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APPLYING MASSIVE BLASTING DURING ORE EXPLOITATION IN UNDERGROUND MINES

YERALTI MADENLERİNDE MADEN ÜRETİMİ SIRASINDA BÜYÜK PATLATMA UYGULAMASI

Rafet Zeqiri[a,*]

[a] Faculty of Geosciences, University of Mitrovica, 40000, Mitrovica, KOSOVO

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ABSTRACT

Underground exploitation of lead (Pb) and Zinc (Zn) metal ore is one of the issues that requires safety during the exploitation and professional solutions for economic issues, moreover, the complicated exploitation of ore in great underground depths is imposed by the various geological mass layers that limit the production volume. In the ore exploitation process, drilling and blasting technology is applied for rock cutting, especially in the sublevel exploitation method and in particular the difficulty of applying drilling and blasting is in vein shaped sources. The mineral blasting process is done initially by performing the drilling, charging up the drill holes with explosives by aiming to blast the mineral while preventing the ore blocking as a consequence of sufficient charging of the holes with explosives. In this paper we analyze the number of drills, drilling depth, length of charging drilled holes with explosives, specific consumption of explosives.

Anahtar Sözcükler:
Madencilik,
Makine,
Üretim,
Özgül tüketim.

ÖZ

Kurşun (Pb) ve Çinko (Zn) metal cevherinin yeraltında üretimi, kazı sırasında güvenlik ve ekonomik sorunlara profesyonel çözümler gerektiren konulardan biridir, ayrıca cevherin büyük yer altı derinliklerinde karmaşık bir şekilde üretilmesi çeşitli jeolojik kütleler ve katmanlar tarafından sınırlandırılır. Cevher üretim sürecinde, özellikle yer altı işletme yönteminde kaya kazısı için delme ve patlatma teknolojisi uygulanmaktadır ve özellikle delme ve patlatma, uygulama zorluğu damar şeklinden kaynaklanır. Maden üretimine, patlatma işlemi, öncelikle delme işlemi yapılarak, patlatma deliklerinin patlayıcılarla şarj edilmesi amaçlanarak yapılırken, deliklerin yeterli miktarda patlayıcı ile doldurulması sonucunda cevherin tıkanması engellenir. Bu çalışma, matkap sayısını, matkabın uzunluğunu, patlayıcı ile doldurma uzunluğunu, patlayıcının spesifik tüketimini analiz etmektedir.

* Sorumlu yazar / *Corresponding author :* rafet.zeqiri@umib.net • https://orcid.org/ 0000-0002-9071-3105

INTRODUCTION

Mass mining in underground mines is conducted with difficulties due to the geological circumstances of the source and the rock mass. The exploitation and extraction of the lead and zinc ore with the subfloors' method is accomplished with deep drillings depending on the ore block size that will be exploited.

The blast drilling is utilized with the aim of knocking down and fragmentizing the ore, and each hole is drilled in a certain angle, whereas, they are ordered in the shape of hand fans in accordance with the rules of mining techniques.

The order of the drillings according to their angle and length is characterized by the added amount of explosives (20% - 50%) for one ton of ore with uneven granulation of the knocked down ore compared to the parallel mining scheme (Rafet, 2020-a; Jahit et al., 2016)

Upon the creation of cracks with fan drilling the gas pressure is rapidly reduced which weakens the effects of ore crumbling. With the equal presence of the explosive energy various figures for charging explosive drill holes are applied in practice, namely some explosive drills are with a varying charging coefficient. It is a rule that fan drills are filled in a zig-zag pattern, namely one drill is filled the next one remains with a small amount of explosive and so on and in each drill there will be various differences between them. This difference of charging the holes is applied in order to create the possibility of blasting the mineral while preventing the ore blocking as a consequence of sufficient charging of the holes (Rafet et al., 2016)

1. THE MECHANISM OF EXPLOITING FAN DRILLING

The mechanic drilling method for mining implies the use of drilling rigs to achieve the complete mechanization of works (drilling, positioning of drilling hammer, controlling of drilling angles and dismantling of drilling equipment). In addition, the drilling rig is distinguished in the mechanical method of movement (from one chamber to the other) by using its own engine be it electric or diesel. During drilling the worker operating the rig is protected by the cabin roof and he is positioned at the appropriate height from the mining face in the chamber. The drilling is done with drilling hammers positioned in the lafette, and the lafette is connected on the rig's drilling arm. It has to be emphasized that mines have their differing exploitation specifics, therefore not all mines can apply the existing types of the mechanized units for exploitation drilling, and therefore the basic requirement for the payoff of investments for any mechanization arises (Rafet, 2020-b; Jahit et al., 2016)

