FLOTATION STUDIES OF COPPER ORE MAJDANPEK TO ENHANCE COPPER RECOVERY AND CONCENTRATE GRADE WITH DIFFERENT COLLECTORS

J. Sokolović[1#], R. Stanojlović[1], Lj. Andrić[1,2], Z. Štirbanović[1], N. Ćirić[3]

[1]University of Belgrade, Technical Faculty in Bor, Bor, Serbia
[2]Institute for Technology of Nuclear and other Mineral Raw Materials (ITNMS), Belgrade, Serbia
[3]Zijin Bor Copper d.o.o, Copper Mine Majdanpek – RBM, Majdanpek, Serbia

Abstract

This paper presents the results of mineralogical and flotation studies on the copper ore from the deposit „North Revir" in the Copper Mine Majdanpek, using different collectors. XRD and ore mineralogical analysis showed that the most common minerals are pyrite and chalcopyrite. Chemical analysis confirm that it is a complex low-grade copper ore with average copper content of 0,273%. The content of precious metals (Au and Ag) was 0.2 g/t and 1.2 g/t, respectively. The main aim of flotation studies have been the effect of collector type on the recovery and concentrate grade in the copper flotation process. Various collectors and combinations of them were used in the rough flotation tests of copper ore. The copper recovery was in the range from 79.43% (test no. 4) to 84.96% (test no. 7). The best flotation results were obtained with mixture collectors of sodium isopropyl xanthate (Z11), dialkyl dithiophosphinates (Aerophine 3404) and SKIK BZ 2000. The collector's dosages of 20 g/t Z11, 8 g/t AP3404 and 8 g/t SKIK BZ 2000 produced the copper recovery (84.96 %) with copper concentrate grade of 1.52%

Key words: *Copper; Ore; Majdanpek; Flotation; Collectors.*

1. Introduction

Copper is one of the oldest metals ever used, and has been one of the most important and most useful metals in the development of civilization. Due to its physical and chemical properties and characteristics, copper has exceptional economic potential and strategic importance in the world as well as in the Republic of Serbia.

In 2018 global demand for copper was 23.6 million tons and it will continue to rise to 29.8 Mt by 2027 - at 2.6% annual growth [1]. On the other hand, global copper mine production has grown by 3.2% per annum to 20.6 million tonnes in 2018. In 2018, five countries (Chile, Peru, China, USA and Congo) were producing about 60% of world copper production. Chile is a world's leading copper mine producer in 2018 with a mine output of 5.8 million tonnes of copper [1].

The world copper reserves are estimated at about 5.6 billion tons [2]. According to a recent report published by United States Geological Survey (USGS), the identified and undiscovered reserves are estimated at 2.1 and 3.5 billion tonnes of copper, respectively [2]. Also, about 1.8 billion tonnes are estimated in the porphyry copper deposits [3]. The world's largest estimated copper ore reserves are in Chile and are around 40%. In the Republic of Serbia, it is estimated that the total geological copper ore reserves amount to about 2.576 billion tonnes and total copper reserves currently amount about 8.1 million tonnes [4].

Copper ore processing in Serbia has a long tradition. The most important copper ores in Serbia are located in the Bor metallogenic zone of the Carpatho-Balkanian metallogenic province such as: porphyry copper deposits Borska Reka, Veliki Krivelj and Majdanpek [5].

Copper and gold/silver, accompanied by iron (sulphide, oxide), molybdenum, sporadically PGE,

are the predominant metals in the Bor metallogenic zone. Since 1902, the total production has been approximately 652 Mt of ore with 4.93 Mt of copper and 280 tons of gold [5].

The Copper Mine Majdanpek (RBM), as a part of Zijin Bor Copper d.o.o. (formerly known as RTB Bor), with a long history of copper production in Serbia, is one of the largest copper mines. Located in the eastern part of Serbia, Majdanpek deposit represents one of the most abundant copper reserves in Serbia and in the world.

Majdanpek porphyry copper deposit represents one of the largest copper reserve in Serbia. It is located in the northern part of the Timok Magmatic Complex (TMC), which is a part of a geological framework that includes the Alpine – Balkan – Carpathian - Dinaride metallogenic - geodynamic province [6] also referred to as the Carpatho - Balkan Magmatic Belt [7]. The TMC complex in a lozenge shaped belt, almost 100 km in length in the direction north-south, up to 25 km of width, with a total area of around 1130 sq. km [8].

The Majdanpek deposit, with an average width of 300 m, is approximately 5 km in length [8]. Weak copper mineralization (>0.1% Cu) was detected to a depth of at least 1 km [9]. This deposit consists of porphyry copper-gold deposit with associated replacement deposits (skarns, mantos) and high-sulphidation epithermal massive-enargite (gold) sulphide deposits [10]. Mineralization typically occurs in a form of stockworks, within the metamorphic aureole of the andesitic dykes.

