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3D GEOLOGICAL MODEL OF THE BAUXITE BEARING AREA CRVENE STIJENE (JAJCE, BOSNIA & HERZEGOVINA)

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ABSTRACT

3D geological models can be very useful in many geological, mining and other engineering activities. Constructed model should serve as a 3D geodatabase for variety of input data. Study area represents one of the bauxite bearing sites, Crvene Stijene, near Jajce (Bosnia & Herzegovina). Presented methodology includes the integration, digitalization, organisation and visualisation of different types of input data (600 boreholes, geological maps and sections, DEM, structural measurements from the surface and in the tunnels and adits) in the 3D geological database. In the modeling workflow, different types of geological objects were modeled with different interpolation algorithms. Used interpolation algorithm depends on complexity of geological object, character and spatial distribution of input data. The model is interactive which is important because there are constantly ongoing research and exploitation activities: boreholes, underground mining objects, etc. that can be easily imported into the model. 3D geological model represents a basis for planning new scientific research and mining activity.

Key words: 3D Geological Modelling, Ordinary Kriging, Karst bauxites, Midland Valley Move, Jajce

1. INTRODUCTION

3D geological models represent a solid background, not only for the visualization of geological data, but also for data acquiring, processing and organising them into the 3D geodatabase (Wu et al., 2005). The development of the computer industry and software for 3D geological modelling, introduces the opportunity for their application in solving numerous geological challenges (modified after Xue et al., 2004; Kaufmann & Martin, 2008).

Planning mining activities for the exploitation of raw mineral resources, requires defined geological structure of the area, the spatial distribution and geometry of the exploited ore bodies. Insufficiently geologically explored deposits usually lead to various difficulties in the design and construction of mining objects (Vanneschi et al., 2014). The consequences can be a variety of technical and technological problems during construction, such as a threat to human lives, damage to machinery and a regular increase in the cost of mining object. 3D geological models of the study area can be a great help in more efficient planning of research and mining activities, and with enough input data, they can very accurately represent the geological structure of the area (Caumon et al., 2009; Vanneschi, et al., 2014). Models are especially useful when the ore bodies are in geologically complex settings

This paper presents the methodology for constructing the 3D geological model of the bauxite bearing area of Crvene stijene (Jajce, Bosnia & Herzegovina) (Fig. 1). Several decades of research and exploitation of bauxite have provided a large collection of input data: bauxite footwall and hanging wall stratigraphy, detailed geological maps and sections, detailed topographic maps, over 600 drilled boreholes and over 10 km of underground mining objects (adits and tunnels), etc.

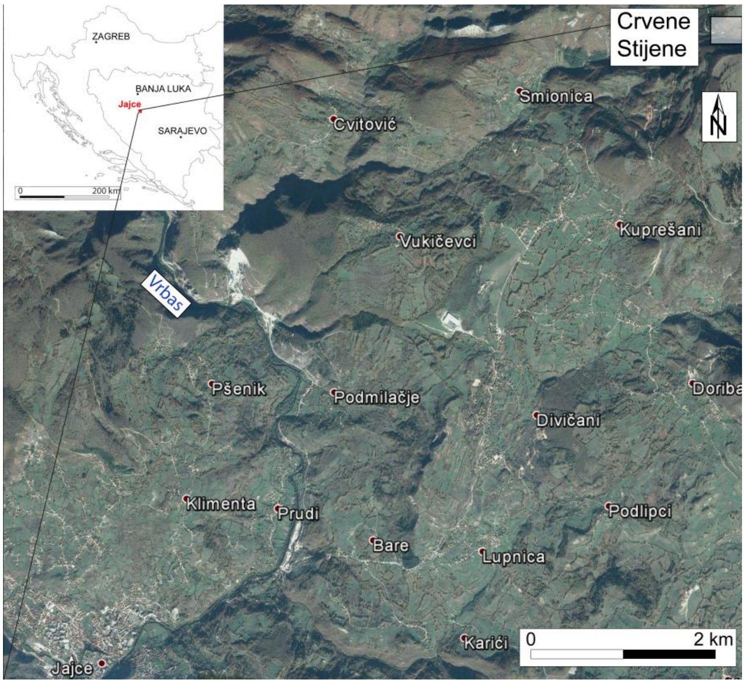

Figure. 1. Geographical location of the bauxite bearing area Crvene stijene, Jajce (Bosnia and Herzegovina) (Pavičić et al., in prep).