During the selection of mechanized units for exploitation drilling, namely drilling during the exploitation of ore sources, one can distinguish the impacting factors such as: drilling research capacity, transverse cutting dimensions of objects through which the unit will move, turn radius, schedule (alignment) of drilling and their direction, drilling radius for mines, length of drilling, qualification and preparation of employees.

As it is shown above, with the application of drilling rigs we achieve the complete mechanization of the drilling work for mining. The movement of drilling rigs is completely mechanized and is done through their own engines (electrical or diesel). In addition there is the option of remotely manipulating the operations during the drilling ((Izet et al., 2013; Shyqri et al., 2012). Upon using the drilling rigs the directions can be horizontal, diagonal, and vertical in parallel of fan alignment. The rigs are adapted to the exploitation methods with relatively underground capacities with tight spaces, therefore with the use of drilling units, namely the Simba Junior and Simba Special units it is possible to drill horizontally, diagonally and vertically with a fan alignment. The drilling operations and positioning of drilling equipment in these units are mechanized thus enabling various alignments of drilling for explosives as well as the specification of drilling rig types from the Simba-Atlas series (Figure 1).

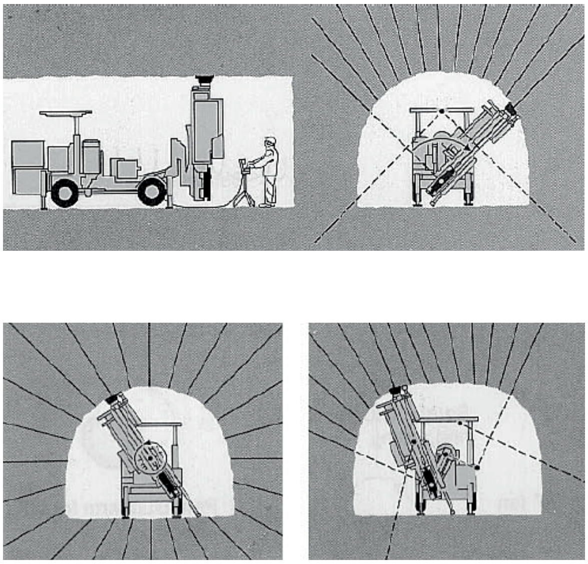

Figure 1, Alignment of drilling for explosives achieved through the use of various types of drilling rigs "Simba-Atlas Copco.

2. ORE BODY DIMENSIONS

The fan drilling system for blasting the ore rock masses can be applied to thin ore bodies as well as the thicker ore bodies which can be exploited in sublevel retreats. The ore block should be mined with fan drilling therefore the position of the gallery should first be determined and then conduct the drilling, in this specific case the gallery should have 3 x 3 m dimensions (Figure 2),

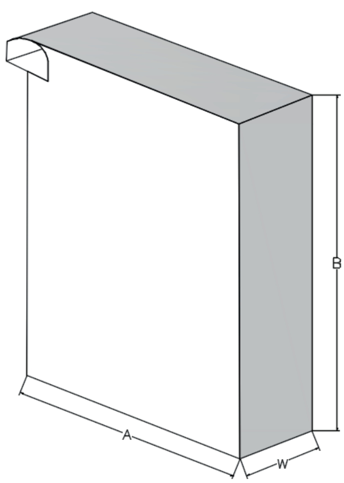

Figure 2. The position of the gallery and the ore block to be mined presented in 3D

The block to be drilled and mined in the sublevel exploitation has the following dimensions, (Kelmendi and Zeqiri 2006; Rafet, Jahir and Festim, 2019):

Block length: A=6 m

Block height: B=10 m

Block thickness: w=2 m

To accomplish the drilling blasting process we take into consideration some technical mining parameters such as:

Drilling capacity coefficient: m=1

Explosive specific consumption: q=0.3 kg/t

Explosive volume mass: $\rho = 1.2kg/m^3$

Explosive work capacity coefficient: e=1.25

Ore volume mass: $\gamma = 3t/m^3$

During the filling of the drill holes with explosive charges the explosives must be compressed in the drilling holes with the aim of increasing the density of the explosive charge. Moreover, the explosive working capacity coefficient depends on the compression of the explosive charge in each drill hole.