This deposit includes two major mining areas, i.e. two different copper deposits: North Revir and South Revir. Both deposits are studied and described in detail by Armstrong et al. (2005) [8]. South Revir is the largest deposit with significant mineralization and copper occurrence, the Cu-Au rich massive Knez Lazar body and a number of contact skarns [8]. The second copper deposit "North Revir" contains three ore bodies: 1) Porphyry ore bodies: "Central ore body" and "Dolovi", 2) Cu-pyrite ore bodies: "Dolovi 2" and "Stari Dušan" and 3) Polymetallic ore body Tenka [9]. According to the Armstrong et al. (2005), it is characterized by the presence of polymetallic Pb-

Zn rich limestone with several smaller porphyry copper ore bodies [8].

The total copper reserves of the ore at Majdanpek were estimated at 800 Mt, containing 0.4-0.8% Cu, and 0.25-1.0 g/t Au [10]. The exploitation in the Copper Mine Majdanpek started in the early 1955. The plans for development of the complex included the opening of an open-pit mine, construction of a flotation plant and related facilities and development of an urban settlement.

During the 1980s, the production capacity reached about 13 million tons of ore per year [11]. Flotation plant produced copper (with gold and silver) and magnetite concentrates. In the recent years, the annual capacity decreased significantly (in 2005 it amounted to about 1.2 million tons of ore), mainly due to the lower content of copper in the ore [11]. Due to the decreased mine production, the flotation plant is reportedly running at 25% of its capacity. The Copper Mine Majdanpek increased its production of copper concentrate, gold and silver by about 40% in 2016 with 7.8 g/t Au, 0.03 g/t Pt, and 0.27 g/t Pd in concentrate [12].

Flotation is a physicochemical process that has been used for more than a century in the concentration of copper ores. Mineralogy, particle size, degree of liberation, collector type and dosage, air flow rate, pulp density, and wash water rate are some of the influential parameters on flotation process efficiency [13-20].

A literature review showed that collectors play a critical role in the flotation of copper ores. A number of different collectors have been evaluated for copper flotation. The xanthates, dialkyl dithiophosphates and dithiocarbamates are the most widely used as collectors for copper flotation [21].

Many studies into collectors for copper flotation have been carried out [22-29].

Hangone et al. (2005), in a study of the effects of thiol collectors: xanthates, dithiophosphates, dithiocarbamates and mixtures of these collectors in the flotation of a copper sulphide ore, showed the di-ethyl-dithiocarbamate was the weakest collector of copper sulphide minerals. It was also

found that highest copper recoveries were obtained with the di-ethyldithiophosphate as well as that a collector mixture of 90% ethyl xanthate : 10% di-ethyldithiophosphate and 90% ethyl xanthate : 10% di-ethyl-dithiocarbamate resulted in enhanced rates and copper recoveries [22].

Bradshaw and O'Connor (1994) showed that an optimum ratio of the constituent collectors of collector mixtures was 90:10% mixture of xanthate and dithiocarbamate collectors in the flotation of pyrite [23]. Later, Bradshaw et al. [24] were tested the synergistic interactions between Potassium n-butyl xanthate (PNBX) and a dithiocarbamate collector (DTC) in sulphide flotation both as pure collectors and as components in a collector mixture. As results of batch flotation, froth surface and thermochemical tests, it is observed that the mixture of collectors showed a stronger adsorption than the pure xanthate, an increase in bubble loading, an improvement in froth characteristics and a greater grade and recovery.

Lee et al. (2009) studied flotation of mixed copper oxide and sulphide minerals with xanthate and hydroxamate collectors [25]. This investigation has shown that using n-octyl hydroxamates (AM28 made by Ausmelt Limited) with traditional sulphide collectors (PAX) can successfully recover copper sulphides and oxides by flotation from a high grade copper–gold deposit in Yukon, Canada.

Corin et al. [26] has investigated the roles of two collectors sodium iso-butyl xanthate (SIBX) and sodium di-ethyldithiophosphate (DTP) in the flotation of platinum group mineral (PGM) ore. Results showed that SIBX is a stronger collector and that DTP plays an important role in the recovery of fine particles and an increase in the recovery of PGEs, especially Pd, from the Platreef deposit in South Africa.

The interaction between the sulfide minerals surface and n-octanohydroxamate collector (pH > 9) was investigated by Parker et al. [27] through electrochemical, Raman spectroscopy and X-ray photoelectron spectroscopy analysis, and it was found that on the ternary sulfide minerals such as chalcocite, bornite and chalcopyrite, Cu hydroxamate was formed between patches of Fe oxide bearing adsorbed Fe hydroxamate and/or hydroxamic acid. Also, these results confirm that pyrite did not react significantly with n-octanohydroxamate unless the surface was pre-oxidized.

The role of collectors and depressants in flotation, based on the extended Derjaguin–Landau–Verwey–Overbeek (DLVO) theoretical model proposed by Suresh and Walz [28] was studied by Xing et al. (2017) [29].

