vinča thrust, experienced by the Starčevo individuality in the interfluve, did not leave any possibility for further continuation of the Starčevo culture – besides, it could not preserve its cultural physiognomy anywhere. The result of the second Vinča impact was the creation of the Sopot culture. To what extent it was merely a cultural pressure and whether it was possibly even a population diffusion is difficult to determine specifically, though it was more probably only a cultural pressure because it is reasonable to assume that even a small population invasion would have integrated this part of the interfluve into the Vinča cultural sphere. The Sopot culture is, therefore, the result of the cultural symbiosis of the late Starčevo and early Vinča cultures."

This poetical description of the birth of the Sopot culture under the strike of force by the dominant and imaginative Vinča population became deeply rooted in the archaeological narrative as a strong foundation for the perception and interpretation of every single find and site ever since. It also bears the reflection of the "clash of the civilization concept", of conquer, of dominant population overwriting and subduing new territories and their inhabitants.

It is clear that the Sopot culture is defined by a *lack of* rather than presence and acknowledgement of simplicity. Little is known about the immediate post-Starčevo period in the area between Drava and Danube. According to some researchers, the post-Starčevo period in the area between Sava and Drava is characterized by the local manifestation Ražište, which predates the Sopot culture and is a "result of Starčevo-LBK-Vinča meeting point in the Drava river valley" (Botić 2020b).

So, the Vinča and Sopot cultures were (and are) declared as separate, clearly divided entities, and as such lived comfortably for several decades. Obvious finds of significant Vinča types are regarded as imports or imitations of the style. It was acknowledged, however, that the Vinča penetrated into the Sopot territory for a brief period of time during its later and final phases (Dimitrijević 1979; Burić 2014).

On the other hand, the absence of some Vinča types and slightly different typology at some sites argues for the division of Sopot and Vinča or seeing Sopot as some local cultural variant on the northwest fringes of the Vinča orbit in present day Croatia (Jakucs et al. 2016).

On the recent maps, made according to the available published papers and archaeological material, the western "borders" of the Vinča culture appear as the open jaws of a dragon around the territory between Drava and Sava (e.g. Whittle et al 2016, maps). Of course, it is only the result of current publications and the consequences of tradition and long-term divisions in scholarly practices. The disintegration of Yugoslavia and the subsequent wars only strengthened this division of cultures for two reasons – for a while it was impossible to compare material, and politically it was also suitable for each side and each Republic's most important researchers to have "their own culture" which expands to the territory of another republic only marginally.

The most western site of the Vinča culture is the site of Kalošević in Tešanj, known as an (earlier) Vinča site from the 1960s. But as Bosnia has always been regarded as a land of the mixture, not much attention was paid to that site. It is also conveniently located next to a big river, so its position is logical. In the last several years, research in Hungary revealed remains of the early phases of Vinča on several sites, moving the Vinča boundary to the north and the west even in its earliest phases (Jakucs and Voicsek 2015; Jakucs et al. 2016).

Aside from the borders, a part of the local identity is also the belief that this is the area where the west and the east are divided, which makes a perfect scenery for the clash of the West and the East in prehistory as well (LBK and Vinča "realms"). The idea of strict boundaries in this area of European prehistory has been recognized and challenged by the researchers recently, for example (Jakucs et al. 2016).

I will argue here that the site of Kremenjača-Gorjani, based on archaeological evidence is no different than typical Vinča sites on its "main territory", dating from earlier phases till the final phases and that we need to search for the answers for different attribution elsewhere. Our arguments are based on radiocarbon dates, pottery and geomagnetic survey.

Archaeological data on the Gorjani Kremenjača site

Site Layout

The site is located on a slope that extends two kilometers to the east from the village of Gorjani, at the altitude of 108 to 115 meters above sea level. The topographic name of the site, Kremenjača, in lowland areas with Quaternary deposits mainly refers to an archaeological site, due to surface findings of lithic artefacts (Croatian *kremen – flint*). The surface is abundant with lithics, pottery and daub fragments.

Magnetic survey

The magnetic survey was conducted in 2018 and 2019 by the Eastern Atlas company. During 2018 Eastern Atlas surveyed an area of 6.3 ha with seven Förster fluxgate gradiometer sensors. During 2019, the survey continued recoding an area of 9 h with 10 Förster fluxgate gradiometer sensors. The probes were mounted on a light and foldable cart. This gradiometer array is a component of the convertible LEA MAX system. The Förster FEREX CON650 fluxgate gradiometer probes register the gradient of the vertical component of the Earth's magnetic field with an accuracy of 0.1 nT (Nanotesla). The measured gradient (the difference between two vertically arranged sensors in the gradiometer probe) is insensitive to the typically large fluctuations of the Earth's magnetic field and is determined only by the magnetization of local subsurface objects (Meyer and Hypiak 2018; Meyer and Zöllner 2019).

The results of the geomagnetic survey showed that the Neolithic settlement had a centripetal layout (Fig. 2). All enclosures extend radially from each other suggesting the simultaneity of most of the ditches. Outer parts are marked by a triple outer enclosure which is comprised of ditches and palisades. The visible dimensions of the outer enclosure are 430 x approx. 400 m, enclosing an

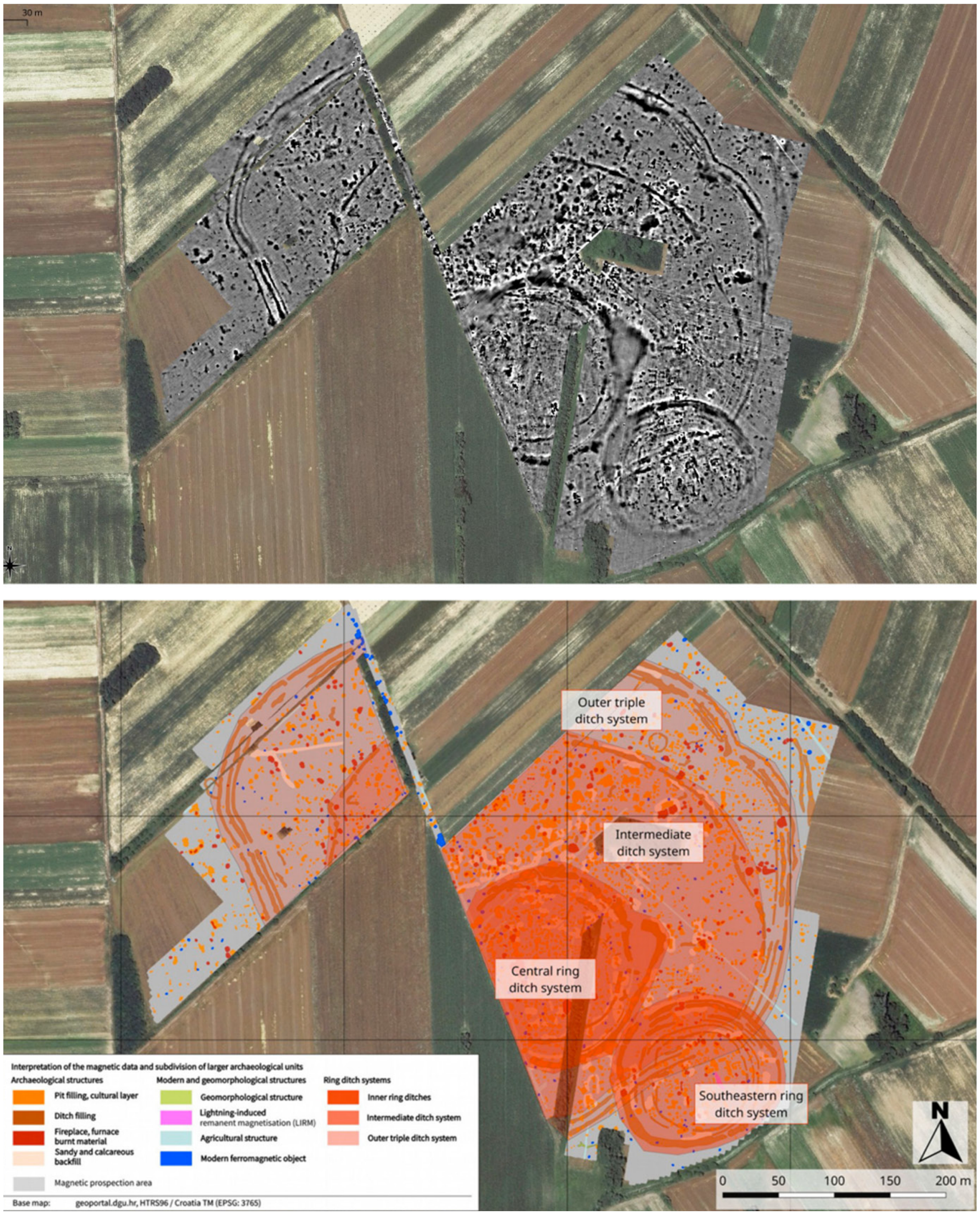

Figure 2. Magnetic survey and the interpretation of Gorjani Kremenjača. (Author: Cornelius Meyer).

area of around 20 ha. The ditch is 7 m wide. Further towards the center is the intermediate ditch system enclosing an area of c. 10 ha. The length of the recorded part of the enclosure is 240 m and the width of the ditch is 4.5 m. In the middle, slightly towards SE is the central ring ditch system on an area of 2.4 ha. The dimensions of the outer ditch are 180 m in diameter and the ditch is 7.3 m wide. The inner ditch diameter is 138 m and the ditch is 3 m wide. Next to it is the southeastern ring ditch system comprised of seven circular ditches. According to the geomagnetic survey results, this circle is probably the youngest as it intersects outer and intermediate ditch systems. In the center of it are recorded remains of lighting strike. The majority of the features is oriented SW-NE. Some of the features are oriented in the opposite direction, but they are adjacent to the remains of lightning-induced remanent magnetization (LIRM), which seems to be the central point of the second circular enclosure, so the initial interpretation would be that the lightning strike occurred during the late Neolithic period. Marking the areas of a lighting strike is recorded during the Neolithic period, see (Bates et al. 2019), and this will be a part of our future research.

Small scale excavation

So far, four small trenches of 5x5 m have been excavated in the area between the central and intermediate ditch systems. All but one contained only Neolithic pottery, and one contained Neolithic and Bronze Age pottery. The pottery published in this paper originates from the area just north of the central ditch system. Radiocarbon dates also originate from this trench, with the exception of samples from the coring of the central ditch itself. The features unearthed during the excavation follow the same orientation as recorded with the geomagnetic survey.

Archaeological feature containing layers of burnt daub, compacted yellow loess and post holes extends over almost the entire excavated surface. The layers of compacted loess, burnt daub and layers of charcoal occur on several levels, suggesting that the structure has been renewed several times. The feature is rectangular in shape, extending in the southwest – northeast direction.

^{14}C dates

So far, 12 samples have been dated from the Gorjani – Kremenjača site by ^{14}C AMS dating method (Table 1). Four samples were dated in BETA laboratory and another eight in Debrecen ATOMKI. Eleven samples are from bones and one is a charcoal sample. Six of the samples were taken from the NE corner of the same trench

lab no	^{14}C date	cal BC	SU	material	Element	species
DeA-26042	6201 ± 51	5310-5000	137	bone	metacarpus	cattle
DeA-26043	6152 ± 34	5210-5000	78	bone	tibia	roe deer
DeA-26050	6100 ± 35	5210-4850	137	bone	tibia	domestic cattle
DeA-26041	6088 ± 34	5210-5170, 5080-4850	76	bone	tibia	cattle
DeA-26049	6085 ± 36	5210-5170, 5080-4840	121	bone	metacarpus	size V - large ungulate size (domestic cattle/ red deer)
DeA-26048	6078 ± 35	5210-5170, 5070-4840	52	bone	long bone fragment	size III - small ungulate size (sheep/goat/ roe deer)
Beta - 515335	6040 +/- 30 BP	5016 - 4844	27	bone	astragalus	cattle
DeA-26051	6029 ± 33	5020-4800	126	bone	long bone fragment	size V - large ungulate size (domestic cattle/ red deer)
DeA-26044	6007 ± 33	5000-4790	78	bone	radius and ulna (fused)	cattle
Beta - 515332	5980 +/- 30 BP	4946 - 4787	central ditch	charcoal		
Beta - 515333	5920 +/- 30 BP	4849 - 4717 (93.8%) (1.6%) 4881 - 4870	38	tooth	upper canine	pig
Beta - 515334	5720 +/- 30 BP	4622 - 4486 (84,5%) 4682 - 4633 (10,9%)	30	tooth	lower molar	cattle

Table 1. ^{14}C dates from Gorjani Kremenjača.

Figure 3. The so-called altar with decorations from the Gorjani Kremenjača. (Photo by: B. Jobst).

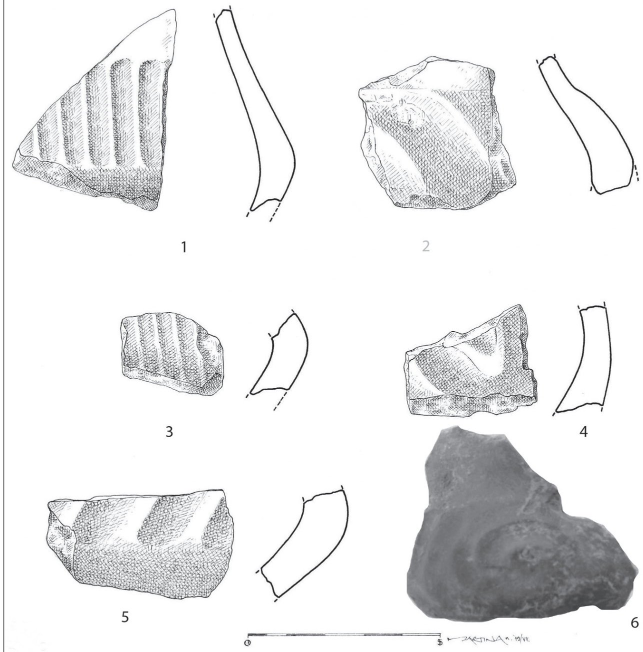

Figure 4. Channelled decorations on pottery fragments. No 6 not to scale. (Made by: M. Rončević).

where concentrations of burnt daub debris were found overlying each other. One date originates from the geological core from the central ditch. Other samples are from layers surrounding the burned debris features.

The nearby Starčevo site of Tomašanci Palača, located less than 1,5 km from Gorjani Kremenjača, is dated 5680 – 5320 BCE (Đukić 2020: 44), almost overlapping with the so far oldest dates at Gorjani Kremenjača.

The youngest date is from a posthole dug into the daub debris, while a sample from upper daub debris (Beta-5153335) is younger than the sample from a thin layer between two burnt daub debris (DeA-26041). The sample from the geological core from the central ditch falls in the range between 4946 – 4787 cal BCE (Beta-515332). Other samples are from layers surrounding the burnt debris feature and cover the period between 5310 – 4486 BCE. Additional samples will be dated and a more detailed analysis of the chronology will be provided, but considering the size of the settlement and the number of features and pottery finds from various phases of the Late Neolithic, I argue that such a long chronological sequence is plausible and probable.

Pottery

The pottery assemblage presented in this paper was excavated from the above described features, but also some were collected as surface finds in the area surrounding the trench. Overall, the entire pottery assemblage is very fragmented. It can be divided into coarse pottery and fine pottery. Fine pottery has black and red burnished/polished surfaces in typical Vinča style. Most numerous vessel types are biconical bowls. The surface is burnished or polished, displaying a glossy effect also typical of the Vinča style (Figs 4, 5, 6). The most common decoration type is channeling (Figs 4, 5, Fig. 6: 8, 9) followed by incised bands with dots. The latter type of decoration is most common of earlier phases of Vinča (Fig. 6: 7, Fig. 7). Remains of white incrustation are present on one fragment (Fig. 6: 7). Detailed pottery analysis is undergoing, while here will be presented most typical and characteristic ornament types. Even though much more information about pottery will be available upon detailed analysis, since almost all of the attribution to the culture and phase of the previously published sites are based on the characteristic pottery ornaments, I would argue that for the initial attribution of the site most typi-

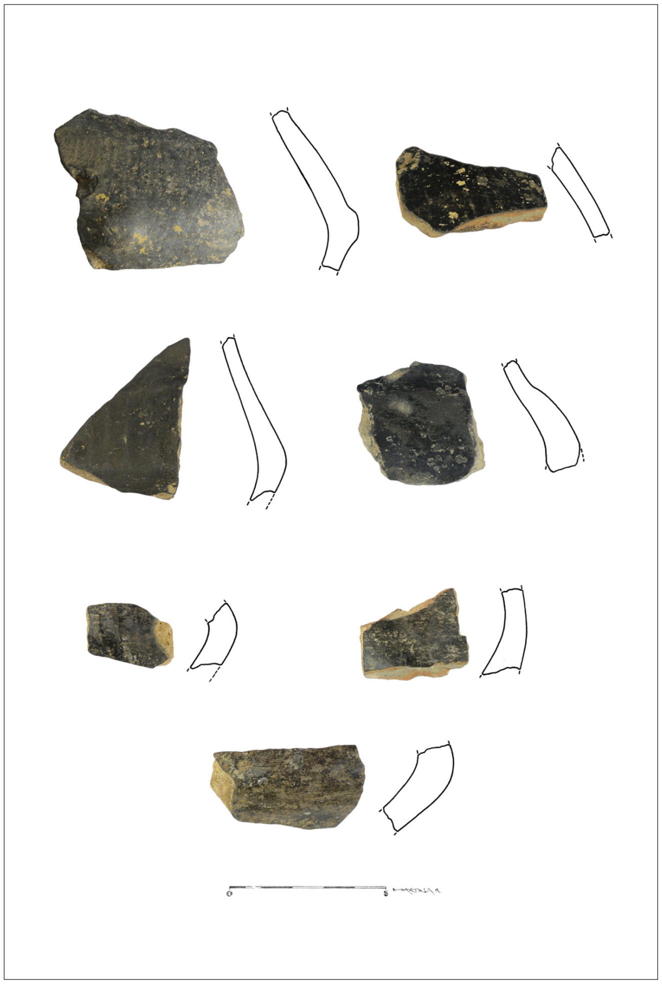

Figure 5. Channelled decorations on pottery fragments.

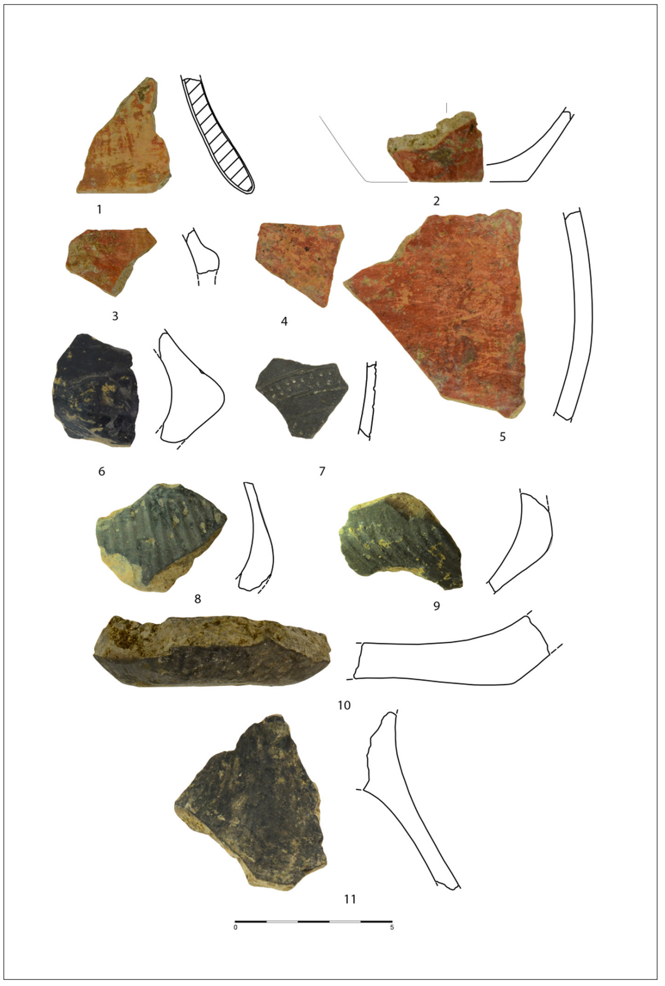

Figure 6. Red (1-5) and black (6, 8-11) burnished/polished surfaces. Fragment with incised bands and dots with remains of white incrustation (7). Channelled decorations (8 and 9).