It is recommended that the compression of the explosive charge in the drill hole is done gradually during the filling process so that the explosive charge has the working capacity during the ignition of the explosive charge and to create satisfactory explosive energy to knock down and fragment the ore.

3. SETTING FAN DRILLING PARAMETERS

The drilling parameters will be adopted based on the dimensions of the work block, such as the drilling diameter and necessary number of holes for the given block (Izet Z., Shyqri K., Jahir G., Rafet Z., Ibrahim K., 2011, Muhamedin H., Rafet Z., 2017). In this analysis we will discuss the option of finding the smallest value of the explosive specific consumption, in which case we will use three types of mining gallery positioning (Gundewar, 2014; Haxhi, 1971).

First case study: Placing the gallery in the ceiling part on the block edges.

Initially we apply the formula that defines the slightest resisting line of the explosives:

$$W = \sqrt{\frac{\pi \cdot d^2 \cdot \rho \cdot e}{4 \cdot q \cdot \gamma \cdot m}} \quad (1)$$

Which are:

d- the filling diameter: [m]

r - explosive volume mass: [gr/m^3]

e- explosive work capacity coefficient

q- explosive specific consumption: [kg/t]

g - Ore volume mass: [t/m^3]

m- mine drilling capacity coefficient

The coefficient of the blast drilling capacity should not have a value lower than 1 (one).

This coefficient reflects the final status of the blast drilling holes that should be drilled in accordance with the planned depths. Additionally, each drilling hole should be cleaned with compressed air so that it does not contain material fragments created during the drilling.

The blast drilling coefficient is achieved when it is concluded that the drill holes are clear and do not contain any fragments of materials or water.

Within the foregoing parameters we specify the drilling diameter:

$$d = \sqrt{\frac{W^2 \cdot 4 \cdot q \cdot \gamma \cdot m}{\pi \cdot \rho \cdot e}} = \sqrt{\frac{2^2 \cdot 4 \cdot 0.3 \cdot 3 \cdot 1}{3.14 \cdot 1200 \cdot 1.25}} = 55mm \quad (2)$$

According to standard diameters of explosive charges, the closest standard diameter is: d=57[mm], therefore for blasting the block we calculate the total ore volume in the block to be mined

$$Q = A \cdot B \cdot W \cdot \gamma = 6 \cdot 10 \cdot 2 \cdot 3 = 360 \text{ tonnage} \quad (3)$$

Whereas the required amount of explosive for mining is:

$$Q_e = Q \cdot q = 360 \cdot 0.3 = 180\ kg\ explosive \quad (4)$$

For using this explosive in holes the drilling has to be performed according to the 0.7 charging coefficient, the entire length of holes for charging is calculated according to the equation:

$$l_u = \frac{4 \cdot Q_e}{d^2 \cdot \pi \cdot \rho \cdot k_p} = \frac{4 \cdot 180}{0.057 \cdot 3.14 \cdot 1200 \cdot 0.7} = 50.38 \text{ m} \quad (5)$$

The average length of drilling for blasting is:

$$l_{mes} = \frac{A + B + \sqrt{A^2 + B^2}}{3} = \frac{6 + 10\sqrt{6^2 + 10^2}}{3} = 9 \text{ m} \quad (6)$$

For blasting the ore block the following number of holes has to be drilled:

$$n = \frac{l_n}{l_{mes}} = \frac{50.38}{9} = 5.59 - \text{namely 6 holes} \quad (7)$$

The holes in the block according to the drilling angle and length of charging with explosives is presented in (Figure 3 and 4).

