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Professional paper

POSSIBILITY OF APPLICATION OF BACKFILL METHODS WITH CEMENTING FILL IN ORE BODY BORSKA REKA

MOGUĆNOST PRIMENE METODA OTKOPAVANJA SA ZAPUNJAVANJEM OTKOPANOG PROSTORA STVRDNJAVAJUĆIM ZASIPOM U USLOVIMA RUDNOG TELA BORSKA REKA

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Abstract: The orebody "Borska Reka" is dipping at great depth and above the ore body there are parts of the settlement and traffic facilities essential for the region. Geological conditions in which ore body occurs, low copper content in the ore and objects on the surface in addition makes the process of adopting the optimum mining method of this ore relative. In addition to the block caving and sublevel method with ore and overburden rocks collapses should be considered and sublevel and open stope mining methods with backfilling the excavated area. Possibility of application of backfill methods with cementing fill for "Borska Reka" orebody condition are presented in this paper.

Key words: "Borska Reka**"** orebody, mining methods, stope backfill

Apstrakt: Rudno telo „Borska Reka“ zaleže na velikoj dubini i iznad samog ležišta nalaze se delovi naselja, kao i saobraćajni objekti bitni za region. Geološki uslovi u kojima se javlja ležište, nizak sadržaj bakra u rudi i objekti na površini terena dodatno usložnjavaju process usvajanja optimalne metode otkopavanja ovog rudnog rela. Pored blokovskih metoda sa zarušavanjem rude i pratećih stena treba uzeti u obzir i metode podetažnog i komornog otkopavanja sa zapunjavanjem otkopanog prostora. Mogućnost primene metoda sa zapunjavanjem otkopanog prostora stvrdnjavajućim zasipom za uslove rudnog tela Borska reka biće dati u ovom radu.

Ključne reči: rudno telo „Borska Reka“, metode otkopvanja, zapunjavanje otkopanog prostora

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1. INTRODUCTION

Design of mining methods at the time when the price of the metal is constantly changing is a complex task, especially for the deposits with low metal content.

The orebody "Borska Reka" is the subject of interest of mining experts for many years. Start exploitation of copper ore from this ore body would be an important contribution to increasing the production of copper in RTB Bor. By excavating ore from this deposit would be provided and sufficient quantities of copper concentrates necessary for newly constructed smelter process plant works. The life of the Bor mine would be continued with the beginning of ore excavation from the largest ore bodies in the Bor deposit.

Currently the remaining reserves of copper ore are excavated in the ore bodies "Brezonik" and "T1" and at the end of 2014 were re-activated exploitation works of ore bodies "Tilva Ros" and P_2A. The exploitation in this ore bodies were stopped after sludge irruption from the bottom of the open pit Bor in 2007. Exploitation works in "Brezonik" ore body are in final phase but are not finished yet. The main reason for this situation is the problem in bringing the flotation waste which fills excavated rooms. The works of excavation the rest reserves of ore in ore body T1 will be finish in next year.

Orebody "Borska Reka" with reserves of about 600 million tons of copper ore represents a safe future of mining in Bor mine. The problem is that the mining method is not adopted yet. The proposition of mining methods which is possible successful use for copper ore excavation is the subject of this research.

2. "BORSKA REKA" ORE BODY CARACTERISTICS

2.1. Geology

"Borska Reka" orebody is located in north-western part of Bor town, below of the Bor river valley and it is within active Bor mine. The deposit has a length of about 1,000 m and a thickness about 500 m, dipping to the west at an angle of 45° to 55°, according with dipping of Bor conglomerates and sandstones. Detailed studies were carried out to K-455 m by exploration drilling from underground (XVII horizon, K-155 m). There is a need for deposits exploration below the K-455 m in width and depth, (Mining and Metallurgy Institute Bor, 2010).