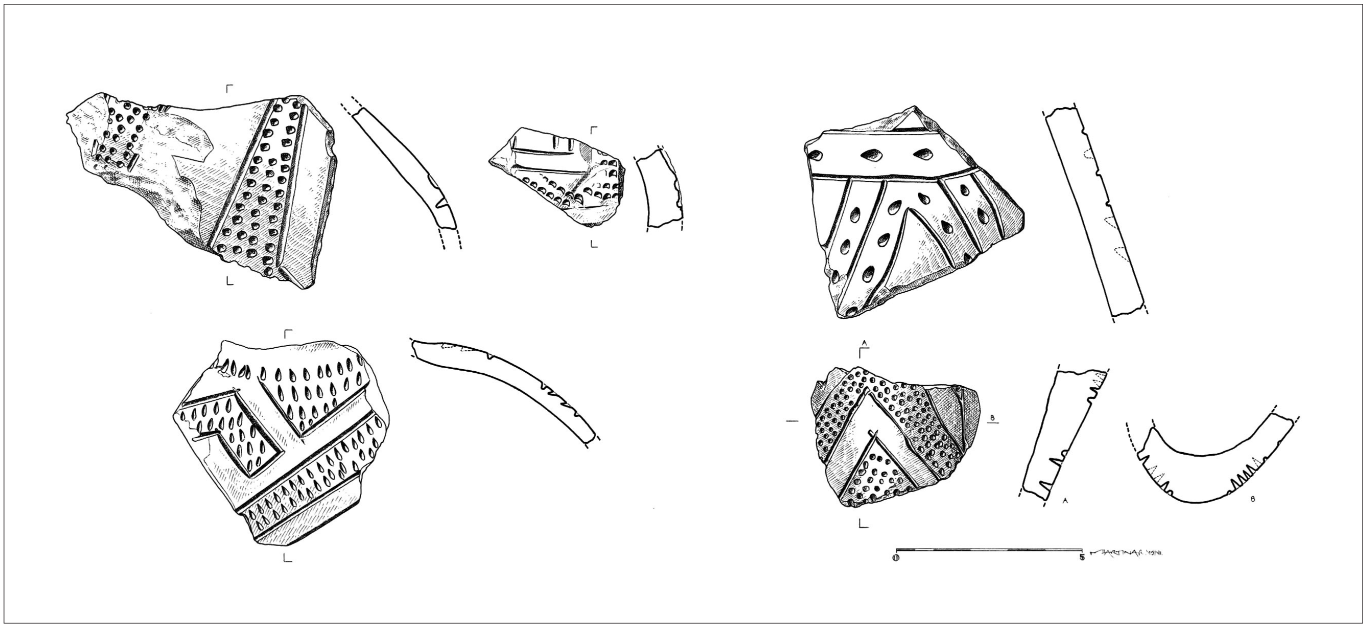

Figure 7. Incised bands with dots on pottery fragments. (Made by: M. Rončević).

cal pottery is still always used and therefore I am using that level of interpretation now. I am aware that this can be regarded as falling into the same trap, but this paper aim is to present the need for a different approach in comparing data from the sites even from the most obvious aspect, that is ornamented pottery. Among other objects made of clay, presented here, is the surface find of the so-called altar (Fig. 3). Geometrically incised, with zoomorphic (and anthropomorphic) protomes it can also be attributed to the earlier phases of Vinča.

Discussion and concluding remarks

I argue here that there is enough archaeological evidence to mark the site of Gorjani Kremenjača as a Vinča site. Black polished pottery, decoration with channelling and incised bands and dots predominate in the pottery assemblage. The type and amount of decorations and types of pottery are typical of the Vinča culture, and despite its absence in the area thus far, they argue in favour of the attribution of the site as belonging to Vinča. In this case we cannot discuss this site as a Sopot site with strong Vinča influence, but rather a Vinča site. Main arguments for this are:

- 14C dates place it among previously dated post-Starčevo sites in the region between Sava and Drava, but also up to the final dates of Late Neolithic.
- The decoration types support a long sequence of Vinča presence at the site.
- Distinctive decorations of earlier phases of the Vinča culture are present – geometric incisions with punched stripes
- Geometrically incised so-called altars with zoomorphic protomas are typical of early Vinča
- Channelling is a dominant decoration technique and appears on various types of pots, channelled ornaments on bowls are present in early Vinča.

Earlier phases are represented by the most typical feature of the earlier Vinča – geometrical incisions with dots and channelled ornaments on bowls (Garašanin and Garašanin 1979).

This type of ornament is common on early Vinča sites, contrary to the suggestion made by Stojan Dimitrijević that it is limited to the later phases of Sopot and associated only with a specific type of vessels and only as an influence, not in the typical Vinča performance. On Gorjani Kremenjača it appears on various types of vessels (Fig. 7).

Channelled spirals on larger pots belong to the later phases of Vinča (Garašanin 1979). Incised bands with dots appear on the larger pots, mainly amphorae. Channelling in the Sopot culture S. Dimitrijević limits only to types of pots on which they do not appear in Vinča, and points that it is very rare in general (Dimitrijević1979: 280). On Gorjani Kremenjača this is not the case.

Geometrically incised *altars* with zoomorphic (and anthropomorphic) protomes can also be attributed to the earlier phases of Vinča (Jakusc et al. 2015: Fig. 21; Borić et al. 2018: 341; Marić 2017).

Furthermore, Gorjani Kremenjača follows the spatial organization pattern observed on the Vinča sites of various sizes (Borić et al. 2018). Multicomponent sites are well known and documented in the area (Hofmann et al. 2019, references therein). Most similar structure is located at the, albeit larger, Vinča site of Drenovac (Perić 2017: 1).

At Gorjani Kremenjača, as well as on the site of Oreškovica-Selište we can observe preconceived pattern for a village-type settlement in the early phases of the Vinča culture (Borić et al. 2018). Circular layout of a settlement and possible enclosures can be observed from the period of Starčevo culture, at sites such as Kneževac, a site of approximately 6ha (Kočić et al. 2020). Similar layout is also reported at the Starčevo site of Svinjarička Čuka, also with incisions with punched stripes on typical Starčevo pottery (Horejs et al. 2018).

Considering the size of the settlement and the thickness of anthropogenic layers, I argue that the longevity of the site is reasonable as a hypothesis, also confirmed by radiocarbon dates. However, pottery finds so far suggest earlier phases, but it is important to keep in mind that all of them originate from the excavation area of just 50 square meters.

In wider perspective, this does not change much, since the western edge of the Vinča is defined by the sites in Bosnia and Hungary (Jakusc et al. 2016) and Gorjani Kremenjača falls in between. In Bosnia, Vinča presence can be documented from the phase B, and in Hungary from its earliest period (A). According to the available 14C dates, Gorjani Kremenjača falls in the time period of phase B, although the pottery finds suggest possibly an even earlier presence.

After several years of research on this site, I feel that the initial interpretation of this site as a Sopot culture site reflects scholarly tradition, boundaries of academic realms and perception in archaeological work rather than conclusions based on a comparison of archaeological evidence.

In the “real” world, distances seem the longest at the borders; that is why in this area several dozen kilometres present unbearable stretches of land between two worlds. As noted in the introduction, this is a consequence of a strong tradition of establishing the territory in question as the area that divides east and west.

Instead of the conclusion, for future work one can only agree with the paper by Jakucs and colleagues from 2016:

“*Rather than explaining the mixture of things, practices and perhaps people at Szederke´ny with reference to problematic notions such as hybridity, we propose instead a more fluid and varied vocabulary, encompassing combination and amalgamation, relationships and performance in the flow of social life, and networks; this makes greater allowance for diversity and interleaving in a context of rapid change*.” (Jakucs et al. 2016).

Placing Gorjani Kremenjača on the Late Neolithic map does not change it significantly, as the western border has already been marked, but rather just closes the dragon’s mouth and opens the discussion regarding the nature and structure of Neolithic assemblages in the area (Fig. 8). I hope, though, that this research will contribute to the discussion on the social interaction and its reflection on material culture during the Neolithic in SE Europe. The important part of the discussion is the awareness of the limits that the reliance on traditional divisions has on the production of archaeological knowledge. Only when we observe through comparative analysis the similarities between the archaeological record we can start to focus on the differences. And by that time, it really will be of much less significance if something is called Sopot or Vinča. As for the present, one could not help but argue that if this assemblage was found on the territory of Serbia it would be without question regarded to Vinča culture.

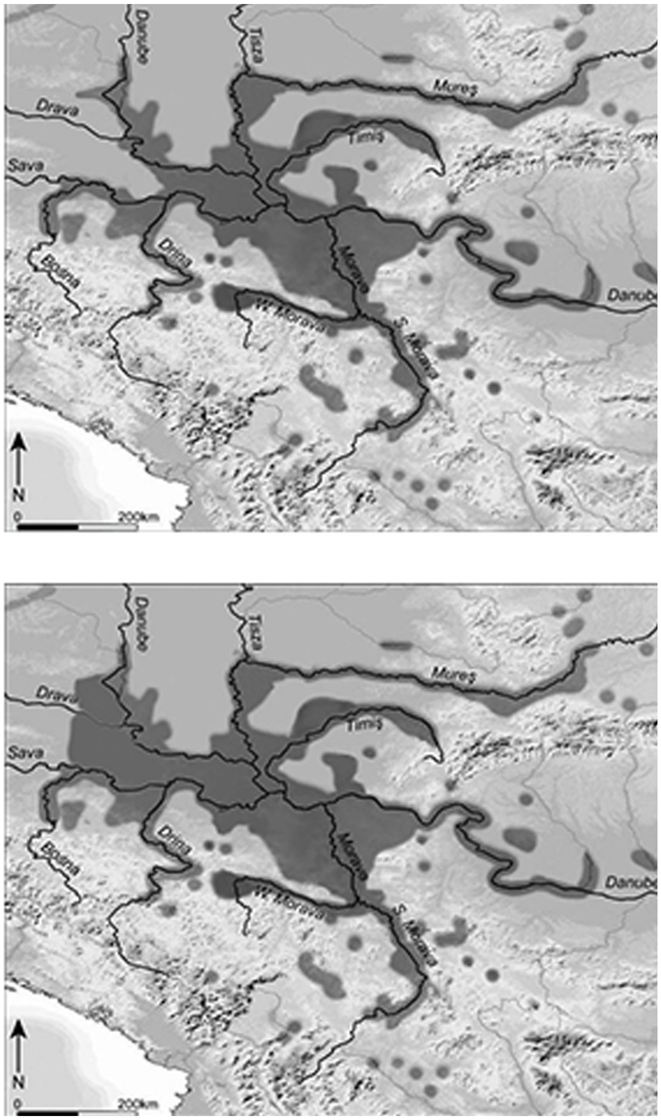

Figure 8. Map of the maximum extent of the occurrence of Vinča ceramics across south-east Europe in Whittle et al 2016, Figure 1. (Modified by the author).

Acknowledgments

Research presented in this paper is supported in part by research project MOPRENS IP-2019-04-5344 financed by Croatian Science Foundation. Drawings and images of pottery are made by Martina Rončević. I would like to express gratitude to; Ivan Lović and county Gorjani for their continuous support without which this research would not be possible; Tomislav Hršak from Archaeological Museum in Osijek for his support and participation in the research; Slobodan Miko and Nikolina Ilijanić from Croatian Geological survey for coring, Hrvoje Kalafatić, Bartul Šiljeg, Goran Tomac, Ina Miloglav, Katarina Gerometta, Giovanni Boschian, Jacqueline Balen, Dragana Rajković and Boban Tripković for participation in the project and to Miroslav Vuković, Marin Mađerić, VeljkoDravec, Antonio Burilo, Goran Saiti and numerous archaeology students and scholars for participating in the fieldwork.

References

Balen, J. and Čataj, L. 2014. Sopotska kultura, In: J. Balen, T. Hršak, and R. Šošić Klindžić (eds.), *Gifts of Earth - The Neolithic between the Sava, Drava and Danube*, Arheološki muzej u Zagrebu, Muzej Slavonije Osijek, Sveučilište u Zagrebu Filozofski fakultet, Zagreb, 59-73.

Bates, C. R., Bates, M., Gaffney, C., Gaffney, V. and Raub, T. D. 2019. Geophysical Investigation of the Neolithic Calanais Landscape, *Remote Sensing* 11 (24), 2975.

Bernardini, W. and Schachner, G. 2018. Comparing Near Eastern Neolithic Megasites and Southwestern Pueblos: Population Size, Exceptionalism, and Historical Trajectories, *Cambridge Archaeological Journal* 28 (4), 647-663. doi:10.1017/S0959774318000276

Borić, D., Hanks, B., Šljivar, D., Kočić, M., Bulatović, Griffiths, S., Doonan, R. and Jacanović, D. 2018. Enclosing the Neolithic World: A Vinča Culture Enclosed and Fortified Settlement in the Balkans, *Current Anthropology* 59 (3), 336-346.

Botić, K. 2020a. Kasnoneolitičko naselje Bršadin – Pašnjak pod selom, kronostratigrafski prikaz tri sezone arheoloških istraživanja, *Annales Instituti Archaeologici* XVI (1), 54-70.

Botić, K. 2020b. Middle Neolithic trasformation: Starčevo–LBK–Vinča meeting point and the emergence of Ražište style in Drava river valley, *Quaternary International* 560-561, 197-207. doi:https://doi.org/10.1016/j.quaint.2020.03.032

Burić, M. 2014. Vinčanska kultura, In: J. Balen, T. Hršak, and R. Šošić Klindžić (eds.), *Gifts of Earth - The Neolithic between the Sava, Drava and Danube*, Arheološki muzej u Zagrebu, Muzej Slavonije Osijek, Sveučilište u Zagrebu Filozofski fakultet, Zagreb, 40-58.

Dimitrijević, S. 1968. *Sopotsko-lenđelska kultura*, Filozofski fakultet Sveučilišta u Zagrebu, Zagreb.

Dimitrijević, S. 1979. Sjeverna zona, In: M. Garašanin (ed.), *Praistorija jugoslavenskih zemalja II -Neolit*, Svjetlost, Sarajevo, 229-363.

Đukić, A. 2020. Starčevo culture settlements, In: J. Balen (ed.), *Tomašanci-Palača - Settlements of the Late Stone, Copper and Bronze Age*, Archaeological Museum in Zagreb, Zagreb, 19-110.

Garašanin, D. and Garašanin, M. 1979. *Supska "Stublina" - praistorijsko naselje vinčanske grupe*, Narodni muzej, Beograd.

Garašanin, M. 1979. Centralnobalkanska zona, In: M. Garašanin (ed.), *Praistorija jugoslavenskih zemalja II -Neolit*, Svjetlost, Sarajevo, 79-213.

Hodder, I. 2006. *The Leopard's Tale: Revealing the Mysteries of Çatalhöyük*, Thames and Hudson, London.

Hofmann, R., Medović, A., Furholt, M., Medović, I., Stanković Pešterac, T., Dreibrodt, S., Martini, S. and Hofmann, A. 2019. Late Neolithic multicomponent sites of the Tisza region and the emergence of centripetal settlement layouts, *Praehistorische Zeitschrift* 94 (2), 1-28. doi:https://doi.org/10.1515/pz-2019-0003

Horejs, B., Bulatović, A., Meyer, C., Milić, B., Schneider, S., Schlöffel, M. and Stevanović, V. 2018. Prehistoric Landscapes of the Pusta Reka Region (Leskovac). New Investigations along the Southern Morava River, *Journal of Serbian Archaeological Society* 34, 23-51.

Jakucs, J. and Voicsek, V. 2015. The northernmost distribution of the early Vinča Culture in the Danube valley: a preliminary study from Szederkény-Kukorica-dűlő (Baranya County, southern Hungary), *Antaeus* 33, 13-54.

Jakucs, J., Bánffy, E., Orros, K., Voicsek, V., Bronk Ramsey, C., Dunbar, E., Kromer, B., Bayliss, A., Hofmann, D., Marshall, P. and Whittle, A. 2016. Between the Vinča and Linearbandkeramik Worlds: The Diversity of Practices and Identities in the 54th–53rd Centuries cal BC in Southwest Hungary and Beyond, *Journal of World Prehistory* 29 (3), 267-336. doi:10.1007/s10963-016-9096-x

Kalafatić, H. and Šiljeg, B. 2016. Everything fears time, but time fears the circles: 7 thousand years old prehistoric enclosures in landscape of the southern Carpathian basin, In: P. Kołodziejczyk, and B. Kwiatkowska-Kopka (eds.), *Cracow Landscape Conference, Landscape as impulsion for culture: research, perception and protection*, Kraków: Institute of Archeology Jagiellonian university in Krakow – Institute of Landscape Architecture Cracow university of technology, Krakow, 111-121.

Kalafatić, H. and Šiljeg, B. 2018. Twin Circles: new insights in the Neolithic settlement pattern, *Prilozi Instituta za arheologiju u Zagrebu* 35, 71-111.

Kalafatić, H., Šošić Klindžić, R. and Šiljeg, B. 2020. Being Enclosed as a Lifestyle: Complex Neolithic Settlements of Eastern Croatia Re-Evaluated through Aerial and Magnetic Survey, *Geosciences* 10, 384, 2-19. doi:https://doi.org/10.3390/geosciences10100384

Kočić, M., Hanks, B., Kaličanin Krstić, M., Brennan, M., Basar, P. and Mlyniec, M. 2020. Identifying Early Neolithic Settlements in the Šumadija Region of Serbia Through Combined Pedestrian Survey and Archaeological Geophysical Prospection, *Interdisciplinaria Archaeologica*, 11 (1), 9-19.

Marić, M. 2017. Encircled in water: Modelling watercourses of the late Neolithic – early Copper Age Vinča culture sites in the Danube region (c. 5300 – 4500 BC), *Quaternary International* 429 (A), 54-63.

Meyer, C. and Hypiak, V. 2018. *Magnetic prospection at the Neolithic site of Kremenjača in Gorjani (Đakovo, Osijek-Baranja County, Croatia)*, Report, Berlin.

Meyer, C. and Zöllner, H. 2019. *Magnetic prospection at the Neolithic site of Kremenjača in Gorjani (Đakovo, Osijek-Baranja County, Croatia), Campaign of 2019*, Report, Berlin.

Minichreiter, K. 1992. *Starčevačka kultura u sjevernoj Hrvatskoj*, Arheološki zavod Filozofskog fakulteta sveučilišta u Zagrebu, Zagreb.

Perić, S. 2017. Drenovac: a Neolithic settlement in the Middle Morava Valley, Serbia, *Antiquity* 91 (357), 1-4.

Šiljeg, B. and Kalafatić, H. 2015. Zračna arheologija u istočnoj slavoniji 2014. godine, *Annales Instituti Archaeologici* 11, 135-141.

Šiljeg, B. and Kalafatić, H. 2016. Zračno rekognosciranje, osječko baranjska županija 2015, godine, *Annales Instituti Archaeologici* 12, 1-2.

Šiljeg, B., and Kalafatić, H. 2017. Zračno rekognosciranje u istočnoj Slavoniji 2016. godine, *Annales Instituti Archaeologici* 13, 168-173.

Šošić Klindžić, R., Kalafatić, H., Šiljeg, B. and Hršak, T. 2019. Circles and ceramics through the centuries: Characteristics of Neolithic Sopot culture settlements, *Prilozi Instituta za arheologiju u Zagrebu* 36, 41-48. doi:https://doi.org/10.33254/piaz.36.2

Tripković, B. 2014. Housing and the organizaton of settlements, In: J. Balen, T. Hršak, and R. Šošić Klindžić (eds.), *Gifts of Earth - The Neolithic between the Sava, Drava and Danube*, Arheološki muzej u Zagrebu, Muzej Slavonije Osijek, Sveučilište u Zagrebu Filozofski fakultet, Zagreb, 129-155.

Whittle, A., Bayliss, A., Barclay, A., Gaydarska, B., Bánffy, E., Borić, D., Vander Linden, M. 2016. A Vinča potscape: formal chronological models for the use and development of Vinča ceramics in south-east Europe, *Documenta* Praehistorica XLIII, 1-60. doi:10.4312/dp.43.1

Micropetrographic analysis as a tool for the determination of limestone sources in Istria – applications and limitations

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https://doi.org/10.17234/METARH.2022.10

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Determining the source of a stone raw material, for example, limestone for building a villa rustica, can be very useful in enlightening the distribution networks of different types of raw material. One of the analyses that can help locate the sources is the micropetrographic analysis. This method, to an extent, allows us to identify the type and geological age of raw material used for an activity. This data can be a starting point in raw material provenance study, using geological maps of the potential area of procurement. However, micropetrographic analysis besides obvious advantages has some shortcomings, and its results are not always enough for answering specific archaeological questions. This paper will showcase the application and limitations of the micropetrographic analysis in determining the archaeological raw material sources.

