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POSSIBILITY FOR APPLICATION OF GIS TECHNOLOGIES IN RTB BOR GROUP

Abstract

Modern mining is characterized by highly mechanized production, large – scale projects with huge amounts of mined ore and waste, large areas influenced by mining works, large tailings and waste deposits, deep underground mines, constant development of existing and introduction of new technologies, huge influence of global financial and market trends to economy of mines and obligations related to environmental protection. On the other hand, development of IT sector enabled application of advanced systems for management of spatial data and their integration into common spatial information system – GIS.

Main goal of introducing GIS into RTB Bor Group is to improve the processes of mineral resource management and create spatial information system of the copper mines with a geobase, with information from spatial plan documentation, as well as visualization of all graphic and alphanumeric data from geo-database, using GIS portals and Web GIS. Application of GIS system would enable simpler and more comprehensive approach to information in the areas of geological explorations, mining, mineral processing and metallurgy, all included in RTB Bor Group.

***Keywords**: mining, GIS, spatial data, geobase*

1 INTRODUCTION

Development of geoinformation technologies enabled the application of advanced systems for spatial data management and their integration into unique spatial information system – GIS (Geographic Information System). By general definition, GIS represents a "…computerized database management system for capture, storage, retrieval, manipulation, analysis and display of spatial (i.e. locationally defined) data" [1].

GIS is a technology that combines location of natural and artificial objects (their spatial elements), with different types of information (descriptive spatial elements), thus forming a unique system of spatial data base – geobase [2]. GIS technology integrates usual operations on geo databases, such as searches, queries or statistical analyses, with unique advantages of visualization and spatial analysis given by plans. Significant advantage of GIS is connection of descriptive, alphanumeric, nonspatial data with spatial data and provides their analysis, processing and presentation.

GIS consists of four interactive components: subsystem for data entry, which converts maps and other spatial data into digital form (data digitalization), subsystem for data storage and queries, subsystem for analysis and export system for map plotting, creating tables and responding to queries. Digital model includes spatial and descriptive images of reality and provides a base for operation and communication between users (Figure 1). Spatial images define shape, dimensions and location, i.e.

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geometric properties. Spatial images of reality can be well and concisely presented in a form of graphical presentation, while descriptive aspects, in many cases, are better represented by text and numbers. Graphical presentation enables better understanding of real situation, thus providing high level of abstraction, or description of connections with adjacent objects, while textual – numerical presentation is more suitable for aspects that cannot be described graphically. Digital model has to enable connection of these two presentations.

Main concept of physical implementation of geospatial data is to create simple and undisturbed flow of spatial data to geo databases, where they are stored, and to user. That flow requires corresponding network and technical infrastructure, designed in accordance with norms and standards [2].

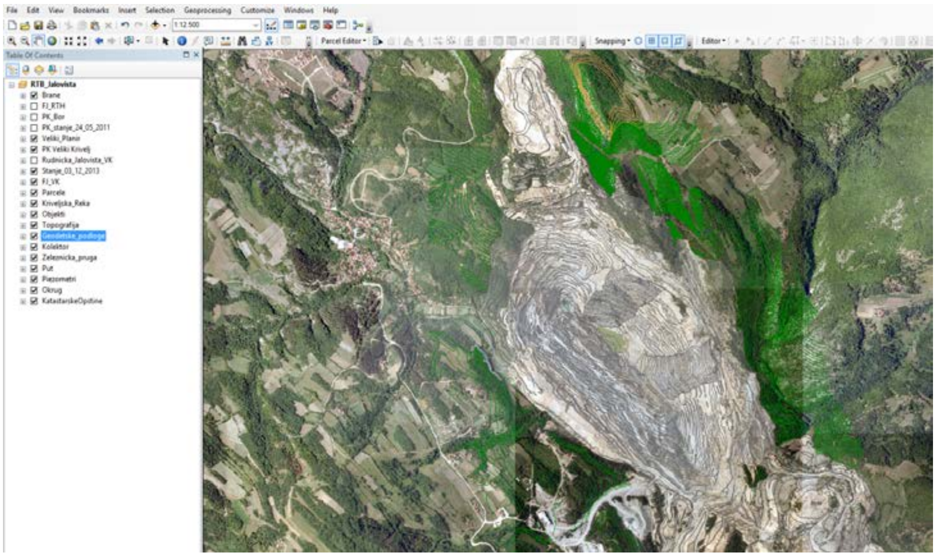

Figure 1 *Digital model of Veliki Krivelj open pit*

ESRI created one of the most complex GIS platforms, ArcGIS® [3, 4]. This integrated family of software provides all the functions needed for design of spatial information system. ArcGIS contains number of software, adjustable to a single or multiple users, on desktop computers, servers, via web connections or on remote devices.

