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Professional paper

UNDERGROUND MINING EXPLORATION IN THE "LAJKOVAČA" COPPER DEPOSIT IN VALJEVO - KOSJERIĆ

JAMSKI ISTRAŽNI RADOVI U LEŽIŠTU BAKRA "LAJKOVAČA" VALJEVO – KOSJERIĆ

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Abstract: For the purposes of exploration of copper and accompanying metals in Jablanik and Povlen area, on the entire exploration area on the west of Valjevo toward Kosjerić, a new underground exploration rooms are provided, as well as the repair and rehabilitation of the existing underground mine rooms.

Beside the location and geology of the "Lajkovača" deposit, this paper presents technical description of the underground exploration rooms, the solution for collapsed rooms repairing, material transportation, room supporting, ventilation and method of sampling for technological tests.

Key words: underground exploration, room rehabilitation, sampling, Lajkovača

Apstrakt: Za potrebe istraživanja bakra i pratećih metala na području Jablanika i Povlena, na celom istražnom prostoru zapadno od Valjeva prema Kosjeriću, predviđena je izrada novih jamskih istražnih prostorija, kao i sanacija i revitalizacija postojećih jamskih prostorija.

Pored lokacije i geoloških podataka o ležištu, u radu je dat opis prostorija, tehničko rešenje sanacije ruševina, podgrađivanje, transport i ventilacija, kao i mesta i način uzimanja uzoraka.

Ključne reči: jamski istražni radovi, revitalizacija prostorija, uzorkovanje, Lajkovača

1. INTRODUCTION

Copper deposit "Lajkovača" is located west of Valjevo, near Kosjerić. For the purposes of sampling for the technological tests, adequate documentation was made (Geo Consulting Studio 2010, 2011, 2012). Sampling, in the maximum amount of 25 t, will be taken through the geological explorations and examinations which will be realized by the company "Empire Mining SR d.o.o." from Belgrade. This company is

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the holder of geological exploration of copper and associated metals in Jablanik and Povlen area, including the entire exploration area to the west of Valjevo - Kosjerić, on the field that covers parts of the mountain range from Medvednik in the northwest through Jablanik to Povlen in the southeast, with an area of approximately 90 km^2.

As the part of *Project of geological exploration of copper and accompanying metals in Jablanik and Povlen* (Geo Consulting Studio, 2010), beside standard geological activities, additional underground works for the repair and rehabilitation of mine exploration rooms, were anticipated. In fact, in the previous geological explorations at the "Lajkovača" deposit, which was performed in the period 1970-1977, underground explorations were realised, with the total length of about 490 m. From these underground rooms, samples were taken for technological tests. Together with the other samples, those were examined and some good results were obtained. After the sampling, exploration underground rooms were abandoned, so eventually, the partial collapse occurred.

The additional problem was the fact that the entrance into the mine was covered by some surface material throughout the time; therefore, approach was completely disabled. After removing the collapsed material, access to underground mining exploration rooms was provided, and the preliminary survey of the state in the mine was enabled. The report on the state was used as the basis for the development of the necessary documentation and preparation of the implementation plan of exploration works.

2. GEOGRAPHICAL POSITION AND GEOLOGICAL FEATURES

The exploration area is located in western Serbia, west of Valjevo to Kosjerić. The terrain covers parts of the mountain range in the north west of mountains Medvednik over Jablanik to Povlen to the southeast (Figure 1) (Institut za geološko-rudarska istraživanja i ispitivanja nuklearnih i drugih mineralnih sirovina, 1973).

The exploration area has relatively good transportation links with Valjevo and Kosjerić. Through the northwestern part of the terrain runs regional road Valjevo-Bjelovar via Debelo brdo, as well as through the southeastern part of the regional road Valjevo-Kosjerić-Užice. In addition to these roads, there is a well-developed network of rural gravel roads of earth harder passable for common cars. Through this part of the exploration area, there is a major railroad Belgrade-Valjevo-Užice-Bar with the only station in Sušica village.

In terms of orography, the terrain is common for low mountain - mountain relief of western Serbia. In the northwest part of the field, there is mountain Jablanik (1,273 m) and the range continues to the southeast to mountain Povlen.

Structural geological map of the "Radanovci-Taor" mine field to which "Lajkovača" deposit belongs is shown in Figure 1 (Geo Consulting Studio, 2012).

Diabase-chert formations of western and southwestern Serbia on so called "podrinjsko-polimska" area was developed in two parallel zones divided by Drina-Ivanjica-Golija Paleozoic formations. The first zone covers an area of Jablanik, Povlen, Maljen, Kablar, Jelica up to Čemerno mountain, southwest of Kraljevo, while the second zone covers an area of Tara, Zlatibor, Prijepolje, Jadovnik and Sjenica.

