

NEW CHALLENGES TO THE DEEP DEVELOPMENT OF THE BULQIZA CHROME MINES

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Abstract: *Bulqiza chrome mine is one of the most important chromium mines and mining activities in Albania. It is the deepest mine in the Balkans and possibly even in Europe. Recently, the inner shaft of the mine reached a depth of 1000 m, measured from the surface, or -180 m below sea level. Like all deep metal mines, this mine also faces a different set of challenges during its development. The first and most important challenge is that of improving the degree of geological research and knowledge of this mine and assessment of geological resources and reserves according to JORC Code 2012 edition. In addition, a series of other challenges related to increasing the depth of the mine represent the object of this paper: rock and ore stability and the underground voids support; improvement of mining methods and technologies; groundwater and its pumping; temperature, air parameters and mine ventilation. Among other things, these problems were solved using various computation and simulation programs.*

Keywords: *chromium mine, inner shaft, rock and ore stability, mining method, mine ventilation, VENTSIM*

1. General considerations

Bulqiza deposit itself is the most important chromium deposit in Albania and unique in its kind.

The documented beginning of chromium production in Bulqize show that mine started in 1948, and from that year on it continuously increased to reach the highest value in 1986 of 467,000 tons; meanwhile the ore production from Bulqiza North mine has been 270 000 tons/year [1].

By the end of the previous year, Bulqize produced 14.74 million tons. The amount of mineral resources/reserves and the realized production show that the Bulqize deposit is the most important source of chrome ore in Albania.

The exploitation of this source has been done with underground way by experimenting different mining methods and using, definitively, the sub-level stopping mining method.

Until 2001, the Chromium Mining Bulqizë had the status of a state-owned enterprise, while it is currently part of the concession agreement of the company "ALBCHROME sh.p.k. The chromium ore production trend of this mine was almost the same as that of the country, representing more than 50% of it.

A series of mining capital works have been constructed for the ore exploitation of Bulqiza North Mine, from its beginning until 2014, such as:

- About 2,100 m vertical shafts with diameter 4.-4.5 m;
- More than 1,120 m of declines with a cross-section over 7.2 m²;
- About 35 km of horizontal works for the preparation and use of minerals in the levels;
- A large number of vertical mine workings for ventilation and escape way;
- Significant constructions and installations for the provision of infrastructure and power, compressed air and water supply. (see Figure 1)

Currently, this mine, like other mines and chromium ore processing units as well as two ferrochrome smelters belong to the local concessionary company "ALBCHROME" Ltd, which is part of BALFIN Group

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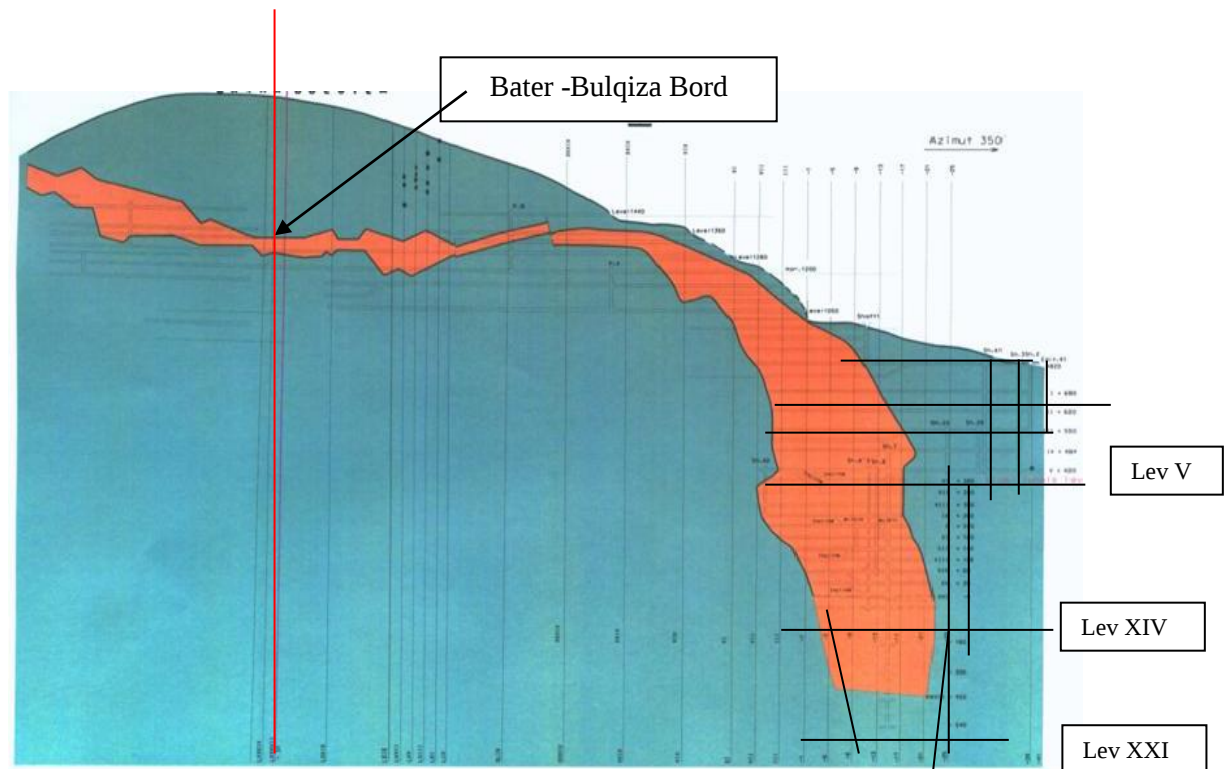