2 MODELING OF SPATIAL DATABASE – GEOBASE

Spatial database or geobase is a basic component of GIS. Geobases represent a collection of geographic data of different types, stored into a catalogue of database system, or a base of management system for related databases, such as Oracle, IBM DB2, PostgreSQL, Infomix, Microsoft SQL Server, etc. More precisely, geobase a collection of logically related data, including: attributes (data for numerical or textual description of geographic entity), geometry (data that define shape, size and spatial layout of the entity) and topology (data that define relations between different geographic entities) [1].

Consequently, there are three main groups of data in GIS: vectors, attributes and raster. There are three main ways to create a geobase. If collections of spatial data that should be included into a common base are already available in some of acceptable formats, then these data are simply imported into a new database. ArcGIS enables import of data from traditional relation databases, XML and Excel documents, as well as vectors from AutoCAD or other CAD software.

3 GIS SOLUTIONS IN MINING

Advantages of Geographic Information Systems (GIS) are modestly used in Serbian mining. On the other hand, increasing complexity of engineering tasks creates a need for computer tools able to provide quality technical support in order to fulfill monthly and annual plans. Main goal of establishing GIS solutions in mining is to improve the process of mineral resources' management and to form a spatial information system of the mines with a geobase, where all the information from maps and documentation are stored, as well as visualization of all geospatial and alphanumeric data in a geobase, via GIS portals and Web GIS [2].

GIS provides creating, classifying, maintenance, presentation and distribution of numerical, descriptive and spatial data on following items: geologically verified deposits; mining, mineral processing and metallurgical infrastructure; cadastre of exploration and extraction areas; cadastre of active mining works and structural objects; cadastre of mining and mineral processing tailings; operative plans of ore and waste outputs at open pits; dispatch monitoring of machines at open pits; any other information relevant for mining and mineral processing processes.

Geospatial data from deferent sources have to be georeferenced to the same geodetic datum and coordinate system [2]. That way, GIS enables information exchange with other geoinformation systems and harmonization of all relevant geoinformation on a local, national, or international level. GIS supports three modes of spatial information management:

- Geo-database – GIS is a comprehensive spatial database (geobase), which consists of groups of graphical data (raster and vector data, topology, networks) and groups of alphanumeric data (tables, reports).
- Geo-visualization – GIS includes "intelligent" maps, which can present mining operations at a wider geographic area of the mine and their interaction with the environment. It is possible to create maps with different layers of spatial information in order to enable easier analysis of geoinformation.
- Geo-processing – GIS provides set of tools for information transformation, from existing groups of geodata into new geodata and geoinformation. Geo-processing applies analytic functions to existing groups of geodata and store gained results into new geodata groups.

Application of GIS enables creating of regional or more detailed maps of active, or new surface mines; monitoring of geology of the area; estimating of ore reserves; planning of annual outputs; monitoring of statistical data on production costs; monitoring of machines (shovels, trucks, conveyor belts, etc.), monitoring of advance of mining operations (ore extraction, waste deposits), etc. Application of GIS is especially important for environmental protection, since it provides constant monitoring of influence of mining operations to the environment, including air, water and land pollution, influence to flora and fauna, health hazards and finally enables measures of environment protection. Also, GIS enables support in different types of projects related to monitoring of any relevant industrial process, easier management of mineral resources and helps in decision making at any level. Finally, GIS provides faster and more efficient operating in daily procedures and information flow, thus making operative management more efficient.

4 GIS SOLUTION FOR MORE EFFICIENT MONITORING OF MINING OPERATIONS AT VELIKI KRIVELJ OPEN PIT

Basic platform of GIS solution in RTB Bor is a unified base of spatial data, where all of the data on industrial area are stored (active open pits, mineral processing plants, smelting plant, tailings, etc.). After the analysis of existing documentation, and based on gained spatial parameters and evaluation of geodata, first step was to create unified spatial database of RTB Bor Group, by converting of digital data into unified system of geo-objects. Knowing the fact that a digital datum does not carry additional information about the object it represents, conversion of data included integration of graphics with analytic documentation of geodetic maps. Efficient storage and acquisition of elements depends not only on structure of data in spatial data base, but also on optimized structures, representations and algorithms for operations with data.