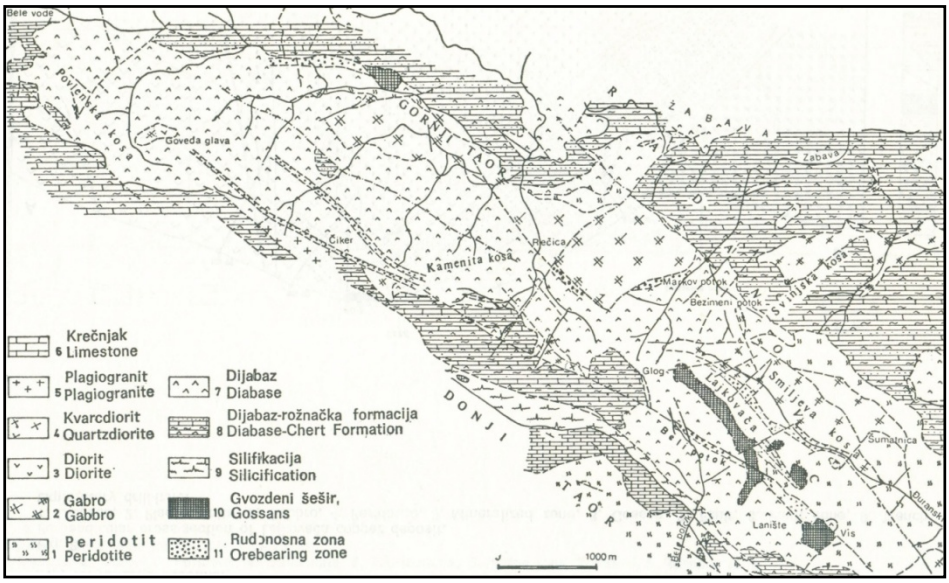

Figure 1 - Structural geological map of the "Radanovci-Taor" mine field

The cross section of the copper deposit "Lajkovača" is shown in Figure 2.

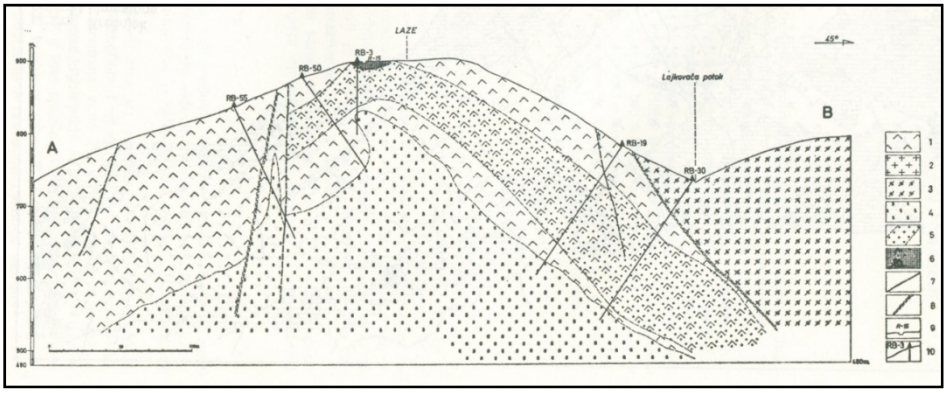

Figure 2 - The geological cross section of the "Lajkovača" copper deposit

Numerous ore occurrences and deposits of copper (Ljubovidja, Orovica, Rečica, Rebelj, Lajkovača, Vis, Jarmovac, Međani, etc.) were, within the diabase-chert formations, subject of exploitation by the Romans and Sasa miners, which is evidenced by the numerous remnants of old mining works; the existing smelter slag dumps are assumed to originate from that time. The first written records of this formation date from the late nineteenth and the early twentieth century in the works of our geologists and miners.

2.1. Pyrite – copper deposit "Lajkovača"

The deposit is located in the diabases along breccia hydrothermally altered zones. The deposit was studied by exploratory drilling and mining operations on the length of 1,300 m. Hydrothermal alterations are represented by intense silificatation, and carbonatization, chloritization while albitization and epidotization is found sporadically. Strike of the mineralized zones is in accordance with the strike of diabase-chert formation (northwest-southeast), with mostly steep dip towards the southeast at the angle of 60-80°. The boundaries with the surrounding rocks are tectonic and are mostly represented by fracture zones, with the thickness of a few to a dozen meters with a distinct sericitization and chloritiztion in the footwall. The overlaying rocks are mostly gabbro, while the underlying rocks are diabase (Figures 1 and 2).

