# RELIEF FEATURES OF LOWLAND AREAS AS INDICATORS OF ARCHAEOLOGICAL POTENTIAL

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*Filomena SIROVICA, Andreja KUDELIĆ & Dinko TRESIĆ PAVIČIĆ*

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*This paper presents the use of the data obtained by terrestrial topographic survey in analysis and assessment of archaeological potential of lowland areas. The analysis is based on investigation of relief features of the site Kurilovec-Belinščica, which is located in the lowland area of Turopolje region. By comparison with the data acquired from terrestrial topographic survey carried out prior to archaeological excavations in the south part of the city of Osijek, it is presented how the obtained results can contribute to analysis and interpretation of the results of archaeological excavations. Based on the conclusions of the study, new guidelines are suggested for documenting archaeological sites which can expand the methodological approach of acquiring data before conducting archaeological excavations.*

*Key words: terrestrial topographic survey, digital elevation model (DEM), lowland, archaeological potential, cultural resource management.*

## INTRODUCTION

The development of technology, accompanied by reduced costs, but also by a considerable growth in the quantity of acquired data, has to a great extent enabled comprehensive procedures of documenting archaeological remains in the landscape. The usual purpose of such procedures is to understand the spatial distribution of archaeological remains and document their relation to the landscape, which primarily contributes to the development of methods of assessment of regional archaeological potential and thus to a more efficient cultural resource management (Werbrouck *et al.* 2011: 8173–8174). Namely, the understanding of distribution of archaeological remains is a basic requirement for decision making in the segment of cultural resource management, and this segment has been significantly expanded in recent years by considerations of heritage in a wider context of cultural landscapes. In both contexts, the most significant problems include mitigation strategies in cases when archaeological remains are threatened.

The common methods of systematic documenting of distribution of archaeological remains are field survey and aerial photography, which are usually complemented with cartographic studies and data acquired from other kinds of more or less destructive archaeological investigation (Doneus *et al.* 2007: 275; Chapman 2009: 11, 27, 89). However, the archaeological remains, whatever their form may be, become truly meaningful only in a compelx relation to each other, the local relief and regional landscape, which together represent a comprehensive spatio-temporal context (Mlekuž *et al.* 2006: 254; Chapman 2009: 98). Nevertheless, by accepting the idea about the connection between settlement strategies and variations in landscape (Stafford & Hajic 1992: 137), as well as its inevitable cultural-symbolic meaning (Chapman 2009: 40), documenting the three-dimensional element of landscape becomes crucially important in all analyses of archaeological remains (Chapman 2009: 99). But the level of landform diversity still significantly affects the inclusion of these ideas in standard archaeological analyses and interpretations, and the areas with uniform geomorphic features, that is, with simple relief marked by mild changes in the landscape, are still usually quite neglected in this context. So the objective of this paper is to examine the archaeological potential of lowland areas as indicated by the relief, to demonstrate a simple method of acquiring data about relief features of smaller areas, to present the potential contribution of such approach to interpretation and presentation and to point out to a significant impact it can have on cultural resource management.

For this reason, the results of the analysis of relief features carried out on three archaeological sites in two lowland regions will be presented in the following text. The analyses, which are based on digital elevation models (DEM)[1] as three-dimensional visualisation of the site's location, serve to assist and complement other methods of archaeological potential evaluation of a particular area. Finally, it should be emphasised that the objective of the approach presented here is not to analyse and interpret individual archaeological sites, but to reach conclusions about the potential of data acquired and derived from this type of investigation.

## KURILOVEC-BELINŠČICA

The archaeological site Kurilovec-Belinščica is located in the lowland area of Turopolje region, south of Velika Gorica (Fig. 1). Although today the area of the Turopolje lowlands is favourable for settlement and agrarian production, in the past, before modern construction of the flood control system, it was characterised by variable conditions caused by constant changes in water levels. Nevertheless, the smaller elevations, which sometimes rise only 20 cm above

