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MINING AND ENVIRONMENTAL PROTECTION

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CUT AND FILL UNDERGROUND MINING METHOD WITH PASTE BACKFILL – TECHNOLOGY WITH HIGH LEVEL OF ENVIRONMENTAL PROTECTION

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Abstract: *Given the shortcomings of Underground Methods for Sublevell caving among which are degradation of the terrain above the ore deposit, high level of dilution, large ore losses, difficult ventilation etc. It is booming today the application of the Cut and Fill Mining Method with filling in the form of a thick mixture – paste fill. This excavation technology allows tailings to be returned in the place where it was produced. In the paper as a case study is taken the mine "Sasa" where in the design and implementation phase is Cut and Fill Mining Method with paste backfill. The paper briefly describes the mining-geological characteristics of the mining site "Svinja Reka", the conditions for application and description of the method with details of the excavation cycle.*

Keywords: *method, excavation, backfilling, paste, distribution.*

1. INTRODUCTION

The evolution of excavation technology by filling excavated areas is closely related to the type and characteristics of the material used as excavation, [1]. Starting from the tailings material obtained during the construction of the underground preparatory facilities – dry backfill, the waste material obtained from the flotation plants – hydraulic fill, then cement hydraulic fill, today in expansion is the application of backfill in the form of a thick mixture, so called paste, [2].

Research in the field of technologies for filling the excavated areas has yielded significant results, so that today a backfill with high solid phase density is produced (from 75% to 85% by weight), [5]. In the period from 2000 until today, a number of mines around the world in their production have successfully introduced the backfill in the form of a thick mixture – paste. In the immediate vicinity are the Chelopech Copper Mine, R. Bulgaria, the Olympic Copper Mine, R. Greece, and others. The reasons for the conversion of the hydraulic fill into a backfill in the form of a paste are:

- economic,
- ecologic
- geotechnical and
- security benefits

Today, many mines around the world are in the process of moving to this type of backfill, focusing on examination of the possibilities for utilization of the sand obtained directly from the flotation plant and the sand previously deposited in hydro-flotation tailings, as one of the components for creating backfill in the form of a paste.

The main advantages of a paste filling system compared to a conventional system with hydraulic fill are:

- higher backfill strength can be achieved at an equivalent cement content,
- drainage of backfill water is minimal and the need to build barriers, expensive drainage works and drainage pumps is reduced,
- in some cases, unclassified tailings material may be used to make paste, as opposed to the cycloning required for the hydraulic fill,
- a shorter filling cycle can be achieved because the equivalent hardness (load capacity) of the backfill can be achieved in a shorted time with the backfill in the form of a paste,
- paste filling systems achieve lower porosity than conventional backfill which requires a larger mass of material to fill the same spaces,
- because when embedding the paste there is no segregation of the masses, better strength properties are achieved, unlike the hydraulic fill where the cement particles as a binder are usually taken away from the water.

Disadvantages of paste filling systems are:

- these systems are characterized by higher capital costs compared to the systems with hydraulic fill,
- the pumping of the paste is very sensitive to small changes in the water content and the granulometric composition of the solid component,
- the paste distribution network in the mine requires a higher level of engineering performance to control pipeline pressures.

2. MINING-GEOLOGICAL CHARACTERISTICS OF THE SITE “SVINJA REKA”

The ore deposit for lead and zinc “Svinja Reka” in the interval between horizons 990 and 750, where the excavation method is located and needs to be adapted for excavation with drifts and filling the excavated areas with a thick mixture – paste, is a continuous ore body after stretching and decline, with the following basic parameters:

- length about 900 m
- width from min 4.5m to max 30m, or medium 17.2 m
- angle of inclination of 30° ÷ 45°, medium (37.5)°.

The mineral deposit “Svinja Reka”, Fig. 1, has hydrothermal origin, and it is deposited in the series of quartz-graphite shales that represent its surface and hanging wall. The uniaxial compressive strength of the shale is 71.44 MPa and that of the ore is 172.93 MPa.

Quartz graphite shales on contact with the ore bodies are characterized by numerous cracks, filled with clay, are unstable and prone to collapse.