The deposit "Lajkovača" has the estimated reserves of C_1 category, which, together with the estimated metal grade, are shown in Table 1.

Data of the copper grade in the ore are given in Table 1, and they are based on the detailed geological surveys, carried out in 1973 (Geokarta 1959-1965; Putnik 1981), and reserves are shown according to the explorations realised in 1979.

Table 1 - Evaluation of ore reserves of 1979

Deposit	Category	Ore [t]	Density of ore [t/m^3]	Grade Cu [%]	Amount of metal [t]
Lajkovača	C_1	3,161,333	2.9	0.85	26,871.33
OVERALL	C_1	3,161,333	2.9	0.85	26,871.33

3. TECHNICAL DESCRIPTION OF THE UNDERGROUND ROOMS WITH THE LIST OF NECESSARY WORKS

Situation plan of the "Lajkovača" mine is shown in Figure 3.

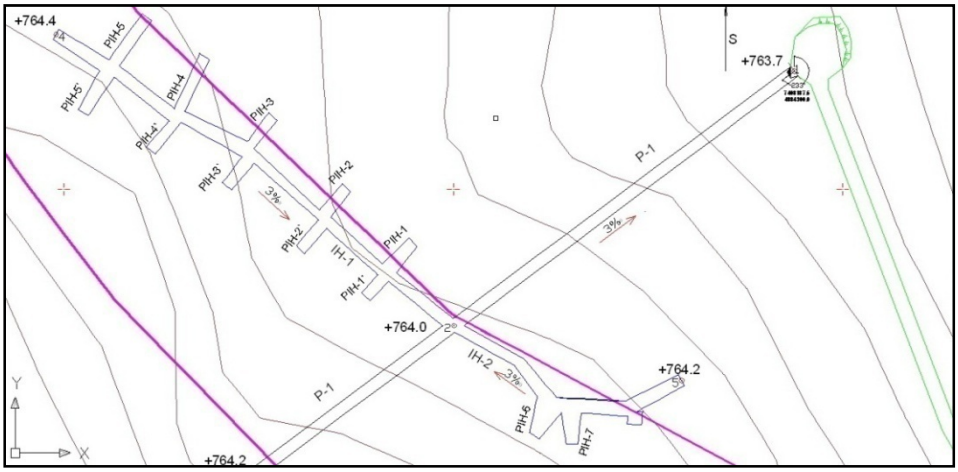

Figure 3 - Situation plan of the "Lajkovača" mine

"Lajkovača" deposit is opened with elevation to +763.7 m, by the investigation adit P-1, which have the length of 178.5 m, with a trapezoidal cross-section of 2.50 m x 2.45 m, (S_{sv} = 5.5 m^2), with a dewatering channel measuring 0.4 m x 0.3 m.

It is supported by a 20 cm thick wooden support. Investigating adit P-1 was realized under the rise of 3‰, and there were mounted (Geo Consulting Studio, 2011) rails with the mass of 22.4 kg/m, with the distance of 600 mm between the rails.

At approximately 108.9 m from the entrance to the mine, at an elevation +764.0 m, in the left and right side of the P-1, with the rise of 3 ‰, investigating drifts IH-1 and IH-2, measuring 2.50 m x 2.45 m, with the low-arc shaped cross-section, bright cross-section surface of S_{sv} = 5.6 m^2, were made. If the supporting is necessary, the trapezoidal wooden frame support 20 cm thick will be applied. In the case of supporting, shape and dimensions of the cross section will be identical to the P-1. Length of the IH-1 drift is 126 m, while the length of IH-2 is. In the IH-1 and IH-2 rails were built with the mass of 22.4 kg/m with the distance between the rails of 600 mm, and, also the channel for dewatering, size 0.4 m x 0.3 m, is built.

From the exploration drift IH-1, from its sides, at the axial distance of 20 m - 25 m, short exploration drifts ("querreys") PIH 1 to 5 (10 drifts), in the average length of 10 m and a total length of about 100 m, were made. All the above mentioned drifts are the same size as IH-1.

From the exploration drift IH-2 i.e. from its right side, at the axial distance of 5 m, short exploration drifts PIH 6 and 7, in the average length of 10 m (overall 20 m) were made. These drifts are also the same size as IH-1.

3.1. The necessary reconstruction works for the underground rooms

In order to access the entrance of the mine, it was necessary to level the square in front of the entrance and clear the vegetation obstructing the entrance of the mine. After that, the entrance was cleared, and partial inspection of the underground rooms was realized.

