

MICROSCOPY ANALYSIS OF COPPER SLAG AND ITS PROCESSING BY FLOTATION

Zoran Markovic¹, Zoran Stirbanovic¹, Dragan Milanovic², Daniela Urosevic², Florian Kongoli³

¹University of Belgrade – Technical Faculty in Bor, Vojske Jugoslavije 12, 19210 Bor, Serbia;

²Institute for Mining and Metallurgy Bor, Zeleni Bulevar bb, 19210 Bor, Serbia;

³Flogen Technologies Inc., 1255 Laird Blvd. Suite 388, Quebec, Canada, H3P2T1;

ABSTRACT

A smelting plant in Bor extract copper from copper ores and copper concentrates by a pyrometallurgical process. During years of operation, a considerable amount of copper slag has been generated as a by-product and has been dumped. Copper contents in these slags are as high as 0.6 up to 0.8%. As such, this slag could be considered as a secondary source for copper re-utilization. In this context, microscopy analysis of slag samples was carried out in order to determinate its mineralogical composition and to find a possibility for re-extraction of remaining copper from the slag. According to results of the investigation and phase occurrences in slag, it is possible to apply flotation for recovery of copper from these slags.

Keywords: Smelter slag, Copper, Mineralogical analyses, Flotation

INTRODUCTION

Copper concentrates, as well as rich sulfide ores, are being processed by pyrometallurgical processes, which are divided into conventional and autogenous processes. Conventional processes include the processing of raw materials in the shaft (WJ), reverberatory and electric furnaces. Due to a number of shortcomings of conventional processing technologies and because of the stricter laws that deal with environmental issues at the beginning of the 70s, conventional processes started to be replaced by with autogenous smelting processes.

Bor smelting plant started operating in 1906 and since 1961 it uses reverberatory furnaces with a designed capacity of 600 thousand tons per year. In 2010, it began the construction of a new smelter with BAT technology with a capacity of 400 thousand tons per year.

The technology for processing copper concentrates in reverberatory furnaces is characterized by production of large quantities of slag that is discarded [1]. It is estimated that in the last hundred years the smelting plant in Bor produced between 16 and 18 million tons of smelter slag, with an average content of copper from 0.6-0.8%, gold 0.4 g/t and silver 7.50 g/t [2]. Bearing in mind the content of copper and precious metals in the ores that are currently being processed, it can be said that slag could be an important raw material for the production of copper.

Flotation is one of the possible methods for the reprocessing of smelter slag and recovering copper and other metals [3, 4].

EXPERIMENTAL

Mineralogical analyses

Copper slag samples were taken from copper slag landfill. Mineralogical composition of slag was determined by ore microscopy and X-ray diffraction analysis.

a) X-ray diffraction analysis

X-ray diffraction analysis was performed using a SIEMENS device, and for the test was used Cu anti-cathode with filtered radiation, Ni filters, with voltage supply of 40KV and current intensity of 20 mA.

A sample of the results of x-ray diffraction analysis are shown in Figure 1.