Keywords: *raw material sources, micropetrographic analysis, limestone, Istria, Antiquity*

Introduction

The Istrian peninsula is characterized by predominantly carbonate surface deposits of Jurassic, Cretaceous and Paleogene age, as well as with terra rossa and alluvium deposits of Quaternary age. Figure 1 shows a lithostratigraphic map of the deposits in Istria. The blue shades represent the limestones and dolomites of Jurassic age, while shades of green represent the Cretaceous limestones and dolomites. The yellow and orange colours represent various rocks of Paleogene age, mainly foraminiferal limestones, and flysch deposits. The youngest deposits are the Quaternary terra rossa and alluvium (Miko et al. 2013).

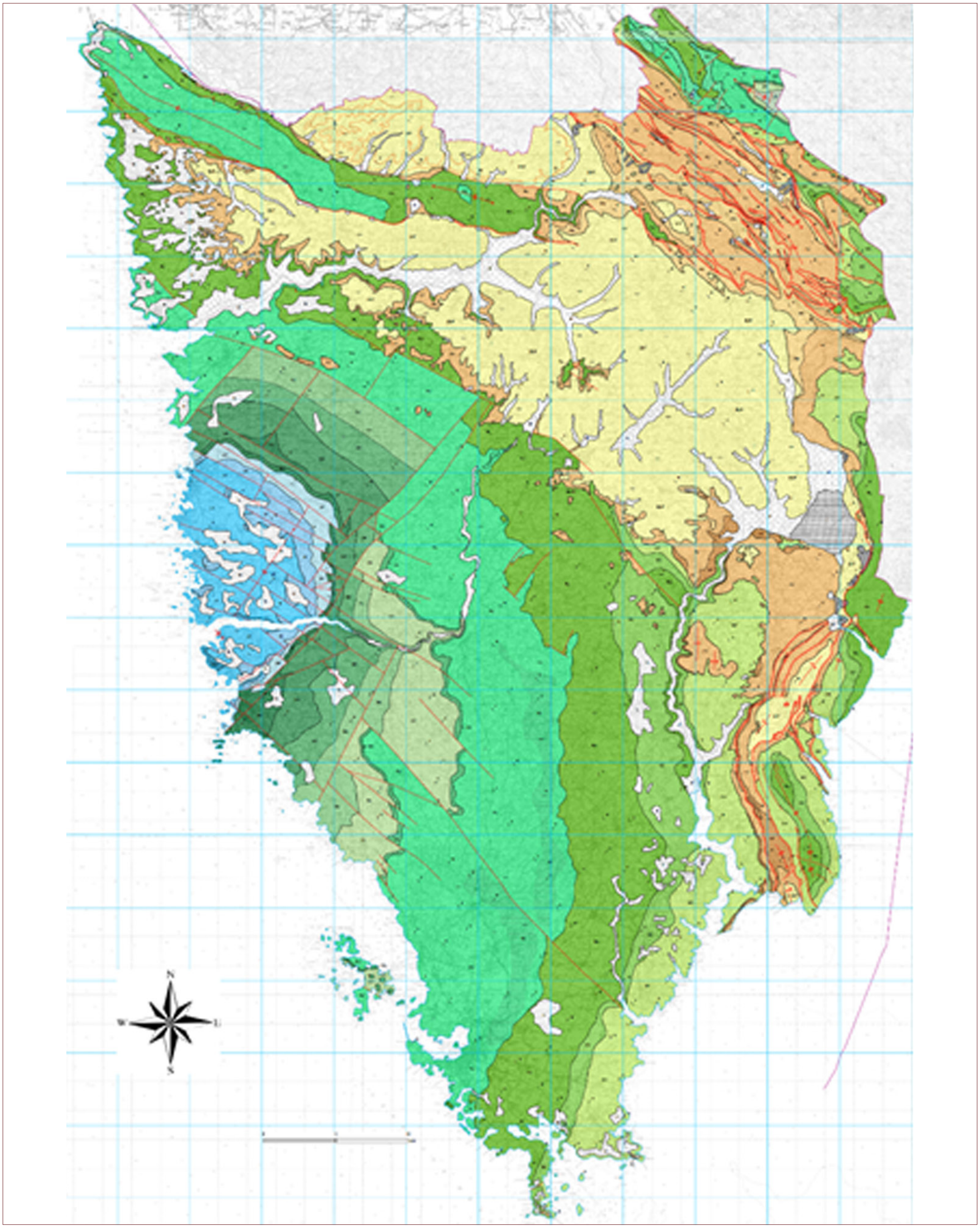

Figure 1. Lithostratigraphic map of the Croatian part of Istria, Istria County. Shades of blue – Jurassic limestones and dolomites, shades of green – Cretaceous limestones and dolomites, shades of orange and yellow – Paleogene foraminiferal limestones and flysch deposits, other - Quaternary (after Miko et al. 2013).

Stone trade in roman Istria

The relatively high-quality limestone has been quarried since Prehistory. Limestone was used for the construction of ramparts and houses in some places as early as the end of the Early Bronze Age (Hänsel et al. 1997), as well as for the construction of stone tombs or monuments (Buršić Matijašić 2008: 20). It is assumed that for the construction of the ramparts of prehistoric forts, stone was extracted from the very tops and slopes of the hills or in the immediate vicinity of the construction of settlements (Buršić Matijašić 2008: 91). However, Istrian limestone was exploited more systematically in Antiquity. We have several Roman quarries mentioned in the bibliography of the last several decades (Šonje 1980; Matijašić 1998), and more have been discovered in the last few years. Some of them were discovered using Airborne Laser Scanning data and targeted field surveys as a part of the ArchaeoCulTour project,[1] while others were discovered using geographical and topographical maps (Šprem 2021). All Roman quarries in the Croatian part of Istria can be seen on Figure 2.

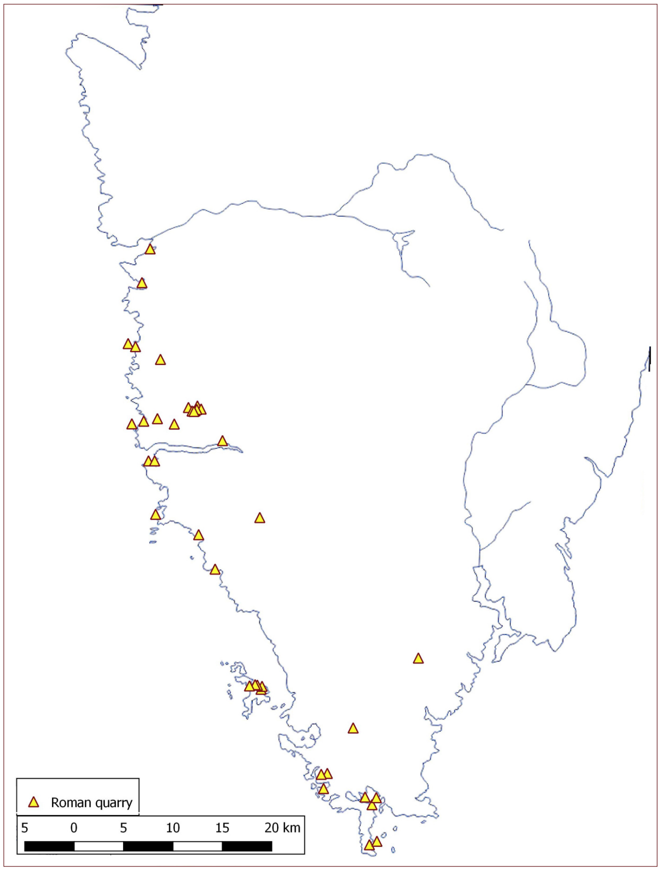

Figure 2. A map of Roman quarries in the Croatian part of the Istrian peninsula. (After Šonje 1980; Matijašić 1998; Šprem 2021; map source www.d-maps.com).

In their time in the Istrian peninsula, the Romans have produced a large number of stone monuments, whether funerary or otherwise in nature, most of them made from local limestone. We have recently sampled several stone monuments from *Pola* and *Parentium* in an attempt to discover the provenance of the stone used for their manufacture using micropetrographic analysis. A prime example of the use of micropetrographic analysis in determining the provenance of stone is that of Crnković (1991). He determined that the stone for the outer curved wall of the Pola Amphitheatre derives from the Cave Romane quarry in Vinkuran near Pola (Crnković 1991). Since the Romans mostly used the stone that was closely available, our hypothesis is that for the manufacture of the *Pola* and *Parentium* monuments, they used stone from the nearest Roman quarry; for *Parentium* that may be the quarries in the broader Vrsar area and for *Pola* the famous Cave Romane quarry in Vinkuran (Fig. 5) or the newly discovered Pješčana Uvala quarry, also in the vicinity of Pula (Fig. 3).

Stone blocks from the aforementioned quarries could have also been transported throughout Istria by land or by sea. The fragment of Diocletian's Price Edict (*Edictum De Pretiis Rerum Venalium*) found in *Aphrodisias* in *Caria*, gives us an approximate price ratio of different modes of transport. Thus, the ratio of the sea to the river downstream to the river upstream to land transport costs of 1: 3,9: 7,7: 42 was extrapolated (Russell 2014: 95) which clearly shows that maritime transport was the cheapest mode of transport. The indented western coast of Istria was connected to the surrounding areas already in prehistoric times by maritime trade, but also by looting and pirating (Gabrovec and Mihovilić 1987: 322-324). Every bay from Medulin in the south to Savudrija in the north could have provided anchorage and shelter for ships and later had an even larger economic impact due to the import and export of various products. On the other hand, the eastern, Liburnian coast of Istria, was steep and inaccessible (Matijašić 1998: 419). The short-distance navigation along the eastern Adriatic coast was especially developed, and this type of navigation almost completely replaced land transport. The main route ran between the larger islands and the mainland so that the vessels were protected from the high seas, and also close enough to a cove to take shelter if needed (Matijašić 2009: 201). In addition to the larger cities, which all had ports, smaller settlements, as well

Figure 3. Pješčana Uvala Roman quarry near Pola. (Photo by: D. Bulić).

as individual villae rusticae or villae maritimae had their own port. Municipii also had ports (Matijašić 2009: 201) and through these ports, local products were exported further (Koncani Uhač 2018: 151). The main economic activity of Roman Istria was the production of olive oil or wine, while other important products were stone, lime, timber, fish products and others (Koncani Uhač 2018: 162-166).

Micropetrographic analysis

Limestones and dolomites, the most common and widespread rocks in Istria, are mainly marine carbonate sedimentary rocks composed exclusively of calcite ($CaCO_3$) and dolomite ($CaMg(CO_3)_2$) minerals or their various mixtures. They commonly contain fossils or microfossils, as well as their fragments or debris, which are also mainly made of carbonate minerals. Along with the macroscopic descriptions in the field, a common method for the description and determination of sedimentary rocks is the micropetrographic analysis. Micropetrographic analysis of limestones aims to identify its composition (skeletal and non-skeletal components of rock, together with the binding material), its fabric (arrangement of all constituents within a rock) and diagenetic changes (processes occurring within the sediment after its deposition). Marine limestones can be then classified after Folk (1959; 1962), or after Dunham (1962) with modifications after Embry and Klovan (1972). For more specific investigation purposes, it can be important to determine facies, a body, or a pocket of sedimentary rock with specific features that distinguish it from other facies. According to specific features observed, the concepts of lithofacies, biofacies or microfacies can be applied for limestones.

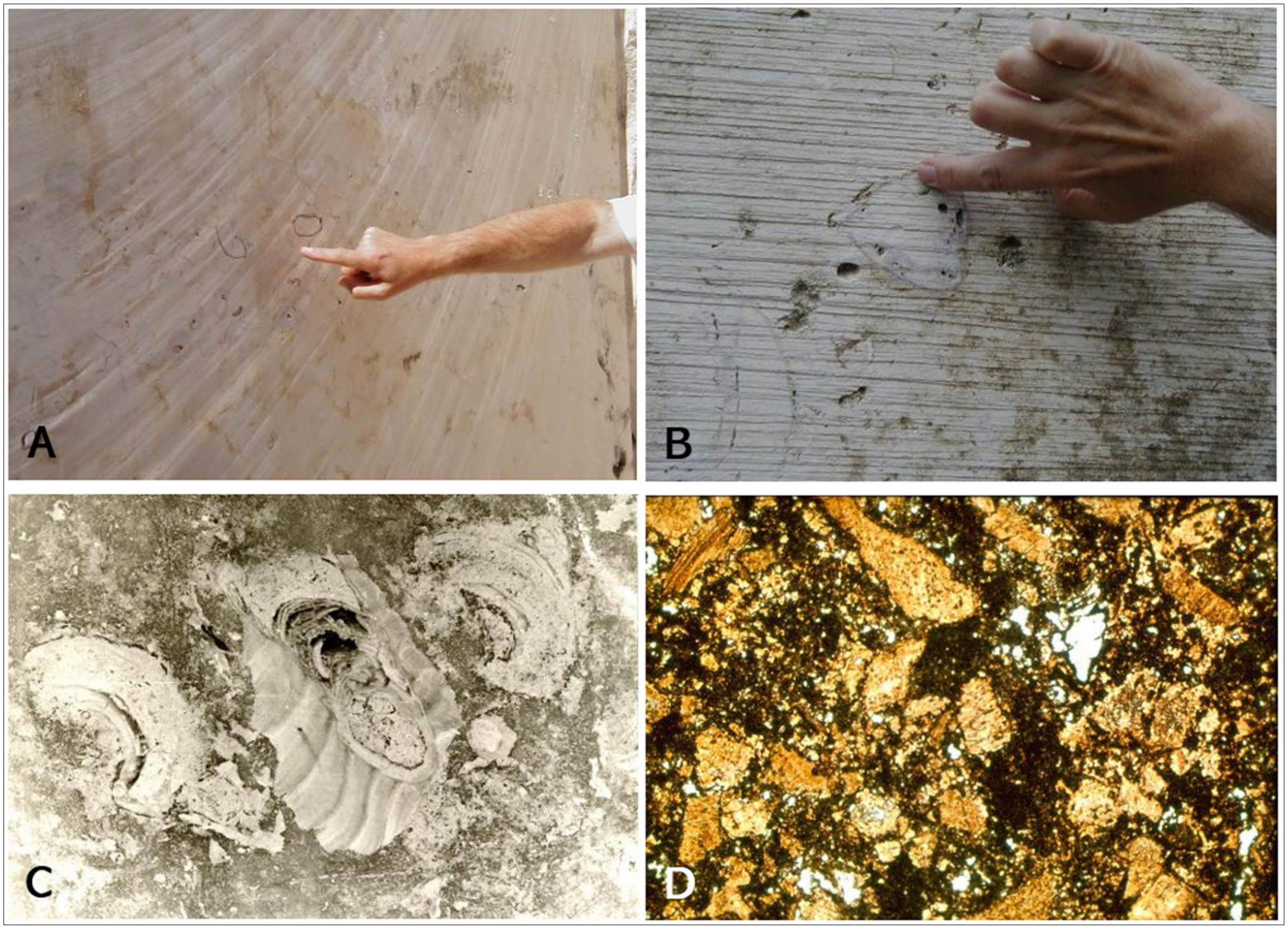

Figure 4. A, B and C showing rudist limestone in the Cave Romane quarry with skeletons of rudist bivalves. C – field of view approximately 10 cm; D – photomicrograph of limestone with rudist debris also from the Cave Romane, Vinkuran (field of view 1,5 mm).

More refined descriptions and concepts of microfacies of carbonate rocks are extensively described in Flügel (2004).

However, application of the results obtained from micropetrographic analysis for some specific (i.e., archaeological or conservation) purposes is not always simple and straightforward, and some precautions should be considered (see examples in Maričić et al. 2020). To unambiguously compare thin sections of rock samples taken from the outcrops or quarries, with the samples of stone taken from the archaeological objects (buildings or monuments), the following facts need to be taken into account and strongly considered:

a) The samples of sedimentary rocks taken from the specific outcrop represent larger area, due to lateral extension of the sedimentary layer along its strike. Sometimes, lateral extension can be even tens to hundreds of kilometres (see on the lithostratigraphic map of Istria – Miko et al. 2013). Therefore, one cannot be undoubtedly positive about the exact position of the outcrop or quarry from which the compared stone material came from.

b) Sedimentary facies change in the vertical succession of sedimentary rocks randomly, or more often, cyclically (ABAB, ABCABC or similar). Samples taken vertically one upon the other at the outcrops or in the quarries reflect these vertical changes in sedimentation within a given timeframe, sometimes even at the centimetre scale (see numerous examples from Istria in Tišljar 2001; fig. 4). Therefore, more frequent and precise sampling is needed while investigating vertical successions of limestones in quarries and outcrops in detail.

Figure 5. Tool traces on a quarry wall in the Roman part of the quarry, Cave Romane, Vinkuran. Height of the wooden meter – two meters.

Discussion

One common problem arising in archaeological research is how to precisely identify the stone sources or quarries from which stone materials used in buildings and monuments originated. Geological fieldwork and approach can be of great help, and additional knowledge about compared materials can be obtained by micropetrographic analysis of stone from archaeological objects and rock samples taken from the quarries and outcrops. For carbonate sedimentary rocks, especially marine limestones, application of the microfacies concept (after Flügel 2004) can often be of more advantage than standard classification schemes (Folk 1959; 1962; Dunham 1962; Embry and Klovan 1972).

Two previously highlighted facts, possible large lateral extension of sedimentary layer along its strike and sedimentary facies change in the vertical succession, complicate straightforward interpretation and comparation of the results obtained by micropetrographic analysis. There is no unique solution for all possible problems and situations, but general guidelines can be drawn. It may be pointed that justifiable application of micropetrographic analysis largely depends on the scale or size of the object investigated, as well as on its archaeological context (i.e., possible and probable transportation routes).

An example of such a large archaeological object is the Roman Amphitheatre (Arena) in Pola, closely associated with the Cave Romane quarry in Vinkuran near Pola as its possible (and probable) source of stone material (Fig. 4). Fieldwork and macroscopic determination of similar rudist limestone lithotypes in Arena and Vinkuran quarry would be enough to connect these two objects, and archaeological context (possible transportation routes) will be a decisive factor for final interpretation. Micropetrographic analysis and microfacies determination can be applied while analysing later stages of quarry development and Arena reconstructions.

On the other hand, micropetrographic analysis should not be avoided while investigating smaller scale objects (i.e., monuments), because its archaeological context allows for a broader set of solutions (they can be more easily and likely imported). With microfacies determination, one can at least eliminate or narrow the local sources of stone materials, or even determinate its origin within the broader research area, and then incorporate results within the archaeological context.

Conclusion

Micropetrographic analysis of limestones is the identification of its composition, its fabric and diagenetic changes. This method, to an extent, allows us to identify the type and narrow the geological age of limestone used for a certain activity. Data gathered with this analysis can be a starting point in raw material provenance study, with the help of available geological and lithostratigraphic maps of the potential area of procurement.

While micropetrographic analysis is a valuable tool for answering certain archaeological questions, the application of the results obtained with this analysis is not always simple or straightforward. Sedimentary layers of limestone can be laterally extended along its strike tens or even hundreds of kilometres. This prevents us from undoubtedly locating the exact source of limestone blocks used in a building since similar petrographic samples can be taken from Vinkuran in the south of Istria and Umag in the northwestern part of the peninsula (see the lithostratigraphic map of Istria – Fig. 1). However, we can safely assume that the probable source of limestone blocks was the one closest to the site being investigated (the example of the Pola Amphitheatre). Nevertheless, the western Istrian coastline is rich in well-protected bays and coves and since maritime transport was the cheapest during Antiquity it almost completely replaced land transport (Matijašić 2009: 201). The low cost of maritime transport is also one of the reasons Roman quarries were mostly situated on the coastline (see Fig. 2) – the stone blocks could easily have been loaded onto ships and transported further, whether to a different place in Histria or even further away.

Furthermore, sedimentary facies of limestones can also change in vertical succession randomly or cyclically which reflects the changes in sedimentation within a given timeframe. This means that a more frequent, precise, and detailed sampling of a quarry or an outcrop is needed for the investigation of the provenance of raw material. These facts need to be strongly pondered while considering micropetrographic analysis.