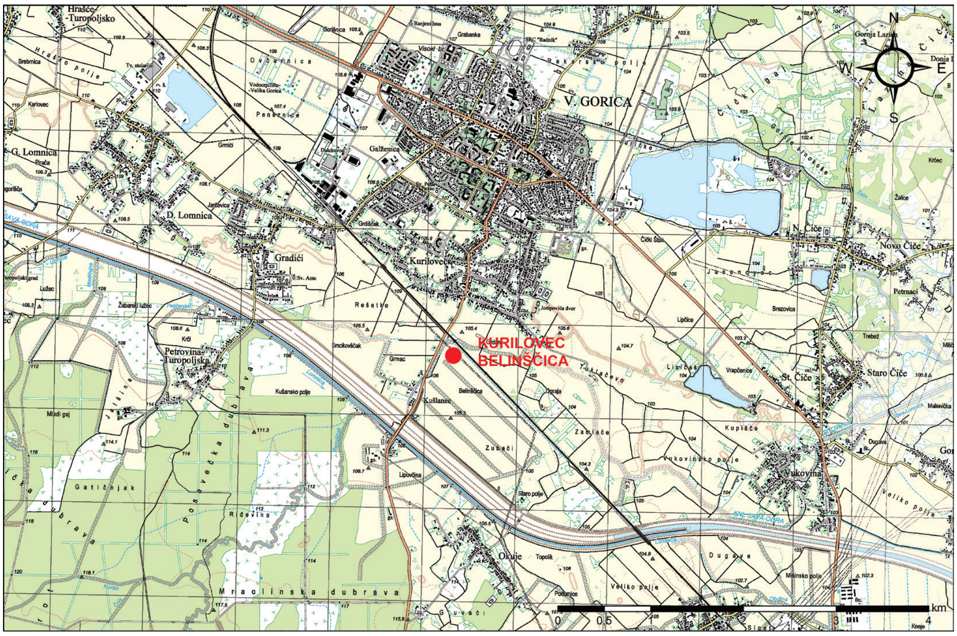


*Figure 1: Location of the site (source: Topographic map 1 : 25,000 (TK),* ***Državna geodetska uprava*** */ State Geodetic Administration (DGU); modified by: D. Tresić Pavičić ).*

[1] The term is used in this paper to refer to models of digital surface with all variations of relief through space.

the surrounding area, were used for settlement in Turopolje lowlands since prehistory. On one such position, situated by the Ramiščak stream, the remains of Bronze Age settlement were discovered.

Based on the results of an intensive systematic field survey of the first section of the Zagreb – Sisak motorway, archaeological excavation covering the surface of 2,540 m² was carried out at this location during 2006.[2] Although only a small amount of movable archaeological material was gathered during the field survey (Burmaz 2005) and the results of the survey did not indicate an area characterised by intensive human activities, the results of the archaeological excavation changed that assumption. The excavation revealed the remains of a larger Bronze Age settlement as well as a small number of deposits containing fragments of ceramic vessels with La Tène and Roman period features (Fig. 2; Burmaz & Bugar 2006). The Bronze Age material, which represented over 80% of established movable and immovable archaeological remains, was more precisely dated to the end of the Middle and the earliest phase of the Late Bronze Age (Kudelić 2015; 2016).

The remains of the Bronze Age settlement were preserved in the form of a large number of small circular cut features and sporadically some larger pits of various shapes. Smaller, circular cuts probably represent holes for wooden posts which supported the above-ground structures, while the majority of movable material was found in various pits. The spatial distribution of archaeological features established by the excavation indicates intensive continuous settlement of the investigated area and, aside from the large quantity of gathered finds and density of postholes, this is also supported by cross-cutting of some of the Bronze Age features. Based on the insights presented here, we can say that the Bronze Age settlement consisted of above-ground structures which occupied most part of the investigated area in the main phase of site occupation. However, the analysis of the established situation indicates the possibility of isolating one separate, later phase of settlement which can be dated exclusively to the Late Bronze Age (Kudelić 2016: 39–40). It was also established that the settlement occupied larger area than that which was investigated, and that parts of the settlement were probably destroyed during the construction of the local road Kurilovec – Pokupsko to the northwest and the construction of the Zagreb – Sisak railroad to the east of the site. According to the data from the excavation report (Burmaz & Bugar 2006), the site spreads towards the west and northwest, and to a considerably lesser extent towards the north. It was also noticed that cut features are scarcer in the south and east part of the investigated segment of

