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OPENING THE ORE BODY “ČOKA MARIN-1” BELOW K+535 m^{***}

Abstract

The need to open the lower parts of the ore body was caused by a number of reasons. One of the reasons is the high price of precious and non-ferrous metals on the stock market, which is far higher than the one used in calculation the technical-economic assessment in the project study on mineral reserves from 2004. Another reason for opening the lower parts of the ore body would be the remaining part of the balance reserves verified by the project study on ore reserves, not included in the main mining design on mining the ore body “Čoka Marin – 1”.

Keywords: *opening, ore body, balance reserves*

INTRODUCTION

The hill “Čoka Marin” (with its peak 648 m), or the area in which the deposit “Čoka Marin” is situated and the ore body “Čoka Marin – 1”, is located on the triabudment of the villages Vlaole, Jasikovo and Leskovo (Fig. 1), about 13 km south of Majdanpek in the air route. It territorially belongs to the municipality of Majdanpek.

The site “Čoka Marin” can be reached via the inter - municipal road Majdanpek - Leskovo - Jasikovo - Vlaole - Gornjane - Bor and the railroad Belgrade - Majdanpek - Bor - Zaječar. The nearest railway station, Jasikovo, is about 1 km. By the railroad from Bor to the station Vlaole is 26 km, from Bor to Leskovo 36 km and 46 km to Majdanpek.

Along the ridge towards the villages of Leskovo, Vlaole and Jasikovo, the village and forest roads run that are passable mainly in dry periods.

The ore deposit “Čoka Marin” is located in the eastern part of the Timok Magmatic Complex (TMC), i.e. the Bor Metallogenic Zone (BMZ).

Besides the ore body “Čoka Marin - 1”, two ore bodies “Čoka Marin - 2” and “Čoka Marin - 3”, were discovered at distance of 1.5 km and 2.2 km (Fig. 2).

The narrow area of the ore body “Čoka Marin” was mainly built of hydrothermally altered volcanic rocks and series of pelytes (marls, tuffs and tuffites), volcanic breccias, quartz diorite - porphyryites, secondary quartzites and quaternary formations.

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Figure 1 Geographical position of the deposit “Čoka Marin”

Figure 2 Schematic view of the ore bodies in the deposit “Čoka Marin”

There are also smaller breakthroughs of diorite and quartz diorite and veins of quartz diorite porphyrite and diorite porphyrite. A widely distributed hydro quartzite (with increase concentrations of gold) was observed directly above the ore bodies.

The ore body "Čoka Marin 1" has a tubular shape, with the expansion in the central part from the level +550 to +530 m, so that it takes in the horizontal sections a shape of lens, direction of NE-SW, with a very steep slope towards SE. The floor of the ore body is made of volcanogenic-sedimentary series of pelytes with the interstratified tuffs and volcanic breccias. The ore body "Čoka Marin - 1" is built of polymetallic (with Au, Cu, Zn, Pb and Ag), massive-sulphide (with Au, Cu and Ag) and stock work - impregnation mineralization (with Au and Ag). The ore body "Čoka Marin - 1" (according to the Rule Book) has been included in the first group, the first subgroup of gold ore bodies.

EXPERIMENTAL PART

The experimental part is reflected in a detailed geological exploration, sampling and analysis of samples obtained from exploration adits and drillholes.

Three types of mineralization are quantitatively and qualitatively separated in a contour of cut-off grade of 0.40% for copper and sulfur, in a contour of cut-off grade of zinc content of 0.50% for Zn and Pb, and in a contour of cut-off grade of gold of 0.5 g/t for Au and Ag:

1. Polymetallic mineralization is represented by gold, silver, copper, sulfur, zinc and lead. This mineralization is 29% of total balance reserves of ore
2. Massive - sulphide mineralization with gold, silver, copper and sulfur makes 47.4% of total balance reserves of ore.
3. Stock work-impregnation mineralization contains gold and silver. The amount of balance ore is 23.6%. This

mineralization extends deeper (to K + 340 m), is made elaborate the categorization of balance reserves was carried out to K + 440 m by the Project Study.

The data shows that economically most interesting is the polymetallic mineralization with 29% of balance ore reserves, which includes 71% of gold, 82% of silver and 59.4% of copper, 40.5% of sulfur and 100% of lead and zinc.

A contour of the ore body was obtained within these cut-off grades, which extends by the height from the K + 440 m to K + 580 m, and which was the base for development the Project Study on mineral reserves from 2004.

For calculation the balance reserves in the ore body "Čoka Marin - 1", it was started from the amount that is 337,017.45 t. When this value is reduced by the moisture content of 3.5%, the amount of dry ore is obtained of 325,221.84 t, which are the balance reserves.