Acknowledgements

ArchaeoCulTour project (HRZZ-PAR-2017-02-1) is financed by the Croatian Science Foundation, Vrsar Municipality, Vrsar Tourist Board and Maistra d.d. Rovinj and the doctoral position of Katarina Šprem at the Juraj Dobrila University of Pula is financed by the European Social Fund and the Croatian Science Foundation (ESF-DOK-01-2018).

References

Buršić Matijašić, K. 2008. Gradinska naselja. *Gradine Istre u vremenu i prostoru*, Leykam international, Zagreb.

Crnković, B. 1991. The Origin of the Dimension Stone of the Arena in Pula, *Rudarsko-geološko-naftni zbornik* 3, 63-67.

Dunham, J. B. 1962. Classification of carbonate rocks according to depositional texture. In: W. E. Ham (ed.), *Classification of Carbonate Rocks*, AAPG Memoir 1, Tulsa, 108-121.

Embry A. F. and Klovan, E. J. 1972. Absolute water depths limits of Late Devonian paleoecological zones, *Geologische Rundschau* 61 (2), 672-686.

Flügel, E. 2004. *Microfacies of Carbonate Rocks: Analysis, Interpretation and Application*, Springer-Verlag, Heidelberg.

Folk, L. R. 1959. Practical petrographic classification of limestones, *American Association of Petroleum Geologists Bulletin* 43, 1-38.

Folk, L. R. 1962. Spectral Subdivision of limestone types, In: W. E. Ham, (ed.), *Classification of Carbonate Rocks*, AAPG Memoir 1, Tulsa, 62-84.

Gabrovec, S. and Mihovilić, K. 1987. Istarska grupa, In: A. Benac (ed.), *Praistorija jugoslavenskih zemalja* 5, Sarajevo, 293-338.

Hänsel, B., Mihovilić, K. and Teržan, B. 1997. Monkodonja. Utvrđeno protourbano naselje starijeg i srednjeg brončanog doba kod Rovinja u Istri, *Histria archaeologica* 28, 37-107.

Koncani Uhač, I. 2018. *Rimski lučki uređaji u Istri i njihov arheološki kontekst* (Roman port installations in Istria and their archaeological context, summary in English), University of Zadar, unpublished PhD dissertation.

Maričić, A., Fricki, D., Barudžija, U. and Horvat, M. 2020. Origin of the Stone Varieties used in the Cultural Heritage Buildings of Lumbarda, Island of Korčula, Croatia, *Journal of Anthropological and Archaeological Sciences* 2 (4), 279-286. (doi:10.32474/JAAS.2020.02.000144).

Matijašić, R. 1998. *Gospodarstvo antičke Istre*, Zavičajna naklada „Žakan Juri" Pula, Pula.

Matijašić, R. 2009. *Povijest hrvatskih zemalja u antici do cara Dioklecijana*, Leykam International, Zagreb.

Miko, S., Kruk, B., Dedić, Ž., Kruk, LJ., Peh, Z., Kovačević-Galović, E. and Gabrić, A. 2013. *Rudarsko-geološka studija potencijala i gospodarenja mineralnim sirovinama Istarske županije*, Hrvatski geološki institut, Zagreb.

Russell, B. 2014. *The Economics of the Roman Stone Trade*, Oxford University Press, Oxford.

Šonje, A. 1980. Iz kojeg istarskog kamena potječe kupola Teodorikova mauzoleja u Ravenni. In: M. Suić and M. Zaninović (eds.), *Materijali, tehnike i strukture, Odjel za arheologiju*, Centar za povijesne znanosti, Zagreb, 149-160.

Šprem, K. 2021. All aboard! Quarries and transport in Roman Istria. In: I. Miloglav (ed.), *Proceedings from the 7th Scientific Conference Methodology and Archaeometry*, Zagreb, 67-85.

Tišljar, J. 2001. *Sedimentologija karbonata i evaporita*, Institut za geološka istraživanja, Zagreb.

Volume density of antique and late antique pottery and spatial analysis of the late antique settlement in Lobor – preliminary results

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https://doi.org/10.17234/METARH.2022.11

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The hilltop settlement at the site of Lobor - Majka Božja Gorska (Hrvatsko zagorje, Croatia) has been in use since the Middle Bronze Age. The continuous building activity, as well as medieval and post-medieval burials, have disturbed the archaeological strata of the site to a great extent. Prehistoric and antique layers suffered the most damage by later interventions. Pottery sherds are the most numerous finds belonging to antique and late antique periods, dating from the end of the 2nd or the beginning of the 3rd until the first quarter of the 6th century, but they are rarely found in intact archaeological contexts. The comparison of the volume density of pottery finds (the number of sherds per excavated volume unit) on different parts of the site is a method used for its spatial analysis. The analysis focuses on the pottery finds from two trenches located almost at opposite sides of the Sanctuary of Our Lady of the Mountain (Majka Božja Gorska), the one from 2010 located south-east of the enclosure wall and the one from 2014 located north of the enclosure wall. The two trenches were selected because of their similar excavation circumstances and almost the same average pottery fragmentation. The 1998 trench 3 was selected as a control trench. Since area density isn't as correct, due to the lack of depth data, volume density is the more accurate method of analyzing pottery distribution in a settlement with disturbed layers or in an area where a suspected settlement is still to be located. The exact position and size of the antique and late antique settlement at the Lobor – Majka Božja Gorska site is still unknown and will be determined by the use of this method.

Keywords: *Lobor, hilltop settlement, pottery, volume density*

Introduction

In this paper, a part of the research of pottery finds from the archaeological site of Lobor - Majka Božja Gorska will be presented. Pottery research has been carried out as part of the project „Lobor - Early Medieval Center of Power" (LearlyCoP IP-2016-06-6622) and the „Young Researchers' Career Development Project – Training New Doctoral Students" (DOK-2018-09-5720), both with the financial support of the Croatian Science Foundation. Considering the time period covered by the projects, the research has been focused on antique, late antique and early medieval pottery, which is sometimes hard to differentiate, especially if the fragments are very

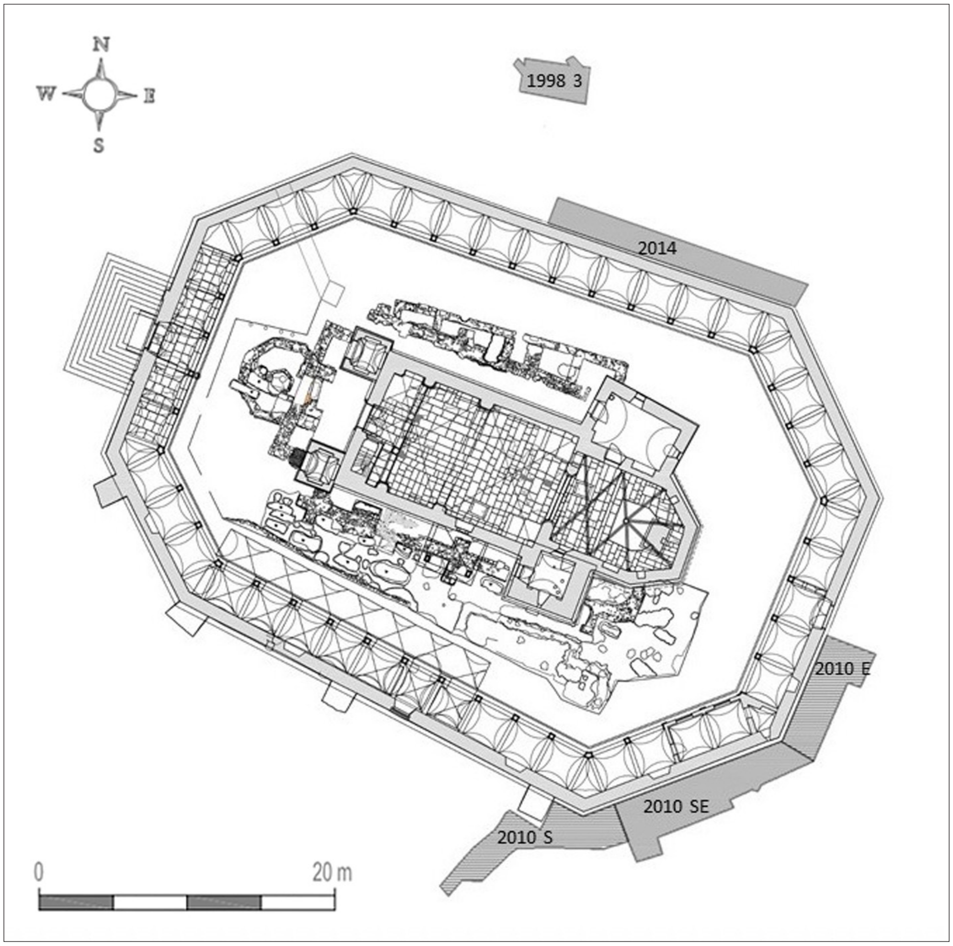


Figure 1. Plan of the Sanctuary of Our Lady of the Mountain (Majka Božja Gorska) with trenches mentioned in the text. (Made by: P. Nikšić, after: Arheo Plan d.o.o.).

small. More precisely, the pottery analyzed in this paper has been dated from the end of the 2nd or the begging of the 3rd until the first quarter of the 6th century. It is important to emphasize that the research results presented here are only preliminary. In other words, the pottery finds from just two archaeological trenches were used to test a model for spatial analysis that will, hopefully, as the research continues, be successfully applied to the rest of the site, and not only on pottery but also on other groups of archaeological finds, such as metal, stone, glass, animal and human bones, etc. The third trench, chosen as a control trench, was supposed to confirm the results. The raw numbers of collected sherds are combined with the total volume of excavated deposit, which provides the number of sherds per meter cube of deposit (volume density) for each trench or, when possible, certain stratigraphic units. After mapping the gathered data, the clusters of finds are supposed to form, which should indicate any particular parts of the site occupied at certain periods.

The archaeological site

The archaeological site of Lobor - Majka Božja Gorska is located in Hrvatsko zagorje, on the southern slopes of the mountain Ivanščica, north of today's center of Lobor. The site shares the hill with the Sanctuary of Majka Božja Gorska, which consists of a Gothic church, a Baroque crypt and an enclosure wall of the same period (Fig. 1). The Roman site in the center of the village has been known since the middle of the 19th century (Brunšmid 1908-1909: 165-166, fig. 360; Migotti 2009), and the medieval one on the hill since the middle of the 20th century when parts of stone monuments belonging to the early medieval church were found built into the Gothic church and the walls of surrounding houses (Strahuljak 1950: 260). After those finds, at least two field surveys of the plateau and the southern slopes of the hill were conducted (Gorenc 1977-1978: 265-266; Tomičić 1999: 50, f.n. 9), during which large quantities of prehistoric, antique and medieval pottery sherds were found. Unfortunately, those finds were never quantified, published or, maybe, even collected. The history of archaeological research before the excavations started was presented in detail in the exhibition catalogue (Filipec and Jurica Turk 2002).

Archaeological excavations at the site have been conducted by Dr. Krešimir Filipec of the Department of Archaeology (Faculty of Humanities and Social Sciences, University of Zagreb) almost continuously since their beginning in 1998 (Filipec 2010). The main purpose of the excavations was to provide a cleared space where it was necessary to build a drainage system, designed to help preserving the existing walls of the sanctuary. Therefore, the excavations were focused on the area around the church and around the enclosure wall, although nine trenches of various sizes were excavated outside of the drainage system plan. Along with the remains of the early Christian church and baptistery buildings and pre-Romanesque and Romanesque churches (Filipec 2008; 2009; 2017b; 2020), more than one thousand more or less intact graves dating from Late Antiquity to the 19th century were found, some of which were analyzed and published (Filipec 2009; 2016; Vrančić and Perušina 2018). Construction activity, and burial pits, even more, damaged the layers that preceded them and made the processing of the archaeological material more difficult.

Methodology

Vertical stratigraphy of the site consists of three main layers: humus, debris connected with the levelling of the site for the construction of the Gothic church, and the layer with burials. Other stratigraphic units are mostly grave pits, postholes, and other small parts of architectural remains. Unfortunately, the composition of the soil from the grave pits does not differ from the composition of the soil of the layers in which the grave pits were dug. Since the graves are mostly without any architectural elements, the borders of the grave pits are impossible to detect, as is the walking surface used at the time they were dug. Apart from the remains of the church and baptistery buildings, no other larger late antique or medieval fixed structures were found. Only a small part of the northern stone rampart was detected. Therefore, the spatial analysis of the site using stratigraphic units, mostly buildings or their parts, in the current state of research is, unfortunately, impossible. As a result of that, a model using pottery as the main indicator of the late antique settlement's size and structure was selected.

Quantification of pottery alone does not contribute to spatial analysis of an archaeological site without a context, especially if the sherds were not found within closed and well-defined stratigraphic units. To make the picture of the site clearer, it is necessary to combine raw numbers of sherds with units of measurement, such as area or volume (Fig. 2 a-d). By doing so, the density with which pottery sherds occur is estimated and can be used as a measure of the size and development of the site, in chronological order, depending on the type of pottery found in particular parts of the site. Density can be expressed in two ways: as density per excavated area or as density per excavated volume (SDAC 2020). Although area density is easier to calculate and more widely used due to the greater availability of the data, volume density seems to be a more accurate method because it includes the variable of depth into the calculation, which changes significantly at this site. The main disadvantage of this method is the relative inaccuracy that can occur because, due to the irregularity of the trench itself and the stratigraphic units, the calculation of the volume of excavated deposit depends on the precision of documenting (field drawing, surveying, etc.) during the excavation. Nevertheless, precisely because the depth is taken into account when calculating the volume density, large differences in density between volume and area density are possible, as can be seen from the following hypothetical calculation for the same number of fragments (1000):

Case 1: $A_1 = 1\ m^2 \rightarrow A_1d = 1000/1 = 1000\ sherds/m^2$,
$dep_1 = 1\ m,\ V_1 = 1\ m^3 \rightarrow V_1d = 1000/1 = 1000\ sherds/m^3$

Case 2: $A_2 = 1\ m^2 \rightarrow A_2d = 1000/1 = 1000\ sherds/m^2$,
$dep_2 = 2\ m,\ V_2 = 2\ m^3 \rightarrow V_2d = 1000/2 = 500\ sherds/m^3$

Case 3: $A_3 = 2\ m^2 \rightarrow A_3d = 1000/2 = 500\ sherds/m^2$,
$dep_3 = 1\ m,\ V_3 = 2\ m^3 \rightarrow V_3d = 1000/2 = 500\ sherds/m^3$

Thus, with increasing depth, the volume density for the same surface area decreases, while the volume density can be the same despite the different surface area if the volume of the excavated deposit is the same. Calculating and mapping the area of volume density is sometimes found under the term quantitative analysis (Vágvölgyi 2015).

For the start of the application of this method, two trenches were selected, the one excavated in 2010, which is located southeast of the enclosure wall, and the one excavated in 2014, which is located north of the enclosure wall. The 2010 trench was chosen because it is

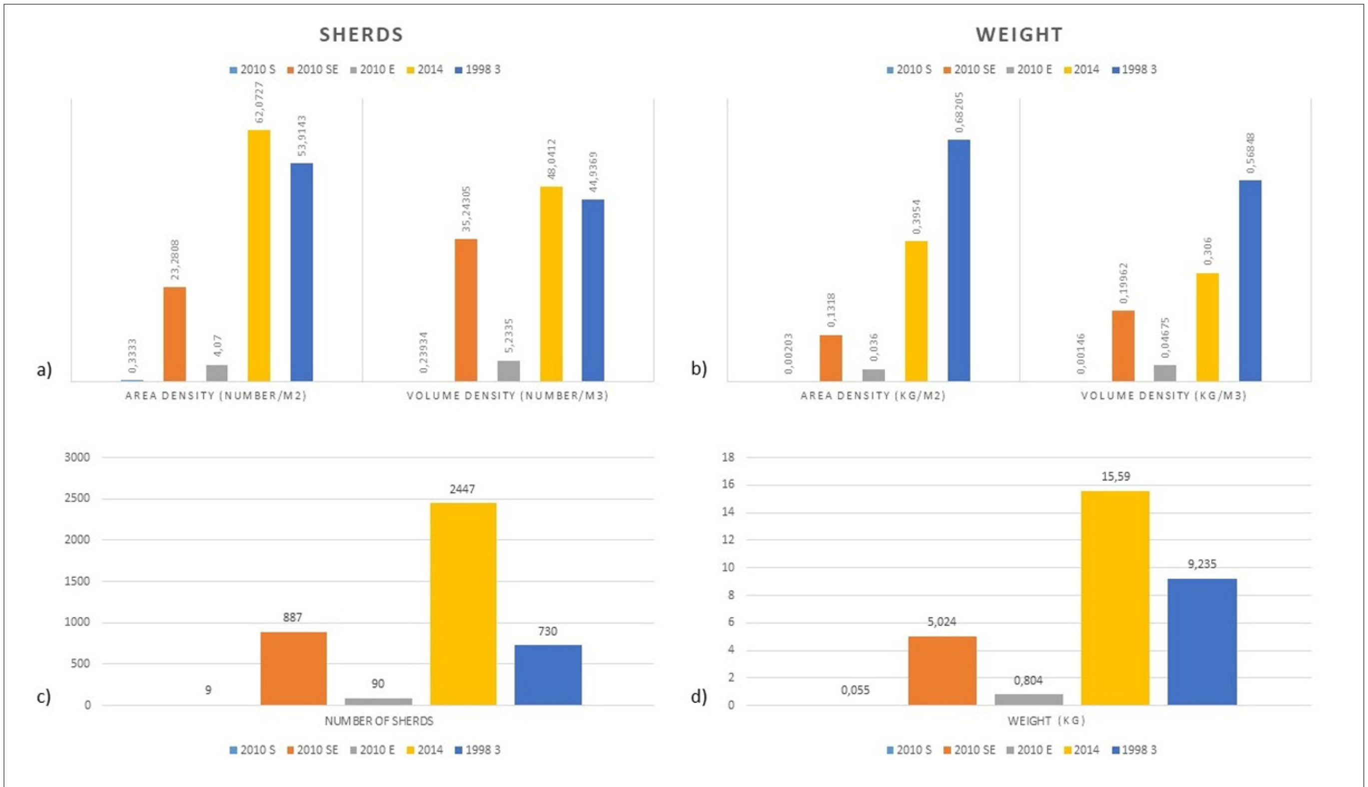


Figure 2. a) area density vs. volume density, total number of sherds, b) area density vs. volume density, total weight, c) total number of sherds, d) total weight. (Made by: P. Nikšić).

the only one located on the southern slopes of the hill, where the remains of ancient architecture and numerous pottery sherds were found during the field survey and none of which was mentioned for the northern part of the site (Gorenc 1977-1978: 265-266). It should be emphasized that M. Gorenc did not conduct the field survey according to the current standards, but inspected the places where the soil had already been tilted or excavated due to agricultural or construction works. The 2014 trench was chosen because it was located almost on the opposite side of the site in comparison to the 2010 one, and the data are easily comparable due to the same degree of average fragmentation. During the research, it was noticed that a larger quantity of antique and especially late antique pottery sherds was found in trench 3 excavated in 1998. This trench was located in the immediate vicinity of the 2014 trench, on the plateau further north. Data obtained by the quantification of the finds from the 1998 trench 3 was included in the study as a control element, which should further prove the existence of settlement pottery in larger quantities even between the church complex and the northern rampart, and confirm the accuracy of the results obtained by the analysis of the volume density of pottery finds from the 2010 and 2014 trenches, which were the first two areas selected for the comparison. The main difference between the pottery finds from the 1998 trench 3 and those from the other two mentioned trenches is the degree of pottery fragmentation caused by the presence or lack of the Baroque period construction activity in those trenches. The only interventions into the strata of the 1998 trench 3 after Late Antiquity were the medieval grave pits. Since the degree of pottery fragmentation in trench 3 is lower, the necessary corrections were made in relation to the number of fragments obtained by quantification. The correction factor was obtained on the basis of the hypothesis that, if the same amount of interventions into the antique and late antique strata had been present in the 1998 trench 3 as it was in the 2010 and the 2014 trenches, the same pottery fragmentation would occur. Therefore, using the difference in average sherd weight between pottery finds in the 2010 (the SE section) and the 2014 trenches, and those in the 1998 trench 3, the correction factor was estimated to be 2.17,

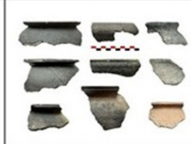
GROUP 1	GROUP 2	GROUP 3	GROUP 4	GROUP 5	GROUP 6	GROUP 7
Glazed pottery	Slipware	Burnished pottery	Gray fineware	Red fineware	Gritty pottery	Coarse pottery
						
- glazed pottery - glazed pottery with slip - glazed pottery with burnished surface or decoration	- terra sigillata - PGW - ARS/LRC - red, orange, brown, gray, black slipware	- pottery with burnished or semi burnished surface - pottery with burnished decoration	- light to dark gray fine or very fine pottery	- yellow, orange and red very fine or fine pottery	- fine-grained coarse pottery	- large-grained coarse pottery
- mortars - bowls/plates - cups - jugs	- bowls/plates - jugs	- jugs - pots - bowls	- jugs - pots - lids	- jugs - pots	- pots - bowls - jugs	- pots - bowls - jugs

Figure 3. Pottery groups 1-7. (Made by: P. Nikšić).

and the number of sherds from the 1998 trench 3 was multiplied by that number. The quantitative data from the 1998 trench 3, their analysis and results are also important because it is one of few trenches excavated at the site in Lobor that was not connected with the preservation of the present-day structures or the construction of the drainage system, and as such should confirm the higher density of pottery finds in the northern part of the site than in the southern, where the position of the antique and late antique settlement at the site of Lobor – Majka Božja Gorska was previously assumed.