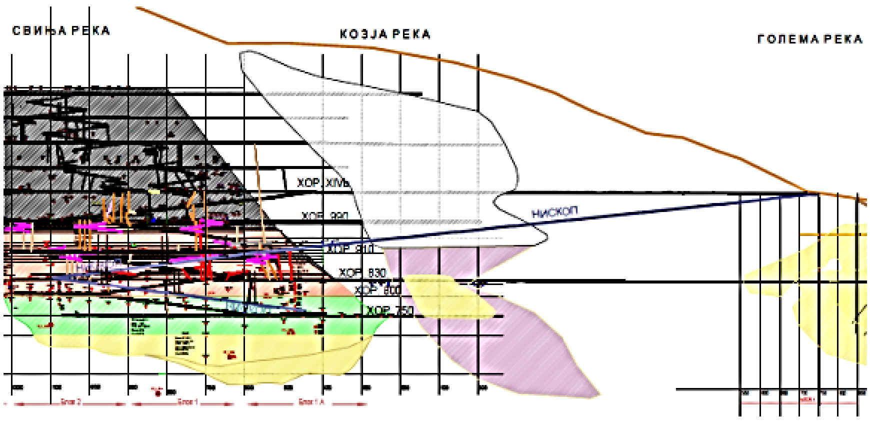

***Figure 1.** Longitudinal section of the lead and zinc ore deposit "Svinja Reka"*

3. CONDITION FOR APPLICATION OF THE MINING METHOD BY FILLING THE EXCAVATED AREAS – DRIFT AND FILL

The excavation of the "Svinja Reka" ore deposit below the 990 horizon, and especially bellow the 830 horizon, is conditioned by several factors, of which the most important are the following:

- mining-geological conditions of mining ore zone and surrounding rocks,
- technical-economic conditions, which are perceived through the high recovery coefficient and low dilution of the ore during the excavation,
- protection of the environment from possible deformations and cavings on the terrain above the ore deposit,
- protection of the environment by returning the flotation tailings to the excavated areas.

For the excavation of the ore bodies that have, as mentioned earlier, a variable thickness, of drift and fill mining method will be applied. Depending on the thickness of the ore body, one, two or three excavation drifts to the strike will be made.

Characteristic for the application of the planned excavation method as stated is protection of the environment and protection of the objects from demolition, but it has another advantage that allows the application of modern and capacitive mechanization what contributes to increasing the intensity of excavation, high concentration of excavation works, very favorable technical-economic parameters of excavation leading to the realization of low production costs per ton of ore produced.

4. OPENING AND DEVELOPMENT OF THE ORE DEPOSIT UNDER THE HORIZON 990

The basic facilities for opening and development of the ore deposit "Svinja Reka" under the horizon 990 are:

- main undermining of the hor. XIVb with a length of 2300 m,
- main export service ramp XIVb – 830, with a length of 3000 m and a slope of 12%,
- basic undermining of the hor. 830, with a length of 5500 m,
- main transport service decline (area – hor. 750), with a length of 2800 m.

The horizontal objects for processing, i.e. the capital drifts are made at a vertical distance of 80 m, and they are the capital drifts of: hor. 990, hor. 910, hor. 830, and hor. 750. They are located in the bottom shales, and sometimes pass through gneisses, are usually made at a distance of 20 to 30 m away from the mining ore zone.

5. DESCRIPTION OF THE DRIFT AND FILL MINING METHOD

The excavation of the ore bodies with an average power of 17.5 m and an average angle of inclination of (37.5)° between the horizons 990 and 750 will be performed with "Cut and Fill Mining Method ore its variant Drift and Fill Mining Method with paste backfill". The mining ore zone will be divided into three excavation blocks with dimensions 300 x 500 m, fig.2.

5.1 Development works

The preparation of the excavation block with a length of 300 m is envisaged with the following mining facilities:

- Excavation service ramp located in the foot wall shale, at a distance of 30-30 m, with a slope of 15% and a transverse profile 4 x 4 m. Its purpose is to open the horizontal belts at a height of 20 m, servicing the excavation, access with mechanization, etc.
- Access drifts located in the foot wall of the mining ore zone and the are the connection of the excavation ramp with the excavations, the ore pit and the ventilation shaft.
- Ventilation raises also located in the floor central to the excavation block in the waste rocks, with a profile of 2 x 2 m, slope 60° and length 56 m.
- Ore pass located in the foot wall, central to the excavation block and directly connected to the access drifts / crossings. Their length is 56 m, the slope is 60° and the dimensions of the profile are 2 x 2 m.

