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SLOT DEVELOPMENT USING THE CONTROLLED BLASTING IN THE ORE BODY "BORSKA REKA"[**]

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Abstract

The occurrence of deviations in the drilling of long blast holes can negatively impact the quality of blasting and safety of personnel and pillars in the room and pillar mining methods. The application of controlled blasting through a two-step blasting process for creating a compensation chamber (slot) is presented due to the occurrence of blast hole deviations. Initiation sequences of holes in the two-step blasting process were determined by surveying the holes and simulating blasting in the Datamine Aegis software. Blasting the lower and upper parts of the slot created a free space of approximately 840 m³ with an approximate specific explosive consumption of 2.25 kg/m³.

Keywords: *controlled blasting, slot, room and pillar, Datamine Aegis, powder factor*

INTRODUCTION

Blasting refers to the technical use of the destructive force of explosives, which is used in mining for breaking rocks and mineral raw materials during underground and surface mining operations [1].

For this purpose, a cavity of appropriate dimensions (blast hole, blast chamber) is created in the rock mass or mineral raw material to accommodate a corresponding amount of explosive, known as explosive charge, and prepared for detonation using an appropriate initiation device. Such an amount of explosive, placed and prepared for detonation, is known as a mine.

Drilling of holes is to a greater or lesser extent accompanied by deviations, which can negatively impact the quality of blasting, ore dilution, and the safety of personnel, excavations or safety pillars [1].

The arrangement of blast holes can vary depending on the applied blasting method, type of cut, hole deviations, physical and mechanical properties of the rock mass in which the mining object is being constructed, and dimensions of it. The arrangement of blast holes at a particular worksite, which includes all blast holes for a single blasting operation, is called a blasting pattern [1].

This paper provides a detailed description of application the controlled blasting in creation a compensation chamber, specifically a slot, for the purposes of room-and-pillar mining in the "Borska reka" ore body.

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MINING METHOD IN THE "BORSKA REKA" ORE BODY

The planned mining method in the 'Borska Reka' ore body is the room and pillar block method of excavation with backfilling of excavated space using the paste backfill.

The basic parameters of adopted excavation method are: room (chamber) width 12 m, pillar width 12 m, room height 20 m, and room length variable from 30 to 50 m [2,3].

The number of access drifts to the room is typically related to the room size, but in this case, two access drifts are planned. Dimensions of the access drifts are 4.5 x 4 m and they are constructed along the room axis. The factor influencing the planned dimensions of access drifts includes the equipment used, ventilation requirements, as well as considerations the stability of excavations. The stability and safety of the drifts are primarily ensured by appropriate ground support using shotcrete, anchors, and mesh [2,3].