Exploration works on "Borska Reka" orebody were carried out during the period since 1976 to 1999 with a large volume of research works and with 53,390 m exploration drilling from the surface, 6 489 m exploration drilling from the parts of the mine, 1 378 m of mining works and 1 119 m of additional mining operations, all accompanied by geological and laboratory work with about 20 000 chemical analysis, mineralogical and physic - chemical petrologic testing (Mining and Metallurgy Institute Bor, 2010).

Detailed exploration works were carried out to the level K-455 m and it is assumed that deposit is dipping to the elevation of -800 m and even deeper.

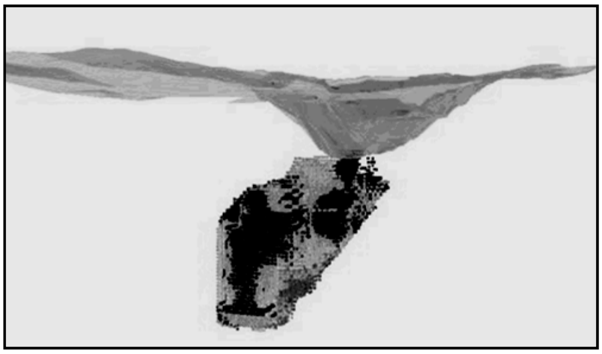

Figure 1 - Block model of "Borska Reka" orebody (Mihajlović et al. 2008)

Total geological ore reserves in "Borska Reka" ore body in the contours of the border 0.3% Cu content, which belong to A, B and C1 categories to K-455 m level are 556.9 million tons of copper ore. There are and additional elements such as gold, silver, molybdenum, etc. Certified balance reserves are determined on the basis of exploration data, and techno-economic evaluation for the ore body part above the level K-455 m. To this level a total of 319.9 million tons of copper ore with 0.50% Cu, 0.204 g/t gold ore, silver 1.62 g/t, Mo 35.89 g/t and 7.8% sulfur has been calculated, (Milić et al. 2011).

2.2. Opening of the orebody "Borska Reka"

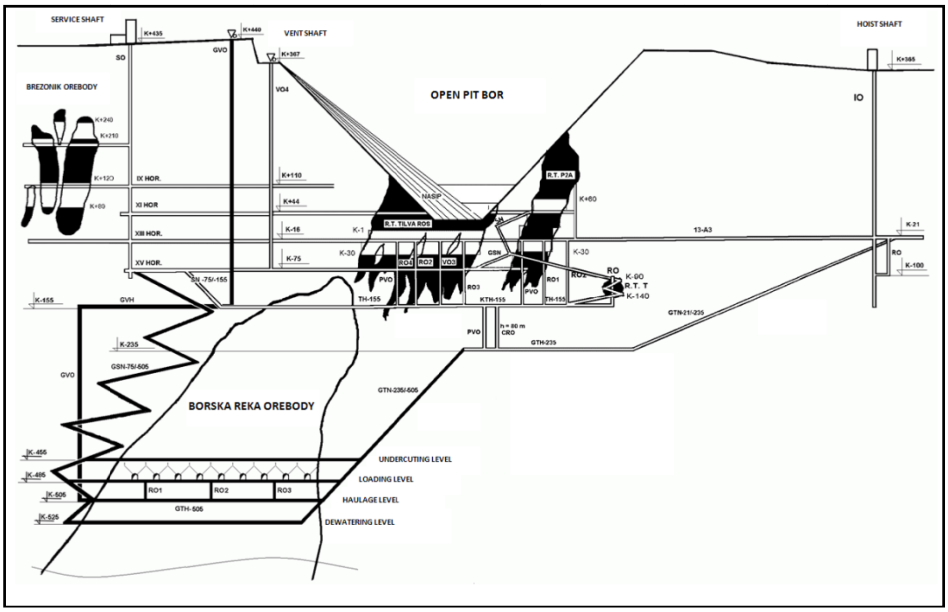

Figure 2 - Variant of opening "Borska Reka" orebody to the K-505 level
(Milić et al. 2011, Petrović at al. 2012)