Previously, copper flotation and the effect of collector type on the recovery of the flotation process have been studied on copper ore from Majdanpek deposit [30-31].

The flotation studies on ore from Majdanpek deposit have been conducted in order to determine the efficiency of flotation in dependence of a minerals liberation degree and different collectors. In this study, Grujic et al. [30] used a 3418-A, S-7518, APS9090 and S-5415 collectors. The characteristics of flotation reagents, the redox potential of minerals in pulp, solubility product of minerals (M+, A-) and reactivity of flotation reagents anions and cations were investigated too. Results showed that the solubility product of minerals (M+, A-) and redox potential of sulfide minerals of Cu, Au and Pt are changing in dependence of collectors chemical structures as well as with a mixture of collectors obtained a recovery of copper, gold and platinum minerals was 87%, 58% and 57%, respectively.

Jovanovic et al. [31] studied the effect of different collectors on the quality of copper concentrate from the deposit ore body Tenka-3 - North Mining District, Copper Mine Majdanpek. The following reagents were used as collectors as well as their combinations: sodium isopropyl xanthate (NaIPX), ditiophosphinate (3418 A) and ethoxycarbonyl thiourea (AP 5500). It was found that the best results were obtained using the collector AP 5500 at higher pH values range (10.0 – 11.5).

This paper discusses the effect of collector type and dosage on copper recovery and concentrate grade. In the study, dithiophosphate and a mixture of xanthate and dithiophosphate collectors were

investigated with mineralogical characterization of copper ore.

2. Experimental

2.1. Materials

A representative sample of copper ore (about 160 kg) was collected from the flotation plant in the Copper Mine Majdanpek (Serbia) during 2014. The sample was dried and crushed in a laboratory jaw crusher within the closed cycle with 3.37 mm sieve for grinding and flotation tests. Also, a representative sample of hydrocyclone overlow was taken for XRD and ore mineralogical analysis. Both samples represent a part of the copper ore that has been exploited and processed from the deposit "North Revir" with the same physico-chemical characteristics and there was no difference in the composition.

2.2. Particle size analysis

Particle size analysis was determined by sieving of both samples on series of Tyler sieves in the range of 0.037 to 2.362 mm. Particle size analysis of the both samples are given in Table 1 and Table 2.

Particle size analysis have shown that the main size fraction are (+2.362) mm, (-2.362+1.651) mm, (-1.651+0.417) mm and (-0.037+0) mm. These results confirm that the participation of coarse size is more dominant. The highest content is in the grain size fraction from 0.417 to 1.651 mm which amounts to 29.6%. The most particles are distributed in grain size fraction 0–37 μm in the hydrocyclone overlow.

As it can be seen from table 2, the content of <37 μm was determined as 43.20%.

Table 1. Particle size analysis of copper ore sample

Grain size (mm)	Mass M (%)	Cumulative mass D (%)
+ 2.362	21.2	100.0
- 2.362 + 1.651	10.8	78.8
- 1.651 + 0.417	29.6	68.0
- 0.417 + 0.295	4.6	38.4
- 0.295 + 0.208	4.0	33.8
- 0.208 + 0.147	0.8	29.8
- 0.147 + 0.104	5.8	29.0
- 0.104 + 0.074	2.0	23.2
- 0. 074 + 0.053	2.4	21.2
- 0.053 + 0.037	0.6	18.8
- 0.037 + 0	18.2	18.2
∑	100.0	

Table 2. Particle size analysis of hydrocyclone overlow

Grain size (mm)	Mass M (%)	Cumulative mass D (%)
+ 0.147	14.55	100.00
- 0.147 + 0.074	26.50	85.45
- 0.074 + 0.037	15.75	58.95
- 0.037 + 0	43.20	43.20
∑	100.00	

2.3. Chemical analyses

The average chemical composition of copper ore sample is presented in table 3 [32].

Chemical analyses showed that average copper content was 0.273% with a dominant partition of sulfide copper (0.253%). The content of precious metals (Au and Ag) was 0.2 g/t and 1.2 g/t, respectively.

Table 3. Chemical analyses of copper ore sample

Elements	Cu^{tot} (%)	Cu^{sul} (%)	Cu^{ox} (%)	S (%)	Pb (%)	Zn (%)	Ag (g/t)	Au (g/t)
Content	0.273	0.253	0.02	4.63	Ø	0.08	1.20	0.20

2.4. X-ray diffraction (XRD) analysis

X-ray diffraction (XRD) analysis was performed

on the hydrocyclone overlow sample by GNR Expoler diffractometer, with scintillation counter as detector, geometry of goniometer θ-θ, without a

secondary monochromator. X-ray source radiation is a copper anode tube which emits characteristic CuKα radiation of wavelength 1.54 A. Recording was done on x-ray 40 kV tubes and 30 mA with a scanning rate of 3° 2θ/min.

