Preliminary study on collectorless flotation of chalcocite, bornite and copper-bearing shale in the presence of selected frothers

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Abstract. Flotation of carbonaceous copper-bearing shale and copper sulfide minerals such as chalcocite and bornite in the presence of only frother was investigated. It was determined that all investigated solids did not float in pure water in the absence of flotation reagents. However, an addition of a frother rendered both shale and bornite floatable, while the recovery of chalcocite was negligible. These findings suggest that removal of carbonaceous matter from the ore by the so-called pre-flotation process can be a suitable procedure to reduce the amount of organic carbon in the concentrates provided that the feed does not contain bornite. Otherwise, simple pre-flotation must be replaced with a more sophisticated process in which flotation of bornite is suppressed.

1. Introduction

Many sedimentary type ores contain organic carbon in the form of kerogen, bitumen and graphite [1-4]. Also the Kupferschiefer sedimentary ore located in SW Poland contains organic carbon [5-7]. The presence of organic carbon in the ore creates difficulties during its processing by flotation as well as during flash smelting of copper concentrates [8]. Industrial trials conducted to remove organic carbon from the Kupferschiefer sedimentary ore were proved to be successful [9]. However, too much useful sulfide minerals floated together with carbonaceous shale in the so-called pre-flotation process, in which the ore is subjected to flotation in the presence of only frother (collectorless flotation) [10]. Such flotation is possible because shale, being a part of the ore and containing organic carbon, is naturally hydrophobic [11]. However, sulfide minerals can also be hydrophobic [12]. Therefore, it becomes essential to determine flotation properties of mineral components of the Kupferschiefer ore. For this purpose, laboratory flotation tests were performed in a monobubble Hallimond tube to determine flotation properties of selected components of the Kupferschiefer sedimentary ore, that is copper-bearing shale, chalcocite and bornite.

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2. Experimental

2.1. Materials

Natural carbonaceous copper-bearing shale, chalcocite and bornite, all originated from the copper ore, called the Kupferschiefer sedimentary ore, mined by KGHM Polska Miedz S.A. located in Poland, were investigated. The identity and purity of the solids were checked by XRD and XRF analyses. The solids exhibited natural hydrophobicity with the contact angle greater than zero [11,13]. Distilled water, without pH regulation, was used in all experiments. Poly(ethylene glycol) alkyl ether ($C_nH_{2n+1}O(C_2H_4O)_mH$, $C_{16}E_{20}$) and methylisobutylcarbinol (MIBC) were used as the frothers. The reagents were obtained from Sigma-Aldrich (≥98% pure) and were used without further purification.

2.2. Procedures

Flotation tests were performed in a monobubble Hallimond tube with an increased length of the compartment containing the feed (Fig. 1). The purpose of using such a tall tube was to reduce the mechanical entrainment of particles during flotation. The volume of the Hallimond tube was 200 cm^3. The receiver of the Hallimond tube was calibrated to be able to determine the volumetric recovery of the floating particles. A solid sample of 3 grams and distilled water were mixed together and agitated for two minutes in a beaker, and next transferred to the Hallimond tube. In each flotation tests the air flow rate was $6.25 \cdot 10^{-7}$ m^3/s.

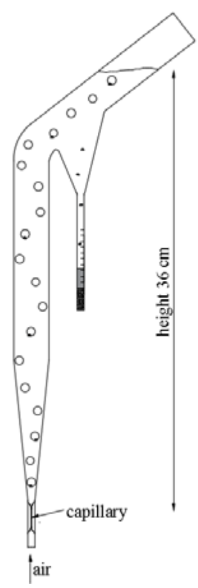

Figure 1. Monobubble Hallimond tube used in all experiments.

3. Results and discussion

The results of flotation of natural carbonaceous copper-bearing shale, chalcocite and bornite in pure water and in the presence of aqueous solution of frothers at different concentrations are shown in Figs. 2-4, respectively.

 DOI: 10.1051/e3sconf/20160801031

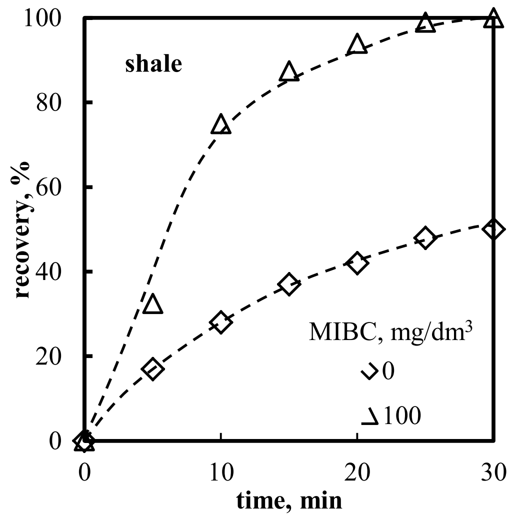

Figure. 2. Flotation kinetics of shale (0.075-0.040 mm) in water and the presence of MIBC.

