University of Belgrade
Technical Faculty in Bor and
Mining and Metallurgy Institue Bor

Technical Faculty in Bor
University of Belgrade

51st International October Conference on Mining and Metallurgy

PROCEEDINGS

Editors:

Prof. dr Srba Mladenović
Prof. dr Čedomir Maluckov

Bor Lake, Serbia,
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IOC 2019
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MICROBIAL SOLUBILIZATION OF COPPER AND ZINC FROM POLYMATALLIC SULPHIDE ORE

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Abstract

The object of this study was to investigate the possibility of copper and zinc leaching from polymetallic sulphide ore from the Bobija deposit (Western Serbia) by Acidithiobacillus sp.B2. Iron-oxidizing Acidithiobacillus sp. B2 was isolated from copper sulphide mine wastewater (Lake Robule) in Bor, Serbia. The bacterium was identified by 16SrDNA oligonucleotide sequence.

Leaching experiment by the shake flask testing technique was performed during a period of four weeks at a temperature of 28 °C. The percentage of Cu and Zn leached at the end of this experiment was 65% and 67% respectively.

This study shows that iron-oxidizing Acidithiobacillus sp. B2 can have a very important role in the extraction of copper and zinc from polymetallic sulphide ore from the Bobija deposit.

***Keywords**: bioleaching, polymetallic sulphide ore, Bobija deposit*

1. INTRODUCTION

Reserves of rich ores from year to year are getting lower. Investigation of the new procedures for the use of low-grade ores (e.g. Cu and Zn) is one of the current issues in the extractive metallurgy in the developed countries [1]. These ores include polymetallic ores from which is impossible to recover concentrates with a satisfactory content of metal for future processing [2].

In recent times, the focus of research are the biohydrometallurgical procedures, which are more selective than the classic ones and which could enable a more successful processing of this type of raw materials.

The object of this study was to investigate the possibility of copper and zinc leaching from polymetallic sulphide ore from the Bobija deposit (Western Serbia)

2. EXPERIMENTAL

2.1. Chemical analysis of polymetallic sulphide ore

The polymetallic sulphide ore was pulverized and sieved through a 63 μm stainless steel sieve in preparation for chemical and leaching studies. For determination of Cu and Zn the sample of polymetallic sulphide ore was decomposed with a mixture of $HClO_4$ and HF. The metals were determined by atomic emission flame spectrophotometry (PERKIN ELMER Aanalyst 300).

The contents of elements in solution (Cu and Zn) were determined by inductively coupled plasma optical emission spectrometry (ICP-OES). ICP-OES measurement was performed using Thermo Scientific iCAP 6500 Duo ICP (Thermo Fisher Scientific, Cambridge, United Kingdom) spectrometer with iTEVA operational software according to the instrument instruction manual.

2.2. X-ray diffraction (XRD) analysis of polymetallic sulphide ore

XRD patterns were obtained on a Philips PW-1710 automated diffractometer using a Cu tube operated at 40 kV and 30 mA. The diffraction data were collected in the 2h Bragg angle range from $5^{o}$to 60^{o}, counting for 0.5 s at every 0.02^{o}step. The divergence and receiving slits were fixed at 1 and 0.1 units, respectively. The XRD measurements were performed at room temperature in a stationary sample holder.

2.3. Leaching experiments

The leaching experiments were carried out with bacterium *Acidithiobacillus* sp. B2 (NCBI GenBank KC69130). Experimental conditions were: leaching period of 28 d, 50 ml leaching solution (g/L): $(NH_4)_2SO_4$ (3), K_2HPO_4 (0.5), $MgSO_4$ x $7H_2O$(0.5), KCl (0.1), $Ca(NO_3)_2$ (0.01), at a pH of 2.5 in 150 mL Erlenmeyer flasks at a pulp density of 10% (m/V) (5 g leaching substrate-polimetallic ore in 50 ml solution). The initial number of microogranisms was 10^7 per mL, determined by the Most Probable Number method [3]. The control suspension had the same chemical content and pH value as the suspension with *Acidithiobacillus* sp. B2, but the *Acidithiobacillus*sp. B2 culture had been inactivated by sterilization. The study was realized on a horizontal shaker New Brunswick Scientific. The incubation temperature was 28 °C and the rotation speed 150 rpm [4].