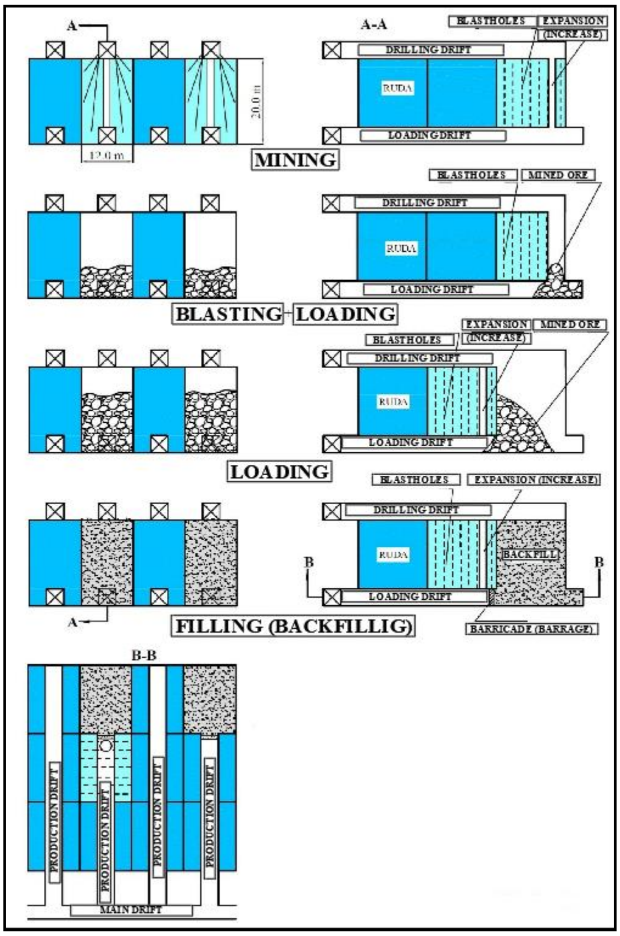


Figure 1 *Mining method in the "Borska reka" ore body [2,3]*

Division is necessary on each level through level drifts constructed within the ore body itself, forming sectors for the phased excavation of the mining area, significantly reducing the start-up time of excavation in the mining field [2,3].

The ore excavation in the room is achieved through drilling and blasting. Access to the room is obtained by constructing the access drifts longitudinally relative to the direction of ore body excavation [2,3].

The first phase involves creating a slot between levels that define the planned face area of the room, with a height of 20 m and width of 12 m [2,3].

The room formation is achieved by the blasting ring-shaped blast holes between two levels, but for the initial opening of the face of the room, it is necessary to create an initial opening or expansion that provides sufficient void for ore compensation by blasting the initial ring of blast holes. The compensation chamber or slot is formed at the full height of the chamber, in this case connecting the upper drilling access drift with the lower loading access drift [2,3].

After achieving the planned length of the room and removing the mined ore, that segment of the room is backfilled with the paste fill. After it has hardened according to a specified schedule, excavation in the room continues [2,3].

The rings must be drilled parallel to each other, and in this case, a vertical direction for the rows of blast holes in the rings was chosen. It is crucial that the filling of the rings is done completely accurately to prevent the formation of oversized ore pieces or jeopardize the cement paste fill, which could lead to the ore dilution and reduce the stability of pillars or rooms. Proper blasting ensures that the pillars remain undistorted, allowing for the extraction of clean ore from the room, as well as ensuring their stability and safety [2,3].

SLOT DEVELOPMENT METHOD

In the mentioned ore body in the underground mine 'Jama', four methods for creating slots for initial blasting in the sublevel caving method have been tested: creating a conventional raise bore (ALIMAK), using a ring drilling at various angles, drilling parallel blast holes for controlled blasting to form the cut, and creating raises through the two-stage blasting [2].

The new method of slot development is very similar to the previous one (creation of raises through two-stage blasting), where the raise drilling pattern remains the same (Figure 2), and the number of blasts is also two. The difference lies in drilling the additional 24 holes arranged in a ring pattern across three rows and their initiation sequence.

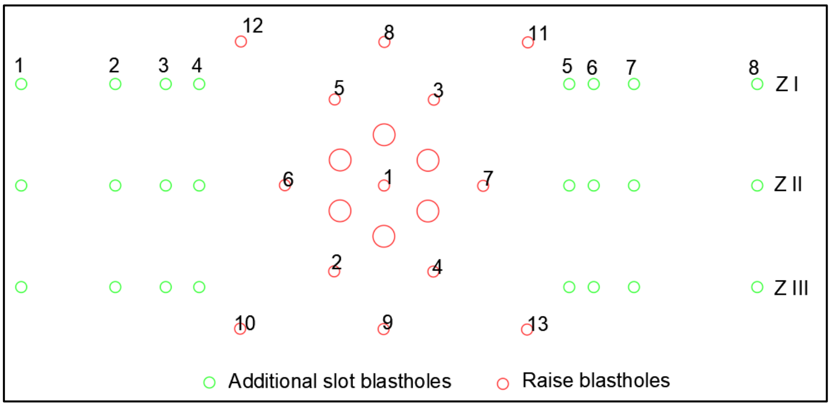


Figure 2 *Slot blastholes pattern*

The holes in the raise are drilled vertically downwards, while the additional holes are drilled at the predefined angles. Drilling is performed using the Atlas Copco Simba 1354 drilling rig. Prior to the drilling phase, surveying work is conducted to mark the central hole and azimuth of the other rows of blast holes. After drilling is completed, top and bottom surveys of the drilled blast holes in the raise are conducted to determine the potential deviations.