2. GEOLOGICAL SETTINGS

The fundamental stratigraphic and tectonic featuresof the study area weredefinedin a Basic Geological Map of Yugoslavia, sheet Jajce, 1:100 000 (Marinković & Ahac, 1975), explanatory notes for the same map, (Marinković & Đorđević, 1975), geological maps of bauxite bearing area Jajce (Dragičević, 1981 and Papeš, 1984) and published and unpublished geological research papers (Dragičević, 1987; Tomić, 1983; Dragičević & Velić, 1994; Dragičević, 1997; Dragičević & Velić,2002 & Dragičević & Velić, 2006, etc.). Geological settings are shown on a geological map in Fig. 2.

The oldest rocks present in the study area are shallow marine, well-layered, and white to grey limestones of Lower Cretaceous age, which end in Albian shallow marine, white - light grey to pink limestones. These rocks are footwall to bauxite deposits. The end of the Lower Cretaceous and the beginning of the Upper Cretaceous on the margin of the carbonate platform was characterized by intense compressional tectonics and emersion of regional impact (Dragičević, 1987; Dragičević & Velić, 2002). The emersion lasted from the Upper Albian to the Coniacian – Maastrichtian, approximately 20 million years when bauxite deposits were formed. The stratigraphic hanging wallof the bauxite deposits in the Crvene

Stijene area is mainly composed of carbonate clastics. Lithologically, they are numerous and diverse lithofacies. The most common types are the carbonate breccia, conglobreccia and conglomerates.

