



## Original Research Paper

## Upgrading of low-grade gold ore samples for improved particle characterisation using Micro-CT and SEM/EDX

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## ABSTRACT

There is a considerable challenge in accurate characterisation of gold (Au) particles in low-grade plant ore mineral samples. This is particularly true for automated mineralogical tools such as X-ray micro-computed tomography (Micro-CT) and scanning electron microscopy (SEM), where the need for statistically meaningful numbers of particles requires many sections to be analysed. While the Vertical Gas Stream (VGS) elutriator is suitable for coarse particle upgrading (i.e.  $>38\ \mu\text{m}$ ), the performance is poor for finer particles (i.e.  $<38\ \mu\text{m}$ ). Consequently, the system has been modified to Vertical Water Stream (VWS) elutriator using higher density fluid (i.e. water) to enable analysis of Au particles below  $38\ \mu\text{m}$ . In this work, the VGS system was used to upgrade Au particles in the  $-53 + 38\ \mu\text{m}$  size fraction (in rougher concentrate, rougher tailings, regrind mill discharge and regrind cyclone underflow) and the VWS system was used to upgrade Au particles in the  $-38\ \mu\text{m}$  size fraction of the regrind mill discharge sample. The VWS elutriator was calibrated using galena (specific gravity, S.G. of 7.58) and quartz (S.G. of 2.65) particles of  $<38\ \mu\text{m}$  size as model minerals. From the calibration tests, partition curves as a function of particle size were generated. Using these measurements, theoretical partition curves for Au (S.G. of 19.3) have been calculated. The VWS concentrate was characterised using Micro-CT and compared with SEM coupled with energy dispersive X-ray (EDX) analysis of  $-53 + 38\ \mu\text{m}$  ore size fraction of the VGS concentrate of the four sample streams. The Micro-CT analysis of VWS Au concentrate showed that sufficient particles (Au) can be upgraded. SEM/EDX results indicate that regrind does not affect changes in free Au particle morphology, aspect ratio and frequency of shearing damage in the  $-53 + 38\ \mu\text{m}$  size fraction. Cyclone classification of the regrind mill discharge in the  $-53 + 38\ \mu\text{m}$  size fraction appears to perform surface cleaning by exposing obscuring silver (Ag) surfaces on Au particles in the mill discharge sample.

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## 1. Introduction

Optimisation of gold recovery in copper–gold ore flotation requires accurate and diagnostic mineralogical and morphological characterisation to estimate the possible gold loss routes. Mineralogical tools such as X-ray microtomography (Micro-CT) and scanning electron microscopy coupled with energy dispersive X-ray spectrometer (SEM/EDX) are commonly used. Major problem associated with gold mineralogical analysis is due to its sparsely distributed grains and low concentration (i.e. 1–2 g/t) in copper–gold ores [1–3]. This warrants the need to pre-concentrate or upgrade gold particles and increase grade from any gold plant sample before mineralogical analysis is performed, without changing gold surface chemistry. In recent times, researchers have proposed the use of pre-concentration methods such as heavy medium separation [4], shaking Wilfley table [5] and hydro separation

[6] for upgrading gold samples to enhance the identification of a statistically significant number of gold particles. These pre-concentration methods which depend on gold grain size are either expensive or toxic to operate, particularly with regard to the chemicals used in heavy medium separation. The VGS elutriator which is central to this study has been used to successfully upgrade grades of gold plant samples from as low as 0.01 g/t and statistically characterise gold particles on size-by-size basis while preserving surface chemistry [7]. Preliminary studies have shown that dense mineral particles could be concentrated by selectively removing low specific gravity materials using the VGS system. This technique is based on sample pre-sizing and the use of a single cylindrical column through which upward-flowing gas (compressed air) is used as the separating medium. However, low specific gravity of gas makes this technique inefficient for upgrading fine particles ( $<38\ \mu\text{m}$ ) due to particle aggregation effect. Also, classification of fine particles is more effective in wet conditions than dry conditions because the particles are well dispersed within the wet system. Therefore, for easy and effective bulk and surface characterisation, there is the need to design a new system for upgrading fine Au particles.

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