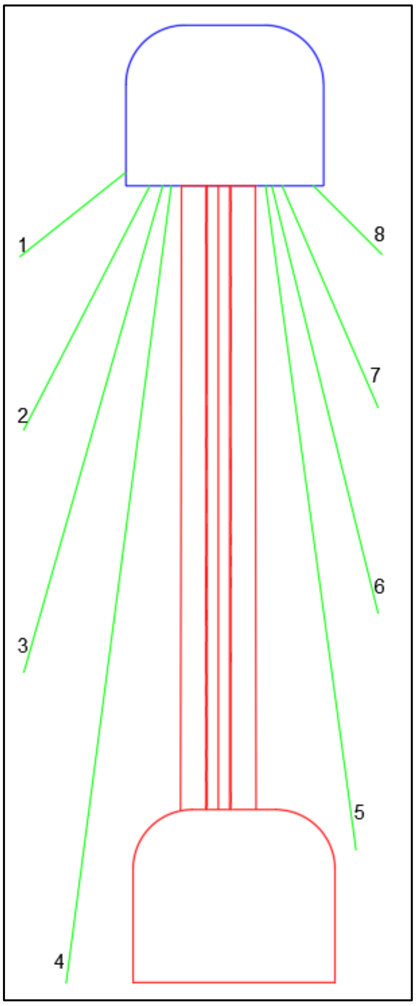


Figure 3 *Cross-section of the raise and ore body blast holes*

It can be seen from Figure 3 that the raise holes are drilled down to intersect the lower drift. This allows for surveying the blast holes after drilling is completed to determine their deviations (Figure 4). This information is crucial for establishing the initiation sequence.

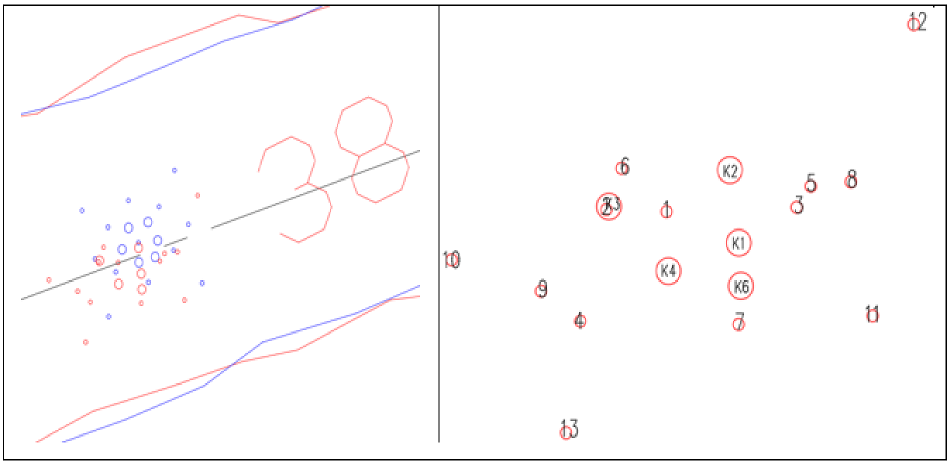
After conducting the survey of blast holes and determining the initiation sequence, the blasting operations follow.

SLOT DEVELOPMENT IN THE DRIFT OH38L

First, the raise holes are initiated to create free space for blasting the rows of blast holes in the side, thus achieving the necessary width of the slot. Upon completion of blasting and ventilation, the operational phase of loading the blasted material follows. Planning for the upper part of the excavation is done similarly, using the same blast hole survey for determining the initiation sequence, with the order now adjusted.

The application of a new method for creating a slot using controlled blasting in the 'Borska Reka' ore body is further described using the example of slot development in the access drift OH38L between two levels, K-110 and K-130.

After marking the central blast hole and azimuth of the other rows of blast holes, they are drilled accordingly. Deviations of the blast holes are determined by surveying the top and bottom of the blast holes in the raise (Figure 4).



a) b)

Figure 4 *Surveyed holes: a) location of blast holes at the level K-110/K-130; b) location of blast holes at the level K-130 due to the deviation*

For a better understanding of the issue, planned and surveyed blast holes were input into the Datamine Aegis software package.