Pottery groups

For the purpose of the research, antique and late antique pottery sherds found at the site of Lobor - Majka Božja Gorska were divided into groups (Fig. 3), as were the sherds from many other sites (Ottományi 1997-1998; Ladstätter 2000: 204-205, fig. 70, 71; Grabherr and Kainrath 2011; Zagermann 2015; Roksandić 2018: 57, fig. 9). It is important to create groups for each site, but also to make them easily comparable with the groups from other sites. The seven main groups form Lobor are: 1) glazed pottery, which includes glazed pottery with orange, red and brown slip, as well as glazed pottery with burnished surface or decoration, 2) slipware, which includes terra sigillata and its imitations, and orange, red, gray, brown and black slipware, as well as slipware with burnished surface or decoration, 3) burnished pottery and pottery with burnished decoration, 4) fine gray reduction fired pottery, 5) fine oxidation fired pottery, which is in the ranges of yellow, orange and red, 6) fine-grained coarse pottery and 7) large-grained coarse pottery. Certain groups, such as group one, two or three, can provide a quite precise dating for the parts of the site where they were found, unlike groups six and seven, which were in use for longer periods. The difference in fabric, size and wall thickness of the pottery that belonged to the mentioned groups is the main reason why weight alone was not taken into account when calculating the volume density of antique and late antique pottery from Lobor, especially since not all groups were equally represented at the various parts of the site in Lobor. For example, a sherd of similar size will weigh more if it belonged to a coarse, thick-walled pot than the one that belonged to a fine, thin-walled jug. Also, thin-walled pottery breaks more easily and into more fragments, which reduces the weight of a single sherd. Since a significantly larger amount of fine pottery sherds was found in the 2014 trench, the weight of the pottery was used to make the aforementioned corrections of the data from the 1998 trench 3.

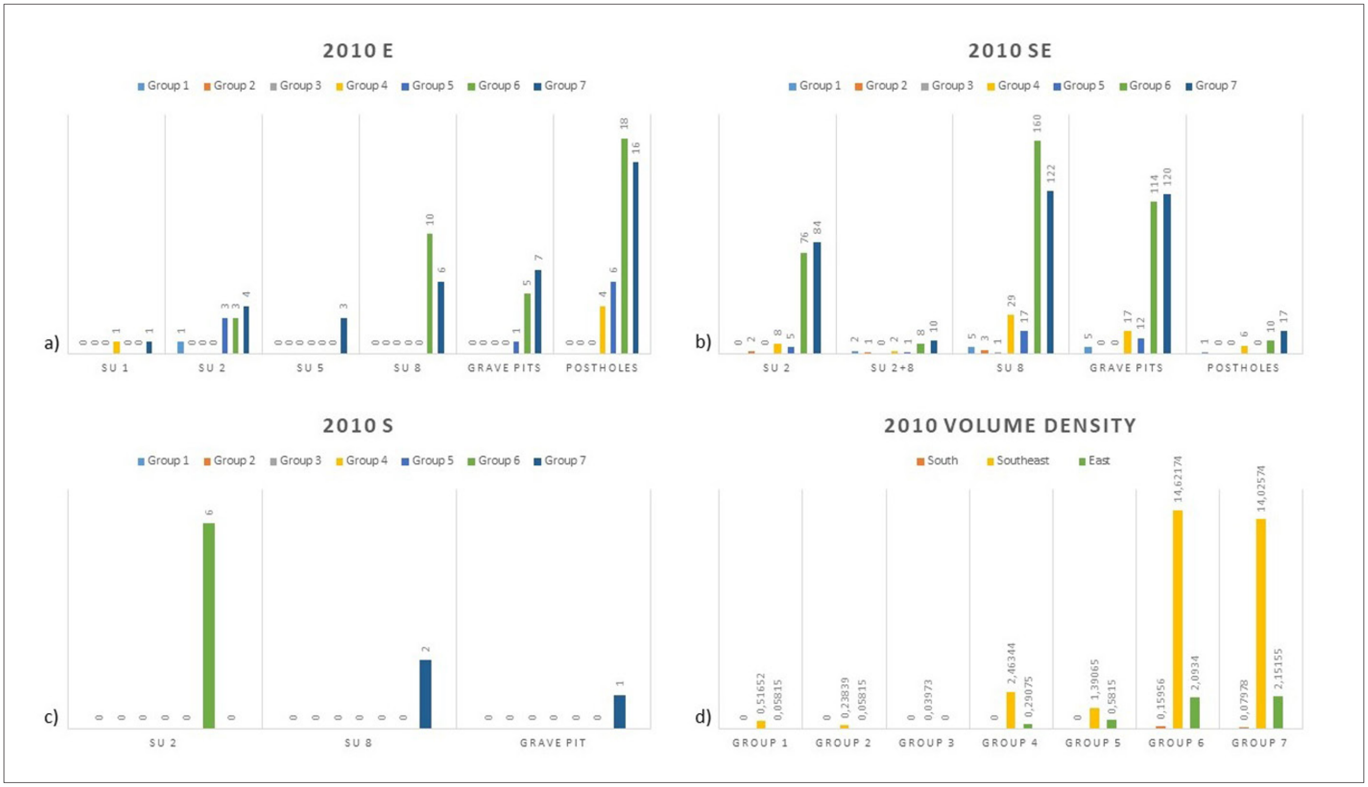


Figure 4. a) total number of sherds in stratigraphic units, section E, b) total number of sherds in stratigraphic units, section SE, c) total number of sherds in stratigraphic units, section S, d) volume density in sections S, SE and E. (Made by: P. Nikšić).

Preliminary results

The trench excavated in 2010 was located outside of the enclosure wall by its southeastern part. It was divided into three sections: southern, southeastern and eastern (Fig. 1). The southern section was excavated in preparation for the construction of the drainage system outflow and it seems that this part of the site had been used for the secondary mass burial of the skeletal remains from the Baroque crypt. A significant find from that year's campaign was a corner part of a stone building found in the southeastern section, showing characteristics of late antique architecture which could be interpreted as the remains of another early Christian church or some other public building (Filipec 2020: 292, fig. 1). Unfortunately, the biggest part of the building is located under the contemporary houses of a nearby hamlet. That was the reason why the trench was only partially expanded towards those buildings. In all three sections of the 2010 trench, coarse pottery dominates, although the number of sherds found in the southern and eastern sections is much smaller than the number found in the southeastern section. Both groups of coarse pottery are almost equally represented. The majority of sherds were found in the stratigraphic unit 8 and grave pits, which were, in most of the cases, dug into that same stratigraphic unit (Fig. 4 a-c). Since the total number of sherds in the southern and eastern sections is small, the volume density in those sections is very low. In comparison, the southeastern section has a much larger number of sherds, so the difference in volume density between the sections and groups appears to be almost the same as the difference in the number of sherds (Fig. 4 d).

The trench excavated in 2014 was located outside of the enclosure wall by its northern part (Fig. 1). It was of rectangular shape and somewhat smaller than the one from 2010, so there was no real need to section it, although in cases of spatial analysis smaller sections or a square grid make the sorting and processing of finds easier, especially of those finds that were not recorded digitally. A significant find from that year's campaign was a small S-shaped fibula, dated to the end of the 5th and the first third of the 6th century, and usually attributed to the Lombards (Filipec 2020: 297, fig. 4). Although the fibula was not found in a closed archaeological context, its finding indicates the possible existence of a destroyed late antique grave nearby, as well as the possibility that

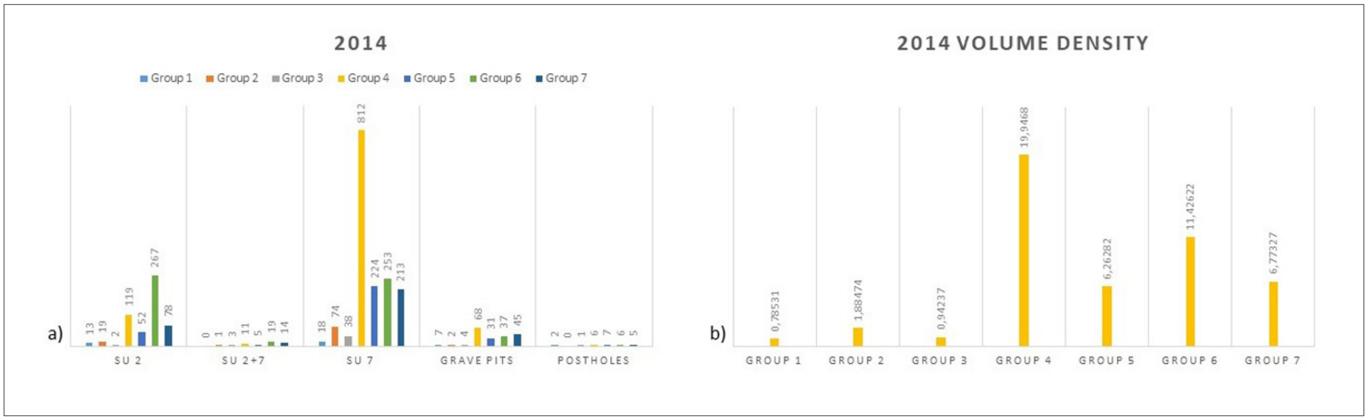


Figure 5. a) total number of sherds in stratigraphic units, b) volume density. (Made by: P. Nikšić).

the settlement relocated from that part of the site in the 6th century and gave place to the cemetery, maybe after the church was built. That theory can be partially proven by the ratio of sherds in pottery groups because, as far as pottery is concerned, the trench excavated in 2014 is the only one where fine gray pottery was found in a much larger quantity than any other pottery group. More than half of the total amount of sherds belong to fine gray tableware, mostly undecorated drinking vessels, such as jugs, beakers and cups, which can be dated to the 5th century at the latest. The biggest number of sherds was found in the stratigraphic unit 7 (Fig. 5 a) that corresponds to the stratigraphic unit 8 in the southeastern section of the 2010 trench. Relating to the number of the sherds, the volume density of group 4 is high, while the volume density of other groups is low for groups 5 to 7 and very low for groups 1 to 3 (Fig. 5 b).

Trench 3 is one of the smaller trenches on the site. It is one of the three trenches excavated in 1998 outside of the enclosure wall in the northern part of the site and it is located quite near the 2014 trench. It is important to mention that this is one of few locations on the site with potential residential architectural remains that could be dated to the antique period. Parts of daub and roof tiles were found in a layer with prehistoric, antique and late antique pottery, but above a layer of prehistoric flooring and a layer of prehistoric pottery. These findings could be interpreted as the antique or late antique house remains. Three joining sherds of a glazed cup with roulette decoration, found in layer 18, grave 2 and grave 8, show how much graves disturbed the strata. Related to that, the biggest number of sherds was found in stratigraphic units 18 and 18+32, but none in the stratigraphic unit 32 alone (Fig. 6 a). Coarse pottery is dominant in trench 3 excavated in 1998, but not as dominant as it is in the southeastern section of the trench from 2010. Volume density of pottery groups in trench 3 is gradually increasing from the groups of fine pottery to those of coarse pottery, which is different than in the other trenches. Volume density of groups 1 to 3 is very low, although group 1 somewhat stands out. Volume density of groups 4 and 5 is low, and groups 6 and 7 high, as was mentioned before (Fig. 6 b).

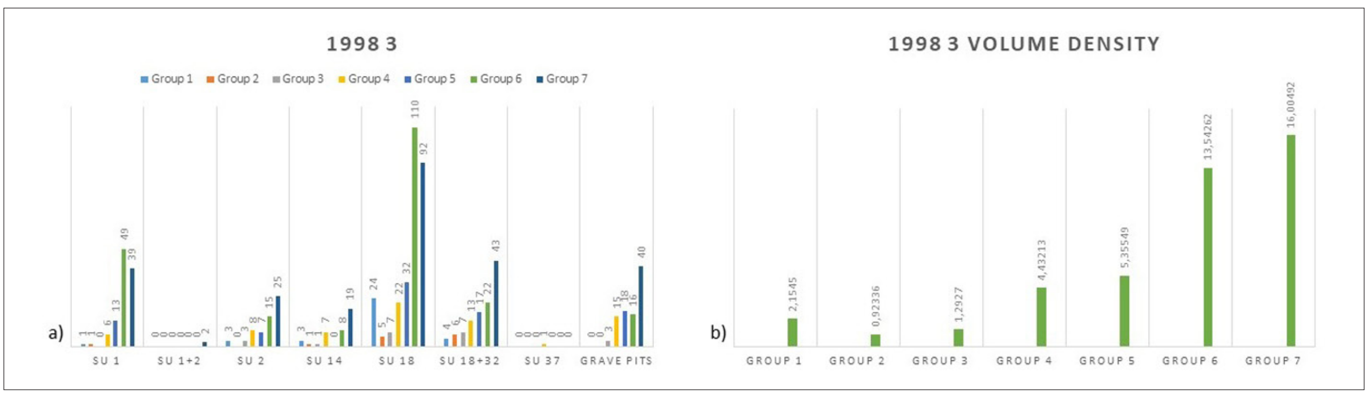


Figure 6. a) total number of sherds in stratigraphic units, b) volume density. (Made by: P. Nikšić).

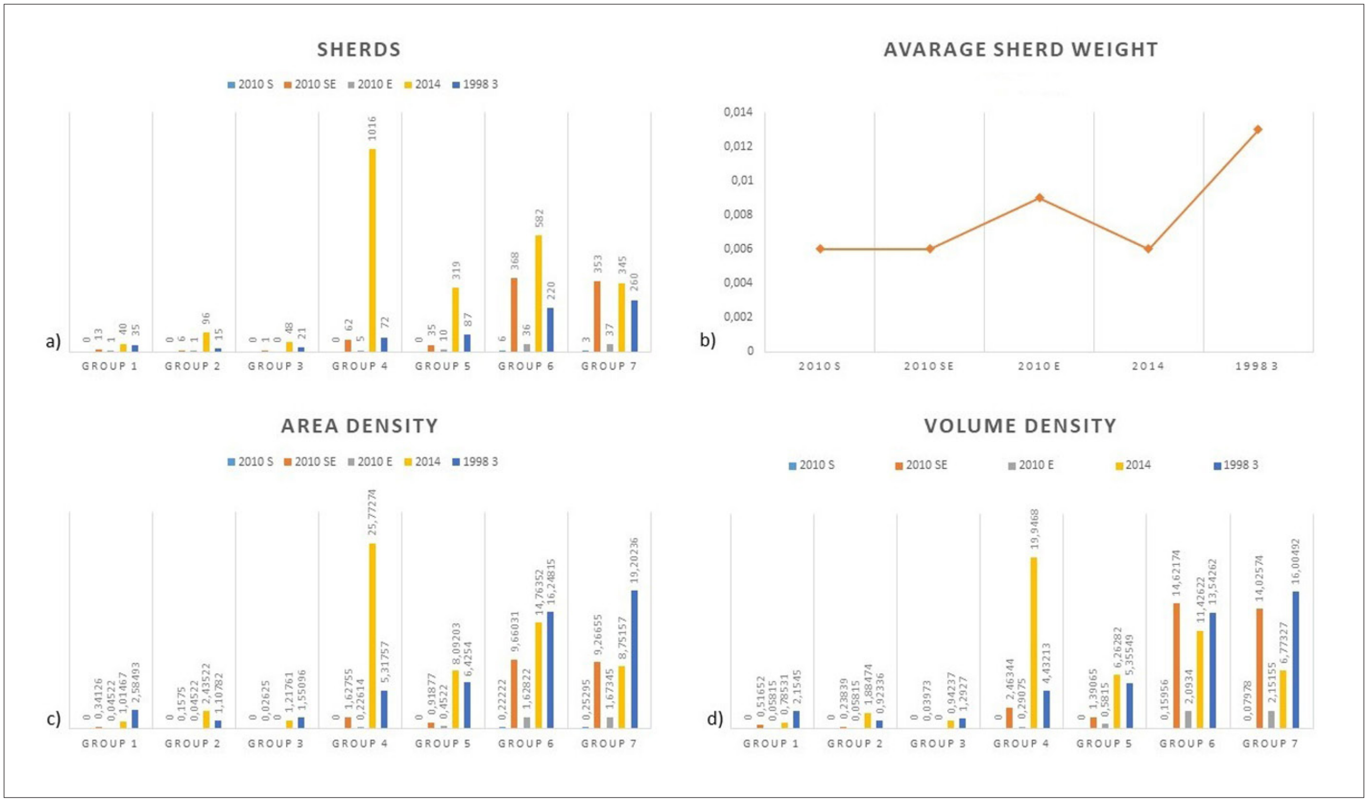


Figure 7. a) number od sherds for groups 1-7, b) average sherd weight in kilograms, c) area density for groups 1-7, d) volume density for groups 1-7. (Made by: P. Nikšić).

When the volume density of pottery sherds in those three trenches is compared (Fig. 2 a-b, 7 d), it becomes apparent that the volume density of trench 2014 is the highest. The volume density of the SE section of the 2010 trench is significantly lower, while that in sections 2010 S and 2010 E is almost insignificant. It is obvious that subsequent interventions of secondary burials from the Baroque crypt in section 2010 S reduced the number of finds almost to zero.

The volume density of the 1998 trench 3 is higher that the one of trench 2010. When it comes to groups, coarse pottery dominates, that is groups 6 and 7, especially in the 1998 trench 3 and southeastern section of the 2010 trench. However, the highest individual volume density is that of group 4 in trench 2014, which in other cases has fairly low numbers, just as group 5 does. Groups 1 to 3 have very low numbers in all of the trenches, which corresponds to the fact that those groups represent a rarer or more exclusive pottery finds. Volume density of groups and in total, when mapped (Fig. 8), represent a start of the spatial analysis of the site in Lobor. It is visible from the color-coded plans of the analyzed trenches that a cluster of overall pottery finds is formed in the area north of the church complex, where the 1998 trench 3 and the 2014 trench were excavated. The fact that gritty and course pottery dominate, with the exception of the dominance of fine reduction fired pottery in the 2014 trench, could signify that both the northern and the southern parts of the site in Lobor followed the general pattern of large quantities of kitchenware. However, in the area excavated in 2014, there must have been a temporary or permanent structure that served for the consumption of food and/or drink, which caused such a deviation of the number of fine pottery sherds. This theory might be proven with further archaeological research and excavation of the surrounding area.

The difference between area and volume density (Fig. 7 c-d) is significant in trenches with larger differences in depth. With the trenches discussed in this paper, this is not the case as much as it will be with some trenches that have been excavated within the enclosure wall.

