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METHODOLOGY & ARCHAEOMETRY

Zagreb, 7th – 8th December 2023

12TH INTERNATIONAL SCIENTIFIC CONFERENCE

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PROCEEDINGS

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Content

1 2 3 4 5 6 7 8 9 10 11 12

MetArh

Preface

Ina Miloglav

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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. https://metarh.ffzg.unizg.hr/

This volume of *Proceedings from the 11th and 12th scientific conferences Methodology and Archaeometry* brings together a selection of papers that explore diverse methodological approaches in contemporary archaeological research, and the application of archaeometric techniques in the documentation, analysis, and interpretation of archaeological data.

The 11th MetArh conference was held on the 7th and 8th of December 2023, and the 12th MetArh conference took place on the 28th of November 2024 at the Faculty of Humanities and Social Sciences, University of Zagreb. Both events brought together researchers from several countries who presented recent results and discussed current challenges in fieldwork, analytical procedures, and interpretative frameworks.

The paper by **Martin Bažoka, Mario Bodružić, Filomena Sirovica, and Lujana Paraman**, *Uncovering Lithic Artefacts in the Dinaric Karst: Challenges of Field Survey in Bristivica near Trogir*, addresses the methodological challenges of conducting field surveys in the Dinaric karst landscape**,** where environmental and anthropogenic factors have heavily transformed the surface archaeological record. Focusing on the area of Bristivica near Trogir, the authors present an artefact-based survey approach adapted to fragmented and vegetation-covered terrain, enabling the detection of lithic artefacts and chert scatters under difficult field conditions. The results emphasise the importance of adapting survey strategies to complex environmental conditions.

In *The use of 3D photogrammetry in analysing the Roman epigraphic monuments: a case study from Kremna village, southwestern Serbia*, **Predrag Đerković** demonstrates the potential of 3D photogrammetry for documenting and analysing Roman epigraphic monuments. His case study highlights how this technology enhances both the preservation and interpretation of stone inscriptions.

Denitsa Sandeva-Minkova, in her paper *Non-destructive methods for registration of archaeological sites and destructive investigation on the territory of the Ludogorsko Plateau, Northeastern Bulgaria*, combines satellite imagery analysis and geophysical surveys to identify and verify archaeological sites from the Bronze and Iron Ages. Her discussion underscores the importance of an integrated methodological approach to recording and assessing archaeological sites, offering new insights into the settlement dynamics of this region.

In his paper *Building materials and the constructional sequence of the burial mound Gomila in Jalžabet*, **Saša Kovačević** presents the results of the rescue excavation of Gomila, one of the largest funerary monuments of the Eastern Hallstatt culture. The study focuses on the construction sequence and building materials of the complex burial chamber, while the analysis provides new insights into the architectural organization and ritual practices that characterize this archaeological site.

In *Interpretive analysis of pottery distribution in the northern part of the late antique hilltop settlement in Lobor, NW Croatia*, **Petra Nikšić and Jana Škrgulja** provide an interpretive spatial analysis of ceramic distribution patterns, offering insights into the internal organization and developmental dynamics of a Late Antique hilltop settlement. The results reveal pottery clusters corresponding to destroyed architectural remains, offering insights into building techniques and the integration of the Lobor site within broader regional settlement patterns.

The study by **Mirja Jarak, Andreja Sironić, and Alexander Cherkinsky**, *Building phases of the triconch church complex at Bilice with regard to mortar dating*, presents the results of mortar radiocarbon dating, contributing to a refined understanding of the construction sequence of the triconch church complex at Bilice and to the methodological validation of archaeometric dating techniques in architectural research.

Finally, **Andrej Janeš and Tomislav Zojčeski**, in *Long time, no siege: non-invasive archaeological methods in the research of Cesargrad castle*, present the results of non-invasive investigations of the medieval Cesargrad Castle, combining the analysis of standing structures with LiDAR survey data to reconstruct the castle's layout and surrounding fortifications. Their study refines the understanding of the site's construction phases and reveals previously unknown features that may represent military installations or siege positions associated with the 1573 Peasant Uprising.

Together, these contributions demonstrate the growing importance of methodological and technological innovation in archaeology. Through interdisciplinary collaboration, the authors advance new standards of research practice and open avenues for further cooperation between archaeologists and natural scientists.

On behalf of the editorial board, we wish to thank all authors and conference participants for their valuable contributions to the exchange of knowledge and the development of contemporary archaeological and archaeometric practice.

Uncovering Lithic Artefacts in the Dinaric Karst: Challenges of Field Survey in Bristivica near Trogir

Martin Bažoka, Mario Bodružić, Filomena Sirovica, Lujana Paraman

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The Dinaric karst landscape presents challenging conditions for the implementation of standard field survey methods. The ubiquitous practices of intensive field clearance and a high level of parcellation of arable land resulted in various types of drystone walls and stone cairns at the edges of fields. In the Dalmatian hinterland, this practice was the main agency of intensive transformation of the landscape and thus the cause of alteration of the surface archaeological record. These factors resulted in a landscape fragmented into small drystone-bounded fields that are mostly unconnected and thus do not form continuous surfaces favourable for field survey practices. On the other hand, the recent general abandonment of agricultural activities, as a consequence of the continuous deruralisation of the Dalmatian hinterland, resulted in an increase in dense vegetation on abandoned fields, significantly reducing the surface soil's availability and visibility.

For these reasons, this paper presents an artefact-based field survey approach, adapted to the described conditions, simultaneously aimed at recording types of surveyed units (drystone wall, cairn, soil surface, scree, etc.) and their visibility rate. The procedure was carried out in the area of Bristivica village, located in the hinterland of Trogir, where different types of surface archaeological material were recorded. As the collected assemblage is marked by the significant presence of lithic artefacts and chert raw materials, the objective is to present the potential of the employed approach for detecting lithic scatters in a Dinaric karst landscape, as well as the difficulties that arise in evaluating the spatial context of their appearance and a more specific chronological frame to which they could be determined.

Keywords: *Central Dalmatia, surface archaeological material, Palaeolithic, lithic scatters, chert, raw material*

Introduction

Lithic scatters represent a significant element of the surface archaeological record, and their systematic recording, together with ethnographic records on hunter-gatherer societies, was instrumental in forming the comprehension of complex patterns of regional mobility, occupational systems and use of the landscape. The advent of systematic field surveys and the change of focus from conventional sites to individual artefacts as the main analytical unit of study placed the lithic scatters at the base for conceptualising Foley's off-site archaeology (Foley 1981), which, in turn, will have a significant impact on the further development of archaeological landscape studies.

Regardless of their significant presence in the landscape and somewhat extensive research, lithic scatters still represent an undervalued and poorly understood component of the archaeological record (Wenban-Smith 1995; Schofield 2000; Altschul 2005; Sirovica 2018: 58-61). The main reasons for their prevailing dismissal as a valuable data source can be attributed to the lack of contextual integrity, as well as the general absence of a significant quantity of chronologically diagnostic artefacts (Carr 2008: 188-191; Cain 2012: 208). The described challenges are further magnified by the fact that their significance is perceived as of a lesser value compared to the data quality of sites with high artefact and/or feature densities and preserved depositional contexts. This view towards surface archaeological data still prevails, regardless of its extensive criticism (Dunnell & Dancey 1983).

Adhering primarily to high-density definitions of archaeological sites had a significant impact on the general perception of the nature of the archaeological record which systematically excludes smaller sets of data (Plog et al. 1978: 387). However, a growing body of literature successfully surpasses such a rigid view and recognises the value of lithic scatters for archaeological inference, although issues regarding their management and protection within many cultural resource management policies remain unsolved (Rieth 2008: 5; Bond 2011: 41; Cain 2012: 208-210; Manning 2016: 7-8).

The interpretative value of lithic scatters is recognised by employing a wider regional view that transcends the conventional high-density site perspective as the concept of landscape opened meaningful possibilities for the comprehension of this type of archaeological phenomenon by treating different frequencies of archaeological surface finds as part of the continuous spatial variables whose informative potential lies in the relationship with other data on landscape characteristics (Briuer & Mathers 1996; Carman 1999; Altschul 2005). These considerations include both physical and symbolic dimensions of the landscape. With the growing popularity of social theory from the mid-1990s onwards, lithic scatters are being considered components of the socially constructed landscape and are interpreted as places of communal life, daily routines and habitual technological practices (Bond 2011: 32). Through the creation of places, lithic scatters are incorporated into the theoretical framework of human–landscape relationships and are consecutively a part of the processes that assign a social, symbolic and historical value to the landscape (Tilley 1994: 17-18).

In the background of such conceptualisation of the landscape, the methodological and theoretical development of artefact-based systematic field surveys is also located. Since the 1970s, the systematic field survey has become an extremely widespread research method, especially in the Mediterranean (Novaković 2008: 35; Knodell et al. 2023: 270), and in the 1980s, regional projects focused on the area of Dalmatia were also being established (Chapman 1989: 6; for individual projects see also Bintliff & Gaffney 1988; Chapman & Shiel 1988; Slapšak 1988; Bintliff et al. 1989; Chapman et al. 1996; Gaffney et al. 1997). Within the framework of regional research projects carried out in Greece (Bintliff 1985), Italy (Terrenato 1996), and also Croatia (Bintliff et al. 1989; Chapman 1989), some of the crucial theoretical and methodological principles of systematic field survey were developed. These encouraged principal considerations on the specific problems of systematic surveying of the Dinaric karst landscape, especially in the context of land use and agricultural practices (Slapšak 1988; Gaffney et al. 1991), which are reconsidered even today (Čučković 2012a; 2012b; Kulenović 2019; Dubolnić et al. 2020).

The Dinaric karst landscape is dominated by carbonate rocks and characterised by high susceptibility to natural processes, mostly connected with sub-surface hydrology and dissolution of the carbonate rocks (Lewin & Woodward 2009; Wainwright 2009). Under these conditions, the Dinaric karst represents a highly geomorphologically diverse environment characterised by a high rate of yearly rainfall but with a generally low surface water retention rate (Matas 2009). As such conditions are accompanied by significant temperature variability, the Dinaric karsts encompass a wide range of diverse climate conditions that range from typical Mediterranean to mountainous (Šegota & Filipčić 2003). Besides susceptibility to natural processes, the formation of the Dinaric karst landscape is highly exposed to intensive human impact, especially in areas with more substantial *terra*

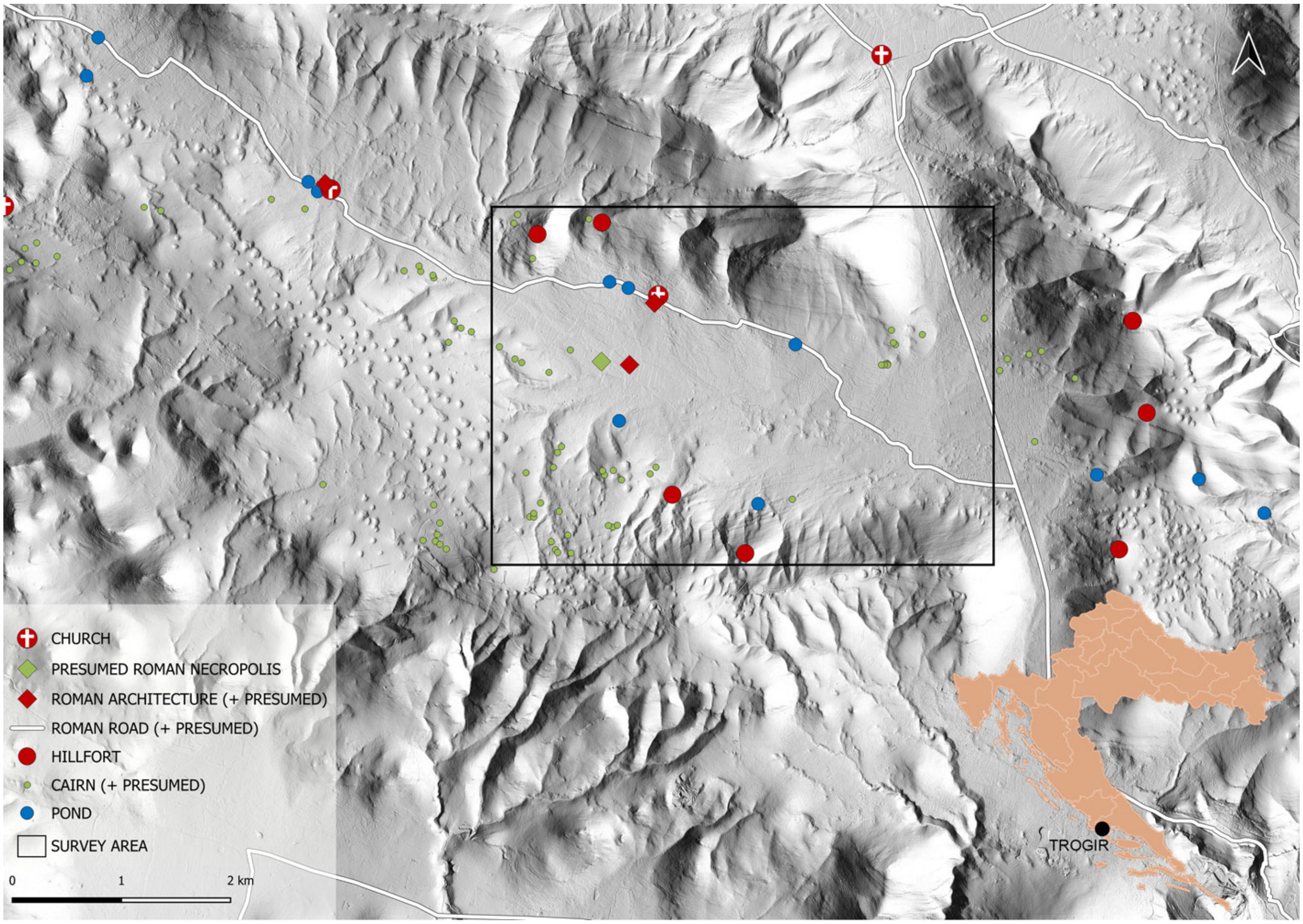


Figure 1. Location of survey area with known archaeological remains in the wider area of Bristivica (made by L. Paraman, M. Bažoka; basemap: State Geodetic Administration of the Republic of Croatia – Digital Elevation Model from Laser Scanning Data in a resolution of 1x1 m, DEM-DGU).

rossa soils. The ubiquitous practices of relief modification and soil cover displacement through terracing, intensive field surface clearance, and a high level of parcellation of arable land resulted in a landscape fragmented into small drystone-bounded plots and terraces, today mostly abandoned and covered in dense vegetation.

These very features are characteristics of the wider area of Bristivica village, where a small-scale field survey project has been carried out thus far.[1] Bristivica is located in Split-Dalmatia county, in the hinterland of Trogir (Fig. 1). This is a karstic valley, *polje* in Karst geomorphological terminology (Monroe 1970), surrounded by a 700 m high Vilaja mountain on the north, Labinštica mountain in the east, and somewhat lower mountains on the south and east. The valley and its surrounding hills and mountains have a characteristic Dinaric direction of extension from the northwest to the southeast. Towards the west, the valley ascends into a karstic plain covered by shrubby vegetation and occasional groves, and with many karstic dolinas. The valley is predominantly used for agriculture with a significant proportion of natural plant cover surrounded by successional forests in the middle and on the edges of the valley. Successional forests, together with Mediterranean shrubby vegetation, natural grasslands and deciduous forests, are also present on the slopes of the surrounding hills and mountains (CLC 2018).

A geological map of Croatia, available on a scale of 1:100 000, shows lithostratigraphic units related to Upper Cretaceous limestones (Marinčić et al. 1971). The north-

[1] The survey was conducted as part of the "Beyond Town Walls" project, carried out in collaboration between the Trogir Town Museum and the Archaeological Museum in Zagreb and it is aimed at valorization and long-term preservation of archaeological heritage in the wider Trogir surroundings. The overall results of the Bristivica field survey were processed as part of MA thesis "Metodologija sustavnog terenskog pregleda krškog krajolika na primjeru zaleđa Trogira" (Bažoka 2024) at the University of Zadar.

Figure 2. Aerial photo of the Bristivica landscape (photo by M. Bažoka).

ern part encompasses the southern slopes of the Vilaja mountain and consists of bouldery and layered limestones with layers of dolomite of the Senonian age, while the lowland part consists of limestones of the Turonian age. To a lesser extent, the existence of clastic and carbonate flysch deposits of Eocene age is possible, which is better represented and mapped in the Labinštica area. In terms of pedology, apart from rocks, the area is covered with brown soil and clay, while Holocene deposits of the *terra rossa* type were confirmed in the field during the survey. All present soils were formed by intense chemical weathering of the carbonate matrix under the influence of rainwater (Magaš & Marinčić 1973; Vukadinović & Vukadinović 2011).

The area has no constant natural water supply in terms of flowing water or lakes. The only water sources are, for karst characteristic natural phenomena, ponds (Croat. *lokve*). The most notable in terms of size and importance is the pond in the centre of Bristivica village, whose water level is maintained by artificial means. In the middle of the valley, close to the centre of the village, there is a small stream channel through which, depending on the intensity of rainfall, water flows intermittently.

Due to the lack of sufficient archaeological research, the history of the area of Bristivica village is scarcely known. Most previously recorded archaeological features refer to visible aboveground structures on the mountains and hills surrounding the valley. Among them, the most notable are prehistoric structures defined as the Bronze and/or Iron Age enclosures located on hilltops (Babić 1984: 28, 31-32; Miletić 2007; Šuta & Bartulović 2007: 20, 40; Šuta 2009: 152-153; 2010: 14-15; Bažoka 2020: 34-43; Paraman et al. 2020: 250-252). Other potential prehistoric remains are many stone cairns (Croat. *gomile*) that are mostly concentrated around the valley edges (Madiraca 2012: 21-24, 30-37; 2013: 828; Paraman et al. 2020: 250; Bažoka 2020: 20-24, 31-33, 43-44; Kudelić et al. 2023: 105-106). Regarding later historical periods, there

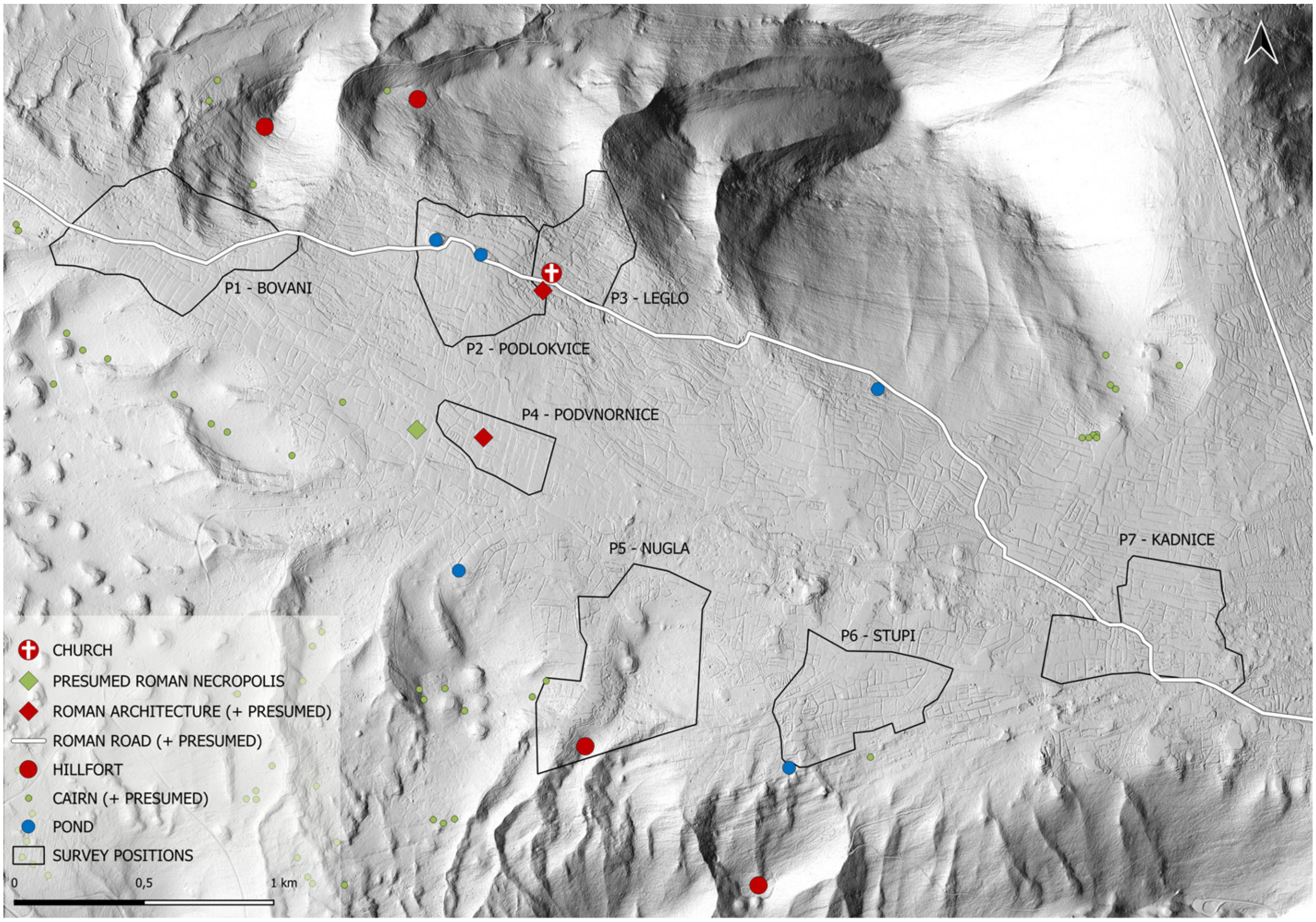


Figure 3. Division of the survey area into seven positions (made by M. Bažoka; basemap: DEM-DGU).

is even less data. Few grave goods brought by the locals to Trogir City Museum in the late 1970s indicate the existence of a Roman-period cemetery while one record in the older literature also mentions the remains of Roman architecture (Babić 1984: 51, n. 50). In the early mediaeval period the area of Bristivica village is known to be a royal feudal estate in Croatian, and later Hungarian-Croatian Primorje (Klis) county (Croat. *županija*, formally established in 9th c. CE), which was passed on to Trogir municipality in 1251. by King Belá IV as a privilege for their help during the Mongol invasion (Burić 2020: 54-55; Bećir 2023: 16-17). Late medieval historical records indicate a well-populated and developed medieval village until the start of the Ottoman raids and later Ottoman-Venetian wars in Dalmatia (Burić 2020: 60, 147, 175; Bećir 2023: 21-22), which was at the time also a parish centre for the surrounding villages of Trogir municipality (Andreis 1977: 195-196, 309-310).

Materials and methods

The landscape of Bristivica is characterised by numerous above-ground drystone structures which form a series of scattered smaller fields under a sporadic tillage system and are generally covered with dense vegetation which contributes to poor ground visibility (Fig. 2). However, the poor visibility is somewhat compensated for by the presence of many above-ground drystone structures, primarily drystone walls and stone cairns. Those structures are a product of local field-clearing practices which are aimed at obtaining as much arable land as possible. During that process, different artefacts are often moved together with the stones. Although through this process the material may undergo multiple displacements, in general, it can be assumed that it would not be displaced too far from its original context.

To adjust the survey methodology to the described conditions, the fieldwork procedure was based on the theoretical and methodological framework developed in the wider Mediterranean area (Bintliff 1985: 200-207; Bintliff et al. 1989: 43-44; Terrenato 1996: 217-221) but methodologically adapted to the specific conditions that occur in the Dinaric karst landscape, anticipating the low level of land cultivation with low visibility of surface soil but with frequent presence of surveyable above ground drystone structures (after Slapšak 1988; Gaffney et al. 1991).[2] Before the fieldwork, the area of Bristivica was divided into smaller units designated as positions. The criteria for selecting positions were the landscape characteristics, recognisable on the Croatian basemap and orthophotographs, that are suitable for conducting a field survey. Criteria primarily included steepness and surface visibility, so the positions that were selected are not too steep and are either not covered by dense vegetation or have an above-ground drystone structure. Also, the assumed archaeological potential of the area based on previous knowledge was taken into account. The predetermined positions were marked with a unique label consisting of the abbreviation P (position), unique numbers and toponym, which were taken from the topographic map (TK25, 1:25000) and the Croatian basemap (HOK, 1:5000). In this way, the area of Bristivica is divided into a total of seven positions (P1–7; Fig. 3).

The field survey was conducted by three participants for nine days. Regarding the situation established in the field and depending on the determined visibility, each predetermined position of the survey was divided into smaller spatial units – locations. Locations were marked with a unique label that consists of the letter L (location) and a unique numeric mark. The main criterion for recording the location was a minimum visibility of 50%. Types of locations were also recorded and they were categorised as fields, drystone walls or sub-walls, or as rubble, cairns, scree, etc. This approach enabled the analysis of data on the distribution of surface archaeological material relative to the type of location and visibility quality. The position of each surveyed location was recorded with coordinates obtained with a hand-held GPS device, and all locations were drawn and sketched on a printout of a digital orthophoto map and photographed. At the same time, every artefact was recorded, while all the data was written into the predesigned forms. Based on GPS data, field sketches, and orthophoto maps, all surveyed locations and constructions were drawn in a GIS environment and attributed with collected data in a tabular form.

[2] A methodological approach developed for this purpose was for the first time used during research conducted as part of the project of a systematic field survey of the municipality of Baška on the island of Krk (Sirovica & Mihelić 2018; Sirovica 2019; Sirovica et al. 2020), and then further elaborated during a field survey in the wider Trogir surroundings.

According to pre-agreed criteria, finds were separated and counted by type, while all statistically and diagnostically significant archaeological material was collected for post-processing. These were, first of all, fragments of pottery, and then other types of archaeological finds: for example, lithics, metal, slag, glass, etc. Simultaneously, building materials, mostly bricks and roof tiles were quantified, occasionally photographed and left onsite. As the area is quite rich in chert, which can only by indirect evidence be considered as raw material and mostly represents natural fragments or geofacts, finds of chert were differently processed. As counting each piece would be impractical and time-consuming, chert was mostly tentatively quantified and its general presence was recorded as low, medium or high, while samples from all locations were collected, giving priority to pieces most likely to present artefacts.

Results

The systematic field survey of the wider area of Bristivica covered a total of seven positions (P1–7) within which a total of 396 locations were surveyed. The data collected refers to the spatial distribution of surface archaeological material on a total area of about 100 ha. A total of nine different types of locations were registered, of which, in terms of quantity, walls and fields dominate (Fig. 4). Among various types of archaeological artefacts (Fig. 5), fragments of pottery predominate. However, the most numerous finds are different pieces of chert, as the counted chert represents only a part of the determined quantity. As the presence of chert is quite substantial throughout the research area, only the pieces that could be considered artefacts or potential raw materials were collected and counted. In most locations, due to its exceptional abundance, the presence of chert was estimated as low, medium or high (Fig. 6). The distribution map shows its highest presence is towards the north and northwest of the valley, at the southern foot of the Vilaja mountain.

Of the 384 pieces of chert collected, 118 (31%) can be considered artefacts, i.e. classified into the categories of standard techno-typological analysis based on morphological features. The rest of the collected material consists of fragments of chert created by natural cracking processes as well as surface alterations due to anthropogenic influences such as tillage. The majority of artifacts (75%) were found on fields or soil surfaces while only a minor number were recorded on drystone structures.

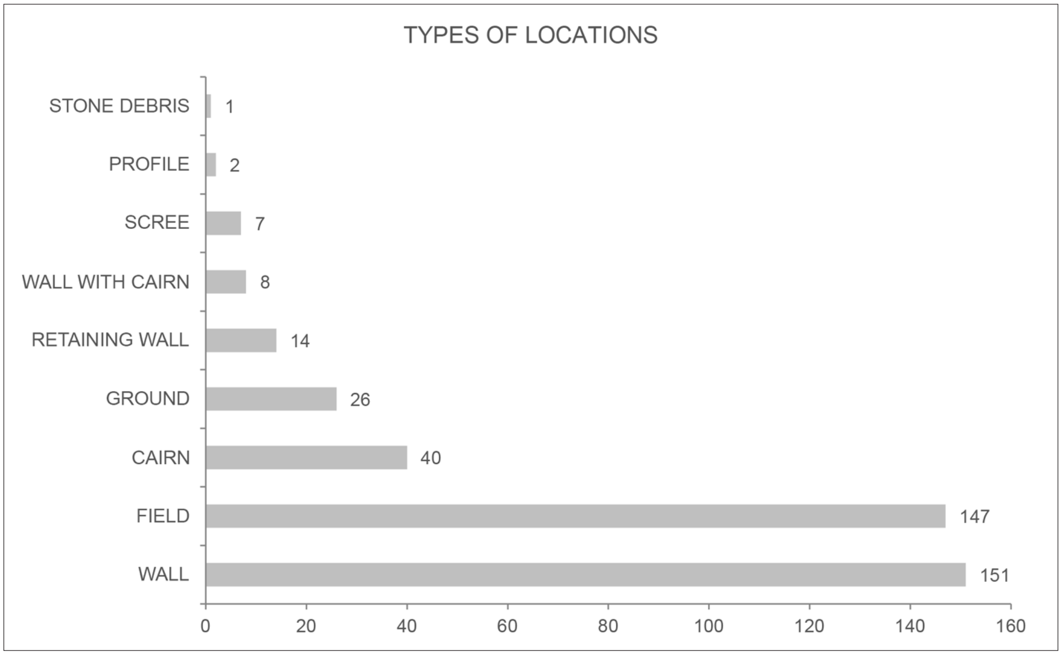


Figure 4. Types of locations recorded during the survey (made by M. Bažoka).

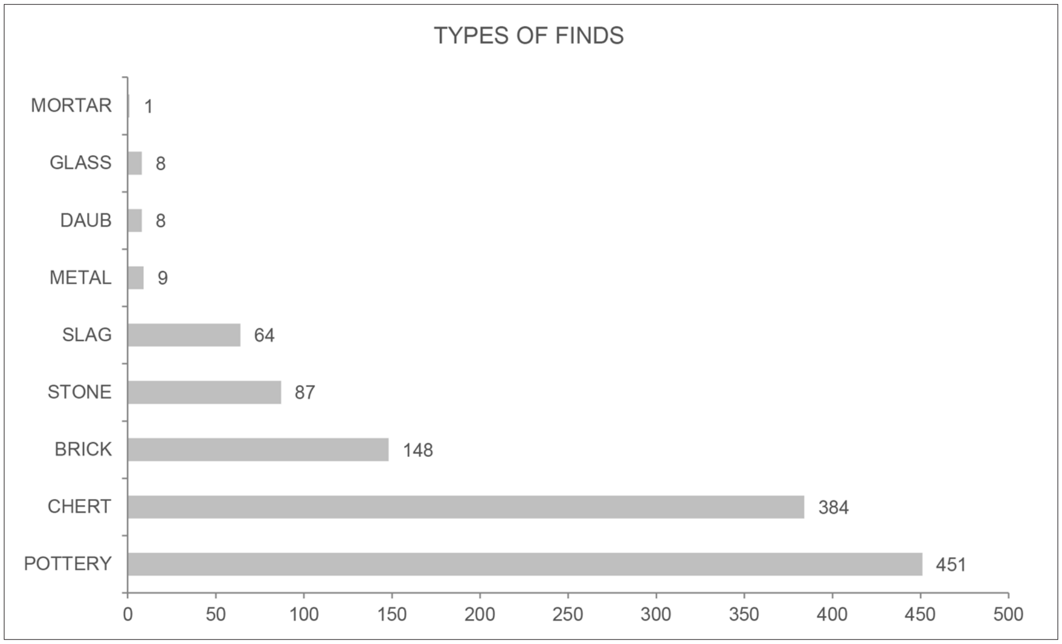


Figure 5. Types of finds collected during the survey (made by M. Bažoka).

The conducted lithic analysis was primarily focused on the separation of artefacts from geofacts and other materials, following the protocol established by Lubinski (Lubinski et al. 2014), with the application of the principle that the attribution of pieces is carried out following the generally prevailing characteristics. This subjective approach leaves the possibility of incorrect attribution, which was to some extent compensated by prioritising the characteristics suggested for geofacts during the final classification. Technological analysis was carried out by classifying materials into basic categories, according to their place in the production process (Inizan et al. 1999). The category *undeterminable* was added for fragments of debitage whose original shape could not be determined due to subsequent fractures. The technological analysis determined that in the total inventory of 118 artefacts (Fig. 7, 8), the most numerous technological category of finds are cores (n=47; 40%), which together with core fragments (n=12; 10%) represent half of the artefacts (T. 1: 1–2, 4, 7; 2: 3, 5). Among the deb-

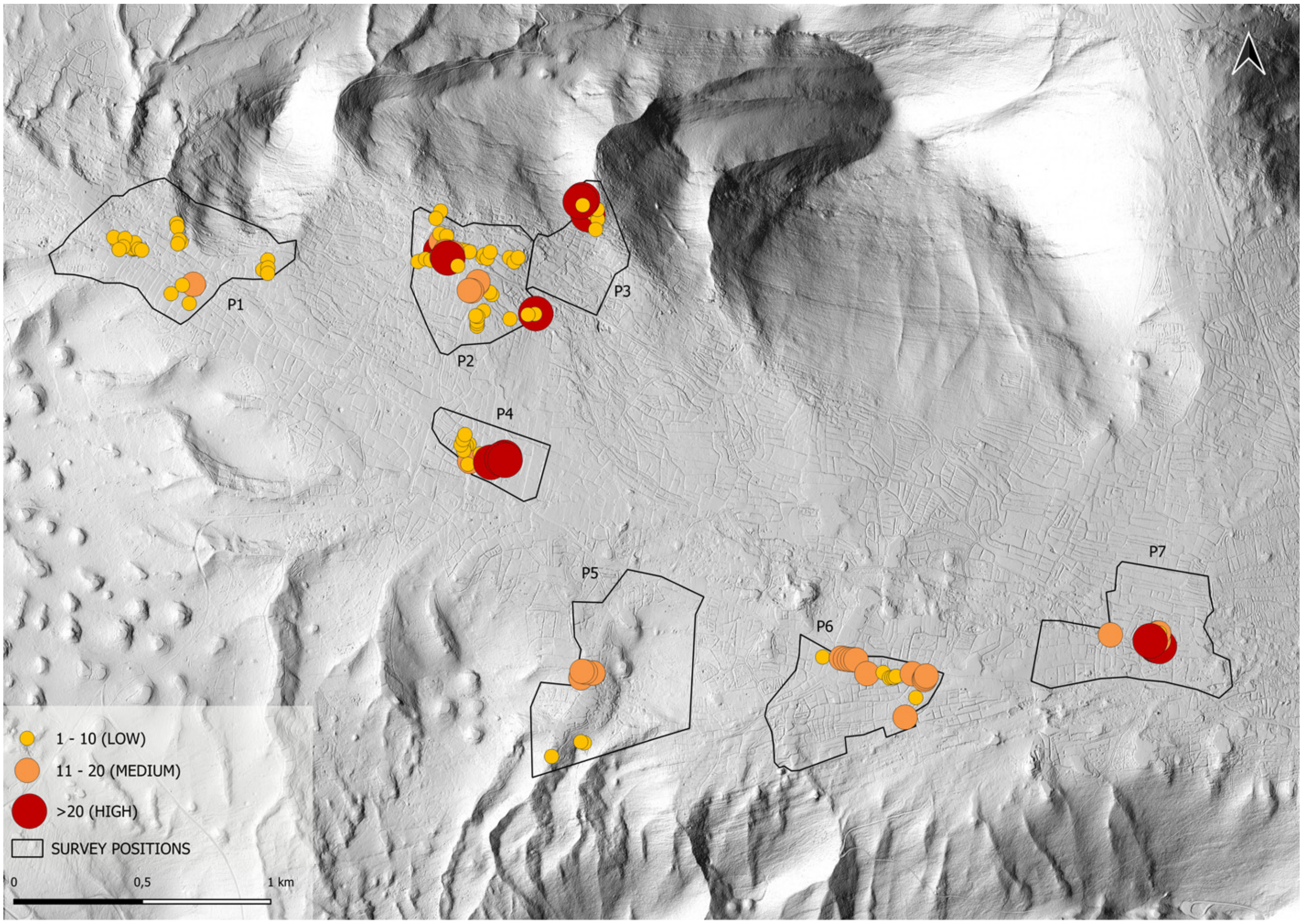
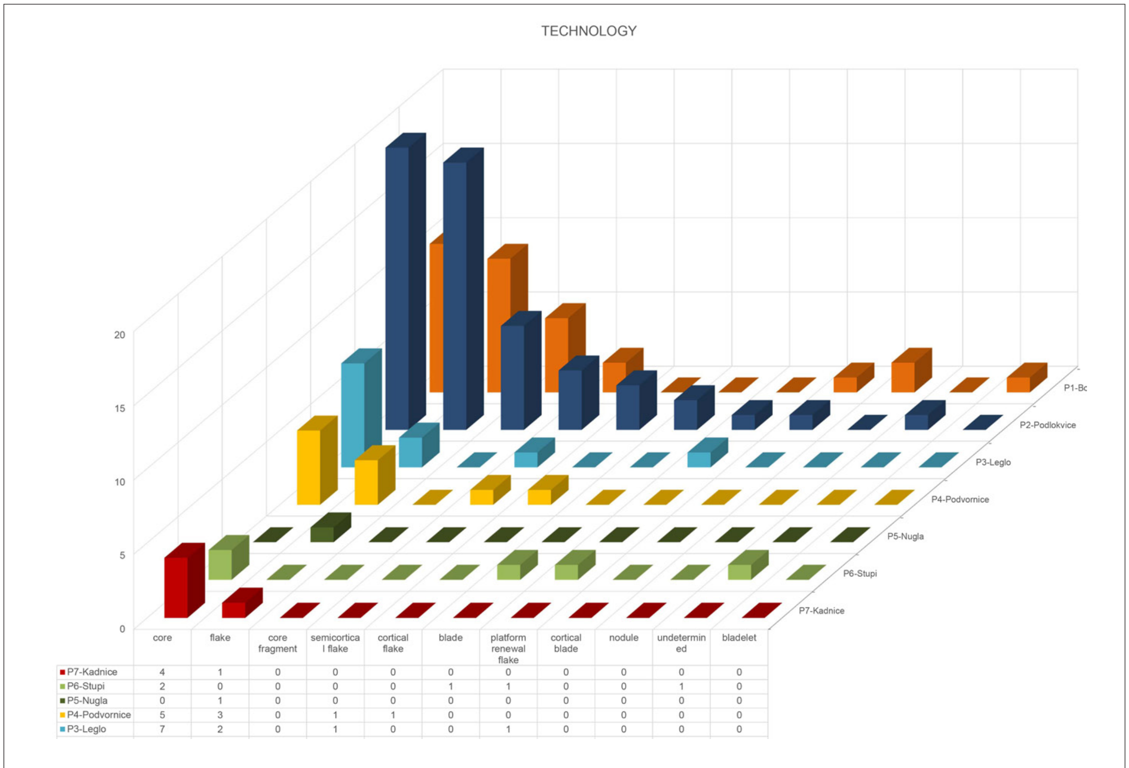


Figure 6. Spatial distribution of chert (made by M. Bažoka, basemap: DEM-DGU).

itage products in total assemblage, the most common are flakes (n=34; 29%), while blades and bladelets are very rare (n=3; 3%). Blades and bladelets are of irregular shape (T. 1: 5), often with remnants of the cortex, and do not indicate the standardised organisation of production or the organisation of the core. The same can be said for the collected cores, which are mostly amorphous. In general, these are flake cores, with multi-directional debitage, on which the roundness and wear of the edges can be noticed, which in some cases have significantly changed the morphology of the object.

Cortex was recorded on less than 10% of the material, which can be partly explained by the discrimination during the survey. As the collection procedure prioritises pieces with possible negative fractures, i.e. evidence of conchoidal breakage as one of the main characteristics of lithic artefacts, limestone cortex would be more often dismissed as a geofact. Positive discrimination during collection, on the other hand, may partially explain the high proportion of cores, which are easily detectable due to the recognisable traces of negatives and the sheer size.

Most of the artefacts on the surface have visible taphonomic changes, primarily patination, which is most pronounced on the material collected in lowland locations. There, iron oxide stains predominate, which probably developed in contact with the geological matrix of the red clay of the *terra rossa* type. Fractures and patina consistent with burning processes are also present in some positions (P1-Bovani and P4-Podvornice). Post-depositional processes of anthropogenic character, such as field cultivation and ploughing, which are credited for the creation of most geofacts, are also evidenced on artefacts in the form of fractures and small edge removals. In some cases, the latter were difficult to distinguish from intentional finishing or retouching, and they were



	core	flake	core fragment	semicortical flake	cortical flake	blade	platform renewal flake	cortical blade	nodule	undetermined	bladelet
P7-Kadnice	4	1	0	0	0	0	0	0	0	0	0
P6-Stupi	2	0	0	0	0	1	1	0	0	1	0
P5-Nugla	0	1	0	0	0	0	0	0	0	0	0
P4-Podvornice	5	3	0	1	1	0	0	0	0	0	0
P3-Leglo	7	2	0	1	0	0	1	0	0	0	0

Figure 7. Frequency of technological categories in assemblages from various positions (made by M. Bodružić).

