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EXAMINATION OF THE POSSIBILITY OF OBTAINING PYRITE CONCENTRATE FROM THE FLOTATION TAILINGS OF THE LECE MINE

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Abstract: The Lece mine is characterized by the fact that it has gold and silver besides the main valuable components in the flotation concentrates of lead and zinc. Practically since the opening of the mine and flotation, research has been carried out with the aim of obtaining better technological indicators on all four valuable metals (lead, zinc, gold and silver), especially on gold. This paper represents a contribution to that research in order to increase the recovery of gold in flotation concentrates. Gold occurs in ore in several ways (native, with lead and zinc, with pyrite and quartz), which requires a complex technological scheme of gold valorization. Most of the gold is bound to galena and is valorized through lead concentrate. A smaller part of the gold is bound to zinc and is valorized through zinc concentrate. However, about 25% of the gold remains in tailings. Researchers ie. the authors of this paper tried to valorize part of the gold that is lost in the tailings by introducing a third pyrite concentrate with an increased gold content.

The paper presents the results of laboratory experiments on the possibility of obtaining pyrite concentrate from the Lece tailings and a proposal for a technological scheme of the process.

Keywords: Lece mine, Flotation, Pyrite concentrate, Gold, Silver

1 INTRODUCTION

Lead concentrate with gold is the most important for the Lece mine, so the most changes were made in this domain in order to improve the technological indicators of the process. The selection of the best flotation machines was performed, so at the end of 2020, a new lead mineral flotation line was put into operation.

Currently, 8 cells RCS-5 are in use for rough and scavenger lead mineral flotation and 4 RCS-3 cells are in use for cleaning lead rough concentrate (Lazić, Nikšić, Stojanović, 2021). The manufacturer of flotation cells is Metso Minerals from Finland. The currently

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installed flotation machines have modern technical and technological characteristics, with accompanying equipment for automatic pulp level control and air consumption. Russian machines installed in 1976 are still in use for zinc mineral flotation.

After the reconstruction, the old line for flotation of lead minerals remained out of use, which can be used for flotation of pyrite minerals, if laboratory experiments show that this is possible.

Hereinafter, a description of the minerals that occur in the deposit is given as a basis for considering the possibility of extracting the third concentrate in the Lece flotation.

In the following text, there is a description of the laboratory experiments of tailings flotation sampled in an industrial plant, a conclusion and a proposal for a technological scheme for flotation of all three minerals (lead, zinc and pyrite).

2 MINERALS THAT OCCUR IN THE LECE DEPOSIT

The ore of the Lece deposit consists of sulphide minerals and quartz. The number of mineral species is relatively small. Ore minerals in the open part of the deposit were formed at low temperatures. These minerals include sphalerite, galena, pyrite, chalcopyrite, and gold-bearing quartz (Jelenković et al. 2010).

Sphalerite is one of the most widespread and abundant sulphide minerals in the deposit, formed at temperatures below 130 ^{o}C. It rarely appears in large crystals; it is mostly fine-grained and contains cadmium.

Galena together with sphalerite is the most important mineral in the deposit. The largest mass of galena is fine-grained in the form of crystals and mineral aggregates. Galena is formed in three phases, the largest part of galena belongs to the third phase, less to the second, and the least to the first phase. The galena of the second and third phases is undifferentiated, forms crystalline masses and nests and contains gold and silver, such galena is called gold-bearing galena. Galena replaces older minerals, and galena is most often replaced by pyrite. It is cracked and catalyzed, in the oxidation zone it is covered with a thinner or thicker crust of cerussite (Radosavljević et al. 2012).

Pyrite is distributed in the deposit in the form of granular aggregates of rounded shape, which indicates formation from gel. Pyrite is often cemented with chalcopyrite, which partially replaces it. He carries some gold and silver.

Chalcopyrite is a carrier of copper and occurs in the ore in small amounts, but it is always present.

Gold occurs in the ore as native. It is found in galena, sphalerite, pyrite, and quartz and shows rounded forms.

3 LABORATORY FLOTATION EXPERIMENTS OF PYRITE FROM MINE TAILINGS LECE

Tailings from the Lece mine flotation process contain from 0.08 to 0.12% Pb, about 0.15 to 0.20% Zn, about 0.6 g/t Au and about 2.2 g/t Ag.

