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THE USE OF 3D GRAPHIC MODELLING IN GEOARCHAEOLOGICAL INVESTIGATIONS (BYKOWSZCZYŻNA ARCHAEOLOGICAL SITE NEAR KOCK, E POLAND)

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Abstract. The objective of this paper was to use the ArcView 3.2 application for spatial modelling of the exploration forms (pits) in the Bykowszczyzna 8 archaeological site. The 3D digital documentation at a specific scale makes possible easy archiving, presentation, and simple spatial analyses of the examined objects. The ArcView 3.2 programme and its extensions (Spatial Analyst and 3D Analyst), commonly used as analytical tools in geomorphology, were inventively used for inventory-making in the archaeological site. Traditional field sketches were only a base, which enables entering data into the programme, and don't documentation material in itself as it used to be. The method of data visualization proposed by the author gives new possibilities for using the GIS platform software.

Keywords: GIS, 3D modelling, data archiving, geomorphology, archaeology

Introduction

On account of a planned investment of the Kock ring road on the Siemiatycze – Lublin – Nisko trunk road No 19, in 2009 the Bykowszczyzna 8 site was qualified (together with three other sites) to the programme of rescue archaeological investigations. After preliminary survey, the area of 1.64 ha was selected for detailed investigations, and it was enlarged up to 1.84 ha during the excavations. The discovered objects and collected artefacts are related to the prehistoric period, Middle Ages, and modern age (XVI-XVIII c.), which indicates the occurrence of multicultural settlement in the examined area (Dzieńkowski et al. 2009).

The successive stages of excavations were documented using traditional archaeological methods, i.e. mostly by drawing field sketches and taking photos. Modern digital methods of data processing with the use of the GIS software and global positioning systems (GIS) which are widely used in geomorphology, in the author's opinion can be also successfully applied in archaeological investigations as analysis, archiving and presentation tools. Such way of documentation was proposed for the Bykowszczyzna 8 site. The documentation carried out by archaeologists was used to generate digital image of the site and selected objects. This technique turned out to be useful and the obtained digital images were used as archiving material

Study site

The Bykowszczyzna 8 site is situated in the Firlej district, Lubartów county, Lublin province. Its geographical position is defined by coordinates $\varphi 51^{\circ}36'35''\text{N}$, $\lambda 22^{\circ}27'57''\text{E}$. According to the physiographic division of the Lublin province (Chałubińska, Wilgat 1954) the site is situated in the Mazowsze (region of second order), which belongs to a region of first order – the so-called Great Valleys Land (Fig. 1). The site is located in the Wieprz pradolina geomorphological unit, in the marginal zone of the Warta ice sheet, on the higher terrace of the Wieprz River, about 2.5 to 3.5 m above the river channel (Dobrowolski 2009).

From a historical perspective the area under study once belonged to the not existing today Rozwadów village and its northern part was within the Wola Skromowska, which was the property of the Skromowski family since the 16th century, and in the second half of the 17th century also of the Chrościkowski family. These facts are noted in the conscription register of the Lublin county from 1531 y. A grange built to the west of the village at the turn of the 19th and 20th centuries adopted the name of village after its disappearance. The area was settled again under the name Bykowszczyzna in the years 1937-1938