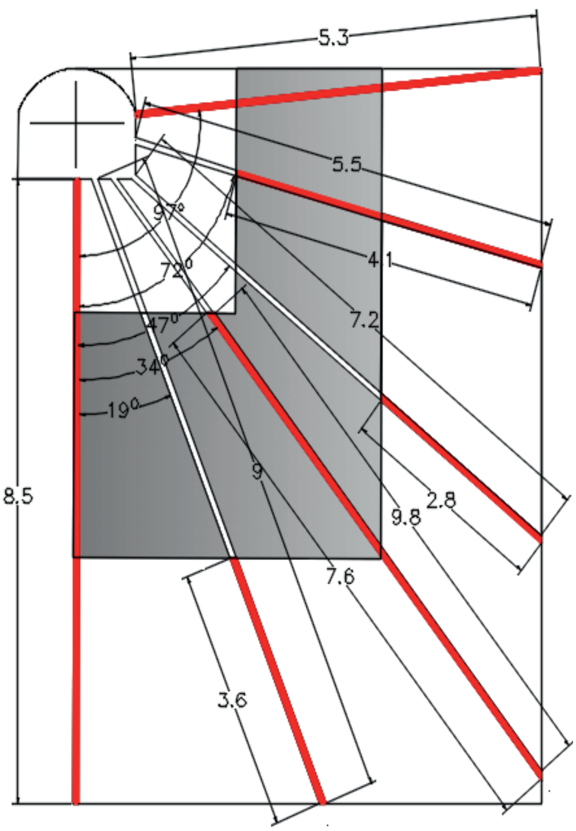

Figure 3. The holes in the block according to the drilling angle and charge length with explosives

For this specific case the total amount of necessary explosives is presented in a table based on the drilling and mining parameters (Table 1).

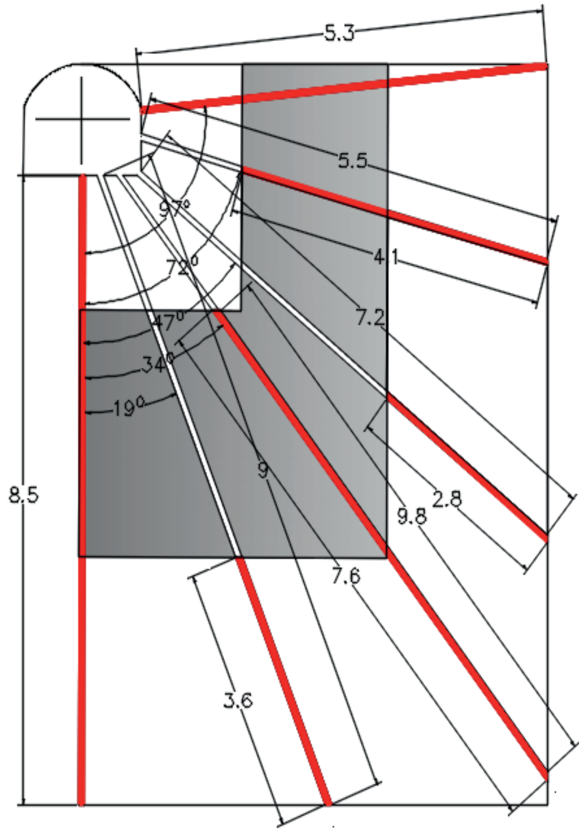

Figure 4. Presentation of explosive holes in the ore block

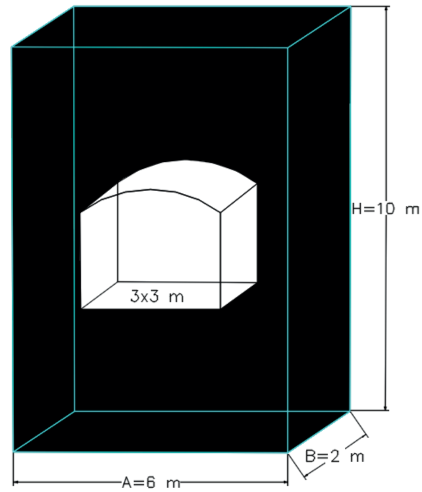

Figure 5. Setting the gallery in the center of the block.

Second case study: Is analyzed by setting up the gallery in the middle of the ore block whereas the fan drilling angle is adopted in a 30^0 and the distance between holes is 0,50-0,70 m, and there are 12 holes in total to be drilled whereas the block dimensions remain the same as in (Figure 5 and 6).

