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Review paper

CONCEPT OF UNDERGROUND MINING OF PHOSPHATE DEPOSITS IN LISINA NEAR BOSILEGRAD

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Abstract: The existence of large amounts of mineral resources in the form of phosphate as basic industrial raw material was proved on location Lisina near Bosilegrad. Concept of underground mining was designed for that location. It consists from different application of room and pillar mining method and mobile plant with underground ore processing with disposal of tailings in the excavated area.

Key words: Underground mining, mining methods, mobile processing ore plant, tailings disposal

1. INTRODUCTION

Lisina phosphate deposit is north-west of the town Bosilegrad, near the border with the Republic of Bulgaria. The deposit has been explored for decades and in year 2008 volume of about 95 million tons of mineral resources was confirmed. Terrain in that area is very mountainous and hilly. First rank road follows the river Božica that flows towards the town Surdulica.

This location is a plate of ore body dipping to the north-east with the average angle of 22°, while the general direction is NW-SE in the length of 5 kilometers. Maximum width of the ore body reaches up to 2 km in horizontal projection. Upper parts the ore body emerges on the surface, and reaches a maximum depth of 300 meters. Plate is bounded in solid sandstone. Floor is made dominantly of granite layer while in the roof rocks are of shale texture, sericite-chlorite and graphitic shale and calc-schists. Figure 1 shows a typical geological profile slots.

The quality of mineral resources is primarily determined by the content of P_2O_5 as basic useful component (about 10% on average) and Fe_2O_3 as harmful component with content of about 5%. Due to the relatively low P_2O_5 content and relatively high content of Fe_2O_3 the ore is of low quality. Concentrated phosphate (32% P_2O_5) is traded on the market and its price is relatively low. Price was determined by large reserves of high-quality raw materials in Morocco, Togo and Russia.

The raw material of this type and quality can be successfully processed with existing technologies and can provide raw materials for industrial use. Basic application of phosphate raw materials is in fertilizer industry, glass and porcelain industry, metallurgy, alloying and partly for military purposes. (Kovačević and Todorović, 2009)

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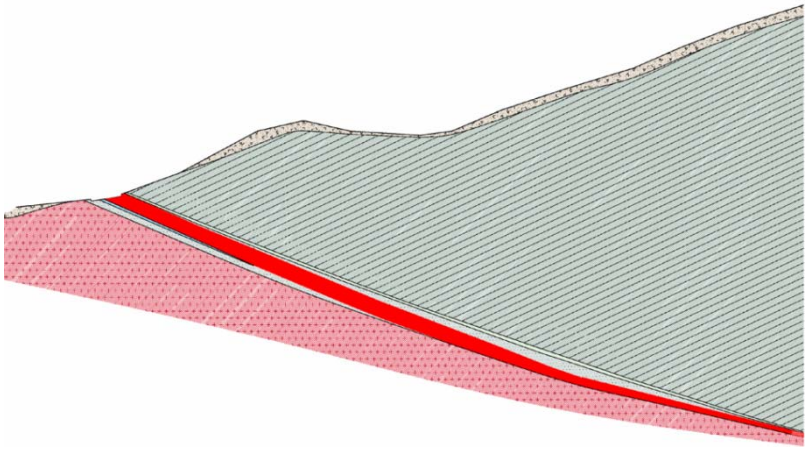

Figure 1 - Typical profile of the ore body

2. FEATURES OF CONVENTIONAL ORE PRODUCTION

Conventional mining production implies that the ore excavated underground is exported to the surface of a field where it is processed in a centrally located facility for the preparation of mineral raw materials. This includes the construction of a large complex of buildings on a large surface. In this case, the construction of such complex would involve extensive and costly degradation on hardly accessible terrain. Great distance between facility and the mines increases costs for transportation of mined ore to the plant. The product of the processing of mineral raw materials is flotation tailings, useless fragmented rock mass that is treated by chemical reagents during processing. Disposal of waste is carried out on the surface with respect to the rigorous rules. This does not only occupy large areas of land, but it occurs as high risk pollution for the living and working environment. In addition to these inconveniences, wasteful and harmful substances are transported over long distances. Use of the mechanical equipment, energy and human potential makes the production much more expensive and this is leading to unsustainability.

The search for a solution that will ensure low production costs and sustainability imposed the changes of the established concept and the integration of all manufacturing processes underground.

3. CONCEPT OF MINING PRODUCTION

Previously presented issues related to the mining of ore and processing phosphate ore imposed quest for a solution to a problem outside the established mining practices. An alternative concept is primarily a function of the actual conditions on the ground and needs to be performed with minimal production costs in order to ensure its sustainability, and to comply with all the regulations that accompany it.