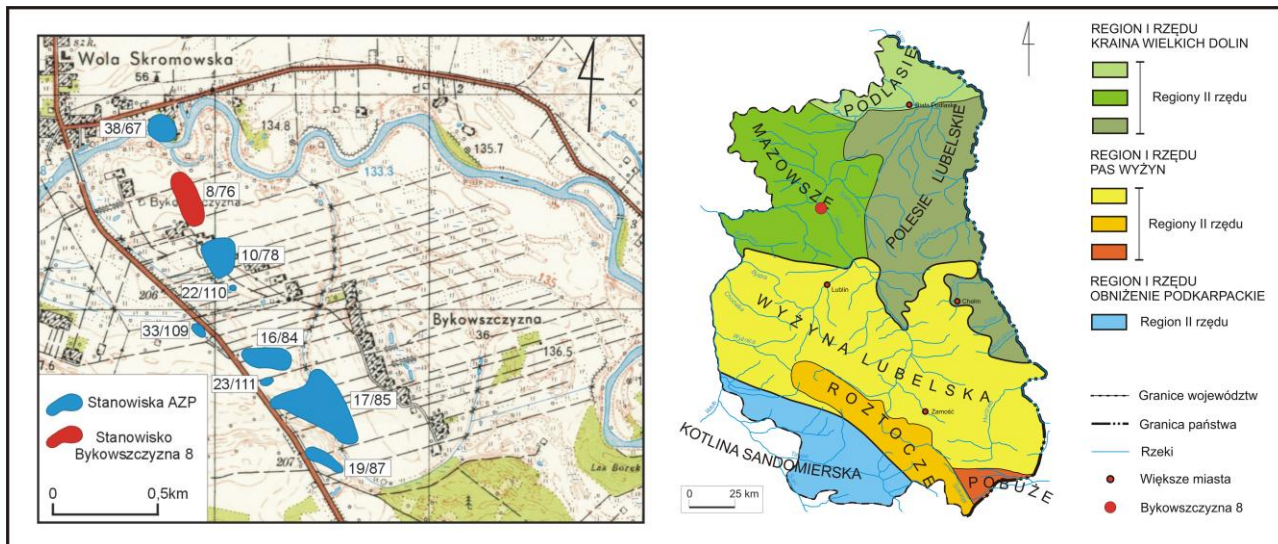


Fig. 1. Location of the Bykowszczyzna 8 site against a background of: A) topographic map 1:25 000, 125.42 sheet, with the location of archaeological sites along the planned Kock ring road (according to Dobrowolski 2009); B) physiographic units of the Lublin province according to Chałubińska and Wilgat (1954)

Methods

Rescue archaeological investigations

The rescue archaeological investigations started with a preliminary field preparation of the area selected for them. The area was covered with the so-called “are grid” (Fig. 2), and 252 fields were outlined in this way. Humus layer was removed from their surface, which was levelled by hand.

The main stage of the excavations was exploration of objects found in the settlement layer (Photo 1). The

removal of material filling the objects left specific exploration pits in the site area, which were documented together with the discovered artefacts. The archaeological investigations were conducted in the successively numbered, one-acre fields grouped into belts. The pits, which were the negative pictures of the objects’ infillings, were measured with the use of geodetic equipment (optical total station) and documented in the form of sketches (Fig. 3) and photos (Photo 1), and then they were filled in. Each sketch of an object consists of its plan and vertical section.

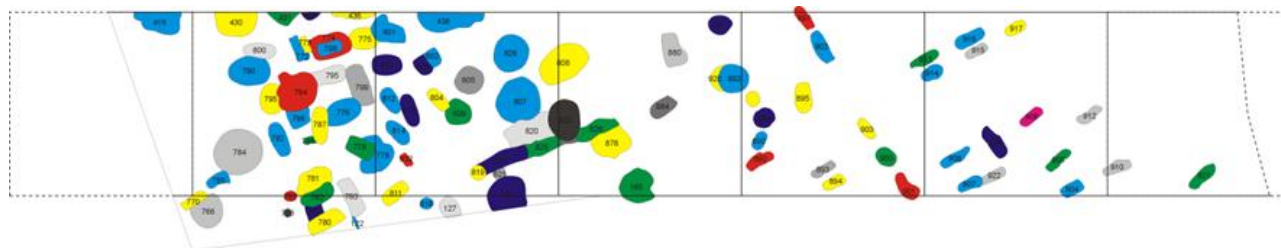


Fig. 2. Plan of analysed objects (21-27) in the belt No 4.