3. RESULTS AND DISCUSSION

The sample of polymetalic ore contained 1.66% Cu and 4.86% Zn.

The polymetallic sulfides ore had the following mineral composition: Pyrite (39.6%), Quartz (15.8%), Barite (38.9%), Sphalerite (4.3%), Galena (1.4%). XRD pattern of the polymetallic ore is shown in Figure 1.

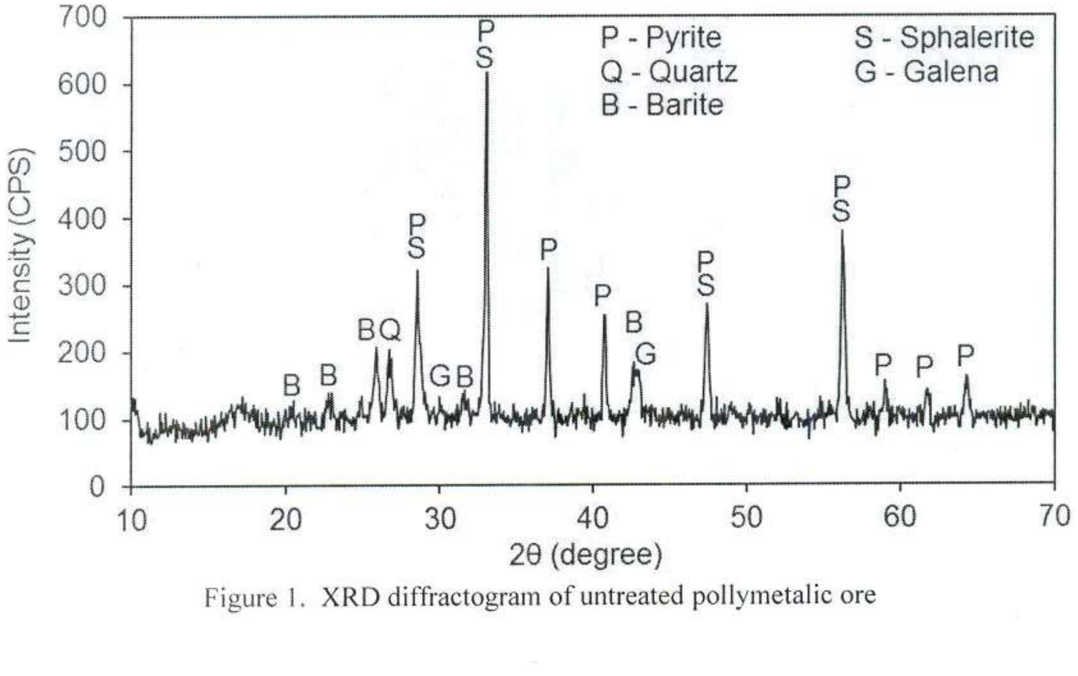

Figure 1. XRD diffractogram of untreated pollymetalic ore

XRD pattern of the polymetallic ore after leaching experiments is shown in Figure 2.