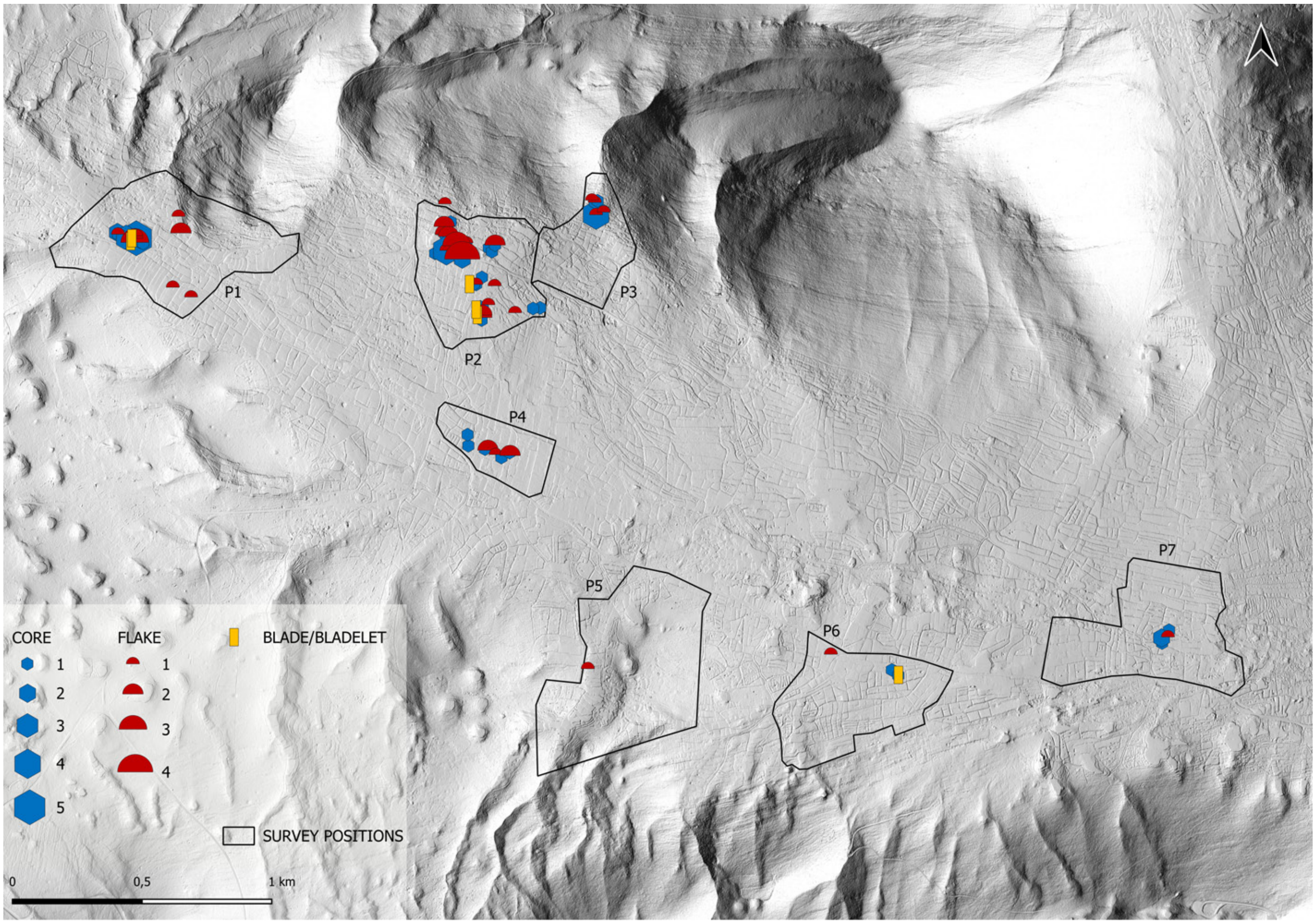
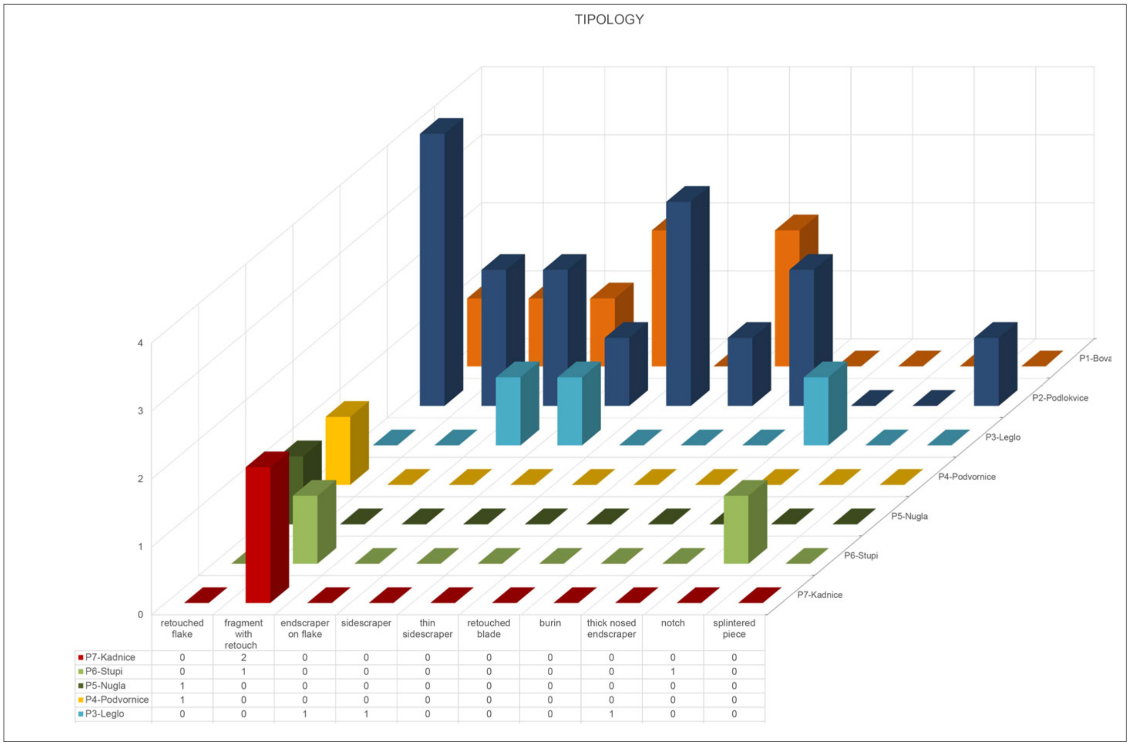


Figure 8. Spatial distribution of cores, flakes, and blades/bladelets (made by M. Bažoka; basemap: DEM-DGU).



	retouched flake	fragment with retouch	endscraper on flake	sidescraper	thin sidescraper	retouched blade	burin	thick nosed endscraper	notch	splintered piece
P7-Kadnice	0	2	0	0	0	0	0	0	0	0
P6-Stupi	0	1	0	0	0	0	0	0	1	0
P5-Nugla	1	0	0	0	0	0	0	0	0	0
P4-Podvornice	1	0	0	0	0	0	0	0	0	0
P3-Leglo	0	0	1	1	0	0	0	1	0	0

Figure 9. Frequency of typological categories in assemblages from various positions (made by M. Bodružić).

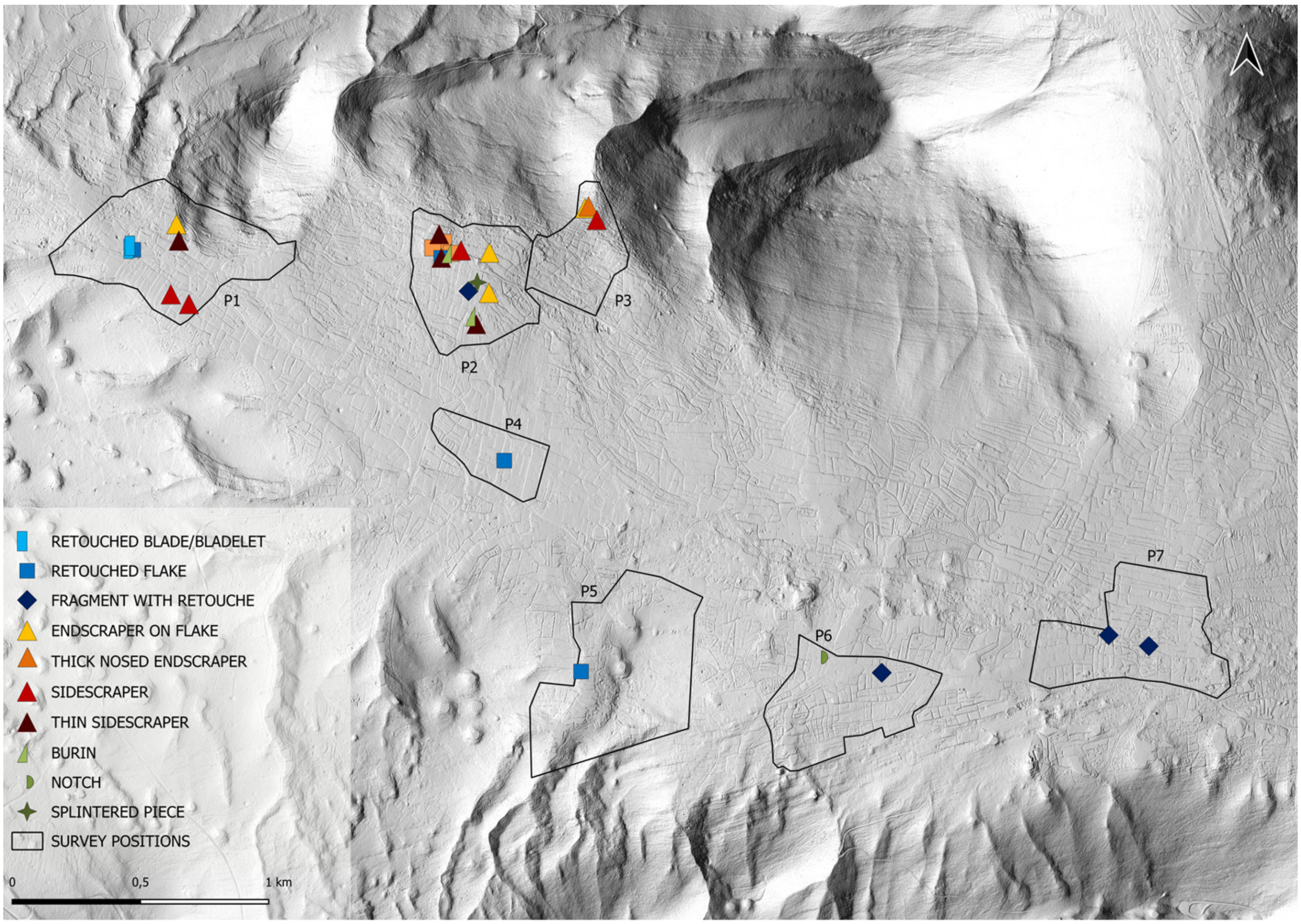


Figure 10. Spatial distribution of lithic tool types (made by M. Bažoka; basemap: DEM-DGU).

excluded from the typological categories unless the morphology of the retouch or the entire piece suggested an intentional action of tool shaping.

Most of the artefacts had traces of small fractures on the edges, and some of the retouched pieces showed subsequent edge fractures that overlapped with older ones. Among them, 32 pieces, or 34%, can be considered tools (Fig. 9, 10) and are classified according to retouch characteristics, morphology and position of retouched edges within the categories of basic typological analysis (Debénath & Dibble 1994). The assemblage is dominated by general types such as retouched flakes (n=7; 21.9%; T. 1: 6; 2: 7) and retouched fragments (n=6; 18.8%), as the category that represents fragmented tools that could not be determined more precisely. Several endscrapers (n=4; 12.5%; T. 1: 3-4; T. 2: 1) and sidescrapers (n=4; 12.5%; T. 2: 4, 6) were also found, followed by thin sidescrapers (n=3; 9.4%; T. 2: 2), retouched blades (n=3; 9.4%; T. 1: 5) and burins (n=2; 6.3%). Thick-nosed endscrapers, notches, and splintered pieces (T. 2: 3) are represented with one specimen each.

The largest number of artefacts were collected at the positions of P2-Podlokvice and P1-Bovani, while at other positions they rarely occur. Geofacts and chert fragments, despite not being the products of human action, suggest the presence of raw material both in positions at the foot of the surrounding hills (P3-Leglo and P1-Bovani), and in low-lying positions within the karst fields (P2-Podlokvice, P4-Podvornice and P6-Stupi), while two nodules at the P1-Bovani position additionally confirm that the source of raw material is located somewhere in the immediate vicinity.

Discussion

As a ubiquitous type of site, lithic scatters display extensive variability in size, patterning and composition. The majority of them, as deprived of depositional contexts, are considered of low interpretable value, although in many regions lithic scatters are the only available data from certain periods (Carr 2008: 191-192; Billington 2016: 22). This is especially true for arid and semiarid environments where identifying archaeological evidence of human occupation is often problematic (Knight & Stratford 2020). The available literature does not provide a universal definition of this type of archaeological record, and they are commonly described as assemblages mostly or completely consisting of debitage (Reith 2008: 1-2; Manning 2016: 5-6). Accordingly, it is relevant to perceive traceable archaeological evidence on the surface as a reflection of human activities in the landscape, which can be analysed independently or relative to high-density locations. With the advent of systematic field surveys, emphasised by processual archaeology, the recognised importance of surface archaeological data resulted in its extensive reconsiderations which repeatedly accentuated that agricultural disturbances do not completely eradicate patterns in the archaeological record. Despite later numerous and well-founded criticisms, developed in the framework of post-processual archaeology, the continuous revision of methodological approaches, the re-examination of theoretical background and constant technological innovations, followed by increased use of their potential (Novaković 2008: 35-39), still make systematic field surveys one of the fundamental methods of landscape archaeology. Although patterns that can be traced on the surface might be variably blurred, and the causes of their occurrence are occasionally incomprehensible, the surface archaeological remains still contain viable data on the human–landscape relationship (Shott 1995: 487; Carr 2008: 192-194).

All the considered features are inevitable characteristics of the surface archaeological record documented in the area of Bristivica. Due to the natural complexity of karstic processes, caused by natural processes or the intensive human impact on the karstic landscape, it's impossible to determine the extent of changes that the landscape of Bristivica has endured after the primary deposition of recorded finds. The same processes have an intensive impact on the archaeological records from all periods, so the primary contexts are often irretrievably lost. However, some characteristics of the recorded distribution suggest that, in general, we can still quite surely assume that the collected lithics could not have been displaced too far from its original contexts. As artefacts are mostly found on soil surfaces, grouped on levelled plateaus or flat fields at the foot of the steep and mostly impassable south side of the Vilaja Mountain, the positions with established finds show no evidence of possible susceptibility to a long-range displacement of material.

This indicates that the area of Bristivica was rich in raw material and represents a known and used source of chert. In the wider area of the Trogir coast and the hinterland, several positions with chert outcrops in lithostratigraphic units of Upper Cretaceous and Eocene age have been identified so far (Perhoč 2009a; 2009b; 2020a), the closest of which is located on the western slope of Sirištak hill, a few kilometres away from the research area. Based on the macroscopic appearance of the material from Bristivica, most of it can be linked to

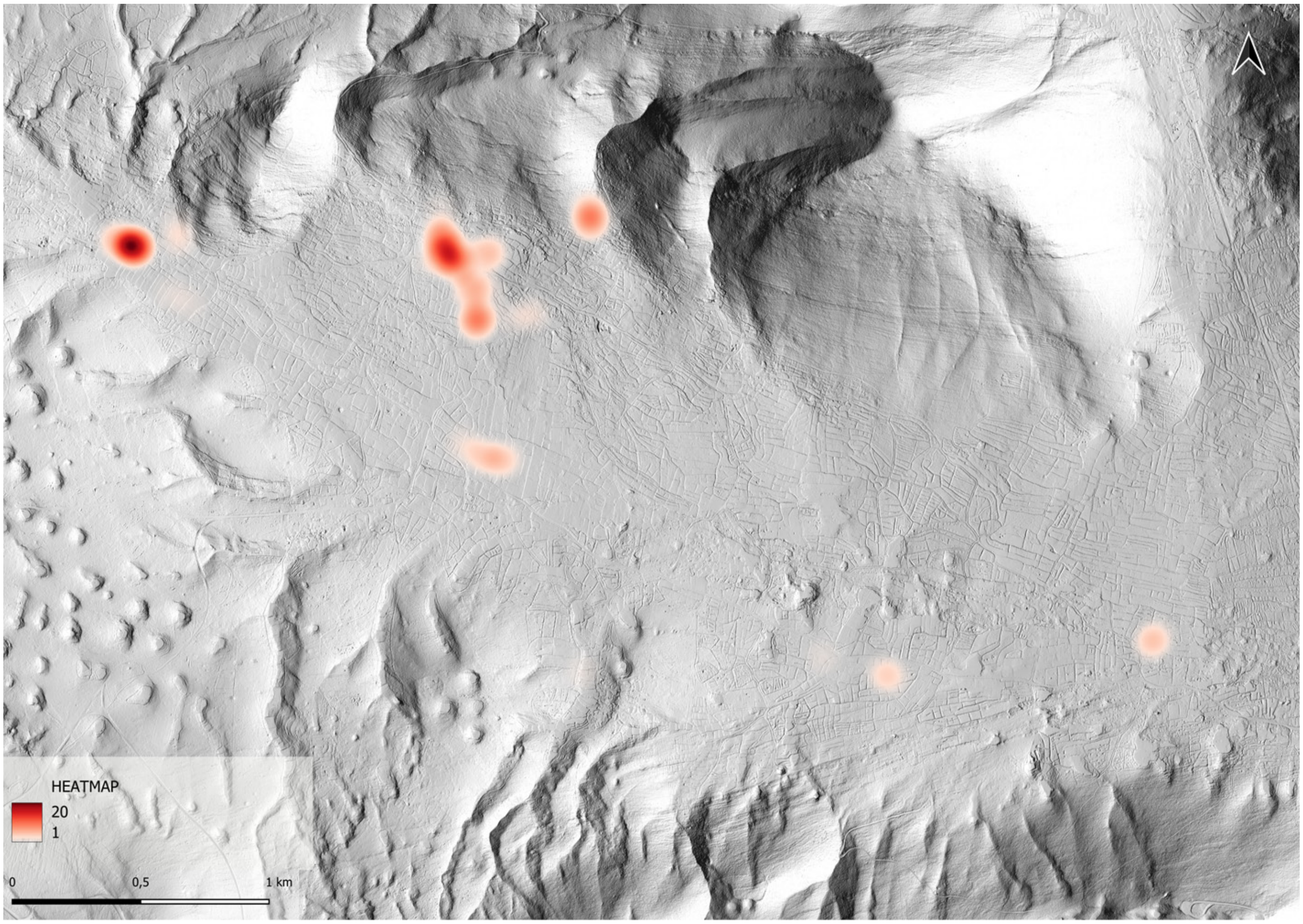


Figure 11. Heatmap (R = 100 m) representing lithic artefact distribution in Bristivica (made by M. Bažoka; basemap: DEM-DGU).

Upper Cretaceous cherts (LMT 48 – Chert Type Vilaja after Perhoč 2020a), but with great caution, since for a reliable attribution, a detailed petrographic analysis is needed. Cherts of this type are present in lithic assemblages of archaeological sites in central Dalmatia, such as Mujina pećina (Karavanić et al. 2008; Perhoč 2020b), Konjevrate-Groblje (Kačar & Podrug 2024; Perhoč 2020a) and Zemunica (Šošić Klindžić et al. 2015), in layers dating from the Middle Palaeolithic to the Late Neolithic periods.

In the Bristivica assemblage, the retouched pieces do not represent morphologically specific shapes, while the scrapers appear throughout the Palaeolithic and do not enable narrower chronological determination. Certain types, such as endscrapers, burins, thin sidescrapers and splintered pieces, are more characteristic of the Upper Palaeolithic, but they also appear in the earlier period.

Even though more precise dating is not possible, extensive studies in debitage analysis provided an understanding of how technological characteristics of lithics may be successfully associated with specific lithic industry types and consequently with corresponding periods. Aided by comparison with data from primary and dated contexts, this enables the grouping of lithic material into relative technological and chronological assemblages (Bond 2011: 32). Even when reliable attribution is not possible, potential attribution precludes dismissal and provides the possibility of inclusion in future research (Cain 2012: 214). Regarding that, it can be expected that with an increase in the number of surveyed units, especially in the vicinity of the two richest positions, there would be an increase in the number of found artefacts which would possibly enable more precise chronological determination. But, as they would still be found on the surface, deprived of their original context, in comparison with complex archaeological sites, this type of data represents very fragmented information whose meaning in many ways eludes us. Nevertheless, if we rid ourselves of an obligation to talk about sites, and see specific differences between positions with archaeological remains

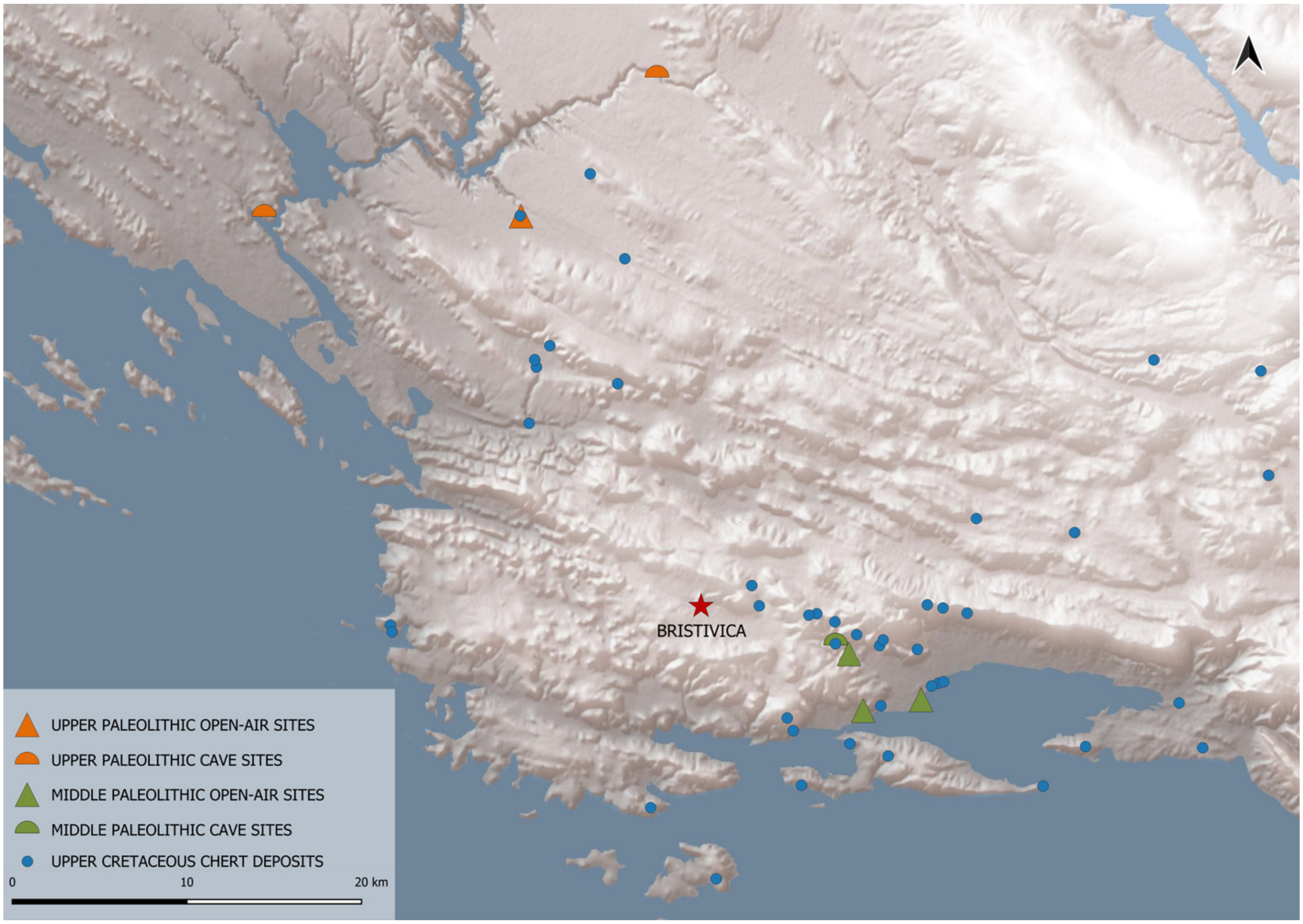


Figure 12. Known Palaeolithic sites and Upper Cretaceous chert deposits in Middle Dalmatia (made by M. Bodružić, M. Bažoka after Perhoč 2020a: Tabelle AS10; Tabelle AS 11).

as reflections of differences in the type and intensity of performed activities, the collected assemblage becomes capable of representing a reflection of a single or a whole variety of activities performed during one or many different points in time (Fig. 11).

As the assemblage collected in Bristivica can be placed in a general timeframe, it ought to be considered in the currently known context of the Palaeolithic in the wider area of Central Dalmatia (Fig. 12). Until recently, the only evidence of Palaeolithic occupation in the relative vicinity was the Mousterian cave site of Mujina pećina (Petrić 1979; Karavanić & Kamenjarin 2020). Due to recently conducted field surveys and rescue archaeological excavations, a denser concentration of Mousterian sites was established. Lithic scatters or open-air sites were established at Karanušići and Malo polje-Krban (Karavanić et al. 2023), the submerged site was discovered at Kaštel Štafilić-Resnik (Barbir et al. 2022), while two isolated finds were recorded at Trogir-Lapidarium of Trogir City Museum and on a submerged position of Malo polje-Kopilica (Karavanić & Paraman 2022). All positions are located south of Mujina pećina, at the fringe of the now -submerged plain between Kaštela and Čiovo. During the Pleistocene, this was probably a karstic field transected by rivers, such as Jadro and its smaller tributaries, which provided a sustainable environment for smaller Neanderthal groups.

Further to the northwest, evidence of Palaeolithic occupations is scarce, with only two known Upper Palaeolithic sites. Jama in Šarina draga was a relatively recently excavated cave site which offers a solid lithic and osseous assemblage along with reliable radiocarbon dates that place the occupation in the early upper palaeolithic (Vujević & Podrug 2015). In Brina near Drniš, two out of three caves, with mainly paleontological evidence and some archaeological finds dated by radiocarbon analysis to the Epigravettian, were excavated in the 1960s (Klisović 2015). A recent excavation at the position of

Konjevrate-Groblje documented an open-air Neolithic and also the only confirmed open-air Epigravettian site in the wider area (Kačar & Podrug 2024). The Epigravettian lithic assemblage of Konjevrate-Groblje, with high quantities of cortical pieces and debris, flakes from the early stages of reduction, opening flakes and cores, implies that the site or its excavated portion probably functioned as a working area orientated mostly towards exploitation of various local and regional cherts, especially Upper Cretaceous cherts of which the so-called Vilaja chert type, characteristic to Bristivica area, represents the most numerous one (Perhoč 2020a: Tabelle KE 1a).

In this context, the Bristivica assemblage can be considered a reflection of activities carried out around the southern slopes of Vilaja mountain and their immediate vicinity. The high ratio of cores, partially explainable as a result of the discrimination process during the survey, could also represent the preferential exploitation of local chert, possibly for opportunistic purposes aimed at carrying out tasks at hand. This is also suggested by high quantities of generic forms such as retouched flakes and fragments, which could point to the opportunistic exploitation of raw material to obtain *ad hoc* tools intended for a specific purpose, possibly followed by immediate disposal.

Although only assumptions, these types of data enable a better understanding of the activity ranges of Palaeolithic communities in the landscape and they can also be considered in the context of newly emerging open-air sites in the wider area of Central Dalmatia. This evidence points to the wide spatial distribution of raw materials and specific characteristics of tool production and utilisation, while simultaneously reflecting human mobility through the area testifying to the complex activities carried out across landscapes. In the same context, the data collected in Bristivica shows that even more demanding terrains were actively used during the considered period.

Another important aspect of these types of lithic scatters is their potential to represent single occupation sites which provide insight into specific applications of technologies for specific purposes (Binzen 2008: 37-39). They are also valuable data sources for inferring the variability of the archaeological record in the landscape which further advances the understanding of regional occupational patterns (Sullivan 1992: 107-111) Accordingly, it is possible to highlight that, regardless of the lack of large continuous areas with good visibility, a well-designed field survey can represent a suitable method for systematic recording of the surface archaeological material in the Dalmatian Dinaric karst landscape. The results gained emphasise the possibilities of this method which can be further expanded for specific investigation of individual positions or their environmental context. By adjusting sampling strategies to enable the collection of environmental data, similar to the methodological framework proposed by Knight and Stratford (2020: 781), this data can considerably expand and complement the knowledge of karst landscape use patterns during the Palaeolithic.

Conclusion

The Dinaric karst landscape presents challenging conditions for the implementation of standard field survey methods. The ubiquitous practices of intensive field clearance and a high level of parcellation of arable land resulted in various types of drystone walls and stone cairns at the edges of fields. In the Dalmatian hinterland, this practice was the main agency of intensive transformation of the landscape and thus the cause of alteration of the surface archaeological record. These factors resulted in a landscape fragmented into small drystone-bounded fields that are mostly unconnected and thus do not form continuous surfaces favourable for field survey practices.

An artefact-based field survey approach, adapted to the described conditions, was conducted in the wider area of Bristivica, located in the hinterland of Trogir. It was aimed at recording the distribution and frequency of surface archaeological material relative to different types of surveyed units (drystone wall, cairn, soil surface, rubble, scree, etc.) and their visibility rate. The gained result showed a high frequency of chert finds among which a significant number of lithic artefacts were recorded which evidence the potential of the employed approach for detecting lithic scatters in a Dinaric karst landscape. Although the artefacts were found on the surface, deprived of their original context, they can have considerable potential to expand our understanding of karst landscape use patterns. Regardless of the difficulties that arise during the process of technological, typological and chronological determination, which can be seen as disabling factors, analysis of collected data enables attempts to their more comprehensive consideration in a given spatiotemporal context. In that context, the Bristivica assemblage shows that this area, rich in raw material, represents a known and used source of chert during the Palaeolithic, thus becoming indispensable evidence of past human activities performed in this specific karst landscape.

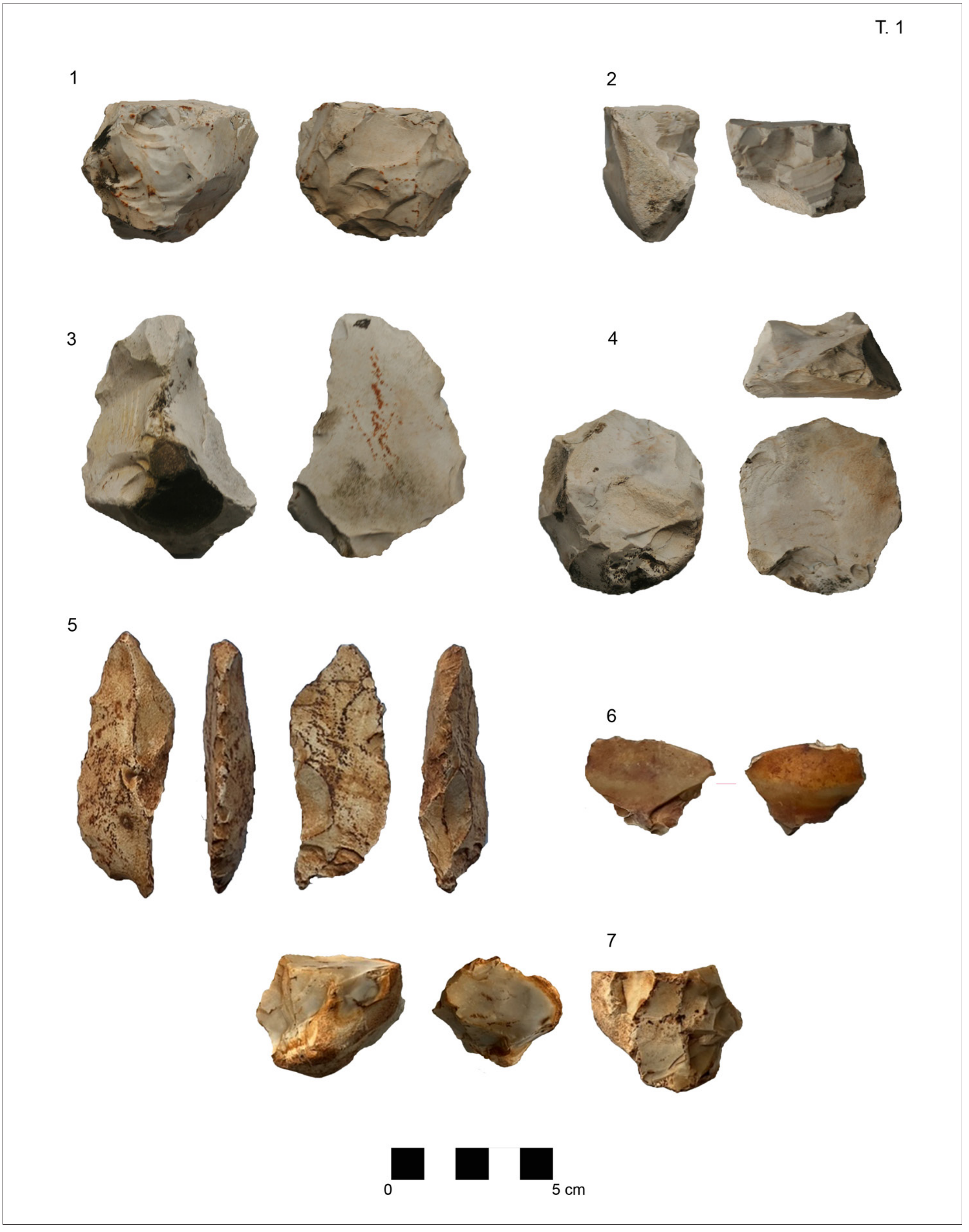


Table. 1. Lithic artefacts from positions P3-Leglo (1–4) and P2-Podlokvice (5–7): 1–2, 7) flake core, 3) endscraper, 4) endscraper on core, 5) retouched blade, 6) retouched flake (made by M. Bodružić).

Table. 2. Lithic artefacts from positions P2-Podlokvice (1-6) and P4-Podvornice (7): l) endscraper on flake, 2) thin sidescraper on flake, 3) splintered piece/core on flake, 4) sidescraper, 5) flake core, 6) sidescraper, 7) retouched flake (made by M. Bodružić).

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The use of 3D photogrammetry in analysing the Roman epigraphic monuments: a case study from Kremna village, southwestern Serbia

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This paper explores the efficacy of different open-source software tools in analysing 3D photogrammetric models of Roman epigraphic monuments. The study, conducted on four monuments from Kremna, Serbia, reveals that advanced software processing significantly enhances the visibility of reliefs and inscriptions, making it possible to record previously unreadable text. A key result is the identification of 27 new letters on one altar, showcasing the method's potential for further epigraphic research. The results show that, at this moment, the most suitable software visualization tool for recovering lost inscriptions is depth mapping in Blender software. The research illustrates the value of 3D modelling for archaeological interpretation and permanent digital preservation of endangered epigraphic monuments.

Keywords: *3D epigraphy, photogrammetry, Roman epigraphy*

Introduction

This paper is the result of research conducted on selected Roman monuments from the village of Kremna in southwestern Serbia, with the aim of determining the possibilities of applying photogrammetric 3D models to uncover lost inscriptions on epigraphic monuments.

As an easy and free form of documentation, 3D photogrammetry is becoming more prevalent in archaeological practice (Al-Ruzouq 2012: 97; Magnani et al. 2020: 2). In recent years, a number of papers (Landes et al. 2013; Calisi 2016; Brutto 2018) on registering various anomalies on artefacts using a series of vizualisations on 3D models were published. It has been shown that, among other things, processing 3D models of epigraphic monuments can result in recording parts of inscriptions, otherwise illegible by traditional epigraphic methods. This is a method that has only recently emerged, as most 3D model software did not have the necessary tools for such analyses until a few years ago. Additionally, computers with powerful processors capable of handling large datasets have only recently become more widely available, including other necessary performance aspects such as graphics cards or RAM capacity. Considering this is a very young field of research, a comprehensive study comparing the success of different software and visualization tools for these purposes has not yet been conducted. This paper will attempt to do just that. With the aim to determine the effectiveness of each visualization tool, the results obtained by different open-source software will be compared. At the same time, this paper will emphasize the importance of 3D modelling for preservation of cultural heritage, especially when it is not properly protected and threatened by environmental factors.

Materials

The Kremna basin is rich in archaeological remains from the Roman period. In addition to a temporary military camp at the site of Trgovište, the remains of Roman funerary monuments, altars, and stone sculptures are scattered around the village, on at least five sites. They have been dated to the II and III centuries, with medieval monuments also recorded at some sites. Despite their large number, only a few of these monuments can provide significant epigraphic data. They are very poorly preserved and have been increasingly affected by external factors over time. With that in mind, four monuments with visible inscription fields, with or without legible letters were selected to be analysed.

The first analysed monument was a funerary stele from the site of Crkvine-Misajlovići (Fig. 1a). It was first described in 1986, when a part of the inscription was recorded: *D(is) M(anibus) Aurel(ius) Cut[ius vi]xit annos R.. D* (Mandić 2015: 207). The same description also mentions dolphin reliefs found alongside the rosette in the middle part of the upper field. The central part of the monument, i.e., the inscription field, is bordered by columns with decorated capitals. The monument has been significantly damaged in previous decades, and today, not a single letter of the inscription is visible, nor are the dolphins in the upper field. At the bottom of the inscription field, the monument is broken in width. In the lower field, reliefs of two confronted hippocamps are visible, and the base is also preserved.

The site Crkvina is located in the hamlet of Rodalji-Čulići. It is a place where minor excavations were conducted in 2004, during which the altar (Fig. 1b) was cleaned and placed at today's position. Report from the excavations mentions that it is a small ancient altar, from which only the letter C in the lower zone of the inscription field can be read (Lj. Mandić, from an unpublished report on field excavations in 2005, the National Museum of Užice).

The third analysed monument (Fig. 1c) is a spolia, built into a modern fountain opposite to Moljković Han (Zotović 1973: 16), and it is known to have been transferred from the site at the Stamenić cemetery (Mandić 2015: 207). Due to the way it was secondarily used, this funerary monument is only partially visible, with the entire lower half of the inscription field and one side today lying below the ground. On this monument, reliefs of the god Attis are visible on both sides, and above them, as well as above the inscription field, relief garlands with rosettes are depicted (Vulić 1941-48: 246). Today, no letters are discernible in the inscription field.

The last monument is a votive altar (Fig. 1d), registered at the Erić cemetery site. It is a limestone altar dedicated to the god Jupiter. During archaeological reconnaissance conducted in 2021, a partially readable inscription was recorded: *I(ovi) O(ptimo) M(aximo) ANVS ROO M* (V. Mihajlović, from an unpublished report from a systematic survey in 2021).

Methodological framework

The process of photographing the monuments from the village of Kremna was preceded by planning all phases of the research, following the steps previously described by Marin-Buzon (Marin-Buzon et al. 2021: 2-3). DSLR camera Canon EOS 700D, a 18-megapixel with EF-S 18-55mm f/3.5-5.6 IS STM lens was used for creating the photographs of all four monuments.

The photographing of the monuments was carried out in September 2022. Only cloudy days were chosen for shooting, as it was important to neutralize shadows on the surface of the monuments. Before photographing, it was necessary to remove vegetation, clean the monument, and, in the case of the stele from Misajlovići, remove rainwater that had accumulated on the inscription field. The ranging pole and markers were placed around each monument, and the distances between them were measured in order to obtain the necessary measurements for scaling the model. All photos were captured in RAW format. Since the shooting conditions were dependent on the external light, aperture was set to *f*/4.5, with ISO 100 for all the monuments, while the exposure of 1/200 seconds was used for photographing the monument built into Moljković fountain and one from Crkvina site and 1/160 seconds exposure was used for the altar from Erić cemetery and stele from Crkvine-Misajlovići. While it would also be purposeful to increase the f-number to achieve a greater depth of field, it was decided to reduce the f-value at the expense of shorter exposure and smaller ISO, in order to assure the photos do

Figures 1a–1d. The present state of the monuments from Kremna village (Photo by: A. Bandović and P. Đerković).

not contain too much noise or are not blurry. Since the photos were not taken in controlled lab conditions, the distance between the camera and the object could not be fixed, but was approximately 80cm for all the monuments. With such settings, DoF (Depth of Field) value comes to around 1.5cm, which is much more than the actual depth of the letters on the flat surface of the monument. However, it is still a very small value, so it was important to use a manual focus and check the photos during shooting.

In recent years, mobile phones with increasingly advanced cameras have been produced. They can provide photos of very high resolution, and a series of performances have made photography faster and easier. The latest generation of iPhone phones even contains a laser scanner, which, along with accompanying software, provides very precise 3D models (Luetzenburg 2021: 2-7). For this reason, all mentioned monuments from the village of Kremna were photographed one additional time, using an iPhone 12 with a 12-megapixel camera, with the aim to illustrate that the method may achieve sufficient success with photos obtained using a mobile phone. DSLR cameras have a significantly larger sensor and the possibility of changing lenses, offering a wide range of possibilities, while mobile phones boast increasingly advanced cameras that provide fast high resolution shooting, recent studies have shown that both can yield comparable results when used properly (Fawzy 2019;

Sahala Samosir & Riyadi 2020; Saif & Alshibani 2022; Patonis 2024). The iPhone photos were taken in automatic mode, with aperture values varying between *f*/1.6 and *f*/2.8, and between 1/800 and 1/200 seconds for exposure, while ISO speed was 32 for all the monuments.

The photographs were inserted into the *Metashape* software for creating 3D models, which is commonly used by archaeologists (Lehoczky & Abdurakhmonov 2021: 9). After aligning the photos, high quality textured models were obtained, with each model containing around 30 million points. A total of 8 models – 4 obtained by DSLR camera and 4 by iPhone camera – were derived and imported in other software. In order to apply different visualizations on their surfaces, four software were used: *Metashape*, *MeshLab*, *CloudCompare* and *Blender*.

The first visualization was creating a digital elevation model (DEM) in the *Metashape* program. This is a simple process used to represent heights on the model by assigning colors on a predetermined scale. Although digital elevation models are most commonly used in archaeology for displaying altitudes during the creation of 3D relief models (Kokalj et al. 2013: 100), they can also be used in the analysis of artifacts. In our case, it was decided to use a planar projection, which allows the user to establish the basic plane in relation to which the height of points on the model will be measured. Ideally, *Metashape* will thus create an elevation model so that the surface of the inscription area is marked with one shade, while irregularities, such as inscribed letters and reliefs, will have different values on a predetermined spectrum of colors.

