GeoTerrace-2020-056

Using GIS in geoarchaeology of Podillya (Ukraine)

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SUMMARY

This study demonstrates the key aspects of the application of geographic information systems for the needs of geoarchaeological research. The basic principles of ArcGIS software are briefly outlined. The process of using ArcGIS for spatial data analysis, as well as the creation and interpretation of maps for basic archaeological needs, is also described. Main features of creation and analysis of electronic geomorphological maps are demonstrated on the example of a digital elevation model map of the Palaeolithic site Ihrovytsia I.

Introduction

The aim of this study is to describe briefly the use and potential of geographic information systems (GIS) for the needs of modern geoarchaeological research. It is important to demonstrate that various archaeological problems and research issues related to the study of landforms can be solved using new technologies, in particular geographic information systems.

GIS for archaeology has been used since the 1980s. These technologies have become especially popular in the field of geoarchaeology, which studies the features of formation of ancient landscapes and their impact on human settlement, as well as post-depositional natural processes and phenomena (for instance, cryoturbation, mass wasting, solifluction, etc.), which affected the state of preservation of archaeological sites (Kvamme 1999).

Method and Theory

The geological structure of the territory affects the landforms, which are important components of the natural environment. Morphological characteristics (in particular, the nature and absolute elevations of the surface, the slope aspect according to the sides of the horizon, erosive dissection of the landforms, etc.) affect the distribution of vegetation, groundwater, the formation of different soil types, distribution of climatic indicators and others. Together with the lithology of cover sediments, the landforms are one of the principal components of the landscape.

Morphological studies of the landforms can be considered as one of the traditional methods of its study. People from ancient times have been attracted to various landforms, especially those places that have not undergone essential external changes for a long time. Such places served as landmarks for human movement on the earth's surface, shelter from unfavourable natural processes and phenomena, etc. During the development of cartography, certain forms of relief were applied to maps as landmarks. Information about landforms, in particular its appearance, gradually accumulated in manuscript sources. Thus the doctrine of the morphology of the earth's surface was born. Gradually, cartographers learned to depict the landforms on maps with the help of isolines. The question of the origin of certain landforms was clearly raised. The selection of landforms, which should be analysed from one point of view, always begins with its morphological (external) analysis, because to distinguish a particular shape from the set of irregularities of the earth’s surface is possible only by considering the landform in nature or on maps (Simonov 2005).

The main problem in this field should be considered the need to improve the content of morphological studies. Information about the morphology of modern landforms helps researchers to reproduce the course of processes that formed the landforms in the past and continue to transform it into the present. Furthermore, morphological researches promote the reproduction of mechanisms of formation of landforms and help with forecasting of its development. Any geomorphological research begins with the study of the appearance of landforms which is carried out using morphographic and morphometric methods. The morphographic method includes the description of the landforms in the form of text, graphs, profiles, block diagrams, photographs, etc. It is closely related to the morphometric method, the purpose of which is to quantify the landforms, to determine the length, width, relative and absolute height, volume, steepness, slope aspect, shape in profile and plan, etc. Morphometric studies are also performed on topographic maps (Simonov 2005). In particular, topographic maps are used to create electronic maps for various purposes using ArcGIS software.

According to the software manufacturer, the main functions of ArcGIS as a geographic information system are data visualization, editing and analysis. The software allows working directly with the geographical component of the data by establishing relationships between objects, as well as predicting their development. ArcGIS Desktop software package includes the following systems: ArcView, ArcEditor, ArcInfo.

Among the main technical and analytical capabilities of editing maps using ArcGIS are the following:

- complex editing of vertices (adding, moving, deleting, closing);
- operations with the geometric shape of objects (splitting, merging, crossing);
- automatic attribute recovery while editing;
- spatial queries (map content analysis) using separate tools;
- object selection operations (interactive selection or selection by attribute, location, etc.);
- operations with several fragments of maps (buffers, cut, merge, intersection, spatial connection);
- virtual presentation and analysis (in the format of diagrams, reports);
- correlation and selection of objects on one map depending on the location and properties of objects on another map;
- adding data groups in layers to create new data.

Many field researchers to study archaeological sites, explore areas and track their archaeological features, such as ancient roads, canals and other details, mainly use the patented ArcGIS software.

Spatial modelling and spatial statistics are used in ArcGIS to perform analyses such as spatial autocorrelation of key features and even predictive modelling. The last one attempts to predict the location of archaeological sites according to tracked patterns in the landforms.

Researchers usually carry out data processing in GIS in one of two main formats – raster or vector. Vector systems, which are more often used for management or land management purposes, have a so-called topological structure consisting of points, lines and polygons. These are the types of systems we usually associate with maps.

GIS raster programs are more commonly used in geoarchaeological research because they make it much easier to obtain data for quantitative analysis and better represent the geomorphology. In these systems, the study area is represented as a grid (matrix), and each grid unit has a row and column coordinates. Each grid square can be added to a number of data categories. The size of the grid square is determined by the nature of the research.

The area where archaeologists typically use GIS and one of the most important issues in the use of GIS in modern archaeological research is the predictive modelling of archaeological sites and the modelling of landforms and palaeorelief (Maschner 1996).