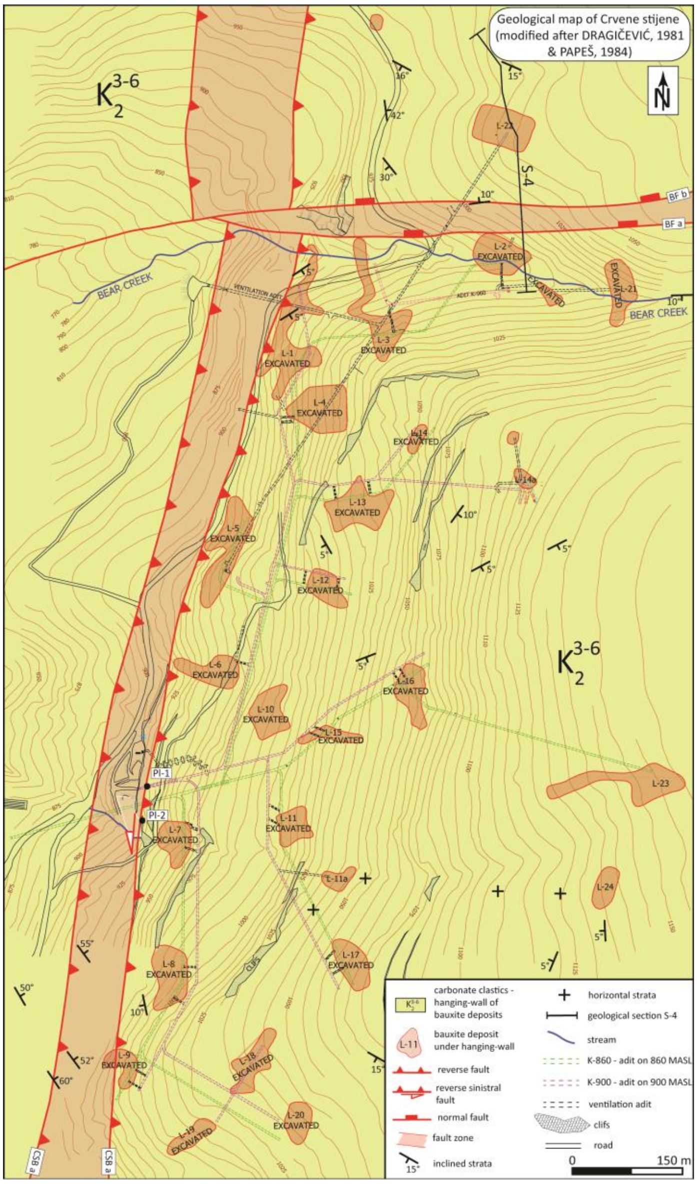

Figure. 2. Detailed geological map of Crvene stijene (modified after Dragičević, 1981 & Papeš 1984). CSB a and b –Crvene stijene-Bešpelj fault zone; BF a, b – Bear fault zone (Pavičić et al., in prep.)

3. METHODOLOGY

The **Midland Valley Move** (http://www.mve.com/) software package was used to build a 3D geological model of Crvene Stijene area. Once all the data was imported into the software, the building of a 3D model could start. Process started with the construction of 46 geological cross-sections and 3 longitudinal sections. Then, fault surfaces, palaeorelief and top of bauxite surfaces could be constructed. The last part of model construction was building solid models of individual bauxite deposits (Fig. 3).

Each of the surfaces was different in character (fault surfaces, palaeorelief surfaces, top of bauxite deposit surfaces) and complexity (Fig. 3). Also, they are defined by a different type, quantity and quality of input data. So, for each type of surface it was necessary to use a different interpolation algorithm. Faults are mostly defined by their surface trace and measurements in the adits, while movements on faults are interpreted based on different depth of horizons in boreholes on both sides of the faults. Palaeorelief surfaces are geometrically the most complex. Palaeorelief is represented with several surfaces and their boundaries are faults and boundary of study area (Fig. 3). Palaeorelief surfaces require the highest amount of input data. So, they were built based on 600 boreholes, and geological sections in areas where there are few or none borehole input data. Top surfaces of bauxite deposits, have relatively small areas and irregular shape in comparison to palaeorelief and fault surfaces. These surfaces are modelled based on two types of input data:

- boreholes which have penetrated the bauxite deposits and imaginary boreholes created for the better interpolation of shape of bauxite top surfaces;
- contours of bauxite deposits from detailed topographic maps (visible in fig. 6), which are digitized and projected onto palaeorelief surfaces.

In order to obtain the geometry, size and volume (in m^3) of bauxite deposits, solid models were created in between palaeorelief surfaces and top of bauxite surfaces (Fig. 3). These solid models show the morphology and geometry of the deposits, so dimensions and volume (in m^3) of individual deposits can easily be calculated.

