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A comparison of 2D and 3D shape characterisations of free gold particles in gravity and flash flotation concentrates

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A B S T R A C T

The focus of this study was to characterise and quantify the nature of free gold particles recovered in a plant setting featuring parallel gravity concentration and flash flotation processes, with an emphasis on the influence of size and shape as a review of the literature suggests the importance of such attributes on a particle's recovery behaviour. Automated mineralogical analysis (AMA) was employed to quantify the free gold particles' circularity and sphericity measurements using two and three dimensional (2D/3D) methods. As expected, the 2D results indicated that free gold particles (−212/+38 μm) reporting to the gravity concentrate in were, on average, more circular than those of the flash concentrate. However, 3D sphericity characterisations of the same samples offered opposing results. Such a conflict identifies the limitation for application of simple 2D and 3D shape characterisations for malleable and irregularly shaped free gold particles.

1. Introduction to the study

The use of gravity recovery and flash flotation operations in a closed loop milling circuit can be an option for recovery of free gold in the milling circuit. As studied in this research, not only does the concentrate grade differ, but the composition and the types of gold captured by each unit are also likely to vary as they are dependent on both unit recovery performance (i.e. efficiency, residence time) and, to some extent, the behaviour of the particle in a slurry.

2. A review of the relevant literature

2.1. Milling

Free gold is malleable and does not comminute well, therefore, it may require 50–100 passes through the milling circuit until it is sufficiently fine enough to report to the downstream process (Laplante, 2000). Build-up of free gold in the milling circuit also occurs due to the element's high density, compared to gangue material. This means that free gold particles much smaller than the intended cut size of the bulk material (for example 20 μm vs. 57 μm) will report to the cyclone underflow and be retained in the milling circuit until sufficient size reduction has occurred for the material to report to cyclone underflow (Banisi et al., 1991). Free gold content in the recirculating load is often greater than several thousand per cent (compared to sulphide minerals around 200%) and thus it is sensible to target recovery of gold from within the milling circuit as it provides a high grade feed source. Removal of free gold in the milling circuit, achieved via either gravity recovery and/or flash flotation, reduces large recirculating loads of free gold and can lessen the effect of incomplete leaching of coarse particles downstream.

Milling will also have an effect on recovery in flotation as it has been demonstrated that there is a varied flotation response between differently shaped particles of similar composition (Aksoy and Yarar, 1989). Large free gold particles do not fracture, but rather smear, and may become flaky due to malleability (Brook et al., 2003). However with continued comminution, free gold particles become compact, spherical shapes, displaying signs of breakage as depicted in Figs. 1–3. These small, spherical milled particles are likely to yield decreased floatability due to gangue impregnation and surface coatings (Banisi et al., 1991).

2.2. Gravity versus flash flotation

In principle, gravity concentration methods separate dense particles (such as gold) from lighter gangue materials based on their response to the force of gravity and the movement of a viscous fluid, which is generally water (Koppalkar, 2009; Wills, 2006). Flash flotation was originally designed to be used ahead of conventional flotation in grinding mill circulating loads in order to reduce

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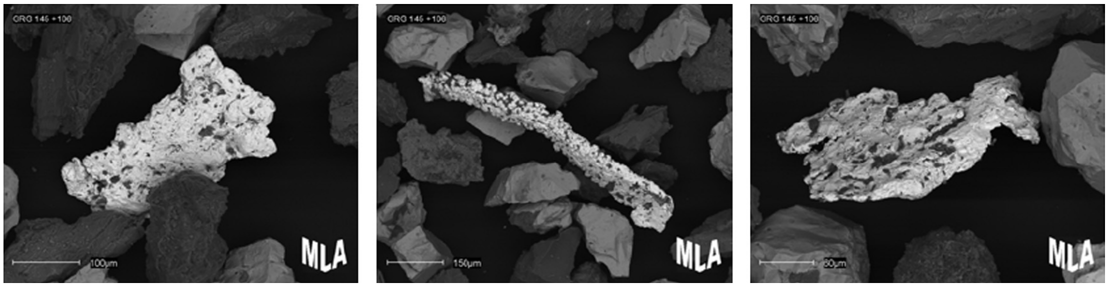

Fig. 1. Free gold grains in a milling circuit in the −150/+106 μm size fraction (Bax and Staunton, 2004).

