METHODOLOGY FOR TOPOGRAPHIC APPROACH AND SPATIAL REPRESENTATION OF ARCHAEOLOGICAL CONTEXTS IN SYSTEMATIC RESEARCH

Assoc.prof. PhD. TUDOR BORŞAN, prof.Ph D. LEVENTE DIMEN
"1 Decembrie 1918" University of Alba Iulia, Romania

ABSTRACT: *The aim of the paper is to illustrate necessary and current stages of modern archaeology by using techniques and methods specific to archaeological topography and Geographic Information Systems, which play an important role both in generating and structuring entities of archaeological interest, and in developing a three-dimensional model of the surrounding area.*

Keywords: *archaeological survey; GIS; systematic research; archaeological site; archaeological excavations; 3D model;*

Introduction

The advantages of using the tools provided by archaeological topography, cartography, and Geographic Information Systems for archaeological research are numerous. The technical presentation of research for spatial delimitation of archaeological sites, using both traditional methods and advanced digital technologies, provides strong arguments for considering these tools as complementary in conducting comprehensive and thorough studies aimed at protecting archaeological heritage.

Planning for the organization of topographic work and establishing priorities for the selection of entities in the measurement process

For a proper organization of the work, I considered several methods through which planning could be implemented. Thus, I found it appropriate to conduct an analysis based on the use of equipment depending on the type of elements of interest that are to be collected. In this regard, it was established that the benchmark points, which will form the basis for defining the digital terrain model, should be acquired using GNSS technology, alongside the 3 points (site markers) placed in protected areas, properly marked with hexagonal FENO markers. These points have functioned alternately as stationary points or as orientation bases in measurements carried out electro-optically (with the total station).

For the collection of breakpoints of archaeological research units, excavation points, as well as those defining the digging level, and archaeological complexes, the appropriate instrument was established as the total station.

Furthermore, at this stage, I also tailored the planning of satellite observations according to the proximity factor based on GPS RTK measurements (the proximity of working receivers to permanent GPS stations capable of providing real-time differential corrections) and, lastly, the absence or partial presence of GSM signal for transmitting differential corrections (in which case, corrections can be transmitted via radio using the relative positioning method)(Fig.1,2)

From the same category, the points acquired using GPS were those surveyed on the ground, necessary for modeling. The technique for collecting these points was based on the gridding formula, where the distance between points was required to fall within the range of 5-10 meters (Fig. 3).

The contact area exceeded the archaeological interest zone, covering approximately 17 hectares from which 3,733 contourable points were collected (Fig. 4).

The collection of detail points was carried out exclusively electro-optically, starting from fixed points that alternated as stationary points or orientation bases.

In this way, 172 points were recorded, distributed as follows: 35 breakpoints corresponding to the 5 archaeological research units and 138 points corresponding to archaeological complexes (Fig. 5).

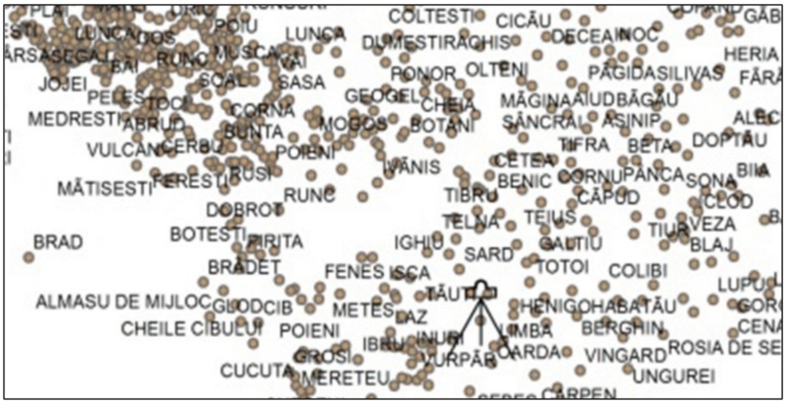


Fig. 1. Determining the locations based on the application of the maximum distance threshold from the SGP Alba