The ore body "Čoka Marin - 1", as already explained, has a different content of useful components in all three mineralizations, or has very little some precious metals in some mineralizations, and the total is received as:

- In 325,221.81 t of dry ore with cut-off grade of copper of 0.40% and the mean content of 1.61%, 5,233.02 t of copper is obtained, after metallurgical treatment, and sulfur, with the mean content of 16.86%, has 54,851.84 t.
- In 262,292.95 t, with the mean content of 5.76 g/t gold, there is 1,510.72 kg, and silver with the mean content of 45.64 g/t, after metallurgical treatment, there is 11,971.71 kg,
- In 64,667.84 t dry ore with the mean content of lead of 1.99%, there is 1,284.85 t and zinc with the mean content of 4.86%, there is 3,142.20 t.

The content of mercury and arsenic is calculated based on sampling from both exploration horizons by the sampling proce-

dure of gold, silver, copper, lead and zinc. It was calculated that in 325.221.81 t balance reserves of ore, there is the total of about 1,500 kg of mercury and 1,000 t of arsenic.

OPENING OF THE ORE BODY “ČOKA MARIN - 1”

The adit 534 (length 230 m) and adit 553 (length 200 m), used to the open ore body, were made at the stage of underground geological explorations the ore body “Čoka Marin - 1”. They will be used in a function of future mining the ore body “Čoka Marin - 1” for ventilation of the mine and haulage of ore. For the purpose of ventilation during excavations, two ventilation shafts were made, respectively PVO 1 (565/534 m) and PVO 2 (557/537 m).

MINING OF THE ORE BODY “ČOKA MARIN - 1”

The sublevel caving method was adopted in the Main Mining Design for mining the ore body “Čoka Marin - 1”, which in this case could provide the optimal results.

The ore mining by this method is carried out in the excavation blocks perpendicular on extension of the ore body. The base of caving blocks is of a rectangular shape, sizes 10 x 10 m, and a block height is 10 m.

Excavation begins from roofing to the footwall of the ore body, with the general direction of excavation from top to the bottom by the height of the ore body.

According to the concept of mining method by the height of the ore body, a sublevel drift (SD) is made at every level by extension of the ore body.

The excavation drifts (ED) are made from sublevel drifts (SD) perpendicular to the ore body in the middle of caving blocks at distance of 10 m.

Sublevels are linked to one side for the pass ventilation shafts, and the other side for the service rises or edits for communication with the outer surface of terrain.

Mining of the ore body will be carried out at four sublevels (levels) as well as:

- I sublevel at K 565 (from K 565 to K 575)
- II sublevel at K555 (from K 555 to K 565)
- III sublevel at K545 (from K 545 to K 555)
- IV sublevel at K535 (from K 535 to K 545)

The entries, size 4 x 3 m, are developed on sublevels from sublevel drifts at the level of ore excavation and they are used for drilling, blasting and loading of ore.

Loading and transport of blasted material from the face of preparation drift will be done using the loading-transport-unloading machine (LTU) diesel - powered. Transport of ore by this machine will be done to the exit of adit (adit 534 or adit 553) where the ore will be reloaded into transport trucks.

OPENING OF THE ORE BODY “ČOKA MARIN - 1” BELOW K+535m

The need to open the lower parts of the ore body was caused by a number of reasons. One of the reasons is the high price of precious and non-ferrous metals on the stock market, which is far higher than the one used in calculation the technical-economic assessment in the project study on mineral reserves from 2004. Prices which have been used in calculation on 31/12.2003 are: 2,800 USD \$ per ton of copper, 12,400 per kilogram of gold and 156 USD\$ per kilogram of silver on the world market.

Current prices (June 2007) of these metals on the world market are as follows: 7,625.50 USD\$ per ton of copper, 21,145.53 USD\$ per kilogram of gold and 428.89 USD\$ per kilogram of silver.

Another reason for opening the lower parts of the ore body would be the remaining part of the balance reserves verified by the project study on ore reserves, not included in the main mining design on mining the ore body “Čoka Marin - 1”.

Another reason this paper is transfer from truck transport (transport of ore from the mine to the Flotation Plant in Majdanpek) to the railway transport.

Opening the lower parts of the ore body would be done by adit, spiral rise and pass ventilation shafts which would be done by deepening the already existing ones (Fig. 3).

Figure 3 Location of opening room of the ore body "Čoka Marin - 1"

Adit 420 would be made from the field surface at K+420 m in the northeast direction of cross section 4x3 m, rise of 3 ‰, with length of 850 m, to the connection with PVO 2 at K +422.5 m (Fig. 3). Adit 420 would also have purpose of transport adit, because a belt conveyor will be located on a part of its length.

PVO 2, by deepening from K + 537 to K + 425 m and connection with adit 420, would have purpose to ventilate the future excavation levels.

Deepened PVO 1 from K + 534 to K + 425 m would have a multiple purpose, that is, it would be a mining shaft, where the crusher would be located at K + 430 m, and therefore to become also an accumulation shaft.

Figure 4 *Opening and development rooms*

Spiral rise (422/535), with a grade of 15%, and length of 750 m, would serve for development the other mining levels or sublevels (Fig. 4).

Connecting drift would be developed over a length of 20 m and connect the adit 420 with PVO 1. The beginning of belt conveyor would be located in this drift, which would be connected over unloading point (at the connection 420 and connecting drift) to the belt in the adit 420.

