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Editors:
Ljubiša Balanović
Dejan Tanikić

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PREFACE

On behalf of the Organizing Committee, it is a great honor and pleasure to welcome all esteemed participants of the **56th International October Conference on Mining and Metallurgy (IOC 2025)**, scheduled to take place at **Bor Lake, Serbia**, from **October 22nd to 25th, 2025**.

The collaborative efforts of the University of Belgrade – Technical Faculty in Bor and the Mining and Metallurgy Institute Bor have once again brought together academia, industry, and research institutions to organize this year's IOC. Our focus remains firmly set on presenting the latest research achievements and technological advancements in geology, mining, metallurgy, materials science, technology, environmental protection, and other engineering disciplines.

This year's conference program is rich and diverse, featuring **4 plenary lectures, 4 invited lectures, 158 full papers, and 6 abstracts**. The proceedings reflect the contributions of authors from **19 countries**: Austria, Bosnia and Herzegovina, Bulgaria, Canada, China, Croatia, Germany, Hungary, India, Mexico, Montenegro, Poland, Romania, Russia, Serbia, Slovakia, Slovenia, Turkey, and the United Kingdom. Among the submitted papers, eight young researchers under the age of 35 have qualified to participate in the "**MDPI Young Researcher Award**" competition, further emphasizing the conference's commitment to supporting and recognizing excellence among the new generation of scientists and engineers.

We are also delighted to host the **9th International Student Conference on Technical Sciences (ISC 2025)**, running in parallel with IOC 2025. The student conference brings together young researchers from Serbia and the wider region, with **one plenary** and **50 student papers** presented, offering an invaluable opportunity for the next generation of scientists and engineers to share their ideas and discuss the future of their disciplines with experts. The "**Professor Dragana Živković Best Student Paper Award**" will be presented to the most outstanding student contribution based on originality, research quality, and presentation.

The Organizing Committee expresses its deepest gratitude to all who have supported this event. Our General Sponsor is the Ministry of Science, Technological Development, and Innovation of the Republic of Serbia. We are especially grateful to our Platinum Donors, HBIS Serbia and Serbia Zijin Mining, as well as our Gold Sponsor, DPM Metals Inc., and our Gold Donors, Copper Mill Sevojno and Serbia Zijin Copper Bor. This year, the conference is also supported by the Silver Donor, "MC LABOR" d.o.o. Beograd.

We proudly host a diverse exhibition, featuring Indemak, Labtim SE d.o.o., MERIS d.o.o., Krug International LTD, Altium International d.o.o., Metalurg Foundry Ltd., Fugro Germany Land GmbH, Analysis d.o.o., Lola institut, Tescan and Mikrolux d.o.o., Trokuttest Serbia, Novos d.o.o., Changsha Rui Rui Technology Co., Ltd., and the Winery of Bukovo Monastery. The official opening of the conference has been supported by Epiroc Srbija a.d.. Finally, we warmly acknowledge our Friends of the Conference: Messer Tehnogas AD Belgrade, the China-Serbia Joint Laboratory on Green Steel Manufacturing, and the Foundation B.Sc. Eng. Boško Injac.

We sincerely thank all authors, committees, reviewers, speakers, and chairpersons for their invaluable contributions to shaping IOC 2025. We are confident that the conference will once again serve as a alive platform for scientific exchange, professional networking, and the promotion of sustainable development in mining, metallurgy, and related fields.

On behalf of the 56th IOC Organizing Committee,
Prof. dr Ljubiša Balanović

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Abstracts

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Original scientific paper

ON THE LEACHABILITY OF COPPER FROM COPPER-IRON MINERALS MIXTURE

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Abstract

Sulphuric acid leaching of the ore sample from the MCM (Mauritanian Copper Mine) was carried out. The achieved leaching degree was ≤ 38%. To improve copper leachability from the ore, TG (thermogravimetric), DSC (differential scanning calorimetry, and DTA (analyses differential thermal analysis) were conducted on the ore, and XRD (X-ray diffraction) analysis was performed on the leach residue. Thermal analysis has shown that goethite quickly transforms to hematite at ≈ 300 °C. The XRD pattern reveals the presence of four main minerals in the leach residue of the ore sample. Among them, the goethite peaks are the most intense. It seems as if the decomposition of goethite (thermally or chemically) could be a cornerstone in increasing the copper leaching degree. Both pathways were checked, and in both cases, a significant increase in the leaching degree was achieved.