"Borska Reka" orebody is opened and developed above the level of K-235 m. Above the horizon XVII orebody is opened to transportation collecting horizon XVII, system exploration drifts and existing transportation drifts. Orebody is connected with primary crushing plant; it is also located on the horizon XVII. That is used in current extraction. By drifting of hauling system at level XIX horizon, which replace horizon XIII, mine was deepened by 220 m. Hauling XIX horizon was driven to enable ore extraction from the current position and extraction of upper parts of "Borska Reka" ore body, too. Large capacity belt conveyors are installed for the ore hauling and hoisting from the horizon XIX to the main hauling horizon XIII. Figure 2 shows a schema of current mine situation and one of variants of the orebody opening to the level K-505 m.

3. PROPOSITION OF MINING METHOD FOR BORSKA REKA OREBODY EXCAVATION

Previous studies aimed at finding the most suitable mining methods for economic exploitation of copper ore from the orebody "Borska Reka" concerned the productive block caving and sublevel mining methods. But a major problem is that the orebody dipping on great depth and that objects important for the city and the region are located within zone of collapses. Also, the old part of the city is located within this zone. The huge investments are required for relocation of the regional road, railway Zaječar - Belgrade, the old cemetery and the part of the city. This would have significan impact on the production costs of copper ore from this deposit.

In addition to the block caving and sublevel mining methods the methods with hydraulic filling the excavated area and room and pillar methods were analyzed (Štrbac and Milićević, 2005). Experience in mining in the world indicates that an increasing number applied sublevel mining and open stope mining methods with backfilling the excavated zone with cemented backfill.

The most suitable conditions and justification for the economical use of backfilling mining methods with cementing fill are in large deposits (Milićević, 2011). Cementing fill material allows post excavation safety pillars which significantly reduces the losses of ore.

Cemented paste backfill is an increasingly used in backfilling underground mines due to its better safety factor for working surroundings and preventive environmental measures against toxic waste minerals. Different parameters play role in mechanical strength and stiffness of CPB including chemical, thermal, and hydraulic factors. Arching effect is a strength improving phenomenon especially in hydraulic and cemented paste backfills that should be considered in designing backfill structures (Sheshpari, 2015).

In addition of this paper of open stope backfilling methods variants with of the cementing fill of excavated area will be briefly presented. These mining methods can be applied for the ore body "Borska Reka" excavation.

3.1. Sublevel open stoping

Sublevel open stoping is used for mining mineral deposits with; steep dip where the footwall inclination exceeds the angle of repose; stable rock in both hanging wall and footwall; competent ore and host rock; and regular ore boundaries. Sublevel open stoping recovers the ore in large open stopes, which are normally backfilled to enable recovery of pillars. The orebody is divided into separate stopes, between which ore sections are set aside for pillars to support the roof and the hanging wall. Pillars are normally shaped as vertical beams, across the orebody. Horizontal sections of ore are also left as crown pillars. Sublevel drifts are located within the orebody, between the main levels, for longhole drilling of blast patterns. The drill pattern accurately specifies where the blastholes are collared, and the depth and angle of each hole. Drawpoints are located below the stope (Sletten, 2012).