The basic idea is to integrate all the processes in one underground system to eliminate problems caused by conventional production. This includes ore mining and processing in its mobile unit for processing ore flotation, located within parts of the mine and the subsequent use of the cavities for flotation tailings disposal. All this is done to reduce chargeable transportation and environmental degradation. Figure 2 shows a principal scheme of production.

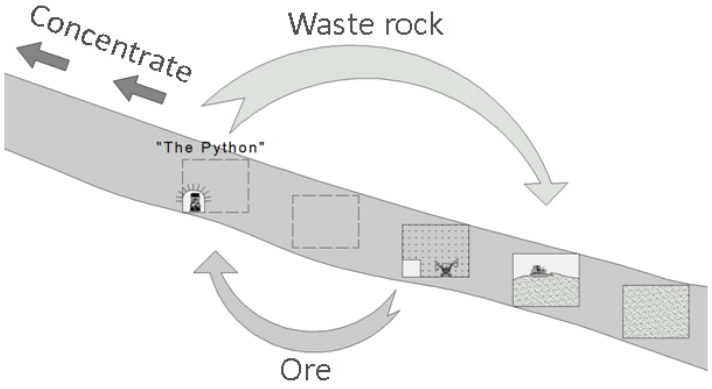

Figure 2 - Principal scheme of integrated mining production

3.1. Opening, preparation for excavation and mining method

Deposit conditions and quality of mineral resources are the two main factors that influence the choice of mining method. Room and pillar method is chosen because it can be done with negligible impoverishment excavation, ore is of low quality and because of low cost increased losses may be allowed. Excavated chambers can be dimensioned in such a way to minimize their sidewise support and later that chambers could be used for the disposal of flotation tailings. On the other hand, block caving methods are not adequate to excavation of the deposit due to the great impoverishment that characterizes them, and the ore itself is very robust and problems can show up during demolitions. Filling methods require additional resources to prepare its installation and backfill, as the ore quality would not able to cover the costss.

In this case, it is obvious that the room and pillar method have an absolute advantage over other groups of methods. Frontal excavation method was chosen as one of variants of the methods. The excavation chamber has to be made horizontally along the direction of the reservoir and gradually declining. Before the excavation is made, a "pilot" corridor is made along the sides of the chamber, allowing the flow of air and provides a communication link with the rest of the pit. Access ramps shall be dug up along the decline in deposits, with slopes of 14% and they should be conditionally parallel. All preparations rooms are made through the ore, because the ore is of high strength and that minimize the need for support. In this way, by making preparation rooms a portion of the ore is processed and that reduce the price of the rooms. Excavation is done by drilling and blasting, using high-capacity self-propelled

equipment. Figure 3 shows the principles of mining method (Gluščević 1974; Torbica and Petrović 1997).

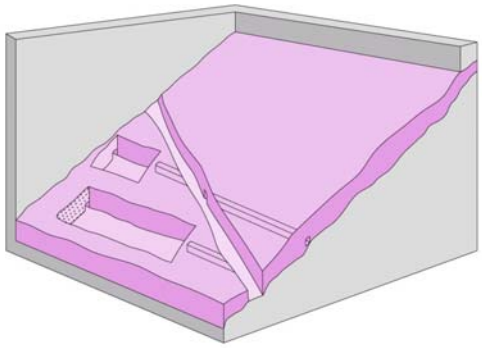

Figure 3 - Principle scheme of mining method

Depending on the thickness of the layer, excavation will be carried out in one or two stages. This is due to the application of drilling circuits Atlas Copco Boomer XE3 (http://www.atlascopco.rs), with a maximum height of drilling horizontal wells of 12 meters, and that will be the thickness of the layer which can be extracted in a single pass. For thicker parts of the layer, excavation will be conducted in two phases as principally shown in Figure 4. Excavation carried out in two phases shall be prepared by a slightly different excavation works. For the thickness up to 12 meters, excavation area is accessed by two ramps in the floor that is made from part of the layer, and in the case of thicker parts, one of the ramps is installed in the roof so the higher parts could be accessed.

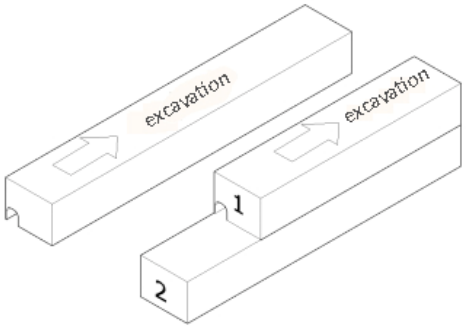

Figure 4 - Principle of single-phase and two-phase pattern mining

3.2. Processing of minerals

In order to reduce the cost of production, main idea is the full integration of mining production in an underground system. The most radical changes of the usual concept refers to the placement of the ore processing plant in the ground, using a

mobile flotation plant. In this way, it significantly reduces the transport distances of the ore and tailings. Tailings are a useless burden for the production.