The qualitative and quantitative analysis of minerals was performed by comparing the recorded diffractograms with diffractograms from a standard database using Match data processing software [33]. With this software, based on the height of the resulting peaks, semi-quantitative determination is possible, i.e. the content of the individual minerals in the sample.

2.5. Ore mineralogical analyses

Qualitative mineralogical analysis of copper ore sample (hydrocyclone overlow) was carried out by ore microscopy. It was performed in reflected light in air and immersion (cedar oil), on Carl Zeiss-Jena, JENAPOL-U microscope and system for microphotography "STUDIO PCTV" (Pinnacle) with identification of ore and non-ore minerals. Objective magnification was from 10 to 50x (exceptionally 100x in oil immersion). Ore preparations for microscopic testing were made in plexiglass, with mineral grain and surface of 2.2 cm^2.

2.6. Grinding test

The grinding test was carried out in a cylindrical laboratory ball mill, dimension (DXL) = (400x125 mm) with standard ball charge. Content of solids in grinding test was a 65% (in weight). Grinding time

to achieve optimal grinding products with 65% of grain size <0,074 mm was 11 min and 25 s [12].

2.7. Flotation tests

After grinding, copper ore samples with 65% of grain size fraction −74 μm were submitted to flotation. Flotation tests were carried out using a 2.7·10^{-3} m^3 DENVER DR-12 laboratory flotation cell with a 1250 rpm agitation rate. Rough flotation tests were carried out with 27% solids (in weight) at pH 11. Furthermore, the conditioning time was 6 min, and flotation time was 17 min [12]. Sodium isopropyl xanthate (Z11), dialkyl dithiophosphinates (Aerophine 3404) and SKIK were used as collectors.

Z11 (sodium isopropyl xanthate) was provided by Chemical Industry Župa Kruševac (Serbia).

Aerophine 3404 promoter (dialkyl dithiophosphinates) is a Cytec collector. It is an effective primary collector in the selective flotation of lead/gold/silver minerals with low copper content. Aerophine 3404 promoter is highly selective against iron.

SKIK, a new domestic collector with corrosion inhibition properties, was supplied by Metoha Technology Novi Sad (Serbia).

AEROFROTH 76A (5 g/t) was used as a frother in all experiments.

The flotation tests were carried out with different collectors (alone or combination) and with different collectors dosage. Type and dosage of collectors (g/t) in the flotation tests are given in table 4 [32].

Table 4. Type and dosage of collectors (g/t) in the flotation tests

Collector	No 1.	No 2.	No 3.	No 4.	No 5.	No 6.	No 7.	No 8.	No 9.	No 10.
Z$_{11}$	25	35	45	-	-	-	20	18	18	20
AP$_{3404}$	-	-	-	25	35	45	8	10	12	16
SKIK	-	-	-	-	-	-	8	8	6	-
A$_{76}$	5	5	5	5	5	5	5	5	5	5

The final flotation products were filtered, dried and analysed on copper (Cu) and Sulphur (S) content, and copper and sulphur recoveries (R) were calculated using Eq. (1) [16]:

$$R = \frac{C\,c}{F\,f}\,x\,100,\,\% \qquad (1)$$

The separation efficiency (SE) was calculated

according to Eq. (2) [16]:

$$SE = \frac{C\,m\,(c\text{-}f)}{F\,f\,(m\text{-}f)} \times 100,\ \%\qquad(2)$$

where C is the dried concentrate weight, c is the grade of Cu or S in the concentrate), F is the dried feed weight, f is the grade of Cu or S in the feed and m is the maximum Cu or S content in the chalcopyrite mineral. Copper and sulphur content were determined by applying Atomic Absorption Spectrophotometry (AAS) and by gas volumetry (GV), respectively [34].

3.   Results and discussion

3.1. Results of XRD analysis

The results of the XRD analysis is shown in the diffractogram in Figure 1, and the estimated semi-quantitative XRD analysis is given in Table 5.

Results of semi-quantitative XRD analysis are shown in table 5 [32].
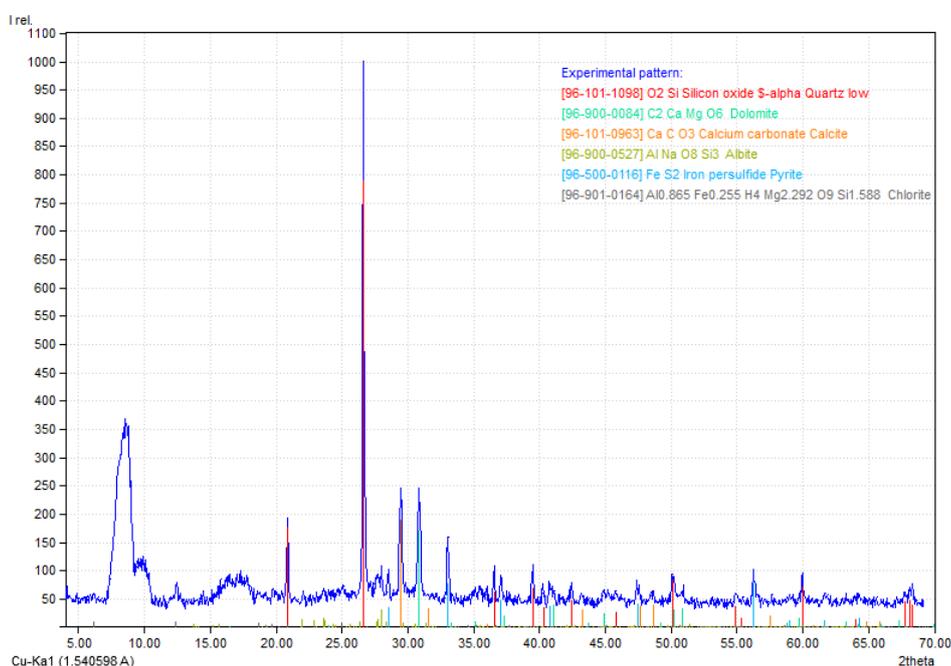
Figure 1. XRD pattern of the copper ore sample (hydrocyclone overflow)