Keywords: *Copper leaching; Thermal analysis; XRD pattern; Sulphation*

1. INTRODUCTION

There are cases in hydrometallurgical literature where some targeted metals cannot be leached from ore to a satisfactory extent, because they are strongly bound to other minerals [1-4]. To increase the leachability, such an ore must be pretreated by introducing either mechanical (additional milling), thermal (calcination), or chemical energy (sulphation) into the ore before leaching.

So happened with the ore, which is the subject of this study. Chemical analysis of the ore, considered in this study, revealed 1.3% Cu, 10% SiO_2, smaller amounts of Mg and Ca (<2%) and a very high concentration of iron minerals (Fe >50%) [1]. The most common among them is goethite. The other heavy metals are present in ppm concentration. Besides, the ore contains 1.3 g/t of Au, as well. Mineralogical analysis of the ore [2] revealed copper oxides and carbonates (sulphides in traces), and those were mostly bound to goethite. In the preliminary experiments, the ore sample was conventionally leached with sulfuric acid solutions. By them, a very modest copper leaching degree of 38 % was achieved. Almost two-thirds of the total copper content remains untouched in the leach residue.

Decomposition of goethite could be a cornerstone in increasing the copper leaching degree. Two pathways can be applied to the leach residue, produced in the classical acid leaching, to recover the remaining copper captured in it:

- thermal degradation of the present goethite, or

- chemical decomposition of the leach residue with H_2SO_4 to convert the locked copper minerals into corresponding sulphates, followed by washing them out with water [3, 4]. Aiming to get a better copper leachability from the ore, TG, DSC and DTA analyses are carried out on the ore sample, as well as XRD analysis of the leach residue.

2. EXPERIMENTAL

The sample of ore was leached with 0.5M H_2SO_4 solution for half an hour, filtered; the solid residue rinsed with distilled water, dried and stored in a desiccator (the residue in the further text), to serve for further investigations, which consisted of thermal degradation of degradable minerals (goethite) and chemical decomposition – sulphation of some minerals from the residue. For that purpose, the dried residue was divided into two parts. The one for thermal degradation and the other for XRD analysis.

A small amount of the leached residue (6 mg) was taken for thermal analysis. The analysis was performed using a DSC-TGA SDT Q600 device (Oxford Instruments). Nitrogen was used as the purging gas, and the flow rate was controlled at 100 mL min^{-1}. The weight of the leached residue (≈ 6 mg) was heated at a heating rate of 10 °C/min in the temperature range of 20 to 500 °C.

XRD analysis was performed on both the residue and the sulphated sample after rinsing and drying, using the Rigaku Mini Flex 600. Other used equipment is common laboratory equipment.

The sulphated sample was prepared by mixing the residue (20 g) with H_2SO_4 (25mL). The obtained paste was heated at 90 °C for 30 minutes and rinsed with warm water for 1 h. In this way, the achieved total copper leaching degree is 98 - 99%.

3. RESULTS

3.1 Thermal analysis

It was assumed that a significant increase in the leaching degree can be obtained by extracting the copper intercalated in the goethite. To confirm this hypothesis, a TG-DTA analysis was performed to get an insight into how goethite will behave under heating. The DTA curve recorded under the above conditions is presented in Figure 1.

