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The response of sulphide and gangue minerals in selected Merensky ores to increased depressant dosages

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Abstract

Depressants are added to flotation circuits to reduce naturally floatable gangue (NFG) present in ores, but under certain conditions have been shown to affect sulphide mineral recovery, particularly guar reducing the recovery of pyrrhotite. Copper sulphate is added to increase sulphide mineral recovery, but may also activate gangue particularly in the presence of dithiophosphate. This has also been shown to vary with ore type. Previous work has shown the usefulness of analysing reagents holistically, decoupling pulp and froth effects and assessing material recovered by true flotation and that recovered by entrainment separately. This work assesses the effect of copper activation on different ores and the ability of two classes of depressants, guar gum (guar) and carboxymethylcellulose (CMC) to reduce this effect and shows that by a depressant dosage of 300 g/t almost all the NFG had been removed from the concentrate. It also evaluates the effect of depressants on the sulphide minerals and shows that pyrrhotite was most affected.

Keywords: Sulphide ores; Flotation depressants; Flotation collectors; Flotation activators

1. Introduction

In all operations that recover platinum group elements (PGE) from the Merensky Reef in the Bushveld Complex, South Africa a polysaccharide depressant is invariably used to control the naturally floatable gangue (mainly talcaceous) minerals present in the ore, and to allow sufficient upgrading of the valuable minerals. A range of reagent suites is used by the various operations to optimise PGE recoveries. These suites are used in conjunction with either modified guar gum (guar) or carboxymethylcellulose (CMC) as the depressant. A range of depressant dosages are used, with very high depressant dosages being used in some cleaner/recleaner sections. These two reagents appear to be almost interchangeable in their efficacy although their basic structure and effect on froth stability is markedly different. The nature of the CMC is such that it has a highly negative charge density which, even in the presence of the high ionic strength waters that are found in the various concentrators can lead to adsorption creating strongly dispersed pulps at high concentrations whereas the guars available have very low charge densities and would never lead to dispersed pulp conditions at high dosages (Harris et al., in press a,b). One of the major influences the depressant has on the flotation system is its effect on the stability of the froth. Consequently any study of depressant performance has to take into account the changes observed in froth stability, particularly at higher depressant dosages (Harris et al., in press a,b).

Previous work at the Depressant Research Facility at UCT has shown that the use of an activator (in the presence of DTP) can lead to some activation of gangue at the constant depressant dosage of 100 g/t (Wiese et al., 2005). This study also investigates whether higher dosages of depressant can counteract this activation. Previous work also examined the effect of varying the type of collector, point of collector addition and the use of an activator on

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the recovery of sulphide minerals from two ores from different parts of the Merensky reef (Wiese et al., 2005a, 2006). However, in order to allow these variables to be assessed more accurately the depressant dosage has always been maintained at a fixed concentration of 100 g/t. It is extremely important when using such depressants that the effect of these reagents on the valuable minerals should be kept to a minimum. It is possible that if the adsorption of the collector on the sulphide minerals is weak or incomplete there may be the possibility that these strongly hydrophilic reagents could co-adsorb on the mineral surface, and, because of the large size of these polysaccharide molecules (molecular weights from 150,000 to 500,000 compared to the 200–300 molecular weight of the collector) could interfere with particle bubble attachment, and reduce the subsequent recovery of the sulphide minerals. Since the adsorption of these types of reagents is assumed to occur via physical bonding forces and is hence dependent on the concentration of the polymer in solution, high dosages may be detrimental to the recovery of the valuable minerals. In addition, as these polymers are likely to adsorb on any hydrophilic surface via hydrogen bonding forces, sulphide minerals which are not fully liberated may also be susceptible to depression.

