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The role of synthetic minerals in determining the relative flotation behaviour of Platreef PGE tellurides and arsenides

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ABSTRACT

The resolve to apply synthetic PGMs for flotation studies in this investigation was necessitated by the need to address the hypothesis that Pt tellurides and arsenide from the Platreef exhibit significantly different flotation behaviour. Isolating naturally occurring PGMs from an ore for this purpose would be impossible due to their rarity and microscopic sizes. Obtaining such PGMs from flotation concentrates which would be a lot easier was not favoured as the PGMs were required with their natural surface chemistry unaltered by flotation reagents. This study shows that synthetic PGMs can be used to simulate the flotation response trends of their natural equivalents. The synthetic PGMs were used to confirm that Pt tellurides produce better flotation response compared to Pt arsenide.

1. Introduction

The world's exploitable platinum group elements (PGEs) resources are virtually all associated with layered intrusions such as the Bushveld Complex in South Africa (Viljoen and Schürmann, 1998). Anglo Platinum, the largest platinum producer in the world, mines all of its Platinum group minerals (PGM) ores from the Bushveld Complex, an igneous formation spanning 250 km × 450 km revealed as outcrops in the North Western, Limpopo and Mpumalanga provinces of South Africa. The Bushveld Complex, Fig. 1, is subdivided into three sections namely, the Western Limb, Eastern Limb and Northern Limb all in which Anglo Platinum has mining interests.

PGM mineralisation of economical value occurs in three reef types hosted in the Bushveld Complex and these are namely, the Platreef, Merensky and UG2. The mineralogical characteristics of these three reef types are summarized in Table 1.

The reef type of interest in this study, the Platreef situated in the Northern Limb, contains disseminated mineralisation and, commonly, some fairly large blebs of composite base metal sulphides (BMS) (Viljoen and Schürmann, 1998). The Platreef has largely been described as the local equivalent of the Merensky reef (Cabri, 2002). The most common base metal sulphides of the Platreef, in order of decreasing abundance are pyrrhotite, pentlandite and chalcopyrite. The distribution of PGMs in the Platreef tends to be erratic. Constituting about 30% of the PGMs and by far the most important class are the Pt/Pd tellurides. Other PGM types occurring in considerably large abundance include arsenides (21%) and alloys (26%). The PGE sulphide content appears to be highly variable, Viljoen and Schürmann (1998) report as high as 19% whereas Armitage et al. (2002) point to the absence of PGE sulphides as a characteristic feature distinguishing the Platreef from other Bushveld PGE reefs. PGM assemblages of the Platreef in the Sandsloot area, the source of the samples used in this study, in a variety of lithologies reveal a complex multi-stage mineralisation history. During crystallisation of the Platreef pyroxenites, PGMs and BMS were distributed throughout the interstitial liquid forming a telluride-dominant assemblage devoid of PGE sulphides (Holwell et al., 2006). The tellurides and arsenides are predominantly enclosed in silicate gangue, although generally in close proximity to the principal BMS. A total of 69% by volume of platinoid minerals are associated with silicate gangue and 31% by volume with BMS (Kinloch, 1982).

The production of final platinum group metals from the mined ores involves various processes and these include valuable minerals concentrating, smelting and refining. This study particularly focuses on valuable mineral concentrating in which the predominant unit process employed is froth flotation. This process for which the main objective is to economically maximise valuable mineral recovery and grades to the concentrate exploits differences in the hydrophobicity of minerals in pulp to achieve selective mineral separation. Concentrators are typically challenged to maximise on achieving this objective. Flotation research has in the past focused on sulphide minerals and BMS in particular (O'Connor, 2005) however, in recent times there has been increased interest in the recovery of PGMs. Maximising technical understanding of the behaviour of the various PGMs in froth flotation, a production

