

**FUNDAMENTALS OF THE FLOTATION
BEHAVIOUR OF PALLADIUM BISMUTH
TELLURIDES**

by

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Ek sal Pa nooit vergeet nie.

GEBED

Laat my nooit U weg verlaat nie,
Laat my in U skadu bly.
Gee dat elke aardse vreugde en vrees
eindelik nietig word vir my.
Elke afdraaipadje ken ek.
Elke keer het ek verdwaal.
Elke keer het U my iewers kom haal,
maak dit Heer my laaste maal.

Elke dag is 'n gedagte
elke kamer net gehuur.
Elke aardse droom van rykdom en roem
net 'n skadu teen die muur.
Wat ek is, is net genade,
wat ek het is net geleen.
Eindelik smag ek na waters van rus.
Lei my Heer vandag daarheen.

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Aan Ilse met liefde

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Soli Deo Gloria

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Abstract

Previous mineralogical investigations (QemSCAN) performed on all effluent flotation streams of Mimosa mine (Zimbabwe) indicated the presence of appreciable amounts of platinum group minerals (PGMs), which are not recovered. Most, generally in excess of 70%, of the liberated PGMs in these streams belonged to the Pt-Pd-Bi-Te class in all the samples investigated.

In the first part of this work, electrochemical investigations, electrochemically-controlled contact angle measurements and Raman spectroscopy have been employed to investigate the interaction of ethyl xanthate with Pd-Bi-Te and PtAs₂. Impedance measurements showed lower capacitance values in solutions containing KEX indicating the formation of a continuous surface layer. Anodic and cathodic polarization diagrams show the mixed potential to be higher than the reversible potential of the xanthate-dixanthogen equilibrium reaction, hence the formation of dixanthogen on the surface is possible.

Electrochemically controlled *in situ* 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 both the minerals (PtAs₂ and Pd-Bi-Te) when the surfaces are anodically polarized. Chemisorbed xanthate could be identified within 120 seconds yielding a hydrophobic surface as indicated by electrochemically-controlled contact angle measurements. Maximum contact angles of 63° were measured in the case Pd-Bi-Te. As a result the mineral surface is expected to be hydrophobic and a lack of collector interaction with the mineral is not the reason for low PGM recoveries experienced.

Secondly, the flotation recovery of synthetically prepared Pd-Bi-Te was compared with that of chalcopyrite (a typical fast-floating mineral) and pyrrhotite (a typical slow-floating mineral), with microflotation tests. These indicated Pd-Bi-Te to be a fast-floater with flotation rates exceeding that of chalcopyrite. Predicted flotation rate constants (from the Ralston model) were significantly lower for small particles (with diameters similar to those lost to the effluent streams) compared with those of particle with intermediate sizes. This supports the suggestion that losses to effluent streams are caused by particle size effects.

Keywords: Precious metal ores, PGM, froth flotation, ore mineralogy, particle size, microflotation, flotation kinetics, platinum flotation, Great Dyke and Pd-bearing bismutho-tellurides.

'n FUNDAMENTELE STUDIE OOR DIE FLOTTASIEGEDRAG VAN PALLADIUM BISMUT TELLURIEDES

deur

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Opsomming

Vorige mineralogiese ondersoeke (QemSCAN) wat op al die uitskotstrome van Mimosamyn (Zimbabwe) uitgevoer is, het getoon dat die strome groot hoeveelhede platinum-groep minerale (PGMe), wat nie tydens die flottasieproses herwin word nie, bevat. Die studie het verder getoon dat die vrygestelde PGMe in die strome hoofsaaklik tot die Pt-Pd-Bi-Te-klas behoort wat gewoonlik meer as 70% van die geïdentifiseerde minerale wat in die monster voorgekom het, uitgemaak het.

Daar is eerstens in hierdie studie van elektrochemiese tegnieke, elektrochemies-beheerde kontakhoeklesings en Ramanspektroskopie gebruik gemaak om die interaksie van etiel-xantaat met Pd-Bi-Te en PtAs_2 , te ondersoek. Impedansiemetings het laer kapasitansiewaardes in oplossings wat KEX bevat het, getoon, wat gedui het op die vorming van 'n kontinue produklaag. Anodiese en katodiese polarisasiediagramme het getoon dat die gemengde potensiaal van die siteem hoër as die uitruilpotensiaal van die xantaat-dixantogeenewewigsreaksie is en dat die vorming van dixantogeen op die oppervlak dus termodinamies moontlik is.

Die elektrochemiesbeheerde *in situ* Ramanspektroskopie het die voorkoms van dixantogeen en xantaat op die oppervlak bevestig wat gedui het op die feit dat xantaat se molekulêre struktuur behoue gebly het tydens die adsorpsie daarvan op die oppervlak van Pd-Bi-Te. Die ondersoek het verder getoon dat dixantogeen op beide die oppervlaktes (PtAs₂ en Pd-Bi-Te) van die minerale tydens anodiese polarisasie, teenwoordig was. Chemies-geadsorbeerde xantaat kon binne die bestek van 120 sekondes op die oppervlak waargeneem word, tot 'n hidrofobiese oppervlak aanleiding gegee het en wat deur elektrochemies-beheerde kontakhoeklesings bevestig is. Maksimum kontakhoeke van 63° is in die geval van Pd-Bi-Te gemeet. Dus, die oppervlak van die mineraal behoort hidrofobies te wees en die swak flottasiegedrag van die minerale is nie te wyte aan die afwesigheid van interaksie tussen die versamelaar en die mineraal nie.

Tweedens, die kinetiese flottasiegedrag van sintetiese Pd-Bi-Te is met dié van chalcopiriet (vinnige flotterder) en pirrotiet (stadige flotterder) tydens mikroflottasietoetse vergelyk. Hierdie toetse het aangedui dat Pd-Bi-Te 'n vinnige flotterder is met flottasietempo's wat hoër as dié van chalcopiriet is. Voorspelde flottasietempokonstantes (deur van die Ralstonmodel gebruik te maak) vir klein partikels (met diameters wat ooreengestem het met partikels wat in die uitskotstrome verlore gegaan het) was wesenlik laer vergeleke met partikels van intermediêre groottes. Dit ondersteun die voorstel dat die partikels wat in die uitskotstrome verlore gaan, aan partikelgrootte-effekte toeskryfbaar is.

Sleutelwoorde: edelmetaalertse, PGM, skuimflottasie, ertsmineralogie, partikelgrootte, mikroflottasie, flottasiekinetika, platinumflottasie, Great Dyke en Pd-bevattende bismutelluriedes.

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