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Characterising chalcopyrite liberation and flotation potential: Examples from an IOCG deposit

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ABSTRACT

A critical aspect of geometallurgy is quantifying mineralogical and textural relationships that affect mineral processing (e.g., liberation and recovery) and it is vital that this information is included in the planning process for both mining and mineral processing. However, to date, this has been an expensive and time consuming venture and only minimal amounts of this type of data are available to be included in the planning process. Our research is focused on developing new methods that will produce the required mineralogical and textural data rapidly and inexpensively. These include obtaining quantified textural data, such as the size and distribution of the valuable phase and its association with other minerals, by extracting it directly from mineral maps. In addition, simulated breakage of drill core samples was used as a rapid way of looking at various particle sizes to determine potential liberation behaviour. The predicted liberation parameter compares favourably with results obtained from typical MLA recovery analysis, is spatially coherent and can be used to recognise domains of high and low liberation potential that are expected to affect the grade recovery curve. The flotation response was evaluated and the technique validated using a small scale test being developed at the Julius Kruttschnitt Mineral Research Centre, i.e. the JKMSI (mineral separability indicator).

1. Introduction

Practical geometallurgy requires a database of parameters that predict mineral processing performance. Obtaining this type of information rapidly and inexpensively is vital so that a representative number of measurements can be carried out and the results included in the planning process for both mining and mineral processing. Recent advances in digital photography, particularly in image processing software, have led to a resurgence of interest in optical microscopy mineralogy as a source of rock texture information. Our work suggests that optical techniques have a place in generating medium quality cost-effective microscale mineral maps with direct application to geometallurgy. In the examples presented here we have used mineral maps produced through optical mineralogy and automated mineral identification plus simulated breakage as a rapid way of looking at various particle sizes to determine potential liberation (and flotation) behaviour. This method does not mimic actual breakage but can provide a way of ranking samples in terms of their relative processing behaviour.

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2. Methodology

2.1. Image collection

Ninety-six 2 m-long samples of half drill core containing copper mineralisation (as chalcopyrite) were chosen from five drill holes to give a cross-section through an iron oxide–copper–gold ore body. Each sample was crushed and a representative (riffle splitter) sample of particles in the size range from −1.18 to +0.6 mm was selected. As this particle size is more than five times the grain size of the Cu minerals it allows the fundamental rock properties to be measured before modification by grinding. The grain mounts typically contain 500 particles and 1000–5000 grains of Cu sulphide. The coarse particles were mounted on a polished thin section and analysed using optical microscope techniques as described in Berry (2008), Berry and McMahon (2008) and Hunt et al. (2010). Image collection for each sample was carried out using a microscope with a high precision stage (<1 μm error in reproducibility) to allow the direct tiling of frames and good registration of multiple image layers. Transmitted-light plane-polarised, transmitted-light cross-polarised and reflected-light plane-polarised images were collected along with a transmitted-light cross-polarised image with a tint plate inserted. All lighting conditions were kept constant for all image acquisition. Exposures were set to avoid any saturated pixels. The images were collected at one third resolution to give a 0.55 megapixel image. The resolution was again reduced (×2) during mosaic generation to give an overall pixel size in the final images of 4.73 μm. This size allows rapid analysis of a 3 cm^2 area. The smallest object recognised at this resolution is 10 μm across.

2.2. Automated mineral identification

Automated mineral identification was facilitated via image analysis that was carried out using the sophisticated object-oriented multi-spectral software Definiens Developer 7 (Definiens, 2008a). Using this software the four RGB images were read directly into 12 greyscale bands. A multi-resolution segmentation algorithm produced small objects based on homogeneity across all bands and the objects were then classified using a complex set of rules (Process Tree) to produce classified images (also referred to as mineral maps; Fig. 1 top). The example deposit has simple sulphide mineralogy and this was easily analysed using the optical microscope system. The valuable phase in this deposit is chalcopyrite and grains greater than 20 μm across were recognised with better than 85% precision.