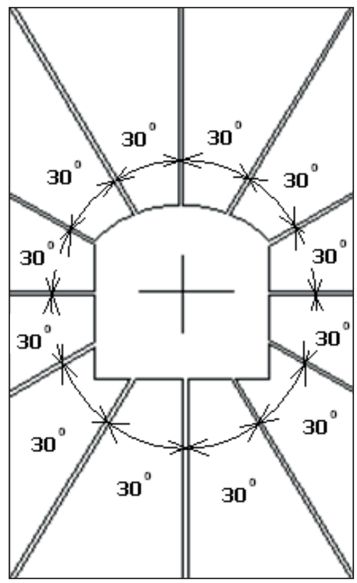

Figure 6. Fan drilling in a 30^0 angle

Table 1. Mining parameters for the ore block according to the first case study.

Number of drills	Drilling angle [^{0}]	Drilling length [m]	Charge length [m]	Length of charges [m]	Number of charges	Weight of charges [gr]	Explosive amount [kg]
1	0	8.5	8.5	16.35	52	500	26.35
2	19	9	3.6	16.35	22	500	11.16
3	34	9.8	7.6	16.35	46	500	23.56
4	47	7.2	2.8	16.35	17	500	8.68
5	72	5.5	4.1	16.35	25	500	12.71
6	97	5.3	5.3	16.35	32	500	16.43
Total		45.3	31.9		95		97.60

Specific consumption of explosives for the first case study is: q=97.60/360=0.271 kg/t.

The drilling and blasting analysis after the second case study has provided various results compared to the first case study, which means that we have a reduction of the specific consumption (Figure 7) and (Table 2).

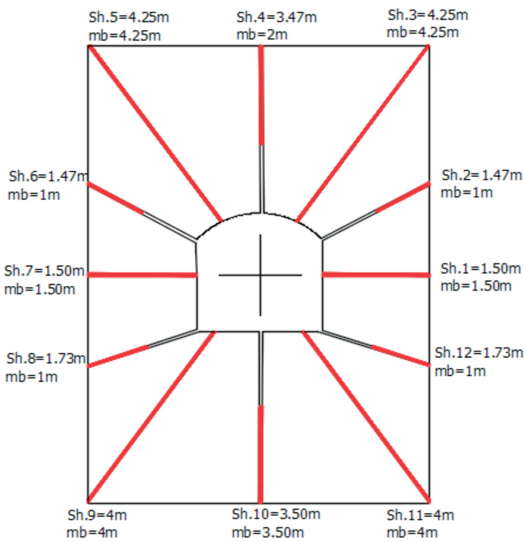

Figure 7. Charging with explosives

Third case study: is also addressed by positioning the gallery in the middle of the ore block whereas the fan drilling is in a varying drilling angle of 140-230 and there is a 30-35 cm distance between holes. The hole diameter is similar to the first and second case study, as is the diameter of charges but the degree and distance between holes is different (Figure 8) and and (Table 3), (Hoek, 2000; Hughes, 2001).

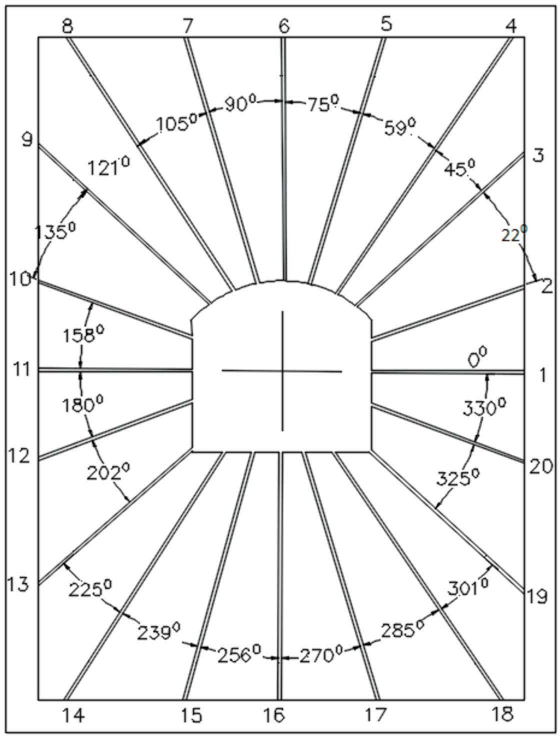

Figure 8. The drilling angle for each hole according to the drilling rig arm rotation

