OPTIMISATION OF THE SELECTIVE FLOTATION OF GALENA AND SPHALERITE AT ROSH PINAH MINE

By

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This thesis is dedicated to my lovely wife Blandine

and

to my dearest daughter Rachel

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Summary

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A study was carried out to improve the flotation selectivity between galena and sphalerite during the flotation of a Cu-Pb-Zn sulphide composite ore from the Rosh Pinah Mine (Namibia). Xanthate collectors were found to be unselective for the flotation of the Rosh Pinah composite sample. It was observed that the recovery of sphalerite increased with both the recovery of galena and the concentrate mass pull. In addition, the recovery of sphalerite increased after activation with Cu(II) ions while that of galena decreased when the composite was dry ground in a mild steel mill with mild steel grinding media. However, the recovery of galena was not affected after wet milling in a stainless steel mill. The recovery of Cu(II)-activated sphalerite was independent of the milling environment (wet or dry) and grinding media.

The activation of sphalerite by cuprous cyanide complexes, which are present in the recycled water, was clearly shown in this study. Both batch flotation tests and XPS analysis have confirmed that sphalerite was activated by copper(I) from the cuprous cyanide complexes. The recovery of copper(I)-activated sphalerite increased further when the composite was dry milled as compared to wet milling.

Batch flotation tests have shown that the use of cyanide alone is not efficient for the depression of sphalerite due to the mineralogical texture of the Rosh Pinah ore. A large quantity of galena locked and/or attached to sphalerite was observed in the lead concentrate. Their prevalence increased with increasing particle size. The use of both cyanide and zinc sulphate improved the depression of sphalerite much better than

cyanide alone. A flowsheet has been proposed to improve selectivity between galena and sphalerite in the lead flotation circuit. It includes the regrinding of the lead rougher concentrate prior to the cleaning stage due to poor liberation between galena and sphalerite.

Keywords: Froth flotation, Sulphide ores, Flotation activators, Flotation depressants, Grinding, Mineralogy

Overview

This thesis focuses on the flotation selectivity between sphalerite and galena during the selective flotation of the Cu-Pb-Zn sulphide ore from the Rosh Pinah Mine (Namibia). The objectives of this study are outlined in Chapter 1. The main objective is to optimize the reagent suite in the lead flotation circuit, thus improving the flotation selectivity between galena and sphalerite. The optimization of the reagent suite is based on the mechanism of sphalerite activation by dissolved heavy metal ions.

Chapter 2 deals with an overview on the flotation of sulphide minerals with thiol collectors and the activation of sphalerite by heavy metal ions such as copper and lead. The different mechanisms of activation of sphalerite by copper and lead ions are discussed. The mineralogy of the Rosh Pinah ore is also presented in order to understand the parameters that may be involved during the selective flotation of the ore.

Since dissolved copper and lead ions are usually present in the process water used at the plant, the effect of water quality on the flotation response of the Rosh Pinah ore is discussed in Chapter 3. The effect of cuprous cyanide on the activation of sphalerite is also discussed. Based on the chemistry of cuprous cyanide complexes, it is assumed that these cyano complexes can promote the activation of sphalerite in the absence of free cyanide.

The experimental procedures are outlined in Chapter 4. The milling procedure and flotation conditions are presented in this chapter. Surface analysis equipment and methods used are also discussed.

The scoping results on the effect of collector dosage and Cu(II) and Pb(II) ions on the flotation recoveries of galena and sphalerite are discussed in Chapter 5. The flotation results indicate that high dosages of xanthate collector of long chain length such as PNBX are detrimental to the flotation selectivity between galena and sphalerite. As expected, Cu(II) is a much stronger activator for sphalerite than Pb(II) ions. It is also

observed that the activation of sphalerite by Pb(II) is affected by the type of milling and thus by the pulp potential. However, the activation of sphalerite by Cu(II) and its subsequent flotation is not affected by the type of milling.

Chapter 6 focuses on the effect of dry and wet milling on the pulp chemistry and flotation response of the Rosh Pinah ore. In addition, the effect of cuprous ions on the flotation of sphalerite and galena is also studied. The measurements of the pulp chemistry show that higher dissolved oxygen and more positive pulp potential are observed when the ore is ground in a dry environment. More negative pulp potential and low dissolved oxygen are observed after wet milling of the ore. It is interesting to observe that both the recovery and grade of sphalerite are higher when the ore is ground in a dry environment compared to the flotation results achieved after wet milling. Since the recovery of galena is enhanced after wet milling while the recovery of sphalerite is lower, it is clear that the pulp chemistry achieved under wet milling conditions is suitable for better selectivity between galena and sphalerite in the lead circuit.

The grade and recovery of pyrite in the lead concentrate are higher after wet milling when compared to dry milling. Thus, it becomes clear that after wet milling the grade of zinc and lead are diluted by the presence of pyrite in the lead concentrate.

The effect of cuprous-cyanide complexes on the activation of sphalerite is also studied in Chapter 6. These cyanide complexes are usually found in the recycled water used at the plant, where cyanide is added to depress sphalerite in the lead flotation circuit. Batch Flotation and XPS results show that copper cyanide complexes present in the recycled water do activate sphalerite, especially when the pulp potential is more positive. This results in more sphalerite being recovered in the lead flotation circuit.

Surface analysis of natural sphalerite samples is investigated by X-ray photoelectron spectroscopy (XPS). XPS results show the presence of copper species on the surface of the activated sphalerite. In addition, the copper species can be removed from the surface of sphalerite by treatment with sodium cyanide.

In Chapter 7, the flotation selectivity between galena and sphalerite is studied in the presence of inorganic depressants such as sodium cyanide and zinc sulphate. The results show that sphalerite can be depressed efficiently with the use of both cyanide and zinc sulphate. However, better selectivity can be achieved with the use of 100g/t NaCN in the lead rougher circuit. Mineralogical analysis of the concentrate and tailings samples is carried out for the understanding of the deportment of sphalerite in the lead concentrate. It is shown that the presence of middlings contributes to the deportment of sphalerite in the galena concentrate due to the intergrowth and association of galena and sphalerite in the concentrate.

Chapter 8 presents the conclusions and recommendations based on the results presented in this study and those reported by investigators from Kumba Resources.

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