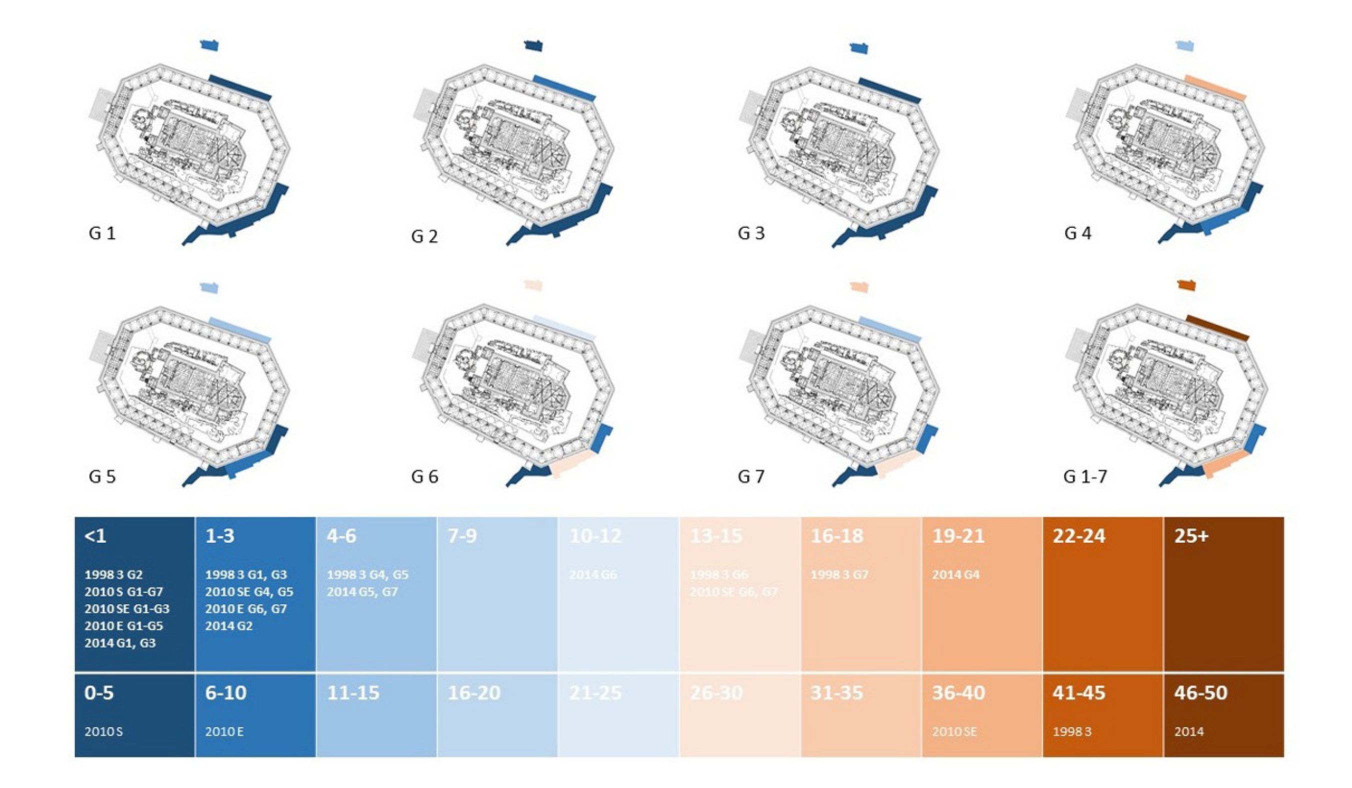


Figure 8. Color-coded mapping of antique and late antique pottery groups and pottery in total. (Made by: P. Nikšić).

It is important to note that the degree of fragmentation in the 2010 and 2014 trenches is almost the same, only slightly higher in trench 2010 E, but given the small number of fragments found there, this difference becomes insignificant when studying the entire trench. In contrast, the degree of fragmentation in the 1998 trench 3 is somewhat lower and the pottery fragments are larger (Fig. 7 b). When the correction factor (2.17) is applied to the number of pottery sherds in the 1998 trench 3, the volume density becomes the highest in the 1998 trench 3. This leads to the conclusion that the center of the cluster of pottery finds is in the central part of the northern plateau between the sanctuary and the northern rampart. The analysis of the volume density of pottery finds from the trenches located near the northern rampart should confirm this result. The current state of research implies that the residential part of the settlement had been located in the same place where the early Christian church complex was built and north of it after its construction.

Conclusion

Although the current state of publication has put emphasis on the exsistence of antique or late antique settlement elements in the southern part of the site and the small plain south of the hill where the field surveys were conducted, the preliminary results of pottery research show a more significant presence of pottery sherds, dated at least from the end of the 2nd or the beginning of the 3rd century until the first quarter of the 6th century, in the northern part of the site. The pottery finds in all three trenches were found alongside late antique poorly preserved architectural remains or small finds. A cluster of antique and late antique pottery finds is visible in the area north of the church complex, where the 1998 trench 3 and the 2014 trench were excavated, while the 2010 trench in comparison does not show particular volume density of pottery finds, either of groups or in total. Gritty and course pottery groups (G6, G7) dominate in all trenches and sections, with the exception of the 2014 trench, where fine reduction fired pottery (G4) is the group with most sherds found. New clusters of antique and late antique pottery finds could, and probably will be, discovered when this model of spatial analysis is applied to the entire part of the site that has been excavated so far. If the results of further analyses are satisfactory, the research will be extended to other groups of archaeological finds. This will, hopefully, solve the problem of the non-existence of a larger number of closed stratigraphic units and provide a much clearer picture of the antique, late antique and early medieval settlement at the site of Lobor - Majka Božja Gorska.

Acknowledgements

The research of antique, late antique and early medieval pottery from the archaeological site of Lobor - Majka Božja Gorska is conducted with the financial support of the Croatian Science Foundation (LearlyCoP IP-2016-06-6622; DOK-2018-09-5720). I would like to thank my PhD supervisor and LearlyCoP project manager Dr. Krešimir Filipec for the pottery finds and the documentation provided, as well as his support and supervision.

References

Brunšmid, J. 1908-1909. Kameni spomenici hrvatskog narodnog muzeja u Zagrebu, *Vjesnik Hrvatskog arheološkog društva*, n. s., sv. X, 151-222.

Filipec, K. and Jurica Turk, V. 2002. *Lobor: Majka Božja Gorska. Katalog izložbe.* Muzeji Hrvatskog zagorja, Muzej seljačkih buna, Gornja Stubica.

Filipec, K. 2008. *Arheološko-povijesni vodič po svetištu Majke Božje Gorske u Loboru*, Župa sv. Ane, Lobor.

Filipec, K. 2009. Slavenski paljevinski grob iz Lobora, *Archaeologia adriatica* III, 347-357.

Filipec, K. 2010. Drvena crkva u Loboru - najstarija franačka misionarska crkva u sjevernoj Hrvatskoj, *Starohrvatska prosvjeta* 37, 112-126.

Filipec, K. 2016. Pokopi u zgrčenom i poluzgrčenom položaju na groblju uz crkvu Majke Božje Gorkse u Loboru, In: S. Krznar, T. Sekelj Ivančan, T. Tkalčec and J. Belaj (eds.), *Groblja i pogrebni običaji u srednjem i ranom novom vijeku na prostoru sjeverne Hrvatske, Zbornik radova prvog međunarodnog znanstvenog skupa srednjovjekovne arheologije Instituta za arheologiju*, Zagreb, 4. lipnja 2014., Institut za arheologiju, Zagreb, 49-56.

Filipec, K. 2017a. Antički nadgrobni spomenici Lobora - prilog poznavanju antičke skulpture panonsko-noričkog žiteljstva i njegove sredine, *Arheološki radovi i rasprave* 17, 95-144.

Filipec, K. 2017b. The End of the Late Antique Fort in Lobor and the Beginning of the Slavic Seizing of Present Day Northwestern Croatia, *Konštantínove Listy* 10/2, 23-34.

Filipec, K. 2020. Ranokršćanska crkva u Loboru – Majka Božja Gorska, ortodoksna ili arijanska?, In: M. Sanader, D. Tončinić, I. Kaić and V. Matijević (eds.), *Zbornik I. Skupa hrvatske ranokršćanske arheologije (HRRANA)*, Arheološki zavod Odsjeka za arheologiju Filozofskog fakulteta Sveučilišta u Zagrebu, Zagreb, 291-301.

Gorenc, M. 1977-1978. Novi podaci s antičkih i ranosrednjovjekovnih lokaliteta Marija Gorska i Černičevina u Loboru, *Vjesnik Arheološkog muzeja u Zagrebu,* 3 s. sv. X-XI, 265-266.

Grabherr, G. and Kainrath, B. (eds.) 2011. *Die spätantike Höhensiedlung auf dem Kirchbichl von Lavant. Eine archäologische und archivalische Spurensuche*, IKARUS, Band 5, Innsbrucker Klassisch-archäologische Universität, Innsbruck.

Ladstätter, S. 2000. *Die materielle Kultur der Spätantike in den Ostalpen, Eine Fallstudie am Beispiel der westlichen Doppelkirchenanlage auf dem Hemmaberg*, Verlag der Österreichischen Akademie der Wissenschaften, Wien.

Migotti, B. 2009. Vojnička nadgrobna stela severskog razdoblja iz Lobora, *Archaeologia adriatica* III, 155-171.

Ottományi, K. 1997-1998. Late Roman Pottery in the Dunabogdány Camp, *ANTAEUS* 24, 333-373, 726-738.

Roksandić, D. 2018. *Vinkovci u kasnorimskom razdoblju. Keramika kao pokazatelj života u kasnorimskim Cibalama / Vinkovci in Late Roman Period. Pottery as an Indicator of Life in Late Roman Cibalae*, Gradski muzej Vinkovci, Vinkovci.

Strahuljak, T. 1950. Naučno-istraživački rad Konzervatsorskog zavoda od 1945. do 1949., *Historijski zbornik* III, 1-4, 260.

Tomičić, Ž. 1999. *Panonski periplus: arheološka topografija kontinentalne Hrvatske*, Hrvatski studiji, Institut za arheologiju, Zagreb.

Vágvölgyi, B. 2015. Quantitative and GIS-based archaeological analysis of the Late Roman rural settlement of Ács-Kovács-rétek, *Dissertationes Archaeologicae ex Instituto Archaeologico Universitatis de Rolando Eötvös nominatae*, Ser. 3. No. 3., 127-189.

Vrančić, N. and Perušina, V. 2018. *Forenzična arheometrija: zagonetni slučaj grofa Tome Keglevića*, Rektorova nagrada 2017./2018. god. Filozofski fakultet Sveučilišta u Zagrebu, Zagreb.

Zagermann, M. 2015. Terra sigillata, Feinkeramik, Gebrauchskeramik und Amphoren vom Säbener Burgberg (Ausgrabung 1978 bis 1982), In: V. Bierbrauer and H. Nothdufter (eds.), *Die Ausgrabungen in spätantik-frühmittelalterlichen Bischofssitz Sabiona-Säben in Südtirol I, Fruhchristliche Kirche und Gräberfeld*, Band 1-3, Münchner Beitrage zur vor- und frühgeschichte, Band 58, München, 603-635.

Internet sources

SDAC 2020 – San Diego Archaeological Center, Volume vs. area density:

https://www.sandiegoarchaeology.org/Laylander/Issues/method.density.htm (Accessed: 7.11.2020.)

Few experiments of log-boats making

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https://doi.org/10.17234/METARH.2022.12

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Several dozen log-boats, which can be classified as medieval ones, were found on the territory of Ukraine. Most of these findings are not well-researched and were found by accident. The number of discoveries and interest in their studies has increased over the past few years. However, the data of the already discovered findings are not complete and poorly introduced into the scientific environment, and the medieval written sources are fragmentary, and therefore don't give a complete picture of the features of log-boats construction in mentioned lands. The most effective method for studying the traditions of making log-boats is to carry out experiments on their studies by comparing the archaeological and ethnographic materials.

Keywords: *log-boat, experimental archaeology, log-boat making technology, Ukraine.*

Introduction

The main type of water transport of the population of Medieval Rus' was a log-boat, also known by the Byzantine name "monoxyl" (De Administrando Imperio 1967: 57-59). In ethnography, the following names of boats of this type have been preserved: dovbanka, struh, dub. This type of vessel was made of a solid piece of wood, by hollowing out the middle (forming a gutter). This technology is called subtractive and is one of the oldest in the world (Дубровин 2000: 63). All the archaeological findings of log-boats in Rus' are accidental (Журавлева and Чубур 2010: 38). Researchers are recording the external features of the structure of this type of vessel, trying to consider some characteristics, but the whole process of making log-boats has not yet been carried out.

Figure1. Small log-boat with two sections. (Archive of the project *Medieval Shipyard*).

Figure 3. Unfinished boat from Starosillya. (Archive of the project *Medieval Shipyard*).

From the written source Rus'ka Pravda (code of law in Medieval Rus' in 11th – 14th century) we know about the existence of at least four types of boats: cheln, struh, naboyna ladia, and morska ladia (Юшков 1935: 137-144). This source indicates the cost of compensation for theft and damage to: for morska ladia - 3 hryvnias, for naboyna ladia - 2 hryvnias, for struh - 1 hryvnia, for cheln - 8 kunas (1 hryvnia is about 200 grams of silver or a little more than 60 kunas). We can read about 60 kunas boat compensation in Zvenugorod birch bark manuscript (a document written on pieces of the birch bark and dated between 1110 – 1137), probably it is a compensation for struh boat (Толочко 2008: 276-278).

However, it is difficult to define each of these types based only on archaeological data. At the moment, we can accurately identify the cheln and the struh. These are the most common types of river vessels, made of a single piece of wood, are low-board, and do not have strakes.

During March-April and September 2019, the project «Medieval Shipyard» (Ivano-Frankivsk) conducted two experiments on log-boats making. We used the prototype boats from Starosillya and Vshchizhchyv. The project set several goals: 1) to investigate the methods and techniques of making a log-boat based on the above-mentioned archaeological sources; 2) identify the stages of construction of the boats; 3) determine the optimal number of workers who could be involved in this type of work; 4) to model and reproduce the appearance of a boat from Starosillya and Vshchizhchyv at final stage of construction, using ethnological data and archaeological evidence.

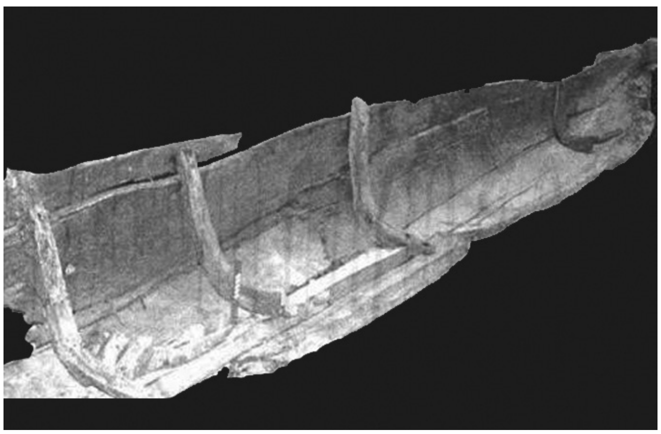

Figure 2. Log-boat with wooden frames (fragment of the boat from Vshchyzhchyv). (Archive of the project *Medieval Shipyard*).

Figure 4. Grooves of unknown purpose on Starosillya. (Archive of the project *Medieval Shipyard*).

Figure 5. Log-boat form Vshchyzhchyv. (Archive of the project *Medieval Shipyard*).

Figure 7. First boat-making experience. (Archive of the project *Medieval Shipyard*).

Log-boats in archaeology

The cheln was a log-boat that had several sections left during the hollowing out of the middle to give the structure rigidity. This type of log-boat is small-sized (between 2-6 m.; low and rough sides) (Fig. 1). Struh is an evolution of the previous type of log-boats (Fig. 2). The main difference is in the process of steaming the sides and replacing the hollowed section with frames (transverse ribs). This made it possible to make the ship larger and more capacious. These two types of boats can be considered purely river transport, they were used mainly for the purpose of local trade and fishing. About 90% of the boats found are made of oak, the remaining 10% are boats made of poplar, linden, willow, and other types of wood.

In the northern lands of Rus' (Novgorod, Ladoga) we could see the influence of Scandinavian tradition in combination with local and Finnish (the most characteristic features of which may be the use of metal rivets and wooden nails and at the same time flexible fastenings with use of a face or roots of pine) and log-boats with obviously Finnish influence (use of flexible fastening) (Дубровин 2002: 109-122).

Figure 6. Frame and wooden nails connection. (Archive of the project *Medieval Shipyard*).

Figure 8. Rotation of the log using human power and wooden lowers. (Archive of the project *Medieval Shipyard*).

Figure 9. Wooden pegs were used to achieve a uniform thickness of the boats. (Archive of the project *Medieval Shipyard*).

Figure 11. Results of steaming. (Archive of the project *Medieval Shipyard*).

As for the south-western lands of Rus', the vessels that can be characterized as a cheln or a struh are about 100% of all found here.

A log-boat was found in August 2015 on the river Styr, near the village Starosillya (Volyn region, Ukraine) (Fig. 3). The length of the artifact is 12.2 m, the diameter is 1.15m, the height is 0.95 m, and the width of the sides is 0.75 m. The find is hollowed log, the distance between the sides is approximately 0.75 m, the edges of the sides are bent to the middle due to the drying of the wood and the reduction in the size of its fibers, which causes «compression (convergence) of the sides» Material oak according to the analysis of Ukrainian laboratories (this laboratory made radiocarbon dating analysis, and boat was dated between 1300 – 1410) and white willow according to the analysis of the laboratory in Klaipeda (Lithuania), (also C14 dating showed results between 1223- 1295 with 95 % probability and 1261-1268 with 68% probability), (Мазурик and Хомич 2015; 2016).

Grooves (rectangular, square and trapezoidal) were found on both sides of the ship, C14 dating analysis showed results between 1260-1274 (68% probability) and 1247-1279 (95% probability) (Fig. 4). Most likely, they were intended for joining several boat blanks and their subsequent, to the place of further work (Гайдук et al. 2020: 416-418). This conclusion is based on the message of the Byzantine emperor Constantine VII that the Slavs made their boats in one place and in the spring with floods floated them to Kyiv, where the boats were completed and made suitable for trade and navigation on the sea (De Administrando Imperio 1967: 57-59). This also confirms the fact that the boat is incomplete, it shows traces of axes and adzes.

Figure 10. First steaming by using the "finish" method. (Archive of the project *Medieval Shipyard*).

Figure 12. Competed boat. (Archive of the project *Medieval Shipyard*).

Figure 13. The second boat. (Archive of the project *Medieval Shipyard*).

In 2001, a fragment of log-boat 8.8 meters was found near Vshchyzhchyv (near Bryansk, Russia), the total length of the boat was about 12 m (Fig. 5). The material is oak. Boat with expanded sides and frames (composite frames, consisting of two parts and fastened with wooden pegs (nails) (Fig. 6). Diameter of boat is 1 m. The thickness of the walls of the sides is 8 cm sides, and 14 cm for the bottom of the boat. In general, a boat of this type could take 6 pairs of oarsmen (Чубур 2004; 2008).

The experiments

The first experiment was made in March and April 2019. A boat was made of poplar. The boat had a length 6 m, a diameter 0.55 m, and width, after spreading the sides, of 1.10 m. The prototype of the boat was the already mentioned finding from Starosillya on a scale of 1:2. We used tools such as axes, adzes, and hand drills. Typologically, the tools compare to archaeological finds from the territory of Rus', however, modern steel is used instead of low-quality iron (wrought iron) made of bog ore. The work on this boat involved 8 people, which created some discomfort associated with a large number of workers compared to the rather small size of the boat. With so many people, the work took 6 days (Fig. 7).

Human power and wooden levers were used to overturn the boat (Fig. 8). The weight of the log was about 4000 kg, and after hollowing become about - 450 kg (wet wood). The thickness of the sides of the boat was 2 cm, increasing to 3-4 cm in the direction of the bottom. Wooden pegs were used to achieve a uniform thickness of the boats (Fig. 9), which were driven across the entire

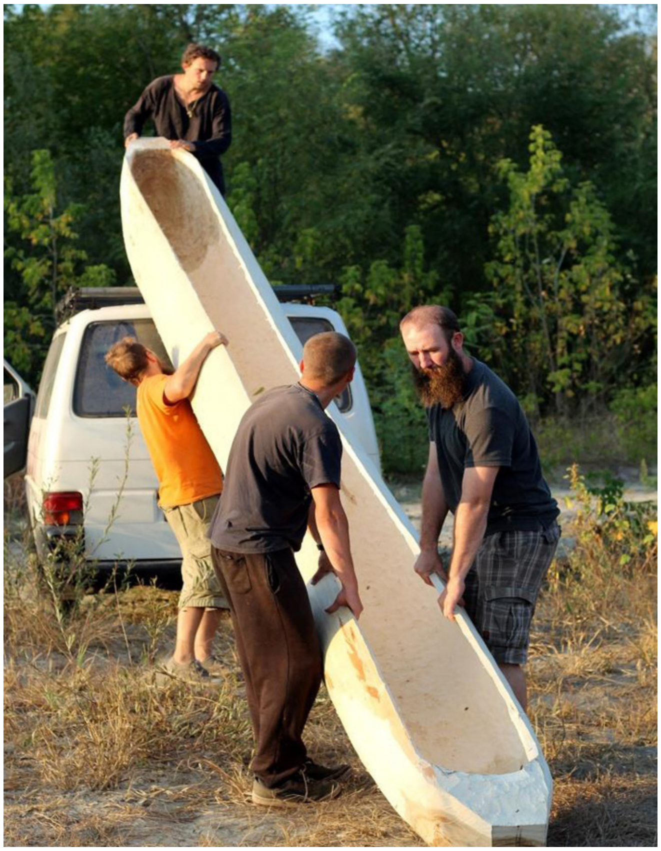

Figure 14. The third boat. (Archive of the project *Medieval Shipyard*).