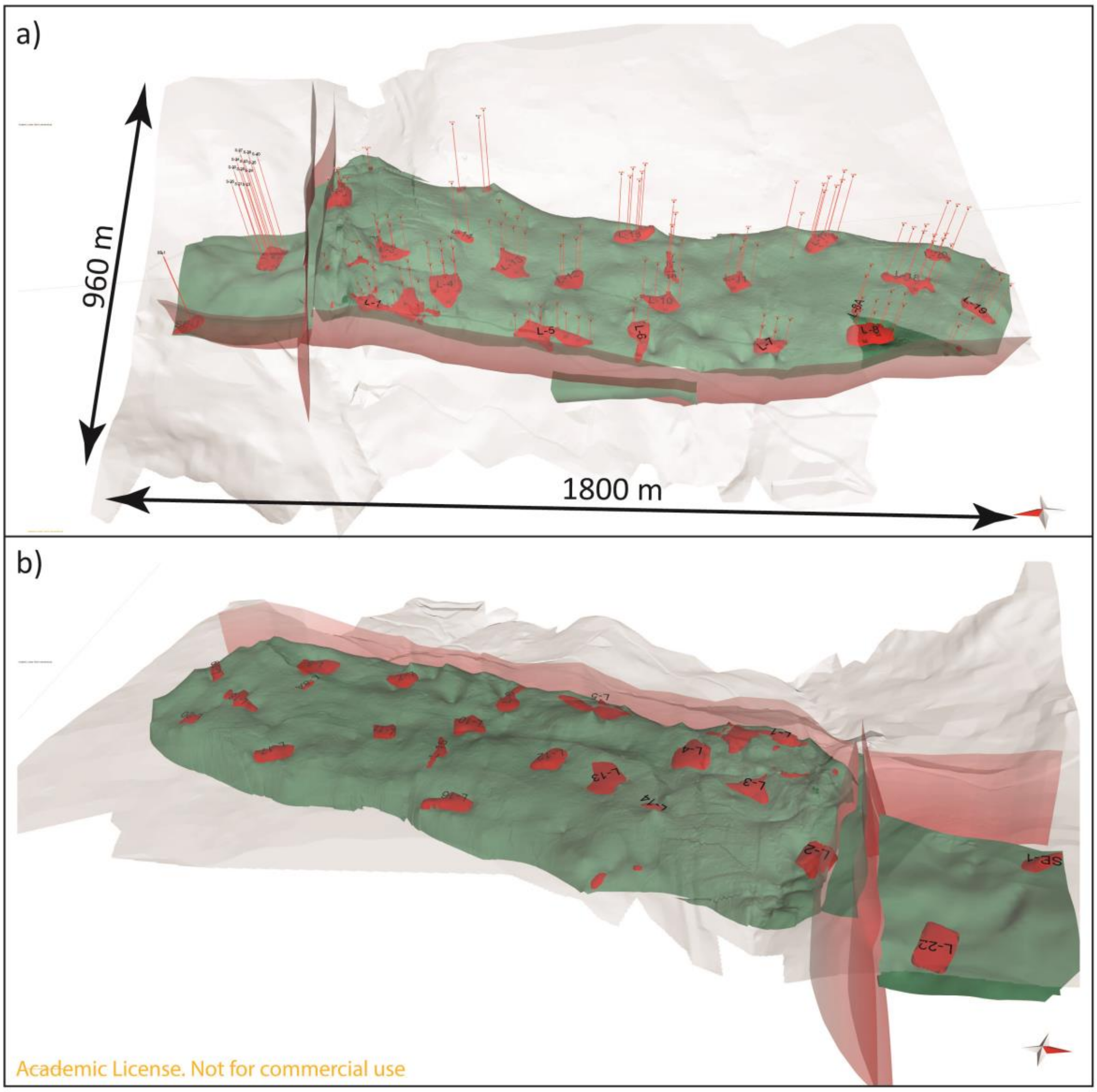

Figure. 3. 3D geological model of palaeorelief surface, bauxites and faults (Pavičić, et al., in prep)

4. DISCUSSION AND CONCLUSION

The paper presentsdeveloped methodology for constructing a reliable 3D geological model based on variety of input data. The methodology includes the integration, digitalization, systematisation and visualisation of different types of data (boreholes, geological maps and sections, DEM, structural measurements from the surface and in the tunnels and adits) in the 3D geodatabase. This is especially useful when there is a large amount of input data (in our example 600 boreholes). In the modeling workflow, different types of geological objects are modeled with different interpolation algorithms. Chosen interpolation algorithm depends on complexity and geometry of geological object, and type, quantity and quality of input data. Therefore, this methodology could be applied in other areas and for other raw mineral resources.The constructed model is interactive and is easily upgraded with new data. This is important because there are constantly ongoing research activities: boreholes, underground mining objects, etc. that can be easily imported into the model. Model is now a basis for planning of ongoing research activity. Furthermore, newly found deposits can quickly be contoured, volumes can be created and calculated.

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