Nume Punct	Data	Ora	Clasa	Inaltime Ant.
1000	15/10/20	04:12:52	MEAS	2.000 m
	Lat.ETRS89		Long.ETRS89	CotaETRS89
	46 17 5.366 N		23 44 53.720 E	312.587 m
Cod	Nord S70		Est S70	Cota MN75
--------	532442.932 m		403680.572 m	271.493 m
	HDOP	VDOP	PrecizieH	PrecizieV
	0.60	0.90	0.0063 m	0.0086 m
Nume Punct	Data	Ora	Clasa	Inaltime Ant.
1001	15/10/20	04:15:35	MEAS	2.000 m
	Lat.ETRS89		Long.ETRS89	CotaETRS89
	46 17 4.693 N		23 44 52.918 E	311.909 m
Cod	Nord S70		Est S70	Cota MN75
--------	532422.426 m		403663.071 m	270.814 m
	HDOP	VDOP	PrecizieH	PrecizieV
	0.60	0.90	0.0057 m	0.0078 m
Nume Punct	Data	Ora	Clasa	Inaltime Ant.
1002	15/10/20	04:20:16	MEAS	2.000 m
	Lat.ETRS89		Long.ETRS89	CotaETRS89
	46 17 6.142 N		23 44 54.476 E	312.089 m
Cod	Nord S70		Est S70	Cota MN75
--------	532466.643 m		403697.113 m	270.995 m
	HDOP	VDOP	PrecizieH	PrecizieV
	0.60	0.90	0.0063 m	0.0084 m
			Referinta:	RTCM-Ref 0001