The second software used was *MeshLab* (Cignoni et al. 2008), which allows 3 different visualization techniques suitable for the aims of this research. The first technique involves adjusting the light source's position to illuminate the monument from different angles, which is not possible in natural conditions, thereby enhancing shading and aiding inscription readability. The second visualization used in *MeshLab* is depth mapping, which is achieved by simultaneously moving the *Zmax* and *Zmin* bars, which denote the boundary values on the Z axis, i.e., the values in the depth of the 3D model. In this way, the software will assign a value of 0 to a certain minimum height, marked with black, while the maximum height will be marked as white, having the value 1. In that way, all points located between the two Z axes will be assigned values expressed in shades of gray, depending on their distance from the axes. While analysing the monuments from the village of Kremna, it was important to place the two axes as close to each other as possible and in close proximity to the inscription area or reliefs. In this way, the very surface of the monument receives the maximum value, while the deepest possible dent receives the minimum one. In other words, the deeper the symbol on the monument is carved in relation to the surface of the inscription area, the lighter it will appear. In addition to the two options mentioned, there is a third useful visualization in *MeshLab*, which, as research on a medieval inscription from western France has shown (Vergne et al. 2018), can provide good results in the analysis of damaged inscriptions. It is called Radiance Scaling (Vergne et al. 2010) and allows the recognition of shapes through shadows and radiance of objects, achieved by differences in the intensity of illumination on convex and concave parts of the object.

CloudCompare (Sautier et al. 2020) was also used for visualizations of the heights of photographed monuments. It is necessary to set a plane against which coloring will be performed, after which it is also possible to choose the type of coloring. The method of creating height ramps in this software is fairly similar to DEM in *Metashape*.

The *Blender* software (Simonds 2013) interface involves inserting functions, in the form of windows, which can later be connected to achieve the desired visualization (Ferdani et al. 2020: 15). Similar to the *MeshLab* program, the process of representing depths is based on establishing two Z axes, values 1 and 0, which can be moved in the Color ramp window.

Results

1. Funerary stele, Crkvine-Misajlovići

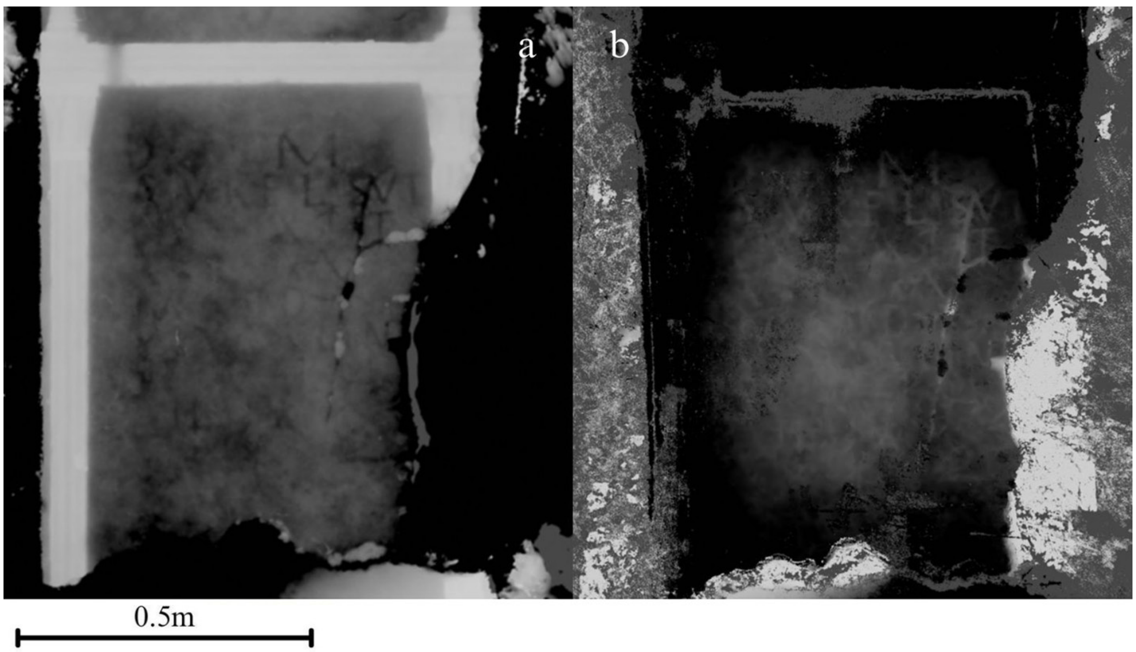
While analysing the, today invisible inscription on the funerary stele from Misajlovići, it was possible to reveal several letters, especially in the upper part of the epigraphic field. DEM analysis in *Metashape* software allowed recording 20 letters (Tab. 1), in the case of DSLR derived photos, and 15 letters on the model created by using an iPhone camera. While artificial manipulation of light source in *MeshLab* software did not result in a significant number of recorded letters, height maps in the same software allowed the reading of as many as 19 letters. Radiance scaling in *MeshLab* also resulted in a significant number of recognizable letters, with Gray Descriptor providing better results than Lit Sphere Radiance Scaling. Analysis conducted in *CloudCompare* proved to be imprecise, since it was not possible to record a single letter on either model. However, processing the models

software visualization	stela, Crkvine - Misajlovići		altar, Crkvina Rodalji - Čulići		funerary monument, Moljkovića česma		altar, Erić cemetery	
	DSLR camera	iPhone camera	DSLR camera	iPhone camera	DSLR camera	iPhone camera	DSLR camera	iPhone camera
Metashape – DEM	20	15	13	13	1	1	9	8
MeshLab – Artificial moving of the light source	3	1	4	4	0	0	8	8
MeshLab – Depth maps	19	12	27	24	2	0	20	19
MeshLab – Radiance scaling (Gray Descriptor)	18	14	25	24	2	1	15	15
MeshLab – Radiance scaling (Lit Sphere Radiance Scaling)	18	8	25	24	3	0	15	15
CloudCompare – Height Ramp	0	0	0	1	0	0	4	4
Blender – Depth maps	21	15	28	27	3	2	21	16
Readable today	0		1		0		11	
Readable in the past	20		1		0		/	

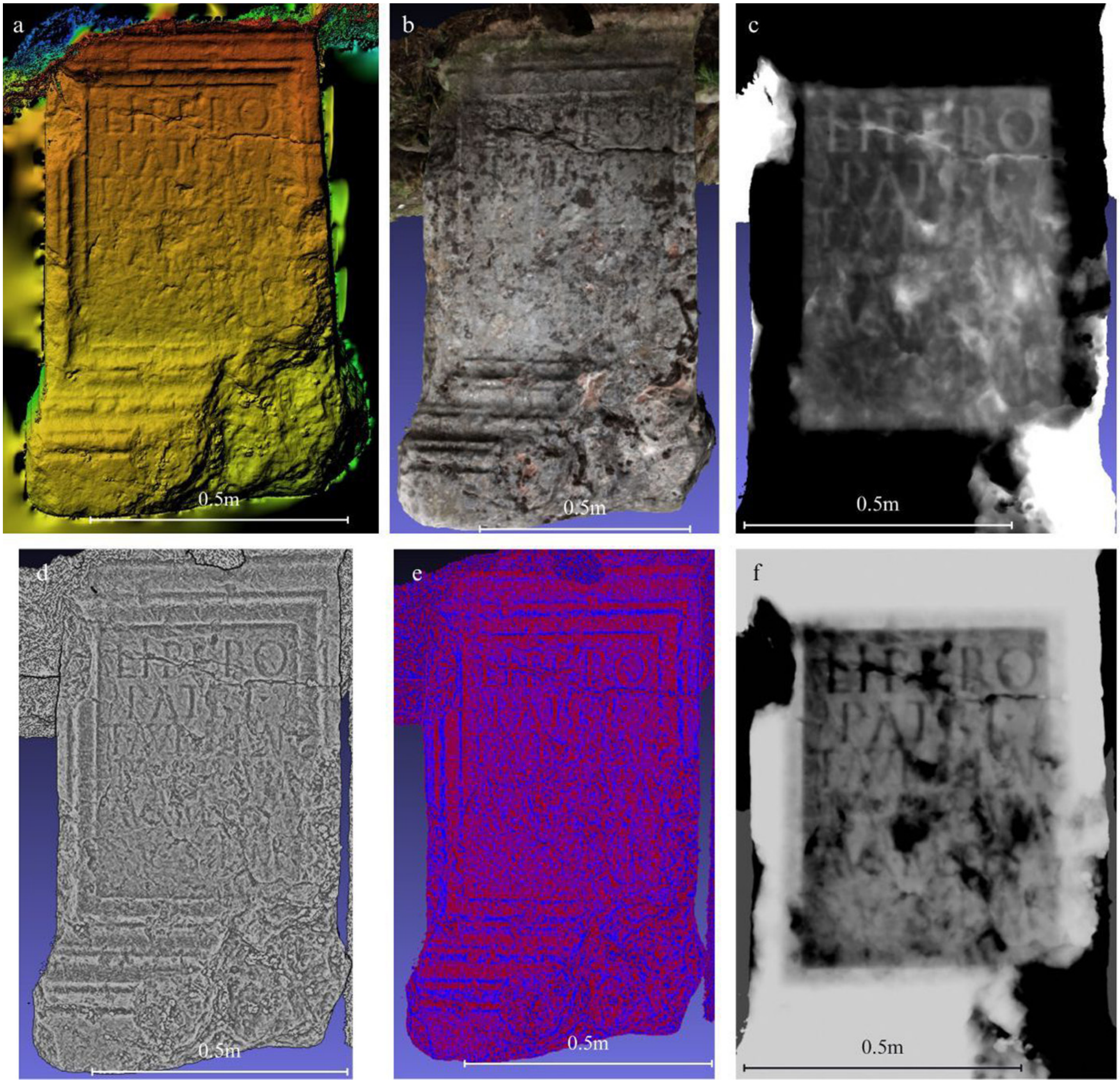
Table 1: Number of observed letters per monument, depending on the applied software visualization and the type of sensor used

in *Blender* gave the best results, with 21 recorded letters on DSLR-derived model (Fig. 2a), and 15 in the case of iPhone camera (Fig. 2b). This means that it was possible to detect the following letters: D M AVREL CVT...XIT...XN..... DT.....D.NS.....M...

By analysing the digital elevation models of the stele from the Misajlovići hamlet in the *Metashape* software, an animal figure resembling a dolphin was observed in the upper left corner of the monument (Fig. 4c). In both models, the rosette in the center of the upper field is clearly visible, together with the columns with capitals and the hippocampi reliefs in the lower field (Fig. 4d).



Figures 2a–2b. Funerary stele from Crkvine-Misajlovići, depth maps in Blender, from DSLR (a) and iPhone photos (b).



Figures 3a – 3f: The comparison of different visualizations on DSLR-derived model of the altar from Crkvina site in the hamlet of Rodalji-Čulići: (a) DEM in Metashape, (b) artificial moving of the light source in MeshLab, (c) depth maps in MeshLab, (d) Gray Descriptor radiance scaling in MeshLab, (e) Lit Sphere radiance scaling in MeshLab, (f) depth maps in Blender.

On both models, analysis conducted using the *MeshLab* software, artificial manipulation of light source allowed better detection of hippocampi in the lower field, especially when it comes to the model derived from photos taken with the DSLR camera, while the dolphin figure in the upper field corner is barely discernible. Regarding the analysis of height maps in the *MeshLab* software, all the mentioned reliefs are clearly visible. Radiance scaling, in the case of both types of visualizations, also allowed for the detection of all figural elements and the columns on this stele. Analysis of this monument's model in the *CloudCompare* software did not give the desired results, as most of the elements on this monument could not be observed. Processing the models in the *Blender* software gave results similar to those provided by *MeshLab*. Regarding relief representations, both models clearly show the rosette and dolphin motif in the upper field, as well as hippocampi in the lower field.

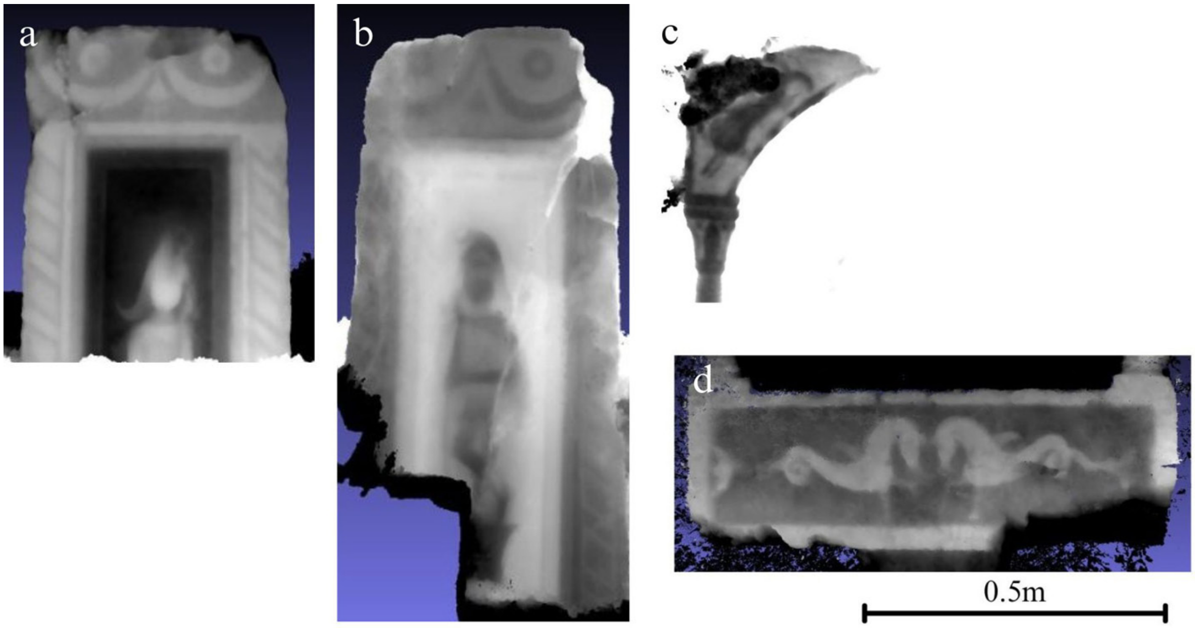


Figure 4: The reliefs visible using Metashape depth maps from DSLR photos on funerary monument from Moljkovića česma (a, b) and stela, Crkvine – Misajlovići (c, d).

2. Monument from the Crkvina site in the hamlet of Rodalji-Čulići

While analysing this, until now barely legible monument, it was noticed that the newly recorded letters were incorrectly oriented, which leads to the conclusion that the monument was placed upside down. This meant that during further processing, the model of the monument from the Crkvina site had to be rotated 180 degrees, in order to read the inscription. The creation of DEM in the *Metashape* software made it possible to see part of the inscription on this monument and in the case of both created models (Fig. 3a) it is possible to read 13 letters. Artificial manipulation of light source in *MeshLab* only resulted in 4 visible letters (Fig. 3b), but height mapping (Fig. 3c) and radiance scaling (Fig. 3d and 3e) in the software enabled much better results. While the same cannot be said in case of *CloudCompare* processing, analysis conducted in *Blender* resulted in the highest number of readable letters – 28 in the case of using the DSLR photos (Fig. 3f) and 27 for the iPhone photographs. Thus, it is possible to read almost the whole epigraphic text: LIBERO PATRI°. T°AVI...AN M...V.. AVR°M... S°V°S°L°M .

3. Tombstone built into the Moljković fountain

Due to the fact that today only a part of the inscription field is located above the ground, results of the analysis of the tombstone built into the Moljković fountain are limited. While DEM analysis in *Metashape* allowed recording a single letter on both produced models, depth maps and radiance scaling in *MeshLab* gave slightly better results on the 3D model created by photos from a DSLR camera (Tab. 1). However, by artificially moving the light source in the software, it was impossible to detect a single letter, which is also the case with height ramps in *CloudCompare*. Again, height mapping in *Blender* gave the best results, enabling 3 letters to be read on the DSLR-derived model. Those letters are: D M .N/M… Since the figure of god Attis on both sides of the monument was visible to the naked eye, most of the used visualizations only enabled a better view of the relief, and the same can be said for the garland reliefs in the upper parts of the monument (Fig. 4a, 4b).

4. Altar from the Erić cemetery

The only monument where today there are some letters visible with a naked eye was the altar from Erić cemetery (Tab. 1). DEM analysis in *Metashape* software, artificial moving of the light source in *MeshLab* and height ramps in *CloudCompare* all resulted in smaller amounts of recorded letters than already mentioned in the previous archaeological report (V. Mihajlović, from an unpublished report from systematic survey in 2021). However, height mapping in *MeshLab* allowed recording 20 letters, in the case of DSLR photos, and 19 letters on the model created by using an iPhone camera. Among all visualizations applied to the model derived from mobile phone photos, depth maps in *MeshLab* gave the best results, which is the only example where *Blender* has not been able to provide the most complete results. Radiance scaling in *MeshLab* resulted in 15 recorded symbols in all cases. Once again, the best results overall were provided by *Blender*, with 21 letters recorded on DSLR model: IOM .T.RD°CS(?) ...ANVS N..IROO VSLM.

Discussion

The issue of recording and interpreting epigraphic monuments can, at least partially, be addressed through the creation of 3D models for archaeological purposes. This approach facilitates an objective and precise documentation, analysis, conservation, and presentation of archaeological material (Vergne et al. 2018: 6). The results of this study underline the necessity of generating 3D models of epigraphic monuments and other archaeological findings, particularly concerning artifacts made of perishable materials or those inadequately protected and presented. The documentation and permanent conservation of epigraphic monuments can be achieved by 3D models, as they offer a relatively quick, cost-effective, and straightforward means to permanently document artifacts such as epigraphic monuments. The production of 3D models of the monuments from Kremna was of particular significance, given their composition of easily degradable limestone, which should under no circumstances be exposed to environmental factors. Their notably poor state of preservation has been known since the late 19th century (Vulić 1941-48: 248; Vulić & fon Premerstein 1900: 50-51), and only by 3D visualizations used in this paper was it possible to record previously invisible features.

The comparison of results depending on the used software tool was the primary focus of this study. Each used option in the mentioned software will be individually discussed at this point. In order to establish a criterion for the success of the results, the visualizations offering the highest number of recognized letters (Tab. 1) were simply marked as the best ones, with a separate focus on the visibility of relief images.

The primary advantage of using DEM in the *Metashape* software is the relatively straightforward execution of analyses, given that this program is most commonly used for creating 3D models in archaeology (Lehoczky & Abdurakhmonov 2021: 6). The elevation models provided sufficiently good results, particularly in terms of the number of observed letters on the stele from the Misajlovići hamlet, although fewer letters were observed in the case of other monuments. The success of analysing monuments through the creation of digital elevation models may depend on several factors, and it is important to note that this method is most commonly used for relief representation in terrain model creation (Kokalj et al. 2013: 100). The advantage of this method lies in providing a comprehensive view of all parts of the monument simultaneously, as it does not depend on the mutual distance of artificially placed axes, as is the case with depth mapping, and it is the software most widely used by the archaeological community.

Concerning the analyses in the *MeshLab* software, it is noticeable that artificial light source displacement did not deliver equally good results as other visualizations. Nevertheless, this by no means implies that this method is useless, given that all relief representations and symbols are significantly more recognizable when using this method. The next used option in the *MeshLab* software was depth mapping. This analysis allowed notably good results for all monuments, and in the case of the mobile phone model of the altar from the Erić cemetery, this visualization provided the highest number of observed letters. Generally speaking, of all the 7 applied visualizations, only the method based on the same principle executed in Blender software provided better results. The third visualization used in the *MeshLab* software, radiance scaling, provided expectedly good results that support earlier conclusions regarding the method's success (Vergne et al. 2018: 7). Although the method did not provide better results than depth mapping, this visualization can also be considered sufficiently detailed for registering damaged inscriptions. Gray Descriptor and Lit Sphere Radiance Scaling, in terms of their success, do not differ significantly, with an advantage of the latter option being the ability to choose desired colors for concaves and convexes. It is necessary to emphasize that, just like digital elevation models and shading methods in *MeshLab*, this method provides a comprehensive view of all parts of the monument simultaneously, which is particularly important for observing reliefs.

The *CloudCompare* program failed to provide sufficiently high-quality data regarding the registration of damaged inscriptions on epigraphic monuments. By applying the described analysis in this software, it was possible to read only a part of the already visible letters. On the other hand, this software tool allowed a slightly better perception of certain relief scenes, although other used software tools proved better for these purposes.

As already mentioned, in almost all cases, depth mapping in *Blender* software provided by far the best results. This is not surprising, considering that this method proved to be very effective in the case of analysing a Roman epigraphic monument from Spain (Andreu & Serrano 2019). On the sample of monuments from the Kremna village, depth maps provided the best results in 7 out of a total of 8 created models. Such a result confirms that, regardless of the choice of physical sensor for photographing, registering inscriptions on illegible or poorly legible epigraphic monuments is best achieved through depth mapping in *Blender* software. However, this by no means implies that only this program could be used for these purposes. Depth mapping and radiance scaling in *MeshLab* software provide nearly as good results, and it is a software with a much simpler interface. Additionally, the disadvantage of *Blender* is that depth mapping prevents simultaneous viewing of all relief representations on the monument, which is not the case with radiance scaling.

While DSLR photogrammetry resulted in models useful for further epigraphic analysis, the mobile phone camera was employed primarily to assess the speed and general utility of creating 3D models with widely used technology. This approach aimed to determine if mobile devices could serve as a valuable preliminary tool for quickly identifying potential inscriptions or features on monuments that warrant more in-depth photographic documentation. The results of this work indicate the existence of the inscriptions on the monuments, and resulted in their correct interpretation. The fast acquisition of photos offered by mobile phones therefore positions them as an effective method for initial site assessment, potentially indicating areas where detailed recording with professional-grade equipment would then be most beneficial. Additionally, precisely calibrated mobile setups can also result in comparable results (Saif & Alshibani 2022; Patonis 2024), and lately smartphones also have LiDAR technology (Antón et al. 2025), which is another direction for future research in the field of 3D epigraphy.

Even though the main aim of this paper was purely methodological, it is impossible to ignore the potential of the results for archaeological interpretation. By combining the results from this paper with the previous readings of the same monument (Mandić 2015: 206), it is possible to interpret the inscription on funerary stele from Misajlovići: *D(is) M(anibus) Aurel(ius) Sut- [- - -]xit [- - -]XN[-] [- - -]DT[- - -] [- - -]D[- - -]N S[- - -] [- - -]M[- - -].* Apart from that, the reliefs that are today unrecognizable were possible to detect, allowing us to capture them before further decay. The most interesting results are the ones regarding the monument from Crkvina in the hamlet of Rodalji-Čulići. Previous researchers could only recognize letter C in the lower part of the monument. However, even that reading was wrong, since the monument was placed upside down by archaeologists, which could be concluded only by the precise methodology used in this paper. After the conducted visualizations, it is now possible to reconstruct nearly the whole inscription: *Libero Patri• T. Aur(elius ?)[- - -]AN M[- - -]V[- - -] Aur(elius, -elia)·M[- - -] S•v(otum)•s(olverunt)•l(ibentes)•m(erito).* Only now can we conclude that this monument is an altar dedicated to Liber, Roman god of fertility, wine, winemaking and freedom (Imamović 1977: 160). As such, Liber was often referred to as *Deus Laetus*, that is, "the happy god" (Olujić 1990: 9). The inscriptions on the altars dedicated to him usually begin like our example, with the dedication Libero Patri. The number of votive monuments dedicated to Liber is quite numerous in Dalmatia, and a higher concentration of such monuments was also recorded in the provinces of Pannonia and Dacia (Olujić 1990: 10). Regarding the monument built into the Moljković fountain, it is now possible to record and interpret a small part of the, never before read inscription: *D(is) M(anibus) [- - -]M*. It is also possible to expand the previous interpretation of the altar from Erić cemetery: *I(ovi) O(ptimo) M(aximo) [- -]T[- - -]RD•CS(?) [- - -]anus N[- - - IIv]ir q(uin)q(uennalis) v(otum) s(olvit) l(ibens) m(erito).*

Conclusions

The findings from the analysis conducted in this paper unequivocally represent the success of three-dimensional photogrammetry in reading weathered, obscured, or faintly discernible epigraphic inscriptions or reliefs on architectural artifacts. Across all surveyed monuments, a substantially larger number of letters was documented compared to conventional techniques, with a notable discovery of 27 previously unnoticed characters. The results of this paper allowed us to record yet unknown archaeological and historical features of the Kremna basin, such as the presence of Liber's cult in this part of Roman Dalmatia. This outcome leads to the suggestion for further usage of the presented methodology, along with the integration of laser scanners and infrared thermography (IRT). Nonetheless, the advantage of 3D photogrammetry lies in its widespread accessibility. It was for these reasons that the described visualizations were examined on models derived from an iPhone camera.

Although outcomes may not match the quality of the results achieved via DSLR cameras, they notably outperform traditional methods of monument interpretation. The methodological framework of this study can serve future studies of 3D epigraphy, particularly in recovering lost inscriptions and reliefs.

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An Integrated Methodological Approach to the Archaeology of the Ludogorsko Plateau, Northeastern Bulgaria[1]

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The study presents the results of non-invasive (remote sensing and geophysical surveys) research conducted in a small area in Northeastern Bulgaria known as the Ludogorsko Plateau. These investigations are part of a broader research project that examines the spatial patterns and dynamics of settlement during the Bronze and Iron Ages in the Ludogorsko Plateau region.[2]

The research includes the identification of archaeological sites through the analysis of satellite imagery. For this purpose, the "History" tool in Google Earth Pro was used, allowing users to view the same area across different years and seasons. The studied sites are clearly distinguishable from the surrounding terrain by the presence of crop marks and soil marks. The subsequent phase entails on-site verification through targeted field surveys.

The archaeological materials were identified at the visited sites, usually pottery sherds, but in some cases also small finds such as spindle whorls, flints, and stone tools were also present. Geophysical surveys were conducted at several of the recorded sites, revealing anomalies with varying characteristics. The data show a high concentration of soil marks in the Topchiyska River area, which appears to have played an important role in the past. This study discusses examples of sites identified through non-invasive methods, particularly in the vicinity of the villages of Medovene, Brestovene, Pobit kamak, and Kamenovo in the Razgrad region.

Keywords: *non-invasive investigations, satellite imagery, Ludogorsko Plateau, Late Bronze Age, soil marks, geophysical surveys*

Introduction

The purpose of this paper is to present the results of preliminary observations, followed by field and geophysical surveys of four sites from the Late Bronze Age. These sites are located in Northeastern Bulgaria, in the area of the so-called Ludogorsko Plateau. Their examination includes the sequential implementation of precisely defined separate research components or steps in the study of each site: 1. Preliminary observation using software tools; 2. Field survey to the site and its registration (during which pottery sherds and finds from the surface are collected); 3. Geophysical survey. Consequently, a logically consistent system is established for the study and mutual verification of each subsequent stage and result with the preceding ones.

[1] The research is part of a doctoral thesis on "Spatial patterns and dynamics of the settlement of the Ludogorsko Plateau during the Bronze and Iron Ages".

[2] The publication is part of the realisation of a project "Non-destructive archaeology: an interdisciplinary study of the settlement pattern of the Ludogorsko Plateau in the Bronze and Early Iron Age", contract between The National Archaeological Institute with Museum at the Bulgarian Academy of Sciences and the Bulgarian National Science Fund No. КП-06-Н80/12 from 15.12.2023.

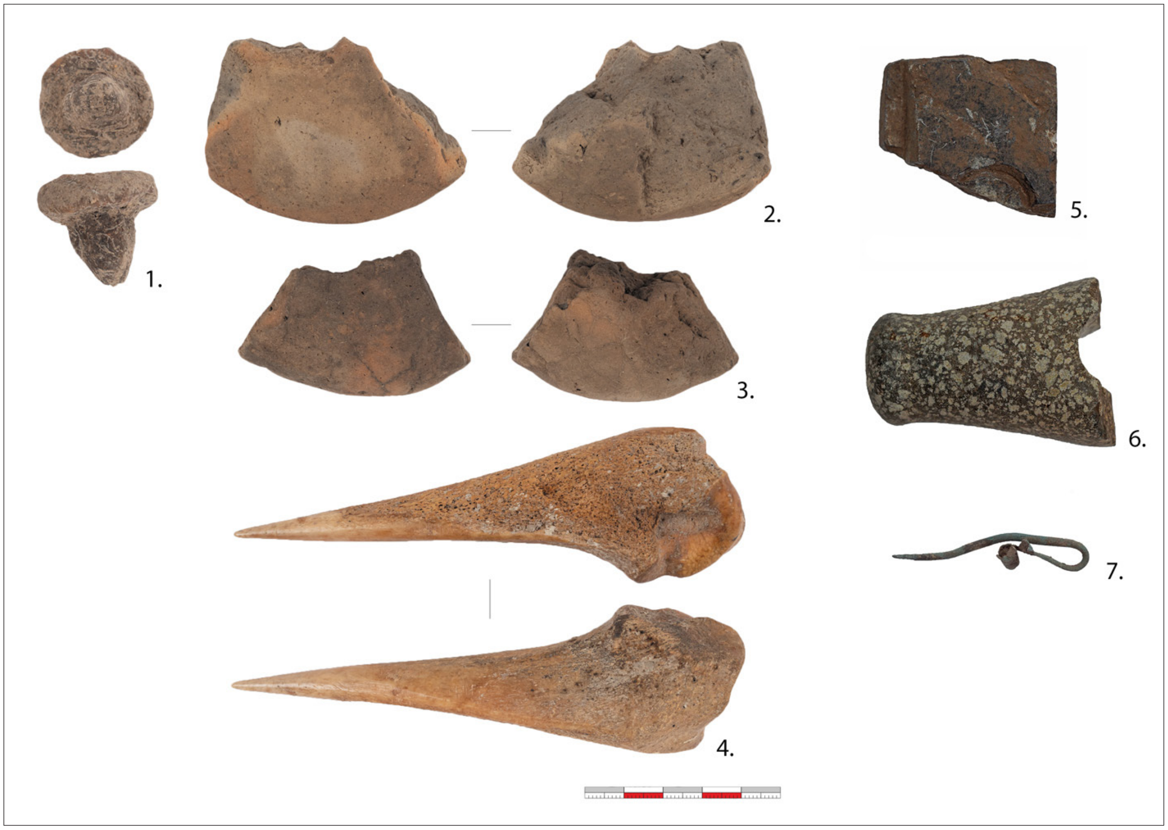

Figure 1. Finds from the Kamenovo, Yurtluka area, Feature No. 1: 1. Clay stopper; 2-3. Fragments of clay discs 1-3 (Minkov et al. 2024: 200, fig. 17); 4. Bone awl; Medovene: 5. Fragment of a stone mould; 6. Fragment of a stone axe; 7. Bronze pin 5-7 (Popov et al. 2025: 25), (photos by M. Raykovska).

History of the Research

The results presented in the study constitute a component of a large-scale project, the initial phase of which commenced in 2021 and covers significant territories in the Ludogorsko Plateau. The present project aims to investigate the possibility of establishing the presence of sites from the Late Bronze and Early Iron Ages in the area of Pobit kamak, Dabravata district – where the notable find of stone moulds originated (Leshtakov 2018). Among the objects that generated the most significant interest were the hoards of stone moulds utilised for the casting of metal objects of various types, including weapons, jewellery, and tools. These hoards were discovered fortuitously and lack an archaeological context, which complicates the investigation of their use, association with specific sites, cultural identification, interpretation, and chronology. This discovery has prompted scientific interest in determining the nature of the find, including whether it is accidental or not, and whether it belongs to a settlement feature or is an isolated deposit. These questions also relate to the presence of several hoards of metal artefacts from the Late Bronze Age, which are relevant to the issues concerning the origin and nature of such objects in this area. During the Late Bronze Age, the region exhibited a high concentration of hoards associated with Late Bronze Age metallurgy. Among them can be mentioned the deposits and single finds of metal discovered at the villages of Ionkovo, Sokol, Loznitsa, Kubrat, Dulovo, Isperih, and others. Sickles and hollow axes of Celtic type were found in many of these collective finds (Hristova 2018).

The research conducted in this study encompasses the territories of the contemporary villages of Kamenovo, Pobit kamak, Medovene, Brestovene, Ostrovo, and Savin, which are located in proximity to the contemporary town of Kubrat. Consequently, several sites have been registered, interpreted as settlements of the Late Bronze Age. This interpretation is based on an analysis of the mass ceramic material, the finds – including spindle whorls, flint and stone tools, as well as exceptional individual finds – stone moulds, and pieces of bronze pin, insignia (fragment of a stone axe/scepter) – that have been discovered (Hristova & Sandeva, forthcoming; Minkov et al., forthcoming *b*; Popov &

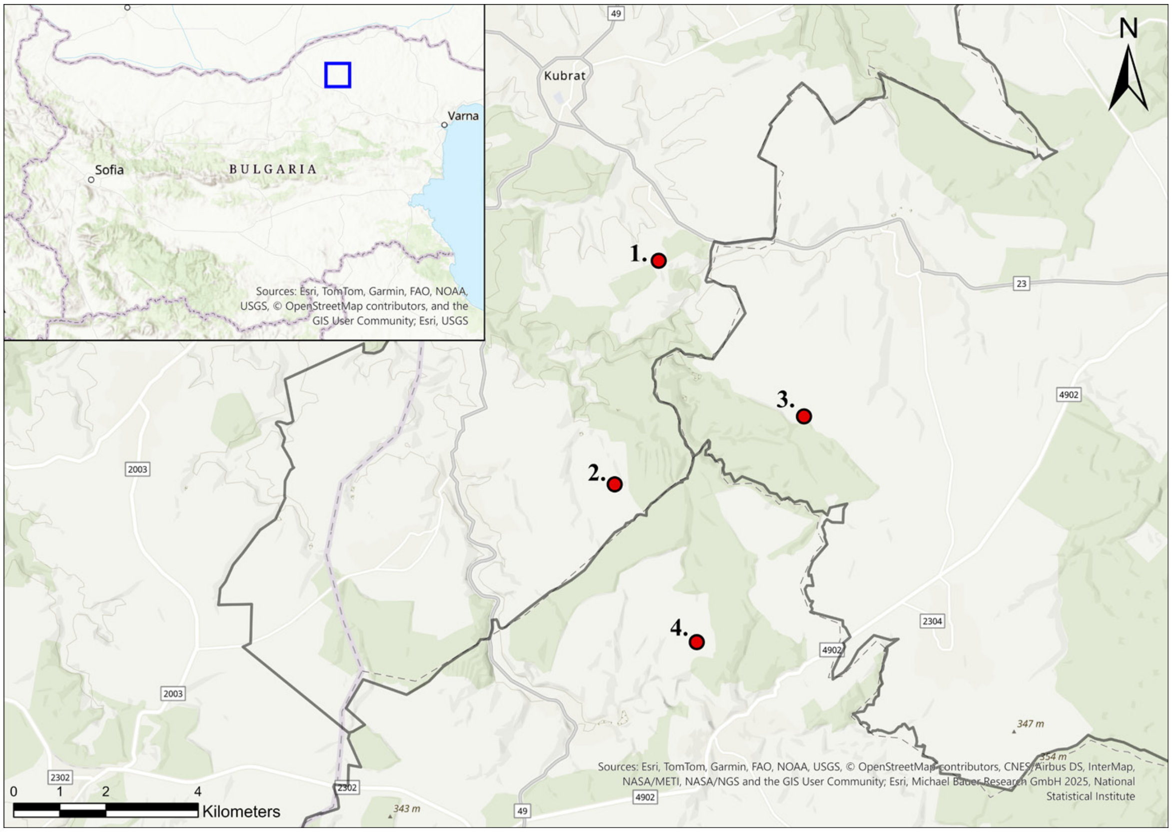

Figure 2. Map of the Ludogorsko Plateau, sites at: 1.Medovene; 2.Kamenovo; 3. Brestovene; 4. Pobit kamak (made by D. Sandeva).

Georgiev, forthcoming *a*; Popov, Georgiev, forthcoming *b*; Popov et al. 2025) (Fig. 1), along with the obtained 14C data.

Following the conclusion of field surveys in the areas of Kamenovo, Medovene, Brestovene, and Pobit kamak, geophysical surveys have been conducted.[3] In these areas, pottery sherds dating to the Late Bronze Age have been unearthed. A number of these sites coincide with previously identified artefacts and extend the empirical basis regarding the metalworking and metallurgy typical of this geographical region.

Geographical area. Main characteristics

The geographical area of the study, in which the four sites that are the focus of the research are located – Medovene, Brestovene, Kamenovo, and Pobit kamak – the Ludogorsko Plateau is located in Northeastern Bulgaria (Fig. 2). The term "crazy forest" is associated with the name of this region. The old name of the Ludogorie – Deliorman was used until 1942 (Iliev 2007: 34) and has been known since 16th century (Iliev 1999: 9). The boundaries of the area extend westwards to the Beli Lom and Topchiyskaya rivers, bordering the Razgrad and Samuilov Heights to the south, and reaching the Dobrudja Plateau to the east (Vladev 2020: 51; Vladev 2022: 4). The most prevalent soil type is black soil (chernozem), which is characterized by its exceptional fertility. Additionally, a large number of grey forest soils occur, which is due to the centuries-old oak forests for which the area is famous (Doykov & Doykov 2017: 38-39). The Topchiyska River constitutes one of the primary water sources in the region, and a substantial number of archaeological sites have been documented in its valley.

[3] All geophysical studies included in this research were conducted by Assoc. Prof. N. Tonkov and A. Atanasov (NAIM-BAS).

Materials and Methods

Before the beginning of archaeological ivestigations, several preparatory steps were taken, including the examination of satellite images and the analysis of topographical maps at scales of 1:5000 and 1:50 000. These sources provided significant insights into the toponymy of the region.

A variety of investigative methods were employed, including remote sensing using satellite imagery, field verification of potential archaeological sites identified from satellite imagery, and collection of archaeological surface material. Google Earth Pro enables users to „travel back in time“ to 1985, when the first images of the Northeastern Bulgaria region were captured. In the initial phase, however, the image quality is insufficient and none of the recorded sites from this period could be identified. Since 2009, the multitude of satellite images have been carried out, which have shown very good image quality, especially in recent years (since 2019), allowing detailed observations of the areas and recognition of changes in the surrounding terrain. Over the past two decades, with advances in technology, an increasing number of satellite images have been acquired – sometimes two to three per year in different seasons – allowing the observation of plots at various stages of their agricultural use. A key advantage of this non-invasive remote sensing technique lies in its ability to capture temporal variations in the observed at different times. The images used to locate the archaeological sites were not subjected to post-processing. All possible variations are traced back in time, and the best images are selected for subsequent analysis of size, number of soil marks, and spacing. In the present study, this method was employed to identify crop marks and soil marks that could be potential archaeological sites (Gojda 2005; Verhoeven & Doneus 2011; Materazzi & Pacifici 2022).

The subsequent phase entails the substantiation of the soil marks, although they resemble anomalies attributable to prior human intervention, it is possible that natural changes influenced by the environment are responsible. Verification involves a site visit to the previously identified soil marks. The area is surveyed by a team of archaeologists, who walk either at regular intervals (15 to 20–25 m) or at uneven intervals across the site, depending on the chosen method, collecting any archaeological material that can serve as a chronological indicator – such as characteristic pottery sherds and finds, if present. Global Positioning System (GPS) is utilised to mark locations with elevated concentrations of archaeological material or finds, so their positions are known even though the land has often been deeply ploughed and some material may have been redeposited and scattered.

The soil marks previously identified for visitation are surveyed, and the surrounding area is also examined to allow for the detection of other concentrations of material that have no visible distinction from the surrounding terrain on satellite imagery. If archaeological material is present on the surface, a plan survey is conducted to determine the possible limits and extent of the archaeological site.

Subsequent to the verification and confirmation of the presence of archaeological sites, a geophysical survey is conducted, employing magnetic gradiometry in a dual fluxgate gradiometer configuration (Popov et al. 2025: 25).

Results

The results below are presented for each site, following the sequence of steps set out at the beginning. The following data concern the sites at Medovene, Kamenovo, Brestovene, and Pobit kamak[4]. These sites form the core of the study of the Late Bronze Age and are the only sites on which stone forms were discovered during the excavations in the area. The field surveys revealed medium to high concentrations of archaeological material, including pottery sherds, plaster, flints, stone objects, and small ceramic finds (spindle whorls, loom weights). These findings corresponds to the location of the soil marks observed in the satellite imagery during the field inspection. This observation suggests that the highest concentration of archaeological materials and finds – bones and charcoal – are found in the area of dark soil marks[5]. Single archaeological materials are often found outside the soil marks, but they are in much lower concentration and may have been dispersed during agricultural cultivation.

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[4] The data from the geophysical surveys have not yet been published, and the author would like to thank Assist. Prof. P. Minkov, PhD (NAIM-BAS) and Assist. Prof. Zh. Vasileva, PhD (NAIM-BAS) for the information provided.

[5] Some of the archaeological finds were presented in a temporary exhibition entitled »Bulgarian Archaeology 2024« at the National Archaeological Institute with Museum at the Bulgarian Academy of Sciences and in the accompanying catalog.

Figure 3. Aerial photograph of the LBA site near the village of Medovene (photo by Eng. V. Valchev).

Most of the soil marks are more clearly visible in Google Earth Pro when the monitored area is left fallow or ploughed, that is, during the months of February to April and October to November. During these periods, the soil marks become more visible and display an intensely dark colour, usually dark brown to black, standing out clearly from the surrounding terrain. In other cases, a clear distinction from the surrounding terrain can be discerned in the presence of emerging vegetation (May to July), where the presence of archaeological features is indicated by denser vegetation or by the absence of such features and the presence of areas without plants. The soil marks are related to the so-called vegetation indicators, where areas with less and anomalous vegetation indicate the presence of archaeological features (Orlando & Villa 2011: 156). This is also clearly visible when photographing the terrain with a drone (Fig. 3) According to some studies, agricultural plants are „thicker, taller or ripen later“, which is explained by a higher moisture content of the soil, or they develop more slowly and less well when there is insufficient moisture, as was the case in the presence of an archaeological feature with stones (Aqdus et al. 2008: 361).

The dimensions of the soil marks at the Late Bronze Age archaeological sites of Medovene, Brestovene, Kamenovo and Pobit kamak have been documented, with variations in size ranging from 10-20 m for the smaller marks to 50-60 m for the largest. The majority of the marks exhibit an average diameter of 30–40 m and are often grouped in groups of several traces.