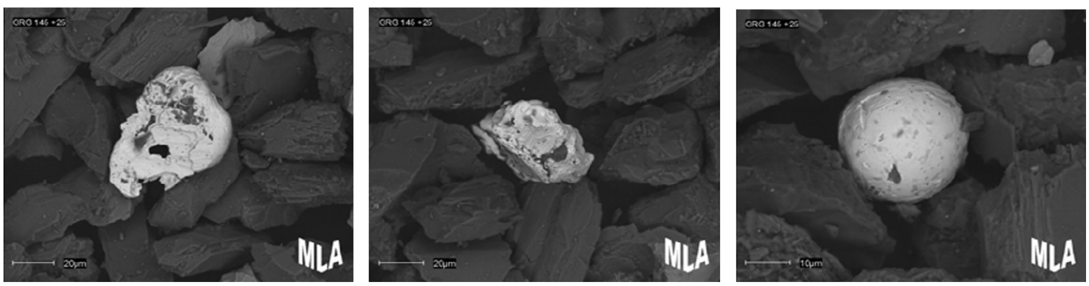

Fig. 2. Free gold grains in a milling circuit in the −38/+25 μm size fraction (Bax and Staunton, 2004).

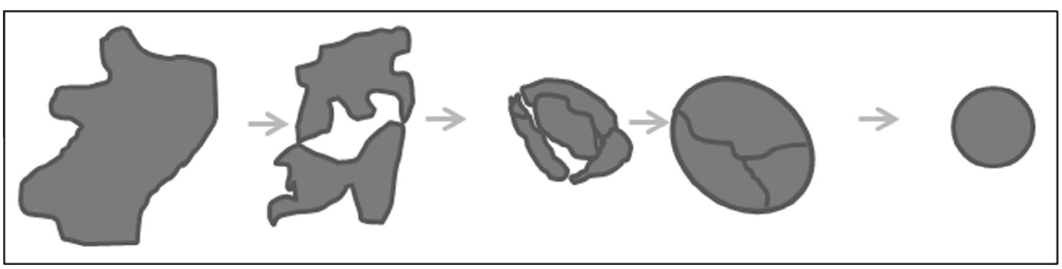

Fig. 3. Proposed changes in free gold shape from flat/flaky particles to compact spherical shapes as a function of increased residence time in the milling circuit (McGrath, 2014).

the over-grinding of sulphides (Bourke, 2002). When the two types of concentrators are acting upon the same feed stream the literature suggests that gravity recovery of coarse (+212 μm) free via batch or semi-continuous units, such as Knelson or Falcon batch centrifugal concentrators (BCCs) gold will be preferred. For example, on average, BCCs will recover 40% of +38 μm gold particles and only 10% of −38 μm gold particles (Chryssoulis and Dimov, 2004) in a single pass efficiency with only seconds of residence time. Laplante and Dunne (2002a) found that the −38 μm free gold particles which are unlikely to be recovered in the gravity circuit can instead be captured in the flash flotation circuit which generally has longer residence time of two or three minutes. In fact, Malhotra and Harris (1999) suggest free gold particles up to 200 μm in size can be recovered efficiently by flotation. Therefore, it is fine free gold and unliberated or locked gold particles which are targeted for recovery within the milling circuit by continuous flash flotation units, capable of achieving the much higher yield required to produce a sulphide concentrate (Laplante and Gray, 2005). The ideal recovery performance curves for gravity and flash flotation in a parallel configuration are demonstrated in Fig. 4 (Laplante and Gray, 2005).

Laplante and Dunne (2002a) suggest that while free gold particles larger than 212 μm will preferentially report to a gravity concentrator and free gold particles smaller than 38 μm will report to flash flotation when the units are operated in parallel within a closed loop milling circuit, there is an intermediate −212/+38 μm fraction with an unquantified propensity for either recovery mechanism. An important, but not well understood, factor in the response of a gold particle to concentration efforts by gravity or flotation devices is shape which has been suggested to affect the potential for recovery in the milling circuit (Laplante and Gray, 2005).

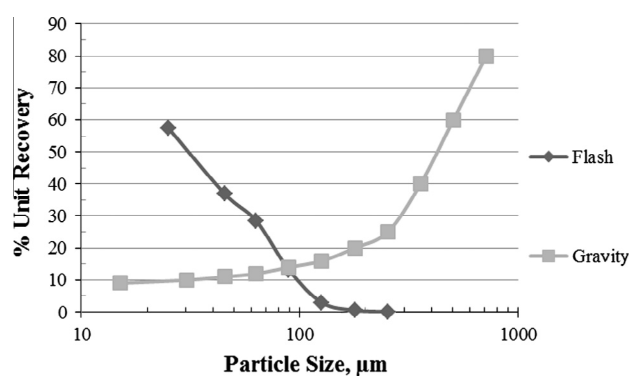

Fig. 4. Comparative unit performance for recovery of gravity recoverable gold (GRG) (Laplante and Dunne, 2002b).

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