Fig. 2. Accuracy parameters in GNSS observations

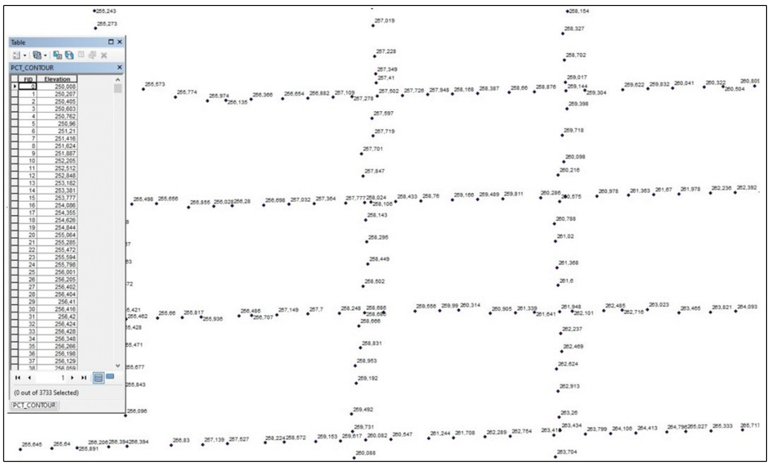


Fig. 3. The GPS technique for collecting elevation points

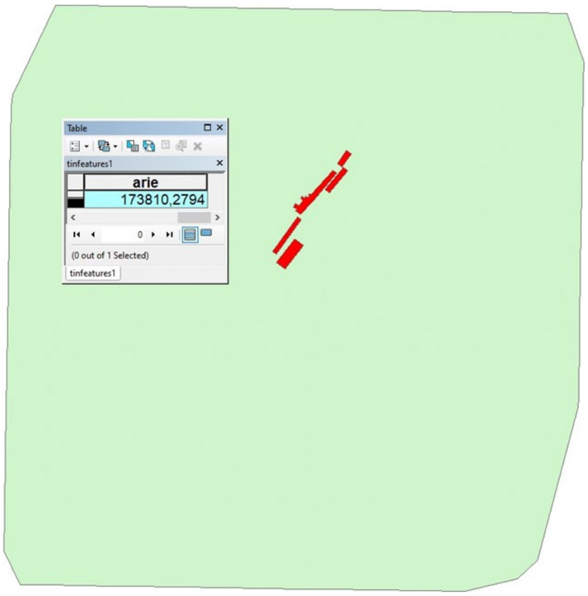


Fig. 4. The area for collecting contourable points

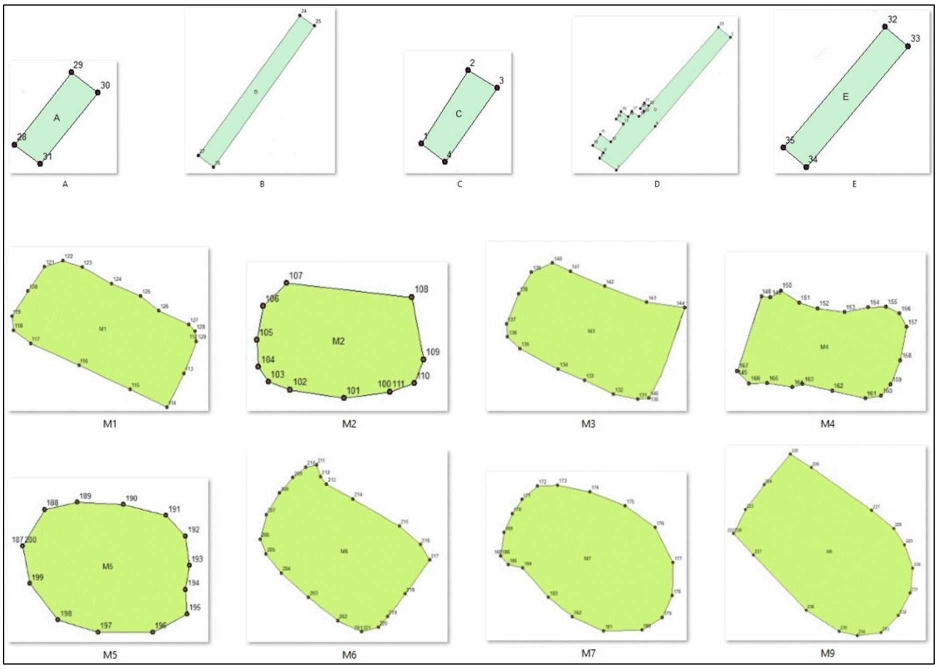


Fig. 5. Recording of archaeological points of interest

Primary data processing

Primary data processing involves starting with an ASCII file containing a coordinate inventory (x,y,z) or (y,x,z), which can be processed to transform it into a tabular format (csv or xls). Moreover, defining fields associated with values is taken into account, so that when importing data and especially generating points in the GIS environment, their correct positioning is determined by the association of fields with the relevant values.

To ensure the integrated use of all measured data in a GIS environment, it was necessary to process the ASCII file obtained from GNSS observations, so that the coordinate values and absolute elevations of the recorded points structurally align with those obtained through the transfer of data measured with the total station. Even though this aspect (the unitary character) was taken into account, to facilitate distinct data processing based on the layers defined in the design phase, I established a measure to divide the data block into several files, with a clear assignment of points to the themes that will compose the representation (Fig. 6, 7).

secondary data processing, requires clarifying some conceptual aspects of what databases represent in a GIS environment.

A database can be viewed as a collection of interconnected files containing essential data for an information system. It can be considered a model of certain aspects of reality from a specific situation, modeled through data. Various objects of interest in reality are called classes or entities.

```
531,403715.226,532475.638,269.733,
530,403711.325,532478.008,269.556,
529,403705.094,532468.266,270.270,
528,403708.286,532465.835,270.357,
526,403680.103,532408.051,270.421,
525,403666.521,532391.226,270.436,
524,403660.421,532395.836,270.692,
523,403657.705,532404.142,270.056,
522,403660.459,532402.041,270.632,
521,403678.508,532427.326,271.541,
520,403675.907,532429.149,271.201,
1002,403697.113,532466.643,270.995,
1001,403663.071,532422.426,270.814,
1000,403680.572,532442.932,271.493,
RTCM-Ref 0001,389245.086,509666.412,265.425,
```