Total length of the belt conveyor would be $780 + 20 = 800$ m.

At the exit of adit, at $K + 420$ m, a plateau would be made to accommodate the ore, size 10×10 m (Fig. 3). The ore loading would be done from this plateau into wagons in two ways: directly from belt or by loader.

THE REMAINING MINEABLE RESERVES

The amount of geological reserves, verified by the Project Study on the ore serves of 2004, amounts to 337,017.45 t. The Main Mining Design on ore mining in the ore body "Čoka Marin - 1" will mine to 179,866 t of mineable reserves.

Coefficients of utilization and depletion, calculated in the said MMD, will be used for calculation the mineable reserves at the lower parts of the ore body. The coefficients depend on the mining method. The sublevel caving method would be also used for excavation the lower parts of the ore body, because they are of small thickness and incline that their exploitation do not jeopardize the structures on the surface.

Total mineable reserves are calculated by the formula:

$$Q_e = \frac{Q_g \cdot K_{ir}}{1 - K_{or}} = \frac{337,017.45 \cdot 0.85}{1 - 0.1} = \frac{0.85 \cdot 138,428.26(2.16 - 0.3)}{1.97 - 0.3} =$$

$$= 318,294.26 \text{ t} \quad = 131,050.95$$

where:

- K_{ir} - coefficient of ore utilization
- K_{or} - coefficient of ore depletion

The remaining mineable reserves are:

$$Q_{e_2} = Q_e - Q_{e_1} =$$

$$= 318,294.26 - 179,866 = 138,428.26 \text{ t}$$

Exploitation life:

$$T = \frac{Q_{e_2}}{20000 \text{ t / year}} = 6.9 \text{ year} \approx 7 \text{ year}$$

The amount of run-of-mine ore is obtained by the formula:

$$Q_r = \frac{K_{ir} \cdot Q_{e_2} (m - m_j)}{m_r - m_j} =$$

$$Q_r = 131,050.95 \text{ t}$$

where:

- m_r – metal content in run-of-mine ore,
- m_j – metal content in waste rock,
- m – metal content in ore reserves.

INVESTMENTS

Investments include the construction of all the above mentioned facilities to start the exploitation. Values of costs, which will be used in calculation, are taken from the Technical Design of ore mining in the ore body "Čoka Marin - 1".

Table 1 Development costs of the mining rooms

Order No.	Room name	Type of development	Room length, (m)	Unit price, (USD\$/m')	Total (USD\$)
A	B	C	D	E	F
1	Drift 420	Development and supporting	850	700	595,000
2	PVO 1	Development and supporting	109	500	54,500
3	PVO 2	Development and supporting	112	500	56,000
4	Spiral rise	Development and supporting	750	797	597,750
5	Connecting drift	Development and supporting	20	700	14,000
				Total	1,317,250

Labor costs are reflected in the time needed for construction the mining facilities and installation the additional equipment. By the beginning of exploitation, it is

necessary that 12 workers work in two shifts 250 working days. If the price of gross wage is 25 USD\$, the value of 150,000 USD\$ is obtained.

Table 2 *Other costs*

Order No.	Name	Investments	Total (USD\$)
A	B	C	D
1	Loader	Purchase	200,000
2	Crusher	Purchase and installation	300,000
3	Belt conveyor	Purchase and installation	400,000
4	Plateau at the entrance of adit	Purchase of land and preparation of plateau	30,000
5	Room for crusher	Preparation and supporting	20,000
6	Designing	Project development	50,000
Total (USD\$)			1,000,000

Total costs in opening the lower parts of the ore body "Čoka Marin - 1" are the sum of these costs:

$$Tuk = Tir + Trs + Tot$$

and the costs per ton of ore:

$$Tr = Tuk / Qr =$$

$$= 2,467,250 / 131,050.95 = 18.83 \text{ USD\$} / t$$

$$Tuk = 1,317,250 + 150,000 + 1,000,000$$

$$Tuk = 2,467,250 \text{ USD\$}$$

CONCLUSION

The task of this study was to show a possible way of opening the lower parts of the ore body "Čoka Marin - 1".

There are advantages of a new way of opening, reflected through:

1. The possibility of mining 138,428.26 t of mineable reserves, not affected by the MMD on mining from 2007.
 2. The possibility to change the external transport of the ore body "Čoka Marin - 1", as well as savings on transportation costs:
- By transfer from truck transport to the railway transport, the transport route is shorten to up to 10 km in one direction, and at the same time the transport costs are reduced, as the costs of railway transport are much lower than the cost of truck transport.

- Shortening of internal transport by loaders is obtained, an average of 200 m in one direction, because their transport route will be to PVO 1, a does not come from the adit.

3. The price of excavation per ton of ore would be reduced.
4. Development the adit 420 comes up to level at which there are peaks of the ore bodies "Čoka Marin 2 and 3," what would facilitate their opening and exploitation in the future period.
5. Increase the prices of precious and non-ferrous metals on the market, allows excavation the ore body "Čoka Marin - 1" in the other boundaries with much lower content of useful components, and the opening of the lower parts of the ore body is necessary.

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