

Assessment and Mapping of Georisk in Mining Areas Above Abandoned Chrome Mines in Albania



Engineering

KEYWORDS : georisk, susceptibility, vulnerability, mapping, land use, parametric model, GIS.

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ABSTRACT

The major influence of underground abandoned exploitations in chrome mining areas in Albania are categorized as sinkholes, block caving and sometimes progressive hanging walls. These forms mainly relate to the sublevel open stopping mining method used, leading to the self-collapse of surrounding rocks located in the roof of the mineral body. Depending on the thickness of exploitable ore bodies, the thickness of the bedrock, the thickness of the diluions and the size of underground cavities, there is a substantial impact on the ground surface or an extended zone of movement and collapse within the rock mass. Their appearance on the ground surface endangers the lives of people and animals, and may also damage the environment, or have an impact on the various facilities that occupy the surface of the mining region. As a result of this phenomenon, studies have been conducted in order to evaluate the potential impact and locations of upcoming sinkholes or subsidence in order to take the appropriate measures as to remove the objects from these areas, as well as the prohibition of the movement of people in the areas declared dangerous. In order to increase the security level of human activity on the ground surface and to realize a more effective use of land in the affected areas, studies have been conducted on the assessment of susceptibility of abandoned mining exploitations, classifying it into 5 classes. In this study, based on the intensity of susceptibility and the rate of vulnerability, the geo-risk is estimated and the mapping is performed using GIS technology.

INTRODUCTION

Construction of georisk maps is a very important basis for urban planning and land use. Two components of georisk, assessment of susceptibility intensity and classification of vulnerability of buildings, have become the subject of numerous studies [1], [2] in order to obtain the ranges of georisk intensity. The georisk analysis is intended to perform the prognosis of the risk expectations and the forecasting of the expected damages by introducing the concept of acceptable risk [3]. In mining areas of chrome exploitations in Albania land is occupied mainly by industrial objects related to the process of exploitation (mine entries, mineral processing plant, warehouse explosives, roads for transporting the ore, sterile deposits, etc.), administrative buildings (administration offices), social and cultural facilities (cafeteria, the workers' dormitories, cinemas, libraries, etc.), natural objects (streams, forests, pastures) [2]. Following the abandonment of the underground exploitation, ground installations are also abandoned. The lack of projects for the reuse of these areas, mainly during the period 1990-2005, had also resulted in a lack of attention to the damage caused by the impact of underground abandoned exploitations. After 2005, due to price increases of chrome in the international market, in almost all of Albania's chrome mines, the exploitation activities restarted, aiming the use of chrome reserves that were previously considered as technologically unprofitable. In these circumstances, it has become necessary to conduct a georisk analysis in the mining areas and to map it, by first estimating the susceptibility (probability of occurrence of risk) as well as the vulnerability of buildings that should be protected in the ground surface [4], [5], [6]. The effect of abandoned mining exploitations on the ground surface is calculated through the method of indexing, based on the mapping of influencing parameters (5 influencing parameters) and the weighting of their impact on the assessment of susceptibility [2]. The method is performed by mapping the surface of relief, the contact surface between diluions and the bedrock, the contact of bedrock with the ore body and the contact of ore bodies with the rock floor, which are the main parameters affecting the form and the nature of occurrence of the impact of underground exploitations in the ground surface in the area of chrome exploitations. The constructed model is verified by the very good agreement between the prediction and the sinkholes that occurred in the area with very strong susceptibility [7]. This product (Fig. 1) is modelled using GIS technology (parametric model) that allows us the evaluation of degree of risk on the various facilities that occupy the ground surface of the mining area.

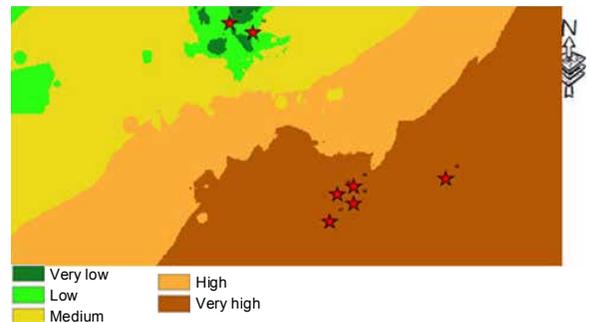


Figure 1: Susceptibility map and the sinkholes that are present in the area (study area) [7].

Vulnerability is evaluated through mapping the objects in the mining area, while the product "georisk map" is obtained by processing via the "ModelBuilder" module of ArcGIS [8], [9], using as input maps of susceptibility and raster maps of land use.

CREATING AND PROCESSING THE DATABASE

To create the database associated with the susceptibility, the method of indexing based on the mapping of influencing parameters is used [2]. For all chrome mines in Albania there is a full graphic documentation that it was used to digitize points for the construction of relief surface, the contact between the diluvional rocks and the bedrocks, the contact between the bedrock and the roof of the ore body and the contact between the floor of the ore body and the surrounding rocks. These points are memorized in "feature Class" type "Point" within a "Personal Geodatabase". These are the "Input" parameters to a "ModelBuilder" where through geoprocessors IDW (Inverse Distance Weighted), "Reclassify" and "Weighted Overlay" (Fig. 2) the susceptibility map is obtained (Fig. 1).