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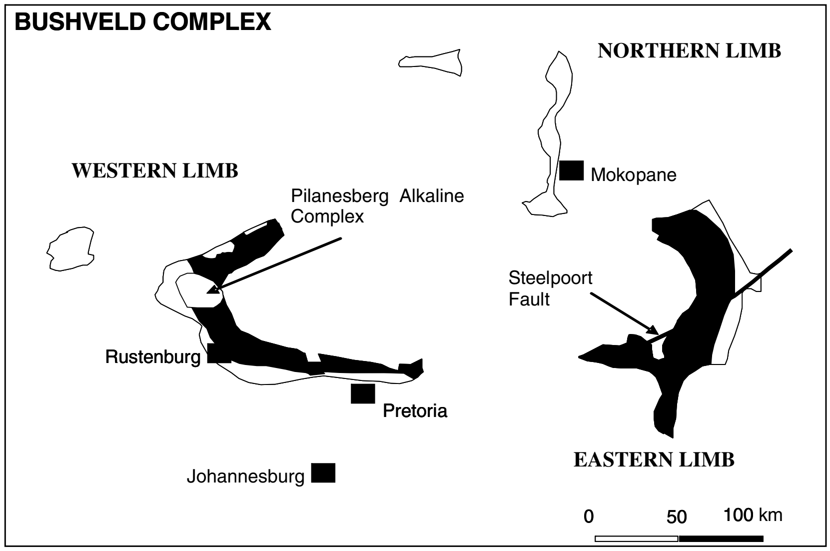

Fig. 1. A map showing the Bushveld Complex outcrops (modified after Vermaak et al., 2004).

Table 1
A summary of the bulk mineralogy and PGMs distribution of the Platreef, Merensky and UG2

	Platreef	Merensky	UG2
Bulk mineralogy	Pyroxene Serpentine Calc silicates Base metal sulphides	Pyroxene Feldspar Base metal sulphides	Chromite Pyroxene Feldspar Base metal sulphides
PGM distribution	Tellurides ~ 30% Arsenides ~ 21% Alloys ~ 26% Sulphides ~ 3% Rest ~ 20%	Tellurides ~ 30% Arsenides ~ 7% Alloys ~ 7% Sulphides ~ 36% Rest ~ 20%	Tellurides < 5% Arsenides < 5% Alloys ~ 20% Sulphides ~ 70% Rest < 5%

stage which can result in substantial gains or losses is thus imprative.

Platreef ores are treated at Mogalakwena Division (formerly PPL concentrator) set up in Mokopane in the Limpopo province. As Mogalakwena Division accounts for about 8% of Anglo Platinum's platinum production, subsequently making it a substantial source of the company's revenue, it is imperative that efforts are made to maximise PGM recoveries.

It has been hypothesised that Pt tellurides exhibit significantly different flotation behaviour compared to Pt arsenides. This was mainly based on a general observation of higher distribution of the tellurides in the Mogalakwena Division flotation tailings. Improving the recoveries of any these two PGM species which collectively constitute in excess of 50% of the Platreef PGMs is cardinal and dependent on furthering knowledge of their flotation characteristics. It was therefore the objective of this study to explore the said hypothesis and by so doing make a contribution to the understanding of the flotation characteristics of these PGMs.

2. Experimental

Carrying out this objective included comparing the flotation responses of these minerals as they occur in a natural ore as well as in synthesised ores. The use of synthetic ores in this case was necessitated by the need to carry out some of the experiments on samples in which the contained PGM types and their content could be carefully controlled. Using naturally occurring PGMs for this purpose is impractical due to the tremendous difficulty in isolating sufficient quantities of such minerals in their natural state from PGM ores. Obtaining such PGMs from flotation concentrates which would be a lot easier was not favoured as the PGMs were required with their natural surface chemistry unaltered by flotation reagents.

2.1. Ores

Flotation tests were carried out on the following ores:

– Natural Platreef (Sandsloot North Pit).
– A series of synthetic ores made by spiking the natural Platreef ore with incremental amounts of a fixed blend of synthetic PGMs (sperrylite, moncheite and merenskyite).
– Feldspathic pyroxenite separately spiked with sperrylite and moncheite to produce similar Pt head grades.

2.2. Synthetic PGMs

The synthetic minerals, sperrylite ($PtAs_2$), moncheite ($(PtPd(BiTe))_2$) and merenskyite ($(PdPt(BiTe))_2$) were synthesised and provided by Shackleton et al. (2007a,b). Up to 10 g of each synthetic mineral type was availed for the tests. They were precrushed to -38 μm and stored under argon to minimize surface oxidation. Synthetic ores were made by spiking measured combinations of the synthetic PGMs to a naturally occurring ore during the conditioning stage of flotation ahead of reagents addition.