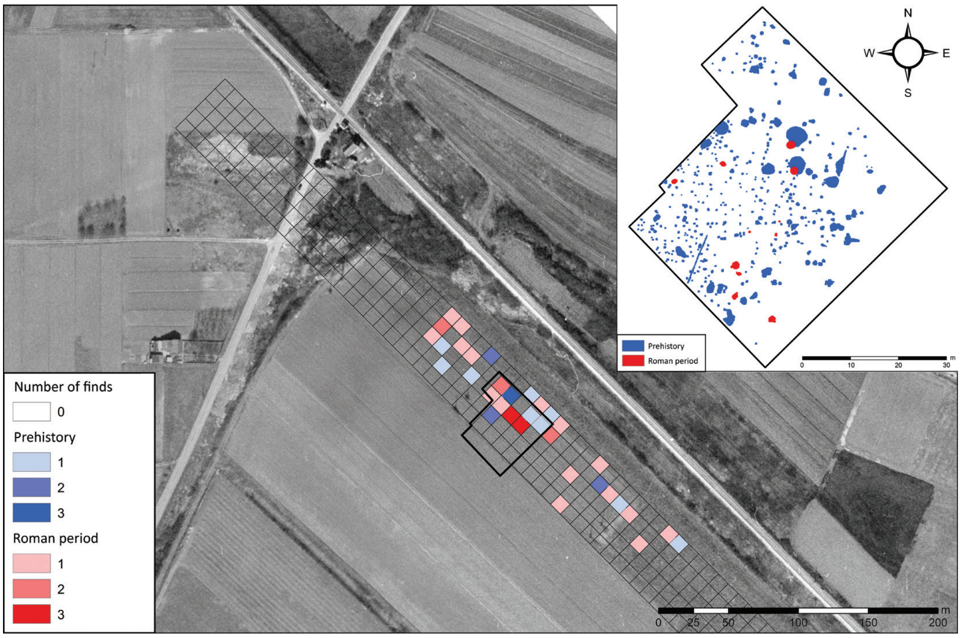


*Figure 2: Results of the systematic field survey and archaeological excavation (author: D. Tresić Pavičić; source: Kaducej d. o. o. Archive).*

[2] The field survey was carried out during December 2004 and January 2005, and the site was registered by the name of Velika Gorica-jug [Velika Gorica-south]. As well as the subsequent archaeological excavation, it was carried out by the archaeological company Kaducej d. o. o. and directed by Josip Burmaz.

the site so it was assumed that the periphery of the settlement is to be expected in this area.

## Method of data acquisition and processing

The analysis of the results of the field survey and their comparison with the results of the archaeological excavation indicated that the applied non-invasive method of investigation independently does not represent a suitable form of obtaining data on the more general characteristics of the site. It thus became necessary to consider other methods which would complement the data acquired from previous archaeological investigations. By studying the characteristics of the wider landscape, as well as the immediate surroundings of the site, and considering the current land-use,[3] the conclusion was reached that the data sets which would enable a quality analysis of the wider surroundings of the investigated area could be obtained by combining different kinds of non-invasive investigation methods. In accordance with this, the main focus was towards obtaining three-dimensional spatial data needed for visualisation and analysis of relief features of the wider landscape.

Spatial data can be obtained in various ways and in different resolutions, which affects the types and precision of feasible analyses and thus also the reliability of final results (Chapman 2009: 57; Roosevelt 2014: 29). For this reason, consideration of the optimal data acquisition methodology represents an indispensable segment of each attempt of digital relief modelling. The resolution of commercial or publicly available data is usually low, which is especially observable in relation to lowland areas with less pronounced relief. More detailed data can be acquired in various ways: by using Airborne Laser Scanning (ALS) method, by photogrammetric procedures or terrestrial topographic surveys. Since ALS is still unattainable due to its costs and the data obtained via photogrammetric procedures are not usable for areas covered in high vegetation, terrestrial topographic survey with total station imposed itself as, at this moment, the only acceptable way of obtaining data on the relief features of the site Kurilovec-Belinščica.

Survey was carried out in the wider area of the archaeological site in three phases from 2011 to 2013.[4] It was conducted in different seasons of the year, by one team of two persons during 15 workdays in total. The survey included the immediate surround-