2.3. Simulated fragmentation

The chessboard segmentation algorithm available in Definiens Developer 7 was used to create simulated fragments from the mineral map of each sample. In this algorithm a square grid of fixed size, aligned to the left and top borders, is applied to the mineral map and the image is cut in squares along grid lines (Fig. 1 bottom; Definiens, 2008a,b). We chose to use grids that would create simulated fragments with sides of approximate length 150, 75 and 38 μm. These equate to simulated fragments with sides of length 32, 16 and 8 pixels. Simulated fragments with no chalcopyrite

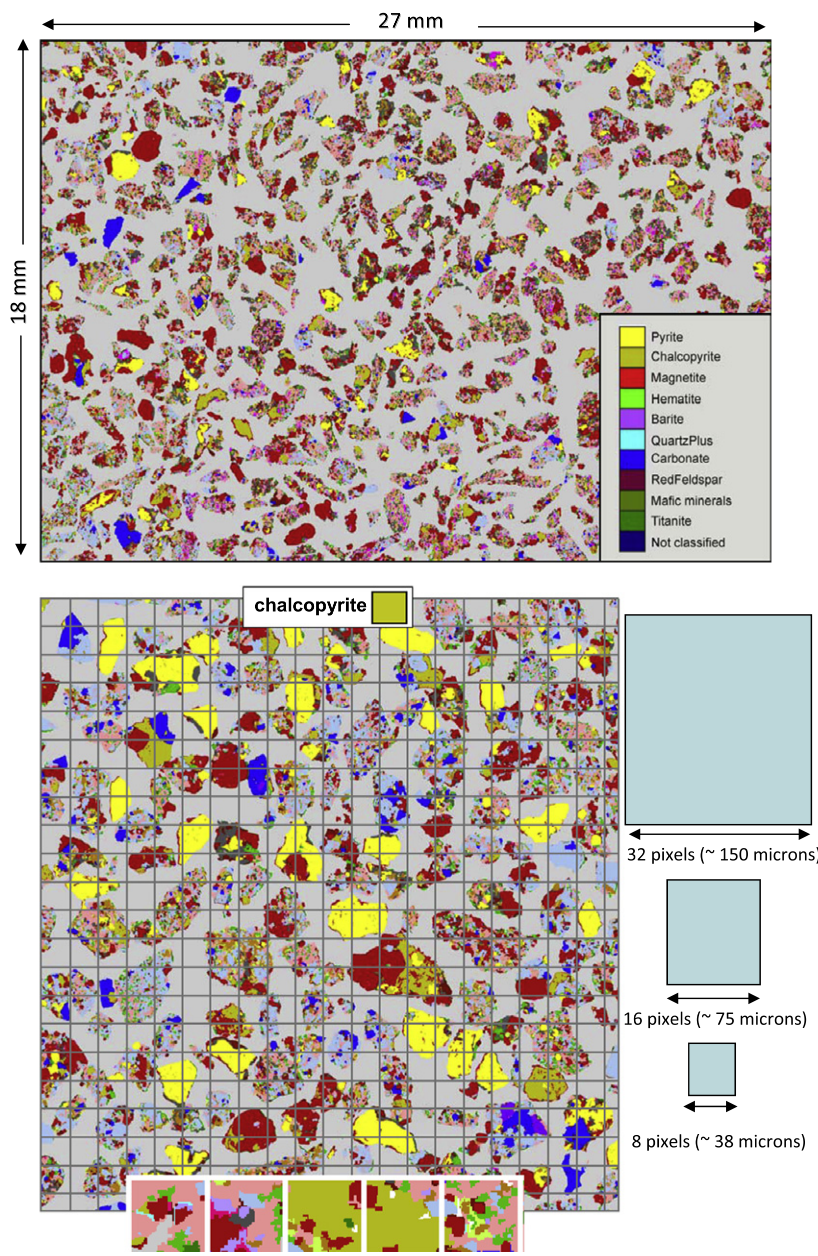

Fig. 1. Top – typical example of a mineral map; bottom – example of simulated fragmentation of a mineral map. Three sizes of simulated fragments were used with sides of approximately 150, 75 and 38 μm.