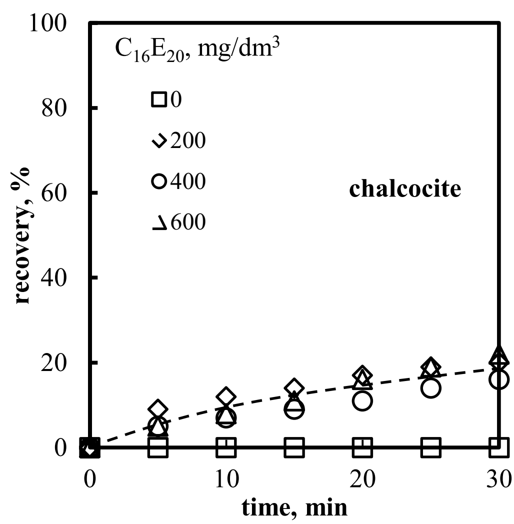

Figure. 3. Flotation kinetics of chalcocite (0.075-0.025 mm) in water and the presence of $C_{16}E_{20}$.

The data presented in Figs. 2-4 clearly show that there is no flotation of shale, chalcocite and bornite in pure water. Some particles recovery, after a long time of flotation, points to their entrainment, which still is accompanying the flotation process even though the Hallimond tube was modified to avoid excessive mechanical flotation. Figure 5 confirms that the recovery of particles after 30 minutes of flotation is partially due to entrainment and partially due to true flotation. The recovery in pure water is dependent of the density of the material subjected to flotation (Fig. 5).

The presence of frother in the flotation system renders shale and bornite floatable, while chalcocite is still non-floatable (Figs. 2-4). It indicates that separation of bornite from shale, when present together in a feed, is not possible, while separation of shale and chalcocite is feasible.

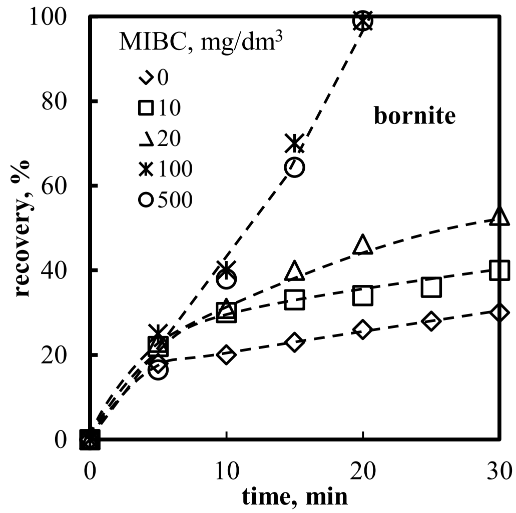

Figure 4. Flotation kinetics of bornite (0.100-0.040 mm) in water and the presence of MIBC.

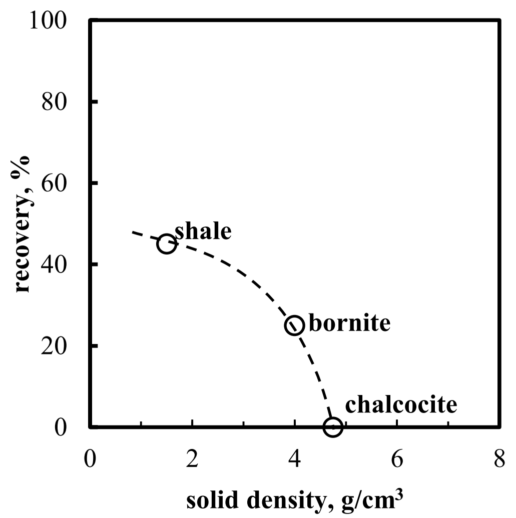

Figure 5. Influence of density of shale, bornite and chalcocite in pure water on entrainment in the investigated Hallimond tube. Flotation time 30 min. Density (in g/cm^3) of shale was 2.4-2.7 (in water about 1.5) [14], bornite 4.9-5.3 (in water about 4.0) and chalcocite 5.5-5.8 (in water about 4.6) [15].

4. Conclusions

Flotation data involving carbonaceous copper-bearing shale, bornite and chalcocite indicate that separation of shale from chalcocite by pre-flotation performed in the presence of only frother is possible, while separation of shale from bornite would require additional, more sophisticated operations in which flotation of bornite is suppressed. These findings can be useful in choosing the most appropriate procedure of processing of the Kupferschiefer sedimentary ore located in Poland, which is rich in organic carbon making its processing difficult.

Acknowledgements

This work was partially financed by the Polish Statutory Research Grant 0401/0186/16.

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