According to the distribution, the metal loss in tailings amounts to about 8-10% for lead and zinc, about 22-25% for gold and about 20% for silver (Lece, 2020).

Such "high losses of gold and silver" in tailings deserve special attention and at the same time offer the possibility of improving technological indicators. This paper is the result of detailed research into the possibility of "production" of the third concentrate in "Lece" flotation - a pyrite concentrate with an increased content of gold and silver.

At the exit from the existing flotation process, the pH of the pulp is about 9.5-10, and for the pyrite flotation process, the recommended pH is about 7 - 8 (Drakšić, 1986; Ćalić, 1990). $FeSO_4$ was chosen as a reagent for lowering the pH of the flotation pulp. This reagent is the safest to work in the plant, and in the flotation pulp it have double action as a pH regulator and as a reagent that "washes" the pyrite surfaces from residual reagents from the previous stage of the process.

$CuSO_4$ was added as a pyrite activator in the pulp conditioning cycle before the pyrite flotation process, and potassium amyl xanthate KAX as colector and Dowfroth-200 (D-200) as frother.

The complete reagent regime of pyrite flotation, which was applied in a series of experiments and two pyrite flotation balances where the best results were obtained are shown in further text.

Reagents regime and flotation conditions of Lece tailings in order to obtain pyrite concentrate

A sample of Tailings from Lece flotation (August-22)

A sample, kg 1

Fineness of grinding, % - 74 μm 55.21

Conditioning min. FeS_2

$FeSO_4$, g/t	1500
$CuSO_4$, g/t	150
KAX, g/t	100
D-200, g/t	10
Conditioning time, min	5
pH	7.1

Rough flotation min. FeS_2

5 min. flot. KAX, g/t	100
Flotation time, min	10

Scavenger flotation min. FeS_2

KAX, g/t	50
Flotation time, min	10

I Cleaning min. FeS_2

D-200, g/t	5
pH	7.5
Flotation time, min	4

II Cleaning min. FeS_2

D-200, g/t	5
pH value	7.5
Flotation time, min	3

III Cleaning min. FeS_2

D-200, g/t	5
pH value	7.5
Flotation time, min	2

Flotation concentration balances of tailings from the Lece mine and production of pyrite concentrate

Table 1 Experiment 1 balance

	T%	Pb%	Zn, %	Au g/t	Ag g/t	R%Pb	R%Zn	R%Au	R%Ag
Tailings 1	100.00	0.09	0.13	0.60	2.22	100.00	100.00	100.00	100.00
C/FeS_2	1.99	0.51	0.82	**9.08**	**49.53**	11.06	12.64	**29.83**	**44.32**
M_1/FeS_2	2.48	0.37	0.37	1.82	9.53	10.03	7.13	7.47	10.66
SC/FeS_2	1.74	0.38	0.55	2.37	12.15	7.21	7.42	6.81	9.51
PK/FeS_2	6.20	0.42	0.56	4.30	23.06	28.29	27.18	**44.12**	**64.49**
Tailings 2	93.80	0.07	0.10	0.36	0.84	71.71	72.82	55.88	35.51

Table 2 Experiment 2 balance

	T%	Pb%	Zn,%	Au g/t	Ag g/t	R%Pb	R%Zn	R%Au	R%Ag
Tailings 1	100.00	0.10	0.18	0.61	2.14	100.00	100.00	100.00	100.00
C/FeS_2	2.00	0.61	0.85	**9.00**	**42.26**	12.78	9.56	**29.28**	**39.34**
M_1/FeS_2	2.49	0.32	0.37	1.63	7.64	8.38	5.20	6.63	8.89
SC/FeS_2	2.74	0.37	0.44	2.83	11.7	10.66	6.80	12.66	14.98
PK/FeS_2	7.23	0.42	0.53	4.12	18.73	31.81	21.56	**48.57**	**63.21**
Tailings 2	92.77	0.07	0.15	0.34	0.85	68.19	78.44	51.43	36.79

The balance sheets did not show the sulfur content in the pyrite concentrates, but it ranged from 46.5 to 47.5% S with a sulfur recovery of about 50 to 60%. Pyrite concentrate with these sulfur contents is not a "standard pyrite concentrate" (more than 48% S is required) but considering that it contains gold and silver and that the quality is very close to standard, the obtained pyrite concentrate certainly deserves attention.