As an example, possibility of application of GIS is shown for open pit Veliki Krivelj, in order to provide simpler and comprehensive approach to spatial information about geological explorations, mining and mineral processing operations inside the RTB Bor Group. Verification of developed GIS model was performed on data gained from RTB Bor Group documentation related to Veliki Krivelj. GIS integrates geospatial and alphanumeric data into geo-database, with detailed information on open pit and tailings. Thematic classes included systematization of data in geobases of ArcCatalogue. These data are related to geological exploration works and dynamics of mining operations at the open pit, and they are important segment that requires visual presentation in ArcMap. Geobase, as a key segment of GIS, is a repository for space – time groups of data for planning, monitoring and managing of mining operations at open pits, enabling not only visualization, but also the analysis of stored data.

Storing data in a geobase was performed in two different ways: by importing relevant data from Excel tables utilized in Gemcom software package and by graphical data gained from Mine Surveying Department of RTB Bor Group, and their conversion into shapefiles needed for visualization in ArcMap.

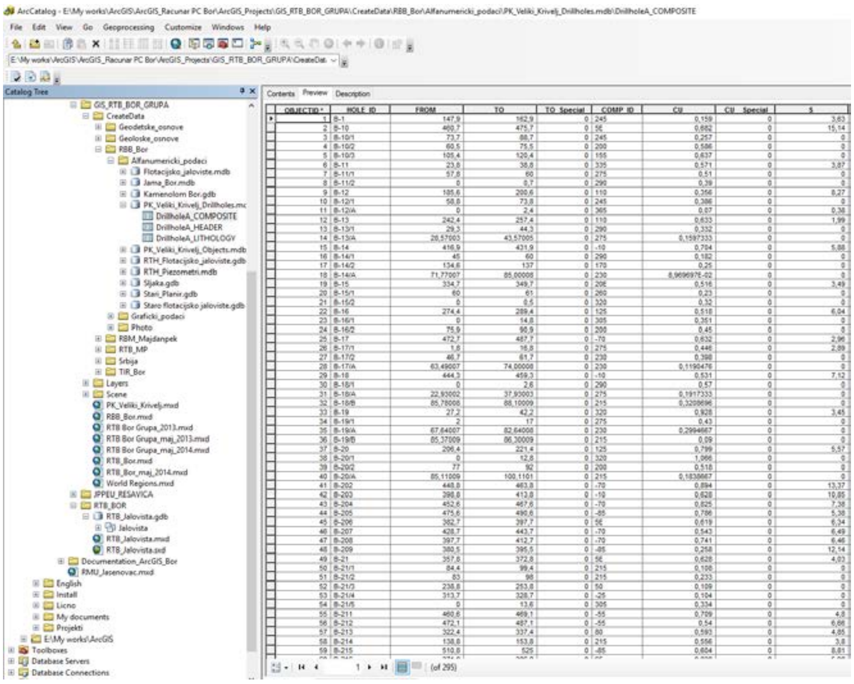

Figure 2 *Creation of geobase for Veliki Krivelj in ArcCatalogue*

Geobase design for Veliki Krivelj started with creation of individual databases (Figure 2), with defined object classes for objects with similar structure, behavior, relations and semantics. Thus, geobase for Veliki Krivelj includes data on: geological explorations, chemical and geotechnical analyses of the cores, infrastructural objects, natural objects, operation points (pit, level, waste deposit), utilized equipment, raster bases (orthophoto images, topographic maps, elevation DMT model).

Figure 3 shows operational environment of Veliki Krivelj open pit, with several thematic layers, presented in the left part of ArcMap panel.