Fig. 6 ASCII file – coordinate inventory

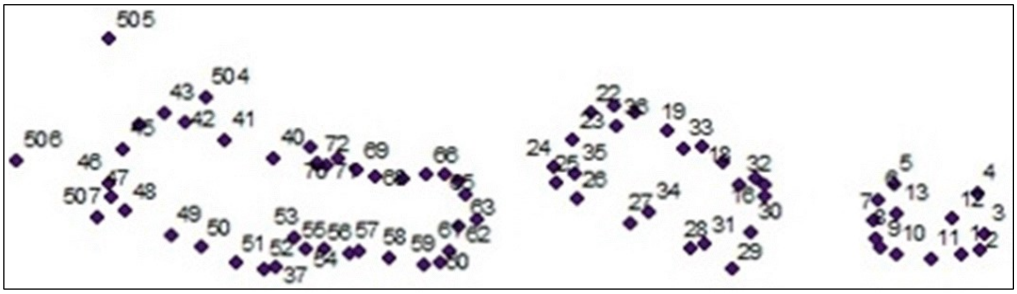


Fig. 7 Displaying points of interest

Secondary data processing

After the primary data processing stage, which highlighted the simple elements (points), priorities were established regarding the future themes that will develop based on the existing data. It was not by chance that I opted to divide the global tabular file into components focused on thematic areas. In this way, I created coordinate inventories for benchmark points, necessary for the three-dimensional representation of the area surrounding the archaeological site, breakpoints of the archaeological research units, and, last but not least, points that will define the archaeological complexes in the necropolis area.

Database design, an important stage in

For these objects, data regarding different characteristics (attributes) are collected and stored. The database thus constitutes an interconnected set of data collections, through which the representation of a reality is achieved.

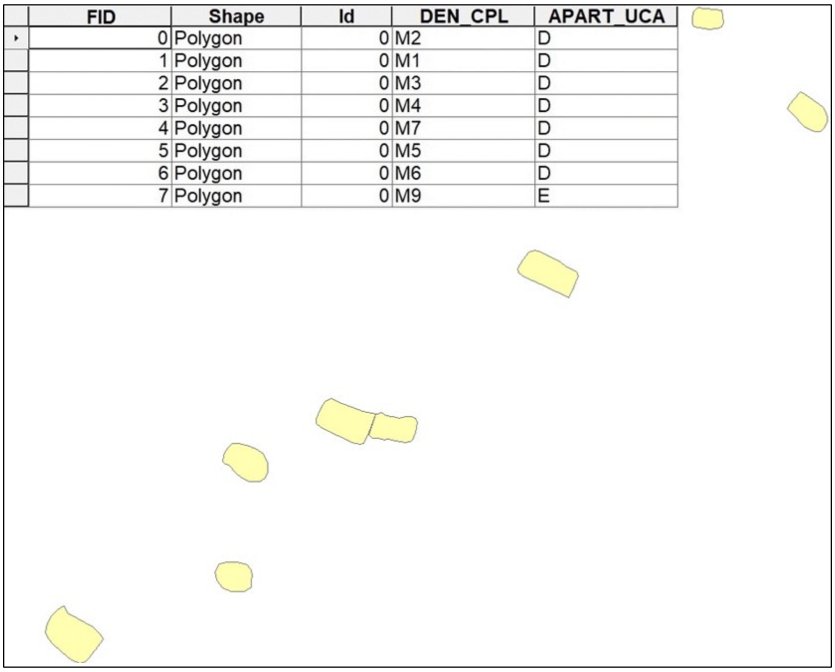
A database must ensure:

- Data abstraction: The database serves as a model of reality.
- Data integration: The database is a collection of interconnected data sets, with controlled redundancy.
- Data integrity: The data loaded and processed must be correct and comply with integrity constraints.
- Data security: Access to the database must be restricted.

- Data sharing: Data must be accessible to multiple users, possibly simultaneously.
- Data independence: The organization of the data must be transparent to users, and changes in the database should not affect application programs.

These thematic layers, generically called UCA (ARCHAEOLOGICAL RESEARCH UNITS) and COMPLEXES (ARCHAEOLOGICAL COMPLEXES – GRAVES), were physically generated in the Arc Catalog tree and will be integrated into the central ArcMap application of the ArcGIS desktop. From a descriptive standpoint, the focus was not on the characteristics of the archaeological research units, but rather on the complexes, especially in terms of their spatial affiliation within the UCA (Fig. 8).