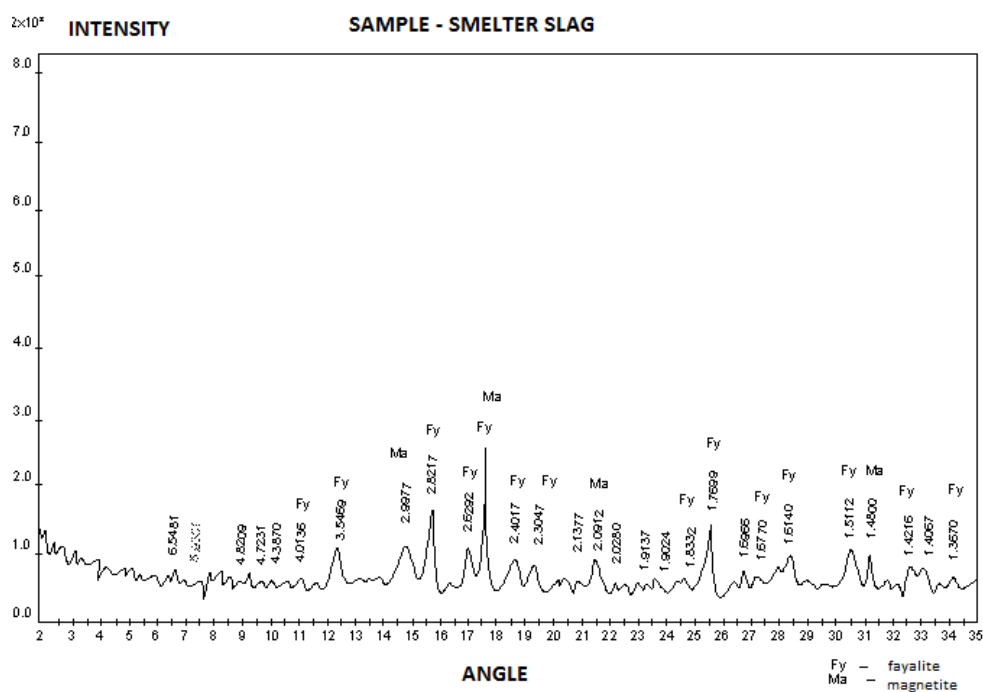


Figure 1. Results of X-ray diffraction analysis of smelter slag sample

As it can be seen, the slag sample shows the presence of two dominant minerals: fayalite and magnetite.

b) Ore microscopy analysis

Qualitative mineralogical analysis was performed with polarizing microscope under reflected light in the air. Lens magnification was in a function of aggregate size and ranged from 10 to 50x, except for very small mineral grains (gold and silver minerals) for which lens with 100x magnification and with immersion were used.

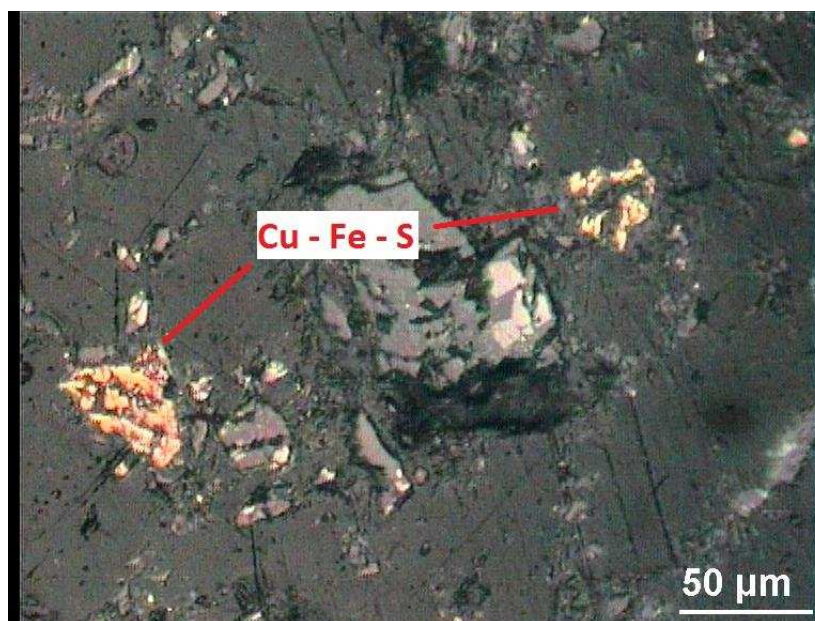
Results of microscopic analysis of smelter slag sample are shown in table Table 1.

Table 1. Mineralogical composition of smelter slag sample

Mineral	Content (%)
Solid solution of Cu-Fe-S	1,164
Chalcocite	0,116
Covelite	< 0,001
Pyrite	0,022
Troilite	1,349
Metal gold	< 0,001
Metal copper	0,115
Cuprite	0,138
Magnetite	8,925
Tailing minerals	88,170
Total:	100,000

As it can be seen, the content of sulfide minerals in entire sample is 2.75 %. The most common ore mineral in the sample is sulfide phase "*sulfide solid solution Cu-Fe-S*" (Figure 2), which does not occur in free grains. It is regularly incorporated in tailings material, usually in the form of spheres of various sizes and shapes. From its optical properties it can be concluded that it belongs to a high temperature mineral system Cu-Fe-S (Cu_5FeS_4 - Cu_2S , or Cu_9S_5).