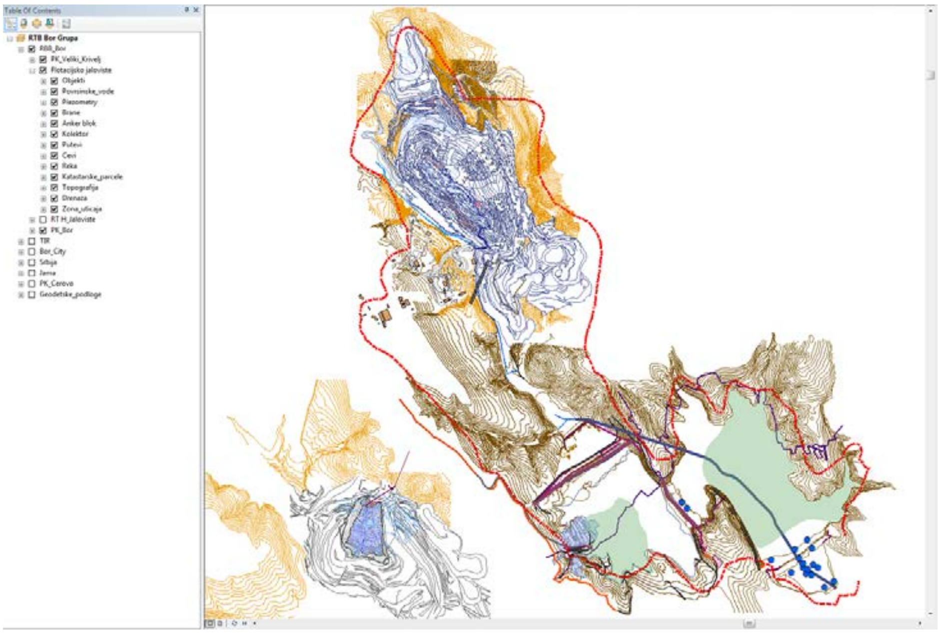

Figure 3 *Current state of mining operations in Veliki Krivelj, with thematic layers in ArcMap*

Spatially referenced geodetic map of the open pit was set as graphical base. After that, polygonal objects were added (open pit limits, tailing contours, structural objects, etc), followed by linear objects (roads, rivers, channels, transport roads) and dotted objects (drillholes, equipment). Each object was georeferenced, i.e. included in Gauss – Kruger coordinate system. This map has a simple symbolization and annotation of objects, but the system enables much more complex symbolization (colors, shapes, line patterns).

Multidimensionality of geospatial data requires different approaches in data structuring and indexing, and consequently application of different mechanisms for their search and analysis. Namely, in traditional relation databases, it is not possible to run spatial queries, such as: “Which drillholes are on 50 m spacing from profile line P1?”; “Which objects are situated inside the area planned for mining in 2017?” and similar. Relations between objects that are the subject of geometric, and not alphanumeric data, cannot be gained by classic SQL queries from traditional databases. Instead, spe cialized geobases are used for that purpose, with built-in system of storing and indexing both alphanumeric and geometric data. GIS technology integrates standard operations on databases, such as searches, queries, or statistical analyses, with unique advantages of visualization and spatial analysis. Power of geobases lies in connecting of geometry and alphanumeric data of spatial objects, thus enabling that each object can be seen on the map and its textual and numerical data can be updated. GIS enables its users to create SQL queries, analyze spatial information, arrange data and maps and present the results of all of these operations. Figure 4 shows the realization of created SQL query over the attributes of Exploration drillholes spatial class.

