

# Electrochemical and Raman spectroscopic studies of the interaction of ethyl xanthate with Pd–Bi–Te

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## Abstract

Previous mineralogical investigations (QemSCAN) performed on all effluent flotation streams of Mimosa mine indicated the presence of appreciable amounts of platinum group minerals (PGMs), which are not recovered. Most of the liberated PGMs in these streams belonged to the Pt–Pd–Bi–Te class, generally in excess of 70%, in all the samples investigated. In this work, electrochemical investigations and Raman spectroscopy have been employed to investigate the interaction of ethyl xanthate with Pd–Bi–Te. Raman spectroscopy has confirmed the co-presence of xanthate with dixanthogen indicating that xanthate retains its molecular integrity when it adsorbs on the surface of the Pd–Bi–Te. The result of this investigation has shown dixanthogen to be present on the mineral when its surface is anodically polarized. This suggests that the poor flotation recovery of the Pd–Bi–Te minerals from flotation feeds cannot be attributed to a lack of interaction of the collector with the surface.

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## 1. Introduction

Research on platinum flotation in the past was mainly focused on the flotation of base metal sulphides because of the association of the PGMs with these minerals. However, the assumption that all PGMs remain associated with the base metal sulphides was challenged by the findings of Penberthy et al. (2000) who conducted a comprehensive study on the recovery of platinum-group elements from UG-2 chromite from the Bushveld Igneous Complex. The platinum-group mineral assemblage of the UG-2 chromite consists mainly of PGE-sulphides (predominantly, cooperite, braggite, malanite and laurite) and a significant component of alloys (such

as Pt–Fe alloy) or various tellurides. Penberthy et al. (2000) found that up to 50% of the PGMs were liberated during milling. This clearly emphasises the importance of studying the flotation behaviour of the PGMs with the main aim to optimise their flotation response.

In sharp contrast to this the principal platinum-group mineral phases found in Wedza-Mimosa platinum deposit in the Great Dyke of Zimbabwe are, in order of decreasing abundance, sperrylite (PtAs<sub>2</sub>), Pt- and Pd-bearing bismutho-tellurides (moncheite and merenskyite, respectively) and hollingworthite (RhAsS) (Prennergast, 1990). The proportions given in Table 1 for Mimosa Mine (Oberthür et al., 2002) are mostly in agreement with mineralogical investigations performed by Mintek (Van Wouw, 2000). These investigations showed that the most common PGMs in the Great Dyke are the Pt–Pd–Bi–Te minerals—including Pd–Bi–Te, Pt–Pd–Bi–Te and Pt–Bi–Te (probably merenskyite, moncheite, kotulskite)—and sperrylite (PtAs<sub>2</sub>) (Van Wouw, 2000). PGE sulpharsenides, Cooperite (PtS), Braggite

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Table 1

The PGM proportions (proportions are by number) of a number of MSZ localities from the Great Dyke in Zimbabwe (Oberthür et al., 2002)

Locality →	Hartley	Mhondoro	Ngezi	Unki	Mimosa
PGM ( <i>n</i> ) → <i>Type</i> [%]	181	43	199	250	134
(Pt,Pd)(Bi,Te)	71	58	60	39	28
PtAs <sub>2</sub>	11	9	11	28	26
(Pt,Pd)S	11	5	16	4	3
PGE-AsS	2	4	2	16	33
Pt-Fe alloys	1	11	6	–	–
Others	4	11	5	12	13

((Pt,Pd,Ni)S) and Au–Ag compounds were also detected (Van Wouw, 2000). Platinum occurs predominantly as PtAs<sub>2</sub>, Pt–Bi–Te, Pt–Pd–Bi–Te and PGM sulpharsenides. In addition to the predominantly bismuth-tellurides of Pt and Pd, Pd occurs in variable amounts in solid solution in pentlandite.