Table 5. Results of semi-quantitative XRD analysis the copper ore sample (hydrocyclone overflow)

Mineral	Chemical formula	Content (%)
Quartz	SiO_2	49.10
Dolomite	$CaMgC_2O_6$	15.50
Calcite	$CaCO_3$	13.60
Albite	$NaAlSi_3O_8$	11.50
Pyrite	FeS_2	7.30
Chlorite	$Al_{0,865}\,Fe_{0,255}\,H_4Mg_{2,292}\,O_9Si_{1,588}$	3.10
Chalcopyrite	$CuFeS_2$	0.80
Chalcocite, magnetite, sphalerite	Cu_2S; Fe_3O_4; ZnS	0.20

The semi-quantitative XRD analysis indicated the presence of following minerals: pyrite, chalcopyrite, chalcocite, bornite, covellite, cuprite, magnetite, rutile, limonite, sphalerite, galena, tailings minerals.

3.2. Results of ore mineralogical analysis

Results of ore mineralogical analysis have shown that the main copper mineral is chalcopyrite, which is compared to the ore minerals, represented by about 10%, while other ore minerals (chalcocite, magnetite, sphalerite) account for about 2% (figure 2). Chalcopyrite is free about 65% (figure 2) and about 35% of chalcopyrite is usually in the form of simple and complex intergrowths, inclusions in the silicate tailings (figure 3), but also in the form of appropriations (inclusion) in the sphalerite.
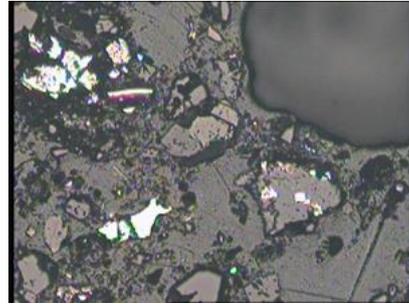
Figure 2. Free grains of chalcopyrite (yellow) and pyrite (light yellow) and inclusion of chalcopyrite in tailings
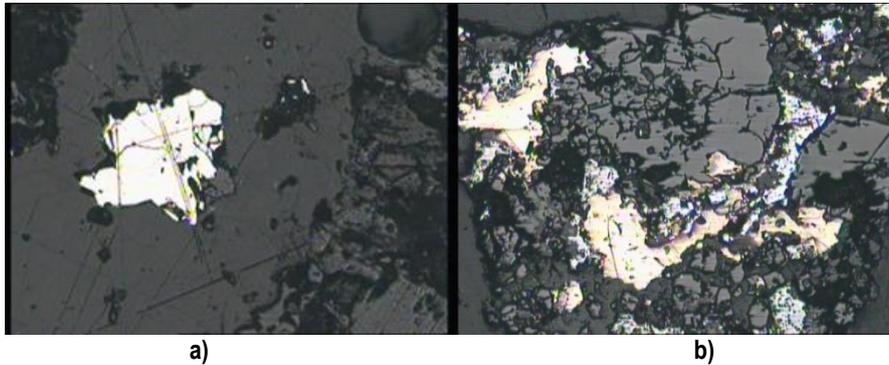
Figure 3. a) Simple and b) complex intergrowts of chalcopyrite in silicate tailings