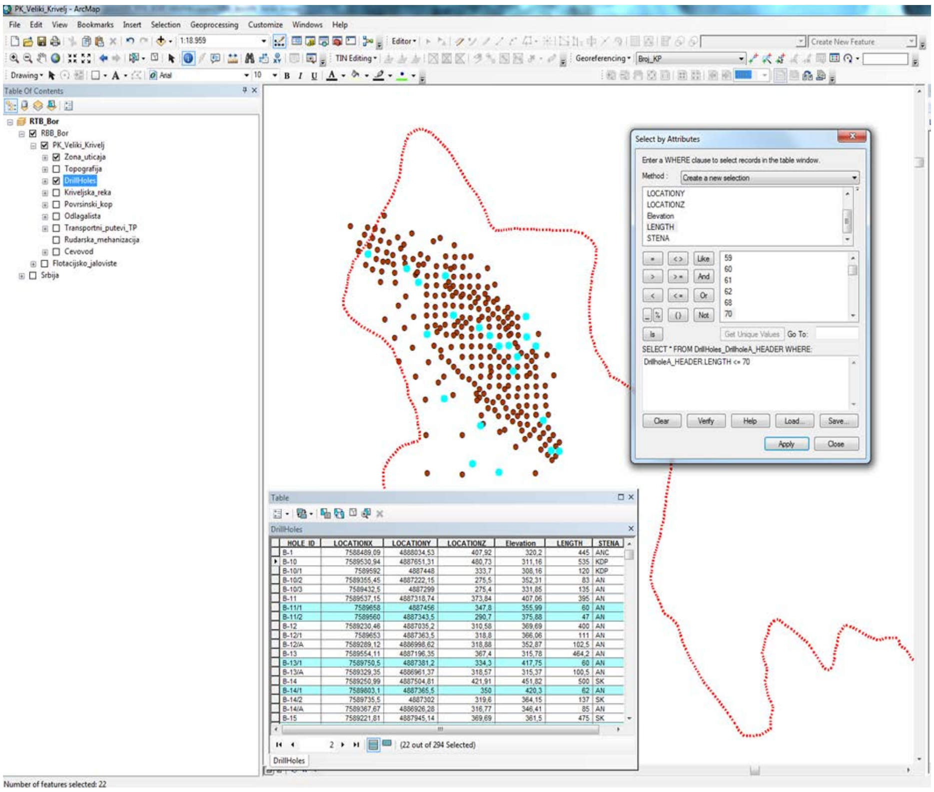

Figure 4 *Realization of SQL query over geobase Veliki Krivelj Exploration drillholes*

Updates of geobase are performed periodically, along with its maintenance, which includes fulfilling of both digital and tabular data.

GIS enables creating of maps for each surface mine level, with layout of drillholes, hydro-geological monitoring, slope stability monitoring, planning of mining operations in ore and overburden, monitoring of costs and positions of mining objects (Figure 5).

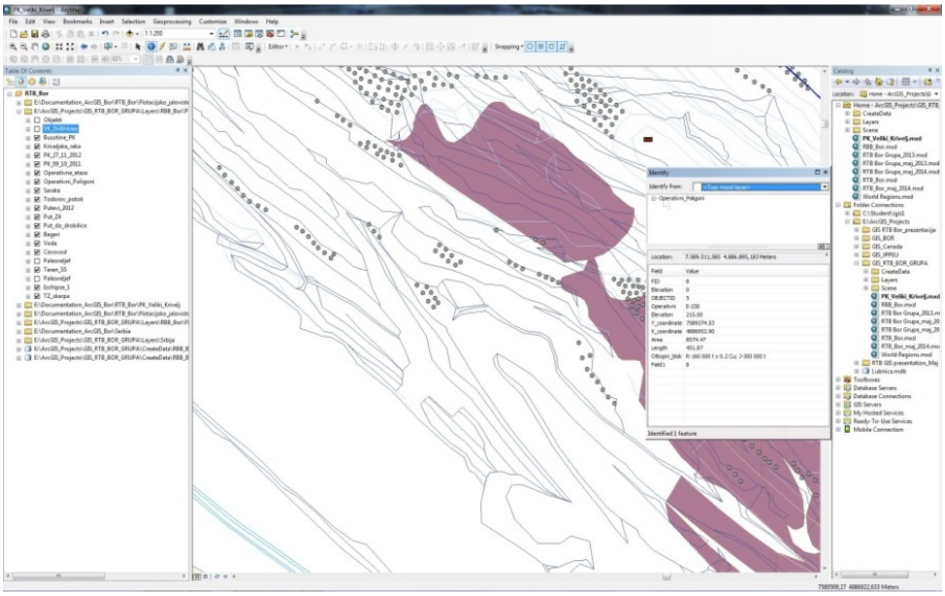

Figure 5 *Map of a single level at Veliki krivelj open pit with thematic layers in ArcMap*

Optimal function of mining equipment requires constant monitoring, which should provide data on machine performances during operation in real time. Intensive development of GIS/GPS/GPRS technologies enabled much more detailed, faster and more accurate monitoring and control of mining operations (Figure 6). Processing and analysis of gained data in a dispatch system enables mine management faster and more successful decision making [2].