This program helps to clearly visualize the direction and magnitude of blast hole deviations both in 2D and 3D views (Figure 5).

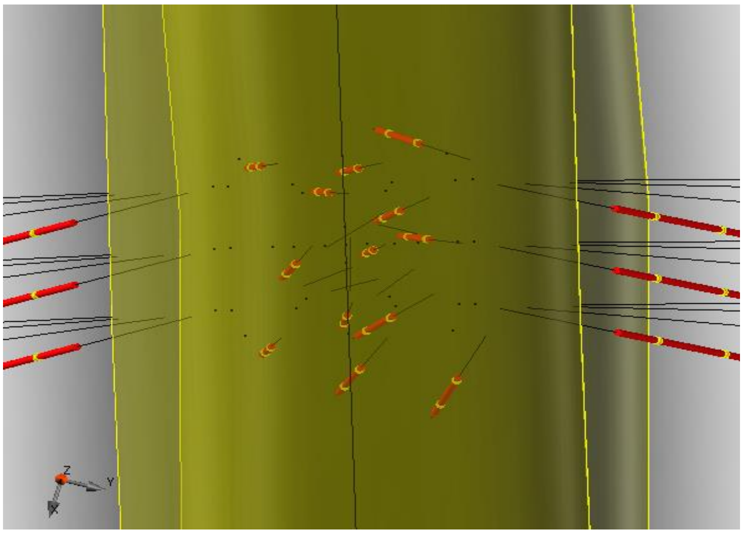


Figure 5 *3D representation of blast hole deviations in Datamine Aegis software (plan view)*

Deviations of the blast holes can also be displayed in 2D views on vertical profiles. Figure 6 shows an example of vertical profiles with surveyed blast holes (left) and planned blast holes (right), clearly illustrating the extent of blast hole deviations.

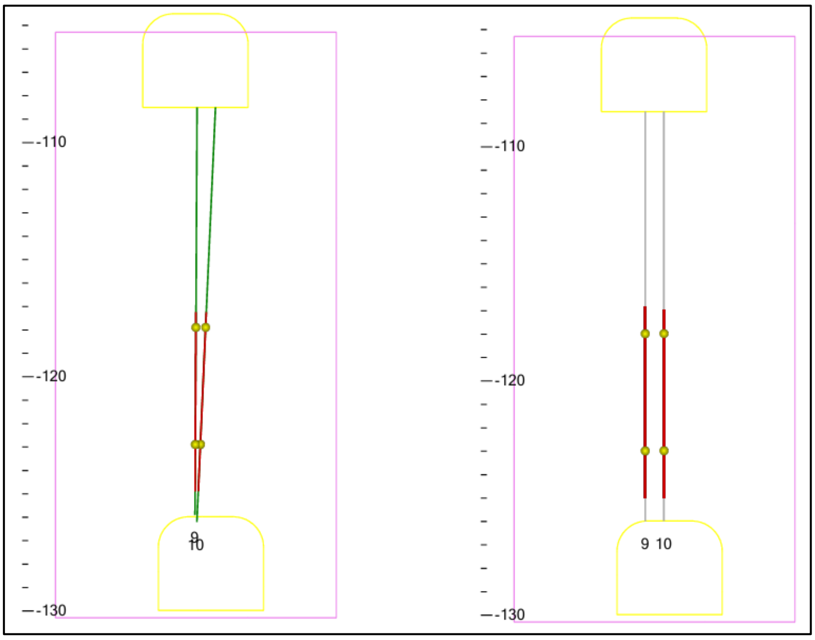
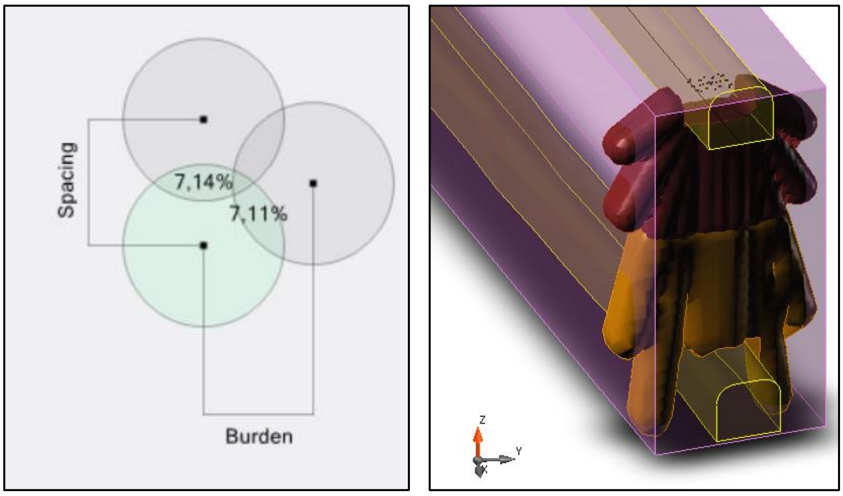