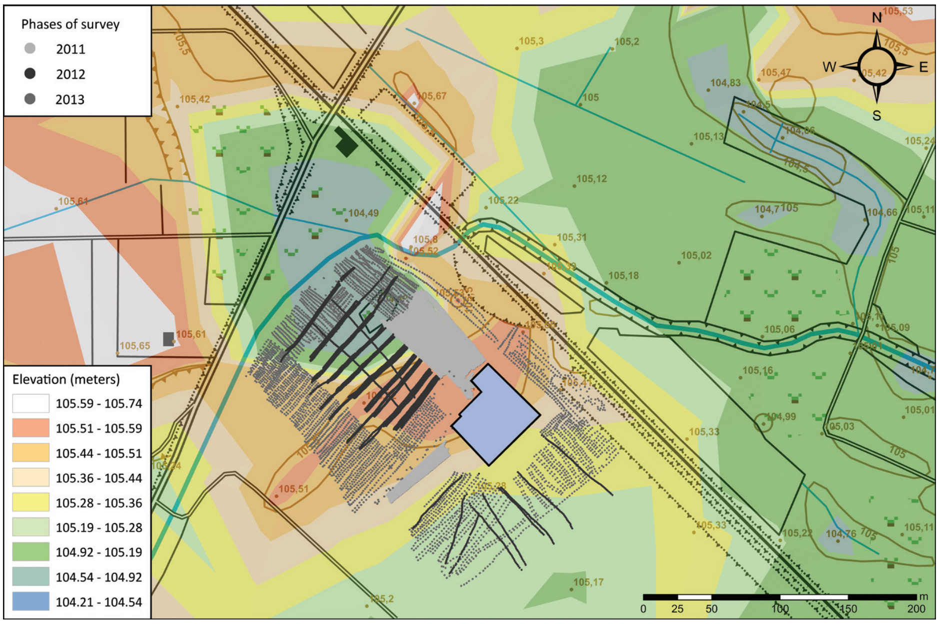


*Figure 3: Data acquisition points for generating a DEM derived from terrestrial topographic survey (author: D. Tresić Pavičić; background after: HOK, DGU).*

3 The area immediately surrounding the site was used for agricultural purposes until a few years ago and it was intensively cultivated with agricultural machinery, but today it is laid fallow and overgrown with high grass and thicket.

4 The investigation was directed by Andreja Kudelić and organised in cooperation between the company Kaducej d. o. o. and Institute of Archaeology, as a part of *Geneza i razvoj brončanodobnih zajednica u sjevernoj Hrvatskoj / The Genesis and Development of Bronze Age Communities in Northern Croatia* (project 197-1970685-0689) project, directed by Snježana Karavanić.

ings of the archaeologically investigated area, that is, the surface of approximately 35,000 m², where over 19,000 points were recorded (Fig. 3).[5] The data were obtained systematically, in regular intervals, but in different resolutions, that is, using the system which reflected the situation encountered in the field, the preliminary results of data processing, but also the financial limitations of the research.

In the first phase, arable land covered in high grass located northwest and southwest of the archaeologically investigated part of the site was surveyed. In these areas, the points were recorded every 0.5 m in dense parallel lines spaced at 1 m intervals. In the second phase, the procedure was modified so that a wider area could be covered in a shorter amount of time. The survey was performed in several parallel lines (4 to 8) which were about 1 m distant from each other, and the points in each line were recorded every 0.5 m. The recording was then continued in the same way at a distance of 5 to 10 m. In the third phase, based on the analysis of the data obtained up to that point, the survey was performed in regular intervals every 2 m and it also included the area which showed inconclusive results.

After the field part of the process was done, the acquired data were stored and analysed in Quantum Geographic Information System (QGIS) environment which serves as a central storage for all spatial data obtained during various types of investigation. Based on the data acquired by terrestrial topographic survey, a digital elevation model was produced. DEM was generated by applying Triangular irregular network (TIN) interpolation which joins known point values in a network of non-overlapping triangles that form a three-dimensional surface (Padney & Pathak 2014: 22). More faithful representation of the real surface was provided by adding breaklines at points of more pronounced deviations in height which were primarily caused by deep ploughing. The result is a model of surveyed area created with a cell size set to 0.2 x 0.2 m. The model was combined with other types of data: results of previous archaeological investigations, available maps and aerial photographs, and DEM which was derived from a segment of the Croatian Base Map (HOK).[6]

## Results of data processing

The summary statistics of data obtained from terrestrial topographic survey showed that the range of absolute heights of surveyed points is between 104.21 and 105.74 m. In order to enhance the per-