Table 2. Mining parameters for the ore block according to the second case study

No. of drills	Drilling angle [0]	Drilling length [m]	Charging length [m]	Length of charges [m]	Number of charges	Weight of charges [gr]	Explosive amount [kg]
1	30	1.50	1.50	16.35	9	500	4.6
2	30	1.74	1.00	16.35	6	500	3.1
3	30	4.25	4.25	16.35	26	500	13.0
4	30	3.74	2.00	16.35	12	500	6.12
5	30	4.25	4.25	16.35	26	500	13.0
6	30	1.74	1.00	16.35	6	500	3.1
7	30	1.50	1.50	16.35	9	500	4.6
8	30	1.73	1.00	16.35	6	500	3.1
9	30	4.0	4.00	16.35	24	500	12.2
10	30	3.50	2.00	16.35	12	500	6.1
11	30	4.00	4.00	16.35	24	500	12.2
12	30	1.73	1.00	16.35	6	500	3.1
Total		33.68	27.50		168		84.1

Specific consumption of explosives for the second case study is: q=84 / 360=0.23 kg / t.

Table 3. Mining parameters for the ore block according to the second case study

No. of drills	Drilling rig arm rotation	Drilling angle for each hole	Drilling length [m]	Charge length [m]	Length of charges [m]	Number of charges	Weight of charges [gr]	Explosive amount [kg]
1	0	0	1.50	0.50	16.35	3	500	1.5
2	22	23	1.64	1.64	16.35	10	500	5.0
3	45	14	2.61	1.50	16.35	9	500	4.6
4	59	16	4.23	4.23	16.35	26	500	12.9
5	75	15	3.65	2.50	16.35	15	500	7.6
6	90	15	3.49	3.00	16.35	18	500	9.2
7	105	16	3.66	2.50	16.35	15	500	7.6
8	121	14	4.23	4.23	16.35	26	500	12.9
9	135	23	2.59	1.50	16.35	9	500	4.6
10	158	22	1.60	1.60	16.35	10	500	4.9
11	180	22	1.50	0.50	16.35	3	500	1.5
12	202	23	1.6	1.60	16.35	10	500	4.9
13	225	14	2.05	1.50	16.35	9	500	4.6
14	239	17	4.07	4.07	16.35	25	500	12.4
15	256	14	3.62	2.50	16.35	15	500	7.6
16	270	15	3.51	3.00	16.35	18	500	9.2
17	285	16	3.63	2.50	16.35	15	500	7.6
18	301	14	4.07	4.07	16.35	25	500	12.4
19	315	23	2.23	1.50	16.35	9	500	4.6
20	338	23	1.64	1.64	16.35	10	500	5.0
Average		17.0						
Total			57.12	46.08		282		140.9

Specific consumption of explosives for the second case study is: q=140.9 / 360=0.39 kg / t.

4. CONCLUSION

This scientific paper is of special importance and requires dedication and detailed studying in relation to the application of the drilling and blasting technique. During the study of this problem the drilling rig was selected and based on the block dimensions we chose the drilling diameter, the drilling depth and drilling angle.

While applying the blast drillings we are obliged to observe the rules of mining techniques so that the drill holes are ordered in accordance with the projections of the professional engineers. In addition, the filling of the drilled holes with explosive charges should be done in a controlled and professional manner. The lack of explosive charges endangers and complicates the ore exploitation, whereas the exceeded concentration of the explosive charge causes shocks to the surrounding rocks that manifest pressures in mine works.

This method of charging the holes may yield good and bad results if the foregoing factors are not analyzed. This hole charging alternative should be applied with the aim of acquiring the desired granulation and keep the specific consumption within satisfactory limits. During our case studies the number of drills, length of drilling, length of charging the holes with explosives were correct and finally we acquired the amount of explosives for each hole and also the specific consumption for all three case studies (Table 4).

Table 4. Results of specific consumption of explosives for the three case studies

Case studies	Ore reserves [t]	Explosive amount [kg]	Specific consumption [kg/t]
First case study-positioning the gallery in the ceiling part of the block	360	98	0.27
Second case study-positioning the gallery in the center of the block with a 300 drilling angle	360	84	0.23
Second case study-positioning the gallery in the center of the block with various drilling angles	360	141	0.39

Based on the foregoing mining parameters for the specific case we prefer and choose the second case study to apply for blasting the ore by positioning the gallery in the center of the block with a 300 drilling angle, in which case we have the minimum specific consumption of explosives compared to the first and third case studies.

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