Photo 1. Object No 401. The example of typical storage pit from the grange (Photo by T. Dzieńkowski)

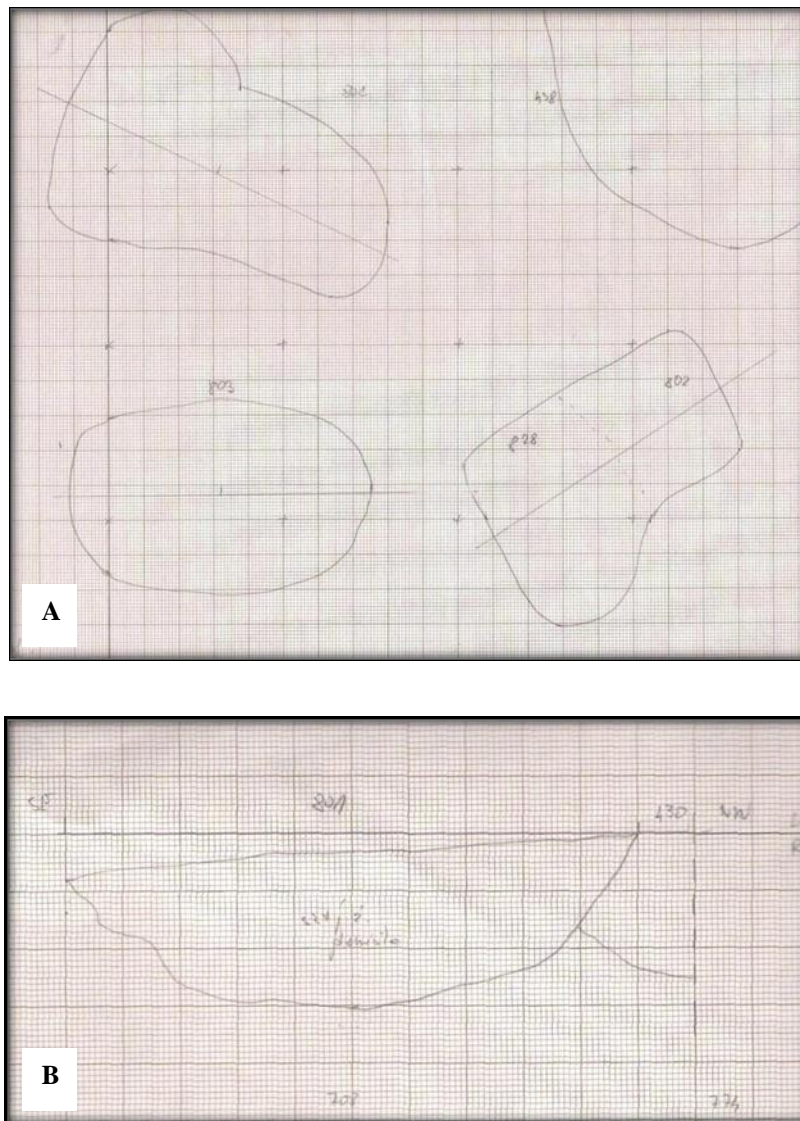


Fig. 3. A fragment of field sketch with the plans of selected objects (A) and the vertical section of the object No 801 (B) (Dzięnkowski 2009).

Methods of digital archiving in the ArcView

A Digital Elevation Model (DEM) can be created in several ways (Magnuszewski 1999). Weibel and Heller (1991) describe three methods: Digital Line Graph (DGL), Triangulated Irregular Network (TIN), and Regular Raster Grid (GRID). In this work the TIN method was used, which combines the good points of vector and raster recording, so the digital record is precise and volumetrically economical (Czyżkowski 2006). Moreover, the TIN method turned out to be optimal for the modelled pits, which are characterized by almost vertical walls. The processing of point data into the layer of continuous data can be spatially carried out in two ways: by the Spline and Inverse Distance Weighted (IDW) methods (Czyżkowski 2006). The Spline method (of glued functions) generates the surfaces so as to obtain the best mutual fitting of their fragments. In the IDW method the resultant grid cell values are calculated (Czyżkowski

2006). In this work, after analysis of the preliminary results, the Spline method has been recognized as the one giving better results.