The total coefficient of development works depends on the thickness of the ore body and for an excavation block with length of 300 m is 2.85 m per 1000 tons of prepared ore in the excavation block.

5.2 Details of the excavation process

The excavation starts from horizon 750 with the construction of the access drift, and crosscut that intersects the thickness of the ore body. Thus, the excavation block is divided into two semi-blocks with dimensions of 150 m. Then ore drift in strike is made in the hanging wall of the mining ore zone to the border of the excavation block. The dimensions of the excavation corridors are 4 x 4 m. If it is a matter of thin ore bodies up to 8 m thick, then an ore drift in strike is made, and the rest of the ore is excavated on the retreat access drift. In case of thicker ore bodies, with a thickness of over 8 m, in that case three or more drifts in strike are made, with the excavation being done through one corridor, in which way a protective pillar is left. A barricade is made at the crosscut and ore drift in hanging wall is filled with paste fill.

For exploitation drilling, drills of electro-hydraulic drive are provided, with a length of mine holes of 3 m during the construction of the excavation drifts.

Blasting: In the current practice, powdered emulsion explosives 0.43 kg/t have been used, and the initiation is done with nonel detonators.

Loading and haulage in stopes: Diesel freight transport machines (LHD), produced by the company Epiroc, with a shovel capacity of 2.8 m^3 are envisaged.

