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RESEARCHES REGARDING THE USE OF G.I.S. TECHNOLOGIES IN MODELLING AND SPATIAL ANALYSIS OF THE VARATEC MINING COMPLEX, MARAMURES COUNTY

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Abstract

The purpose of this paper is to use GIS techniques for the modelling and spatial analysis of Varatec mining complex, Maramures County. The practical result of this paper, consists in the creation of the GIS database and the integration into it of maps and plans from the mining complex. A spatial analysis of a mine field is based on the effectiveness of a GIS database which will lead to 3D modelling and the representation of the topography. Among the parameters used will be slope and slope orientation or aspect because the slope determines the intensity and type of processes that model the substrate ground, and the slope orientation leads to the evolution of geomorphological processes due to climatic factors that are not evenly dispersed over the land area: solar radiation, sun exposure, precipitation and temperatures. Regarding the mining exploitation, an important element is the land use category, which was taken over by expeditious methods from the L-35-013-A-a Orthophotoplan. Another desirable aspect in this case study is the integration of the general plan from Varatec mining complex into the GIS database and spatial modelling, but also making thematic map on the main geological layers in the Varatec mining complex in order to highlight the applicability of GIS technologies in mining. The various modifications and the evaluation of the subsidence processes within the mining complex can be analysed over the years through remote sensing methods, but especially during the period when the mining complex was closed following the closure action organized by CNMPN REMIN.

***Key words**: GIS, mining, modelling, spatial analysis.*

INTRODUCTION

Situated approximately in the centre of Maramures county (Figures 1 and 2), the Varatec mine, near the Varatec peak, 1351 m high was closed by CNMPN REMIN in 2006 according to the Decision no. 644/2007 approving the final closure and monitoring the environmental factors after the closure of some mines and quarries, the 10th stage (www.remin.ro).

This paper will use the Varatec mining field as a case study in GIS modelling.

Mine is the unit production of a mining enterprise which, through its mining works and facilities, provides for the extraction of useful minerals, aeration, illumination and water evacuation. There are 3 types of deposits (Covaci St., 1972):

1. Group I include deposits and the known parts of them, with a simple structure and a constant thickness.
2. Group II includes deposits with a more complicated structure of variable thickness, in which the determination of the reserves from A category is more expensive.
3. Group III includes very complicated fields with very variable thicknesses.

Mining topography is closely related to geographic information systems or GIS as it helps to manage the mining activity by integrating the results into a database that can easily be accessed by a user. An efficient management is based on technical information, including topographical ones; an effective technical data management tool is represented by a geospatial database such as the Geographic Information System (Manu C.S.).

It is possible to quantify the novelty of the present paper because it enrols in the current trends regarding the mining management.

MATERIALS AND METHODS

Figure 1. Framing the study area: Maramures County and the contour of Varatec mine complex

The general plan of the mine contains all mining works from all horizons of exploitation or research and in all layers, with stratigraphic and tectonic details opened by sterile and useful works. There are not shown the short-term preparatory work, such as: risings, training, pre-essays, channels, etc. on this plan (Radulescu et al., 2017). From this plan, there are eight galleries, a blind pit and over 30 risings.

Figure 2. Varatec Mine

Galleries are horizontal mining works with a slope of less than 7s/1000m, much longer than the cross section. It is used for transport, ventilation, water evacuation, piping installation, electrical cable installation, etc. (Popa A. et al., 1986). Types of galleries: Coastal galleries digging into a hillside (mountain) to open a reservoir. Depending on the angle they make with the direction of the deposit, they can be transverse (perpendicular to the direction of the deposit), directional (in the direction of the deposit, or parallel to it) and diagonal (making an angle with the direction of the deposit). The tunnel is a horizontal mining work, which has two exits on the opposite slopes of a hill or mountain.

The puncture gallery (or the crossing gallery) is transversely cut from the bed to the roof of the deposit.

The pre-work gallery is executed in the deposit, depending on the method of exploitation chosen (Popa A. et al., 1986).

According to the general plan of the mine, there are: the Varatec transversal gallery, the Babeica transversal gallery, the coastal gallery I, II and III, the Jelenszki gallery, the Borcut gallery and other 1090 gallery.

Risings are executed after puncturing the deposits with cross-galleries. Are mining works less inclined than pits, with two or three compartments (exploration or exploitation) and linking two horizons, compartmenting the deposit in panels. It is used for research as well as for exploitation (Aron et al., 1986).

Blind pit makes the connection between two or more horizons without having an exit (Lețu et.al., 1986).

RESULTS AND DISCUSSIONS

GIS modelling and spatial analysis will take into account certain parameters such as slope, slope orientation, land use category and mine horizons.

1st Parameter: Slope

Based on the digital elevation model of the mining field, the slope of the terrain was calculated. As can be seen in Figure 3, the mining field has a slope that exceeds 35 degrees. It is an important parameter because slope determines the intensity and the type of processes that model the substrate ground, determining the stability of the whole mine.