Figure 1. Bulqiza mine vertical section with main mine workings

2. Geological challenge and estimation of chromium mineral resources / reserves

The Bulqiza deposit itself, from a geological point of view, including the ore body shape, the tectonics, the fracturing system, the extension, the deep angle, and further development is unique in its kind. For this reason it has been paid special attention by local and foreign researchers and designers.

The geological works carried out years ago could provide data regarding the geological construction of the deposit, its structure and texture of the ore body, the tectonics and the estimation of the ore reserves [2].

On the market economy, the banks, the mining companies and the shareholders involved in the mining industry provide investment and support the development of the mining industry by conducting exploration, exploitation and processing of ore resources. Under these conditions, the concession company and the operators are engaged to carry out geological works in order to ensure the obtaining of the necessary information, which will enable the assessment of resources / reserves by any international classifications [3].

The abundant information obtained from the numerous geological drilling carried out in the underground can be analyzed simultaneously in order to [4]:

- Make clear the value of mineral resources based on certain classifications including parameters such as: tonnage, average content, statistic, and geo-statistic parameters as well as technological and economic aspects;

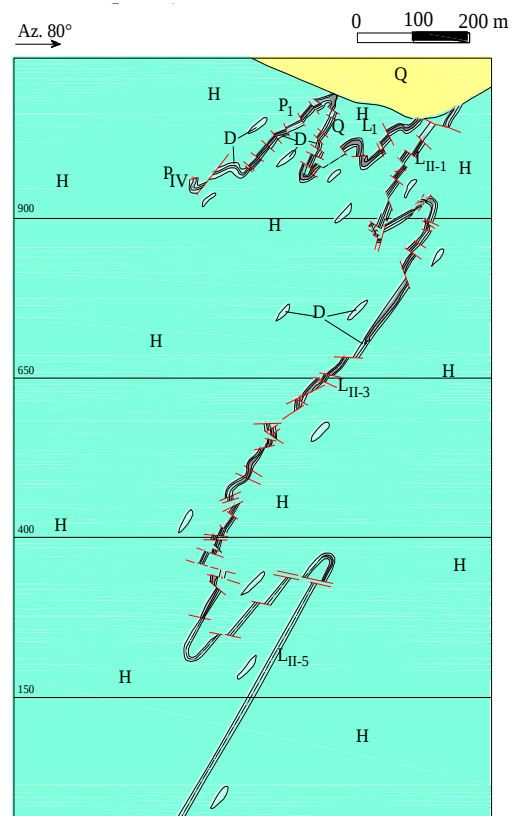


Figure 2. Vertical cross-section of Bulqiza deposit

- Collect enough data to evaluate the current mining method and to see the possibility of using another mining method;
- Collect multiple data to make the assessment by means of the geotechnical classification of rock massifs and ore body and to judge about the types of support that can be used in the deep of the mine;
- Obtain samples of methane, hydrogen and other gases that are present in the mines.

Carrying out more 25,000 ml of a 76 mm diameter geological drilling, other geological works as galleries, traverses, raises, numerous geological documentation, measuring the zenithal and azimuthal deviation of drilling wells, sampling and performing various chemical analyzes made it possible to comply with the strict rules of JORC Code 2012 and CIM 2000.

The main data about the average thickness of 2.6-3 m, the average content of Cr_2O_3 of 42.31 %, the deep angle of 60-75° the total ore body length on each level of 800 m, the intensity of the tectonics and the other elements also are used in DATAMINE program to geometrize the ore body in 3D.