explore, document, and analyze archaeological sites. These models provide an accurate three-dimensional representation of the land surface, facilitating the discovery and interpretation of ancient relics. One of the most significant contributions of DTMs in archaeology is the ability to detect and locate archaeological sites that are otherwise difficult to observe on the ground. The use of technologies such as LiDAR (Light Detection and Ranging) allows researchers to penetrate dense vegetation and obtain detailed images of the ground. These images can reveal hidden structures, roads, walls, and other features that indicate the presence of ancient human activities. By creating detailed three-dimensional models, archaeologists can accurately record the current state of a site. This is essential for heritage



FID	Shape	Id	DEN_CPL	APART_UCA
0	Polygon	0	M2	D
1	Polygon	0	M1	D
2	Polygon	0	M3	D
3	Polygon	0	M4	D
4	Polygon	0	M7	D
5	Polygon	0	M5	D
6	Polygon	0	M6	D
7	Polygon	0	M9	E

Fig. 8. The affiliation of the COMPLEXES layer to the UCA

It is observed that a single complex (M9) stands out, being located within the UCA (E), essentially a successful attempt by the specialists to discover a new grave by extending the research into the proximity area of UCA – D with the opening of the new unit E (Fig. 9).

Results and discussions

Digital Terrain Models (DTMs) have become essential tools in systematic archaeological activities, revolutionizing the way researchers

conservation, allowing researchers to monitor changes over time and take preventive measures to protect sites from erosion, vandalism, or other forms of damage, whether natural or anthropogenic.

DTMs allow archaeologists to analyze the landscape in which archaeological sites are located and better understand the historical and geographical context of these places. By studying the terrain and natural features, researchers can reconstruct how ancient communities interacted with their environment.

This can reveal valuable information about agriculture, resource management, and how they adapted to climate changes or other environmental challenges (Fig. 10).

DTMs are extremely useful in the planning and execution of archaeological excavations. It is observed that the elevation values corresponding to the surrounding terrain model of the site range from 251m to 271m, meaning there is an elevation difference of approximately 20m. This information provides a detailed map of the area, helping archaeologists identify the regions with the greatest potential for discoveries. During excavations, DTMs can be used to record progress and coordinate the research team's efforts.

Additionally, digital models can be integrated with other archaeological data, such as geophysical images, to create a comprehensive view of the site. In this context, the figure below shows the elevation registration correlated with the planimetric positions of the excavations, which are framed within an elevation range of 264 – 268m (Fig. 11).