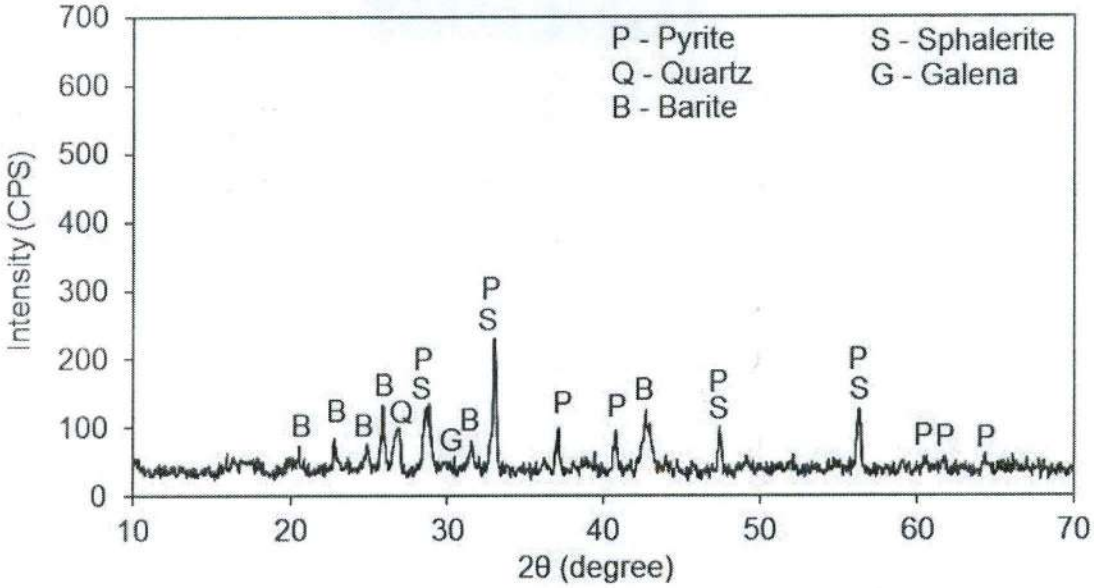

Figure 2. XRD diffractogram of residue after leaching experiments by *Acidithiobacillus* sp. B2

The leaching experiment of pollymetalic ore was performed using bacterial culture *Acidithiobacillus* sp. B2 and was completed after 28 d.

The process of leaching is based on the fact that acidophilic microorganisms provide metabolic energy by oxidizing ferrous iron released from pyrite, generating ferric iron [2,5].

$$FeS_2 + 6Fe^{3+} + 3H_2O \rightarrow S_2O_3^{2-} + 7Fe^{2+} + 6H^+ \quad (1)$$

$$S_2O_3^{2-} + 8Fe^{3+} + 5H_2O \rightarrow 2SO_4^{2-} + 8Fe^{2+} + 10H^+ \quad (2)$$

Fe^{2+} (produced in reactions 1 and 2) can be reoxydized to Fe^{3+} by acting of iron-oxidizing microorganism *Acidithiobacillus* sp. B2.

$$2Fe^{2+} + 0{,}5O_2 + 2H^+ \rightarrow 2Fe^{3+} + H_2O \quad (3)$$

Key role of *Acidithiobacillus* sp. B2 is to regenerate sulphuric acid and Fe^{3+}, which is strong oxidizing agent, so it can oxidize metal sulfides, such as pyrite, sfalerit, enargite, and chalcopyrite. All these things lead to lower pH and leaching of metals from polymetallic sulphide ore [6, 7].

The obtained results are presented in Tabele 1. and Tabele 2.

Tabele 1- Number of iron-oxidizing *Acidithiobacillus*sp. B2 and pH profiles of suspensions during leaching

	pH		**Number of microorganisms per mL**	
	control	*Acidithiobacillus* sp. B2	control	*Acidithiobacillus* sp. B2
0 d	2,42	2,41	/	10^7
14 d	2,64	1,88	/	10^9
28 d	2,34	1,47	/	10^7

The experiment of microbiological ore leaching was completed after 28 d with the same microorganism number as at the beginning, 10^7 per ml. This fact implicates than substrate did not have a toxic effect on the bacteria.

Tabele 2- Leaching of the tested metals during 28 d

	Zn (%)		Cu (%)	
	control	*Acidithiobacillus* sp. B2	control	*Acidithiobacillus* sp. B2
0	7,22	7,19	6,32	6,16
14	16,35	40,27	13,33	45,71
28	20,91	67,11	15,69	65,23
	Zn (%)		Cu (%)	
	control	*Acidithiobacillus* sp. B2	control	*Acidithiobacillus* sp. B2
The efective metal leaching	13,69	59,92	9,37	59,07

At the end of the leaching process, the effective metal leaching (calculated by subtraction of percentage metal leaching in the control suspension from that in the *Acidithiobacillus* sp. B2 suspension) of zinc was 59,92% and copper was 59,07%. This shows that iron-oxidizing *Acidithiobacillus* sp. B2 can have a very important role in the dissolution of metals from poliymetallic ore.

4. CONCLUSION

The results indicated that the poliymetallic ore from the Bobija deposit was a suitable substrate for microbiological leaching processes. Also, this study shows that *Acidithiobacillus* sp. B2 can have a very important role in the dissolution of metals from poliymetallic sulphide ore.

Due to its low cost and environmental acceptance, bioleaching of polymetallic sulfides ore by acidophilic iron- and sulphur-oxidizing bacteria could become an attractive and alternative way to recover of copper and zinc from the polymetallic sulfides ore.

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