Pyrite is most abundant mineral in relation to other ore minerals. Its representation in relation to the mineral ore is about 88% (its absolute representation in the sample is about 9%). Pyrite is free about 78% and about 22% of pyrite was intergrown in the form of simple or complex twins (Figure 4).
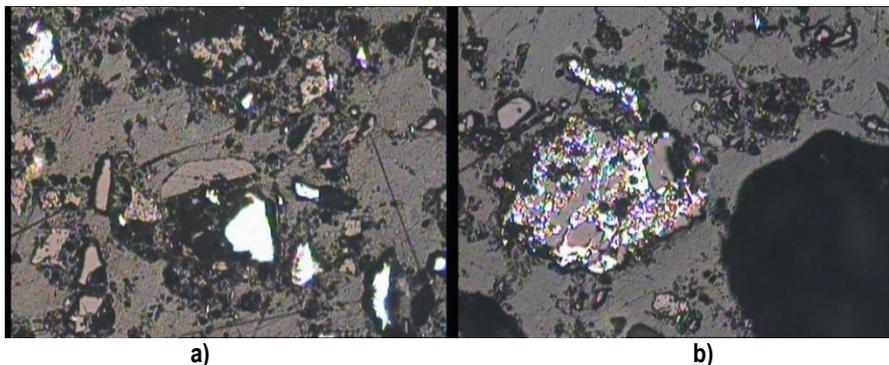
Figure 4. a) Liberated grains of pyrite (light yellow) and b) simple intergrowts of pyrite in silicate tailings

The nonmetallic minerals (tailings) are feldspar (K-feldspar and plagioclase), quartz, carbonate, calcite, albite and chlorites, and the accessory tourmaline, apatite and zircon.

3.3. Results of flotation tests

Results of rough flotation tests of copper ore are shown in table 6 [32].

Table 6. Results of rough flotation tests of copper ore

Test No.	Mass yield (%)	Concentrate grade		Recovery		Separation efficiency	
		Cu (%)	S (%)	Cu (%)	S (%)	Cu (%)	S (%)
1	16.39	1.39	19.87	83.45	70.34	67.50	69.08
2	14.63	1.55	21.58	83.06	68.19	68.88	68.58
3	15.61	1.42	22.72	81.19	76.60	66.01	78.10
4	14.08	1.54	15.99	79.43	48.63	65.77	44.24
5	14.44	1.58	17.92	83.57	55.89	69.58	53.07
6	17.31	1.32	20.32	83.70	75.97	66.82	75.11
7	15.26	1.52	24.81	84.96	81.77	70.16	85.17
8	14.88	1.50	21.92	81.76	70.45	67.32	71.15
9	14.09	1.57	23.43	81.03	71.30	67.38	73.26
10	14.82	1.55	22.83	84.14	73.08	69.78	74.59

The effects of different collectors on the recovery, concentrate grade as well as the separation efficiency are given on figure 5, 6 and 7, respectively.
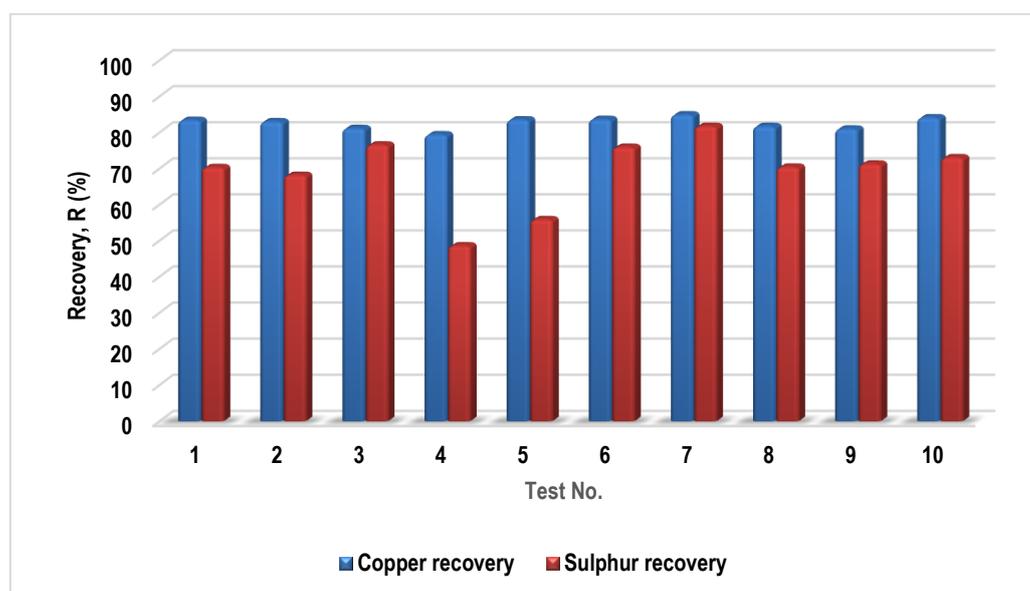
Figure 5. Effect of different collectors on the recovery

Comparing the results of the flotation tests, it can be seen that the results (the recovery, the concentrate grade as well as the separation efficiency) of tests 5, 7 and 10 are relatively better than the others.

As it can be seen from table 6 (test no. 7), the collectors dosages of 20 g/t Z11, 8 g/t AP3404 and 8 g/t SKIK BZ 2000 gave the maximum copper recovery (84.96%). Also, rough copper concentrate grade was 1.52%.

From Fig. 7 can be seen that with these mixture of collectors a maximum values of the separation efficiency of copper (70.16%) and sulphur (85.17%) can be also obtained.