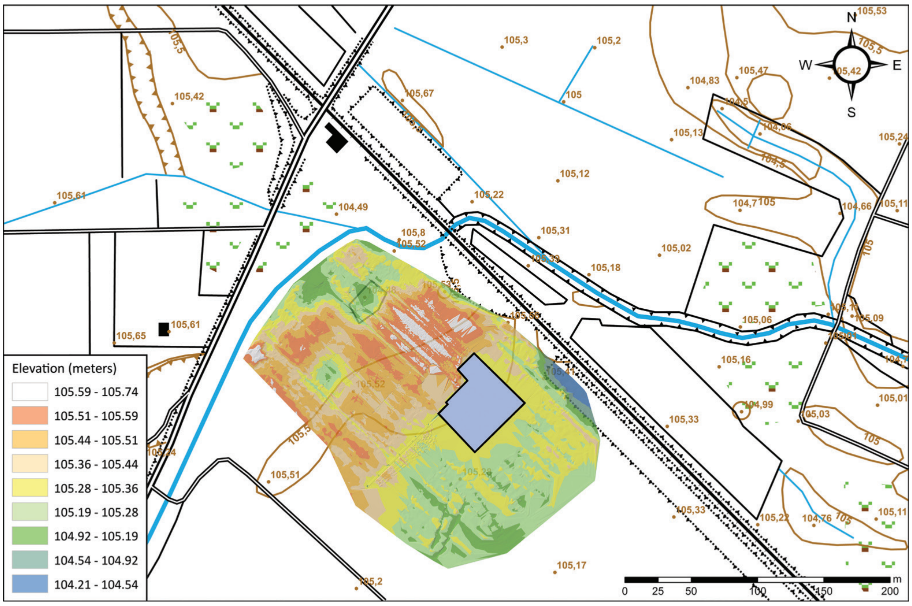


*Figure 4: DEM derived from terrestrial topographic survey (author: D. Tresić Pavičić; background after: HOK, DGU).*

5 The procedure was partly presented in a report published after the second phase of investigation (Kudelić *et al.* 2013).

6 HOK is made at a scale of 1 : 5,000 and it contains contour lines and points with elevation attributes from which the DEM was created using TIN interpolation with a cell size set to 0.2 x 0.2 m. The derived DEM serves for better visualisation of the results of the investigation and presentation of differences between models derived from data in different resolutions.

ception of the present morphology, the elevations were classified in nine intervals which are presented in different colours (Fig. 4). If the contemporary canal by the railroad, which is marked in two nuances of blue colour, is extracted from these data, the height distance between the highest and the lowest surveyed point is 82 cm. DEM shows that the elevation on which the Bronze Age site is located stretches from the northeast to the southwest. The terrain mildly slopes towards the southwest, while its highest part is situated to the northwest of the archaeologically investigated area. This is also the area for which it is possible to claim that the Bronze Age settlement has certainly occupied, although other parts of the elevation, as well as its surroundings, are also suitable for different kind of uses, as it is indicated by the distribution of surface archaeological material gathered during the systematic field survey (Fig. 5).

The analysis of data obtained in the survey provided clearer insight in relief configuration of the immediate surroundings of Kurilovec-Belinščica site. Combining acquired data with the data obtained from other types of archaeological investigations contributed to clearer understanding of possibilities of use of this area in the Bronze Age. The acquired data, the results obtained by their analysis as well as the established scientific potential of the site, aside from raising many new questions, also suggest an approach for further research which can provide a more thorough understanding of not only the site, but also of wider landscape of Turopolje.

## FRIGIS AND FRIGIS 1, OSIJEK

Archaeological sites Frigis and Frigis 2 are located in the south part of the city of Osijek, some 2.3 km