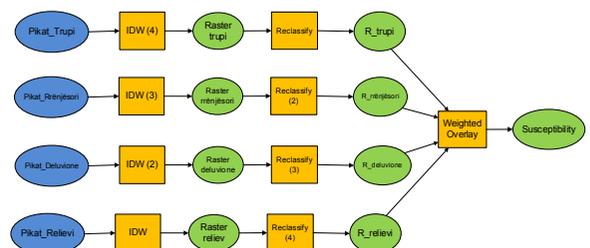


Figure 2: Parametric modelling for the assessment of susceptibility.

The creation of data for the vulnerability is related to the construction of the map of land use. In Albania, for this purpose, orthophotos with a 35 cm minimum pixel resolution can be used (2007 edition). This is influenced by the fact that on the ground surface above the abandoned mining exploitations, no building activities are conducted, consequently the situation in use of land has remained unchanged. The resumption of the activity of underground mining operations in chrome mines, results in an increase in the risk level, because within the area affected from the previous underground operations the stability observed through time is deteriorated. This fact is reflected through the calculation of the susceptibility.

To concretize the acquisition of data related to the vulnerability, it is considered the fragment of mining area of Bulqiza chrome mine shown in Figure 3.

Facilities identified in this region are typical for all areas located above abandoned underground mining exploitations of chrome. This has been specifically identified:

- Piles of mining waste;
- Objects in activity;
- Formally abandoned objects, but informally in use: for example to deposit the chrome ore collected from the old waste piles;
- Facilities and parking places for vehicles;
- Abandoned objects;
- Motorways;
- Natural terrain (with a sparse or dense forestation).

Based on the orthophoto of the area, the map of the land used was constructed (vector format) (Fig. 4). The data was memorized in a "Feature Class" file of type "Polygon" within a "Personal Geodatabase" in which the raster formats of graphic documentation of the mine were also memorized. All records for points and surfaces, fault lines as well as the polygons for the underground mining workings were obtained by digitizing the graphic documentation.



Figure 3: Fragment from the orthophoto above the abandoned mining exploitations in Bulqiza mine.

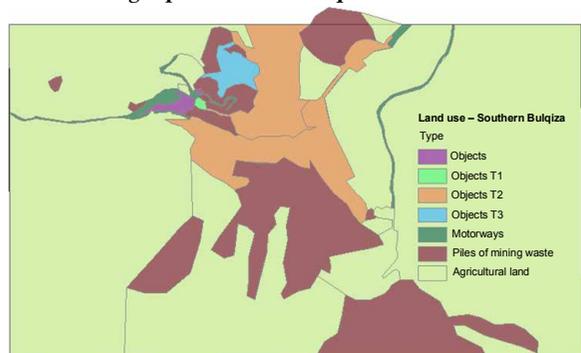


Figure 4: Mapping and identification of objects above abandoned mining exploitations

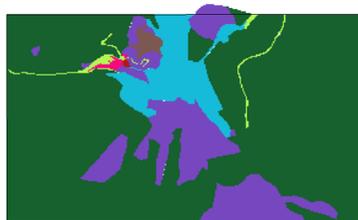


Figure 5: Raster format for land use and the classification in 7 groups.

The vector format built for mapping and identification of objects was converted to raster format, where the objects are classified into 7 groups (Fig. 5).

INDEXING VULNERABILITY

Given that the vulnerability has to do with the extent of expected damage corresponding to a certain level of susceptibility, we consider that the qualitative categorization of vulnerability for facilities present in the raster map of land use can be given as follows:

- Very low (natural terrain, group 5);
- Low (definitely abandoned objects, group 3);
- Medium (piles of mining waste, group 0)
- High (formally abandoned objects, group 4);
- Very high (objects in activity, parking places, motorways, groups 1, 2, 6).

GEOPROCESSING OF PARAMETERS FOR OBTAINING A MAP OF GEORISK

To build a map of georisk both inputs are used:

Map of susceptibility;

Map of land use.

The processing was conducted using geoprocessor "Weighted Overlay".

The weighting of the above mentioned two parameters was completed based on two statements:

The stronger the intensity of susceptibility and the higher the degree of vulnerability are, the stronger the georisk is;

The susceptibility, as well as the vulnerability have the same impact weight on the georisk measure.

The parametric model built adding both mentioned factors is given in Figure 6 and the obtained maps of georisk are presented in Figure 7.

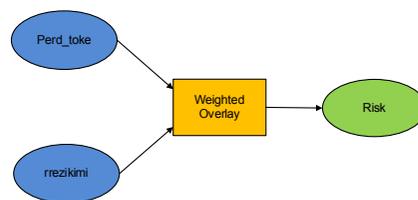


Figure 6: Geoprocessing of parameters for mapping the georisk intensity



Figure 7: Map of georisk for the study area

CONCLUSIONS

The areas above abandoned underground mining exploitations in chrome mines in Albania are vulnerable to the appearance of sinkholes, block caving and sometimes progressive hanging wall caving.

Resumption of mining activity in the abandoned mines resulted in the reactivation of the influence on the ground surface.

Abandoned objects, as well as new ones, are at risk of damage due to the reactivation of mining exploitation process, therefore it is necessary to perform the risk assessment by considering the degree of vulnerability of buildings.

The creation of georisk maps for mining areas above abandoned exploitations assists in the decision making in order to reduce or eliminate the damage to objects in vulnerable areas.

The use of GIS technology in the assessment of susceptibility and creation of georisk maps requires standardization of data, this is also in the interest of their use for purposes of other studies.

The method of indexing of influential factors that affects the damages on the ground surface and the degree of risk on the facilities is realized through the geoprocessing of parameters. Created models are parametric ones and can be used for each case by accepting a set of input parameters and using output parameters as input in a recursive way till the generation of the final result.

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