It can be noticed that in the flotation tests no. 5 and 10, obtained copper recoveries were 83.57% and 84.14%. The separation efficiencies were 69.58% and 69.78%, respectively. Dialkyl dithiophosphinate was used alone in the test no. 5 and the combination of collectors Z11 (sodium isopropyl xanthate) and Aerophine 3404 promoter (dialkyl dithiophosphinates) were used in test no.10. Slightly better results were achieved in the flotation test no.10.
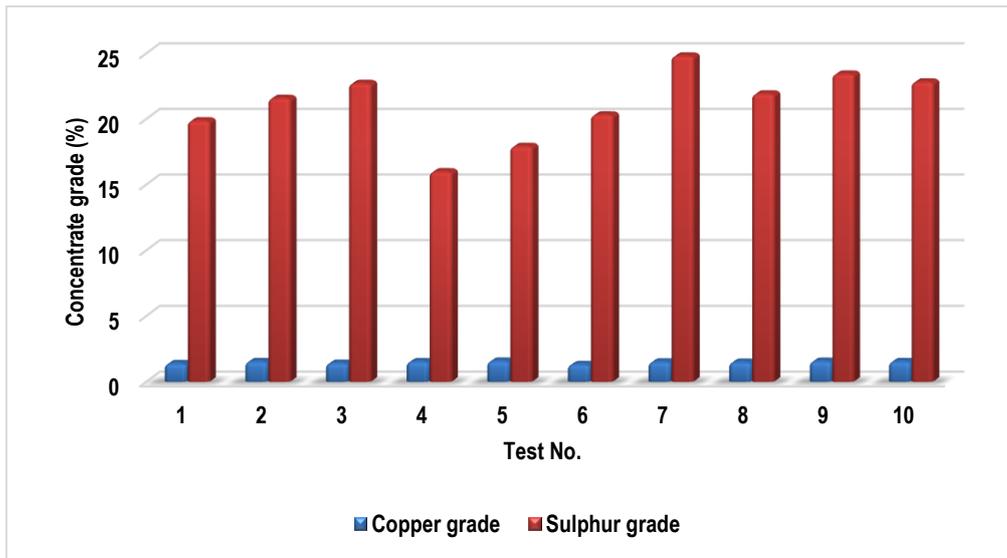
Figure 6. Effect of different collectors on the concentrate grade
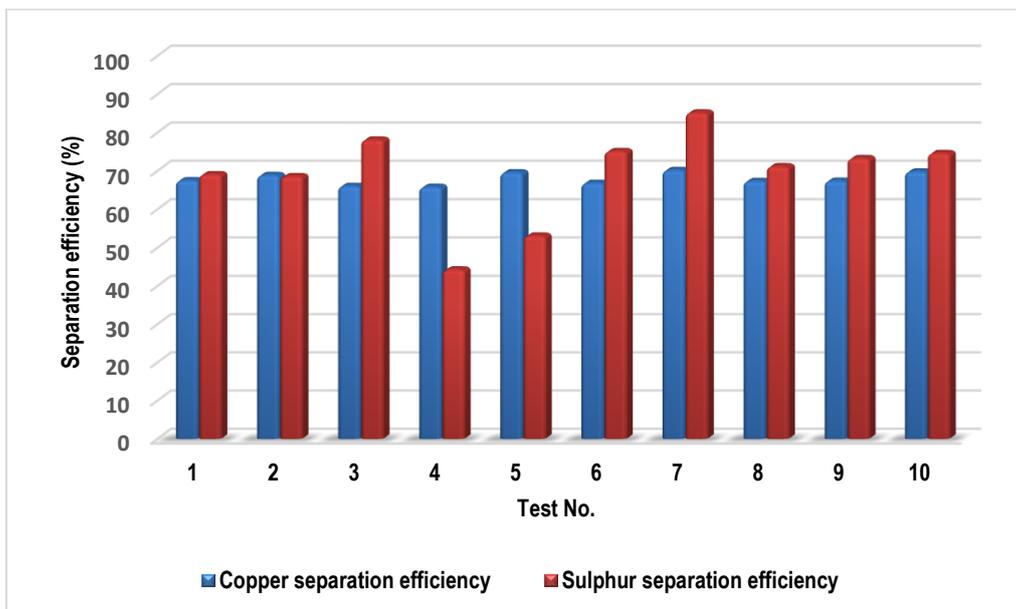
Figure 7. Effect of different collectors on the separation efficiency

The results showed that with Z11 (sodium isopropyl xanthate) alone (test no. 1), even in smaller dosage, very good flotation results are achieved, while the use of Aerophine AP3404 in the flotation of copper ore (tests no. 5 and 6) requires a significantly higher dosage to achieve more efficient flotation.