Ore would be carried out by mobile facility "The Python" (http://www.gekkos.com), located in the premises of preparation rooms, as it can be seen in Figure 5. The plant is placed in a corridor measuring 5x5 meters, which is projected along the planned excavations and in the later stages of excavation will serve as preparation for the excavation of the rooms. The facility was developed primarily for gravity concentration of gold, and then the very idea of a mobile processing plant was used for flotation concentration. The technological process is in no way different from the process in conventional plants, and includes grinding with sizing and flotation processing.

Figure 5 - Plants mounted on the surface

In addition to reducing transportation costs of ore and tailings, the plant has other favorable characteristics:

- Electricity consumption of the fragmentation is 8 kWh/t, compared to 16 kWh/t for conventional plants;
- Reduced number of workers required for the system. Only 2 workers (one shall feed plants, the other controls the operation of the plant);
- The plant is stored in an underground room measuring 5x5 meters, and thus there is no need to build complex structures on the surface. That simplifies the design, construction and maintenance;
- The materials obtained by processing the ore are deposited in the mined out areas and thereby avoiding the degradation of large areas of the field and eliminating the possibility of contamination of the environment;
- Underground constant climate conditions ensure flotation throughout the year.

Products of the processing mineral raw materials are phosphate concentrate and tailings that still contains water. In order to transport both processing products, on sites, within the treatment plant, complex filter press will be installed. Press will be used for the drainage. After dewatering, phosphate concentrate is exported to the surface by truck and from there further distribution is conducted. The tailings are disposed in previously dug spaces with bulldozer, as shown in Figure 6.

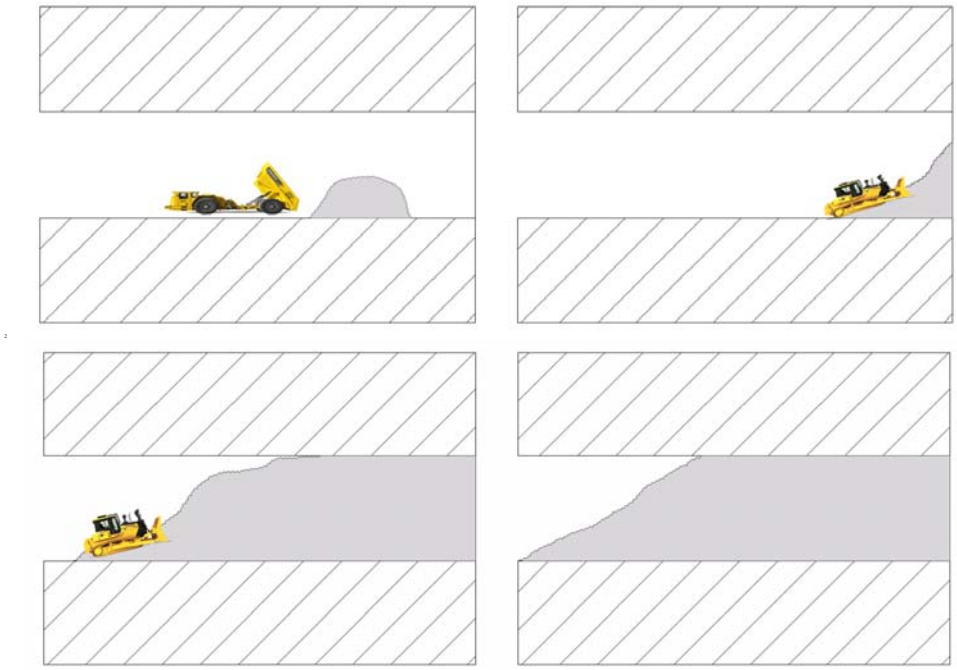

Figure 6 - Principle scheme of dumping

4. CONCLUSION

In the paper is shown that by applying the method of pole chamber and mobile plant for ore flotation processing, ore bodies inclined in plate can be successfully extracted.

With this concept of technological processes it was primarily intended to influence the reduction of transport costs of ore and tailings, and to eliminate risks to environmental pollution. By placing the ore processing plant under ground, degradation of the field would be avoided and it would greatly simplify the design and operation of the system.

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