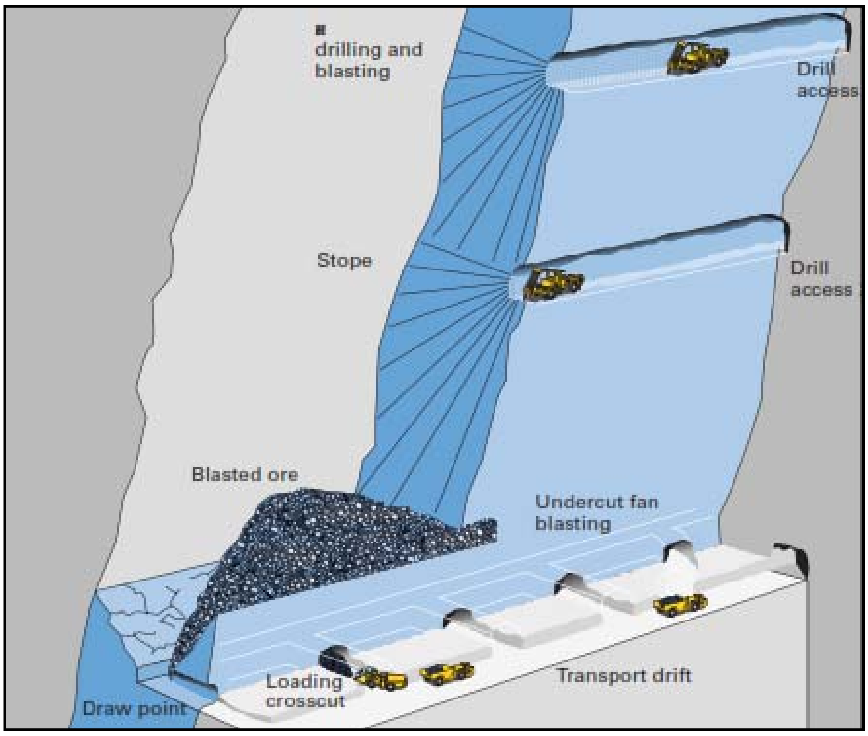

Figure 3 - Sublevel open stoping method (Atlas Copco, 2007)

3.2. Bighole stoping method

Bighole stoping is an up-scaled variant of sublevel open stoping, using longer, larger-diameter DTH blastholes, ranging from 140 mm to 165 mm. Blast patterns are similar to sublevel open stoping, but with holes up to 100 m long. However, the risk of damage to the rock structures has to be taken into account by the mine planners, as the larger holes contain more explosives (Atlas Copco, 2007).

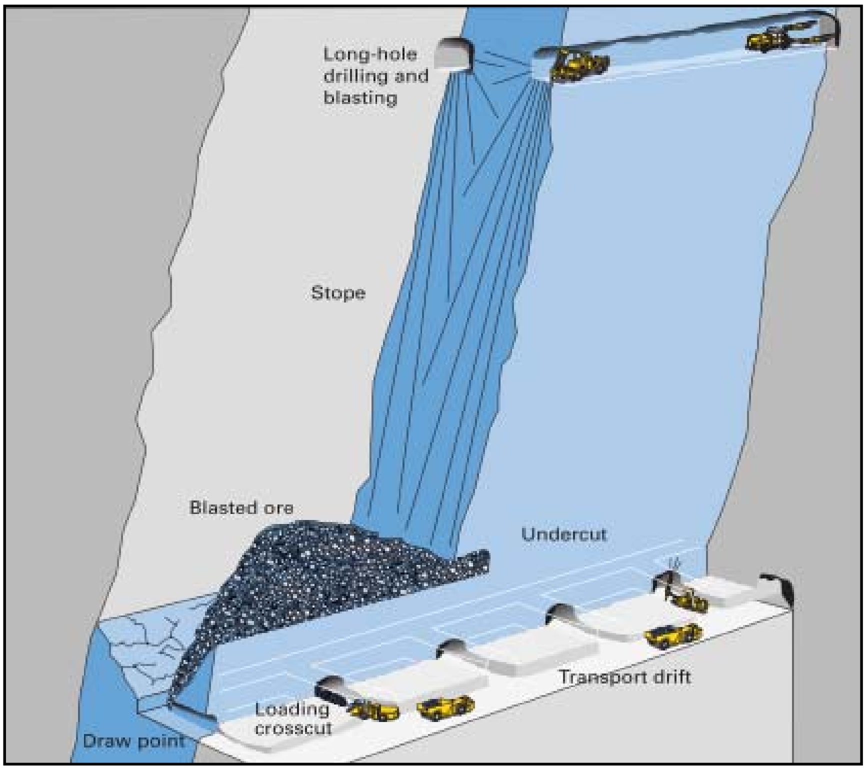

Figure 4 - Bighole stoping method (Atlas Copco, 2007)