It can be noticed that in the flotation tests in which 25 g/t of both collectors were used, the following, noticeably different results of copper recovery were obtained: Z11 (test no. 1) – 83.45%; and AP3404 (test no. 4) - 79.43%. It was found that copper recovery increased from 79.43% to 83.70% with increasing dosage of AP3404 collector from 25 to 45 g/t. These results were achieved with a collector distribution pattern of 100%.

Slightly better results were achieved with combination of both collectors such as: 20 g/t Z11 and 16 g/t AP3404 (test no. 10). Achieved copper recovery was 84.14% with 1.55% copper concentrate grade. Result of this study also show that the average copper grade in the rough concentrate was from 1.39% (test no. 1) to 1.58% (test no. 5).

By comparing obtained laboratory result with industrial result [12, 35] it can be seen that the better flotation result was achieved in the laboratory rough flotation test than in the industrial flotation plant of the Copper Mine Majdanpek. The mass yield, copper recovery and concentrate copper grade were 20.43%, 78.58% and 1.2%, respectively [12, 35]. The results of these studies confirm the necessity of applying new collectors, mixture of collectors and optimization of the collector dosage to enhance copper recovery in the flotation plant of Copper Mine Majdanpek.

4.   Conclusion

Copper mine Majdanpek is one of the largest copper producers in Serbia. In order to improve the results of the industrial process of flotation concentration, mineralogical and rough flotation tests were carried out on ore from the deposit „North Revir".

XRD and ore microscopic analysis showed that the copper ore is mineralogically and texturally complex. The main copper mineral is chalcopyrite, which is, compared to the ore minerals, represented with about 10% (its absolute representation in the sample is about 0.8%), while other ore minerals account for about 2% (their absolute representation in the sample to 0.2%). Liberation of chalcopyrite is about 65%. Pyrite is the most abundant mineral in relation to other ore mineral (about 88 %). Pyrite is liberated about 78% and about 22% of pyrite was intergrown in the form of simple or complex intergrowths (generally tailings).

The main focus of flotation studies has been the effect of a collector type on the copper recovery and concentrate grade of the flotation process. These results showed that the mixture of collectors sodium isopropyl xanthate (Z11), dialkyl dithio-phosphinates (Aerophine 3404) and SKIK BZ 2000 (56%, 22%, 22%) can produce the highest recovery (84.96%). Copper grade in the rough concentrate was 1.52%. The optimal dosages to achieve maximum recovery were found to be 20 g/t Z11, 8 g/t AP3404 and 8 g/t SKIK BZ 2000. Applying this combination of collectors would significantly increase copper recovery in the flotation plant of Copper Mine Majdanpek.

5.   Note

6.   Acknowledgements

7. References

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FLOTACIJSKA ISPITIVANJA MAJDANPEČKE RUDE BAKRA U CILJU POBOLJŠANJA ISKORIŠĆENJA BAKRA I KVALITETA KONCENTRATA PRIMENOM RAZLIČITIH KOLEKTORA

J. Sokolović[1#], R. Stanojlović[1], Lj. Andrić[1,2], Z. Štirbanović[1], N. Ćirić[3]

[1]University of Belgrade, Technical Faculty in Bor, V.J. 12, 19210 Bor, Serbia
[2]Institute for Technology of Nuclear and other Mineral Raw Materials (ITNMS),
Bulevar Franše d'Eperea 86, 11000 Belgrade, Serbia
[3]Zijin Bor Copper d.o.o, Copper Mine Majdanpek – RBM, Svetog Save 2, 19250 Majdanpek, Serbia

Izvod

U ovom radu predstavljeni su rezultati mineraloških i flotacijskih ispitivanja rude bakra iz ležišta „Severni revir" u Rudniku bakra Majdanpek, primenom različitih kolektora. XRD i rudna mineraloška analiza pokazali su da su u najčešći prisutni minerali pirit i halkopirit. Hemijske analize potvrđuju da je to kompleksna, nisko-kvalitetna ruda bakra sa prosečnim sadržajem bakra od 0,273%. Sadržaj plemenitih metala (Au i Ag) iznosio je 0,2 g/t, odnosno 1,2 g/t, respektivno. Glavni cilj flotacijskih ispitivanja bio je uticaj vrste kolektora na iskorišćenje i kvalitet koncentrata u procesu flotacije bakra. U testovima osnovnog flotiranja rude bakra korišćeni su različiti kolektori i kombinacije istih. Iskorišćenje bakra iznosilo je opsegu od 79,43% (test br. 4) do 84,96% (test br. 7). Najbolji rezultati flotiranja dobijeni su sa sledećm mešavinom kolektora: natrijum izopropil ksantat (Z11), dialkil ditiofosfat (Aerophine 3404) i SKIK BZ 2000. Sa dozom kolektora od 20 g/t Z11, 8 g/t AP3404 i 8 g/t SKIK BZ 2000 ostvareno je iskorišćenje bakra (84,96%) sa sadržajem bakra u koncentratu od 1.52%.

Ključne reči: *Bakar; Ruda; Majdanpek; Flotacija; Kolektori.*