After the mine inspection, we made the conclusion that, in the first stage, it was necessary to secure access - enter into the mine with the wooden support - portal, in order to prevent re-collapse of material into the entry. Also, in this stage, it was necessary to remove the old, decayed roof support, and then clean and realize systematic supporting of the exploration adit - entrance in the P-1 in order to ensure undisturbed and safe work (Geo Consulting Studio, 2011).

Also, during the mine inspection, it was determined that the mine is not flooded, and the underground rooms are in good condition. It is necessary to repair the collapsed sectors in the horizon 763 (P-1). Other planned works are: dewatering channel cleaning and reconstruction of railway. The total of 492 m of underground rooms on the level 763 is planned to be reconstructed.

3.1.1. Ruins rehabilitation

The collapsed rooms - ruins mostly appear in the areas of crushed waste rock and ore body through which the underground rooms were lined. Cavities as the result

of increased underground pressure appear in the sides and roof of the rooms, and cause significant demolitions. Particularly dangerous ruins were in the remaining unfilled old underground works and there are remnants of ore that is crushed under the pressure and accumulates over the room lining (Geo Consulting Studio, 2011).

Wet ruins are usually more dangerous than the dry ones, and until the water flow is reduced to the minimum, it is not possible to sanate the ruin using the perforation penetration. If the ruin is dry and the underground rooms are collapsed by the large blocks of stone, and the roof is hollow, it is necessary to wait for some period until the space is at least partially filled-up in the roof zone, and then it can be approached with caution by the penetration support.

In parts of the ore vein - ore body, in the rooms which are lined through loose and crushed material, the penetration support can be applied, but larger pieces or blocks of rock complicate the proper work in resolving the problem.

Wooden penetration support can be applied in the case of making the drift through old works and for the increasing height of the drifts of low height which were made through crushed material or ore.

In the case of partial collapsing of the underground rooms, when the bigger or smaller cavities can appear, a double underground support could be lined, so that the taking-over, back-filling and lagging of part of the open space is realized. For smaller collapsings and cavities, high support units of 3 m high can be applied. Reconstructed underground room is shown in Figure 4a.

In case of larger collapsing, in specific cases, all necessary safety procedures can not be determined in advance, but only during the reconstruction work. Mine site manager must define specific guidelines to determine the methods for safety and health at work during the collapsing rooms reconstruction.

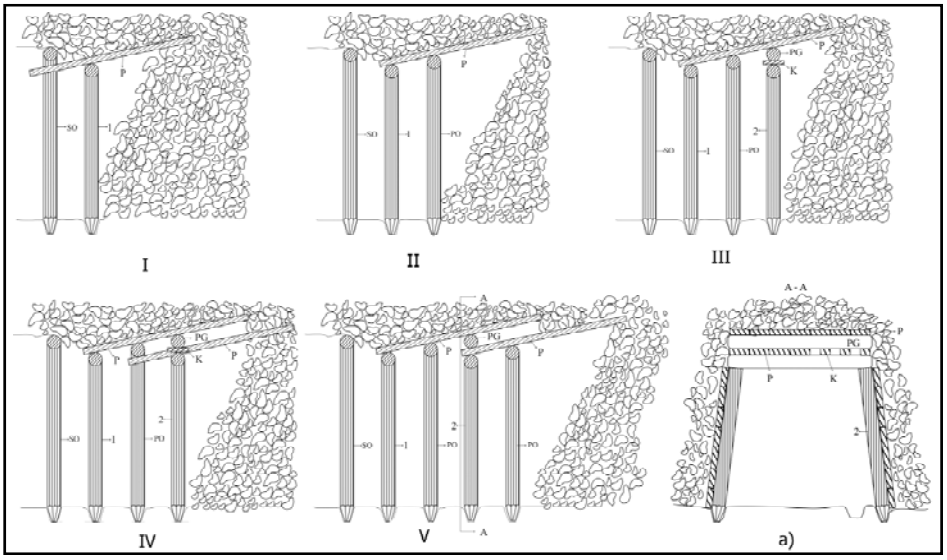

Figure 4 - Method for reconstruction of collapsed rooms in phases (I-V) and cross section of the reconstructed underground room (a) (marks: SO - old support; 1, 2 - new support; PO - auxiliary support, PG - beam, P - penetration lath(s), K - wedge)

Reconstruction of underground rooms by using wooden penetration support is shown in Figure 4.