3.3. Vertical crater retreat mining method - VCR

Vertical Crater Retreat method applies to orebodies with steep dip and competent rock in both ore and host rock. Part of the blasted ore will remain in the stope over the production cycle, serving as temporary support. This mechanized method can be regarded as a considerably safer form of shrinkage stoping, as no men have to work inside the stope. Concentrated spherical charges are used to excavate the ore in horizontal slices, from the stope bottom upwards. The ore gravitates to the stope bottom draw points, and is removed by loaders. Each stope is cleaned out before backfilling with cemented hydraulic fill. Development for VCR stoping consists of: a haulage drift along the orebody at the drawpoint level; a drawpoint loading arrangement underneath the stope; an undercut; and an overcut access for drilling and charging. VCR charging is complex, and its techniques have to be mastered in order to avoid damaging the surrounding rock (Atlas Copco, 2007).

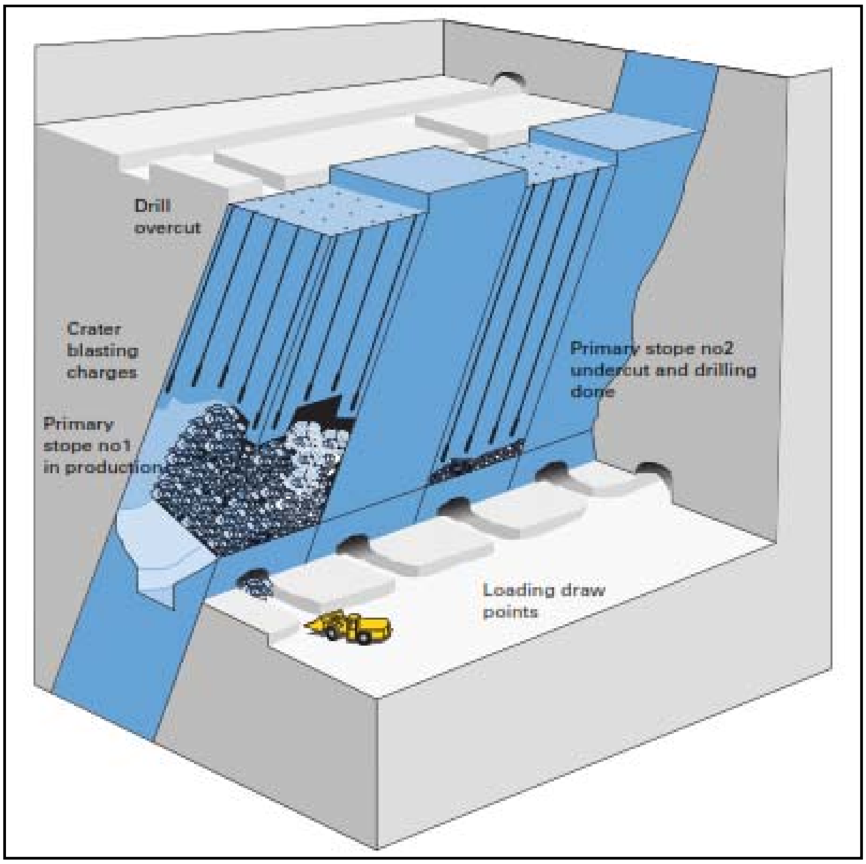

Figure 5 - Vertical crater retreat mining method (Atlas Copco, 2007)

3.4. Sublevel stoping

The geological and geotechnical characteristics of significant portions of the newly discovered orebodies allow mining using more productive longhole methods instead of cut-and-fill. Lappberget orebody (Grapenberg mine), for instance, can be 60 m wide through considerable vertical distances, and has proved to be suitable for sublevel stoping using a system of primary and secondary stopes progressing upwards. Primary Stopes are 15 m wide and 40 m high and filled with paste made from concentrator tailings mixed with about 5% cement. The 20 m wide secondary stopes are filled with development muck without cement. High precision drilling is necessary to get optimum ore recovery and fragmentation (Atlas Copco, 2007).