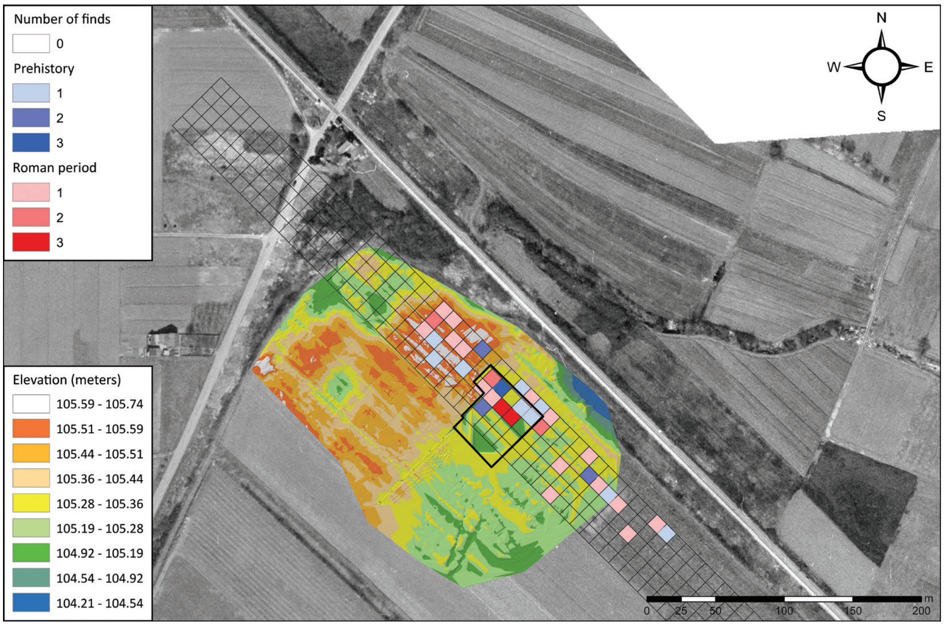


*Figure 5: Distribution of surface archaeological material in relation to DEM (author: D. Tresić Pavičić; source: Kaducej d. o. o. Archive).*

south of the current flow of Drava River (Fig. 6). They are located in an area which belongs to the Pannonian geographic region, that is, the lowland and flat, northeast part of eastern Croatia where Drava river flow played an important role in landscape forming. In 2013, archaeological excavations were carried out on these locations as a prerequisite for the construction of the south pavement of the south bypass of Osijek.[7]

Northwest of the highest part of the elevation, closer to Ramiščak stream, a sudden gap in distribution of surface material was observed. DEM shows that this is the area with lower height values which occur on a surface of about 15 m and stretch from the northeast to the southwest for some 120 m. For now it can only be assumed that these are the traces of the Ramiščak paleochannel, whose current form is probably the result of the more recent interventions. Aerial photographs of this area, which show clear differences in soil colour in the same area (Fig. 2), support this assumption.

[7] The excavation of Frigis was directed by Dinko Tresić Pavičić and organised by the company Kaducej d. o. o. The excavation of Frigis 2 was directed by Vedran Katavić and organised in cooperation between Kaducej d. o. o. and Kaukal d. o. o. companies.

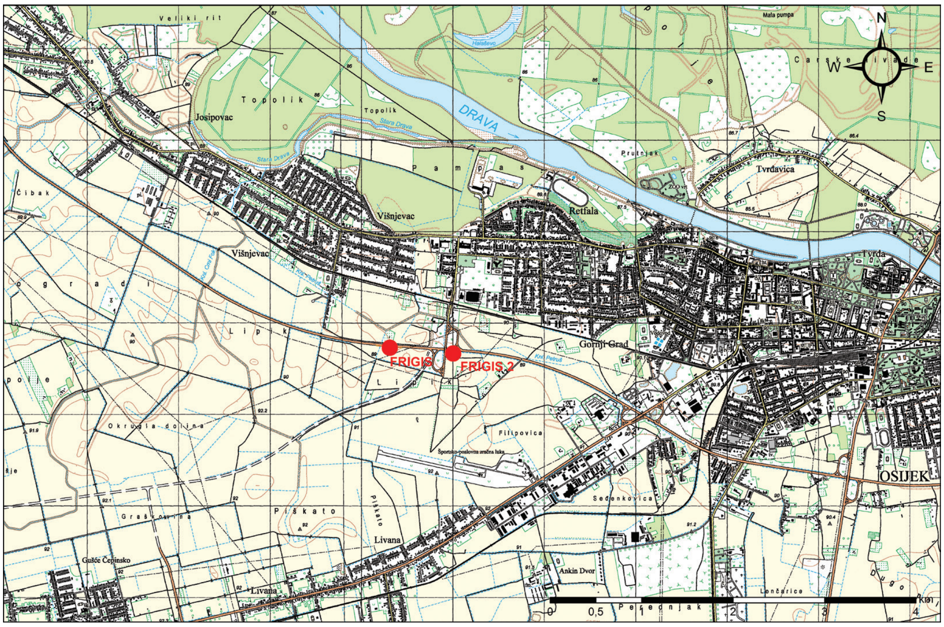


*Figure 6: Location of the sites (source: TK, DGU; modified by: D. Tresić Pavičić).*

The site Frigis is located on the south part of a mild, irregularly elongated elevation which surmounts the surrounding area by 1 m and stretches from the northwest to the southeast. In spite of the intensive infrastructural works to which the site was exposed in recent times, the archaeological record, investigated on a surface of 4,303 m$^2$, was well preserved and it showed traces of human activities from the Copper and Bronze Age, as well as the Roman and Modern period (Tresić Pavičić 2013).