Figure 6 *Vertical profile of surveyed (left) and planned (right) blast holes 9, 10*

Deviation was observed only in the raise blast holes, due to the current lack of instruments for measuring deviations in the side blast holes. These side holes are not drilled to intersect the drift at the lower level; instead, their bottom remains in the rock mass.

Based on the provided data, the initiation sequence was determined graphically using the software, and a mining model was created in the Aegis software. Through simulation in the software for each blast hole, an approximate radius of explosive effect was obtained, and the initiation sequences of the lower part of the drift were determined due to the overlapping of these radii (Figure 7), as shown in Table 1.



a) *b)*

Figure 7 *Determining the blast radius (a) and simulation of the slot blasting (b)*

Table 1 *Blasting parameters of the slot bottom part*

Slot blasting bottom part OH 38L -110/-130				
Blast hole ID	**Series**	**Delay (ms)**	**No. of det. + bust.**	**Explosive amount per series (kg)**
1	1	100	2	30.61
2,3	2	800	4	61.22
6,7	3	2500	4	61.22
4, 5	4	4500	4	61.22
8, 9, 10, 11, 12, 13	5	5000	12	183.66
ZIII - 4, 5	6	5500	2	93.05
ZII - 4, 5	7	6025	2	93.05
ZI - 4, 5	8	6525	2	93.05
ZI - 3, 6	9	7050	2	33.06
ZII - 3, 6	10	7575	2	33.06
ZIII - 3, 6	11	8500	2	33.06

Schematic representation of a detonator conection in the bottom part of the slot is shown in Figure 8.

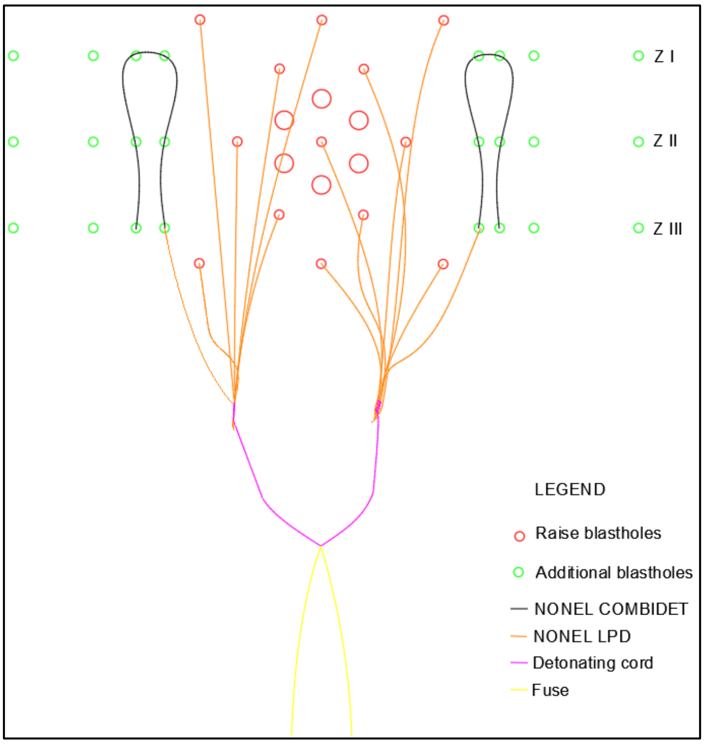


Figure 8 *Schematic representation of detonator conection in the bottom part of the slot*