The sequence of actions for reconstruction of collapsed rooms by the wooden penetration support is as follows:

1. Set the first new support frame (1) at the necessary distance from the old support (SO).
2. Pound in the first row of penetration laths (P). Laths should be pounded up to the half of their lenght.
3. If the incoherent material appears in the sides of the drift, those must be lagged by planks.
4. Load part of the material.
5. Place auxiliary support (PO).
6. Penetration laths should be pounded in their whole lenght.
7. Place and attach the beam (PG).
8. Place the second frame of support (2).
9. Place wedges (K) between the beam and the second frame of support, to maintain (sustain) distance for penetrationa laths.
10. Take out the wedges, and afterwads, place the penetration laths.
11. Laths should be pounded in half of their lenght.
12. Load part of the material.
13. Place the second auxiliary support (PO).
14. Penetration laths should be pounded in their whole length.

3.2. Underground rooms supporting

Supporting in the "Lajkovača" mine has been realized by a three-tiered wooden trapeze support with a lagging which is set in a classic way. For the wooden support, beech or oak lumber $d = 20$ cm thick will be used and, if necessary, for lagging of supporting frames wooden stubs will be used.

Exploration adit P-1 is, from the entrance in the length of 30 m, systematically supported in its full-length, with the spacing of 1.0 m between trapeze frames, with the lagging of sides and the roof of the adit. If necessary and if it is estimated that the work environment is extremely disturbed, parts of the P-1 will be supported in the "shrot" style - one frame to another, with lagging.

Exploration (IH) and Across exploration drifts (PIH) will be supported, if it is necessary, with frames at the distance of 1.0 m and lagging where it is estimated that there is danger of falling of bulk and loose material. On the parts that may have been affected by the ruin (collapsed drift-rooms), after the ruin rehabilitation, supporting will be realized in the "shrot" style, with lagging.

3.3. Mine ventilation

During the reconstruction and sampling, ventilation will be carried out separately, by compression method, which is more suitable than depressing or combined system delivery. Fresh air is delivered directly to the site where the workers

are located, the fan is placed once, without moving, and the power supply is much shorter.

3.4. Dewatering

Dewatering of the underground rooms in the mine "Lajkovača" will be performed gravitationally, using the water channel, made in the sides of mine adit and drifts. In needed, a submersible pump with the suitable characteristics will be mounted. The channel must be cleaned regularly and maintained in order to prevent the leakage of water from it.

4. SAMPLING

After the completion of the previously mentioned works, it is possible to start sampling of the technological tests from the "Lajkovača" mine.

Sampling from the reconstructed drifts of the "Lajkovača" mine will be realized in two ways:

Samples for chemical analysis (single ore samples) will be taken using "channel sample" method in the dimensions of 100 cm x 10 cm x 5 cm. Sampling will be conducted with the geological hammer with steel bar, and, if necessary, the chisel will be used to undercut parts where some stronger rocks appear. Sampling will be conducted in parallel, from both sides of the adit and drifts, at the same distance from the reference point (the entrance to the mine, start of side drift, raise). The weight of the sample for chemical analysis is about 2 kg. The total number of samples for chemical analysis is maximum 200 to 500 pieces (Geo Consulting Studio, 2011). Sampling equipment is manual: hammer of 5 kg - 10 kg ("mazzola") and larger chisels and handspikes.

Samples for technological and metallurgical tests (Mass Samples for semi-industrial testing) will be taken from the selected ore zones. The maximum amount of these samples to be taken for technological testing of the mine "Lajkovača" is 25.0 t. In order to examine the contents of Cu and other useful components in the ore deposit "Lajkovača", the sampling method will be realized as a standard industrial test. Sampling will cover the sides and roof of the ore zone.

Loading of samples will be done manually, in the "Raduša" type wagons, which have the capacity-volume of 0.8 m^3 - 0.9 m^3. Wagons with samples will be manually pushed-out through the horizon H-763, to the end of the adit P-1 – to the surface, i.e. selected place for samples deposition.

5. CONCLUSION

One of the areas of potential exploitation of metallic minerals is located within the diabase-chert Podrinje formation zone, in the mineral zone of the same name, in the southeastern part of Valjevo near Kosjerić and includes economic ore reserves of copper, gold and silver in the deposits: Lajkovača-Taor (the content of gold and silver ores copper participates in at least 40% of the value of ore) and Novakovača.

Realizer of the geological exploration for "Lajkovača" deposit is the "Empire Mining SR Ltd." company from Belgrade. For the purpose of sampling for technological tests, adequate technical documentation was made.

In order to carry out the sampling, it was necessary to reconstruct and revitalize mine exploration rooms, which were made in the period 1970-1977, for the purpose of sampling for technological testing. After the sampling, exploration rooms were abandoned at the time, and eventually, the partial collapsing occurred.

This paper presents the complete overview of activities necessary to accomplish the re-sampling for purposes of chemical, technological and metallurgical testing.

ACKNOWLEDGEMENT

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