In order to create the spatial image of exploration pits, their distinctive points (transferred from the plans and vertical sections) were loaded into the programme, and an isohypse drawing was obtained. The nature of spatial data contained in these field sketches (small number of measured points) required some corrections during the digitizing process. The correction was mostly applied to the isohypse drawing, which required the removing of inessential fragments. It was also necessary to change the values of adjacent isohypses in order to obtain steep, almost vertical walls of the object model. This stage of work required some intuition and spatial imagination, which conditioned a correct, as near as possible to reality, result of modelling.

The final stage of modelling was generation of spatial image of the objects under study, and creation of a

range of colour. The Spatial Analyst and 3D Analyst programme extensions make possible the complete edition of 3D image, and also the presentation of the objects in different planes.

Results

Field measurements, sketches and photos carried out by archaeologists were the database for 3D graphic modelling using the ArcView 3.2 programme. Several spatial models were made on three levels: for belt No 4 (Fig. 4), field No 22 (Fig. 5), and object No 801 (Fig. 6). The Spatial Analyst and 3D Analyst extensions enable image edition both as shaded plans of forms (Figs 4A, 5A, 6A) and 3D visualizations oriented in different planes (Figs 4B, 5B, 6B). The used range of colour and putting the objects

in calibrated space give the possibility of easy reading of morphometric features of the objects, and carrying out of spatial analyses (e.g. calculation of area and volume of an object).

The belt No 4, which consists of 7 fields (Figs 2, 4) was presented in detail. The shaded plans of forms and 3D visualizations were made for the whole belt, for the fields No 22, 23, 24, 25, 26, and for the selected objects No 901, 805, 822/802, 907/922. The object plans were accurately reconstructed during the modelling of the belt, while the third dimension was generated from several points marking the relief of form bottom.

The particular objects (pits) were presented with higher resolution if the number of points used during modelling was higher