Nonmetallic minerals (tailings) are presented in the glass with the advent of various eutectic dendrites such as: fayalite, etc.

**Figure 2.** Solid solution of Cu-Fe-S in fayalite matrix

Flotation tests

After an evaluation of the microscopic analysis of the smelter slags, flotation was chosen as a possible method for recovery of copper and other valuable metals. Flotation tests were carried out using smelter slag samples grounded to different fine portions of 50 %, 60 %, 70 %, 80 % and 90 % of grain size fraction $-74\ \mu\text{m}$, by using a laboratory flotation machine DENVER DR-12 with a 2.6 l stainless steel cell. For all flotation tests the conditions were as follows: 30% (in

weight) of solid in the pulp, impeller speed 1600 rpm, air flow 460 l=min, pulp pH: 12, conditioning time: 10 minutes and flotation time: 20 minutes.

Recovery rates of copper and share of liberated copper bearing particles in flotation feed are shown in Figure 3.

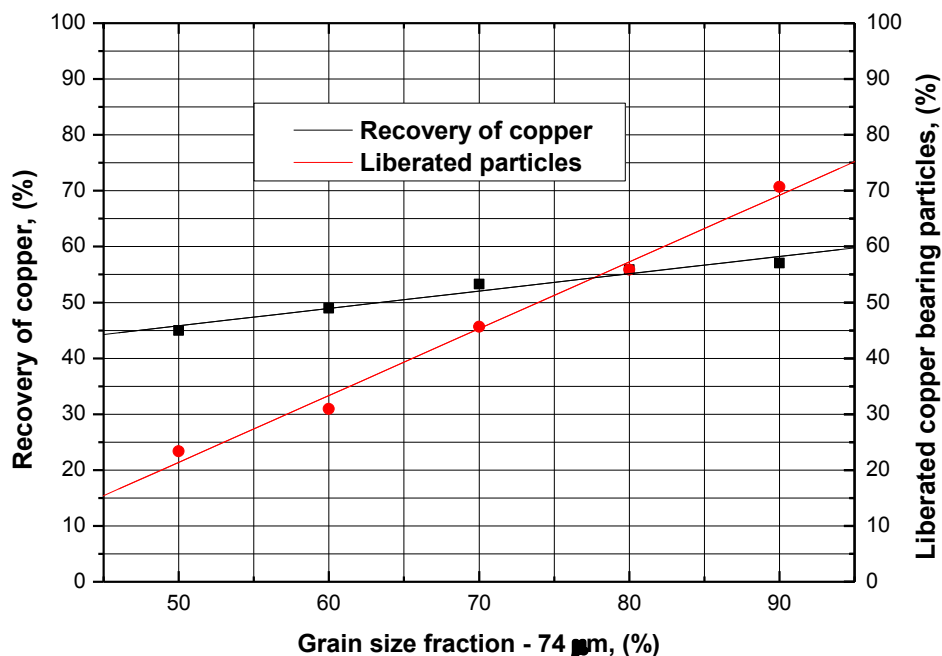


Figure 3. Recovery rates of copper and copper grades in concentrates

As it can be seen, the recovery rate of copper is dependent on grain size fraction -74 µm in flotation feed. The highest recovery rate of copper was obtained in a test with 90 % of grain size fraction -74 µm. This can be explained by the fact that with increasing portions of grinding increase the liberation of copper bearing particles, which also lead to increasing of recovery of copper.

CONCLUSIONS

The amount of slags produced and landfilled from a reverberatory furnace in Bor over decades is estimated as 16-18 million tons. Generally, the contents of copper, gold and silver in these slags are up to two times higher from contents of these metals in primary ores that are being exploited at present.

Mineralogical composition of these slag carried out in this work showed that the most dominant oxide minerals in these slag are fayalite and magnetite phases while the most dominant sulfide minerals is a solid solution of Cu-Fe-S.

Flotation was selected as a process for processing the slag with the aim of recovering copper. Flotation test showed that the recovery rate of copper depends on portion of fine grinding, because the higher the portion of fine grinding the higher the liberation rate of copper bearing particles.

ACKNOWLEDGEMENTS

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