Orthopyroxene is a major silicate mineral in Merensky ore. Whereas this develops floatable properties by reaction with the flotation system, other geological processes can produce naturally floatable gangue (NFG). Serpentinisation is an alteration process that converts the olivine, over time, to serpentine under pressure, at an elevated temperature in the presence of water. Serpentinisation can also be accompanied by other alteration processes such as the conversion of pyroxene to talc. In such cases, the talc is often found in veins or fissures in the orebody. The ores used in this study are from the southern limb of the Bushveld Complex where serpentinisation is minor, however, alteration areas do exist in some of these deeper mining areas (Kinloch, 1982; Peyerl, 1983).

Orthopyroxene constitutes approximately 50–60% of the bulk modal assembly of unserpentinised ores. In this study ore A contains approximately 48% pyroxene whereas for ore B the figure is in the region of 63%. Previous work by Wiese et al. (2005b) illustrated the inadvertent activation by copper sulphate ($CuSO_4 \cdot 5H_2O$) together with dithiophosphate of NFG present in these ores. Becker et al. (2006) used Qem*SCAN to analyse liberation of Merensky ores sampled from the same areas and noted that partial rims or coatings of talc are present around pyroxene particles which would cause the pyroxene to be floatable.

The batch flotation technique developed at UCT allows for the separation of gangue that is actually floating from gangue that is entrained. This can be used to study the effect of increasing the dosage of the depressant on the amount of naturally floating gangue reporting to the concentrate at the same time as monitoring the response of the sulphide minerals from different parts of the Merensky Reef to higher depressant dosages.

Two Merensky ores from different operations were selected for examination using a CMC and guar depressant at varying dosages (100, 200 and 300 g/t). A constant collector combination of xanthate and dithiophosphate (DTP), both with and without copper activation was used in all tests.

2. Experimental details

Two ore samples, weighing approximately 200 kg each, were obtained from different parts of the southern section of the Merensky Reef in the Bushveld Complex (Wiese et al., 2005a,b). The bulk samples were crushed to 100% passing 3 mm. They were then blended, riffled and split using a rotary sample splitter into 1 kg portions (Allen, 1990).

All batch flotation tests were conducted using synthetic plant water containing 80 ppm calcium, 70 ppm magnesium and total dissolved solids of 1023 ppm (Wiese et al., 2005a,b).

The 1 kg portions of the ore sample were milled at 66% solids in synthetic plant water to achieve a grind of 60% passing 75 μm using a laboratory scale stainless steel rod mill. The grind of 60% passing 75 μm was chosen as it matches the first rougher grind used by the operations processing this type of ore. The milled slurry was transferred to a modified 3 L Leeds flotation cell. The volume in the cell was made up to produce 35% solids using synthetic plant water. The flotation cell was fitted with a variable speed drive and the pulp level was controlled manually by the addition of synthetic plant water. The impeller speed was set at 1200 rpm.

The frother used for all the batch flotation tests was DOW 200 at a fixed dosage of 40 g/t. The primary collector was sodium isobutyl xanthate (SIBX), which was used in conjunction with a secondary DTP collector, Senkol 5 (a mixture of butyl and other dithiophosphates). The collectors were added to the mill prior to grinding for all tests at a combined dosage of 75 g/t (50% SIBX, 50% Senkol 5). The polymeric depressants used in the batch flotation tests were Depramin 267, a carboxymethylcellulose (CMC) and Stypres 504, a modified guar gum. The depressants were both added at dosages of 100, 200 and 300 g/t, the active content was not taken into account. Copper sulphate ($CuSO_4 \cdot 5H_2O$) at a dosage of 40 g/t was added as the activator in tests where activation was employed. Due to the fact that the collectors were added to the mill, the activator was added after the collectors. The authors have shown the significant effects that the point of collector and activator addition have on flotation performance (Wiese et al., 2005a,b, 2006).

The collectors SIBX and Senkol 5 were supplied by Senmin. The CMC depressant, Depramin 267, was supplied by Akzo Nobel Functional Chemicals and the modified guar depressant, Stypres 504, by Chemquest. The frother, DOW 200, was supplied by Betachem. All the chemical salts used in making up the synthetic plant water, as well