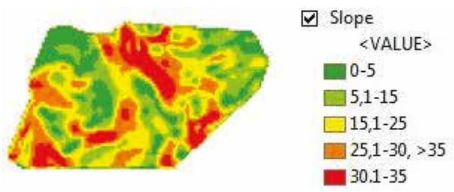

Figure 3. Slope

2nd Parameter: Slope Orientation

Based on the digital elevation model of the mining field, the slope orientation was calculated as seen in Figure 4. This parameter leads to the evolution of geomorphological processes due to climatic factors that are not evenly dispersed over the land area: solar radiation, sun exposure, precipitation and temperatures, very important to consider in the preparation and opening of the minefield.

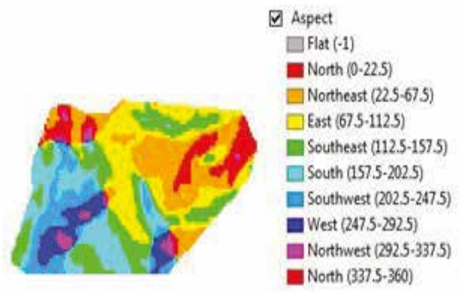

Figure 4. Slope orientation

3rd Parameter: Land use in the mining complex

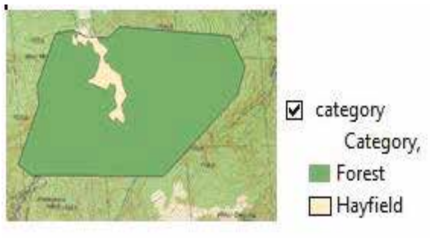

Figure 5. Land use in Varatec Mine Complex

Figure 6. Orthophotomap L-35-013-A-a and the contour of the mine

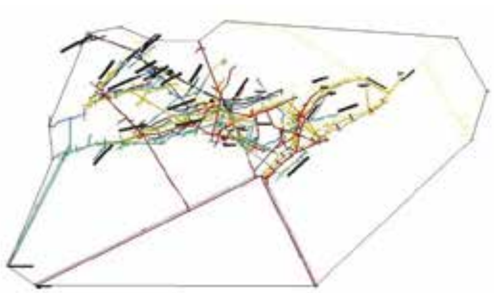

Figure 7. The horizons the mine

It is made through expositive methods directly on Orthophotomap L-35-013-A-a (Figure 6). First of all, the Orthophotomap was georeferenced in ArcMap, a new polygon shape file was created and edited and the result can be observed in Figure 6. 10% of the mine complex is hayfield and 90% forest as seen in Figure 5.

Horizons of the mine

The horizons of the mine vary as follows: there are horizons on the surface and underground at different levels ranging from +70 meters and –295 meters (Figure 8).

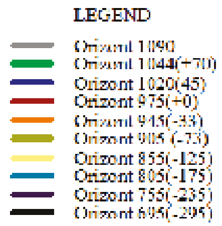

Figure 8. Horizons of the mine, between +70 and -295 m

In order to create a topographic map in ArcMap a hill shade and contour lines must be created.

A hill shade is a greyscale 3D representation of the surface, with the sun's relative position taken into account for shading the image (Figure 9).

This function uses the altitude and azimuth properties to specify the sun's position (http://desktop.arcgis.com/en/arcmap/10.3/manage-data/raster-and-images/hillshade-function.html).

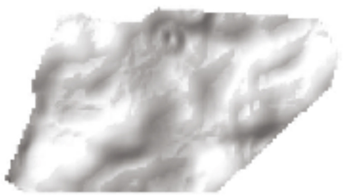

Figure 9. Hill shade

The contour lines for topographic map can be seen in Figure 10. Because the altitude in the mining complex is between 861 and 1351 meter, there are intermediate lines and index lines (thicker) that go from 900 to 1300 meters, at 100 meters interval.

Figure 10. Contour lines

Based on the contour lines, a TIN (Triangular irregular networks) surface is created. It has been used by the GIS community for many years and are a digital means to represent surface morphology. It is form of vector-based digital geographic data and are constructed by triangulating a set of vertices (points). The vertices are connected with a series of edges to form a network of triangles (http://desktop.arcgis.com/en/arcmap/10.3/manage-data/tin/fundamentals-of-tin-surfaces.htm). TIN created only for the Varatec mine complex can be observed below, in Figure 11 with the elevation distributed in 8 classes.

Figure 11. TIN surface

CONCLUSIONS

This paper work was aimed at accentuating the importance of GIS in mining works. Before starting such work, there are some factors that should be taken into consideration and this type of spatial analysis can be achieved with GIS in order to estimate the degree of land degradation.
In order to quantify the value of the probability of degraded land, Government Decree 447/2003 proposed a method that refers to an analysis of quantitative and qualitative terms. The model validation is possible using morphological and morphometric parameters derived from digital elevation model (DEM) (Petrea et al., 2014).
Overall, the maps and plans integrated in a database can easily be consulted by a user.

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