Finally, taking into account all the results obtained from previously made geological works and those of recent years, application experts JORC Code 2012 and CIM 2000 conclude that the amount of reserves represents 2.12 million tons of mineral Chromium below the 17th level, classified accordingly:

- JORC Cod 2012: 50% of reserves measured, 20% indicated and 30% inferred;
- CIM (2000): 70% of reserves proved and 20% probable.

Appropriate evaluation of chromium ore reserves provided security investors with the ability to study, project and continue investment in mining depth up to the absolute quota of -250 below sea level.

In the mining perspective, the team in charge of drafting the depth project should solve the problems of the mining method, the support that can applied to different mine workings according to the kind of rocks in which they will be constructed, the mechanization of the works and the security problems related to the presence of different gases in the mines and mine ventilation.

3. Mining Method

The mining method that is still used in the mines is the sub level stopping. This mining method has shown superiority compared to other mining methods experimented in this mine and is likely to continue to be used.

Of course, in the case of an important ore body thickness, it needs a lot of improvements and mechanisms to maintain proper performance and to use machinery with compressed air (see Figures 3 and 4).

This mining method is also favored by the stability of the rocks of the body hanging part, which are often composed by rocks with a RMR greater than 70, while the mineral body displays an RMR lower than 50. These geotechnical classification values also favor the use of the shrinkage mining method, which is expected to be experimented soon.



Figure 3. Pneumatic Mucking Machine LHD



Figure 4. Mini scoop with bucket capacity of 0.5m³ type ARAMINE

4. The geotechnical classification of rock massifs and ore body and types of support to be used

As noted above, geological works carried out years ago, those carried out in recent years as well as the experience accumulated by the mining works carried out during these 40 years of mining activity in this mine enabled the gathering of new data, while applying the geotechnical classification of different types of rocks and body [5].

The RMR classification is applicable in the case when the rock mass along a drift is divided into a number of structural regions, i.e. zones in which certain geological features are more or less uniform [5]. The following six parameters are used to classify a rock mass using the RMR system:

- Uniaxial compressive rock strength;
- Rock Quality Designation (RQD);
- Discontinuities spacing;
- Discontinuities condition;
- Groundwater conditions;
- Discontinuities orientation.

The six above parameters for each kind of rock are determined by field measurements. Once the classification parameters are determined, the ratings are assigned to each parameter. In this respect, the typical, rather than the worst conditions, are evaluated for a considerable number of cases with the aim to take into consideration all rock types.

After the evaluations carried out, the average value of Rock Masses Rating results, while the main mining works for mine preparation are as follows:

- In the 1st class, “Very good rock”, with an average value of RMR 83, about 15% of the rocks are included and are represented by pyroxenes;
- In the 2nd class, “Good rock”, with an average value of RMR 65, about 60% of the rocks are included and are represented by periodontitis;
- In the 3rd class, “Fair rock”, with an average value of RMR 49, about 12% of the rocks are included and are represented by dunites;
- In the 4th class, “Poor rock”, with an average value of RMR 36, about 13% of the rocks are included and are represented by breccia tectonic zone and ore body.

Figure 5, *Bieniawski* diagram, displays a considerable rock estimation. According to the respective classes, considering the roof span and the service time of the mine works, the appropriate support has been proposed and applied (see figures 6 and 7).

Mine ventilation is a very important challenge because it must be able to withstand a number of important problems related to the deep development of the mines.

First, it is important to take into consideration that the ranges of temperature and pressure caused by deepness variations and heat transfers produce changes in the air density that exceed 5 % and analyses that ignore these changes will produce consistent errors that impact significantly on the accuracy of planned ventilation system parameters.