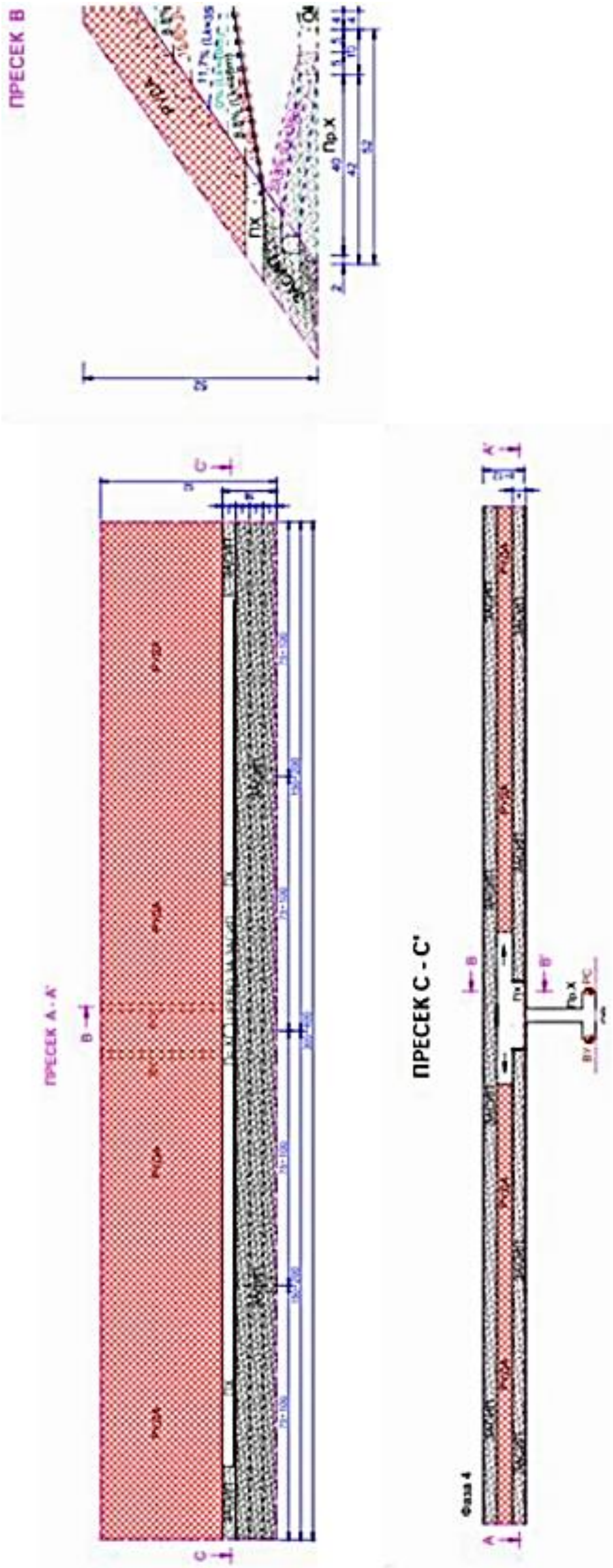

Figure 2. Schema for Drift and Fill Mining Method

5.3 Backfilling

The backfilling of the excavated spaces will be done with filled material in the form of paste-slurry, which is composed of the following components: flotation tailings, cement, and fly ash-product of the thermal power plants. A special plant will be built for the production of the paste. The paste production plant will be located on the plateau near the entrance of the old Adit XIVo, south of the ore body, Fig.3. The location was chosen due to proximity of the entrance of Adit XIVb through which the route of the paste pipeline and the available space will be guided.

Figure 3. Location of the Paste Production Plant

The tailings obtained from flotation will thicken and must first be drained before being filtered, [3]. The filtered mixture will go either to the tailings dump or to the paste production plant. The mixture that will enter the paste production plant will be mixed with water and binder (cement and fly ash) to make a paste, [4]. The paste will be pumped into the pit by means of positive displacement pumps. The conceptual sketch of the technological process is shown in Figure.4.

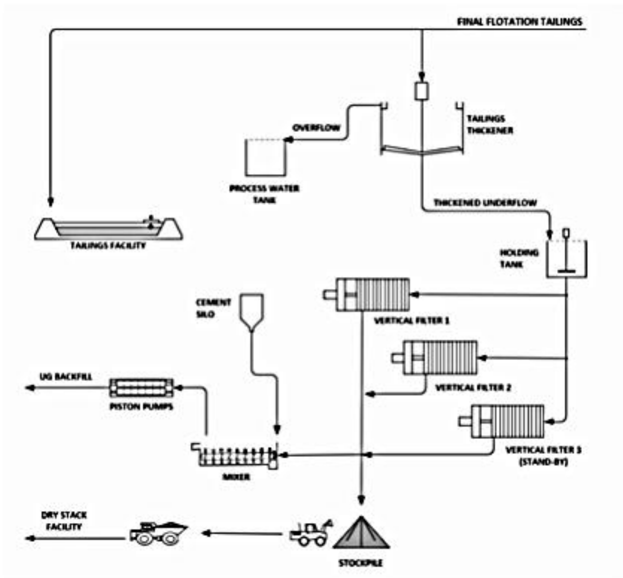

Figure 4. Conceptual scheme for flotation tailings management (P&C)

5.4 Backfilling

In order to cover all excavation zones where the Drift and Fill Mining Method will be applied, it is necessary to install about 7.5 km of pipeline and 1 km of boreholes.

The proposed reticulation layout includes the following major components:

- Common surface pipeline running from pastefill plant to the XIVb Portal (approx. 160m),
- Common underground pipeline running from XIVb Portal to the first borehole,
- Common underground pipeline running through the New Decline to the 910 Horizon,
- Common underground boreholes connecting Horizons and linking internal ramps,
- Common underground main trunk pipelines connecting Horizons, and Footwall drives,
- Dedicated pipelines for each internal ramp,
- Dedicated pipelines to the level cross-cuts.

The filling capacity will be 70 m^3 / h and the paste will be transported through steel pipes (6 inches and a pressure of 13 bar).

Delivery of the paste from Paste Production Plant to the stopes will be regulated by an automatic regulation system – SCADA system.

System for dewatering of the stopes will be carried through the ventilation and drainage raises, Fig.2., so that the water will be pumped to the hor.830, from where it will be taken from the main dewatering system of the mine.

Supporting of the ore drifts will be done with anchors in combination with steel mesh and sprayed concrete. However, a definite selection of the technical parameters of the substructure system will be made after a detailed geomechanical classification of the working environment in the experimental phase of the excavation.

Ventilation of the stopes will be done so that the fresh air current of the excavation blocks will come from the horizon 750, then through the Ventilation raises and Access drifts it comes to the stope, where it branches and ventilates the two wings of the excavation block, with a length of 150 m. The amount of fresh air for ventilation of the stope is 9.5 m^3/s.

The productivity of the excavations is 8.37 t/men-shift and at the same time they should be 4 ore blocks.

6. CONCLUSION

From the previous text it can be concluded that Drift and Fill Mining Method with paste is a technical solution for excavation of rich and medium rich ores that offers a high degree of environmental protection despite higher production costs per ton of mined ore.

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