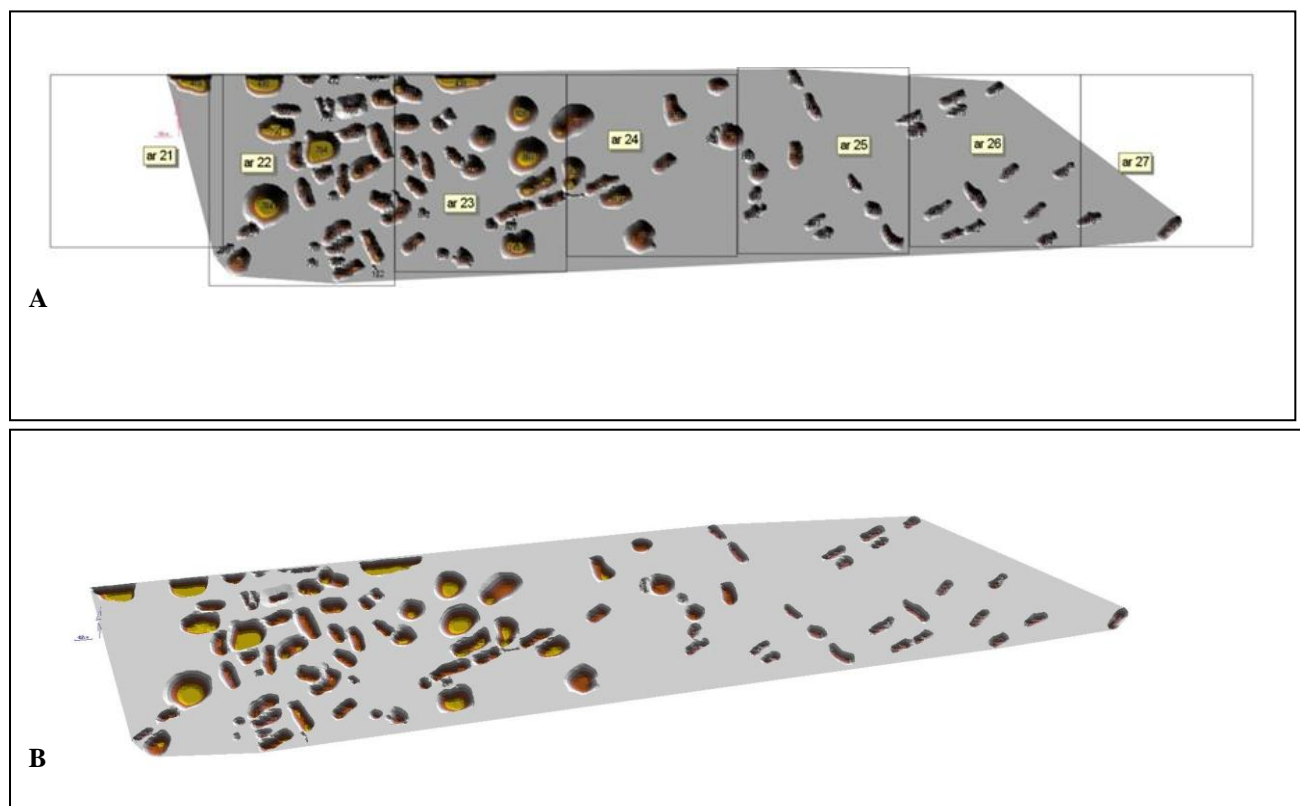


Fig. 4. Hypsometric plan of the belt No 4 (A) and its 3D visualization (B).