According to the TG-DTA analysis, heating the sample, a total weight loss of 5.94 % is detected. One endothermic peak at 299.26 °C appeared during the heating process. This peak corresponds to the goethite dehydration, followed by the formation of hematite according to the equation [5]:

$2FeOOH \rightarrow Fe_2O_3 + H_2O$

The process occurs quickly and is completed within 4.5 to 5 minutes. Based on the DSC analysis, it was found that the heat energy of 11.27 J/g, spent at 299.67 °C. According on the literature data [5], the authors assumed that the obtained heat energy could be attributed to the phase transition from goethite to hematite [5].

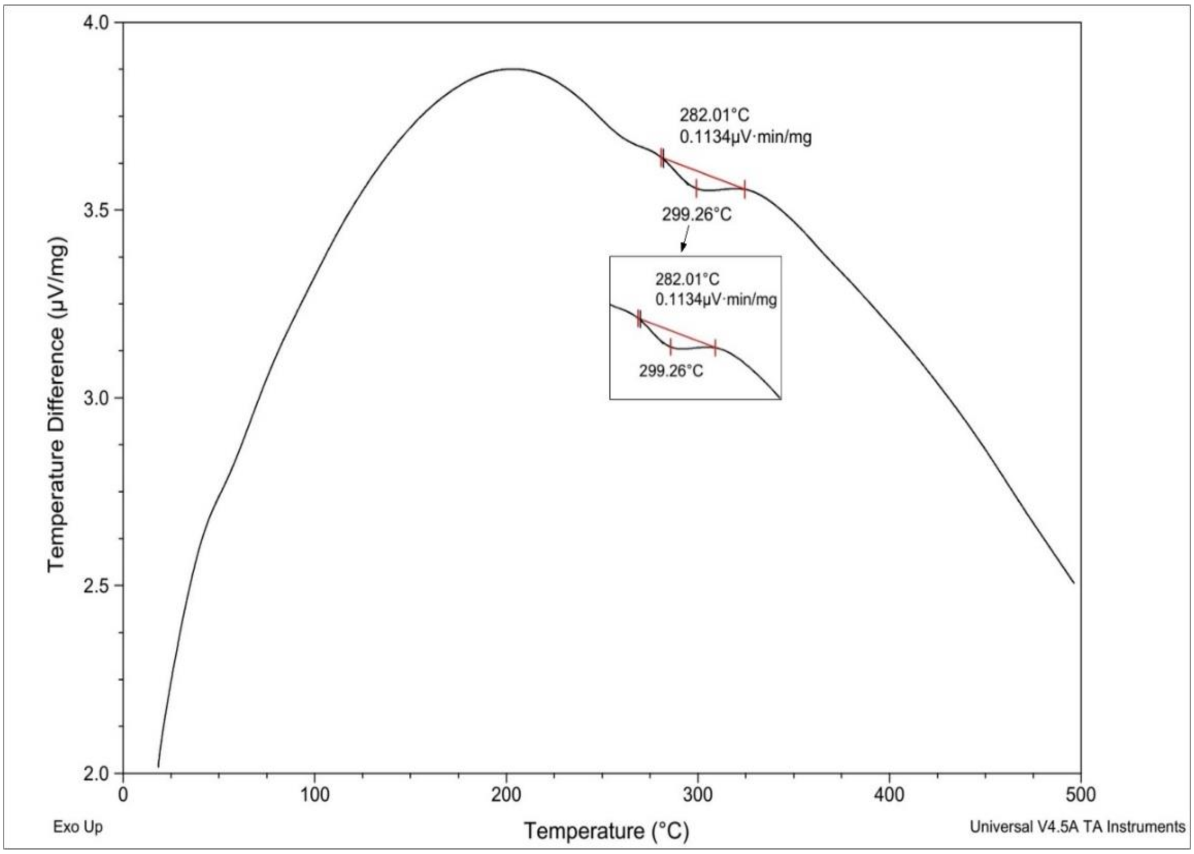

Figure 1. DTA curve of the residue

Thermal analysis defined the conditions for the phase transformation of goethite to hematite (>300 °C). Calcination of the residue at temperatures >300 °C converts goethite to hematite, allowing the leaching agent to reach copper minerals trapped within the iron ones, to leach them out. That would result in an overall increase in the degree of copper leaching. To confirm this, a portion of the residue was calcined at 400 °C for 30 minutes. After cooling the calcined residue, it was leached under the same conditions as before. The overall achieved leaching degree was 67%.