I. Medovene

The archaeological site is situated in the village of Medovene, Kubrat municipality, Razgrad region, in the Sayaorman area, on privately owned agricultural land. The topography of the site is predominantly flat, exhibiting a gradual incline toward the southern direction (Minkov et al., forthcoming c). The southern and eastern boundaries of the region are delineated by contemporary forested regions, while the western landscape is distinguished by a shallow, north-south trending ravine. This site is part of a network of dry valleys that are characteristic of the Ludogorsko Plateau (Minkov et al., forthcoming *c*).

Figure 4. Soil marks at Medovene (source: Google Earth Pro) and the results of the geophysical survey (Assoc. Prof. Dr. Eng. N. Tonkov and A. Atanasov, NAIM-BAS; Minkov et al. forthcoming c).

Preliminary observation

When observing satellite images from Google Earth Pro using the History view tool throughout different seasons, under different climatic conditions and with different land cultivation, large dark soil mark with an approximately circular/oval shape were identified. Review of the images over different time periods shows the highest contrast after terrain treatment, in the absence of grown crops. The soil marks occupy the southern part of the site, clearly differing from the surrounding environment. They are compactly located among themselves, with no preliminary planning or organisation noticeable. It can be said that the distances between them are approximately the same.

Visit, search, registration

The site was visited and registered in 2021 (Popov & Georgiev, forthcoming *a*). During the site visit, large soil marks of dark brown soil were clearly visible, containing pottery sherds, individual finds, and animal bones. Charcoal and plaster are often visible on the surface of some of the soil marks. Some of the soil marks are discernible on the ground as slightly elevated, smooth, positive shapes. Consequently, in addition to the color indicator, there is also a criterion related to the terrain relief is identified that corresponds to the observed dark soil marks. The registered remains have been interpreted as a Bronze Age settlement.

Geophysical Survey[6]

In 2024, geophysical investigations were conducted, with magnetic gradiometry serving as the primary survey method. The study utilised a dual-configuration fluxgate gradiometer (GRAD 601) manufactured by Bartington Instruments in the United Kingdom (Minkov et al., forthcoming *c*).

A total area of almost 94 decares was examined (Minkov et al., forthcoming c). The results indicated the presence of a notably elevated concentration of potential archaeological anomalies, which were subsequently categorised into three relatively compact clusters: northwestern, central, and southern (Minkov et al., forthcoming *c*).

The northwestern cluster displays the highest anomaly density while covering the smallest area. The central cluster is the most extensive in both size and number of recorded anomalies, characterised by a moderately compact spatial distribution (Minkov et al., forthcoming c). Within this group, two larger anomalies stand out and may corre-

6 The information on the area of all geophysical surveys mentioned below (at the sites near Kamenovo, Brestovene, Medovene, and Pobit Kamak) was obtained from data in annual archaeological reports and includes data to be published in Bulgarian with a summary in English (Minkov et al., forthcoming a; Minkov et al., forthcoming c; Minkov et al., forthcoming d; Minkov et al., forthcoming e; Vasileva et al., forthcoming)

spond to structures of residential or economic function. The southern cluster was only partially surveyed due to the presence of a forested massif in the western and southwestern sections of the site, as well as a dirt road running parallel to the forest boundary (Minkov et al., forthcoming *c*).

Conclusions

In consideration of the results that have been presented, it is possible to formulate a number of conclusions. The archaeological anomalies are distributed across two compact groups, coinciding with the area of the dark soil marks. However, there is no topographical overlap between the shape and size of the anomalies and the dark soil marks. That is to say, there is no correspondence between the field data and the results of the geophysical survey. However, the presence of colored markers and a high concentration of ceramic materials indicate the existence of a site that was recorded during field searches and whose boundaries were refined through geophysical surveys (Fig. 4).

II. Kamenovo

The site is situated in a region of cultivated agricultural land within the village of Kamenovo, in the Kubrat municipality, in the Yurtluka area. The site is naturally confined to the east and northeast by a dry riverbed, which belongs to a larger network of arid river channels (Minkov et al., forthcoming a; Minkov et al., forthcoming b). The topography of the area under consideration is predominantly flat, exhibiting a minor inclination toward the south-southeast. The geographical entity under scrutiny is composed of two distinct regions, a northern portion that is comparatively diminutive in size and a southern region that is the primary and most sizable part of this geographical area of concern 2023 (Minkov et al., forthcoming *b*) and (Minkov et al., forthcoming e).

Preliminary observation

The presence of a group of dark soil marks, which are round to oval in shape, is indicative of this phenomenon. The soil marks under consideration are located in a relatively narrow linear section, oriented northwest-southeast. The colour contrast between the two is pronounced, creating a striking visual effect that immediately draws the viewer's attention. The soil marks exhibit a random distribution across the terrain, with no discernible pattern or arrangement. One of the soil marks exhibits an extensive, concentric soil mark of a deep grey colour.

Visit, search, registration

The site near Kamenovo was also registered in 2021 (Popov & Georgiev, forthcoming *a*). In a manner consistent with the preceding site, dark soil marks were identified on the terrain, devoid of relief forms and „swelling“ on the surface (as observed in Medovene). In the southern portion of the site, which constitutes the primary area of interest, there is a notable concentration of pottery sherds, burnt organic matter, animal bones, and individual artefacts, including ceramic plugs, wheel models, and moulds. One of the dark soil marks, which is also the largest, exhibits a light grey hue due to the presence of intensely saturated ash in the central portion of the soil mark. In the northern section of the site, the soil marks are less prevalent, with the site extending north and east into a contemporary forest. It is noteworthy that in this region of the site, a prominent central soil mark is evident, accompanied by several smaller soil marks of round to oval configuration, exhibiting no discernible pattern in their arrangement.

Geophysical survey

Geophysical surveys of the site began in 2022 and continued in 2024 (Minkov et al. 2024: 187-191; Minkov et al., forthcoming *b*; Minkov et al. forthcoming *e*). The results obtained demonstrate a topographic pattern analogous to that observed in Medovene. In the southern part of the site, there is a medium to high concentration of anomalies, which are divided into two groups: northern and southern, with a clear break between them (Minkov et al., forthcoming b; Minkov et al., forthcoming, e). Within the two prominent anomalies, there is an observable internal stratification of individual anomalies into discrete, smaller groups, as evidenced by the analysis of magnetograms. This principle applies universally, irrespective of the magnitude of the anomaly in question (Minkov et al., forthcoming b). This approach enables the discernment of anomalies that might be pits, farm buildings, residential features, or features with ambiguous functions and characteristics. In the northern part of the site, a much simpler picture

Figure 5. Soil marks at Kamenovo (source: Google Earth Pro) and the results of the geophysical survey (Assoc. Prof. Dr. Eng. N. Tonkov and A. Atanasov, NAIM-BAS; after: Minkov et al. 2024: 189, fig. 7).

can be observed. The terrain contains two groups of anomalies, which are dispersed and scattered across the terrain in a chaotic and dispersed manner. There is an absence of any discernible internal arrangement or layout. The observed frequency of anomalies is notably low, and the spatial extent of the site is delineated with clear boundaries (Minkov et al., forthcoming *b*; Minkov et al. forthcoming *e*).

Archaeological excavations

The archaeological excavations at the site were conducted in 2023 (Minkov et al., forthcoming *a* and Minkov et. al 2024). One of the registered anomalies has been the subject of preliminary investigation. The investigation established that the anomaly found in the geophysical survey is precisely what was observed. This feature, which is approximately 4.50 m x 4.50 m in size, was dug to a depth of 3.25 m in sterile sediment. Presently, however, its function remains unclear, as only half of it has been studied (Minkov et al. 2024: 191-193; Minkov et al., forthcoming *a*). The site is characterised by the presence of loose soil and a substantial quantity of ash, which significantly facilitates the investigation of this depth. It is noteworthy that the feature itself is situated within a layer of dark reddish-brown sediment, which likely represents a cultural layer saturated with small fragments of plaster and charcoal. A noteworthy discovery was made during the registration process of the site on the terrain, specifically at the location of the feature in question. This registration revealed the presence of clay stoppers and wheel models, exhibiting a striking similarity to those previously identified during the in-depth study.

Conclusions

It is important to note that this is the only site in the area where a complete chain of operations was carried out during the survey. These include satellite monitoring, field surveys, geophysical surveys and archaeological excavations. This allowed for a comprehensive observation of the individual elements of the site. The results of the preliminary observation and geophysical survey differ in terms of the overlap of the large soil marks and the actual anomalies “located beneath them.” There is no correspondence in terms of their location, size, and grouping on the ground. The geophysical survey and the subsequent archaeological research showed complete agreement in the results obtained for one of the anomalies, and subsequently in its study (Fig. 5).

III. Brestovene

The site's geographical location within a region of cultivated agricultural land in the vicinity of the village of Brestovene, municipality of Zavet, in the Kodzhaekinlik area, renders it a subject of particular interest. The southernmost extent of the area is delineated naturally by a dry riverbed, which constitutes a segment of a larger interconnected system of channels (Minkov et al., forthcoming d). A contemporary unpaved route traverses the system's medial sector, tracing the path of one of the riverbeds present in this geographic location. The site is divided into two primary sectors: eastern (East) and western (West). Both sectors demonstrate a gradual southward incline toward the primary dry riverbed (Minkov et al., forthcoming *d*).

Preliminary observation

The site is identified by the presence of dark soil marks, which are irregularly round to oval in shape and of approximately equal size. Several of these marks display a light grey central area, which is similar to one of the soil marks identified near Kamenovo. Preliminary field observations suggest that the soil marks may extend southwards into the adjacent forested area, indicating a possible connection between the two parts of the site.

Visit, search, registration

The archaeological site was registered in 2022 (Popov & Georgiev forthcoming *b).* During a site visit, large soil marks of dark brown soil are clearly visible on the surface of the terrain, which differs from the surrounding light brown soil. The presence of ceramic materials and artefacts is particularly pronounced within these soil marks. The soil marks, which during the observations have grey central parts, turn out to be saturated with ash.

Geophysical search

Geophysical surveys were carried out in 2024 (Popov et al. 2025; Minkov et al., forthcoming *d*). Two local square grid systems - Sector West and Sector East were established within the archaeological site (Minkov et al., forthcoming d). The geophysical survey of the first sector (West) covered an area of almost 40 decares. The results reveal two main zones with a concentration of anomalies: one in the northwest and one in the southeast (Minkov et al., forthcoming d). Numerous negative archaeological features, likely pits, were recorded in these areas, along with several anomalies that may correspond to residential or economic structures. The anomalies are dispersed across the terrain and do not form dense clusters or coherent patterns (Minkov et al., forthcoming d). It is possible that the dirt road running through the southeast has disrupted and affected the southeastern edge of this sector of the site (Minkov et al., forthcoming *d*).

In the sector East, an area of almost 39 decares has been surveyed (Minkov et al., forthcoming d). The geophysical survey results indicate the presence of a medium to high concentration of potential archaeological anomalies within the designated area (Minkov et al., forthcoming d). In the northwestern part, relatively compactly arranged archaeological features (probably pits) have been identified (Minkov et al., forthcoming d). In the southern part of the sector, isolated anomalies have also been recorded, providing information about dugins (Minkov et al., forthcoming *d*).

The observations made on the eastern periphery of the sector corroborate the aforementioned assertions. The easternmost corner of the sector exhibited a solitary anomaly, which could potentially delineate the perimeter of the site (Minkov et al., forthcoming *d*). It has been observed that within the plowed furrow located at the easternmost edge of the site, there are minor anomalies that are clearly discernible. At this juncture, however, it is challenging to ascertain whether these anomalies are authentic archaeological features (Minkov et al., forthcoming *d*).

Conclusions

Here, too, the observations of a discrepancy between the large soil marks visible during the observation and registration of the site and the results obtained for the anomalies from the subsequent geophysical survey should be repeated. The presence of a relatively low number of anomalies, against the background of the large soil marks located at close distances, is of interest (Fig. 6).

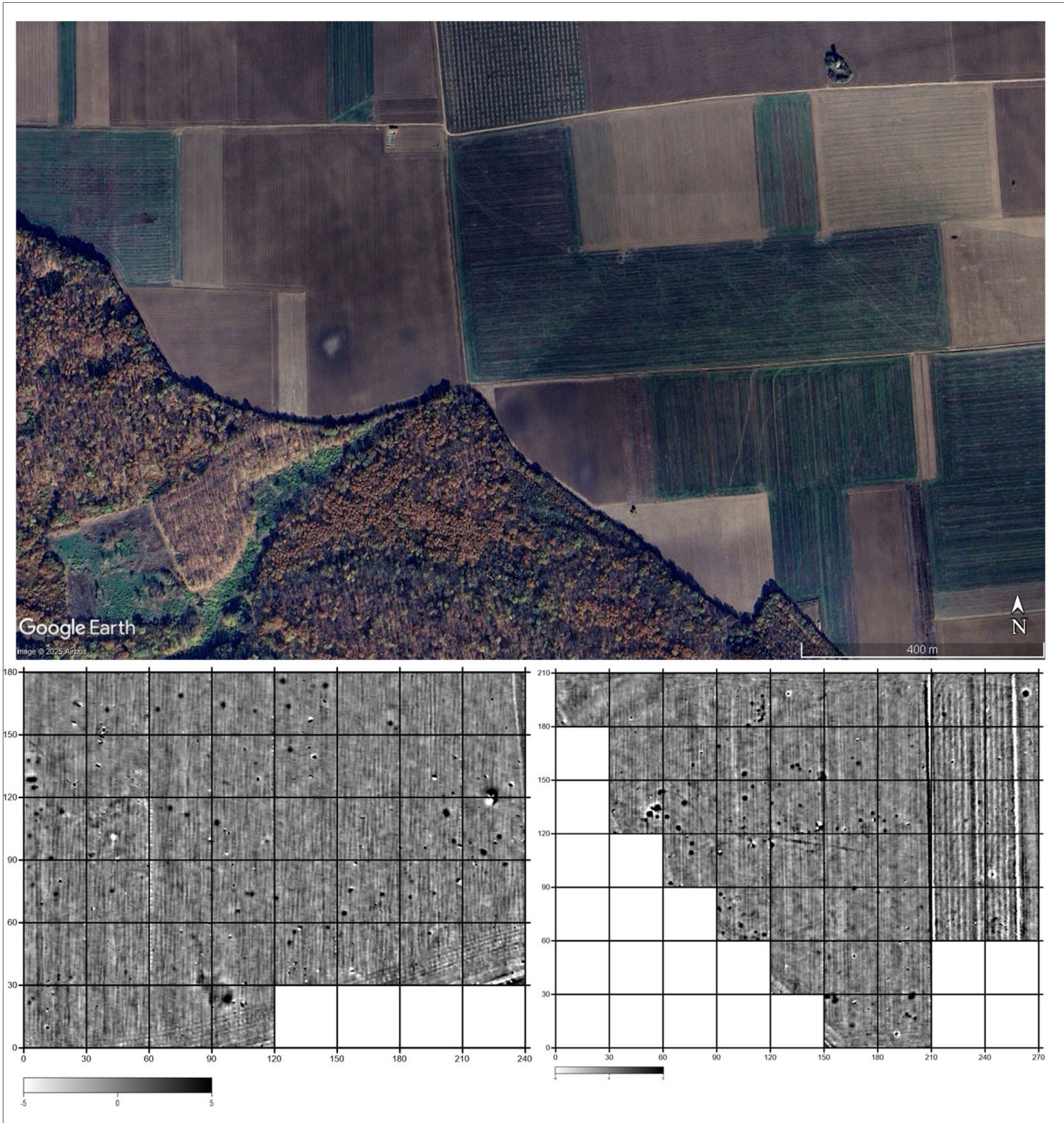

Figure 6. Soil marks at Brestovene (source: Google Earth Pro) and the results of the geophysical survey (Assoc. Prof. Dr. Eng. N. Tonkov and A. Atanasov, NAIM-BAS; Minkov et al. forthcoming d).

IV. Pobit kamak

The archaeological site under consideration is located within the confines of the village of Pobit Kamak, which is part of the Kubrat municipality within the Razgrad region. More specifically, the site is situated in the area referred to as Dabravata.

The site is located within the confines of privately owned arable land. The site's topography is defined by a vast, level expanse that slopes towards the south (Vasileva et al., forthcoming). The northern, southern, and eastern boundaries of the site

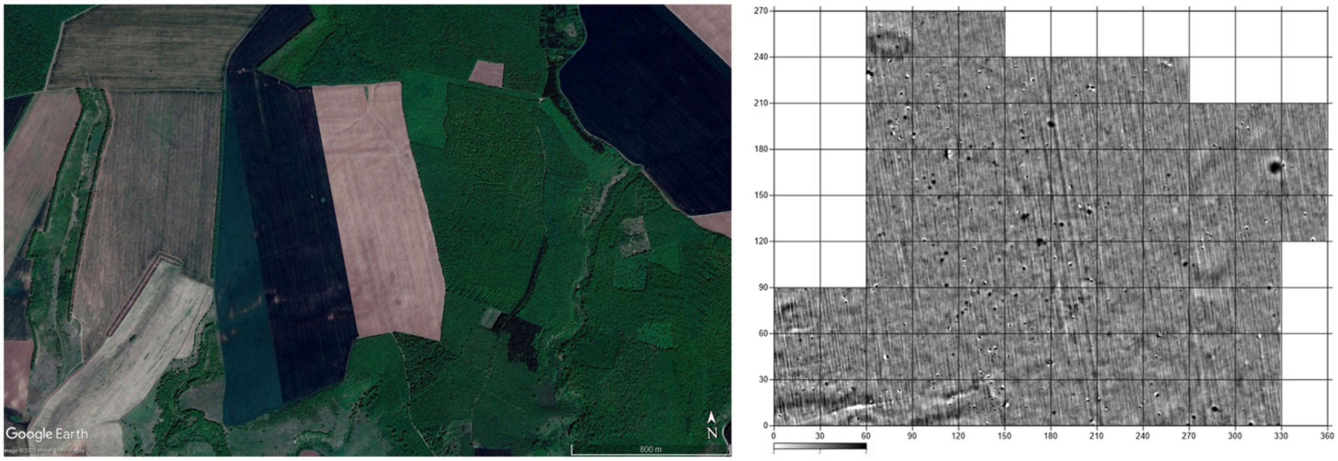

Figure 7. Soil marks at Pobit kamak (source: Google Earth Pro) and the results of the geophysical survey (Assoc. Prof. Dr. Eng. N. Tonkov and A. Atanasov, NAIM-BAS; Vasileva et al. forthcoming).

are represented by contemporary forest massifs (Vasileva et al., forthcoming). The topography of the region, as observed from a western vantage point, is characterised by the presence of a shallow ravine that exhibits an east-west orientation. This topographical feature is a constituent element of a dry valley, a common geographical phenomenon that is characteristic of the Ludogorsko Plateau (Vasileva et al., forthcoming). The identification of this site is of particular interest, given the aforementioned eponymous find of stone moulds for the metallurgy of the Late Bronze Age from the Lower Danube region.

Preliminary observation

This site presents the most challenging observation when utilising the capabilities of Google Earth Pro. In spite of the variations in terrain or the season, this site poses significant challenges in the observation of soil marks. However, under certain conditions, individual soil marks became faintly visible, barely distinguishable from the surrounding terrain. Based on this, and on information that a collective find of stone moulds was discovered there in the past, the site was visited in person.

Visit, search, registration

The archaeological site at Pobit Kamak was registered during surveys in 2021 (Popov, Georgiev, forthcoming b). The site was visited multiple times over several years and seasons, with varying terrain treatment. On one occasion, stains were observed on the surface, similar to those from the previous sites. Furthermore, a modest assemblage of pottery sherds, individual artefacts and a single fragment of a stone mould were collected from the surface of the site. The soil marks are amorphous, not compact and are significantly scattered across the terrain, as a result of agricultural treatment. This significantly complicates its registration, determination of its boundaries and area.

Geophysical search

In 2024, geophysical investigations were conducted on an area of nearly 75 decares (Popov et al. 2025; Vasileva et al., forthcoming). The analysis revealed a moderate density of potential archaeological features, which are dispersed across the surveyed area rather than forming consolidated clusters. The distribution of these elements exhibits a general northwest-southeast orientation (Vasileva et al., forthcoming). While the majority of the detected anomalies are relatively small in scale, a single, notably large feature was identified in the northeastern sector of the site, suggesting localised variation in subsurface activity (Vasileva et al., forthcoming).

Conclusions

The results obtained from the observation and geophysical survey suggest that it is possible to register the presence of a site, even when the initial factors are not the most favourable. In such cases, a long and repeated visit to the site in different seasons and with different treatments of the terrain is necessary. That is, if for some sites this is visible and accessible from the preliminary observation, then for others, a more in-depth and permanent repetition of direct observations on site is necessary. Criteria such as the presence of archaeological materials and finds are mandatory to indicate its presence (Fig. 7).

Discussion

A methodological approach was implemented in the research conducted in the Ludogorsko Plateau, with a focus on the sites from the Late Bronze Age. This approach entailed the following interconnected stages: initial observation of satellite images, selection of a potential site for further investigation, registration of the site, execution of a geophysical survey, and, in a single instance, the undertaking of archaeological excavations.

This system raises several important questions and draws some conclusions. The cited sites share similar geographical and topographic characteristics: they are located on elevated ridges next to flooded ravines, which are close to each respective site. A slight southward slope of the terrain is usually observed, a consistent and stable feature of Late Bronze Age sites. When viewed on satellite images, these sites are identified by large dark soil marks, which on the ground correspond to extensive soil marks of soil darker than the surrounding terrain, saturated with pottery sherds, animal bones, stone, ceramic finds, as well as, in a single case, the discovery of a bronze needle and moulds for casting metal objects. Thus, with certain agricultural processing of the area where the site is located under similar conditions, it is possible to identify archaeological sites from the Late Bronze Age.

An additional observation from the geophysical surveys also indicates an overlap in the data obtained. The sites exhibit anomalies, with the concentration varying for each. For example, the sites near Medovene and Kamenovo have the highest concentration of anomalies, followed by Brestovene and Pobit kamak. It is worth noting that the concentration of archaeological materials does not correspond to the number of geophysical anomalies. They are usually divided into two or three groups according to terrain, for which various explanations can be given – horizontal stratigraphy; consolidation of separate "neighbourhoods" within the site, etc. At some of the sites, the so-called sectorization is also determined by natural features, such as at Brestovene, where the site is located on two of the terraces, above the existing ravine, with no recorded direct connection between them.

The data and results of the preliminary studies presented here were obtained from four sites that share similar characteristics in terms of chronology and material culture. Despite the observations concern four sites, it can be assumed that this represents a sustainably established model, which is traced in a uniform natural environment, characterised by relatively similar climatic, geographical, topographic and hydrographic factors and conditions.

This enables the use of modern methods of preliminary observation to be used to identify and track, using Google Earth Pro's History feature, relatively consistent results for objects of the same category within the same territory. This is particularly important for the creation, analysis, and interpretation of different information units or clusters of such units, and for developing theoretical models of spatial presence, settlement, and internal migrations within a distinct and enclosed area.

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Building materials and the constructional sequence of the burial mound Gomila in Jalžabet

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Rescue excavation of the burial mound 1 - Gomila in Jalžabet was carried out between 2017 and 2021. The project was financed by the Ministry of Culture and Media of the Republic of Croatia. Inside one of the largest burial monuments from the Eastern Hallstatt culture, researchers uncovered a complex burial chamber constructed from wood, stone, clay, and charcoal, situated in the center of a massive stone crepidoma. To the east, a ceremonial passage-dromos was discovered. Inside the burial chamber, a layer of cremated bones was placed simply on the chamber's floor, which was paved with split stone tiles and lined with wood. Above this layer, several stratigraphic layers associated with a rest from the cremation pyre were identified. These layers contained abundant burned material, along with some artifacts that had survived the fire, indicating a specific burial rite. Additionally, a significant quantity of archaeologically sterile charcoal was deposited on the exterior walls of both the burial chamber and the dromos. This paper focuses particularly on analyzing the construction sequence of the monument and the materials employed in its building.

Keywords: *Jalžabet (Northwest Croatia), Early Iron Age, Eastern Hallstatt culture, princely burial mound, building techniques and materials, burial rite*

Introduction

Following the Second World War, research into the Early Iron Age in the continental part of Croatia began in the basin of the Plitvica and Bednja Rivers, encompassing areas of the present-day Jalžabet and Martijanec municipalities, East of Varaždin (Fig. 1A). In recent years, the Institute of Archaeology in Zagreb has conducted archaeological research and interdisciplinary studies in the region.[*] The Early Iron Age landscape comprises several distinct zones. The first zone stretches along the flatlands adjacent to the Plitvica River, which runs parallel to the Drava River. The second zone lies several hundred meters further south, on the second terrace of the Drava River, near the southern edge of the river valley. The third zone is situated in the hilly hinterland, with sites atop the prominent peaks of the hills further to the south. Well-known sites and monuments within the micro-region include the burial mound at Martijanec – Gamulica and Gamula, the Jalžabet – Bistričak necropolis with Gomila and burial mound 2, the Jalžabet-Carev Jarek settlement, the late Hallstatt settlement at Zbelava – Pod Lipom, as well as settlements at Zbelavčak I–III. Additionally, there are multi-layered settlements at Šemovec – Šarnjak, Sigetec, and Sv. Petar Ludbreški (Fig. 1B).

[*] This paper was created within the project *Synergy of Diversity: Archeology of Landscape and Technological Traditions in Continental and Adriatic Croatia* (SirAkt), funded by the European Union-NextGenerationEU.

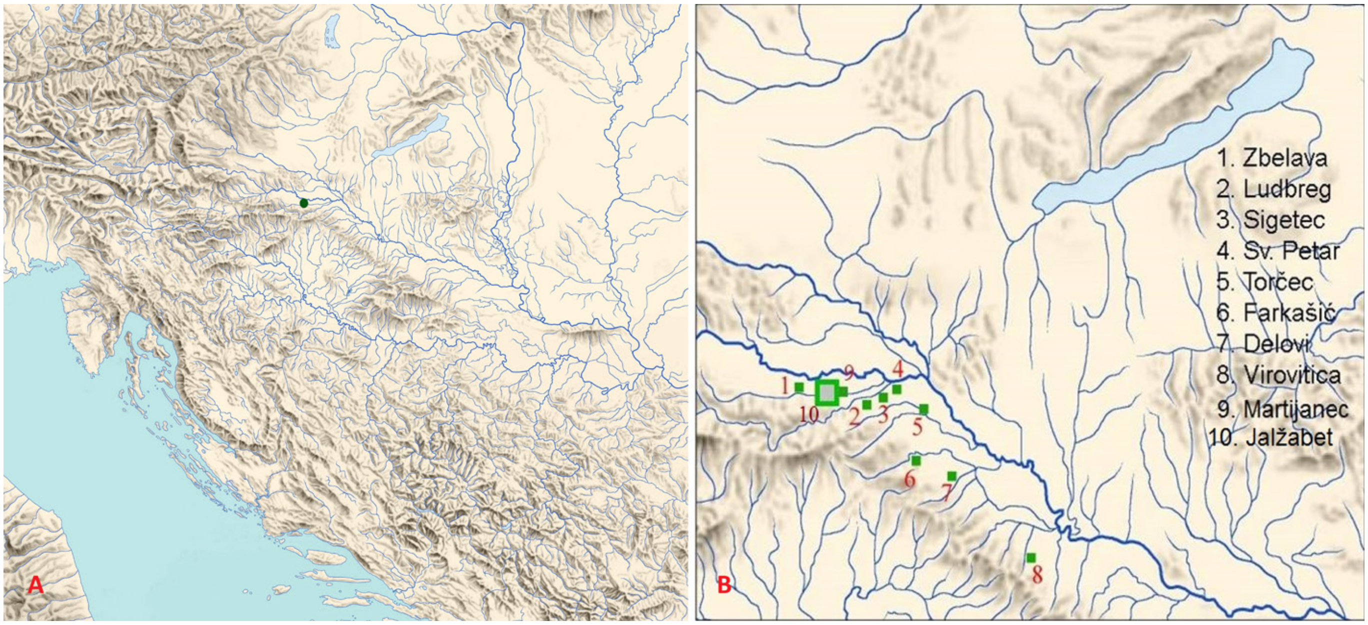

Figure 1. A: The geographic position of Jalžabet; B: The Early Iron Age sites in the micro-region (made by S. Kovačević).

These archaeological sites are published or analyzed in various studies (e.g., Vinski-Gasparini 1961, 1978, 1987; Šimek 1989, 1998, 2001, 2004, 2004a; Teržan 1990; Registar 1997; Kovačević & Kalafatić 2022). The region encompassing the Pltivica and Bednja Rivers basin, between Zbelava on the western end and Sv. Petar Ludbreški on the East is approximately 20 km long and up to 8 km wide. During the Early Iron Age, the area belonged to the Eastern Hallstatt culture with pronounced similarities to other sites within the same circle of the Hallstatt Culture in today's Northeast Slovenia, Southeast Austria, and Transdanubia[1]. More detailed research in this micro-region south of the Drava could provide a valuable cross-section of settlement patterns and burial customs from the end of the Late Bronze Age to the Roman Empire. To the list of previously mentioned sites, we are adding the recently confirmed and investigated (2023, 2024) large settlement of the Eastern Hallstatt culture at Martijanec - Kazinščak (Kovačević 2023). In the third zone, on the highest point of the Kalnik northwest mountain slopes, lies the prehistoric hillfort Slanje - Stari Gradec (2023, 2024).

Thanks to the project "*Monumental Landscapes of the Early Iron Age of the Danube Region*" (*Iron-Age-Danube* Interreg DTP, 2017-2019), co-financed by the EU[2], and the rescue archaeological research of burial mound 1 – Gomila in Jalžabet (2017–2021), financed by the Ministry of Culture and Media of the Republic of Croatia, the foundations of further research have been laid in the basin of the Plitvice and Bednja Rivers. As part of *the Iron-Age-Danube* Interreg DTP project, a comprehensive LIDAR survey of the entire region was conducted. This served as a base for subsequent targeted geophysical and archaeological investigations in both Jalžabet and Martijanec. We would like to express our special thanks to the Municipalities of Martijanec and Jalžabet for recognizing the significance of their valuable prehistoric archaeological heritage and for co-financing our research over the past few years. Following the rescue archaeological excavation of Gomila in Jalžabet in 2021, and in parallel with our ongoing research in the region, the phase of presentation and construction of the "Jalžabet – Gomila Tourist Presentation Center," undertaken by Varaždin County, has commenced.

[1] See, among others, together with quoted literature: Gabrovec 1964-1965, 1987; Vejvoda & Mirnik 1971; Dobiat 1980; Vinski-Gasparini 1987; Patek 1993; Teržan 1990, 1998, 2019; Egg 1996, 2019; Metzner-Nebelscick 2002; Gutjahr & Mandl 2004; Dular & Tecco Hvala 2007; Egg & Kramer 2013, 2016, 2019; Stegman-Rajtar 2014; Szabó & Fekete 2015; Szabó & Horvath 2015; Fekete & Szabo 2017; Gutjahr et al. 2018; Soós 2020.

[2] »Monumental Landscapes of the Early Iron Age of the Danube Region" or the *Iron-Age-Danube project* was implemented under the Danube Transnational Programme (DTP), funded by the European Regional Development Fund (ERDF: 2169200, DTP-1-1-248-2.2). The Institute of Archaeology participated as a project partner 6 (PP6) with research on the Early Iron Age landscape in Jalžabet. The project implementation time was 01.01.2017 - 30.09.2019. (Kovačević 2019, 2020a).

Figure 2. The position of two large burial mounds, in Jalžabet and Martijanec, on a 19th-century map (Europe in the 19th century. The Third Military Survey, www.maps.arcanum.com, accessed 02/05/2024).

Geography

Jalžabet is situated in the southwestern part of the Pannonian Plain, south of the Drava and Plitvica Rivers, and east of Varaždin in central Croatia. The Drava River, one of the major rivers in Central Europe, originates at an elevation of 1,192 meters above sea level on the Italian-Austrian border, specifically in the Puster Valley (Pusterthal) in South Tyrol, Italy. From its source, the river flows through a deeply incised basin, cutting a path through the landscape as it moves eastward towards Slovenia and Croatia. Its journey passes through the city of Maribor in Slovenia, where it traverses a deeply carved valley, and continues through the Drava Plain (Borovac 2002). Near Ormož, approximately 35 kilometers northwest of Martijanec, the Drava enters the open lowland region known as Podravina. Here, the river bed widens considerably, measuring between 140 and 370 meters across, with depths ranging from 4 to 7 meters, creating a dynamic environment that has historically supported diverse ecosystems, human settlements and facilitated movement and trade (Kurtek 1966; Crkvenčić et al. 1974; Crnički 1983). The lowland area along the Drava River, where Martijanec and Jalžabet are located, gradually ascends toward the northern slopes of the Varaždinske Toplice hills. Further south, in an east-west orientation from Novi Marof in the west to Koprivnica in the east, lies Kalnik Mountain, which rises to 643 meters. To the west of Jalžabet are the final slopes of Ivanščica, the highest peak in Hrvatsko Zagorje, reaching 1,059 meters. On clear days, upstream along the Drava, the distant Pohorje Mountains above Maribor in Slovenia are visible, while across the river to the north, the landscape of southern Hungary can be seen. The region is interconnected by numerous smaller and larger watercourses, most notably the Plitvica and Bednja Rivers, both right tributaries of the Drava (Kovačević & Kalafatić 2022, with cited literature). The Early Iron Age cemetery in Jalžabet is named after one of the nearby watercourses - the stream Bistričak. Bistričak divides the burial ground on the east side from the settlement of Carev Jarek on the west side (Fig. 4).

Researching the early Iron Age in the Jalžabet – Martijanec region

Today, on the southern edge of the Drava River valley, two large burial mounds are visible. One is located in Jalžabet, and the other is in Martijanec, approximately 5 kilometers east of Jalžabet (Fig. 2). After World War II, scientific research into the Early Iron Age in northern Croatia began notably in this region, marked by the excavation of the Gamulica burial mound in Martijanec in 1957. (Fig. 3A). This mound contained a quadratic burial chamber constructed from wood and stone and is

Figure 3. A: Rectangular burial chamber made of wood and stones, Martijanec – Gamulica (after Vinski-Gasparini 1961); B: Rectangular burial chamber made of wood and stone with dromos, burial mound 1 in Jalžabet (after Šimek 1998).

attributed to the developed phase of the Early Iron Age – Ha C2 (Vinski-Gasparini 1961, 1978, 1987; Gabrovec 1964–1965; Teržan 1990; Matijaško 2013-2014). In 1989, an archaeological team from the Varaždin City Museum investigated the flattened burial mound 2 in Jalžabet, which dates to the Ha D1 phase (Šimek 1998, 2001) (Fig. 3B). The excavation revealed a quadratic burial chamber constructed from wood and stone, with a dromos facing east, located on a paved plateau. During a rescue excavation in 1997, conducted along the route of a forthcoming highway between Zagreb and Goričan, the Ha D3 settlement Zbelava-Pod Lipom was uncovered approximately 5 km northwest of Jalžabet (Kovačević 2007, 2008; Kovačević & Kalafatić 2022). In recent years, following the discovery of a robbery, the Institute of Archaeology in Zagreb conducted a rescue excavation of the Gomila in Jalžabet – a gigantic burial mound featuring a monumental burial chamber and dromos containing deposited cremated remains (2017–2021). Both burial mounds from Jalžabet are contemporaneous and can be

Figure 4. A: Early Iron Age settlement Carev Jarek; B: Gomila in Bistričak cemetery in Jalžabet (photo by K. Šobat).

dated to the middle of the 6th century BC, towards the end of the Ha D1 phase (Kovačević 2019, 2019a, 2020). The closest analogies for Gomila in Jalžabet are found in Regöly, Strupka-Magyar Birtok (HU), and Wildon (AT) (Fig. 5B). Unfortunately, both of these burial mounds were damaged and/or only partially excavated.

However, they belong to the same period as Gomila and exhibit pronounced similarities in movable finds – such as gold objects, decorated bone or antler artifacts, and metal items – as well as in monument construction, including the use of charcoal in the building sequence. Further similarities are evident with the Princess of Stična grave (SLO), the princely burial mound at Kleinklein-Kröllkogel (AT), and, to some extent, Hochdorf (DE) (Biel 1985; Gabrovec 1987; Gabrovec & Teržan 2008; Egg & Kramer 2013). From the late Hallstatt period in central Croatia, there are relatively few analogies. Notably, we should mention a burial featuring an equestrian grave and a helmet from Sv. Križ, dating to the end of the 6th century BC (Cvitković & Škoberne 2003; Cvitković 2011). All Early Iron Age burial mounds researched in the Podravina and Međimurje contained cremation burials and can be attributed to the Eastern Hallstatt culture. In both Early Iron Age burial mounds from Jalžabet, we observe clear influences from earlier local traditions of the Podravina and Međimurje regions, particularly in burial customs and the layout of the burial monuments, such as cremation rites, quadratic burial chambers, and pottery. At the same time, there are new elements and advancements, including bi-metal scale armor, “exotic” luxury goods, and the addition of a dromos in burial construction. While princely burial mounds containing cremated remains and high-status finds represent only a part of the broader Early Iron Age archaeological landscape, recent research has expanded to include settlements and other potential burial sites. The restoration of numerous finds from Gomila is currently underway, alongside interdisciplinary analyses of all excavated remains (Kovačević et al. 2021; Kovačević & Golubić 2020; Kovačević et al. 2023). Among the significant recent discoveries in the region are those made during small-scale excavations of Early Iron Age settlements, such as at Jalžabet’s Carev Jarek (2017, 2023), the large settlement at Martijanec (2023, 2024), at Kazinščak (Kovačević 2023), and the recent discovery of a fortified hilltop settlement at Slanje – Stari Gradec (2023, 2024).

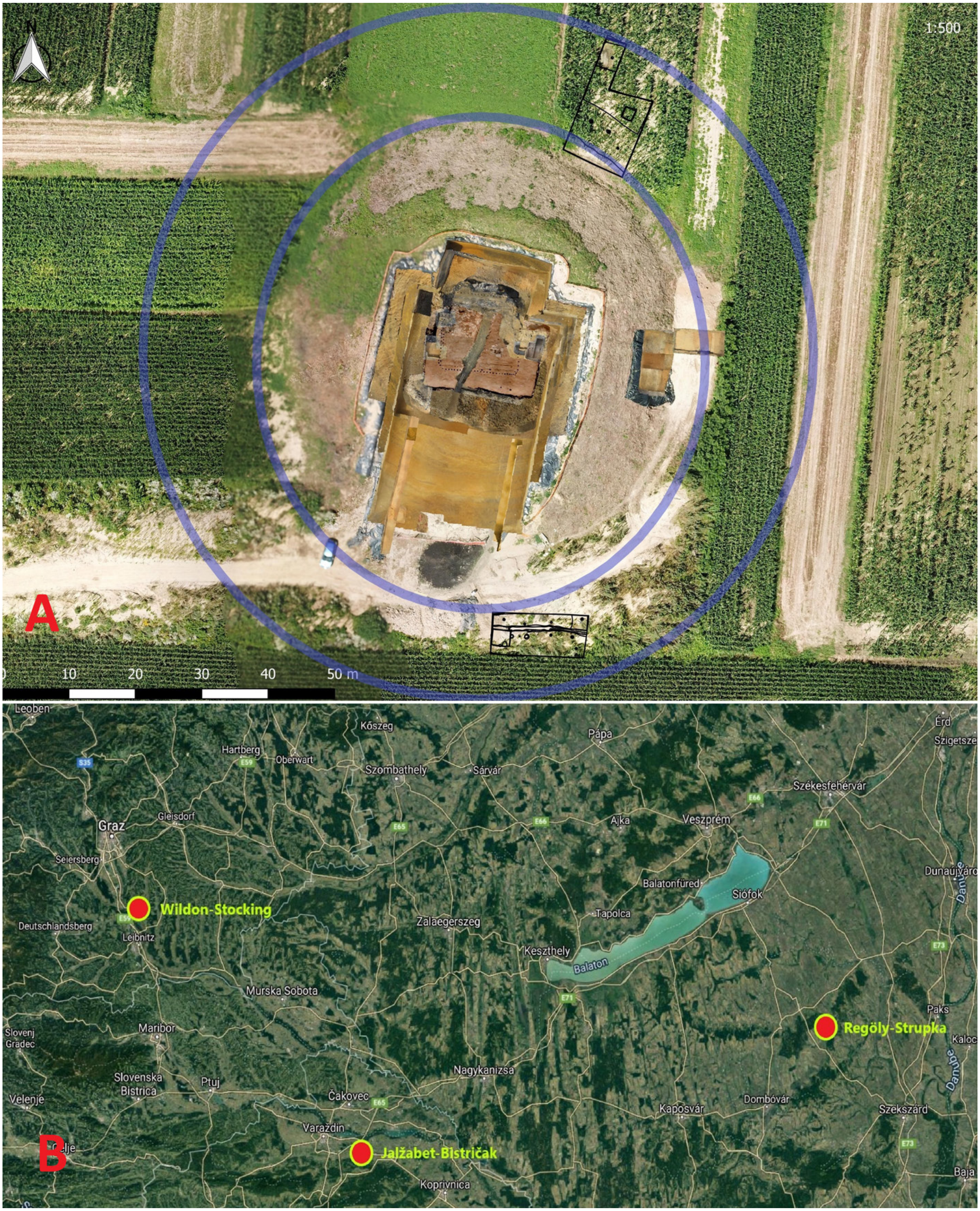

Figure 5. A: Burial mound 1 – Gomila with the position of the circular ditch in Jalžabet; B: the closest cultural and chronological analogies for the finds from the burial mound Gomila in Jalžabet (source: https://www.google.com/maps, edited by S. Kovačević).