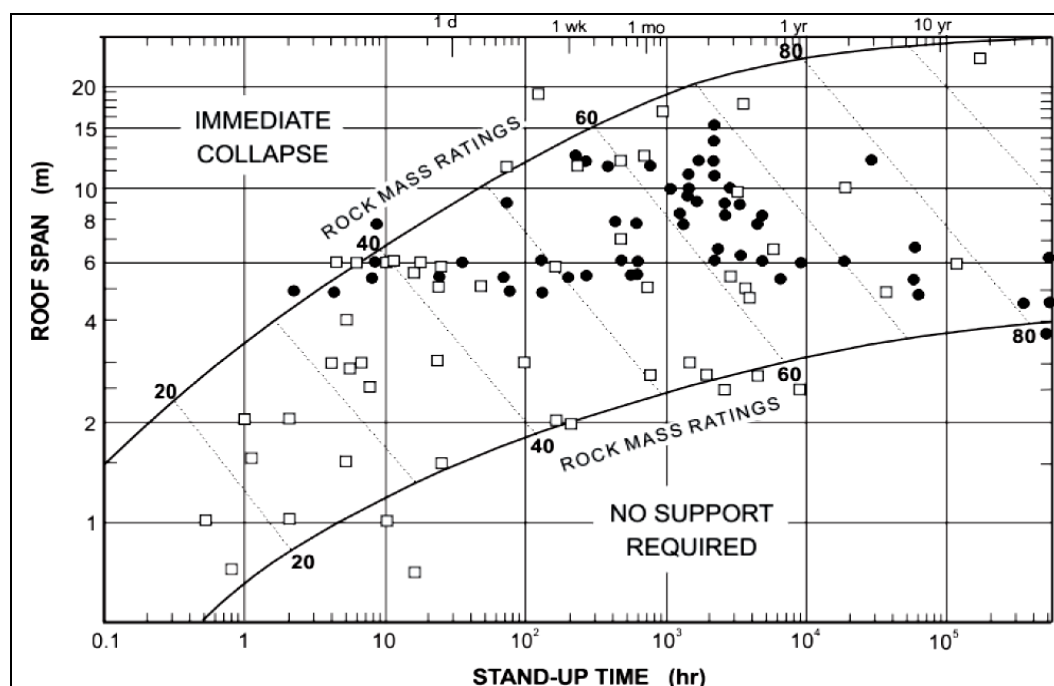


Figure 5. RMR classification of rock masses applied for Bulqiza Mine [5]



Figure 6. Applying of rock support to the 4th class



Figure 7. Applying of rock support to the 2nd class

5. Mine ventilation

In practical terms, this means that for underground facilities developing in depths higher than 500 m from the surface, the methods of analysis that ignore the compressibility of air may be incapable of producing results that lie within accurate observational tolerances [6].

Different studies conducted in mines related to microclimates and various psychrometric conditions have revealed significant changes in the physical parameters of the air and working conditions in mines [7].

As the mining depth increases, barometric pressure is expected to grow, almost linearly, and its value at 1200 m depth is expected to be about 16% higher than that on the mining surface. The temperature in the dry bulb is also expected to be 30.12°C, that of the wet bulb of 21.4°C and air density 1.32 kg / m³ (about 20% higher).

Numerous studies and monitoring in mines have shown that, in addition to the factors mentioned above, the further intensification of hydrogen and other gases is also an important problem. In this regard, a series of analyzes and hypotheses have been asserted about their origins. Different geochemical interpretations have contributed to the determination of its origin as a product during the process of *serpentinization* or further oxidation of the fayalite into the tectonic process [3].

All of these factors were used in the application VENTSIM and KLIMSIM software for air quantity determination of 132 kg/sec and dimensioning of the main works which serve as entry air way mainly of inner downcast shaft no. 9.

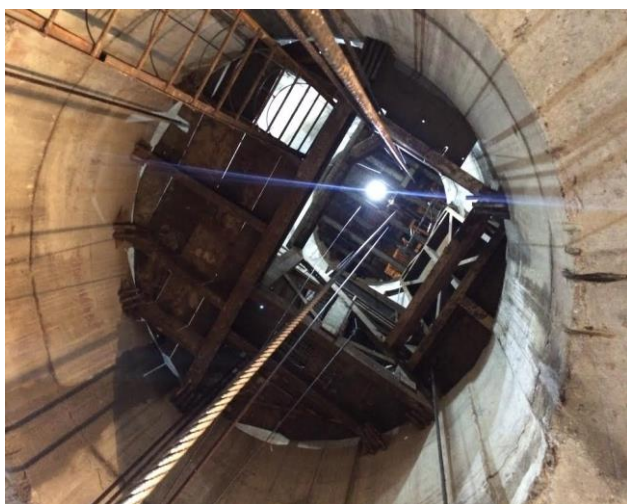


Figure 8. Inner shaft no. 9 cross section



Figure 9. Burning of gases at shaft no. 9 forehead

6. Conclusions

The development of the mine at a profound depth faces a number of important problems, which cannot be dealt upon in detail in this paper.

Inner shaft no. 9 is going deeper and together with it various mining works are being carried out at different levels. Completing them will enable more detailed studies to be carried out regarding the problems addressed in this paper.

As Bulqiza Mine is going deeper and deeper the problems related to gases released in the mines and the determination of their various quantitative and qualitative parameters conditioning the air quantity necessary for the mine ventilation should be paid a particular attention as well;

Gas retention is also an important problem to be studied for the Bulqiza mine future.

Geochemical studies and isotopic analyses about the different gas origins are also very important.

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