3.2 XRD analysis

XRD analysis (Figure 2) of the leach residue revealed strong peaks for goethite and hematite, as well as quartz and clinochlore, and less abundant amphibole and spinel on the diffractogram. A notable change in the diffractogram was observed after treating the leach residue with sulphuric acid at an elevated temperature of 90°C, followed by washing it with water. Due to the sulphation reactions, the intensity of the goethite peaks became slightly smaller, while those of clinochlore decreased significantly. Peaks of hematite became more intense.

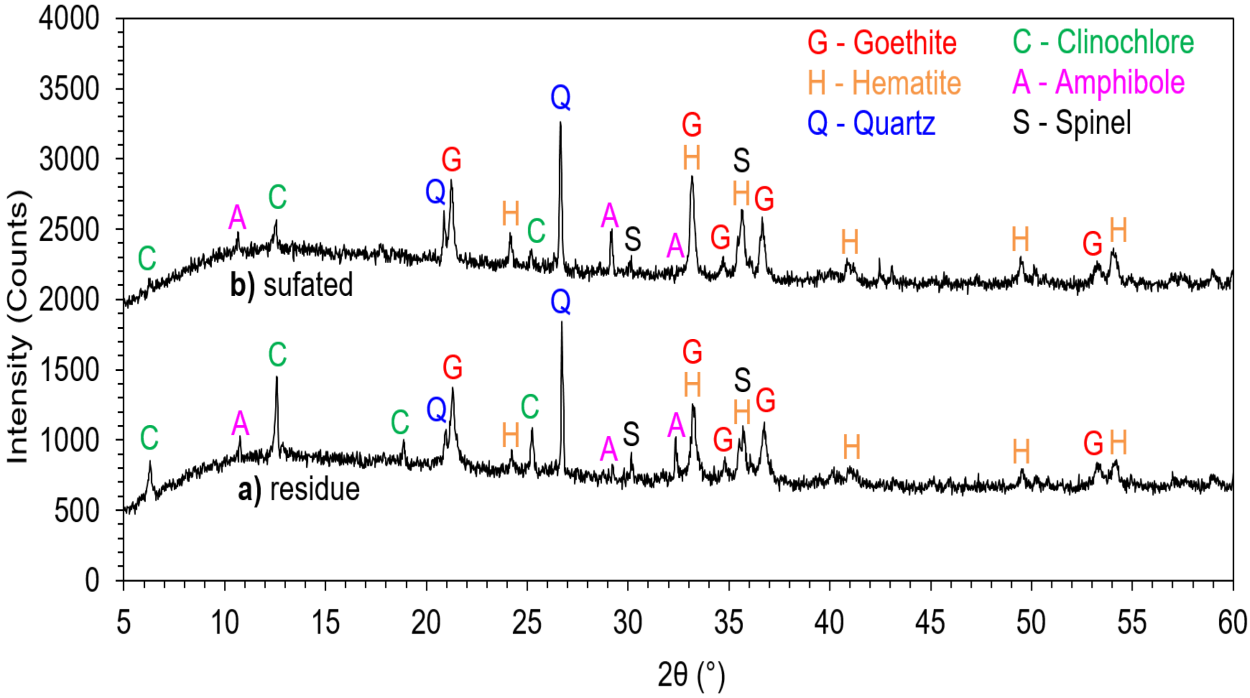

Figure 2. XRD pattern of the residue (a) and after sulphation, rinsing and drying (b)

4. CONCLUSION

It is possible to achieve a high percentage of copper leaching by pretreating the residue from the first stage of leaching, either through thermal or chemical destruction of goethite, which is a major carrier of the locked-in copper.

Chemical decomposition of the leach residue by sulphation seems to be more efficient in terms of the achieved leaching degree than the thermal destruction of goethite.

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