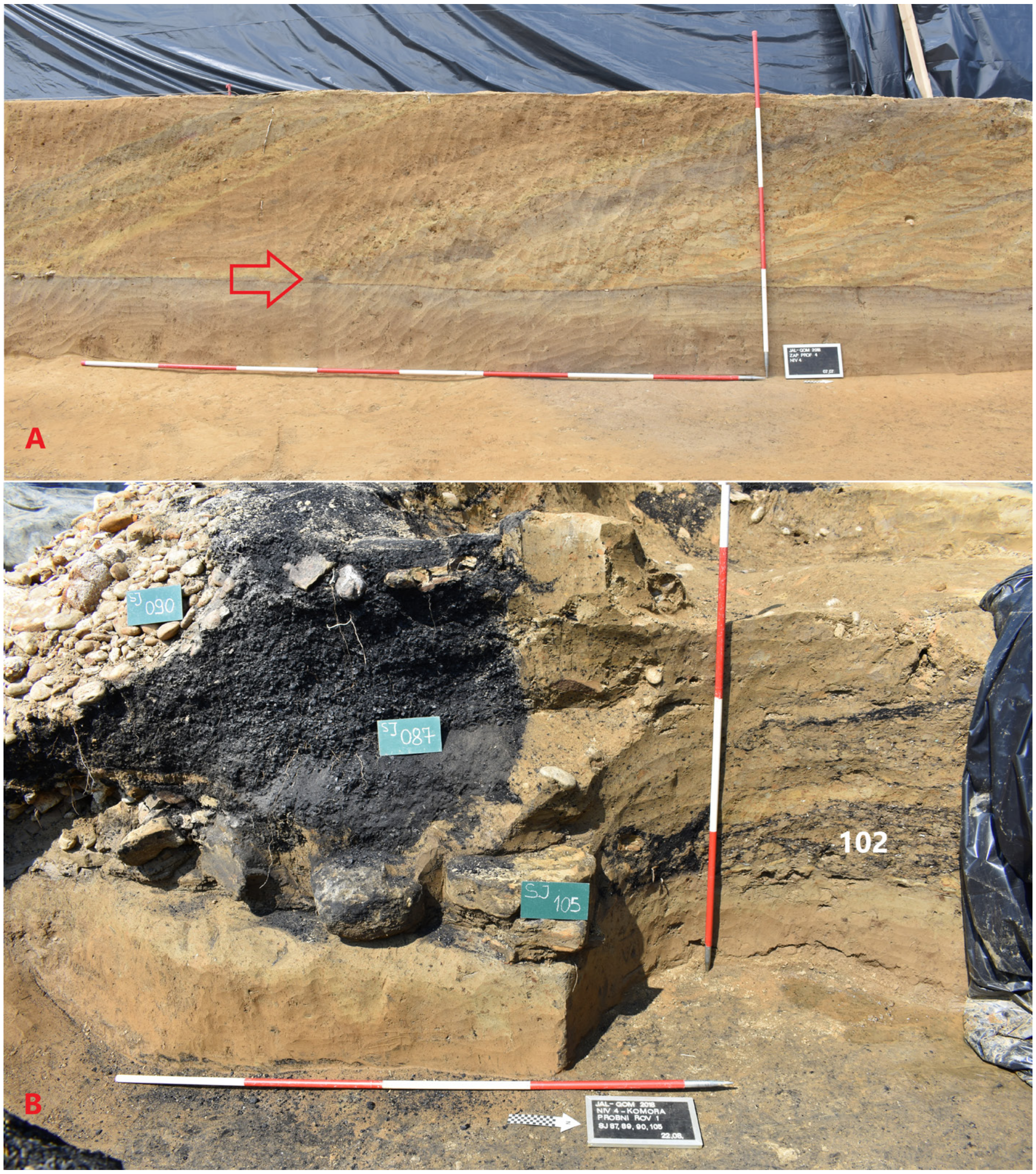

Figure 6. A: west profile of the trench with a plateau on which Gomila was built (red arrow) and visible layers constructing the mound; B: cross-section of the south wall of the burial chamber (in robbers' trench) with a thick layer of charcoal (SU 087) on the outside of the wall and cremated layer with bones on the floor of the burial chamber (SU 102) (photo: S. Kovačević/IARH).

Construction of the burial mound Gomila in Jalžabet

Even by today's standards, the size of the Gomila is of exceptional dimensions. It measures approximately 65 meters in diameter and reaches up to 8 meters in height, with an estimated original height of around 11 meters. It was surrounded by a circular ditch, 100 meters in diameter, 15 meters wide, and up to 2 meters deep (Fig. 5A). The chamber with dromos was constructed of wood, stone, and clay (Fig. 6, 7). Before the construction of the burial chamber, the plateau was leveled and covered with remains of still unidentified plants. The burial chamber had a square layout measuring 11.5 by 11.5 meters and stood approximately 1.6 meters high. The dromos, oriented directly east, was 2.5 meters wide, with its floor and walls lined with wood. The chamber itself was constructed from locally sourced wood, various types of stones, clay, and charcoal.

The construction of the burial chamber was executed in a distinctive manner, through careful planning and coordination. On the leveled and cleared plateau, the area designated for the chamber was paved with split sandstone tiles. Subsequently, the structure's framework was assembled. The framework of the burial chamber comprised multiple layers of walls, creating an impression of several nested chambers within a larger burial chamber, similar to a "babushka doll." Thin stakes,

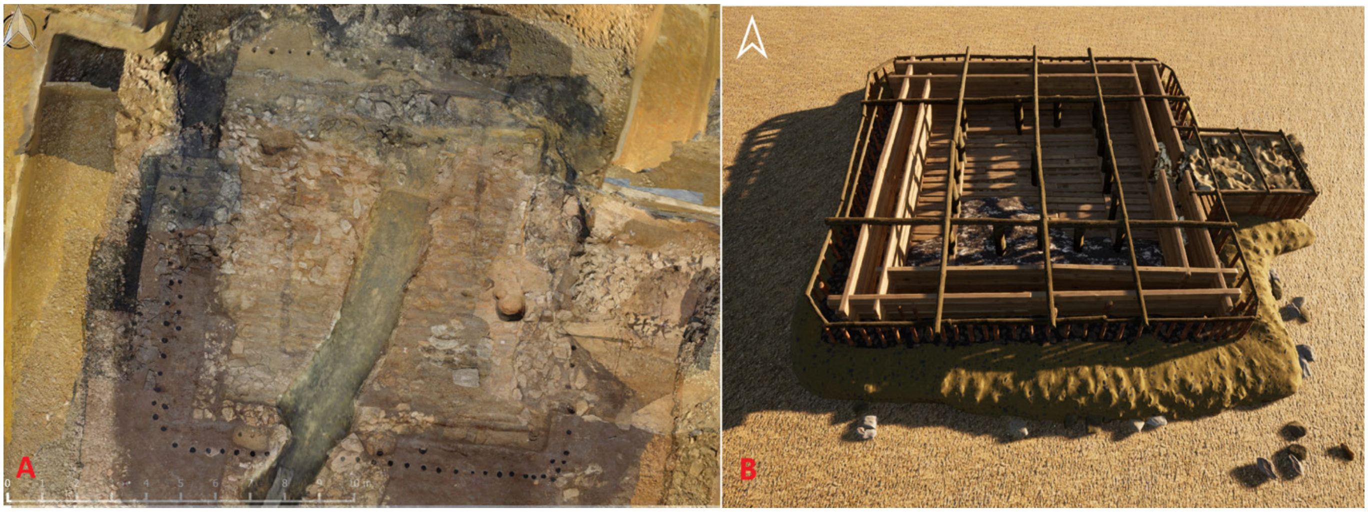

Figure 7. A: Rectangular burial chamber with dromos at the end of excavation, Jalžabet burial mound 1- Gomila (digital documentation M. Mađerić); B: an ideal digital 3D reconstruction of the burial chamber beneath Gomila (made by M. Mađerić).

densely arranged and driven deep into the ground, formed the outermost line of the walls.[3] Two walls constructed from thick wooden planks reinforced with abundant stones and charcoal used as fill material in the interspace between the two, built the inner structure or core of the burial chamber walls. The second wooden wall served as the interior surface of the chamber itself. As previously noted, the entire floor of the burial chamber was paved with split sandstone slabs. After erecting the walls, the floor was further covered with wood and a thin layer of yellow sand. At the center of the chamber, a 5 by 5 meter wooden frame, supported by horizontal beams on the floor and vertical posts, held up a flat roof made of wooden beams. The exterior walls of the burial chamber and dromos were further reinforced by a 50-centimeter-high layer of smaller stones covered with clay. Including this support structure of the outer walls, the size of the burial chamber measures approximately 14.5 by 15 meters. At this step of construction, the outer walls of the burial chamber were covered with a substantial amount of archaeologically sterile charcoal and encased in the crepidoma. The burial chamber was positioned at the center of a stone crepidoma, which was encircled by a perimeter ring of large broken stone slabs. The crepidoma supported the massive structure of the burial chamber, similar to those observed in Scythian burials in the Black Sea region (e.g., Mozolevskiy & Polin 2005:79, Fig. 9; Bidzilja & Polin 2012: 53, Fig. 27, 33). At this stage of construction, it appeared as though the burial chamber was sunken into or buried within the crepidoma; however, in reality, the construction sequence was reversed. After the interment of the burned remains, the entrance of the burial chamber was sealed with a massive wall constructed from large stones bound with clay, and the dromos was at its full height, filled with large stone slabs. Following this, a burial mound was built over the tomb. The burial mound consisted of alternating layers of sandy yellow soil and dense gray clayey soil, which originated from the large circular ditch surrounding Gomila (Fig. 6). Excavations on the slopes of the circular ditch revealed several postholes. On the north side, near the ditch, geophysical surveys suggest the presence of some form of structure—possibly an entrance to the monumental complex—indicating its potential role as a focal point in the ritual landscape following the completion of the burial mound. This hypothesis awaits confirmation through future excavations, but it is already considered a plausible interpretation based on the analysis by Susanne Stegmann-Rajtár of the damaged burial mound in Regöly (kom. Tolna, Hungary), by far the closest analogy to the Gomila in Jalžabet (Stegmann- Rajtár 2014)[4].

The extensive use of diverse materials, particularly stones and wood, is remarkable. The sheer size of the Gomila in Jalžabet further underscores this achievement (Fig. 7). During the construction of burial mound 1 - Gomila and burial mound 2 in Jalžabet, substantial quantities of

[3] Similar can be observed in Regöly (Szabó & Fekete 2019: 290, fig. 2b).

[4] For extensive literature regarding the late Hallstatt period, see also Soós 2020.

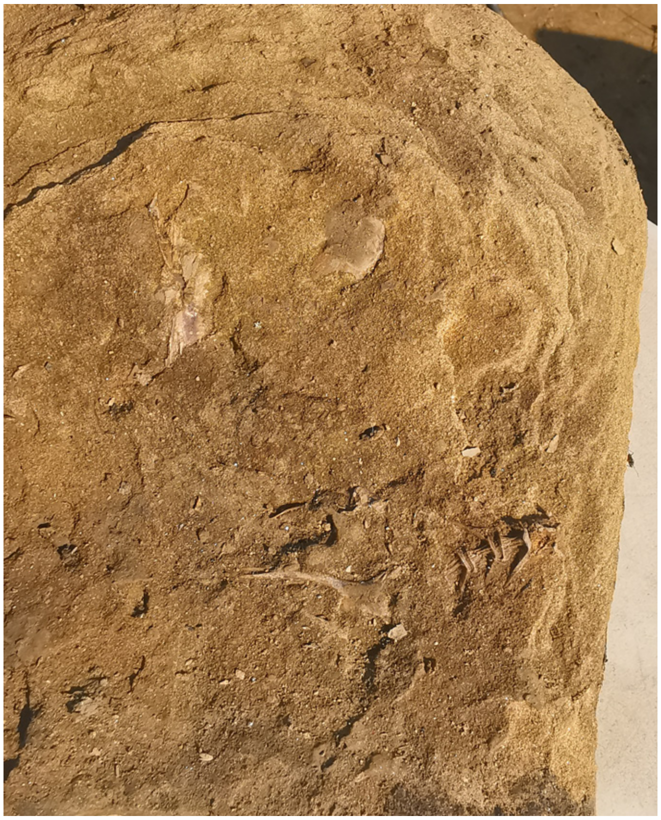

Figure 8. The catfish fossil from the Late Pontian period encased in the sandstone found in the burial chamber in Jalžabet (analysis, determination, and photograph by D. Japundžić/Croatian Natural History Museum).

sandstone, limestone, pebbles, wood, and soil were used. In both cases, the wooden frame of the burial chamber was placed on a prepared, leveled plateau, which was covered with plants. The construction process likely required not only extensive human effort and detailed knowledge of the natural environment as a source of building materials but also advanced organizational skills and highly efficient logistics. It is highly likely that a designated organizer, such as an architect, engineer, or foreman, oversaw the entire burial process. Since the ground on which Gomila was erected consists mostly of loess, sandy soil, together with a substantial amount of timber, every piece of stone found during the excavation would have had to be purposefully transported to the construction site for building the burial chamber. The discovery of a catfish fossil within one of the sandstone slabs helped us determine the age and, at the same time, the likely position of deposits of different types of stones used by Gomila's builders. Large quantities of stone were probably quarried nearby, in the hilly hinterland to the south, where Late Miocene sandstone deposits are close to the surface (Fig. 8).

The construction of the burial chamber could be precisely reconstructed (Fig. 7B). The use of wood and archaeologically sterile wood charcoal in the construction of the burial chamber and dromos played a significant role. Although the exact reason remains unclear, it appears the use of charcoal has been an important aspect of the monument's construction sequence and/or the associated burial rite. Since charcoal possesses little to no structural properties, we might interpret it as an additional buffer zone between the realm of the dead and the living. The builders were quite selective in their choice of wood, predominantly using oak, often from large tree trunks, even when the wood was infected with bark beetles or partially rotten[5]. Concerning movable artifacts, the layer of charcoal applied to the exterior walls of the burial chamber and dromos was completely archaeologically sterile, allowing us to rule out its connection to a funeral pyre in the strict sense of the word. Field research indicates that there were at least two incineration events associated with the Gomila burial. The first involved a funeral pyre used for burning animals, grain, pieces of weaponry, horse equipment, and other archaeologically confirmed finds from the burial chamber. The second was likely used separately for burning a large quantity of wood or charcoal production, as evidenced by archaeologically sterile layers on the outside walls of the chamber and the dromos. The use of archaeologically sterile charcoal has been documented in Early Iron Age burial mounds such as Regöly–Strupka–Magyar, where charcoal was found in positions similar to those at Jalžabet (Szabó 2015: 294, Fig. 3). At another site similar to Jalžabet, Wildon-Grafenkogel (Gutjahr et al. 2018: 70), sterile

[5] Several dozen charcoal samples from various locations outside the walls of the burial chamber were analyzed in detail at the Faculty of Forestry and Wood Technology under the supervision of Ernest Goršić. The preliminary analysis of the animal bones was conducted by Siniša Radović from the Institute for Quaternary Palaeontology and Geology of CASA, and Mario Novak from the Institute of Anthropology in Zagreb. The carbonized macrofossils from the Gomila burial chamber were examined by Renata Šoštarić and Mirjam Kožul from the Division of Botany, Department of Biology, Faculty of Science in Zagreb. Dražen Japundžić from the Natural History Museum in Zagreb assisted in determining the provenance of the stones found at Gomila and in gaining a better understanding of the natural environment in the Plitvice and Bednja River basins during the past. RAMAN and FTIR spectroscopy and pigment analyses of the finds from Jalžabet were performed by Marko Kralj and Marin Petrović from the Institute of Physics in Zagreb, Marko Škrabić from the Department of Physics, Biophysics, and Medical Physics at the School of Medicine, University of Zagreb, along with the team of Marina Van Bos from The Royal Institute for Cultural Heritage- Koninklijk Instituut voor het Kunstpatrimonium Brussels. We are deeply grateful to the entire interdisciplinary team for their valuable contributions.

Figure 9. The project proposal of the future Archaeological Park Gomila in Jalzabet (G. Rako and Radionica arhitekture, financed by Varaždin County).

charcoal in the form of a 20 cm thick layer was placed atop a gravel layer on the roof of the burial chamber. Charcoal in a funerary context has also been found at other Early Iron Age sites in Croatia. For example, in burial mound 26 at Budinjak, a “burnt wooden ring” was identified around the grave (Škoberne 1999: Fig. 15), while in burial mound I at Kaptol-Čemernica, a quadratic ditch or enclosure filled with charcoal was uncovered during excavation (Vejvoda-Mirnik 1971: 188). In these contexts, as at Jalžabet, the presence of charcoal cannot be solely attributed to construction elements of the burials. The use of charcoal, usually on the exterior of burial structures, may serve an apotropaic function, maybe related to cleansing through fire. However, this hypothesis requires further research for confirmation.

Cremation burial rite in Gomila

During the rescue excavation, traces of the funeral pyre weren’t found beneath the Gomila. Huge quantities of food and other finds were probably burnt on the pyre, somewhere in the vicinity. On the pyre, a large number of metal objects made of iron and bronze were burned with the deceased, as well as parts of animals (horse, cattle, ship/goat, etc.), and a substantial number of crops and plants (wheat, barley, spelt, oat, lentil, etc.). The huge amount of wood (predominantly oak), was purposefully burned and turned into coal somewhere near. The interdisciplinary analyses of huge amounts of cremated bones are far from finished. We still haven’t confirmed human remains yet. Among movable finds, we can recognize parts of bi-metal scale armor, iron spearheads, arrow tips, parts of lavish horse equipment, bronze vessels, and other finds melted or deformed by the fire. After the pyre was extinguished, burned bones were carefully selected and placed on the floor of the burial chamber, along the south wall. Other layers from the pyre were then collected and placed above the burnt bones. But, among the cremated bones, and even more in the layers from the pyre above the bones, we have found objects not touched by the fire. Pieces of ceramic vessels, gold objects, amber and bone beads, and antler plaques ornamented with incisions and black and red paint (Kovačević & Golubić 2020; Kovačević et al. 2021; Kovačević et al. 2023). We can presume pieces of pottery, like cups, bowls, and pots, were purposely broken during the burial rite and put on the pyre at the end of the cremation process, as not a single complete ceramic or metal vessel was found during the excavation. In the valuable items like amber and gold ornaments, we can probably see parting gifts of high-status individuals partaking in the funeral ceremony. Antler plaque inlays richly decorated with incisions and red and black paint probably belonged to pieces of furniture, maybe to the funeral bed on which the body of the deceased was carried to the pyre. The furniture was probably violently smashed and, together with gold and amber jewelry, placed on the cremated remains after cremation was finished and the pyre was extinguished, but before the cremated remains were interred in the burial chamber.

Conclusion

Finds from Gomila in Jalžabet are of supra-regional importance, illustrating extensive contacts across different regions of the known world during the early part of the Late Hallstatt period. Goods, ideas, and customs discovered in Jalžabet can be traced across regions from the Baltic to the Black Sea. The entire construction sequence at Gomila was closely intertwined with specific burial rituals, reflecting a sophisticated combination of human effort, organizational expertise, detailed environmental knowledge, and resource management. Evidence suggests that the construction of burial monuments was executed within a relatively short timeframe, involving the burning of large quantities of food on pyres and the inclusion of high-status objects made from amber, gold, bronze, and iron. These findings portray a society that was well-organized, wealthy, and stratified. The individual after whose cremation Gomila was built had to belong to the top of society and embodied social, economic as well as religious power. The circular ditch with some substructures uncovered by geophysics and confirmed by targeted excavation reveals the role of the Gomila as a permanent, commemorative focal point in a landscape, probably even long after the funeral was finished. This was a spot that permanently connected the world of the living and the world of the ancestors. The burial monument itself, the beliefs it represented, and the rituals performed there established social connective tissue; it built and rejuvenated a sense of communal identity. At the same time, it is a monument for eternity, an impressive marker in the landscape, projecting an image of the community that built it as strong, united, and powerful.

Following the rescue excavation of Gomila in Jalžabet, Varaždin County has undertaken the task of presenting this burial monument to the public. Important steps toward establishing the Presentation Center Gomila in Jalžabet have already been taken (Fig. 9). As of 2024, the project is in the process of obtaining the location permit, a preliminary architectural design has been developed, and the land has been purchased from private owners. As the completion of the archaeological-tourist center in Jalžabet draws closer, the findings from the archaeological research and interdisciplinary analyses are expected to be effectively integrated into a new tourist attraction, thereby enhancing the cultural and economic vitality of the local community.

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Interpretive analysis of pottery distribution in the northern part of the late antique hilltop settlement in Lobor, NW Croatia

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Archaeological research of the multi-layered site Lobor - Majka Božja Gorska in northwestern Croatia was mostly concentrated on the church complex and the cemetery belonging to it, which damaged earlier prehistoric, antique and late antique structures. Excavations were also carried out at several positions on the northern plateau outside the church complex. During the excavation, large quantities of late antique pottery were found, which can be dated from the second half of the 3rd to the first half of the 6th century. Although late antique pottery is very fragmented, several clusters of fragments were documented on the northern plateau of the late antique hilltop settlement, between the church complex and the northern rampart. Considering that the architectural remains are few and poorly preserved due to the mentioned damaging, during the late antique pottery research, quantitative analysis of fragments, analysis of spatial distribution and comparative analysis with the contemporary sites of the Noric-Pannonian border area were used in order to interpret the organization of the northern side of the late antique settlement, which was less destroyed by construction and erosion. The results of the research provide insight into the degree of destruction of the site due to the burial of medieval and post-medieval graves and the spread of late antique pottery, as well as how well the clusters of late antique pottery finds match the few remains of late antique architecture. Certain clusters point to the existence of destroyed structures, which indicate different construction techniques within the late antique settlement. The final interpretation of the possible organization of the northern part of the late antique settlement in Lobor based on the pottery finds, shows similarities with other hilltop settlements of the Noric-Pannonian border area and probably indicates the integration of the that settlement into the mentioned area.

Keywords: spatial analysis, pottery, Late Antiquity, hilltop settlement, Lobor

Introduction

The archaeological site of Lobor – Majka Božja Gorska (Hrvatsko Zagorje County, northwestern Croatia) (Fig. 1) is a multi-layered site on a hill at the foot of the Ivanščica Mountain that shows traces of settlement dated to the Bronze and Iron Age, Late Antiquity and Early Middle Ages. From the Early Middle Ages until the 19th century, a large cemetery surrounded the church dedicated to the Virgin Mary, which remains an important place of pilgrimage. More than a thousand burial pits discovered so far have caused con-

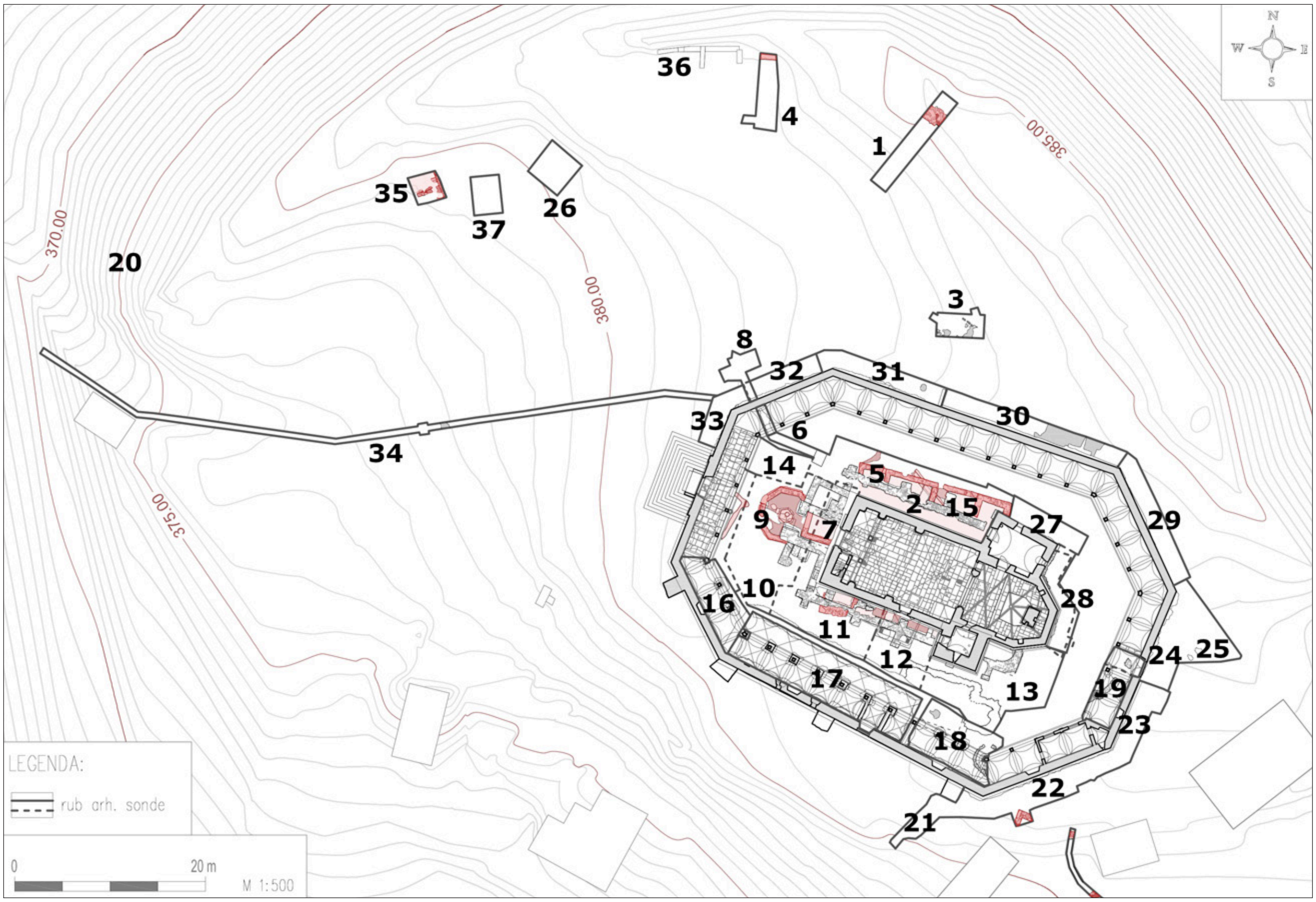

Figure 1. Plan of the Lobor – Majka Božja Gorska site with late antique architectural remains marked in red and the excavated trenches numbered 1–37 (Plan: Arheo Plan d.o.o., Modified by: P. Nikšić): 1. 1998/1; 2. 1998/2; 3. 1998/3; 4. 1998/4; 5. 2002/Dionice 1-4; 6. 2002/Prokop; 7. 2002-2003/Predvorje; 8. 2002/Vanjski šaht; 9. 2003-2005/Pročelje; 10. 2003/Pročelje, Jug 1; 11. 2003/Jug 1; 12. 2003-2005/Jug 2; 13. 2003-2005/Jug 3; 14. 2005/Pročelje kocka; 15. 2005/Sj. strana; 16. 2007/Cinktor jugozapadni kut; 17. 2008/Grobnica; 18. 2009/Jug 3 nastavak; 19. 2009/Istok; 20. 2009/Bedem; 21. 2010/Južni cinktor vanjska strana (JCVS); 22. 2010/Jugoistočni cinktor vanjska strana (JICVS); 23. Istočni cinktor vanjska strana (ICVS); 24. 2011/Istok nastavak; 25. Istok nastavak južno proširenje (INJP) 1-2; 26. 2011/6; 27. 2012/Sjever nastavak; 28. 2012/Istok; 29. 2013/Cinktor sjeveroistok vanjska strana (CVIVS); 30. 2014/Cinktor sjever vanjska strana (CSVS); 31. 2015/Cinktor sjever nastavak (CSN); 32. 2016/Cinktor sjeverozapad vanjska strana (CSZVS); 33. 2017/Cinktor zapad sjeverozapad vanjska strana (CZSZVS); 34. 2018/Zapadni kanal; 35. 2019/1; 36. 2019. Sjeverni bedem 3; 37. 2022/7.

siderable damage to the layers in which they were dug. Although the density of the burials is the highest around the church, it is not insignificant even at the edges of the site near the northern rampart.

Considering the high degree of destruction at the site, especially of the late antique layers and structures, larger parts of preserved structures were defined only in the area around and under the early Christian church complex. Other parts of the site where antique structures were identified include one or possibly two places between the early Christian church complex and the northern rampart and one place along the southeastern edge of the site. So far, all architectural remains under and around the early Christian church complex have been connected to larger public buildings that preceded it or coexisted with it. A corner of a stone building was found at the edge of the site southeast of the early Christian church complex, and a possibility was presented that it might have belonged to a second early Christian church (Filipec 2020: 299). The architectural remains of a smaller stone building besides the northern rampart northwest of the early Christian church complex are still unpublished but represent solid proof of the existence of possibly residential buildings on the northern plateau. The remains of a representative public or residential stone building with the hypocaust heating system is only known from the descriptions of M. Gorenc's field survey (Gorenc 1977-1978: 265-266).

Large quantities of pottery fragments point to the fact that there were more late antique buildings, especially those related to the residential part of the hilltop settlement, and not the church complex. Given that a significant portion of the site outside the present-day sanctuary of Majka Božja Gorska remains unexcavated, an attempt was made to interpret these unexcavated areas of the site using the spatial distribution of late antique pottery fragments from the excavated trenches. This analysis aims to suggest possibilities for further research, with an emphasis on non-invasive methods.

Materials and Methods

The spatial distribution analysis at the site of Majka Božja Gorska in Lobor is based on the density of pottery fragments. This is an established way of identifying the parts of the site that were in residential or commercial use in connection with the production, use and discarding of pottery. The spatial distribution analysis using the density of finds is one of the most common analysis of this type (Conolly & Lake 2006: 173-176). The areas with high density of finds are called clusters, which form the spatial patterning within an archaeological site called spatial clustering or density patterning (Reid Ferring 1984: 116-117). Two methods of calculation were considered for the analysis of the spatial distribution of late antique pottery fragments from the site. An attempt was made to calculate the density of pottery finds per square or cubic meter of excavated soil to determine the clusters of pottery finds within the late antique hilltop settlement from the quantification analyses of the material and its stratigraphic connection. The first method of calculating pottery density at a site per excavated area is easier and more widely used due to the availability of the necessary data. The second method of calculating pottery density at a site per excavated volume should be more accurate due to the depth variable included into the calculation (Nikšić 2022: 133). In the initial stages of the research, it seemed that the method of calculating the density per cubic meter would be more suitable. When calculating the density per square meter, the depth factor is lost, so it is possible that the clusters of pottery finds may be inaccurately positioned if the trench depth significantly varies. Despite the positive results of the trial analysis of the spatial distribution, which included trenches excavated in 2010 and 2014, together with trench 3 from 1998 (Nikšić 2022), during the continuation of the analysis, the method of determining density per cubic meter had to be abandoned due to the lack of necessary data for calculating the volume of excavated soil. Over the span of more than twenty years, which is how long the excavations at the site have been performed, there has been a significant change in the methodology of excavations and documentation. For an accurate calculation, it is necessary to three-dimensionally document the excavated trenches and/or stratigraphic units as precisely as they can be, which is not always possible due to the lack of time or the complexity of the situation at the site. The imperfection of archaeological documentation, the data collected from the site and their quantitative analyses has been recognized by archaeologists and all involved with the processing of features, finds and general archaeological data (Whallon 1984: 242; Bevan 2020: 70). The method of calculating the density of fragments per square meter was chosen for the analysis of the spatial distribution of late antique pottery finds at the site of Lobor – Majka Božja Gorska to be uniform for all research campaigns and all excavated trenches (Fig. 2). A graph showing the spatial distribution made based on the quantification by the weighing method is presented to demonstrate the differences that can occur depending on the degree of pottery fragmentation (Fig. 3). Considering that the square grid method was abandoned during the excavation of the trenches along the western façade and the southern side of the present-day church, from 2003 to 2005, due to a large number of burials and different parts of structural features, which prevented the precise placement and maintenance of the square grid (K. Filipec, personal communication, October 5, 2023), the density of pottery fragments was calculated for each separate trench. It was impossible to conduct the point pattern analysis (Hodder & Orton 1976: 30-52), which would give a more precise location of the pottery fragments within trenches or features, because of the large number of pottery fragments that could not be individually recorded as points. As it was mentioned in the introduction, the layers and the features at the site were significantly disturbed by medieval and post-medieval burials.

It should be noted that the method of calculating the density of pottery fragments per square meter was applied to the entire spectrum of the late antique pottery, as well as the individual pottery groups that had been formed during the primary analysis of the pottery finds. The entire spectrum of late antique pottery finds was divided into seven groups: glazed pottery (**G1**), slip ware (**G2**), burnished pottery and pottery with burnished decoration (**G3**), fine reduction-fired pottery (**G4**), fine oxidation-fired pottery (**G5**), gritty pottery (**G6**) and coarse pottery (**G7**). This division has already been presented in an earlier paper (Nikšić 2022: 135, Fig. 3). These pottery

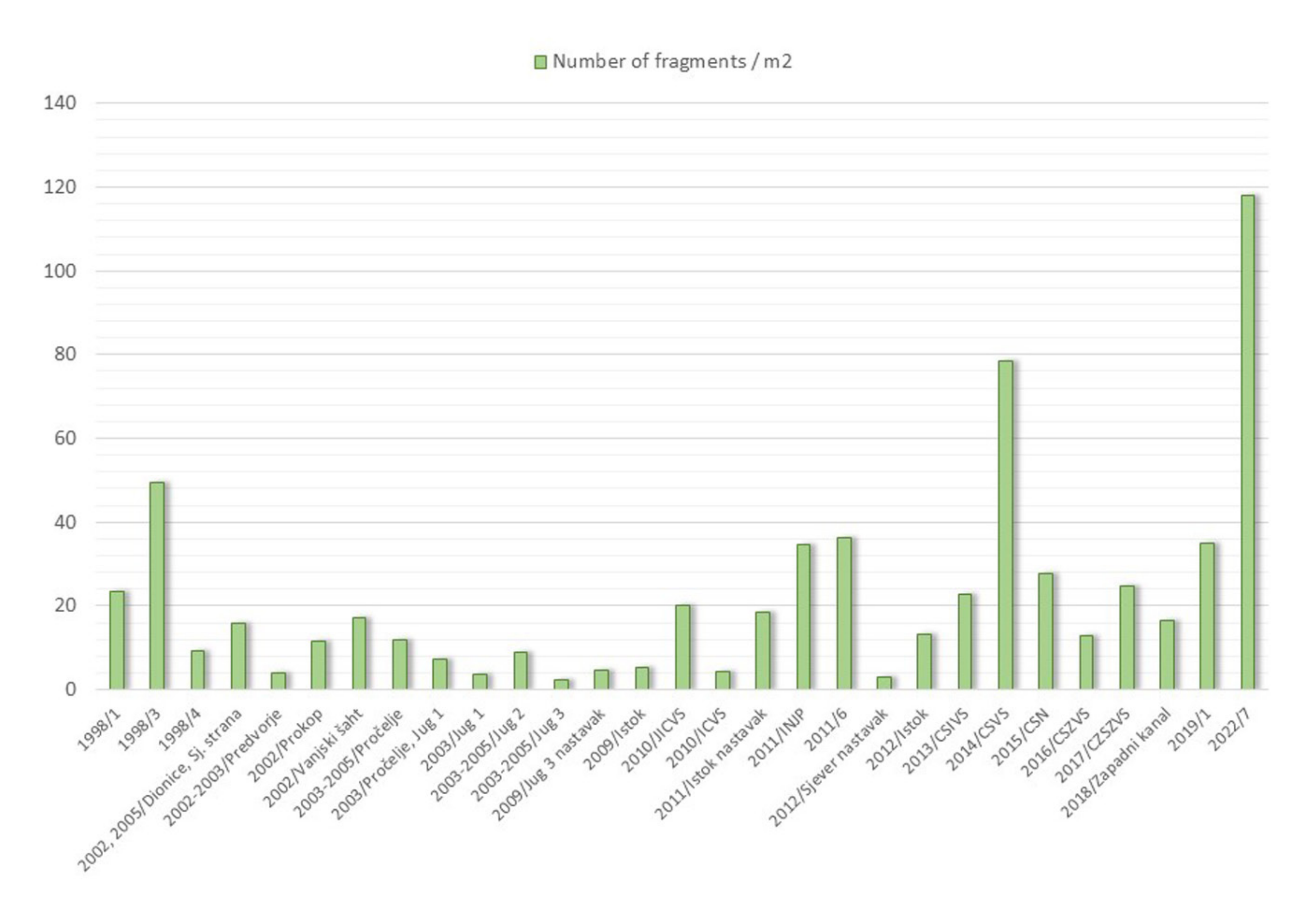

Figure 2. The number of late antique pottery fragments per square meter (Made by: P. Nikšić)

groups were initially developed for the doctoral dissertation research and the better understanding of late antique pottery production and use in Lobor (Nikšić 2023: 72-177). These groups and subgroups, their dating and distribution, as well as some representative finds, were all used for the interpretation of the various parts of the late antique hilltop settlement in Lobor. Groups 1-5 represent fine pottery with various surface treatment or coating, and groups 6 and 7 include pottery with a bigger number of smaller and larger inclusions. The main difference between gritty and coarse pottery from Lobor is in the size and distribution of limestone and quartz inclusions in the clay matrix. A large amount of evenly distributed small temper particles was used for gritty pottery, while a smaller amount of unevenly distributed temper particles of various sizes was used for coarse pottery (Nikšić 2022: 135; 2023: 164-177).

Results: The Density of Pottery Fragments Per Square Meter

By analysing the spatial distribution of the entire spectrum of late antique pottery, based on the quantification using the methods of counting and weighing fragments, three clusters of pottery fragments and a potential one were detected. Trench 3 from 1998 and trenches from 2014 and 2022 stand out. Their total values are significantly higher than those in other trenches. It should also be noted that these trenches are not as deep as those inside the enclosure wall, around the current church building. Trench 6 from 2011 should probably be considered as another cluster. It was not excavated to the natural sterile ground or bedrock. Only the two initial layers were removed: the humus layer and the layer of the levelling debris under it. Three graves were cleaned and removed, but then the excavation was stopped and never finished. This trench was excavated to prevent the

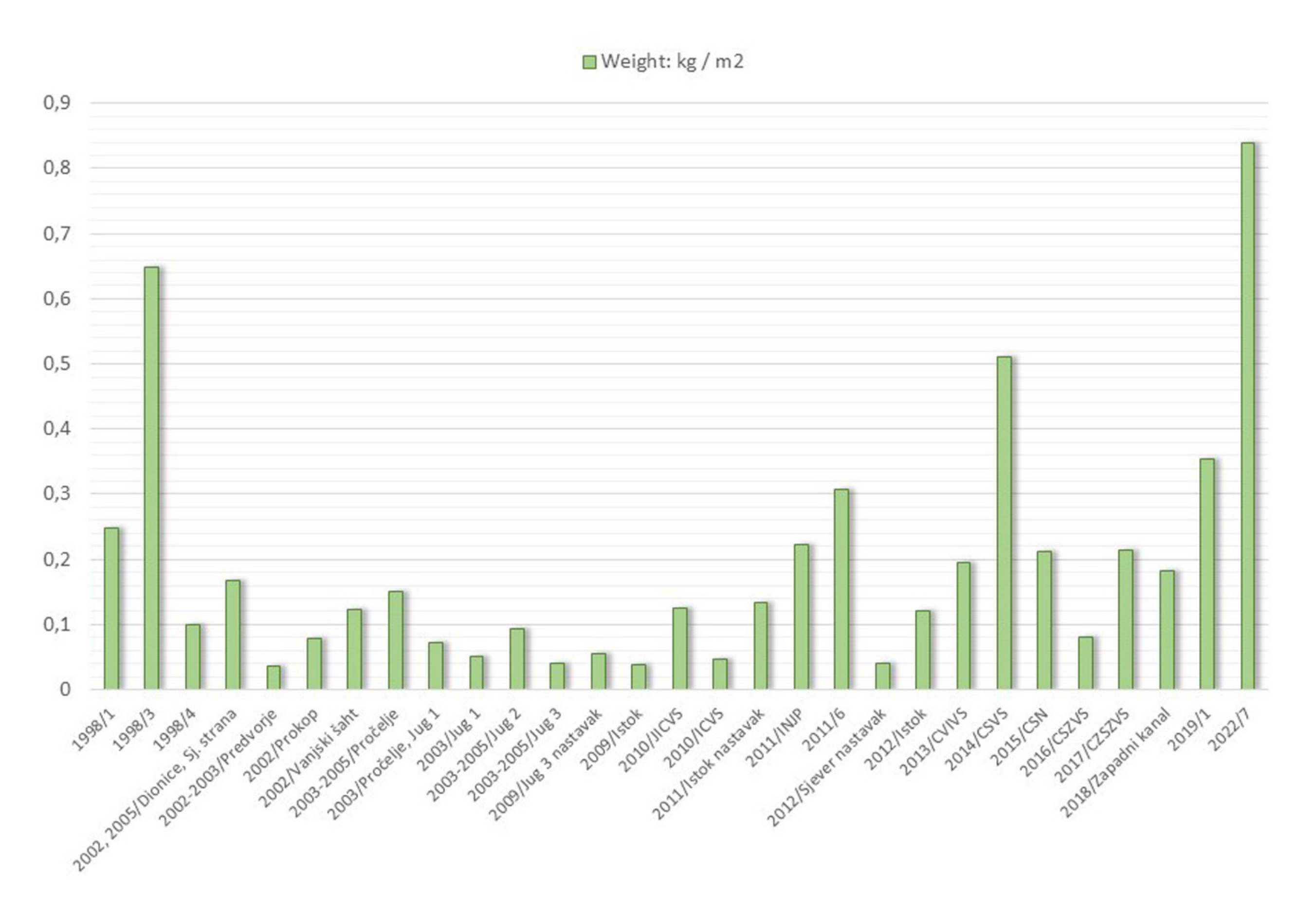

Figure 3. The weight of late antique pottery per square meter in kilograms (Made by: P. Nikšić)

devastation of that part of the site, so in fact the humus layer had already been partially removed, and a part of the data about the number of pottery fragments was lost. Therefore, we can expect a much higher value in that area than the current value of pottery fragments per square meter. All the trenches mentioned here have one thing in common. They were located on the northern plateau and along the northern rampart. It should be emphasised that, if trench 6 from 2011 is excluded, the largest number of pottery fragments per square meter was found in the trench from 2022. This refers to the total number of pottery fragments of all groups.