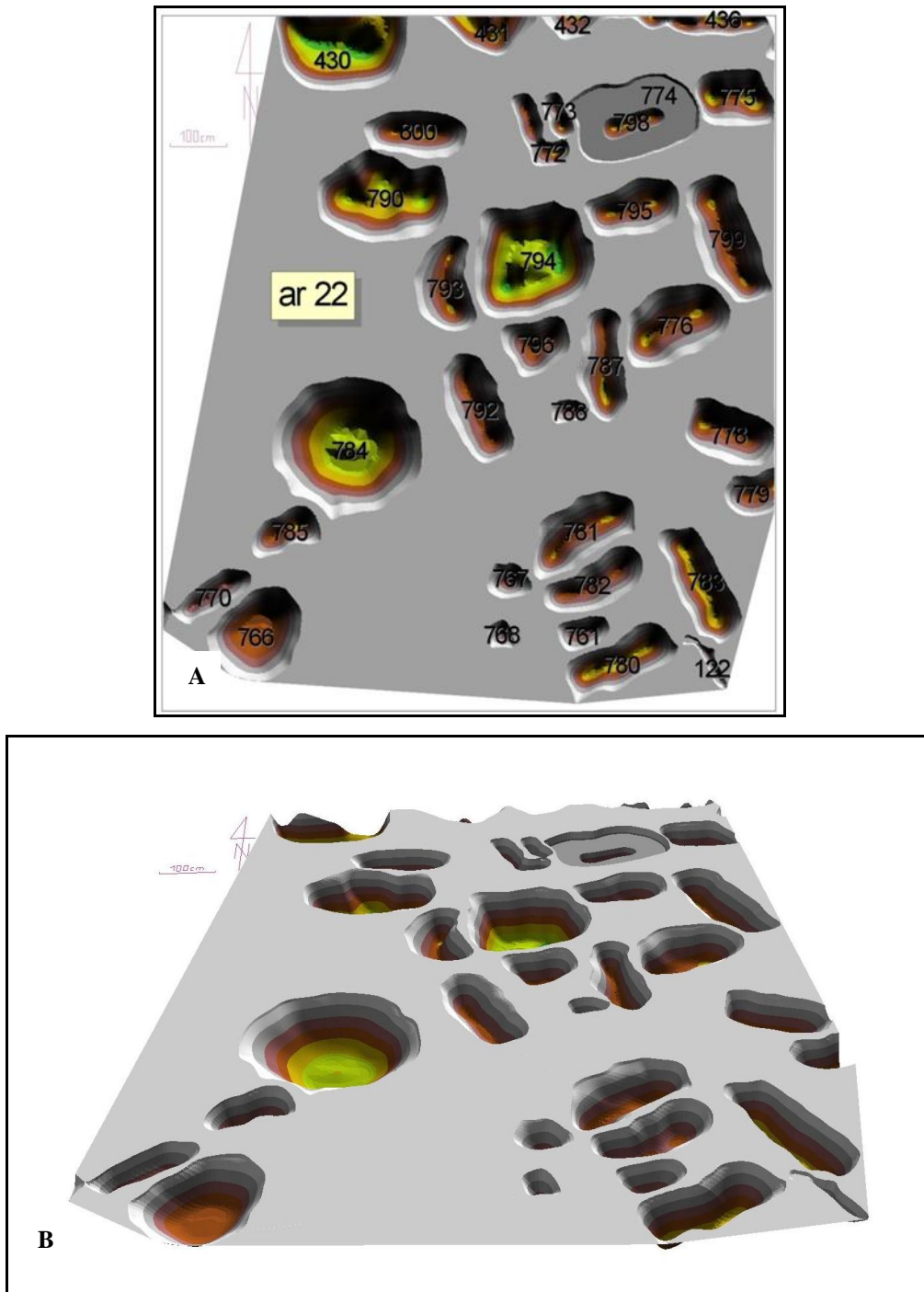


Fig. 5. Hypsometric plan of the field No 22 (A) and its 3D visualization (B).