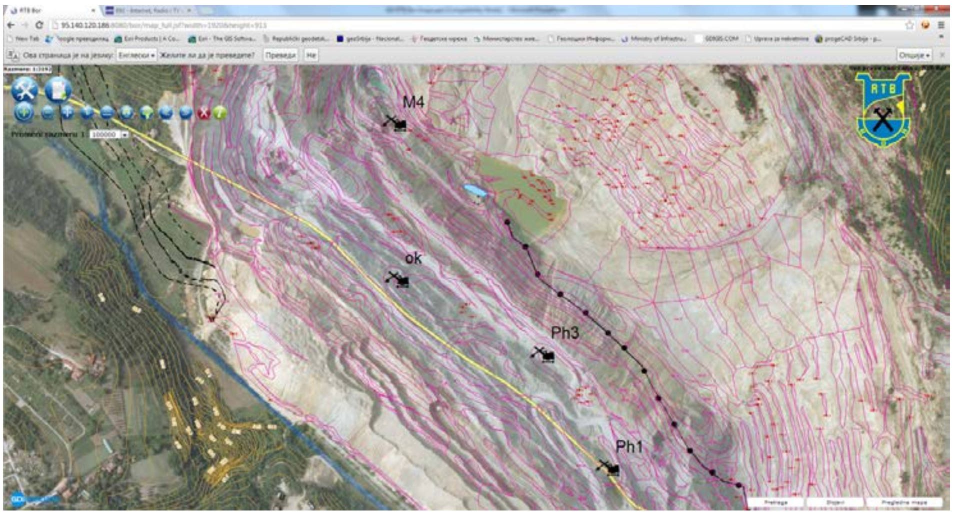

Figure 6 *Monitoring of mining equipment via GIS portal in Veliki Krivelj*

Open pit limits, sanitary zone, zone of influence of mining operations and tailings are also entered into GIS (Figure 7). This enables monitoring of tailings and waste deposits and updating of their advance, estimation of volumes, monitoring of hydrology and management of expropriation with the insight in each individual parcel (Figure 8).

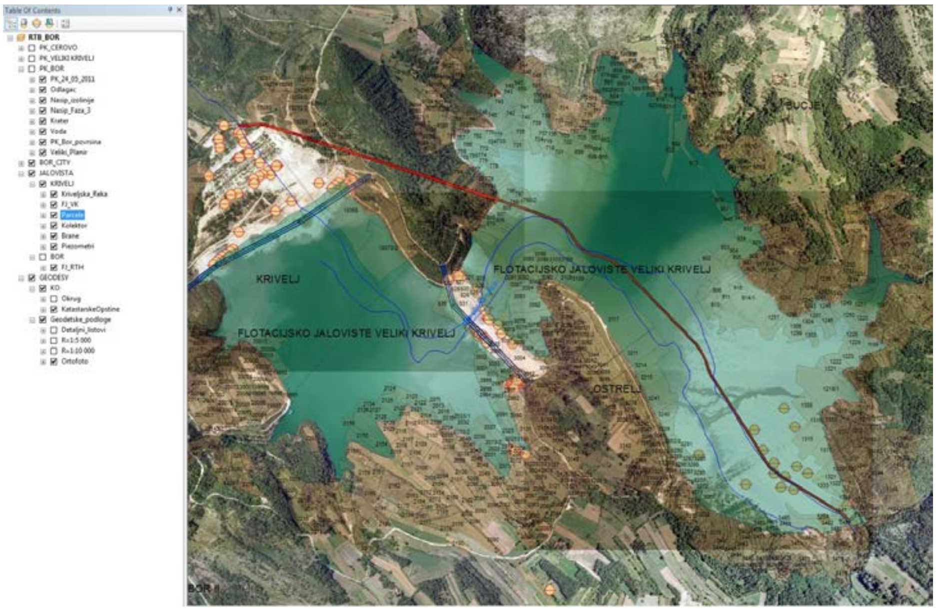

Figure 7 *Tailings of Veliki Krivelj Mineral Processing Plant (Polje 1 and Polje 2)*