Fig. 9 Justification for the expansion of UCA – D

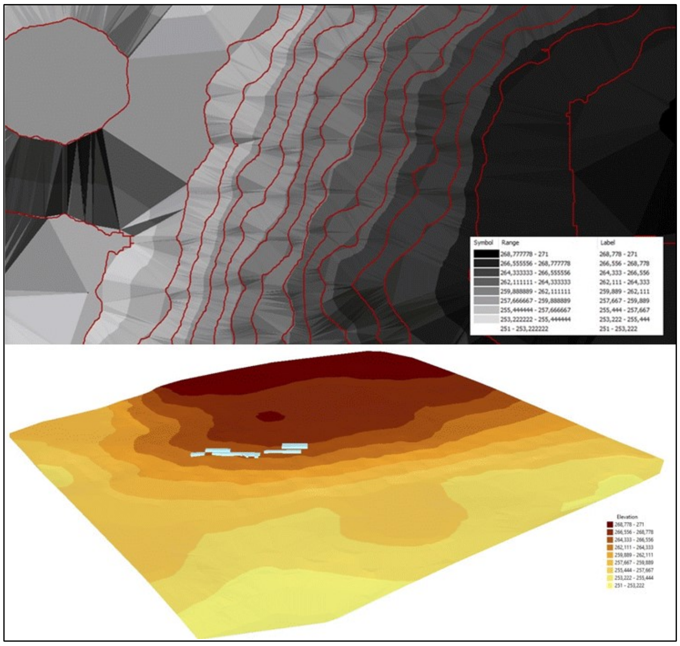


Fig. 10 Configuring the digital terrain models of the area surrounding the site

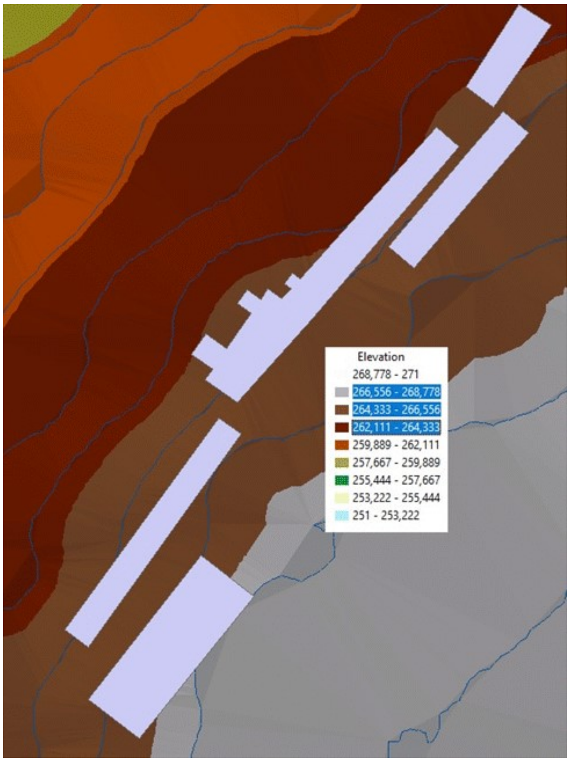


Fig. 11 Determining the elevation levels of the archaeological research units

In conclusion, digital terrain models fundamentally transform archaeological practice, providing advanced tools for detecting, documenting, conserving, and analyzing archaeological sites. These technologies not only improve the efficiency and accuracy of research but also make a significant contribution to the protection of cultural heritage. As technology continues to evolve, it is expected that DTMs will become even more indispensable in systematic archaeology, opening new horizons for discoveries and, especially, for interpreting the archaeological context.

Conclusions

In the modern world of archaeology, the integration of advanced technologies has become essential for deepening our understanding of the past.

This study has made significant contributions to historical knowledge, heritage protection, and the applicability of results in the field of archaeological topography.

One of the fundamental aspects of this work is the integration of Geographic Information Systems (GIS) and modern topographic technologies. These tools enable detailed analysis and accurate representation of archaeological sites, facilitating both the discovery process and the interpretation and presentation of data.

The same work is not only distinguished by its general contributions to the field of archaeology but also by a series of specific conclusions that provide clarifications and essential details for the particular understanding of the studied site. These conclusions reflect the nuances and complexities encountered during the research, highlighting the unique aspects that define the archaeological site's singularity.

A particularly significant aspect of the research is the advanced use of GIS technology for mapping and analyzing the site. The creation of a detailed three-dimensional model not only allowed for a precise visualization of the necropolis but also enabled the identification of structures and landforms that would not have been evident through traditional excavation methods. This technology facilitated the identification and interpretation of both anthropogenic and natural features that influenced the development and use of the site over time.

References

1. Breazu, M.; Borşan, T.; Maican, I., *Noţiuni de bază geodezo-topografico-cartografice utilizate în topografia arheologică*, Sargetia Acta Musei Devensis, 2003;
2. Borşan, T.; Ienciu, I.; Oprea, L.; Voicu, E.G, *Contribuţii privind analiza exploratorie a datelor topografice în cercetarea arheologică sistematică*, Revista Pangeea, vol. 11, 2011;
3. Borşan, T.; Ienciu, I.; Dimen, L.; Oprea, L.; Voicu G. E. *An Exploratory Analysis Of Topographic And Archeological Data Gathered During Systematic Research*, 13th SGEM GeoConference on Informatics, Geoinformatics And Remote Sensing, www.sgem.org, SGEM2013 Conference Proceedings, ISBN 978-954-91818-9-0 / ISSN 1314-2704, June 16-22, 2013, Vol. 1, p. 629 - 636;
4. Borşan, T., *Topografie arheologică şi GIS*, Editura Risoprint, Cluj-Napoca, 2015;
5. Rustoiu, A.; Drăgan, A., *Remembering the ancestors. A grave-marker from the "Scythian" Cemetery at Sâncrai (Alba county)*, Ephemeris Napocensis* XXXII 2022, Editura Academiei Române;
6. Werner, M., *Eisenzeitliche Trensen an der unteren und mittleren Donau*. PBF XVI/4, München 1988.