Clusters of glazed pottery fragments (**G1**) are like the clusters of the total number of fragments **(Fig. 4).** The largest number of fragments was found in the same four trenches mentioned above. The largest number of glazed ware fragments per square meter was found in the trench excavated in 2022, compared to other trenches, and a potential cluster also appeared in trench 6 from 2011, which could be confirmed by completing the excavation in that trench.

The situation with clusters is somewhat different in the group of slip ware (**G2**) **(Fig. 5).** Although it was present in the previously mentioned trenches, it also appeared in the excavation from 2002 and the trench from 2013, where the quantities are comparable to those from trench 3, excavated in 1998. The largest cluster was recorded in the trench from 2014, where this group exceeds the amount found in the trench from 2022, which is a slight difference compared to the group of glazed pottery.

As for the group of burnished pottery and pottery with burnished decoration (**G3**), it was found in larger quantities almost exclusively on the northern plateau in trench 3 from 1998 and even more in the trench from 2014 (Fig. 6). Although pottery fragments with burnished decoration were found in other trenches as well, the quantity

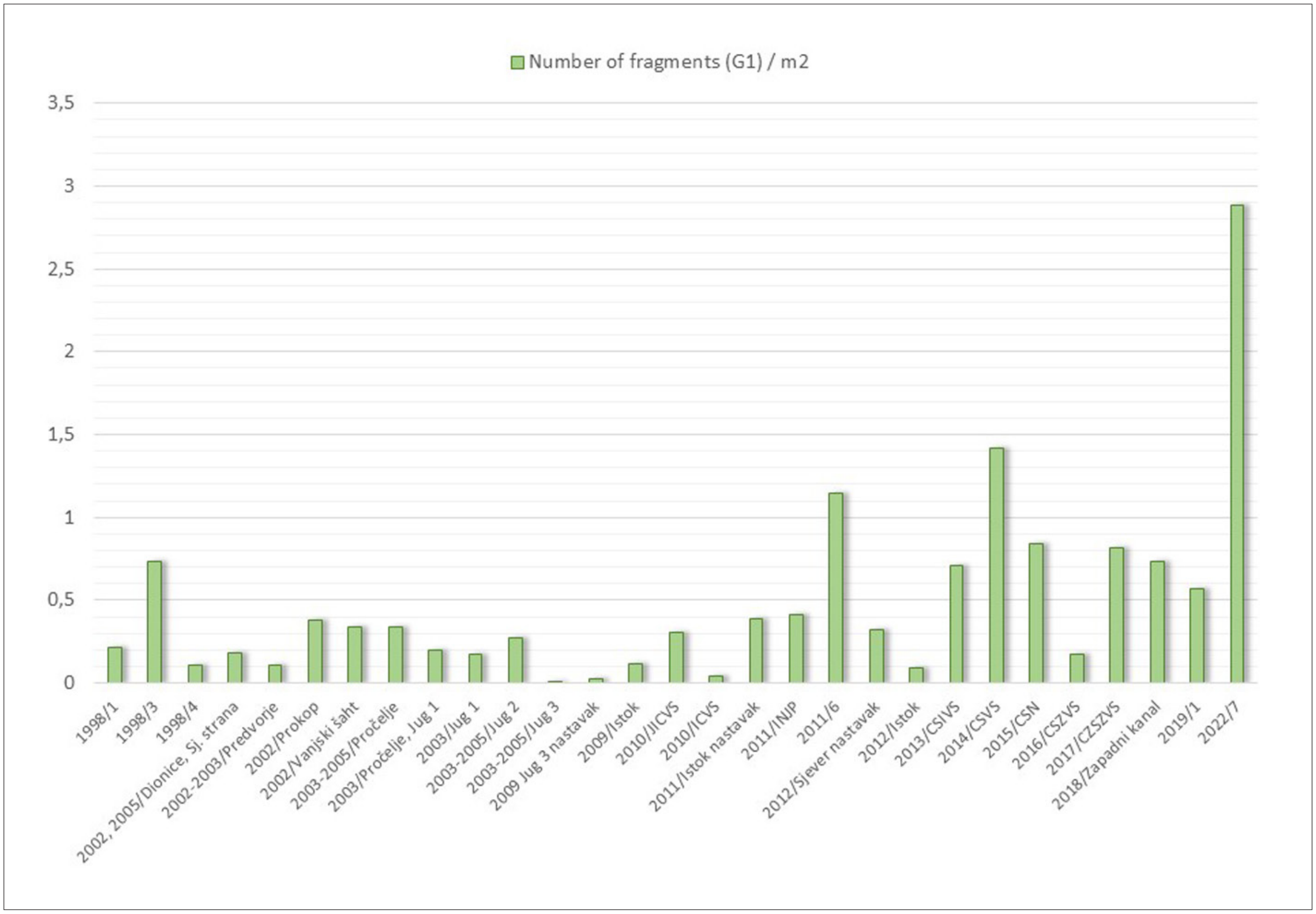

Figure 4. The number of late antique glazed pottery fragments (G1) per square meter (Made by: P. Nikšić)

is almost insignificant in comparison with the two mentioned trenches.

The situation with fine reduction-fired pottery (**G4**) is even more pronounced in favour of the trench from 2014 where the only cluster of this group of pottery was detected (Fig. 7). The number of fine reduction-fired pottery fragments from trench 3 from 1998 and trench from 2022 can also be highlighted but keeping in mind that the amount is seven times smaller than in the trench from 2014.

The spatial distribution of the fragments of fine oxidation-fired pottery (**G5**) is like the spatial distribution of the entire late antique pottery spectrum, although the biggest number of fragments of this group was found in the trench from 2014 **(Fig. 8).** Besides that, two more clusters were recorded in trench 3 from 1998 and the trench from 2022. The quantity is somewhat smaller in the other trenches.

When it comes to coarse pottery fragments, the spatial distribution is somewhat more uniform, and the density for both groups is again the highest in the trench from 2022, with the fact that the density of real coarse pottery fragments (**G7**) is twice higher than the density of gritty pottery fragments (**G6**). The trench from 2022 represents the main cluster of coarse pottery fragments. Smaller clusters of gritty pottery fragments were recorded in trench 3 from 1998, in the southern extension of the eastern trench from 2011 and in the trench from 2014. The densities in trench 6 from 2011 and trench 1 from 2019 have slightly lower values than them **(Fig. 9).** The situation is similar with the real coarse pottery fragments, but the proportions are somewhat different (Fig. 10). The main cluster in the trench from 2022 stands out much more compared to the other trenches, and smaller clusters were established in trench 3 from 1998, trench 6 from 2011 and trench 1 from 2019. No cluster appeared in the trench from 2014 regarding this group,

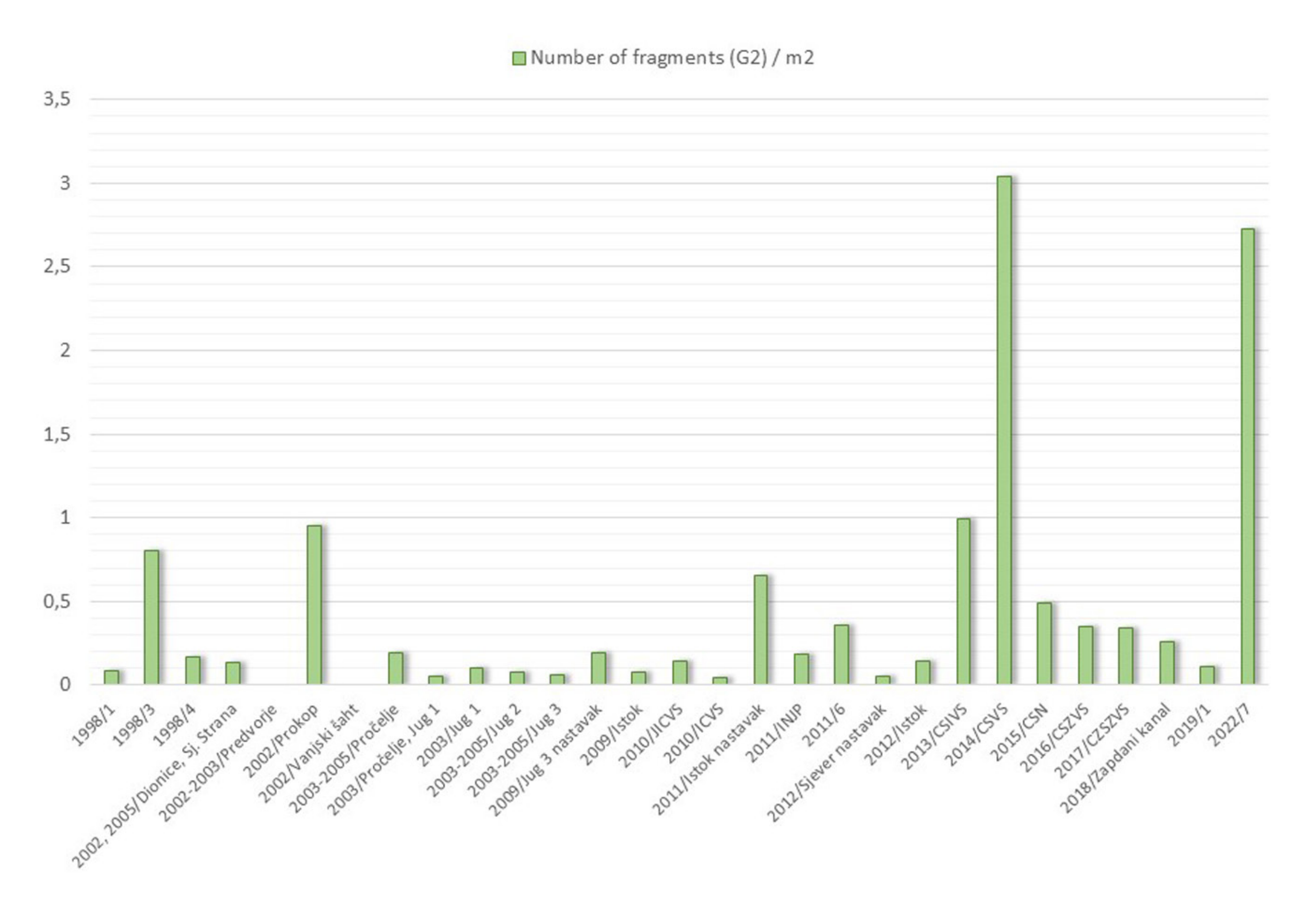

Figure 5. The number of late antique slip ware fragments (G2) per square meter (Made by: P. Nikšić)

and the southern extension of the eastern trench from 2011 shows a slight decrease in density but still stands out from the other trenches.

Discussion: Pottery Clusters as Indicators of the Spatial Organization

Construction activities at the site of the present-day shrine of Majka Božja Gorska in Lobor, which took place mostly within the Baroque enclosure wall, make it almost completely impossible to connect the found pottery fragments with the remains of architecture. Given that it is the area of the late La Tène fortified settlement and the late antique hillfort, where it seems that at least three wooden or masonry public buildings have been erected in those periods, before the construction of the early Christian church complex, it was not to be expected that a large amount of pottery fragments would be found within closed archaeological contexts. However, the amount of pottery fragments in the trenches between the church and the enclosure wall is still not insignificant. Despite that fact, the pottery cannot be connected with the early Christian church complex, which represents the largest construction project at the site, and which is assumed to have been built between the middle of the 5th and the first quarter of the 6th century. There are no pottery finds from the area of the early Christian church complex that can be attributed with certainty to that period. Part of the late antique pottery fragments found south of the present-day sanctuary may have been deposited there during the construction of the Baroque enclosure wall. That part of the site had a steep slope that had to be filled in to create a level surface for the construction, but it is not entirely clear from where the earth was removed. On the other hand, the density and weight values and the number of fragments of late antique pottery in the trenches excavated in that area are even below average, which means that even with the filling, no significant amount of pottery

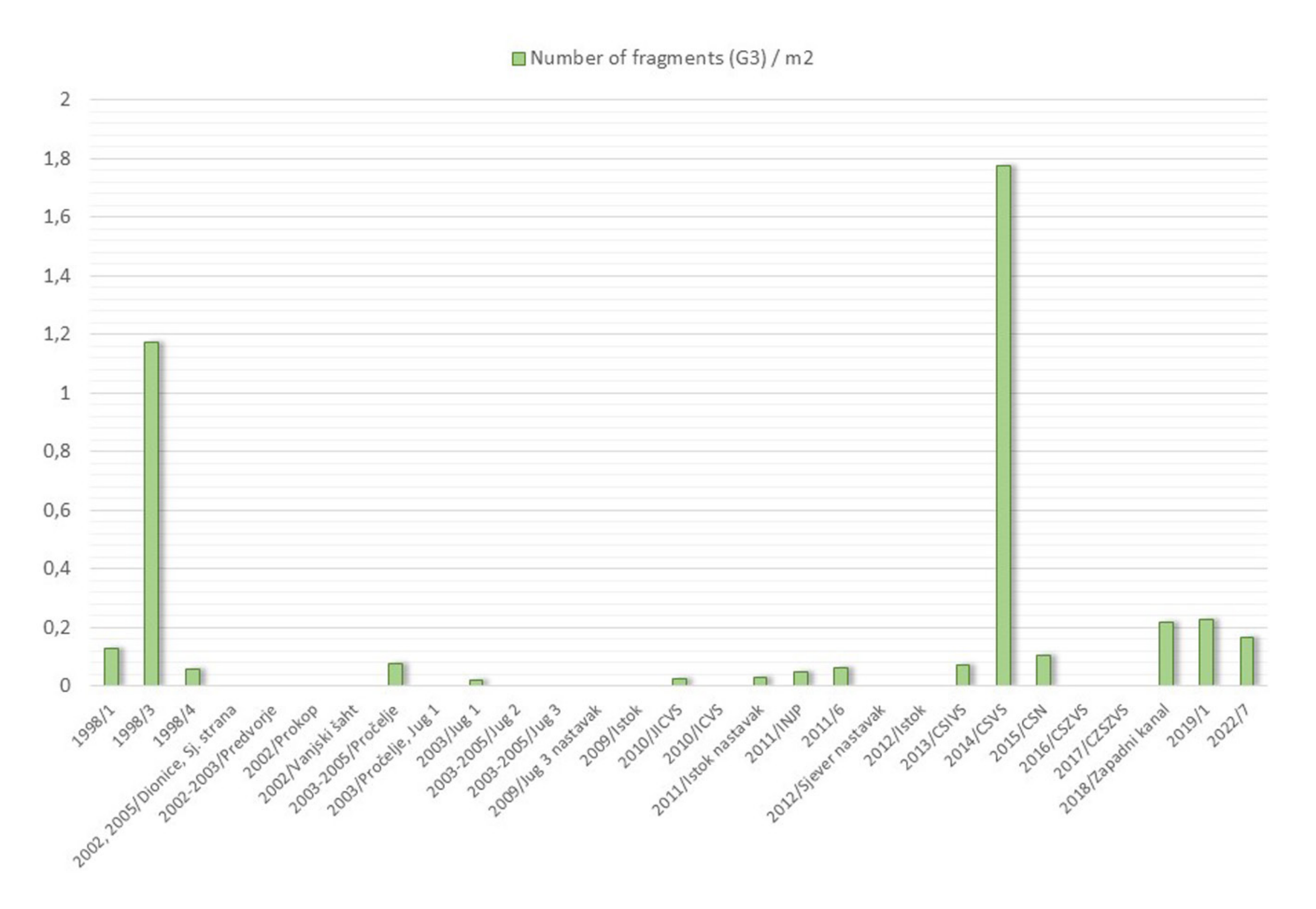

Figure 6. The number of late antique pottery fragments with burnished decoration (G3) per square meter (Made by: P. Nikšić)

fragments was recorded there. This situation, therefore, fully corresponds to the theory that there was one public building or more of them in that area, mostly unrelated to the preparation and consumption of food and drink, and not a residential part of the settlement.

The clusters of late antique pottery fragments were found, as it was mentioned earlier, on the northern plateau between the early Christian church complex and the northern rampart, as well as along the northwestern rampart on the edge of the western plateau, or more precisely, in trench 3 from 1998 and trenches from 2014 and 2022. Although there were indications that the residential part of the settlement could have been located on the southern terraced slopes, which was the conclusion reached after a field survey of that part of the hillfort in the second half of the 20th century (Gorenc 1977-1978: 265-266), the analysis of the density of pottery fragments per square meter and their spatial distribution does not confirm that conclusion. The large amount of late antique pottery fragments from the northern side of the site proves that at least part of the residential area of the settlement was there, although the architectural remains are minimal. The residential area in the northern part of the site is further confirmed by the finds of kitchenware. There has been some speculation that the pottery fragments could have migrated from one part of the site to the other due to erosion. This is certainly true for the southern part of the site, but is impossible for the northern part, which is higher in altitude. Therefore, it is not possible that the northern part of the site was later filled up with soil from some other part to such an extent that this would significantly affect the amount of pottery fragments. Despite the fact that the northern side of the settlement is not so favourable for habitation due to the influence of the mountain climate, mainly strong, cold winds, the clusters of late antique pottery fragments support the theory that the raising of the earthen ram-

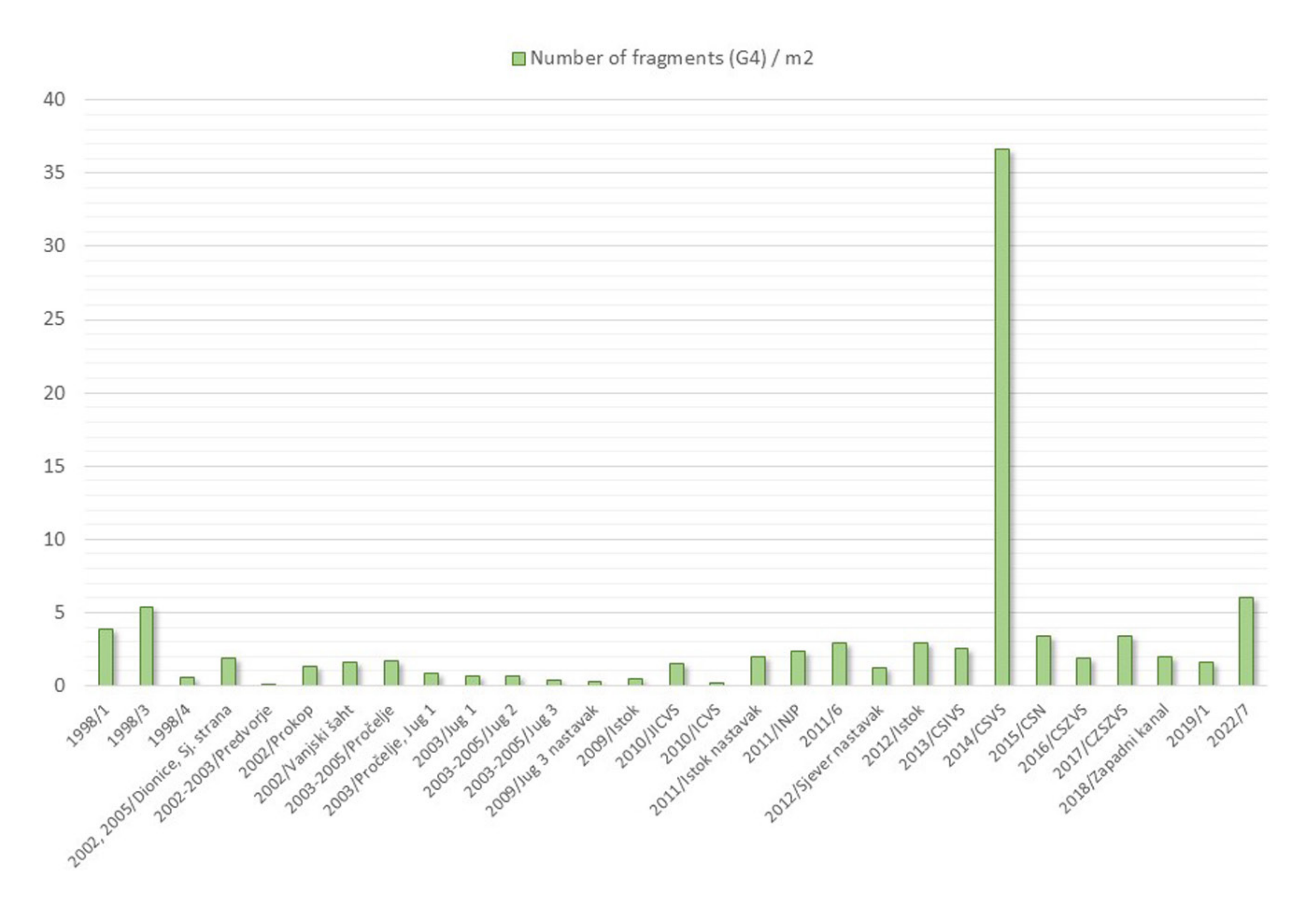

Figure 7. The number of late antique fine reduction-fired pottery fragments (G4) per square meter (Made by: P. Nikšić)

part and the construction of a stone wall on top of it provided enough shelter from the direct adverse influences of the weather so that long-term living there was possible. The walled up north entrances of the early Christian church complex and the Baroque enclosure wall testify that the north wind was a problem for the inhabitants of Lobor (Filipec 2008: 61).

The values of the density of late antique pottery fragments from three main clusters, along with the presumed real value from the cluster in trench 6 from 2011, are followed by the density values from trench 1 from 1998, trench 1 from 2019, the southern extension of the eastern trench from 2011, and the trenches excavated in 2013, 2015, 2017 and 2018. As it can be seen from the plan, those trenches are on the northern plateau next to the rampart, in case of the trench 1 from 2019, and on the northern plateau on the outer side of the enclosure wall, close to the trench from 2014, with a confirmed cluster of fine reduction-fired pottery. Considering its position within the settlement, only the eastern trench from 2011 stands out. It is the easternmost trench excavated inside the settlement, or at least the part of the settlement that was on the inner side of the ramparts. Although there is a possibility that a part of the early Christian cemetery was located there in the 6th century (Filipec 2020: Fig. 1), it is probable that earlier than that, a residential part of the settlement was in that area near the northeastern gate. When the finds from these trenches are combined with the previously established clusters of late antique pottery fragments, it seems that the northern and western plateau were used as the residential area that followed the northern rampart (Fig. 11).

The closest analogy for this kind of spatial organization is at the fortified hilltop settlement in Rifnik where the late antique houses were located between the rampart

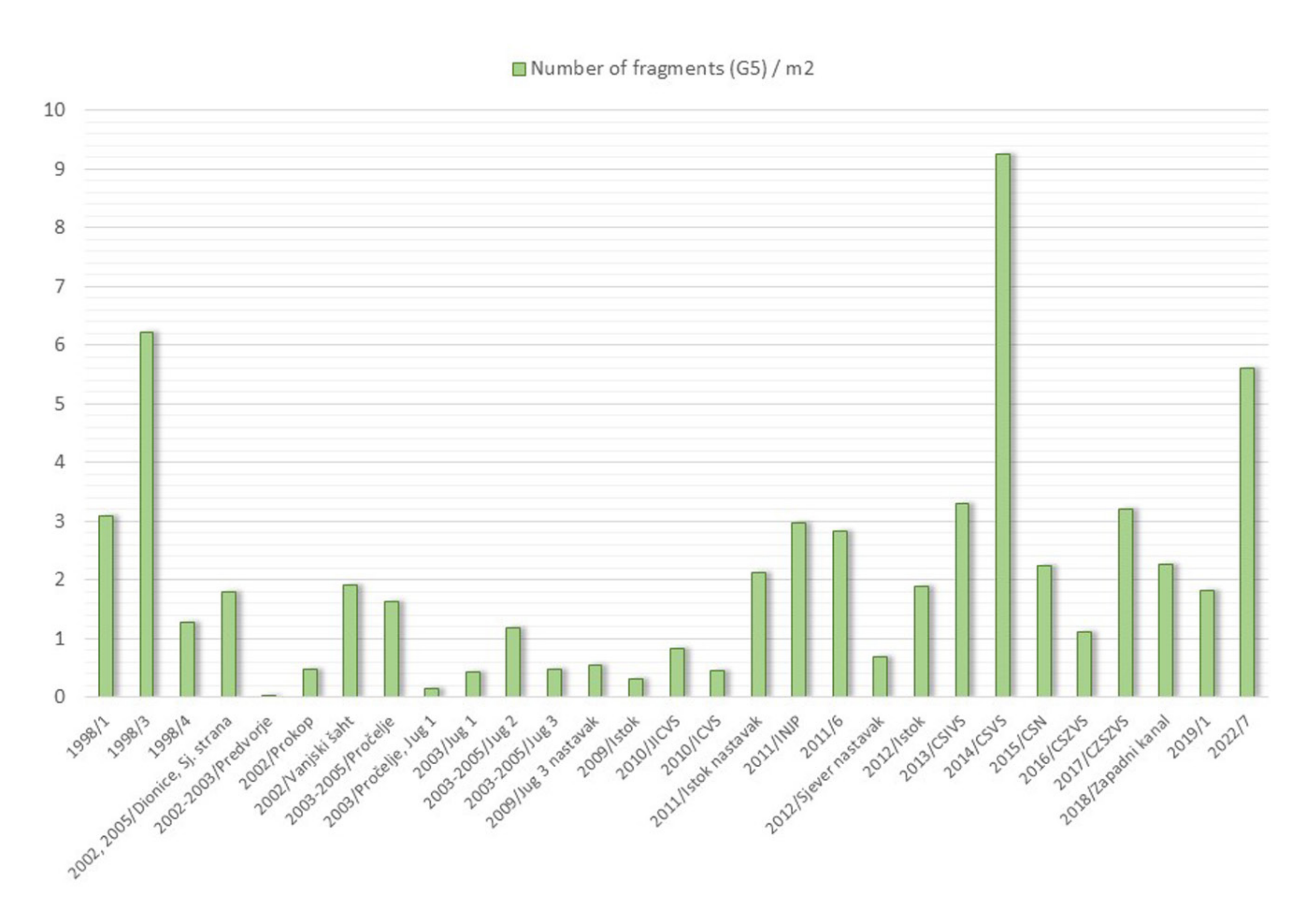

Figure 8. The number of late antique fine oxidation-fired pottery fragments (G5) per square meter (Made by: P. Nikšić)

and the church. Two irregular rows of houses were defined, one attached to the rampart, and the other more towards the church (Bausovac 2011: 265, Att. 1). Considering the find of the stone building next to the northern rampart in Lobor, as well as the probable house debris on the northern plateau, a similar organization of housing is to be expected at the site Lobor – Majka Božja Gorska. The organization of the residential part of the settlement depends highly on the configuration of the terrain, the size of the building and the building density. In some hilltop settlements, the houses were scattered within the empty space between larger church and civil buildings, as can be seen in the plan of Ajdovski gradec above Vranje near Sevnica (Knific 1994: 212-217, Fig. 4), Tonovcov grad near Kobarid (Ciglenečki et al. 2011: Fig. 1.7) and the important early Christian center in Hemmaberg (Ladstätter 2003b: Fig. 2, 4). As the remains of such larger buildings were not detected north and west of the early Christian church complex in Lobor, the organization like the one in Rifnik is more likely. Similar spatial organization can be seen in the hilltop settlement in Duel where the houses are attached to the northern rampart, and there is empty space between the houses and the church (Glaser 1996: Fig. 35). The existence of the bishop's house or another more luxurious residential building on the south side of the hilltop settlement in Lobor is so far just a hypothesis based on the old field survey (Gorenc 1977-1978: 265-266). That part of the site was mainly destroyed during the construction of modern houses, which now serve as vacation homes with extensive gardens, and the area is not available for archaeological research.

Although a black layer that consisted of soil with soot and charcoal, which was found next to the sacristy and north wall of the present-day church building, formed a smaller part of the stratigraphy of the trench from 2002, a significant amount of pottery fragments was found in

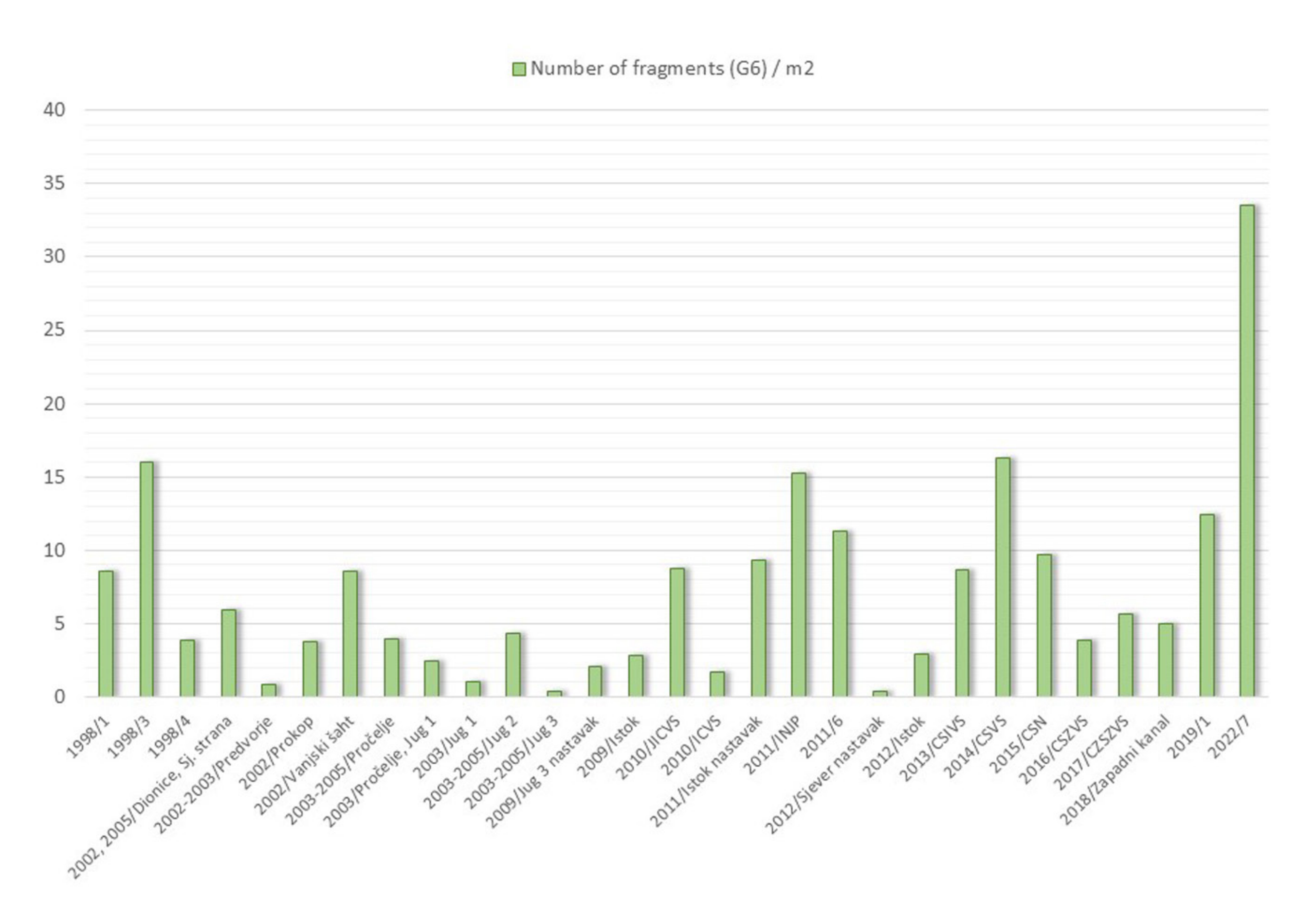

Figure 9. The number of late antique gritty pottery fragments (G6) per square meter (Made by: P. Nikšić)

it. It should also be noted that the pottery found there has a lower degree of fragmentation than the pottery found on other parts of the site. That black layer is mostly associated with the burning and destruction of a late antique building that stood on the site of the early Christian church complex. Pottery fragments found there, especially glazed pottery, confirmed the dating of the destruction of that building around the middle of the 5th century, after which there are no more pottery fragments that could be dated to the second half of the 5th or the 6th century. On the other hand, it is not possible to connect the demolition of an older building and the construction of an early Christian church complex on that site based on the pottery finds. The theory that a religious building had been located there for most of the existence of the hilltop settlement, but before the early Christian church complex was built, was not undoubtedly confirmed by the pottery finds. The fragments of kitchenware, as well as tableware, were found in the before mentioned black layer. In fact, all previously defined pottery groups were found, and the spectrum of pottery finds in the black layers does not differ from the pottery spectrum in other stratigraphic units at different parts of the site. The black layer was not defined only near the present-day church building, where previous late antique building remains were identified, but also in several other place inside the trench from 2002. More precisely, it was defined inside the enclosure wall and outside of it in an external shaft. A late antique arrowhead of a long-lasting form, with a square cross section, was found in that shaft (Filipec & Bunčić 2021: cat. no. 17). Similar arrowheads were found in the fortified hilltop settlement in Kuzelin, which is located around 25 km south of Lobor. Those arrowheads were dated to the second half of the 4th and the beginning of the 5th century (Sokol 1998: 23-25). Considering the fact that only few arrowheads were found inside and around the late antique hilltop settlement in Lobor, which is in line with the general absence of weap-

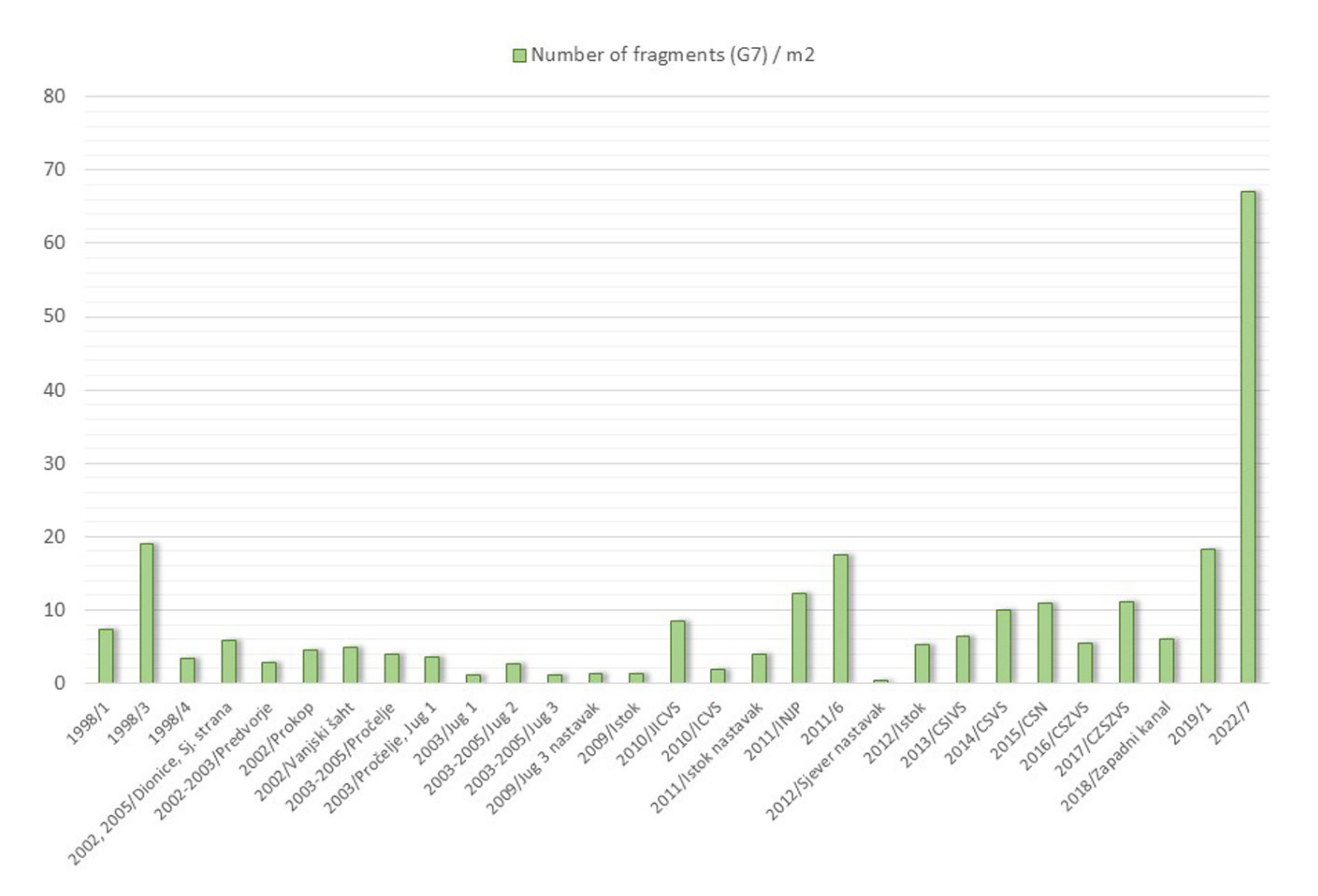

Figure 10. The number of late antique coarse pottery fragments (G7) per square meter (Made by: P. Nikšić)

ons from the settlement, this arrowhead from the black layer may indicate towards a controlled destruction of a pagan temple during the change in religious customs connected to the probable arrival of a new population group at the end of the 4th century. This practice is known from other Noric-Pannonian sites (Walsh 2016: 231-235). In that case, the kitchenware and the tableware found in the black layer, partially beneath the early Christian church complex, could belong to offerings left to a pagan deity.

Two other late antique buildings within the hilltop settlement in Lobor were partly excavated, mainly because the only well-preserved late antique building there is the baptistery building. Other late antique buildings at the site, including the early Christian church, were heavily damaged by later interventions, such as construction work and burials. These two building were to a lesser extent within the excavated trenches, so it is difficult to speculate about their purpose, especially when considering the pottery fragments found there. One of them was a wooden building west of the early Christian baptistery building, mostly underneath the Baroque enclosure wall. The other one was a stone building outside of the enclosure wall in the southeastern part of the site. None of these structures can be associated with the clusters of pottery fragments, and the density of fragments per square meter values in the trenches where the buildings were found are very similar, with variations depending on the degree of fragmentation. The difference, however, is that the pottery fragments found in front of the facade of the present-day church are less fragmented and of a wider range, considering the previously formed pottery groups, so perhaps they can be connected to a wooden building or other structures that were in the area before the construction of the early Christian church complex. On the other hand, it seems

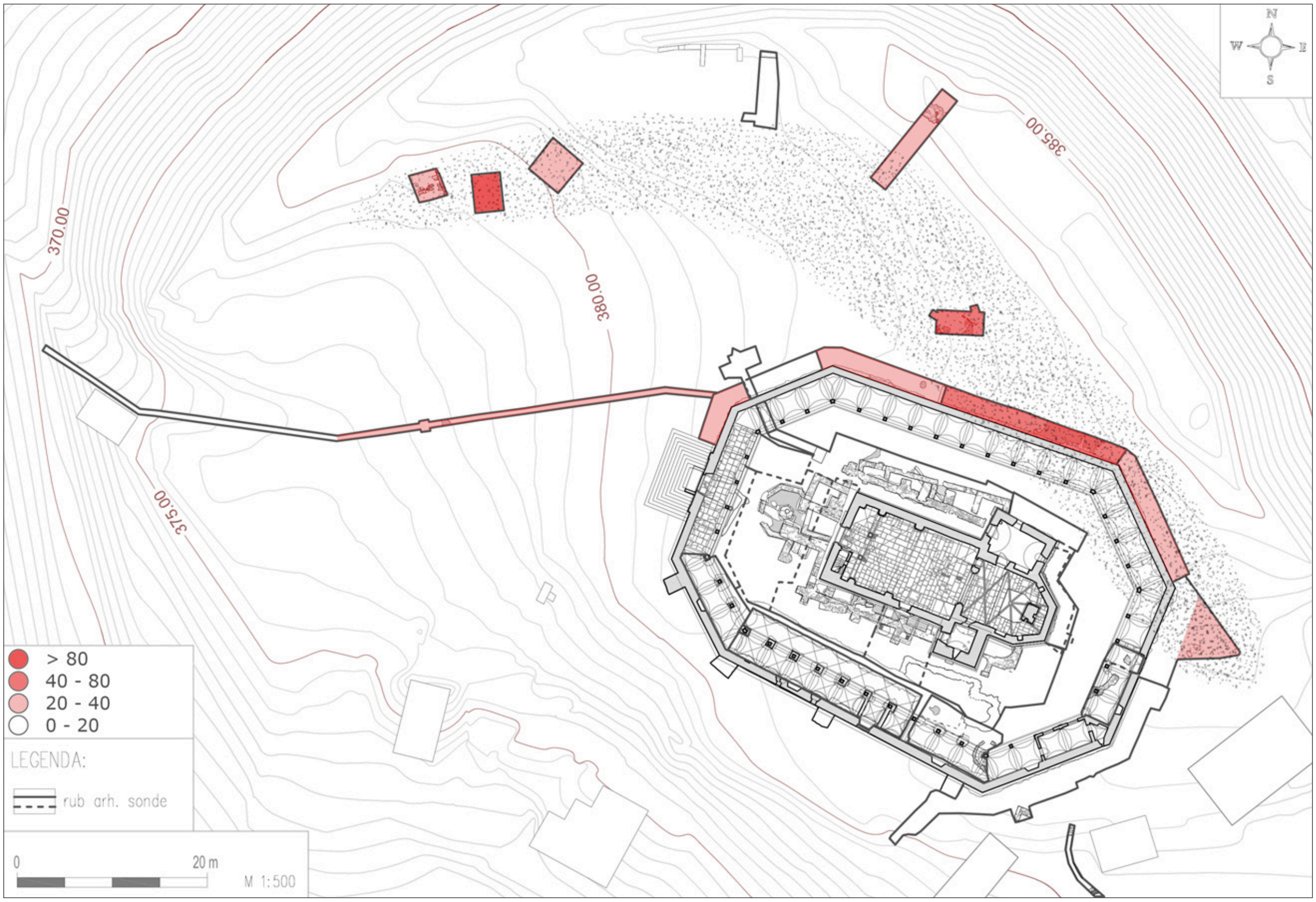

Figure 11. Color-coded plan of the site Lobor – Majka Božja Gorska (density of pottery fragments per square meter) with the proposed area of the residential part of the settlement on the northern and partly western plateau (Plan: Arheo Plan d.o.o., Modified by: P. Nikšić)

that the highly fragmented pottery found in the south-east trench from 2010 outside of the enclosure wall had no connection to the stone building, which is interpreted as a possible second church within the hilltop settlement in Lobor (Filipec 2020: 299).