The Pd-bearing bismutho-tellurides and to a lesser extent the Pt-bearing bismutho-tellurides are the only PGMs containing appreciable amounts of palladium. The palladium recovery is on average about 5% lower compared with platinum (for the Mimosa Mine in the Wedza-Mimosa platinum deposit). It seems, therefore, that the platinum and palladium recoveries are decoupled, which may reflect differences in mineralisation. There is also physical separation of the minerals in the ore deposit: Weiser et al. (1998) reported that the platinum peak lies 50–60 cm below the top of the profile whereas Pd peak lies 50–70 cm below the Pt peak. Similar profiles have been reported by Oberthür et al. (1998) for the Hartley mine.

The proportions and textures of these minerals vary considerably locally and regionally. For instance the relative prevalence of Pt- and Pd-bearing bismutho-tellurides vary from 20% to 80% (see Table 1).

The textural association of the PGMs will greatly influence their recovery potential during flotation. Good associations of base metal sulphides with PGMs are evident for the Merensky and UG-2 reefs. In contrast to this, ores from the Great Dyke show poorer association with the base metal sulphides and a significant portion is associated with the silicate minerals (Van Wouw, 2000). Regrinding of the ore is the only option to avoid significant losses to the tailings.

Mineralogical investigations (QemSCAN) performed on all effluent flotation streams of Mimosa mine have indicated the presence of appreciable amounts of PGMs. The PGE–Bi–Te and PGE–As–S were by far the most common PGM types, generally forming more than 90% of all PGE-bearing grains found in the tailings samples. Especially the large quantity of the Pt–Pd–Bi–Te class, generally in excess of 70%, in all the samples investigated, is noteworthy (Van Wouw, 2003). The reason for the low flotation response of this class of mineral can be threefold; minerals are locked in or attached to silicates, or minerals are liberated but are too small to

be recovered, or minerals are liberated but are not responding well to the flotation stimuli.

Generally more than 50% (by volume) of the grains in the primary rougher tailings of the Mimosa samples have been identified to occur as discrete grains. These results clearly indicate the importance of investigating the flotation behaviour of this class of PGM (Pt–Pd–Bi–Te). Losses to rougher tailings contribute to the lower recoveries typically found in ores from the Great Dyke.

The platinum-group minerals of the Merensky Reef (10–30 and 50–350 µm in diameter) are in general larger than that of the UG-2 Reef (6–10 µm) and Great Dyke (less than 10 µm). Prendergast (1990) reported that the mean grain size of sperrylite and moncheite is ~1000 µm<sup>3</sup>, and of Merenskyite, ~400 µm<sup>3</sup>, corresponding to 12 µm and 9 µm equivalent diameters of spheres. The average grain size of the particles located during the search (Van Wouw, 2003) is between 3 and 4 µm. Nevertheless, these particles should be recoverable by flotation albeit at a lower rate.

The PGM mineralogy of the Platreef in South Africa is very similar to that of the Great Dyke. The Platreef has recently been classified as an economically viable reef (Merkle and McKenzie, 2002). Various new plants are commissioned to exploit the reef through open pit mining. The Platreef is a variable mineralised (PGE, Ni, Cu) composite pyroxinite zone. The distribution of discrete PGMs in the Platreef tends to be erratic but by far the most predominant class of PGM is the Pt–Pd–tellurides (Wilson, 1998). The PGE-telluride fraction can vary from 30–90% of the PGMs depending on the location of the pit (Wilson, 1998). Nevertheless the abundance of these minerals within the Platreef is quite evident. The PGMs are on average coarser than those found in the Merensky, UG-2 and Great Dyke ores. Interestingly enough the tellurides and arsenides are predominantly enclosed in the silicate gangue. According to Wilson (1998) up to 62% of the PGMs can be associated with the silica gangue and 38% by volume with BMSs, and high base-metal sulphide abundances do not necessarily indicate high PGM contents. It has been found that up to 70% of the PGMs can be liberated during the milling process (Dippenaar, 2002). Given the encapsulation by silica, liberation of these particles is therefore a prerequisite for good recoveries and the flo-

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