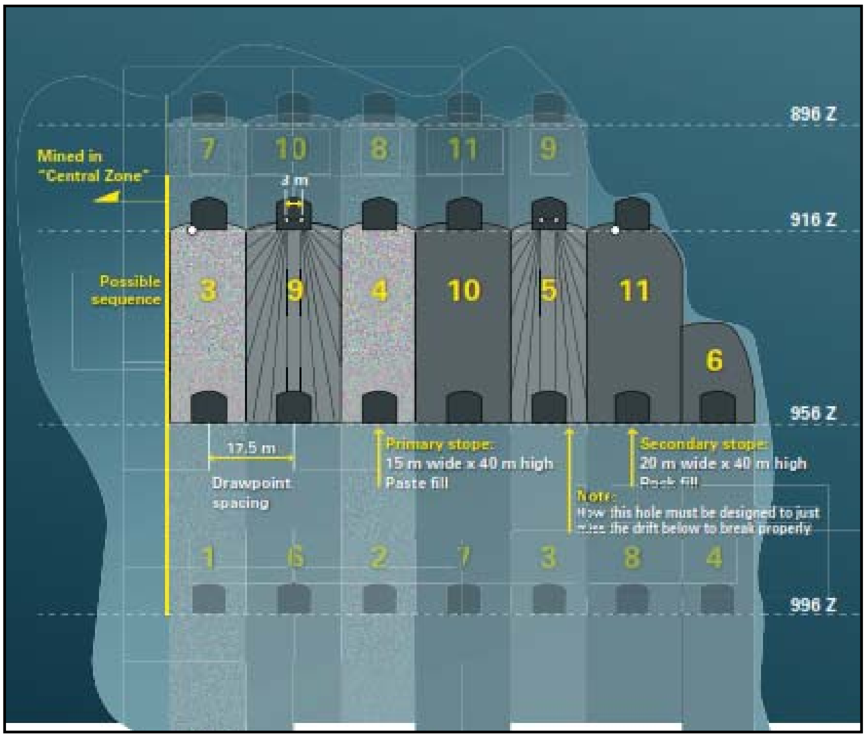

Figure 6 - Variant of sublevel stoping developed for Grapenberg mine (Atlas Copco, 2007)

3.5. Comments

All of the proposed mining methods are applicable in the case of the "Borska Reka" orebody. Sublevel open stope mining method with backfill stopes requiring a higher volume of preparatory works which can be crucial for economic exploitation. When excavation is done by sublevel stoping method with long boreholes for successful excavation, it is important to respect the schedule borehole and quantity of explosives as it may occur that blasted ore are outsized and a slowdown in the process of loading of ore. For use the vertical crater retreat mining method mining method it is necessary to overcut of stope for drilling vertical borehole, so problems may arise about the stability of the roof of stope.

The mining method which is applied in the Grafenberg mine, according to the authors, is the most acceptable solution for "Borska Reka" orebody excavation because the excavation is carried out in the stopes of less height. It is especially important for stope and pillars stability. Experiences in the works on development drifts through the upper parts of the orebody shows that the ore is not too stable, and may cause collapses of stope with great height.

4. CONCLUSION

Application of mining method for which there is no disintegration of the overlying rocks provides acceptable solutions to the "Borska Reka" orebody conditions. The problem that arises when open stope and room and pilar methods are applying are large losses of ore in the safety pillars. Post excavation of safety pillars and loss reduction is possible in conditions of application of stope backfill with material that has great compression strength as well as ore herself. For these reasons, backfilling excavated stopes with cemented backfill allows to reduced the ore losses to a minimum. Flotation waste with the addition of a binder and a certain percentage of different fractions of stone aggregate can be used as a material for filling the excavated stopes. Ecological aspect is one more advantage of using open stope mining method with stope backfill. Storage of flotation waste in the excavated areas in the mine prevents further expansion the flotation tailings on the surface and further environmental pollution.

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