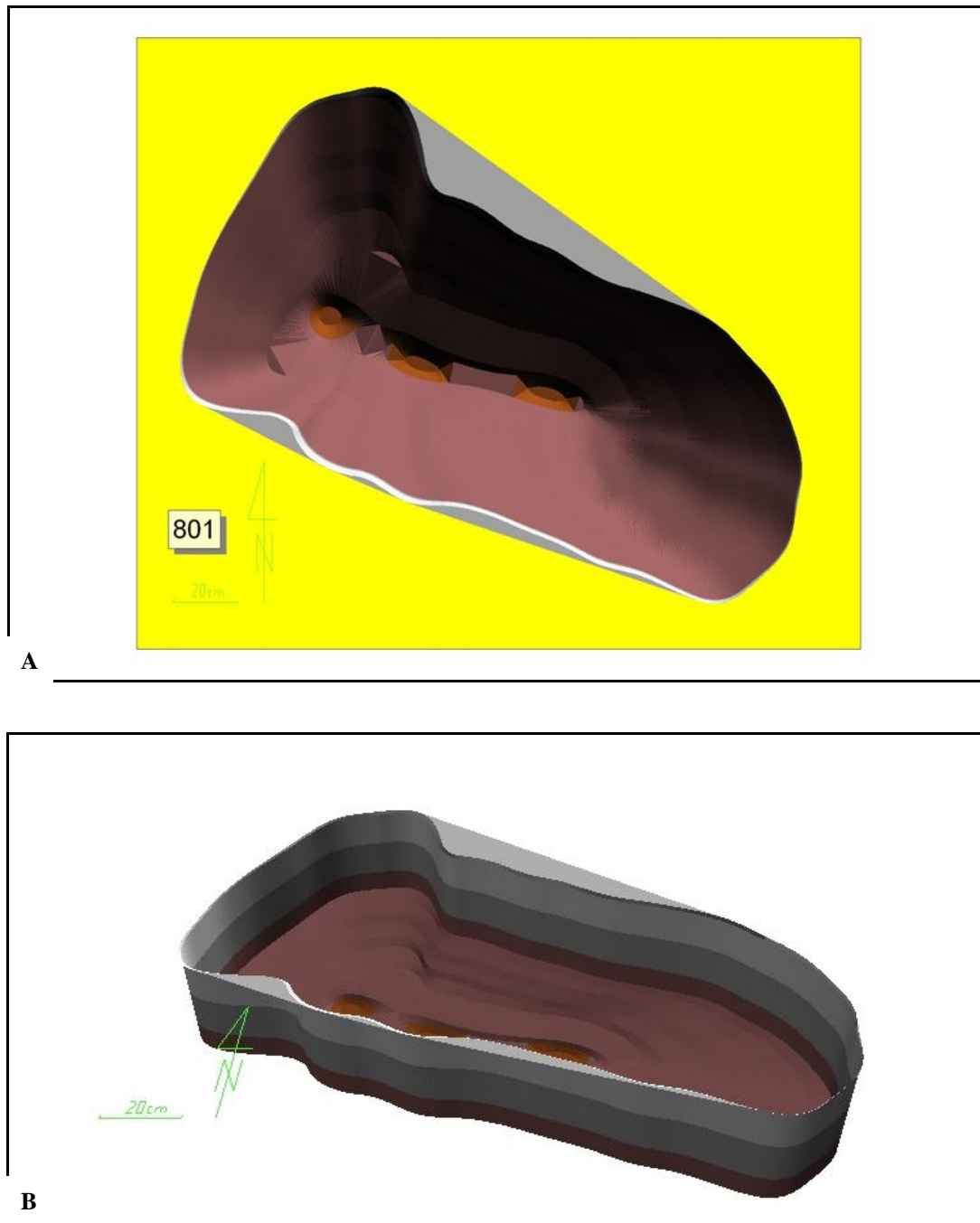


Fig. 6. Visualizations of the object No 801 based on the data read from the field sketch: hypsometric plan (A), and 3D visualization (B).

Final remarks

The ArcView 3.2 software, commonly used in geomorphology, is presented in this paper as a tool supplementary to traditional archaeological methods of documentation. Based on digitally processed spatial data, numerous spatial analyses can be made. The supplementing of database with information obtained using the GIS provides quick orientation in space. Working in calibrated space enables us to put the objects in a specific frame of reference, which is the precondition for the correctness of the spatial analysis results (calculation of plan and real surfaces of an object or its volume). The project is an in-

ventive proposal of using GIS tool archaeological inventorying works, which considerably enhances the possibilities of cooperation between geographers and archaeologists

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Abstrakt

W artykule zaprezentowano projekt wykorzystania aplikacji ArcView 3.2 w modelowaniu obrazu form eksploracyjnych na stanowisku archeologicznym Bykowszczyzna 8. Stanowisko zostało objęte programem ratowniczych badań archeologicznych w związku z budową obwodnicy miasta Kocka na trasie krajowej nr 19 relacji Siemiatycze–Lublin–Nisko. Zasadniczy etap prac archeologicznych na stanowisku Bykowszczyzna 8 obejmował pozyskanie oraz inwentaryzację materiału zabytkowego wypełniającego formy. W wyniku wybrania tego materiału, w obszarze stanowiska pozostają charakterystyczne jamy gospodarcze, które stanowią negatywny obraz wypełnienia formy. Kształt jam jest dokumentowany w postaci szkiców oraz fotografii. Dokumentacja ta stanowi punkt wyjścia procesu digitalizacji (materiał źródłowy). Treścią artykułu jest sporządzenie cyfrowej dokumentacji zawierającej plany stanowiska w kilku poziomach szczegółowości (dla pasa, pola oraz pojedynczych form) oraz wygenerowanie modeli w standardzie 3D. Dokumentacja taka umożliwia łatwą archiwizację oraz czytelną prezentację wybranych obiektów. Możliwe jest również wykonanie analiz przestrzennych. Funkcje programu ArcView 3.2. oraz jego rozszerzeń: Spatial Analyst i 3D Analyst wykorzystywane jako narzędzia analityczne w geomorfologii, w sposób nowatorski zostały zastosowane w pracach inwentaryzacyjnych na stanowisku archeologicznym. Wykonywane tradycyjnymi metodami szkice terenowe, są w tym przypadku tylko podkładem umożliwiającym wprowadzenie danych do programu, a nie jak dotychczas materiałem dokumentacyjnym samym w sobie. Zapropionowana przez autora metoda wizualizacji danych, daje nowe możliwości wykorzystania programów środowiska GIS oraz jest kolejnym krokiem w dziedzinie współpracy geografów i archeologów.

Słowa kluczowe: GIS, modelowanie 3D, dane archiwalne, geomorfologia, archeologia