7. Recommendations for future work

Investigations on natural grains and industrial conditions

The very small size and scarcity of individual grains contribute to the complexity of studying fundamental interactions, which necessitates the use of synthetic minerals. The main advantage of synthesizing these minerals in bulk is the ability of performing microflotation tests to evaluate the flotation kinetics of the minerals. However, natural grains contain minor impurities as Sb, Fe, Ni and S, which may impact on the flotation response. To evaluate the validity of using synthetic grains, single natural grains must be subjected to electrochemical investigations and *in situ* Raman spectroscopy in future work.

Multi-components systems are known for the very complex nature of the interactions between the gangue, minerals and the solution. It is, therefore, crucial to investigate the effect of competing reactions in the pulp solutions on the flotation recovery of Pd-Bi-Te. The oxidation behaviour of the minerals forms an integral part in the full comprehension of the flotation behaviour of this class of PGMs. The oxidation behaviour will dictate the necessity of adding collectors to the mill to avoid excessive oxidation or maybe opting for the utilisation of nitrogen as carrier gas.

The Ralston flotation models have proven to be very useful in the prediction of the flotation rate constants from fundamental relationships, however the fluid velocity and energy dissipation of industrial flotation cells are not known, limiting the usefulness of this model. The cell design can impact greatly on the recoverability of the PGMs and this effect needs to be quantified.

Bubble size

The latest trend in the recovery of liberated particles from tails is to increase the power rating of the flotation cell and as a result increasing the turbulent conditions to enable more effective particle-bubble contact. It is also believed that smaller bubbles are required to float small particles more efficiently (Tortorelli *et al.*, 1997). The predicted effect of bubble size on the recovery of the Pd-Bi-Te particles is shown in Figure 46 (see Tables 11 and 12; all other parameters were kept constant and only the bubble size was changed). These results clearly indicate that – for smaller bubbles - the rate constant for fine particle flotation increases significantly whilst the rate constant of the larger particles is sharply lower. Hence the bubble flotation will only be beneficial to the process if the liberated particles are extremely fine as in the case of liberated PGMs from the Great Dyke.

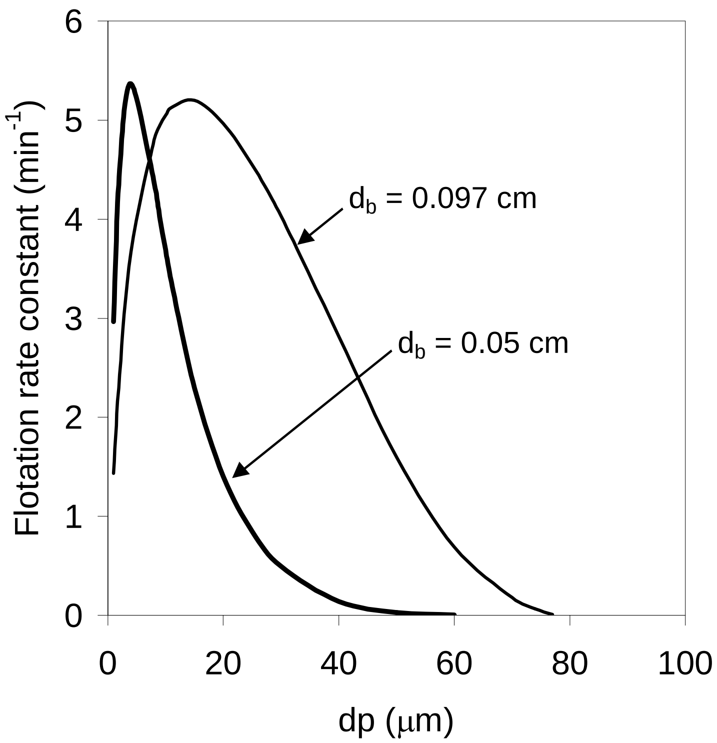

Figure 46. Calculated flotation rate constants at different particle sizes, for two bubble sizes.

Two-phase system

Recent advances in the research of aqueous two-phase systems have indicated the possibility to extract very small particles by employing this separation step. Aqueous two-phase extraction employs two polymer-rich aqueous phases which are immiscible in each other, and with different physicochemical interactions with respect to inorganic particles, to achieve selective separation (Osseo-Asare, 1994; Zeng *et al.*, 2001). The basic principle of extraction involves the selective partitioning of inorganic particles due to physicochemical interactions (for example the interaction of hydrophobic particles with organic polymers) between the surface particles and one of the aqueous phases. The particles can then be selectively removed from the system through the separation of the two aqueous phases. The surface chemistry of the inorganic particles can thus be exploited to concentrate the particles preferentially in one of the two phases.

Aqueous two-phase extraction is very attractive for the separation of very fine particles (even in the nanoparticle range) since two liquids are employed, similar to liquid-liquid extraction processes; there is no limit on the lower-end of the particle size range (Osseo-Asare, 1994; Zeng *et al.*, 2001).

This technology opens up the possibility of the extraction of very small liberated particles, which are not readily recoverable in conventional flotation circuits because of the effect of particle size. Knowing the surface chemistry of the poorly recoverable PGMs an aqueous two-phase system can be engineered to target and recover these particles. However, the complexity associated with industrial pulps will pose many challenges to employing this process on an industrial scale and as a result extensive research in this field is still required