Figure 15. Only four of us and 7000 kg of wood. (Archive of the project *Medieval Shipyard*).

plane of the boat at a distance of 15 cm from each other. For pegs used branches of wolfberries, which after pre-soaking in water darken and become clearly visible on the plane of the sides. This method has archaeological analogies, in particular, on boards of the boat from Vchyzhshchyv and in the ethnographic technology of making boats in the north of Ukraine in the 19th - first half of the 20th century (Онищук 1929: 7-24).

Since the boat from Starosillya is not finished, and its size is quite large, it was suggested that it could be spread on its sides and sewn an additional row of strakes, which would make the boat wider and more stable on the water. This decision was based on ethnographic data (in the absence of archaeological detections) and reports from written sources in Rus' about the existence of a naboyna ladia, which can be translated as a boat with a row of boards (but we don't have archaeological evidence for it, only one fragment with pine sewn board from Novgorod (Дубровин 2000: 118).

We used "Finnish" technology to spread the sides (Fig. 10). Before the process, the boat was immersed in water so that it gained 100% moisture for about a week. Then a fire was lit which corresponded to the size of the boat. The boat itself was placed upside down over a fire at a height of about 0.50 m from the ground. When the boat warmed up to the appropriate temperature and began to steam, its sides began to bend when pressed. Fresh willow branches were used to spread the boards, they are quite elastic and grow in large numbers near rivers. The boat heats up and its sides are spread by the branches, at the same time the boat is turned from side to side, and constantly moistened with water, as the dry sides of the boat can break. It is important in this process not to apply too much force; the pliability of the boards is felt during their spreading. Since the greatest load falls on both ends of the boat, they were pre-tightened with a rope.

The boat managed to spread to a width of 1.20 m. in the central part, with 40 cm of starting width. However, at the final stage of the process, during the installation of the control crossbars so that the sides do not close in the opposite direction, a crack formed at one end of the boat, which was the result of excessive drying of the sides. Therefore, the final width was 1.10 m. in the central part (Fig. 11). After the boat dried, composite frames were installed, which were attached to metal rivets. The boat was covered with birch tar. The first attempt to test the boat on the water took place in June. Since the weight of the boat is quite low 300 kg, it felt insecure on

Figure 16. Another way to steam the boats. (Archive of the project *Medieval Shipyard*).

Figure 17. It was not a pleasurable process. (Archive of the project *Medieval Shipyard*).

Figure 18. Few minutes before the boat has cracked. (Archive of the project *Medieval Shipyard*).

Figure 19. Repair. (Archive of the project *Medieval Shipyard*).

the water - it staggered, to correct this situation, ballast in the form of stones was used, which made it possible to feel confident on the water (Fig. 12). The boat can take 5 people, 3 oarsmen, and one helmsman, and overseer.

In September 2019, another experiment was conducted to make two boats, based on a prototype artefact from Starosillya. Poplar wood was also used. The length of the first boat was 11.5 meters, with a diameter of 1.10 cm (Fig. 13). The weight of the log was approximately 7000 kg. The length of the second boat was 9.40 m. The diameter was 80 cm (Fig. 14). The weight of the workpiece was about 5000 kg.

During these experiments, we used the work of four people. We have spent one-month hollowing out and spreading the sides. This number of people was the most optimal for the manufacture of boats of this size.

This time we used the same methods and tools as in the previous experiment but changed the technology of rotation of the log, and the technology of spreading of the boards.

Since 4 people are not able to turn a log weighing 7000 kg by using only physical force and wooden levers, we faced the problem of how to solve this task. In the absence of information in written sources and ethnography, we used a technique that continues to exist in Central Africa.

To do this we made a flat plane on the deck on one side, to which a wooden lever is attached with ropes, at the free end of which is tied a rope, which performs the main work. This technique allows you to rotate the log with a lot of weight with minimal physical effort (Fig. 15)[1].

In the north of Ukraine in the last century, the technology of spreading boards was different from that which we used in the previous experiment (Онищук 1929: 7-24). For the duration of carving the gutter, a large amount of waste can be used in the process of steaming the boards. To do this we had to dig a shallow pit (approximately 40-45 cm) by the size of the boat in which the fire shall be lit (Fig 16). After the flame burns evenly and reaches a high temperature, it is covered with wet shavings left after hollowing the gutter. When it is heated and the shavings emit start to steam we covered the pit by the boat, and then we waited until the walls of the boat become flexible and pliable (Figs 17, 18). The possibility of such a

[1] Follow this link to see the video of the process - https://www.facebook.com/watch/?v=231528837972370

technology of spreading the sides can be confirmed by the fact that there are traces of soot on the sides of the boat found in Vshchizhchyv.

In this experiment, taking into account the previous experience two different options were made. On the first boat, to reduce the possibility of cracks and breakage, it was decided to cut the sides at both ends of the boat by about 40 cm, which reduced the load on these parts during spreading. In the second boat, both ends of the boat were wrapped with ropes, but this did not save them from cracking (along the entire length of one of the sides).

This crack was later repaired by applying a wooden bar and "stitching" it to the main side with pine roots (Fig. 19). The width of the first boat was 1.80 m in the central part and the second one was 1.60 m. At the moment, the first boat is not completed. The boat №2 was completed, its length is 11 m. (including added stem and stern-post which are nose and back part of boat) width in the central part of 2 m. Two rows of strakes that are 30 cm each were added, which were attached to the sides with frames by wooden nails, metal rivets used to attach the front and rear (stem and stern-post). The boat hull was covered with pine tar. The boat can take a crew of 14 oarsmen and one helmsman.

Conclusion

After several experiments, the main problem we encountered is the weak archaeological base of the log-boats, and the partial or complete lack of quality dating of the found samples. The main sources, in addition to archaeological ones in this study, were ethnological data and information from written sources, which do not yet allow to open a complete picture of the process of building log-boats. In the future, we plan to continue working in this area and involve in our research archaeological findings from neighbouring lands.

References

De Administrando Imperio. By Constantine VII Porphyrogenitus. Greek text edited by Gy. Moravcsik with English translation by R. J. H. Jenkins. Washington, D. C.: Dumbarton Oaks, 1967, revised edition, 57-59.

Гайдук, С., Петраускас, А. and Смагін, І. 2020. Експериментальні дослідження стародавніх водних транспортних засобів і водних шляхів, *Археологічні дослідження в Україні 2019,* 416-418.

Дубровин, Г. 2000. *Водный и сухопутный транспорт средневекового Новгорода X-XV вв*, Москва.

Дубровин, Г. 2002. Находки с Федоровского раскопа в Новгороде, связанные с водным транспортом, *Краткие сообщения Института археологии РАН. Вып.* 213, 109-122.

Журавлева, Ю. and Чубур, А. 2010. Средневековое судостроение в Юго-Восточной Руси (бассейны Десны и Оки) по археологическим источникам, *Вопросы подводной археологии*. 25-44.

Мазурик, Ю. and Хомич, П. 2015. Підводна археологічна знахідка біля с. Старосілля Маневицького району: давній човен-довбанка знайдений під крутим берегом річки Стир, *Минуле і сучасне Волині та Полісся. Місто Володимир-Волинський та Побужжя у світовій та українській історії. Успенський собор в історії міста Володимира-Волинського та України. Науковий збірник. Випуск 55. Матеріали 55 Всеукраїнської наукової історико-краєзнавчої конференції,* 393-398.

Мазурик, Ю. and Хомич, П. 2016. Знахідка човна-довбанки на річці Стир на Волині, *Археологічні дослідження в Україні* 2015, 22-24

Онищук, А. 1929. Виріб човна в с. Старосіллє Остерського повіту на Чернігівщині, *Матеріяли до етнології й антропології,* Том XXI-XXII, частина I, 7-24.

Толочко, О. 2008. «Правда руская» и звенигородская берестяная грамота №2, *Palaeoslavica* XVI/1, 276-278.

Чубур, А. 2004. Древнерусская ладья-однодревка из летописного Вщижа, *Российская археология* №3, 171-174.

Чубур, А. 2008. О предпологаемом парусном вооружении Вщижской ладьи, *Деснинские древности* V, 152-156.

Юшков, С. 1935. *Правда руська*, ВУАН, Київ.

We do need an education: youth participation programmes as a method in archaeology dissemination

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https://doi.org/10.17234/METARH.2022.13

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Community archaeology, as a part of public archaeology, is primarily based on the need to include diverse subjects in the interpretation of the past, implying the mutual education of archaeological heritage professionals and the community itself. The focus of such an approach is particularly the younger population, targeted through schools and teachers, as an involvement priority. Though we cannot talk about the systematic development of the community archaeology in Serbia, there have been some lasting benefits achieved through participatory programmes targeted at the education of youth. They could serve as representative models for the development of a suitable methodology that we have recognized as a possible addition to the archaeology dissemination, which is missing in the general education in Serbia. On this occasion, we will point out some practices conducted in the Viminacium archaeological park, through children's camps and workshops, the Young Romans programme and tourism student internships. Thanks to maintaining the continuous process of their realization and widening the scope of partners` network as well as insisting on permanent cooperation with the representatives of the official formal education, the benefits of this methodology can be raised to the national level. Thus the knowledge about archaeology and the values of cultural heritage can be implemented into the formal educational system from the earliest age to student days, which would ensure that those with appropriate interest may choose the professions related to heritage more easily. In addition, the whole generations may be taught to actively co-exist with their cultural heritage knowing how to preserve it in a more responsible way.

Keywords: *public (community) archaeology, participation, dissemination, education,* Viminacium

Introduction

In the scientific literature the term public archaeology dates back to 1972 when it was acknowledged that the essence of the concept involves the necessity of archaeological heritage conservation for the sake of the general public`s need and right to learn about heritage (McGimsey 1972: 5). Besides, this led to the standpoint that archaeology cannot remain exclusively in the academic field, nor can it be separated from external interests and the contemporary society permeated by various cultural, economic and political influences (Matsuda 2004: 67). However, until now the numerous definitions specified by researchers have not been completely aligned and unified in terms of the modality of public archaeology. According to some authors public archaeology comprises any archaeological activity which achieves interaction with the general public (Schadla-Hall 1999: 147), but it can also be viewed as a sub-discipline which deals with problems that arise when archaeology is transferred to the real world abounding in economic conflicts and political combat, which makes it an object of ethical consideration (Ascherson 2000: 2). Although these approaches do not define the phenomenon of public archaeology precisely, but they rather determine it as a socio-cultural notion, it can be concluded that its fundamental focus is on the relationship between archaeology and the general public, i.e. the audience (Matsuda 2004: 68), so that it represents "the management of the national archaeological heritage in the public interest" (Simpson and Williams 2008: 72). Also, within the notion of public archaeology the concept of community archaeology frequently emerges entailing the participation of the community and its representatives in archaeological activities or projects related to heritage conservation and valorisation. In these processes, education represents an important segment and the aim of this paper is to present examples of such practices in the Viminacium archaeological park. Special emphasis is put on programmes where the young population actively participates because the influence of these programmes is very significant for the constitution of the archaeology knowledge dissemination method. Such methodology could serve as an addition to the formal education in Serbia, where this science is not sufficiently present in existing curricula.

Public archaeology and participation as a methodological frame for dissemination

The field of public archaeology comprises a wide range of topics: the issues of illegal excavations and trade; privatization and human rights in archaeology; featuring archaeology in films, TV and other media; the activities of local communities in the campaigns to conserve cultural heritage or excavation sites; the research into the demography of visitors to archaeological sites and the presence of archaeology in educational programmes (Acherson 2000: 2; Moshenska 2017: 3-4). However, such an inclusive definition of public archaeology as a practice where archaeology opens up to the real world differs from the narrower sense of public archaeology as a synonym for the influence of archaeologists in public. Due to the need to align these approaches a typology of public archaeology was established where the following concepts are distinguished: archaeologists working with the public, archaeology by the public, public sector archaeology, archaeological education, open archaeology, popular archaeology and academic public archaeology (Moshenska 2017: 9-10, fig. 1.1.).

The theoretical frame that serves as a methodological ground for educational activities presented in this paper is based on the synthesis of the three above-mentioned typological fields: archaeologists working with the public, public sector archaeology and archaeological education. The first one is related to the common inclusive concept of public archaeology, which often comprises community archaeology i.e. the work conducted by professionals where the members of the general public and local community are also involved. These projects are usually realized by museums, commercial archaeological departments, university departments or local authorities, sometimes in partnership with schools or specific communities and today, such practice is recognized throughout Europe and America (Simpson and Williams 2008; Nevell 2014; Dhanjal et al. 2015; Moshenska 2017: 6). The basis of such practice can be found in the changes in the theory of archaeology during the last decades of the 20th century, when democratisation in the interpretation of material cultural heritage occurred, enabling a wide range of meanings of an artefact or historical landscape to be formed from different perspectives, which consequently led to the acceptance of the significance of local communities in the process of the comprehension of the past and cultural heritage preservation (Thomas 2017: 14-15).

The next typological category we sequenced is public sector archaeology which includes the activities of all entities at a regional, national and local level which are financed by governments with the aim to manage, preserve, study and communicate archaeological heritage (Moshenska 2017: 7). Finally, the typology which comprises archaeological education is based on the principle that experts have a duty to share their knowledge with those who show interest and respect to the heritage so that heritage can be properly used as a resource. This is achieved through various methods such as expert activities in museums or on sites encompassing informal talks or guided tours, workshops and organized trainings or educational programmes in certain countries (Henson 2004; Baxter 2009; Corbishley 2011; Moshenska 2017: 8). It is necessary to emphasise that the educational efforts of professionals are usually targeted at younger members of the society, especially through schools or activities of teachers enthusiasts, as it ensures a greater effect as the initiative for participation usually does not come from the young (Smardz and Smith 2000; Hansen and Fowler 2008: 332; Jeppson and Brauer 2008; Corbishley 2011: 76-199). In addition, it is important to note that the central point of educational activities about archeology are based on the fundamental principles of this scientific discipline such as learning about the past and from the past or heritage management which ensures the connection of the general public with their own past. As this entails emotional, and not purely intellectual experience (Henson 2017: 45), young generations are the most open to such involvement.

However, the perception of public archaeology or comunity archaeology in our country shows that they are not understood properly, and their processes are often identified as equal to or intertwined with popular archaeology[1] with sporadic realization of activities (Cvjetićanin 2019; 794, 797, 804). Due to the need to change this situation as well as "the perception of archaeological remains in our country rather as an obstacle than an oportunity" (Crnobrnja 2017: 89), we would like to emphasise that it is necessary to create a serious strategic plan in the domain of public archaeology and to put it in action. In our opinion, the key role in this can be seen in participation, bearing in mind that it reflects the changes in contemporary practices of executive authorities and the need to involve various stakeholders including those outside the traditional field of politics. That is why today the emphasis is put on the encouragement of local comunities to take part in cultural activities for the sake of enjoyment along with the so-called political participation, as these are related by the common narrative based on the values of the heritage itself which motivates people to participate in its conservation and derive benefits from it (May 2020: 1). Since this shows the tendency of modern society, its authorities and citizens, to accept the responsibility for heritage and to take steps to preserve it together as much as possible (Димитријевић-Марковић 2010: 186, note 6), in this paper we will point at the potential of its application in education, as an excellent foundation for essential changes within the above mentioned archaeological discipline in our society.

[1] Popular archaeology includes processes where the general public is acquainted with archaeology and its accomplishments through media and popular culture, which may lead to superficial and overly romanticized interpretation of heritage. However, it is held that these activities achieve best effects in terms of procuring political, cultural and economic support to heritage (Holtorf 2007; Moshenska 2017, 9-10).

Participative programmes for the young as educational methodology in the practice of the archaeological park of Viminacium

The archaeological park of Viminacium was founded in 2006 on the site of a Roman military camp and capital of the Roman province Moesia Superior, whose remains lie under the fields in the area of around 450 hectares. This excellent strategic position, in the fertile valley among the Danube and Mlava rivers, was where a military camp of two legions - *IV Flavia* and *VII Caudia* was located in the first decades of the 1st century. Somewhat later, a civil settlement developed on this spot which gained the status of municipium in the 2nd century and the status of a colony during the reign of Emperor Gordianus, when the production of local coins started there (Борић-Брешковић 1986). From the 3rd century onwards, unlike the situation throughout the Empire, Viminacium had large economic, strategic and cultural growth, with approximately 30 000 inhabitants. The city was destroyed during the Hunnic invasions in 441/443 AD (Спасић-Ђурић 2015). Despite the fact that this is one of the rare European sites which is not located under a modern town, today only slightly more than 3% of its area have been explored (Anđelković Grašar et al. 2013: 9). The first excavations in Viminacium began at the end of the 19th century, but only since the 1970s the continuous excavations have been conducted under the supervision of the researchers of the Archaeological Institute in Belgrade in cooperation with the Institute for the Protection of Cultural Monuments of Serbia.[2] Since the beginning of the new millenia, the research has been carried out by an interdisciplinary team of the Institute of Archaeology with the aid of new technologies. Thanks to this research some of the objects originating from the civil settlement, military camp and necropolis zone have been exhibited and presented to the audience (Anđelković Grašar et al. 2013: 10, no. 4-10). After opening to the public, Viminacium finally gained its permanent protection in 2009 in regard to the activities of the strip mine and illegal looting.[3]

The very first basis of the itinerary in Viminacium included the connection among three protected objects at that moment: *Porta praetoria*, *Thermae* and the Mauso-

[2] The site has been under state protection since 1949, while in 1979 it was declared a cultural monument of exceptional importance (Milić and Pejić 1998:19).

[3] More about Viminacium protection in: Nikolić et al. 2013, 213-222; Nikolić et al. 2017, 573-583.

Figure 1. Viminacium Archaeological Park and *Domus Scientiarium*. Source: documentation of the Institute of Archaeology, Belgrade (Viminacium project).

leum of Emperor Hostilian who was probably deceased in Viminacium (Korać et al. 2009: 98-99). Along with the efforts to present the archaeological finds, from the very start lots of attention has been paid to the methods of heritage interpretation and other means of communication with the visitors, in order to transfer knowledge about Roman culture such as reviving the authentic taste of Roman food or souvenirs that are replicas of the original items found during excavation works (Anđelković Grašar et al. 2013: 12). Besides, all necessary tourist infrastructure have been provided starting from the access road, parking lot, walking paths, souvenir shop and a building named *Domus Scientiarum Viminacium* which serves as a scientific, research and visitors centre (Anđelković Grašar et al. 2013: 13; Anđelković Grašar et. al. 2020: 260) (Fig. 1).

The complexity of the management of such cultural heritage site is reflected in the fact that archaeological research has been conducted there parallel with the activities created by its tourist valorisation, representing a good example of modern trends in archaeological sites management which strive to achieve sustainable development (Loulanski and Loulanski 2016: 7). Also, a holistic approach to management (UNESCO 2013: 15), can be noticed in the endeavour to create partnership networks i.e. to achieve the inclusion of various stakeholders (research institutes, tourism organizations, local authorities, relevant ministries, museums, tourists, local community etc.), while it is significant to emphasise that participation has been present as a strategic commitment in the work of the Viminacium Archaeological park. Namely, the local community has been involved in various jobs from the very beginning, which has led to their appropriate education due to the many years of cooperation of the researchers and the residents so that they actively take part in the processes of conservation and presentation of the archaeological heritage. In addition, the scope of illegal excavations have been reduced as well as illegal trade related to archaeological finds, since the representatives of the local community have developed awareness of the value of the heritage having bonded with it and thus becoming its invaluable guardians (Nikolić et al. 2017: 575-576; Anđelković Grašar et. al. 2020: 261-263). Such a concept is an excellent starting point for numerous educational programmes as

Figure 2. Young Romans, living history at Viminacium. Source: documentation of the Institute of Archaeology, Belgrade (Viminacium project).