Examples

Morphometric studies of the landforms for the needs of geoarchaeology are performed on topographic maps. In particular, topographic maps are used to create electronic maps for various purposes using ArcGIS software. To demonstrate the features of such maps, we analyse the landforms in the vicinity of the Palaeolithic site Ihrovytsia I in Ternopil region (Sytnyk et al. 2013; Łanczont, Sytnyk et al. 2014). To investigate the morphometric characteristics of the landforms of the surroundings of the multilayered Palaeolithic site Ihrovytsia I a topographic map of the surrounding areas with a scale of 1:25,000 was taken.

During the analysis of morphometric characteristics of the vicinity of the multilayered Palaeolithic site Ihrovytsia I a digital elevation model was created (Fig. 1).

Analysing the hypsometry of the landforms (Fig. 1), it should be noted that the territory of the study area is highly dissected, the elevation difference is about 60 m. The highest areas with marks of 375-380 m are located in the western and eastern parts of the territory, in particular in the direction of east and west of the settlement and the river valley. In the direction of the central part, where the village of Ihrovytsia and the valley of the river Ihra are located (left tributary of the river Seret, Dnister basin), the elevations gradually decrease and reach 320-330 m. The valley of the river Ihra, which is located in the central part of the map, has absolute elevations of 315-320 m, and the

Palaeolithic site is located in the culminant part of the steep slope of the river left bank and elevations reach marks of 355-360 m.

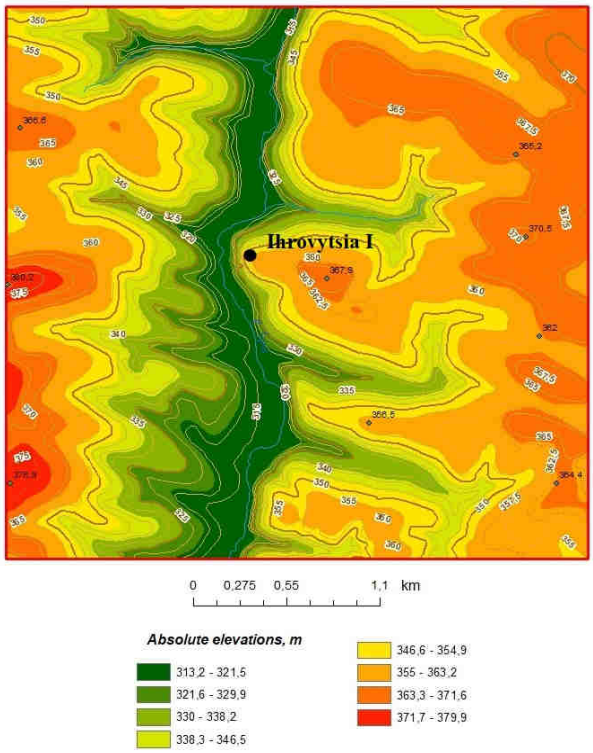

Figure 1 *Digital elevation model of the vicinity of Ihrovytsia I Palaeolithic site*

The study area is typically upland with marks of absolute elevations of 315-380 m. It is quite strongly dissected, which is common for the northern part of Podillya, with flat interfluves and a deeply incised river valley of the Ihra river.

Undoubtedly, among the various types of natural environments of the Earth river valleys are one of the most common in almost all climatic conditions. Ancient people chose the river valleys to settle within. They found protection, and food, and fertile land, and resources for shelter, and ways of moving within the territory here. The valleys of Podillya rivers were not an exception. The Palaeolithic site of Ihrovytsia, together with such well-known and well-studied multilayered Palaeolithic sites as Velykyi Hlybochok, Proniatyn, etc., which are located nearby, according to O. Sytnyk, became part of the Ternopil Palaeolithic Centre (Sytnyk 2015; Łanczont, Madeyska et al. 2014; Łanczont et al. 2015).

Conclusions

The study of landforms and palaeorelief of the area for the needs of geoarchaeology is an integral part of the research, as landforms are one of the most essential natural components that have a determining influence on the settlement of people around the world (Bogucki et al. 2020).

One of the traditional methods of studying the landforms is the morphological analysis, which can be carried out thoroughly and efficiently with the help of GIS.

Based on topographic maps of the area, GIS provides creation and analysis of a wide range of morphometric maps. Among them, the main ones are digital elevation model (hypsometric map), slope aspect map, slope steepness map, vertical (interfluvial dimension) and horizontal (amplitude altimetry) landforms dissection maps, and 3D model of the territory.

Analysis of such a range of electronic maps for geoarchaeological needs allows identifying the causes and main natural factors that influenced the settlement of the ancient people, recreating the ancient landscapes of the study area and performing predictive modelling of archaeological sites, as well as analysing the location of groups of archaeological sites and connections between them.

Acknowledgements

This study partially was supported by the project of National Research Foundation of Ukraine "Development of palaeocryogenic processes in the Pleistocene loess-palaeosol sequences of Ukraine: engineering-geological, soil, climatic, and environmental protection aspects" (project number 2020.02/0165).

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