The site Frigis 2 is located approximately 450 m east of Frigis and is, like Frigis, situated on an elevation which was exposed to intensive devastation in recent times. Those processes changed the natural landscape significantly and probably caused considerable damage to archaeological remains in a wider area. Nevertheless, in the archaeological excavation carried out on a surface of 2,441 m$^2$, the existence of a simple single-period site was established, where all archaeological remains were dated to the Roman period (Nađander & Burmaz 2013).

On both locations, terrestrial topographic survey with total station was carried out before the beginning of excavations. The survey was performed in order to complement the analysis and interpretation of the sites and to permanently document the relief features of the area which are lost in the course of archaeological excavations. It was conducted by one team of two persons during 2 workdays. The data were obtained at regular intervals, in a 5 x 5 m grid, which provided data required for generating DEM. DEM was again generated in Quantum GIS software using TIN interpolation with a cell size set to 0.2 x 0.2 m. For the purpose of visual presentation, differences in height were expressed in six intervals marked in different colours. Finally, the results of terrestrial topographic survey were compared with the results of archaeological excavations and other available spatially referenced data.

At Frigis site, the analysis of the obtained data showed that the DEM derived from terrestrial topographic survey provides possibilities for a more detailed consideration of interrelations between archaeological formations and relief features, and thus an appropriate basis for analysis of spatial distribution of archaeological remains (Fig. 7). Namely, by overlapping all gathered data, it is noticeable that the most numerous, Copper Age archaeological remains, which contain more pronounced settlement indicators, are situated on the central, and at the same time the highest part of the elevation. As opposed to that, the remains from the Roman period are located in the lower, peripheral part of the investigated area and they surround a large channel whose purpose could not be defined with certainty. However, the spatial distribution of the remains dated to the Roman period could indicate that the investigated traces reflect a special type of activity related to the construction of the channel, whose location was probably conditioned by the relief features of the wider area. On the other hand, one modern period pit and a single incineration grave from the Late Bronze Age do not provide enough data for a more detailed analysis.

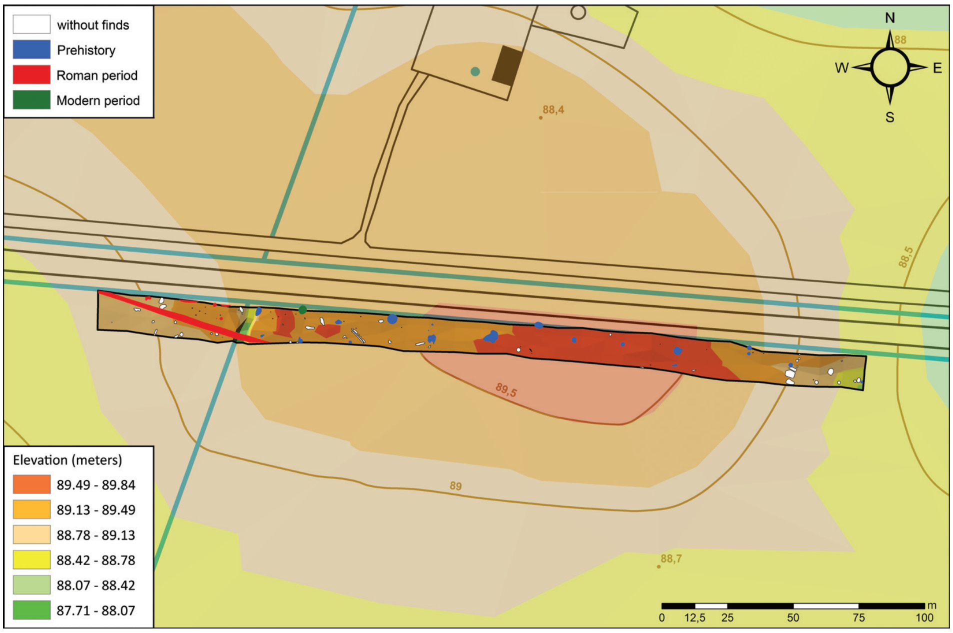


*Figure 7: Frigis: Results of archaeological excavations in relation to DEM derived from terrestrial topographic survey (more pronounced colours) and DEM derived from HOK (less pronounced colours; author: D. Tresić Pavičić; background after: HOK, DGU).*