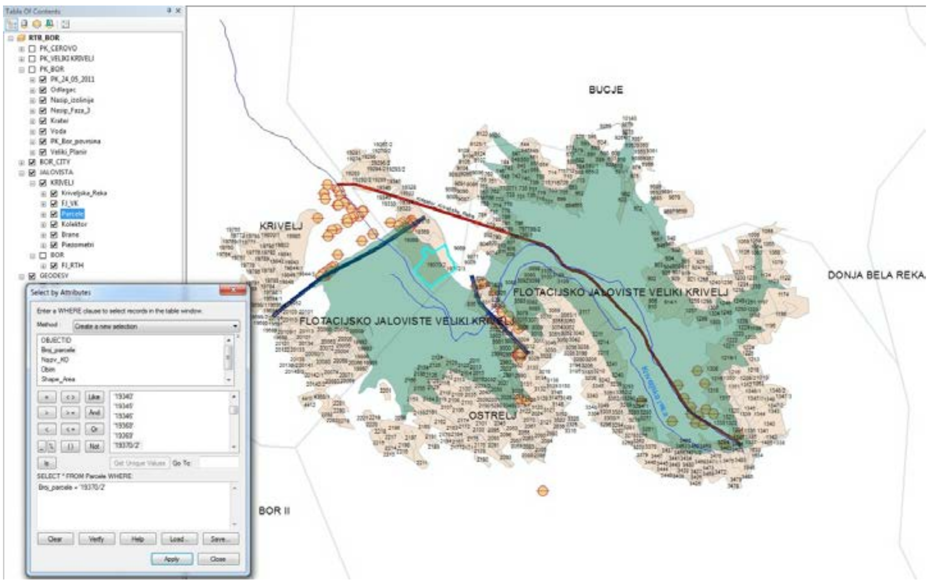

Figure 8 *Tailings of Veliki Krivelj, SQL query for individual parcels*

In order to make the manipulating with geobase simpler, the idea is to present the GIS solution on RTB Bor Group Geo-portal, thus enabling users to overview, search, print or download contents of the geobase in any moment via web (Figure 9).

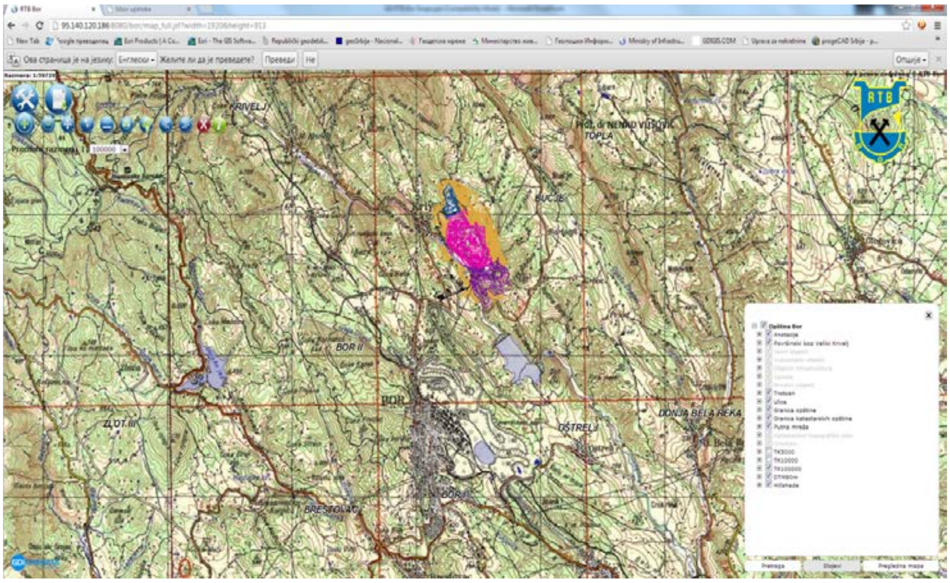

Figure 9 *Web GIS portal of RTB Bor Group, created in ArcGis software*

CONCLUSION

GIS solution presented in this paper is only a first step in design of integrated GIS system for RTB Bor Group. Further activities should be focused to widening of GIS system with thematic classes related to monitoring of production and processing of copper ore, integration with tools for deposit modeling and mine design, monitoring of environment protection, with monitoring of influence of mining operations on air, water and land, as well as planning of protection measures. In order to enable implementing of GIS in RTB Bor Group, it is necessary to make following steps:

- Development of sustainable GIS system, with possibility to widen and be integrated into general information system of RTB. Such GIS system would have to be able to follow the demands and needs of a modern company;
- Establishing of Department of system users, who would be trained for operating GIS tools and able to administrate and improve the system.

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