Figure 3. Young Romans, living history at Viminacium. Source: documentation of the Institute of Archaeology, Belgrade (Viminacium project).

dissemination is one of the dominant activities of Viminacium, realized through numerous activities such as scientific gatherings and conferences, exhibitions, educational programmes for children and youth in the form of camps, workshops etc.[4]

On this occasion, we have singled out a few examples of participation programmes targeted at the education of youth. They can constitute representative models for the development of a suitable methodology which could serve as an addition to the knowledge about archaeology in formal educational curricula in Serbia. First, we will mention the programme *Young Romans* which is the basis of education for children in Viminacium Archaeological park, with the aim to acquaint them with the cultural heritage and the way of life in antiquity (Figs. 2-4). In this programme children wear costumes and spend time in the authentic ambience of *Domus*, taking part in recreating various Roman customs and games, so that through direct participation in accordance with the so-called principle of *living history*[5] they actively

Figure 4. Young Romans, living history at Viminacium. Source: documentation of the Institute of Archaeology, Belgrade (Viminacium project).

learn about the heritage from their surroundings.[6] Also, this concept supports new postulates which show that today's cultural heritage needs to get closer to the so-called spectacle culture, enabling communication with younger generations in the audience. Simultaneously the success of spectacle culture is based on the need of the audience to leave the traditionally passive role, so that, thanks to interaction, learning becomes a supreme entertainment (Ognjević 2013: 152, 154). An indicator of the appeal of the educational programme *Young Romans* and its role in the creation of a better relationship

4 For several years children scientific camps in organization of InterSection – Centre for Science and innovation were held at Viminacium Archaeological Park, while via Erasmus+ programme project "Danube-camps" was held in 2021 in Viminacium Limes Park, hosting 13-year-old pupils from five different EU countries and Serbia.

5 One of the forms of imediate interpretation, especially popular in the USA, is the concept of *living history* or *living heritage*, when the professional staff, usually curators in appropriate costumes, speak to the audience in the role of a historical figure who reconstructs the past. It is important to mention that in the former literature the educational character of this concept was questioned, although it was held that it certainly had an exceptional visual appeal (Reisinger and Steiner 2006).

6 For the purpose of education and promotion of the archaeological site of Viminacium board game "Mistery of the Emperor's death" was created by an archaeologist, PhD Nemanja Mrđić. About the programme Young Romans and the game, see: Mrđić 2012: 124-126.

Figure 5. *Defixiones* project, clay with Latin curse. Photo by: J. Radenković, documentation of TRAME project.

Figure 7. *Defixiones* project, finding fragments. Photo by: J. Radenković, documentation of TRAME project.

Figure 6. *Defixiones* project, excavations. Photo by: J. Radenković, documentation of TRAME project.

between the heritage and the audience is the fact that the researchers from the Institute of Archaeology in Belgrade who had taken part in its creation and realization continue to apply their practical knowledge through the conceptually similar programmes in the region. Also, that is how excellent cooperation has been formed with future professionals i.e. the Archaeology Students Club from the Faculty of Philosophy at Belgrade University which was presented through educational workshops at Roman games in Ptuj in 2021 with great reception in the audience, especially among the young (Anđelković Grašar et al. 2021a; 2021b).

Also, participation programmes that are related to teaching units in formal education which are realized in the authentic setting such as the archaeological park of Viminacium, show multiple benefits as the results attest: they encourage students to acquire knowledge more easily through the so-called creative learning and simultaneously enable forming a relationship between the heritage and the participants which ensure the better acquisition of knowledge from the field of archaeology. This kind of initiative is recognized on EU level and supported by Erasmus + project TRAME (Tracce di memoria 2020-1-IT02-KA201-079794) in which best practices of non-formal and practical learning were researched and

Figure 8. *Defixiones* project, making the whole. Photo by: J. Radenković, documentation of TRAME project.

WORKSHOP EVALUATION (Education unit goals)	Completely realized	Mostly realized	Partially realized	Not realized
The students' have shown that they understood the learning subject in class because they know how to apply it and explain how they came to the solution in the changed conditions of the workshop on the site (this indicator is especially noticeable in the excavation that ended the project).	YES			
The students connect the subject of learning with previously learned in different areas, professional practice and everyday life.	YES			
The students actively contributed to the quality of the project thanks to their comments (projects' evaluation and improvement).		YES		
In an atmosphere of mutual respect, the teacher of practical classes establishes and maintains discipline in accordance with the agreed rules (which is especially contributed by the pleasant atmosphere of the environment).	YES			
The activities in the project are diverse, so that each student can find something close to their interests and personal preferences.	YES			

Table 1. *Defixiones* project evaluation – Education unit goals.

Great organisation and hospitality of proffesionals on the site	50%
Acquisition of new knowledge about Roman history/archaeology in an interesting way	65%
I would gladly visit Viminacium again/ Participate in the similar projects again	50%
Stay and workshop in Viminacium are extremely positive experience	100%

Table 2. *Defixiones* project evaluation - Most common impressions of students who participated.

used as the basis of TRAME innovative methodology aiming to present cultural heritage as the basis in the educational process towards the youth (Анђелковић Грашар 2021: 85; Nocita 2021: 180-185). One of the best practices from Serbia is the project named *Defixiones* which was realized within the school subject of Latin language in the High School in Požarevac, entailing six classes during the week as well as weekend classes in Viminacium. The weekend programme included Latin sayings (curses) which had been previously written on clay plates, then baked, broken into parts and dug in the soil. After that, the students took the role of archaeologists and excavated the fragments with the aim to join them and recreate the appropriate whole (Figs. 5-8). After a short practical training on the spot, the students got acquainted with the method of work of archaeologists and acquired knowledge showing that this kind of education can be very efficient. During the evaluation of the project and the quality of its practical realization, the students actively took part in the analysis of the applied methodology and thus cooperated with the teacher in a better way, while it was evident that the creativity of the approach encourages individual response to the task and the opportunity to develop individual methods of the approach to problem-solving (Table 1). On the other hand, the positive aspects of the project in terms of archaeology apart from the participation in the field practice training relate to the high degree of the participant's satisfaction with the realization of the project in the archaeological park of Viminacium, then significant bonding of the students with the heritage (50% expressed their wish to revisit it), while the hospitality of the researches who welcomed them as well as the method of knowledge acquisition also received high grades in the survey (Table 2).[7]

Permanent partners of the archaeological park of Viminacium among educational institutions include a college of applied studies which educates professionals in the field of tourism industry i.e. The Academy of Applied Studies Belgrade, with the College of Tourism as its department, where students regularly participate in an internship programe lasting for several months. As this is a longer stay, future professionals have an opportunity to get to know all the segments of archaeology park management with all its complexity. They can also gain knowledge about the conservation and presentation of archaeological artefacts as well as the basics of excavating, together with data about Roman history and way of life which is a necessary prerequisite for heritage interpretation. What may be the closest to their future position of tourism professionals is the opportunity to get familiar with the possibility of organizing guided tours, which requires a certain degree of flexibility given that various categories of visitors arrive at the site. Additionally, one of the most significant benefits arising from this cooperation can be noticed in the student`s evaluation survey concerning the aspects of the internship (Table 3). We will single out two of these. First, while 50% of the students stated that they could apply theoretical knowledge in practice, the rest of them was less sure or neutral, which reflects the need to implement changes

7 We express special gratitude to teacher Jovana Radenkovic from The High School in Požarevac who was the leader of this project and who supplied the data about evaluation that we used to create tables in this paper.

INTERNSHIP EVALUATION	Strongly agree	I agree	Neutral	I don't agree	Strongly disagree
Satisfied with the organization where I did my internship	100%				
Satisfied with the communication of the mentors in the organization	100%				
Satisfied with the acquired knowledge regarding the structure (management) of the organization	75%	25%			
I had the opportunity to apply theoretical knowledge in practice	50%	25%	25%		
The internship helped me identify additional interests	50%		25%	25%	
The internship helped me to recognize the area of further professional development	75%	25%			
Satisfied with the entire experience gained during the internship in Viminacium	50%	50%			

Table 3. Evaluation of tourism students internship in Viminacium.

or adaptations in curricula so that they align with the real trends in practice, especially in terms of this type of guiding. Since in this case, a classical tour guide cannot perform the task well, but it would be more appropriate for a professional with wide in-depth knowledge of archaeological heritage and the techniques of its interpretation, along with excellent interpersonal skills, there is an evident need for intersectoral cooperation which would result in the education of a new type of professionals i.e. certified heritage interpreters (Plemić and Rabotić 2018: 128). Heritage interpreters would cover a wide range of positions, starting from tailored guided tours on sites, to educational activities in local communities as well as cooperation with institutions of formal education through campaigns aimed at raising awareness of the significance of cultural heritage. Their potential role would be of great importance for the better valorisation of archaeological heritage in Serbia, the development of heritage tourism and archaeo-tourism as a specific tourist niche on our market. Furthermore, another important data obtained through the above-mentioned evaluation points at the fact that after the completed internship in Viminacium, 75% of students believe that the experience helped them determine the next area of professional training, which attests that they recognize the need for narrowing their professional profile.

Conclusion

In this paper our aim was to point at two important strategic concepts in the work of the archaeological park of Viminacium: their orientation towards participation and their dedication to education,[8] which can give good results through an integrated approach in terms of knowledge acquisition in the field of archaeology and better bonding of the young with cultural heritage. From the above-mentioned examples of good practice, we could conclude that it facilitates the acquisition of lessons in formal education which are not directly related to archaeology, encouraging students` creativity and personal interest in Roman culture, which is the best method to form the audience who will have an appropriate attitude to cultural heritage. Moreover, such participation programmes may be an important addition to the knowledge about archaeology presented in formal educational institutions. Given the fact that topics related

[8] The emphasis on the educational character of the contents in the archaeological park of Viminacium can be proved by the fact that the school excursions amount to the highest percentage of all annual visits. In 2018, school trips amounted to 46% of all annual visits, while in 2019 they comprised 54%. We express our thanks to Dubravka Tomić, the manager of the tourism sector of Viminacium, who gave us access to the above mentioned data.

Figure 9. Entrance to Viminacium Limes Park. Source: documentation of the Institute of Archaeology, Belgrade (Viminacium project).

to archaeological heritage are scarcely present in their curricula, there is also space for consideration of the possibility of integrating them as a permanent supplement to the education system in Serbia. Although until now the participants in the above-mentioned projects mostly belonged to local communities (e.g. the students in the *Defixiones* project come from Požarevac which is the town nearest to the site, while internship in Viminacium was mainly chosen by the students whose families live near the site, for practical reasons), maintaining the continuous process of their realisation and widening the scope of partners` network as well as insisting on permanent cooperation with the representatives of the official formal education, the benefits of this methodology can be raised to the national level. Thus the knowledge about archaeology and the values of cultural heritage can be implemented into the above-mentioned system from the earliest age to student days, which would ensure that those with appropriate interest may choose the professions related to heritage more easily. Also, in a such way whole generations may be taught to actively co-exist with their cultural heritage knowing how to preserve it more responsibly.

Based on this positive experience and youth response Viminacium Archaeological Park enlarged its capacities since 2018, by the building project of Limes Park which purpose can be defined as an educational centre. This complex consists of two large conference/lecture/workshop halls, a kitchen and dinning room, as well as six barracks for possible accommodation of 480 children. It is built in a form to resemble a Roman military camp (Fig. 9). In addition there is a polygon with obstacles, and an adventure park (Korać 2019: 459-490). All these together represent the necessary infrastructure for hosting large educational projects with facilities which could provide undisturbed work for children and youth.

References

Анђелковић Грашар, Ј. 2021. Интерпретација културног наслеђа и формално образовање: ''TRAME'' Еразмус+ пројекат као пример добре праксе, *Српско археолошко друштво XLIV скупштина и годишњи скуп, Параћин, 14. – 16. октобар 2021. године*, *Програм, извештаји и апстракти*, Параћин, 98.

Anđelković Grašar, J., Rogić, D. and Nikolić, E. 2013. Viminacium Archaeological Park – Modern Code for Re-reading the Past of the Roman City and Legionary Camp, In: J. Popielska-Grzybowska and J. Iwaszczuk (eds.), *Studies on Disasters, Catastrophes and the Ends of the World in Sources*, Acta Archaeologica Pultuskiensia, vol. IV, Pultusk, 9-16.

Anđelković Grašar, J., Nikolić, E. and Tapavički-Ilić, M. 2020. Viminacium Archaeological Park as an Instrument of Integration of the Local Community into the Protection of Cultural Heritage, In: R. Carmenati, M. Giuliodori and J. Piccinini (eds.), *Roma e il mondo Adriatico dalla ricerca archeologica alla pianificazione del territorio*, Roma, 259-270.

Anđelković Grašar, J., Mladenović, M., Gavrilović, A., Grujić, D., Đerković, P., Perić, P. and Ilić, I. 2021a. Archaeology Workshops as an Educational Approach in Communication with the Public – Case Study Roman Games in Ptuj, *Archaeology and Science* 17, 135-146.

Anđelković Grašar, J., Tapavički-Ilić, M., Gavrilović, A., Bondžulić, K. and Đorđević, M. 2021b. Paths of Storytelling Focused on Archaeology and its Outreach Potential – Case Study Roman Games in Ptuj, *Archaeology and Science* 17, 147-158.

Ascherson, N. 2000. Editorial, *Public Archaeology* 1(1), 1-4.

Baxter, J. E. 2009. *Archaeological Field Schools: A Guide for Teaching in the Field*, CA: Left Coast Press, Walnut Creek.

Борић-Брешковић, Б. 1986. Реверсне представе на новцу колоније Виминацијума, *Зборник Народног музеја* XII-1, 138–142.

Corbishley, M. 2011. *Pinning Down the Past: Archaeology, Heritage and Education Today*,

Boydell, Woodbridge.

Crnobrnja, A. 2017. Arheološko nasleđe u Srbiji danas – briga države ili posao entuzijasta, *Moderna konzervacija* 5, 77-96.

Cvjetićanin, T. 2019. Teren i javna arheologija (ili Zašto je potrebno preispitivati i naizgled jasne veze?), *Etnoantropološki problemi*, n.s. 14/3, 789-809.

Dhanjal, S., Flinn, A., Lockyear, K. and Moshenska, G. 2015. Dig where we stand, In: K. Lockyear (ed.), *Archaeology in Hertfordshire: Recent Research*, University of Hertfordshire Press, Hatfield, 326-334.

Димитријевић-Марковић, С. 2010. Учешће грађана као предуслов за успешну заштиту наслеђа, *Наслеђе* 11, 185-192.

Hansen, D. and Fowler, J. 2008. Protect and present: Parks Canada and public archaeology in

Atlantic Canada, In: J. Jameson and S. Baugher (eds.), *Past Meets Present: Archaeologists Partnering with Museum Curators, Teachers and Community Groups*, Springer, New York, 321-338.

Henson, D. 2004. Archaeology in schools, In: D. Henson, P. Stone and M. Corbishley (eds.), *Education and the Historic Environment*, Routledge, London, 23-32.

Henson, D. 2017. Archaeology and education, In: G. Moshenska (ed.), *Key Concepts in Public Archaeology*, University College London Press, London, 43-59.

Holtorf, C. 2007. *Archaeology is a Brand! The Meaning of Archaeology in Contemporary Popular Culture*, Archaeopress, Oxford.

Jeppson, P. and Brauer, G. 2008. Archaeology for education needs: An archaeologist and an

educator discuss archaeology in the Baltimore County public schools, In: J. Jameson and

S.Baugher (eds.), *Past Meets Present: Archaeologists Partnering with Museum Curators*,

Teachers and Community Groups, Springer, New York, 231-248.

Korać, M. 2019. *Viminacium Urbs et Castra Legionis: Research, Protection, Presentation and Valorisation*, Institute of Archaeology, Belgrade.

Korać, M., Golubović, S. and Mrđić, N. 2009. *Itinerarium Romanum Serbae: Road of Roman Emperors in Serbia*, Center for New Technologies Viminacium.

Loulanski, V. and Loulanski, T. 2016. Interdisciplinary Integration of Heritage Studies and Sustainable Development, In: V. Katsoni and A. Stratigea (eds.), *Tourism and Culture in the Age of Innovation, Second International Conference IACuDiT*, Athens 2015, 1-15.

Matsuda, A. 2004. The Concept of ''the Public'' and the Aims of Public Archaeology, *Papers from the Institute of Archaeology* 15, 66-76.

May, S. 2020. Heritage, endangerment and participation: alternative futures in the Lake District, *International Journal of Heritage Studies*, 26:1, 71-86.

McGimsey, C. R. 1972. *Public Archeology*, Seminar Press, New York.

Milić, M. and Pejić, S. (eds.) 1998. *Spomeničko nasleđe Srbije: Nepokretna kulturna dobra od izuzetnog i velikog značaja,* Republički zavod za zaštitu spomenika kulture, Beograd.

Moshenska, G. 2017. Introduction: public archaeology as practice and scholarship where

archaeology meets the world, In: G. Moshenska, (ed.), *Key Concepts in Public Archaeology*, University College London Press, London, 1-13.

Mrđić, N. 2012. Roman Cultural Heritage as a Tourist and Educational Resource, In: R. Chowaniec and W. Więckowski (eds.), *Archaeological Heritage: Methods of Education and Popularization*, BAR International Series 2443, Archaeopress, Oxford, 121-127.

Nevell, M.D. 2014. Community archaeology at the University of Salford: 2009 to 2013, *The Museum Archaeologist* 35, 17-21.

Nikolić, E., Anđelković Grašar, J. and Rogić, D. 2017. Viminacium. Research, Protection, Recognition, In: J. R. Dos Santos (ed.), *Preserving Transcultural Heritage: Your Way or My Way? Questions on Authenticity, Identity and Patrimonial Proceedings in the Safeguarding of Architectural Heritage Created in the Meeting of Cultures*, Lisboa, 573-583. https://doi.org/10.30618/978-989-658-467-2_52

Nikolić, E., Rogić, D. and Anđelković Grašar, J. 2013. Catastrophes as an Inevitable Result of Civilizations Flow: Relocation and Dislocation of Historical Physical Structures at the Archaeological Site of Viminacium, Serbia, In: J. Popielska-Grzybowska and J. Iwaszczuk (eds.), *Studies on Disasters, Catastrophes and the Ends of the World in Sources*, Acta Archaeologica Pultuskiensia vol. IV, Pułtusk 2013, 213-222.

Nocita, M. 2021. TRAME antiche e moderne per un nuovo tessuto europeo, in: G. Chiarilli (ed.), *Roma vocazione all'accoglienza e senso di comunita dalla storia al contamporaneo*, Palombi editori, Roma.

Ognjević, T. 2013. Archaeological heritage and modern spectacle as cultural entrepreneurship experiment, *Archaeology and Science* 9, 149-154.

Plemić, B. and Rabotić, B. 2018. Uloga interpretacije u promociji arheološkog nasleđa Srbije, In: M. Stanišić (ed.), *Kultura, nasleđe i razvoj turizma, SITCON (Singidunum International Tourism Conference) 2018*, Univerzitet Singidunum, Beograd, 123-130.

Reisinger, Y. and Steiner, C. 2006. Reconceptualising Interpretation: The Role of Tour Guides in Authentic Tourism, *Current Issues in Services* 9(6), 481-498.

Schadla-Hall, T. 1999. Editorial: Public Archaeology, *European Journal of Archaeology* 2(2), 147-158.

Simpson, F. and Williams, H. 2008. Evaluating community archaeology in the UK. Public, *Archaeology* 7(2), 69–90.

Smardz, K. and Smith, S. (eds.) 2000. *The Archaeology Education Handbook: Sharing the Past with Kids*, CA: AltaMira Press, Walnut Creek.

Спасић-Ђурић, Д. 2015. *Виминацијум. Главни град римске провинције Горње Мезије*, Народни музеј Пожаревац, Пожаревац.

Thomas, S. 2017. Community archaeology, In: G. Moshenska (ed.), *Key Concepts in Public Archaeology*, University College London Press, London, 14-30.

UNESCO 2013. *Managing Cultural World Heritage, UNESCO – World Heritage Centre*, Paris. https://whc.unesco.org/document/125839 (Accessed: 10.03.2022).