The relation between the distribution of archaeological remains and DEM derived from terrestrial topographic survey at site Frigis 2 indicates a clear relationship between the area with highest values and the area with archaeological formations (Fig. 8). Thus, it can be concluded that the distribution of archaeological formations whose presence was established by excavation clearly reflects differences in height obtained by measurements with total station and enables reaching well-based assumptions about the location and dimensions of the area with highest intensity of activity, as well as the perimeter of the archaeological site.


*Figure 8: Frigis 2: Results of archaeological excavations in relation to DEM derived from terrestrial topographic survey (more pronounced colours) and DEM derived from HOK (less pronounced colours; author: D. Tresić Pavičić; background after: HOK, DGU).*

Although the investigation covered only a small part of both sites, the devastations of the Frigis area in recent past will probably make its more thorough understanding impossible. However, relief features of the area meaningfully complement the acquired archaeological data and, even without more detailed analyses, it is possible to observe the way they enrich our understanding of the use of space in different time periods. At the same time, it can be observed that even relatively rough measurements with total station before the rescue excavation enable creating quite precise DEMs, which represent a significant complement to data acquired by other methods of investigation.

## CONCLUSION

Since consideration of relief features is an inevitable component of archaeological investigation, a simple and affordable method of their documenting on small surfaces was presented in this paper. The demonstrated procedure has several advantages and represents a practical solution for efficient obtaining of relevant data. Namely, terrestrial topographic survey represents a simple, affordable and efficient procedure, with results which can be used independently, but also as a significant complement to data acquired by other methods of archaeological investigation (Chapman 2001: 19). They expand the possibilities for analysis and interpretation of archaeological features and archaeological potential of investigated areas, at the same time providing the spatial framework for integration of all kinds of spatially referenced data (Chapman 2009: 54). They can be used for direct visualisation of the surface, which enables a clearer simulation of the real relief, but also, depending on the procedure applied, they may help in surface feature recognition and may simplify their interpretation (Bennett 2011: 22). On the other hand, three-dimensional visualisation of relief can be a valuable contribution to every presentation of gathered archaeological knowledge (Chapman 2009: 73, 168; Sabatini *et al.* 2013: 680).

But what is perhaps most significant is that the results of research established in this manner can complement the data which are used in development project planning and can significantly contribute to the development of cultural resource management strategies. Namely, the basic goals of cultural resource management are mostly limited by the lack of knowledge about the real spatial distribution of archaeological remains, which is especially evident during all kinds of earthworks. When the evaluation of archaeological potential of the immediately endangered area is a prerequisite for their fulfilment, the methods used for establishing this potential include standard procedures usually adapted for regional geomorphic features, but rarely for variability of the local relief, which has considerable influence on space use patterns in all time periods. This is especially noticeable in lowland areas characterised by obscured geomorphic features. The data about such areas available from commercial or publicly available maps are most often insufficiently precise since they contain data in much lower resolution than that required for archaeological investigations. Thus the results of terrestrial topographic surveys can significantly contribute to understanding of existing archaeological remains and help define areas of archaeological interest more clearly, which becomes especially important when threats emerge in the form of development plans and projects. In the same context, the gathered data can represent a good foundation for monitoring changes on archaeological sites and thus contribute to a better understanding of how modern ways of space use influence archaeological record. Finally, they represent a permanent record of the current appearance of the landscape and its features which are permanently lost in case any kind of earthworks takes place, including archaeological excavations.

Therefore, it can be pointed out that detailed terrestrial topographic surveys enable acquiring comprehensive data applicable in planning and implementation of archaeological investigations as well as in interpretation and presentation of the results obtained. At the same time, they influence creating a clearer picture about the distribution of archaeological remains and enable monitoring harmful influences and inevitable changes, thus creating a possibility of reaching better founded decisions on further action. On these foundations it is possible to suggest an expansion of the methodological approach of non-destructive data acquisition on the distribution of immediately threatened archaeological remains which should at the same time represent an indispensable procedure preceding all archaeological excavations.

*Translation: Vinita Ramljak*

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