During the excavation campaign in 2019, a part of a late antique stone building with the earthen flooring was defined in trench 1 next to the northern rampart. The part that was excavated was partially destroyed by the medieval burial pits. Despite this, inside the building, as well as in the trench immediately next to it, which was excavated in 2022, a considerable amount of pottery fragments was found. In addition, it was noticed that the glazed vessels from those trenches differ in the most part from typical examples of the 3rd and 4th century. There are no fragments painted with slip, and the glaze is of lower quality. These vessels can probably be attributed to the later phase of life in the hilltop settlement and should be dated to the 5th century. At the same time, the largest cluster of pottery fragments from Lobor is associated with this building, and it can be said that this is the only place where large quantities of pottery were found in close correlation with architectural remains from the late antique period and definitively confirm the residential purpose of this part of the site.

Another smaller cluster of pottery fragments can perhaps be connected with the layer of ruins of a late antique rural-type structure in trench 3 from 1998. No stone walls were found there, but a large amount of burnt daub. A wide range of pottery that can be dated from the 3rd to the 5th century was found in that trench. Given the presence of tableware and kitchenware, it is quite possible that it was a residential building whose remains was mostly destroyed by the medieval burial pits, which were densely dug in that area.

Given the smaller quantities of late antique pottery in the area of the early Christian church complex and on the northern part of the late antique rampart, which was only sporadically excavated, the pottery cannot be connected with Christian activity within the settlement or with the presence of the army. Aside from the small sections of the northern rampart, no military buildings or features were defined. It seems that all pottery found so far should be connected to the residential part of the settlement, which was mainly used by the civilian population. Although at some hilltop settlements certain groups of pottery can be related to the presence of certain groups of people, like the military in the case of Rifnik (Bausovac and Pirkmajr 2012: 3, Fig. 2), no such connection was made for any of the pottery groups from Lobor. The typical late antique pottery with Christian symbols present at many Noric sites of the same period (Ladstätter 2003a: 309, Abb. 9), was not found in the hilltop settlement in Lobor. The pottery found in Lobor so far therefore cannot be related to Christian activities. The only feature that stands out and does not seem to be connected to civil residences are the stratigraphic units 2+7 in the trench from 2014, where the clusters of fine reduction-fired pottery with and without the burnished decoration were found. Since the vessels found there were mainly jugs and beakers, this feature is certainly in correlation with a private or commercial drinking facility. Taking all the data available from the excavations and the pottery analysis, it can only be confirmed that the residential area of the late antique hilltop settlement in Lobor with minor commercial features existed on the northern part of the site from the middle of the 3rd until the middle of the 6th century.

Conclusion

According to the above-mentioned facts, it can be concluded that most of the residential buildings and buildings in which kitchenware and tableware were used were located on the northern plateau of the late antique hilltop settlement in Lobor. That part of the settlement faces the strong north wind that often blows from the mountain. It seems that the reinforced earthen rampart and the stone wall built on top of it in Late Antiquity nevertheless enabled the construction of houses and relatively favourable living inside by the rampart. A small part of the late antique stone building with an earthen flooring was found in that area, more precisely by the rampart northwest of the early Christian church complex. Considering the position of grave 50 and the finds from destroyed late antique graves north and east of the early Christian church complex (Filipec 2020: 292-293, Fig. 1-2), it is possible that a part of the residential buildings on the northern plateau was already removed in Late Antiquity, after the construction of the early Christian church complex, in order to create space for the cemetery. Since the outer boundary of the late antique cemetery has not been established, it cannot be said whether it could have damaged potential buildings by the rampart, but it destroyed perhaps wooden structures in the position where a large cluster of reduction-fired fine pottery fragments with and without burnished decoration was found, which was mostly used for drinking. Given the character of the vessels, it is possible that it was not a residential area but a drinking place by the still existing pagan temple in the second half of the 4th and first half of the 5th century. Based on the results of the spatial distribution analysis of pottery fragments, it is suggested that, in addition to the previously mentioned buildings, there may have been other structures, likely of a residential nature, adjacent to the northern rampart, which remain to be researched and excavated.

Acknowledgements

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Building phases of the triconch church complex at Bilice with regard to mortar dating

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The paper contains data on the building phases of the early Christian church complex at Bilice near Šibenik. Different chronological phases were already recognised during the first excavations of the complex at the beginning of the 20th century. In the new revision research at the site the existence of earlier and later structures has been confirmed by the position of walls and their connections.

The determination of the phases is provided by radiocarbon mortar dating. In the case of the early Christian complex at Bilice, three mortar samples were radiocarbon dated. The samples originate from different parts of the church complex, two of them from additional structures and one sample from the wall of the triconch church. The paper brings a detailed account of the radiocarbon mortar dating of the Bilice samples, methods used and results in the context of archaeological data on the early Christian church complex in Bilice.

Key words: *Bilice, triconch church complex, mortar dating, building phases, Late Antiquity*

Introduction

The Triconch church complex at Bilice consists of a single-naved church with three apses and annexes at the north, south and west sides of the church. The complex was discovered at the beginning of the 20th century and newly unearthed during the revision archaeological excavations from 2016 to 2019 (Jarak & Jukić Buča 2017: 129-153; Jarak 2019: 37-52).

The triconchal church shape appeared in early Christian architecture and developed through different variations. Dalmatian triconch churches are generally dated to the 6th century, while in other regions there are earlier triconch churches of different typological features, as well as contemporary to the Dalmatian examples. Simple chapels or memories with three conchas, so-called *cellae trichorae*, were very widespread and popular throughout the entire early Christian period (Krautheimer 1986[4]: passim). As a very famous example, *cella trichora* from Sopianae from the end of the 4th century can be mentioned, and the newly discovered sepulchral building of the same type speaks of the popularity of the triconchal memories in the Late Antique Sopianae (Hudák and Nagy 2016: 77-83; Visy 2016: 68-76). Triconch churches differ from *cellae trichorae* with regard to the existence of a nave in front of the triconch termination. The nave is usually long, and besides single-naved churches, three-naved structures are also characteristic in early Christian architecture. With regard to the main topic of this work, namely the triconch church from Bilice, it is interesting to note that all known triconch churches in Dalmatia have been recently dated from the later 5th to the first half of the 6th century (Vežić 2011: 27-66). The dating has been mostly based on the fact that the majority of Dalmatian triconch churches developed in church complexes with annexes during the 6th century. However, there are other opinions in the literature concerning the dating of the triconch churches in Dalmatia, which point to some later building of the churches during the 6th century (Cambi 1984: 45-54; Chevalier 1996: 41-43, 77-79, 91-93, 144-146, 269-271, 394-400). In other parts of the Roman World, triconch churches were built during a broader time span, and as earlier examples of different types of triconch church buildings, the structures from Cimitile-Nola in Italy and Dayr-al-Abiad in Egypt can be mentioned. The Triconch church at Cimitile, dated to the beginning of the 5th century, was attached to an earlier Christian complex dedicated to the martyr Felix. The church has a basilican plan, and its apse formed a trefoil. The architecture in Nola has been well known thanks to the description of Paulinus, who explained the function of the trefoil and its apses. Lateral apses have been determined as a prothesis for the preparation of the Eucharist and chapel for meditation (Krautheimer 1986[4]: 195-196). The architecture at Nola has been constantly researched, and some new details also appeared speaking of several phases during the 5th century (Ebanista 2017: 287-331). At Dayr-al-Abiad (White Monastery), a large basilica has a triconch termination. The church was built in the middle of the 5th century (Krautheimer 1986[4]: 114-117; Ousterhout 2019: 54-56, 132-134). It represents a very monumental early Christian monastic church. Other triconch churches are known from both the eastern and western territories of the early Christian world. The form had further development during the early Middle Ages, e.g. in pre-Romanesque and early Romanesque architecture in Croatia (Vežić 2011: 45-59). It is obvious that early Christian triconch churches in Dalmatia share common features with similar late antique forms, but they also represent a unique group in terms of morphology, function and dating. Archaeological research and analysis of the Bilice triconch church could contribute to better knowledge of this special early Christian church type in Dalmatia.

The triconch churches in Dalmatia are single-naved, modest buildings. With regard to the relation of conches (the majority of churches have connected conches, while some display distanced conches), it is possible to group triconch churches in Dalmatia (Cambi 1984: 45-54). The church from Bilice belongs to the group with interconnected conches decorated with lesenes, together with the churches in Pridraga and Sutivan. It is the most similar to the church from Pridraga. Besides architectural similarities, the churches from Bilice and Pridraga also share very similar stone furniture and certainly were built at the same time.

The task of the analysis of the Bilice triconch church is to check the reliability of its supposed dating according to the general place of triconch churches in Dalmatian early Christian architecture. We have wanted to provide some independent dating and to compare the obtained results with the conventional dating of triconch churches in Dalmatia. A possibility has been found during the new revision of archaeological research in Bilice. Newly unearthed walls have been suitable for mortar analysis that resulted in ^{14}C dating of the early Christian church complex in Bilice.

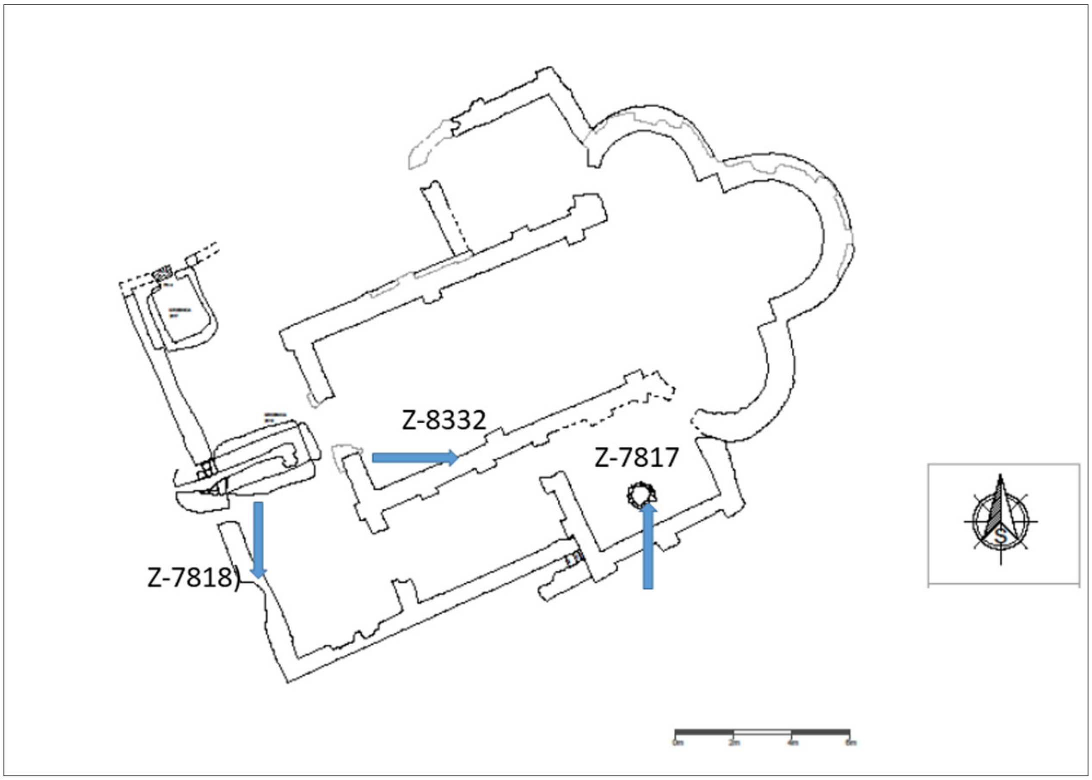


Figure 1. Bilice, ground-plan with locations of mortar samples: Z-7817 – baptistery, Z-7818 - west wall of the narthex, Z-8332 – south wall of the church nave (photo by M. Vuković, modification by M. Jarak).

Mortar can be dated by the radiocarbon dating technique, optically stimulated luminescence (OSL) (Zacharias et al. 2002: 379; Goedicke 2003: 409; 2011: 42; Urbanova et al. 2015: 110; Urbanova 2019: 81) and electron paramagnetic resonance (EPR) (Kabacińska et al. 2012: 825; 2014: 112). Mortar hardens during absorption of atmospheric CO_2, and radiocarbon mortar dating is based on extracting carbonate formed during the mortar hardening process (binder) and determining the amount of remaining natural ^{14}C (Labeyrie & Delibrias 1964: 742). However, mortar is a complex matrix with carbonates originating from aggregate, possible unburned geogenic carbonate, recrystallised carbonate, etc., making it difficult to extract pure binder carbonate that contains information about the date. There is a series of approaches to extract the pure binder or the other representative part (e.g. lime lumps); however, to this day, there is still no consensus on the preferred approach to mortar dating (e.g. Heinemeier et al. 1997: 487; Lindroos & von Konow 1997; Nawrocka et al. 2009: 857; Michalska 2019: 236; Barret et al. 2020; Daugbjerg et al. 2020: 1121). For the mortar samples from the triconch church complex at Bilice, we used the approach of differentiating the binder and geogenic carbonate by sequential dissolution and extrapolation developed in the Zagreb Radiocarbon Laboratory (Sironić et al. 2023: 119; Sironić et al. 2024: 1354). This approach to mortar radiocarbon dating has provided reliable results; however, the method is still being further developed, tested and perfected.

Materials and Methods

Location and sampling

For ^{14}C mortar analysis, three samples were taken from the different parts of the church complex. Two samples were taken from the west wall of the narthex and from the so-called baptistery. The 3rd sample was taken from the south nave wall. So, two samples originate from the annexes, and one from the triconch church (Fig. 1, 2, 3). In all three cases, the mortar was taken from the preserved wall structures that were uncovered during the revision research. The samples were brought to the Ruđer Bošković Institute, Laboratory for low-level radioactivities. The two samples from the annexes were analysed first, and the sample from the nave wall later on.

Figure 2. Bilice, narthex and part of the church nave (photo by M. Vuković).

Figure 3. Bilice, so-called baptistery (photo by M. Vuković).

Description of samples

Three mortar samples (Figs. 4a, b, c) were sampled from the described locations. About 20 g of mortar was sampled. Prior to processing the samples, they were tested with one drop of 0.5 % phenolphthalein for reactivity: if the mortar turned purple at the place of the drop, that meant that it still contained unreacted $Ca(OH)_2$ and the process of mortar hardening was not finished, i.e. that mortar sample contained carbon from all the time after the mortar was applied. All the samples were negative regarding the reaction with phenolphthalein.

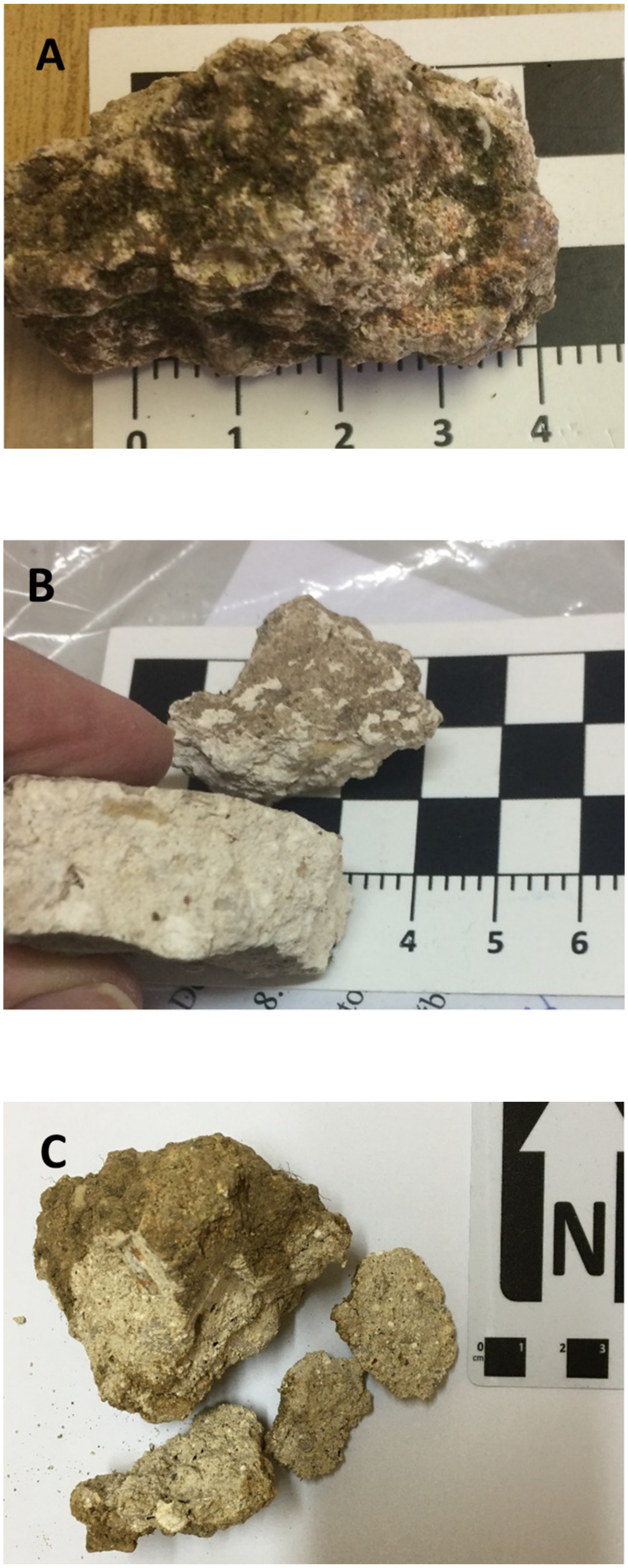
Sample Z-7817, Baptistery (Fig. 4a), was covered with organic fouling such as moss. It was mostly white, implying a large content of carbonate and binder. It contained macroscopic pieces of aggregate and smaller pieces of binder inclusions.

Sample Z-7818, Nartex (Fig. 4b), was mostly homogenous white, while the surface was covered with a darker coating. Some not well-defined inclusions can be spotted, ranging up to 5 mm wide. Some aggregate in the form of white translucent pieces can be observed.

Sample Z-8332, Church nave (Fig. 4c), was darker and more yellowish than the previous samples. Among the smaller observable pieces of aggregate, approximately 0.5 mm wide, smaller pieces of binder inclusion could also be observed (≤ 1 mm), and one piece about 1 cm wide.

Sample preparation for ^{14}C dating

The samples were treated according to the process described in Sironić et al 2023. The samples were cryogenically destabilised, broken with a hammer and inspected for possible charcoal remains, or if the binder inclusions exceeded 1 cm length, in which case the inclusions would be removed. In all the samples, this kind of inclusions were not found. Further on, the samples were gently crushed by a hammer. The powder was dry-sieved to collect particle fraction size 32-63 µm. A kinetic hydrolysis curve was created using 85 % phosphoric acid (H_3PO_4) to select the optimal CO_2 portion collection according to the criteria set in Sironić et al. 2023. Gas CO_2 portions were collected using a kinetic approach (Sironić et al. 2023: 185; 2024: 1354) by 85 % H_3PO_4 and only in the case of sample Z-8332, as a test, using a static approach by 2% HCl (adapted after Daugbjerg et al. 2020: 1121). According to the hydrolysis curve, selected CO_2 portions were collected regarding time frames for the kinetic approach and the HCl equivalent portion to the desired CO_2 amount for the static approach. The collected CO_2 gas was separated for $\delta^{13}C$ analysis and for graphite synthesis needed for ^{14}C analysis (Sironić et al. 2013: 185). The carbon isotope analyses were performed at the Centre for Applied Isotope Studies, Georgia (CAIS) (Cherkinsky



Figures 4a, 4b, 4c. Photographs of mortar samples from the triconch church complex at Bilice: 4a sample Z-7817, 4b sample Z-7818 and 4c sample Z-8332 (photo by A. Sironić).

et al. 2010: 867). ^{14}C values were normalized to $\delta^{13}C$ of -25 ‰ and expressed as $a^{14}C$ and as age before present (BP; Stuiver & Polach 1977: 335; Mook and van der Plicht 1999: 227).

Radiocarbon results for each mortar were extrapolated from the ^{14}C results of the first two CO_2 portions (Sironić et al. 2023: 185; 2024: 1354). Radiocarbon conventional ages were calibrated by OxCal 4.4 software (Bronk Ramsey 2009: 337; Bronk Ramsey 2021) and IntCal20 calibration curves (Reimer et al. 2020: 725).

Results and discussion

The results of the amount of extracted CO_2 portion, $a^{14}C$ and $\delta^{13}C$ for mortar fractions 32-63 µm are summarised in Table 1 and comparative first CO_2 portion dates and extrapolated calibrated dates for each mortar are presented in Fig. 5.

In all the cases, the first CO_2 portion has higher $a^{14}C$ and lower $\delta^{13}C$ values, which is in accordance with the fact that the initial CO_2 portions contain a larger amount of binder carbonate. Therefore, all the samples exhibit typical behaviour for well-preserved non-hydraulic mortars.

For the sample Z-8332 Nave wall, which was prepared twice, using the kinetic and static approach, both extrapolated results are in very good agreement one to another/statistically significantly (*Chi*-square test: df=1 T=0.2, 5% 3.8). Some authors also report the first CO_2 portions as the true ages of mortar, given the series of factors known for the mortars (e.g. Ringbom et al. 2014), and it is also reported here compared to the extrapolated dates. Given that the mortar is a very complex matrix prone to contamination and ^{14}C content alteration, it is important to notice that one of the criteria for checking the trueness of the extrapolated results is that the extrapolated and the first CO_2 portion ^{14}C date should be relatively close. In the case of kinetic approach for Z-8332 when the *Combine* function is applied (Bronk Ramsey 2022) to the first CO_2 portion and the extrapolated results *Chi*-square test fails at 5% probability (df=1 T=15.7, 5% 3.8) meaning that the two results are statically significantly different (there is 95 % chance of the wrong conclusion if it is reported that the results are the same). However, for the static approach, the *Combine* function reports that the *Chi*-square test for the first two CO_2 portion and extrapolated results are statistically significantly the same (1603 ± 24 BP, f=1 T=1.5, 5% 3.8).

Sample ID / name	Z	A	Time frame collection	pCO_2 / %	$a^{14}C$ / pMC ^{14}C date / BP Calibrated dates	$\delta^{13}C$ / ‰
Z-7817 Baptistery	7938	2571	0-3s	0-17	**83.8 ± 0.2** **1420 ± 39** Cal AD 605-652 (68.3%)	-28.7
	7939	2572	3-10 s	17-39	81.8 ± 0.2	-15.8
	Extrapolated				**84.6 ± 0.4** **1343 ± 39** Cal AD 650-684 (44.4 %) Cal AD 744-772 (23.8 %)	-
Z-7818 / Nartex	7828	2529	0-3s	0-7	**83.7 ± 0.2** **1429 ± 38** Cal AD 602-650 (68.3%)	-19.7
	7829	2530	3-10 s	7-28	80.5 ± 0.2	-7.6
	Extrapolated				**84.6 ± 0.4** **1348 ± 39 BP** Cal AD 647-684 (47.7 %) Cal AD 744-772 (20.6 %)	-
	8332	2990	whole fraction	0-100	72.6 ± 0.2	-11.7
Z-8332 / Church nave	8493	3190	0-4 s	0-14	**81.8 ± 0.2** **1713 ± 30** Cal AD 260-277 (14.2%) Cal AD 338-402 (54.1%)	-20.3
	8494	3191	4-10 s	14-37	79.7 ± 0.2	-10.8
	Extrapolated - kinetic				**82.5 ± 0.4** **1542 ± 39** Cal AD 436-463 (14.6 %) Cal AD 476-499 (14.1 %) Cal AD 531-586 (39.5 %)	-
	8365*	3011	1st portion 0.5 ml HCl	0-13	**80.80 ± 0.23** **1624 ± 29** Cal AD 412-439 (25.7%) Cal AD 460-478 (13.6%) Cal AD 496-34 (28.9%)	-12.76
	8367*	3012	+2nd portion 0.5 ml HCl	13-49	75.09 ± 0.22	-11.94
	Extrapolated* - static				**82.3 ± 0.4** **1545 ± 39** Cal AD 436-64 (15.8%) Cal AD 475-500 (14.9%) Cal AD 530-80 (34.9%)	

Table 1. $a^{14}C$ and $\delta^{13}C$ results for CO2 portions of mortar particle fraction size 32-63 μm. Laboratory sample ID number, Z, A – Zagreb laboratory radiocarbon analysis ID number and graphite number, pCO2 – relative amount of hydrolysed CO2 gas, $\delta^{13}C$ is with standard deviation of 0.1 ‰, ^{14}C date and calibrated dates for 68.3 % probability (1σ) are presented only for the extrapolated results (bold). The results are given for the kinetic approach of CO2 portion collection, except for samples marked with *, which are given for the static approach of CO_2 collection.

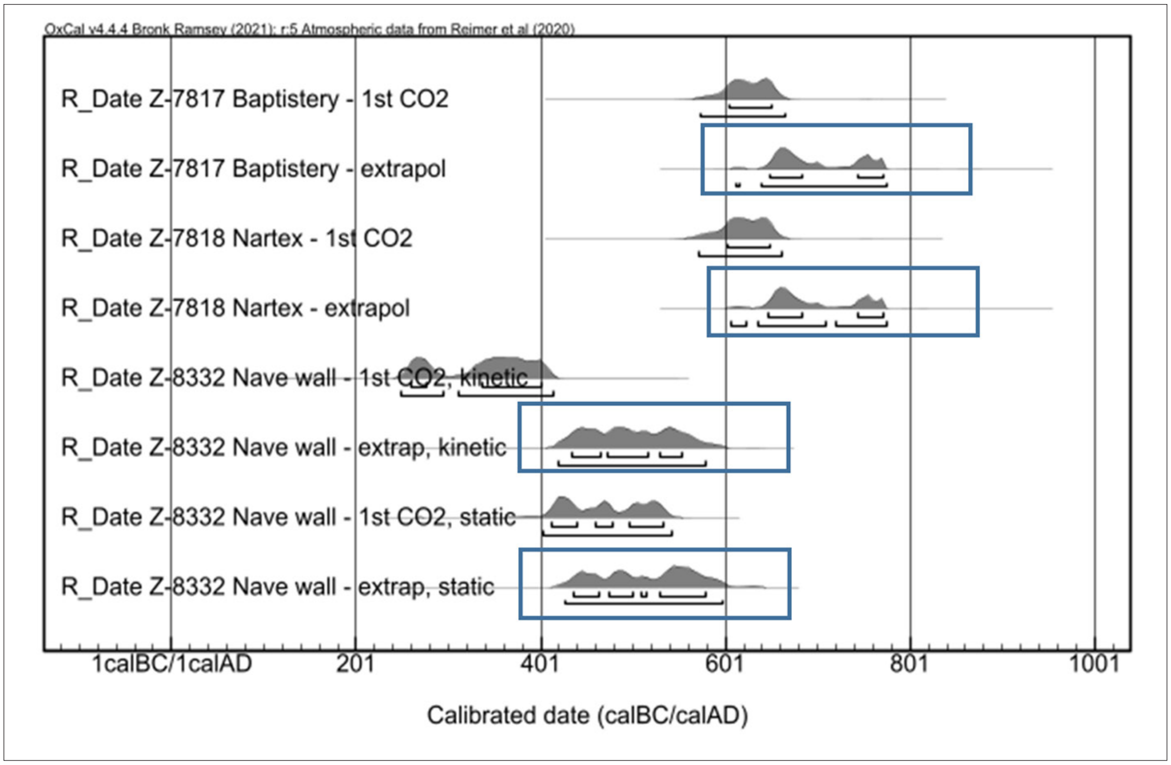


Figure 5. Calibrated results of the first CO2 portions and extrapolated results (in blue squares) for mortar samples from the triconch church complex in Bilice. The first calibrated date spans are marked for 68.3 % probability (1σ), and the second for 95.4% probability (2σ) of 14C radiocarbon dates (Drawing by A. Sironić).

Calibrated combine results for the first CO_2 portion and extrapolated result for static approach for the Nave wall are cal AD 424-440 (14.1%), cal AD 454- 478 AD (20.6%) and cal AD 496-534 (33.6%).

Similarly, when combined the first CO_2 portion and extrapolated result for Z-7817 Baptistery (1400 ± 24 BP, df=1 T=1.9, 5% 3.8), and for Z-7818 Nartex (1393 ± 24 BP, df=1 T=2.8, 5% 3.8), the results are statistically significantly the same at 95 % probability. This means that both the extrapolated and the first CO_2 portion ^{14}C dates can be used in interpretation. When calibrated, the combined results of the calendar ages for Z-7817 Baptistery are cal AD 610-617 (8.5 %) and cal AD 640 – 661 (59.8 %) and for Z-7818 Nartex is cal AD 610-618 (15.4 %) and cal AD 640-658 (52,9 %).

For both extrapolated and the first CO_2 portion ^{14}C results samples from Baptistery (Z-7817) and from Nartex (Z-7818) show the same calibrated dates placing them in the beginning to middle 7th century, while from the nave (Z-8332) shows about 200 years older dates (5th and the beginning of 6th century) which points to the fact that the church complex was built in at least two periods. When observing the morphology of mortar (Fig. 4a, b, c), it is also obvious that the sample Z-8332 differs from the other two.

Another thing that should be pointed out is that it is preferable to take petrographic and X-ray analysis of the mortars to check for recrystallisation, which can incorporate foreign carbon into the sample and for magnesite content, which can cause delayed hardening, which in this case was not performed. Therefore, this ^{14}C analysis should be taken mostly as a landmark for the true results.

The results of mortar dating, in spite of their limitations, can be compared with the archaeological interpretation of the building phases of the Bilice church complex. That interpretation is mostly based on the relations of the walls, which point to different times of building of the church and annexes.

Among earlier opinions concerning building phases, the most important is the notion of Luka Jelić, who analysed the Bilice complex after the first excavations at the beginning of the 20th century (Jelić 1912: 69-80). Jelić described three building phases, mostly based on the structure of the walls of the church and annexes. He saw differences in the structures of the walls of the Bilice church complex. According to Jelić single-naved triconch church was the first object of the complex, and it was built in the 6th century. The second building phase embraces two eastern annexes, northeastern and south-

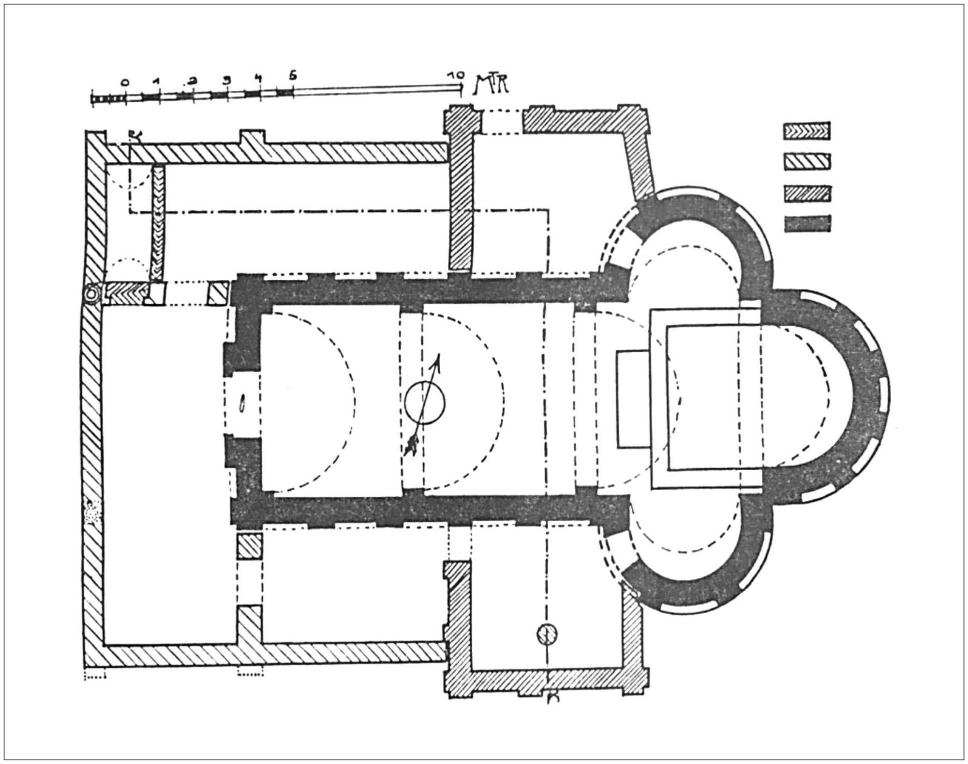


Figure 6. Bilice, ground-plan from the Jelić archives (AMS).

eastern quadrangular rooms that were built close to the walls of the lateral apses. In order to connect the annexes, the builders made openings in the apsidal walls. Jelić dated the 2nd phase to the second half of the 6th century. To his 3rd phase belong the narthex and two western annexes (northwest and southwest). The 3rd phase was dated to the early Middle Ages, from the 9th to the 11th century.

Possible differences in the wall structures, which were underlined by L. Jelić, are insignificantly discernible on the preserved wall remains of the complex, and besides, they could be explained by the different functions of the annexes in relation to the church alone. The church might have been visually separated from the auxiliary rooms by the manner of building of its walls, which were built of somewhat larger and more regular pieces of stone on the outside and internal face, with a filling of smaller rubble between the faces. The walls of the annexes have masonry work of roughly shaped rubble in copious layers of mortar. The manner of building certainly doesn't prove temporal succession, or at least it is not sufficient for such conclusions. Much important for differentiation of the building phases could be lesenes on the walls of the church and its annexes, which point to the temporal succession of the parts of the church complex.

Lesenes are still discernible, and they speak of at least two phases in the building of the church and annexes. Shallow lesenes are depicted on the ground-plan from the Jelić archives, and they were partially preserved on the walls unearthed in the revision excavations (Fig. 6). On some parts of the architecture, e.g. on the badly preserved wall of the south conch, lesenes have completely disappeared. Where they were preserved, like on the south church wall, they exhibit the same features in terms of number and position as on the old ground-plan. So, the correspondence between preserved lesenes and the old ground-plan testifies to the reliability of the latter. That is important with regard to the different phases of the Bilice church complex. Additional rooms, annexes around the single-naved church, have embraced the lesenes on the church walls. Shallow lesenes on the exterior of church walls had primarily a decorative function, and their position inside the annexes is not accessible and testifies to the secondary building of the annexes. The lesenes also have some importance regarding the building history of the annexes. Namely, lesenes on the west wall of the southeastern annex are situated inside the southwestern annex, which perhaps speaks of two different building phases. On the other hand, the north side of the church, the northeastern annex is without illogical lesenes, so the situation at the south side might

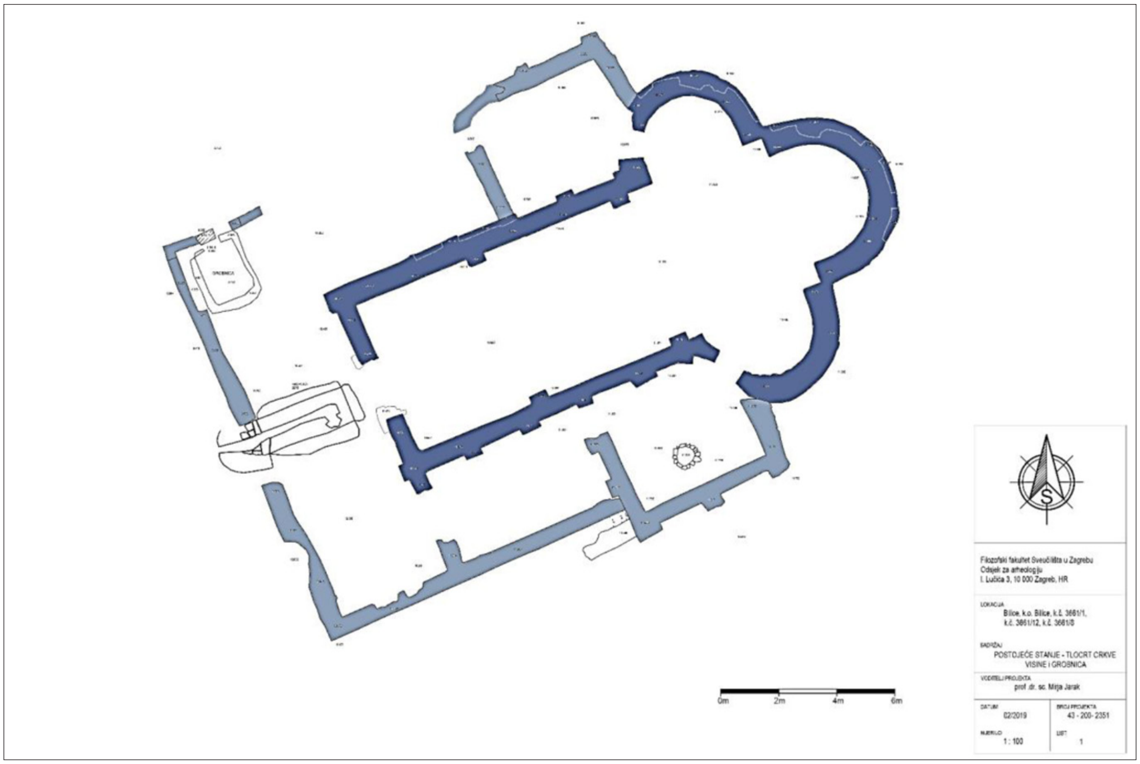


Figure 7. Bilice, new ground-plan with two building phases (Photo by M. Vuković, modification by P. Jeršek after M. Jarak).

be an accidental appearance or a result of the changing of the building plan. It could be concluded that the primary plan included only two eastern annexes. Accordingly, on the west wall of the southeastern annex the lesenes were built. The plan was probably changed during its execution and extended by the narthex and western annexes. All annexes very probably belong to one building phase that could last a longer time. In favour of the late antique building of the narthex speak two vaulted tombs connected with its walls, a typical tomb form for the late Antiquity and well known from many early Christian sites in Dalmatia. Narthex in the Bilice church complex certainly was not built in the early Middle Ages, as suggested by L. Jelić, but in the late antique building phase. Based on the preserved remains as well as the old ground-plan, it seems that the Bilice church complex had two building phases – the 1st belongs single-naved church and the 2nd all annexes. That is in accordance with the mortar dating, which points to different dating of the nave and annexes. Specially important is the same dating of the mortar samples from different annexes (baptistery and narthex), which are clearly younger in relation to the mortar from the single-naved church and support the existence of two building phases of the Bilice early Christian complex (Fig. 7).

Conclusion

Three mortar samples were dated from the early Christian church complex at Bilice near Šibenik using the method of sequential dissolution and extrapolation. The dating reveals at least two different building phases, first during the 5th – 6th century and later in the 7th – 8th century.

The narrower dating of the 1st phase or triconch church alone speaks to its stone furniture. All remains of the stone sculpture have the same stylistic features and have been dated in the literature in the second half of the 6th century (Mišković 2015: 7-20; Jarak 2019: 37-52; Jarak & Maričić 2023: 327-335). Early Christian stone sculpture from Bilice was discovered in the first excavation of the site at the beginning of the 20th century. The most important are the fragments of plutei decorated with a single motif that covers the whole main field of each pluteus. On one pluteus, there is a motif of the shells (squammae), and on the other, the intersected circles. While the shells were very popular during the entire early Christian period, the intersected circles executed by double-branched strips should be dated to the end of Antiquity, to the second half of the 6th or even to the beginning of the 7th century. The flat carving and style belong to the highly developed geometrical phase of the late antique sculpture. Similar sculpture has been known from several localities in Dalmatia and is connected to the Salonitan stonemason workshop from the second half of the 6th century. The best analogies come from Srima and Pridraga, and it is important that the sculpture from Srima has been precisely dated on the basis of the broad context of architecture and sculpture from the locality (Maršić 2005: 73-188; Mišković 2015: 7-20; Josipović 2018).

In the revision of archaeological research in Bilice, a few stone fragments with profiles were found. They have characteristics of church furniture and probably belong to an altar-screen or ambo plutei. Although only small parts of the plutei have been preserved, they can be compared with old findings from the same locality, i.e. with the important plutei with shells and intersected circles which have very prominent upper edges. The newly discovered plutei fragments also have prominent upper edges and could belong to the same time as the earlier discovered church furniture from Bilice. One of the newly found fragments has been petrographically analysed. The stone sample shows similarities with the Seget stone variety, permitting us to assume that the stone used for the Bilice church furniture originates from the Seget quarry. That quarry was very important for the Salonitan stonemason workshops, and the petrographic determination of the analysed sample points to the Salonitan origin of the Bilice church furniture, which has also been established by the stylistic analysis of the sculpture from Bilice and connected localities. On the basis of the stone sculpture, the dating of the single-naved triconch church at Bilice would be from the middle to the end of the 6th century. The dating of the annexes would be during the first half of the 7th century, according to the present interpretation of the historical circumstances during the 7th and 8th centuries.

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Long time, no siege: non-invasive archaeological methods in the research of Cesargrad castle

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The remains of the Cesargrad castle are located on a hill, on the left bank of the Sutla River gorge, overlooking the market town of Klanjec. The most famous historical event connected to it was the siege in 1573, during the Great Peasant Uprising. The archaeological research of the castle was centered around the core of the castle, where the standing structures are still visible above ground. In two excavation campaigns (2008 and 2010), the western tower and the palace were partially researched. During the 2018 campaign, the analysis of the standing structures was conducted through the application of the archaeology of standing structures. The results partially coincide with the known written documents, but also indicate an older date for the construction of the castle. The castle is composed of the inner core and the outer ward. Most of the structures of the presumed outer ward are partially recognizable in the terrain morphology. To trace these remains in 2021, a LiDAR survey was conducted. Lidar data were later processed and classified to obtain a precise and detailed DTM of a wider area around the castle, which was then visualized and interpreted for archaeological remains. The newly found archaeological features can be interpreted as possible military installations or siege positions erected during a strife.

Keywords: *Cesargrad, castle studies, archaeology of architecture, LiDAR survey, siege, conflict archaeology*

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Introduction

The remains of the Cesargrad 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 centre, while a moat served as additional protection of the valley in the east. At the top, the architectural remains span east of the moat and, combined with the two far-west 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 2014a: 313).