4 TECHOLOGICAL SCHEME OF THE PROCESS OF PYRITE CONCENTRATE PRODUCTION

The scheme of the technological process of pyrite production is shown in Figure 1. The flotation underflow of Pb-Zn ore from the existing flotation (current tailings) is subjected to a conditioning process with the addition of ($FeSO_4$). The role of ferrous sulfate is to lower the pH of the pulp to about 8, to "wash the pyrite surfaces" and prepare for the activation process. Activation of pyrite was performed using ($CuSO_4$) and collection was performed using potassium amylxanthate KAX. Dowfroth 200 (D-200) it was used as a frother. The process of rough and scavenger flotation with three-stage cleaning of the rough pyrite concentrate follows after conditioning. The applied scheme of the technological process and the reagent regime yield a definitive pyrite concentrate of significant quality (911 Metallurgist, 2016).

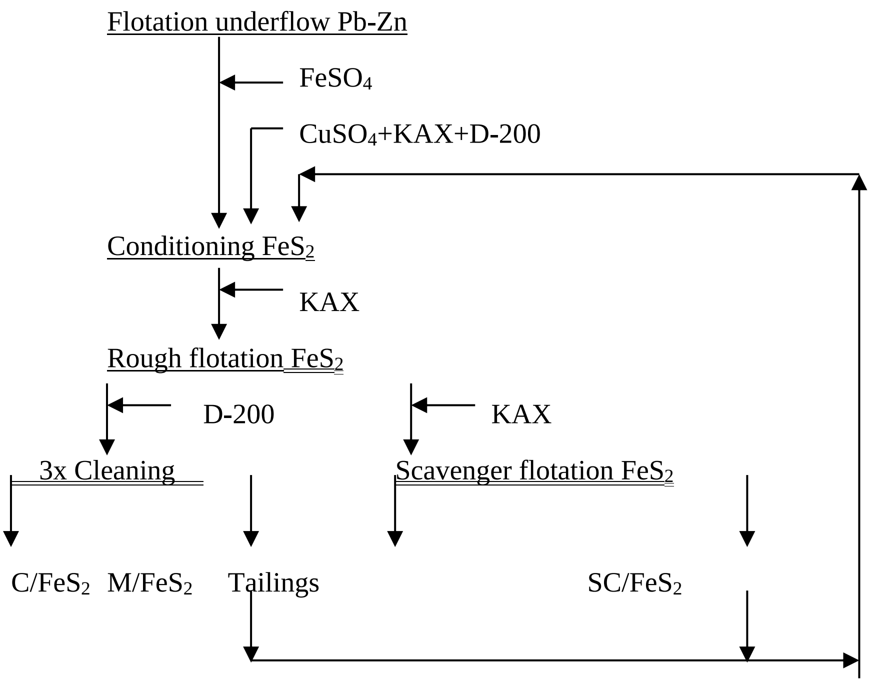

Figure 1 Technological scheme of the process of pyrite concentrate production

5 CONCLUSION

Based on the results presented in this paper, the following can be concluded:

The loss of gold in the current tailings of about 25% deserves special attention. Given that part of the gold is bound to pyrite, and that there is a free line for flotation in the

"Lece" flotation, an attempt was made to obtain pyrite concentrate on that line, as the third product of flotation plant.

The presented results of laboratory tests show that with the applied reagent regime and technological scheme, it is possible to obtain an interesting pyrite concentrate with a sulfur content of about 47% S, sulfur recovery of about 50-60%, with a gold content in this concentrate of up to about 9 g/t and silver of about 40-50 g/t. The recovery of gold from tailings about 30% and silver about 40%.

Given that the loss of gold in the current Pb-Zn flotation tailings is about 25% and that the recovery of gold from that tailing through pyrite concentrate is about 30%, under favorable flotation conditions the total recovery of gold can be increased by about 7.5%, which is very good. Similar to this, the loss of silver in the current Pb-Zn flotation tailings is about 20%, and recovery from this tailing through pyrite concentrate is about 40%. The production of pyrite concentrate would increase the total utilization of silver by about 8%.

The research results presented in this paper are encouraging and deserve an industrial trial in order to confirm these results.

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