Table 2 *Blasting parameters of the slot upper part*

Slot blasting upper part OH 38L -110/-130				
Blast hole ID	**Series**	**Delay (ms)**	**No. of det. + bust.**	**Explosive amount per series (kg)**
1	1	100	2	30.61
2,3	2	500	4	61.22
4, 5	3	700	4	61.22
6, 7	4	900	4	61.22
8, 9, 10, 11, 12, 13	5	1200	12	183.66
ZI - ZIII 4, 5	6	1600	6	230.16
ZI - ZIII 3, 6	7	2500	6	236.28
ZI - ZIII 2, 7	8	4500	6	170.16
ZI - ZIII 1, 8	9	6000	6	77.13

Schematic representation of a detonator conection in the upper part of the slot is shown in Figure 9.

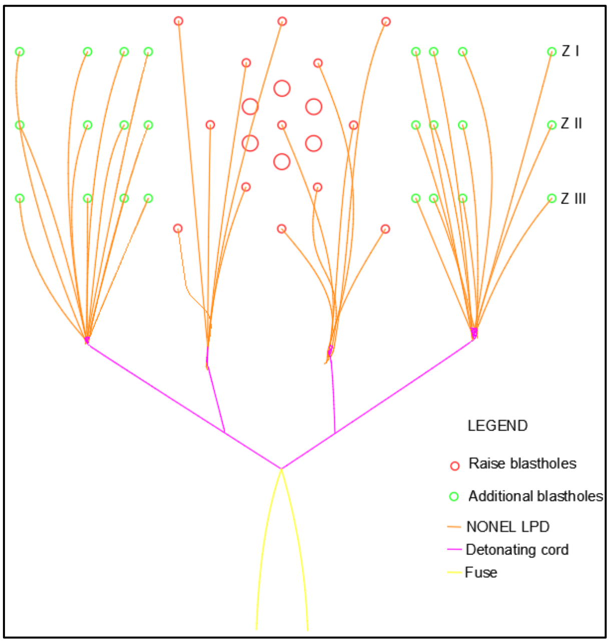


Figure 9 *Schematic representation of a detonator conection in the upper part of the slot*

RESULTS AND DISCUSSION

Slot blasting was carried out according to the method described above. The blasting of the upper and lower parts of the slot was successfully completed without any issues. A free space approximately 3.5 m x 12 m x 20 m was opened, resulting in approximately 840 m^3 of rock mass being blasted. These dimensions are approximate due to the inability to measure more precisely.

Based on this, the approximate specific consumption of explosives can be calculated as follows [4]:

$$PF = \frac{W_e}{V_o, W_o}$$

where:

PF – powder factor,

We – weight of explosive used in blast,

Vo, Wo – volume or weight of blasted ore (in this case, volume).

PF = 2.25 kg/m^3

There were no occurrences of the oversize pieces in the muck pile, while in the surrounding rock mass, there were no major damages or occurrences of the hanging rock pieces.

CONCLUSION

The new method of slot development has proven to be successful and fast. The difference in construction speed between the new and old methods is 1 day, or 3 shifts.

It has been demonstrated that this approach can efficiently and safely create the required slot for further successful blasting of the rings.

To further study the slot construction, consideration should be given to blasting the slot in one blast using an appropriate combination of delays and connection schemes.

REFERENCES

[1] Ž. Milićević, Mining Methods of Mineral Deposits, University in Belgrade, Technical Faculty Bor, 2010 (In Serbian)

[2] Project: Supplementary Mining Design for the Copper Ore Exploitation from the Borska reka Deposit above the XIX Horizon (k-235 m) with Preservation of the Terrain Surface; Mining and Metallurgy Institute Bor, 2016 (In Serbian)

[3] R. Rajković, D. Kržanović, M. Stojanović, D. Šabaz, I. Vojinović, Block Method Excavation with Backfilling of the Excavated Space of the Borska Reka Deposit, Mining and Metallurgy Engineering Bor, 1 (2024) 29-38.

[4] I. Vojinović, M. Stojanović, D. Šabaz, The Effect of Explosive Properties on Optimization the Drill and Blast Ring Design, Mining and Metallurgy Engineering Bor, 2 (2023) 1-8.