Cesargrad Castle was mentioned for the first time in 1399 when King Sigismund of Luxembourg gave a big part of today's north-west Croatia to Hermann II, Count of Cilli (Laszowski 1902: 81; Klaić 1910: 134; Szabo 1912: 209; Adamček 1970: 88). Three royal charters made Counts of Cilli the lords and hereditary Counts of Zagorje. They owned the entire Zagorje region with parts of Lower Styria, Carniola and Carinthia until 1456, when the murder of Hermann's grandson Ulrich II in Belgrade on 9th November 1456 led to the extinction of the family (Janeš 2014a: 314). Disputes over the ownership of Cesargrad Castle, between different Styrian noblemen, lasted for several decades. In 1521, Tamás Bakócz from the Erdödy family, who later became archbishop of Esztergom, was finally registered as the owner of Cesargrad Castle. After the archbishop's death, his entire estate was inherited by his nephew Peter Erdödy, and Cesargrad Castle finally became property of a single family, one of the most powerful at that time.

Archaeological research was undertaken in 2008 and 2010, encompassing the excavation of tower H with its immediate surroundings and the southern wing of the palace complex. These excavations yielded the remains of a putative tile stove base located on the first floor of tower H (Fig. 8: tower 3), together with an architectural structure appended to the tower's northern wall (Madiraca & Čimin 2009: 225-226). Within the southern wing of the palace, remnants of a hypothesized wooden plank floor, dated to the mid-15th century, were documented (Janeš 2011: 259-260; 2014b: 44).

In 2018, a structural survey has been conducted on the standing structures of the castle. The survey comprised the remains of the castle's core and some parts of the outer yard and ramparts, visible above ground (Janeš 2019: 265-267).

A LiDAR survey of the castle's area was performed in December 2021, covering the Cesargrad castle and the surrounding area of the Cesarsko hill.

The aforementioned chronology of operations demonstrates that, owing primarily to limited financial resources, diverse methodological approaches have been utilized in investigating this medieval castle. The aim is to assess the applicability of non-destructive archaeological methods at Cesargrad and to demonstrate the resultant data these methods can yield, as well as their impact on potential reinterpretations of the site. The application of the archaeology of architecture has enabled the determination of constructional phases in the fortification's development, thereby providing a more comprehensive developmental sequence. Through the analysis of LiDAR data of the outer courtyard and proximate environs of the fortification, coupled with GIS analysis, efforts were made to identify possible structural features within the courtyard and surrounding area that remain undocumented in previous research.

Methods

Three methods were utilized in the application of non-destructive techniques to the remains of the Cesargrad castle.

Method 1. 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. 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 (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 writen ones; legal acts and graphic historical sources, as well as the results of archaeological excavations and archaeometry analyses with the goal of ascertaining the absolute chronology (Brogiolo & Cagnana 2017: 25).

Method 2. A close-range LiDAR survey of the castle's area was conducted in December of 2021 by company Ruina

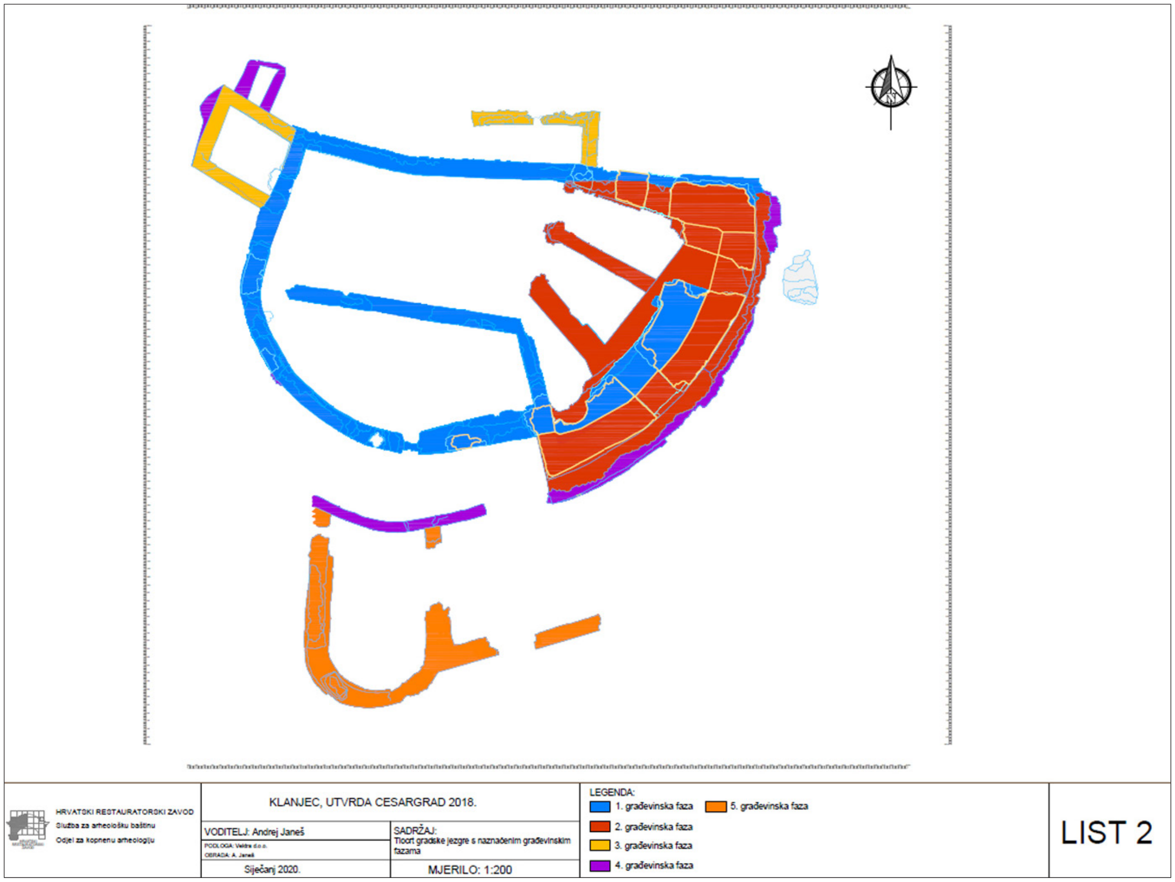

Figure 1. Cesargrad ground plan with construction phases (plan by: Vektra Ltd, edited by: A. Janeš).

Ltd., covering the Cesargrad castle and the surrounding area of the Cesarsko hill. The survey was carried out using an UAV system with LiDAR sensor which was flown at 70 m altitude in a double acquisition grid pattern for a more denser and accurate point cloud. The flights were operated during December to obtain more ground points, because during this period, there was less undergrowth and foliage in the trees. The survey area included 35 hectares of forested landscape covered mostly by lower shrub and oak trees that were bare during this period. The resulting data acquired included both high resolution ortho-photomosaic and a digital elevation model. Classification was done to include ground data as well as standing features, which were of archaeological interest and subsequently created a DFM. After processing, classification and filtering, a high-resolution DFM (0.1 m) was generated. The point cloud was then exported as a raster which was visualized and interpreted for archaeological remains. Visualization of the data was done by using the Relief visualization toolbox – RVT (Kokalj & Hesse 2017), while all the interpretation, mapping and spatial analysis was completed in GIS software.

Method 3. By using the GIS-based viewshed analysis in theory, it would be possible to confirm or eliminate the potential siege positions. After determining the input information needed, the first step was to create a binary viewshed visibility map for each of the Cesargrad towers (Čučković 2016). All information about each position and range of weapon had to be considered, so the analysis could show siege potential of suspected locations but also uncover any possible positions obscured from the Cesargrad towers that might have been used during the siege. Additionally, after discovering the siege positions, a visibility map for the besieging side was created to show the attacking possibilities of these locations.

Results and Discussion

3.1. Analysis of the standing structures

Five phases can be identified in the construction and architectural development of the castle. All of them are visible in the castle's centre (Fig. 1). The first construction phase is identified by the remains of a smaller castle around the rectangular court with a palace on the south-

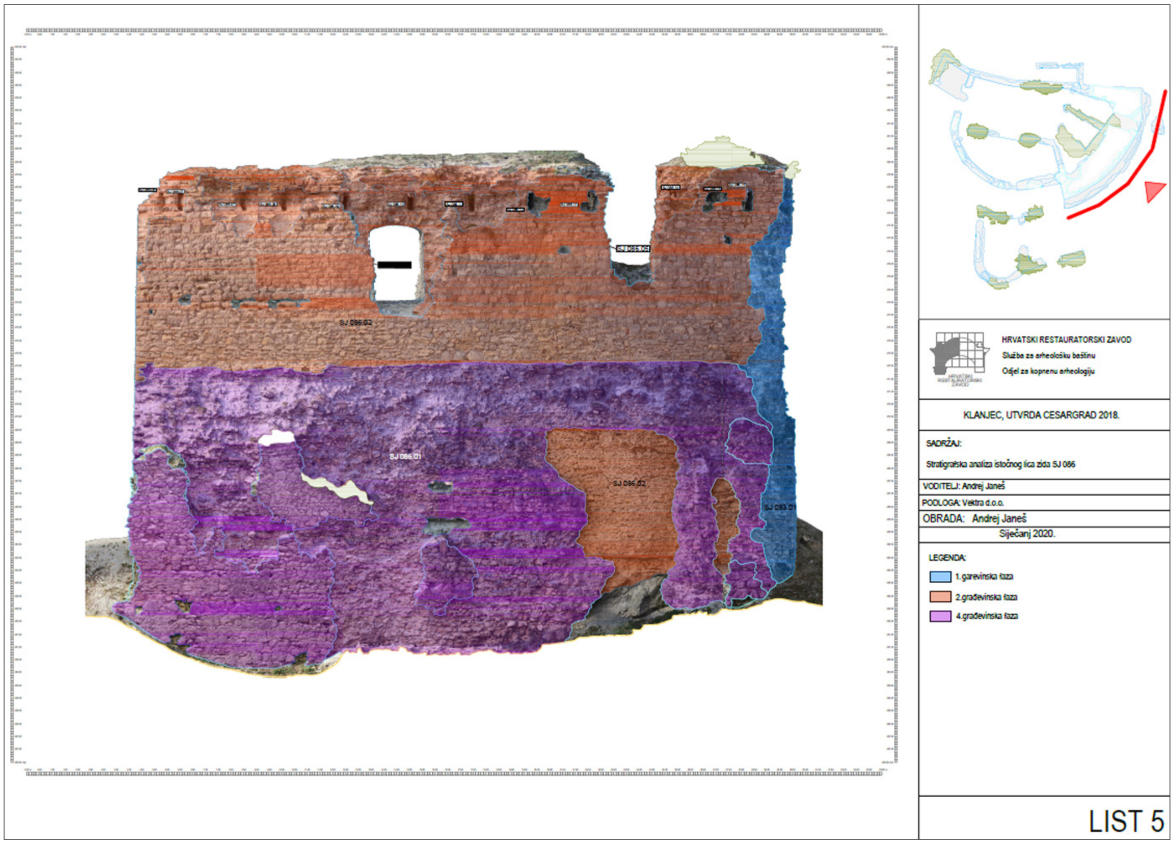

Figure 2. Stratigraphic sequencing of the eastern wall (Schildmauer) of Cesargrad's core (plan by: Vektra Ltd., edited by: A. Janeš).

ern side. It was constructed during the 14th or maybe even the late 13th century.

The core of the castle was constructed using irregular rows of rubble stone, with the gaps filled in with smaller and finer stone fragments. The choice of location also suggests that the original construction of the fortress core predates the first written mention of it in the late 14th century. Examples of castles built on the lower of two hilltops can be found at the Tuščak Castle in the Žumberak Mountains, constructed during the 12th century (Lapajne & Mahović 2007: 77), and Stupčanica on the slopes of Papuk, whose construction is dated to the 13th or the very beginning of the 14th century (Horvat 2007: 38). In later phases, both castles were expanded onto the adjacent, higher hilltop. A ground plan similar to that of the Cesargrad core is found at Borl Castle in Slovenia, which was first mentioned in 1255 (Stopar 1977: 100-102).

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. The construction of such structures is characteristic of German regions in the 13th and 14th centuries (Antonow 1977). The inner side of the wall has two rooms. Above them, on the upper floor, were two other rooms. Above the northern room was the castle chapel, of which a polygonal-ended sanctuary has been preserved. The chapel was vaulted with a ribbed cross vault and was lit by windows on the northern side. Interventions in that part can be dated to the 15th century (Horvat 1999: 183, 194). The only preserved stylistic element in the chapel is a section of a rib with a single groove. Openings for massive beams are still visible at the top today, believed to have been part of a large wooden structure of a defensive gallery (Horvat 2006: 152) (Fig. 2).

During the third construction phase, the entrance in the northern wall was relocated eastward and reinforced with a tower. A square tower was added to the northwestern 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

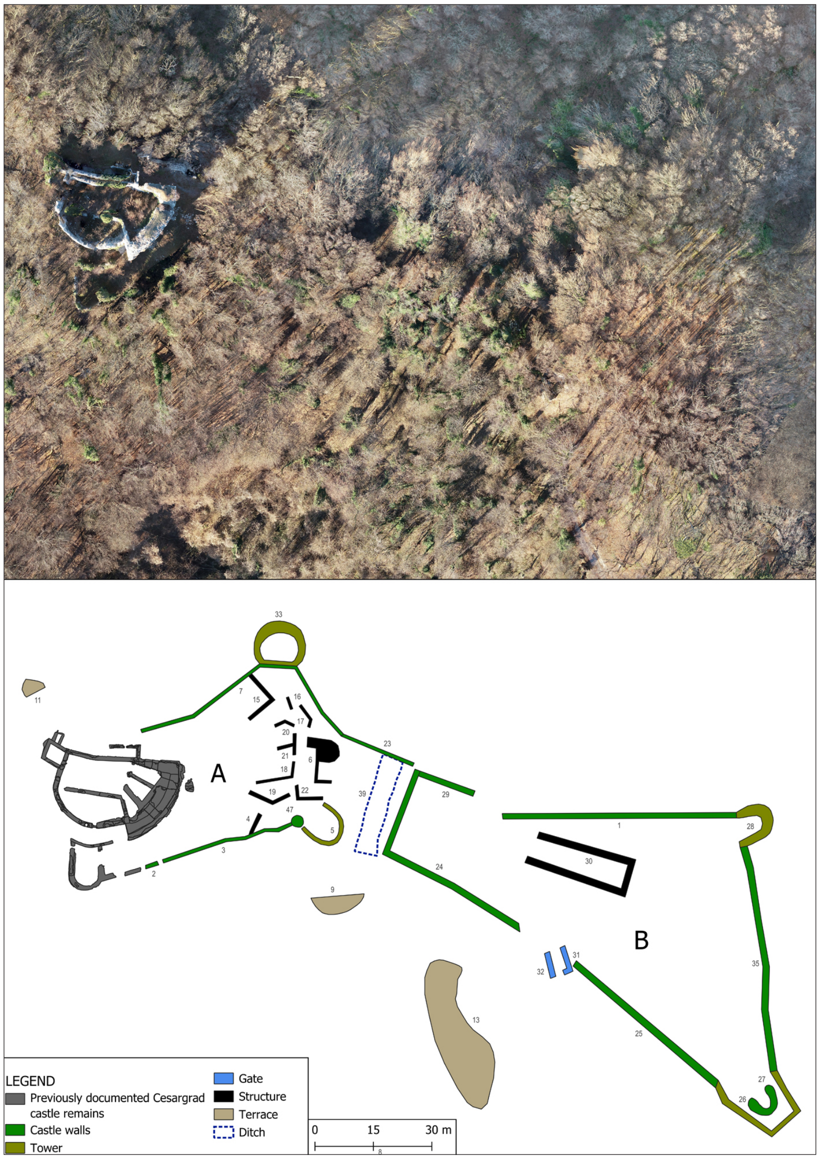

Figure 3. Areal photo and ground plan of Cesargrad castle (photo and map by: T. Zojčeski).

centre was added in the fifth phase. During archaeological excavations in 2008, a rectangular masonry structure perpendicular to the north-west tower was discovered to the north of it (Madiraca & Čimin 2009: 226). So far, it has been established that the outer wall from the third construction phase abuts this structure, which makes it older than the early 16th century, when that wall was built. Finds from the layers covering this structure date its likely demolition to the mid-16th century.

In the fifth phase on the southern side of the castle, a large artillery tower has been constructed, and a wall that encompassed the area to the east of the castle core. This area was additionally defended by a ditch. The artillery tower, equipped for housing cannons, has parallels in several medieval fortifications in the Zagorje region, all of which were built during the first half of the 16th century.

These phases are dated after 1521, when the castle was owned by the Erdődy Family (Janeš 2020: 87-88).

In the area between the defensive ditch and the castle, the remains of a round tower are still preserved above ground. The tower is positioned on the southern edge of the ditch. On the northern side of this area, the remains of a rectangular building are still visible above ground.

Additional structures could be recognized in the morphology of the terrain in the area between the castle core and the ditch, but also in the area east of the defensive ditch.

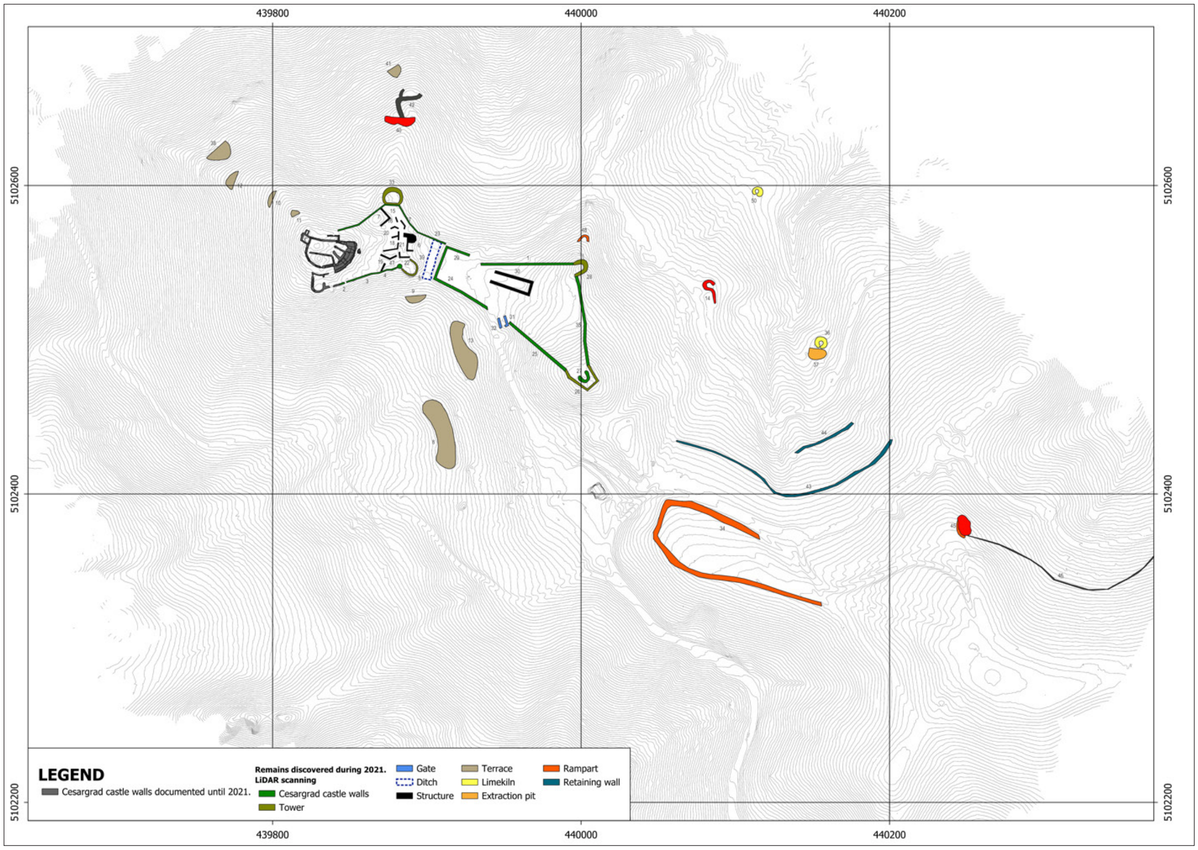

Figure 4. Ground plan of Cesargrad castle with main features (plan by: T. Zojčeski).

3.2. LiDAR survey of the castle

The data obtained by the ALS survey provided new information about the Cesargrad castle itself and its surroundings, but also helped discover some new locations around the castle, which were previously completely unknown.

Besides the aforementioned part of the castle core (A), which was extensively documented prior to this campaign, other parts of the castle brought to light were completely unknown before or only speculated about, and never documented (Fig. 3).

East of the *Schildmauer* wall, a new section of the castle was discovered. Traces of collapsed walls are preserved today as lower banks and are visible in the morphology of the terrain. ALS data show remains of different structures (4, 6, 15 - 22) enclosed by a curtain wall on northern and southern sides (2, 3, 7) connecting two additional semicircular towers (5, 33) with the castle core. In the outlines of collapsed walls, multiple rooms or objects can be distinguished and one of them, semicircular in shape (6), is positioned next to and looking at the defensive ditch (39) (Fig. 4).

All of the structures are positioned on the edge of the ditch with no other protective wall guarding the entrance to the castle area A from the ditch. It can be suggested that the semicircular building (6) with nearby structure (22) were actually a part of the defensive wall towards the ditch and connected to semicircular tower 1 (5). On the northern part of the ditch, the situation is even less straightforward, with a curtain wall (23) which is connected to the northern semicircular tower 2 (33), closing the northern edge of the ditch by joining the enclosing walls of the castle area B.

To the east of the ditch, the remains of another larger castle area B was identified. The remains of curtain walls (29, 24, 1, 35, 25) can be traced on the whole area of this younger part of the Cesargrad castle. Its irregular polygonal shape is widening to the east and ending with two towers looking to the east and southeast (28, 26). The northern semicircular tower (tower 5) is looking towards the east, while the southern one (tower 6) has outer walls of polygonal shape looking to the southeast. Inside the walls of this tower a rounded earthwork can be identified.

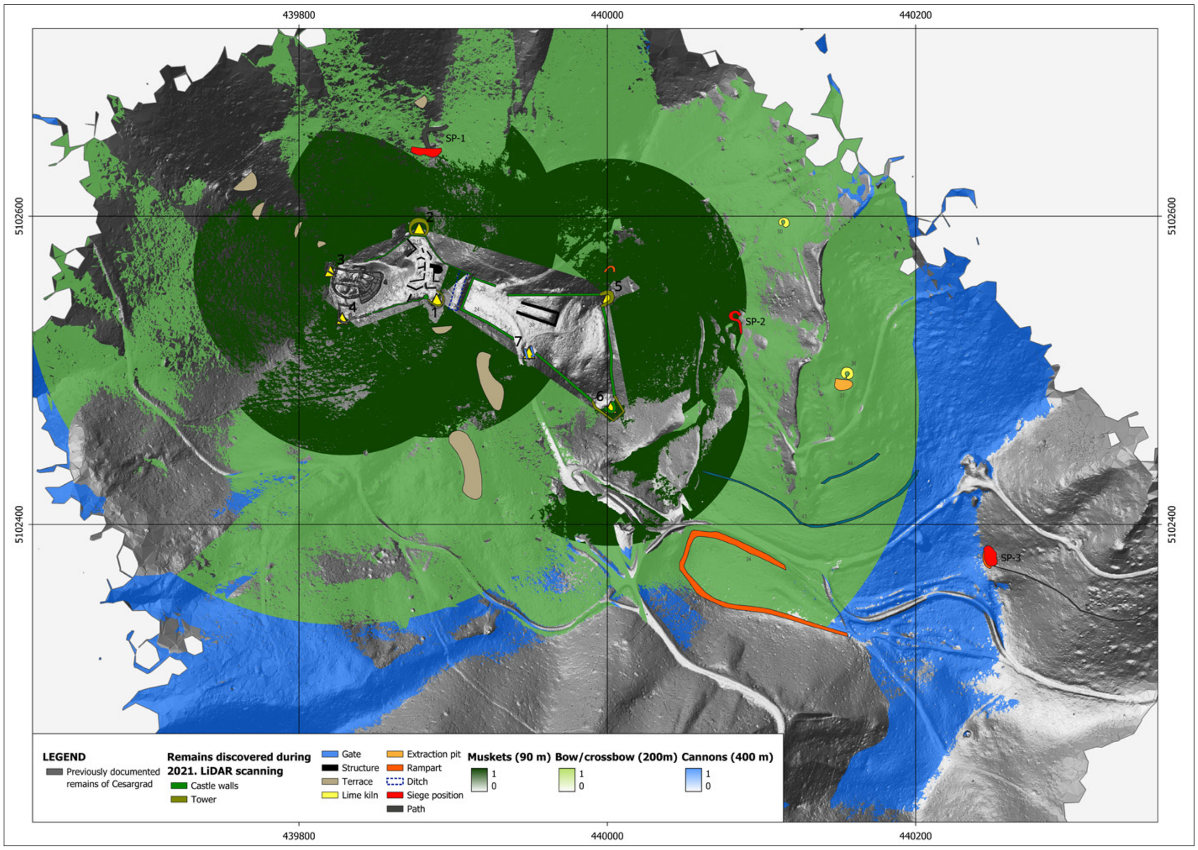

Figure 5. Range coverage of cannons, muskets and bows/crossbows from Ceasargrad's towers (map by: T. Zojčeski).

In the middle part of the southern wall (24, 25), remains of the squared gate tower (31, 32) can be recognized, positioned unaligned to the wall and orientated to the south. The only feature visible inside the perimeter of castle B is an elongated, dug-out feature in the middle part, with banks on all three sides. The feature is 26 meters long and 8 meters wide.

Different features were recognized around the castle as well. Remains of limekilns (36, 50) with extraction pits can be seen to the east of the castle, probably belonging to the same period since no other building remains were found in the vicinity. Mortar was required for building and maintenance of buildings in the castle and other needs during everyday life. (Zlatunić 2010: 303.) Larger enclosure (34) with earthen rampart can be identified on a nearby hill with ramparts positioned on northern, southern and western sides and an entrance area to the east.

As can be seen by analysing ALS data of Cesargrad castle and neighbouring hills, a new layout map of the castle was created, and different positions around the castle were discovered and mapped. That included remains that can be interpreted as defensive positions directed towards the castle itself. Thus, the new information collected during the lidar survey campaign of 2021. provided us with a chance to try and reconstruct the famous siege of Cesargrad castle on the night between 27th and 28th January 1573. When the Croatian Great Peasant Revolt started. (Janeš 2014b: 36.) The primary locations that had remains of said characteristics were enclosure (34) and different trench-like features (40/42, 14, 45/46). Before any conclusion could be made, the viewshed visibility map needed to be created. Different parameters were taken into account based on the data about the Cesargrad castle original design and information about the warfare in the 16th century, primarily focused on sieges. (i) The height of the towers, which could theoretically hold artillery, needed to be recreated and were approximated at seven meters from today's ground level. (ii) The azimuth angle for each tower was calculated, so the viewshed analysis covered the maximum possible area that artillery could cover from every tower. (iii) Range of projectile weapons used during 16th-century warfare and possibly appearing during the 1573 siege needed to be taken into account. Even though the range of all projectile weapons used during the 16th century varied greatly, which is especially true

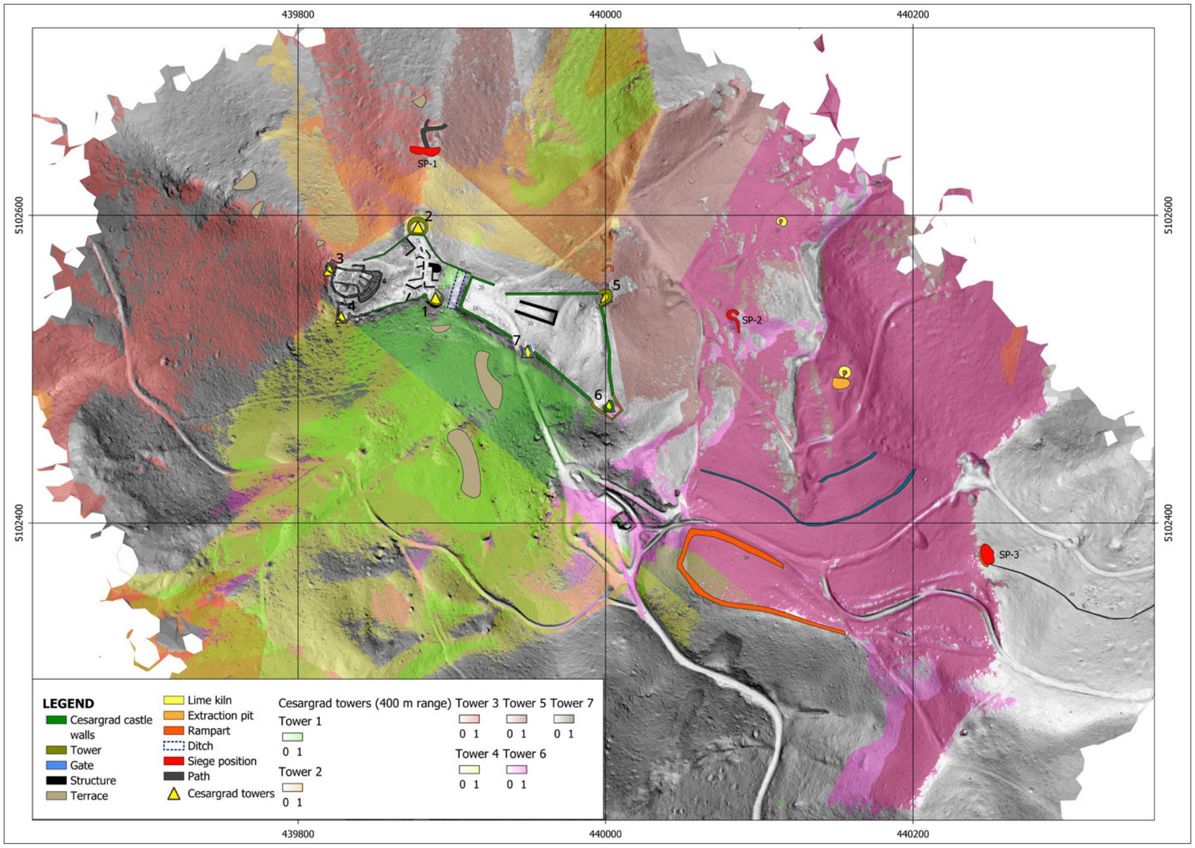

Figure 6. Areas covered from each of the towers of Cesargrad (map by: T. Zojčeski).

with cannons and muskets, the effective range of cannons used for the viewshed analysis was defined at 400 meters, 90 meters for muskets and 200 m in the case of bows and crossbows. (Strzyż 2012: 7; Loades 2018: 74) (Fig. 5). It is known from written sources that the rebels' goal was to take the castle "so, that they could get the cannons and ammunition, so, they could take other castles" (Čičko 2018: 31). It is a direct proof that the castle's defenses were equipped with cannons.

Further, there are other limitations of the described method that need to be considered before any conclusion is made, such as the state of vegetation around the castle, which is missing from historic data, and would influence the visibility, but also the exact information about the number and caliber of cannons Cesargrad castle held during or before the siege.

3.3. Viewshed Analysis Results

The results show that siege positions SP-1 and SP-2, although not ideal for the besieging side, could have been used in the siege, but also uncover the location of SP-3. First location (SP-1) is situated at the northern slopes of the hill and was probably used during the final phase of the Cesargrad siege. That is expected because although protected from the view of Cesargrad towers, it only offers good visibility of castle core entrance and the easternmost part of area B (Fig. 6).

Next siege position (SP-2) located to the east of the castle area B is somewhat protected from direct view from the towers and offers a direct attack trajectory at towers 5 and 6. This position has protective elements, such as a rounded position surrounded by an earthwork or rampart, which then continues in a straight line for 8.5 meters and could've offered some protection during the siege. Last siege position (SP-3) is located further to the east of the castle areas and is composed of a rounded depression in the ground with an earthwork facing toward the castle. The location of the rampart (34) was entirely exposed to the attacks from the castle, and even though ramparts did potentially offer some protection, it most likely predates and wasn't used during the 1573 siege (Fig. 7).

The siege positions discovered need to be archaeologically surveyed in the future, but at this point, they show the general direction in which the Cesargrad castle attack happened. Most likely, the attacking forces came from the east and began the siege from SP-3 and SP-2 by

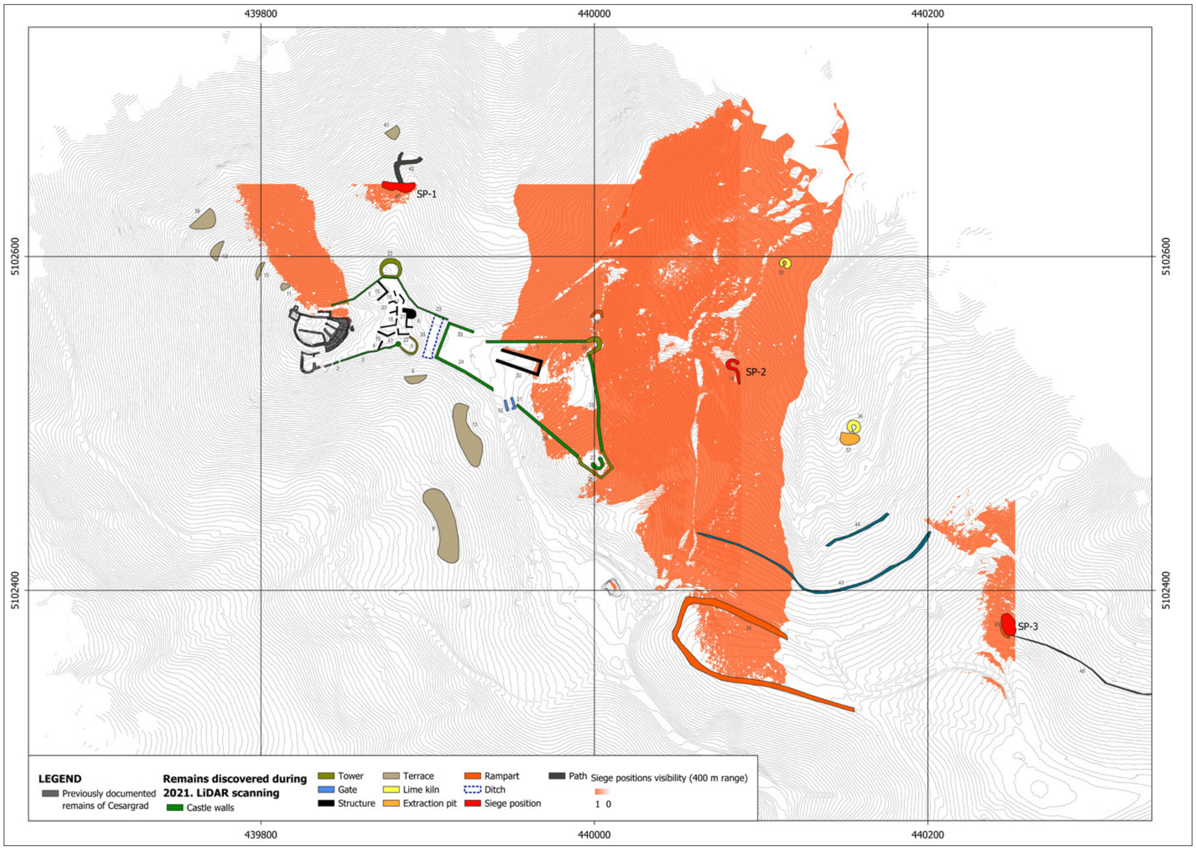

Figure 7. Viewshed from siege positions around Cesargrad castle (map by: T. Zojčeski).

attacking and disabling the towers of castle area B. After that, only SP-1 was used as a support while storming the castle entrance on the northern side. Two positions (SP-2 and SP-3) hold remains of defensive earthwork orientated towards the castle, so some preparation of positions before the siege did happen, as was recorded in other examples where siege remains were discovered. (Mazáčková et al. 2023: 68.) By analyzing the visibility capabilities of different locations in and around the Cesargrad castle, what can be noticed is the strategic advantage of tower 6 (Fig. 8).

The position of this tower is actually the only spot higher in elevation than the Cesargrad castle core and from where a siege attack could seriously threaten the castle. By examining the layout of the complete castle areas, it is immediately noticeable that the elongated shape of castle area B with wider eastern part. It is most likely that the complete Cesargrad area B was constructed in the first place to occupy the tower 6 position and disable the besiegers from using it. Furthermore, it's also a possibility that an older siege of the castle happened before 1573, in which this location played a pivotal role, so by expanding the castle builders removed the most dangerous position. As was mentioned earlier, the rampart on a nearby hill was almost completely exposed and vulnerable to attacks from Cesargrad towers, especially tower 6, so it's arguable that this rampart was constructed and used during an earlier siege before the expansion of the castle. It is also unlikely that the attacking side in the 1573 siege had time to prepare positions with elaborate defensive capabilities before the attack started.

Conslusion

With the use of non-invasive archaeological methods for the archaeology of standing structures and LiDAR-acquired data, it was possible to get new insights into the historical development of a medieval castle. Applying the archaeology of standing structures, combined with written data, it was possible to reconstruct the construction history of Cesargrad castle, spanning from the 13th to the 16th centuries. This way, plans for future systematic archaeological excavations and conservation works can be made.

New data was acquired with the LiDAR scan of the castle and its surroundings, which brought to light possible new structures on the outer courts of the castle. Also,

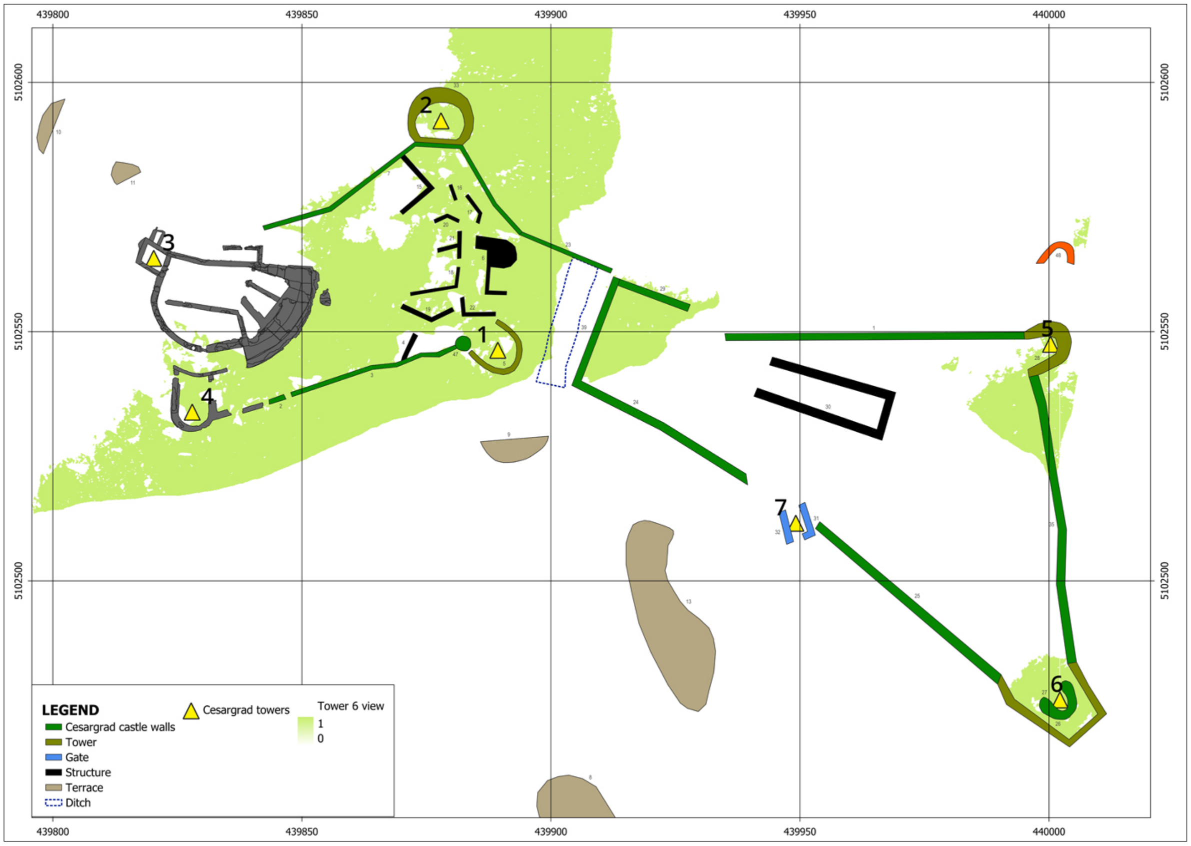

Figure 8. Areas of the castle visible from tower 6 (map by: T. Zojčeski).

new features visible in the terrain morphology have been documented in the immediate surroundings of the castle. New features have been documented in the area close to the castle's core, confirming the existence of auxiliary structures or buildings in the castle. Similar features have been detected in the outer court. The most innovative result of the LiDAR data analysis is the identification of potential siege positions around Cesargrad. These positions have been used by possible besieging troops to attack the castle and control the area around it. By the 15th century fire arms, cannons and muskets were an essential part of any army's equipment. Cesargrad castle was attacked at he beginning of the Great Peasant Revolt of 1573 and taken by the rebels. So, some of these positions can be connected to this single historical event. From written sources, it is known that the assailants were equipped at least with muskets. One of the rebel commanders requested 60 muskets from the rebelled peasants of the Cesargrad estate (Despot & Tatić 2013: 185). As seen by the analysis some of the positions were covered by the defenders from the towers so they could indicate to some older conflicts concerning the castle. They could be connected to the conflicts that followed in the region after the death of Ulrik of Cilli in 1453, when a number of Styrian nobles fought for his estates (Čičko 2018: 22-24).

The acquired data shows similarities with research results in Czechia on sites of documented sieges occurred during the 15th century like the siege camps in Hradečnice and Kostelec nad Sázavou (Koscelnik 2013: 191-193). Documented features around the castle could fall in the category that primarily includes linear structures such as fortifications of camps, approach trenches and earthworks (Koscelnik 2013: 197). The assembled data has to be verified with filed surveys and excavations but they put Cesargrad on the map of archaeology of conflicts.

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