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The role of vein-type mineralisation in mineral liberation

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A R T I C L E I N F O

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A B S T R A C T

This paper provides a further investigation of the role of vein structures in the ease of mineral liberation by random masking simulation of breakage. A copper porphyry ore with vein-type mineralisation underwent different methods of sample preparation for liberation analysis. A selected core was cut into semicircular slabs and another core underwent crushing. The slabs and the crushed particles were analysed in the MLA and subjected to simulated breakage from which the liberation of sulphides was determined. The result was linked with the liberation measured from particles of the same ore that have undergone actual breakage. The analysis further provided an indication of the significant contribution of veins in liberation. This information points out to a proper approach of texture and liberation analyses, and the better use of textural data from core scale logging relevant to mineral processing.

1. Introduction

Earlier simulation works of Tungpalan et al. (2017) and Wightman et al. (2014) have shown the influence of ore mesotextures, particularly the presence of veins, in the ease of mineral liberation using classified images of semicircular slabs from the Mineral Liberation Analyser (MLA). Simulated breakage of the vein-style mineralisation yielded a higher degree of sulphide liberation than the disseminated grains. It was also observed that the liberation of sulphides started at coarser simulated fragmentation size. The simulation results suggest that the presence of veins contributes to an increased degree of liberation and allows liberation to start at a coarser particle size. The presence of veins also provided a better understanding and interpretation of the origin of mineral liberation. Moreover, their works presented an alternative method of drill core preparation for texture analysis that could preserve the micro- and mesotextural features of the ore.

This paper investigates further the role of veins in mineral liberation. In this research, the simulated liberation obtained from semicircular slabs with vein structure was linked with the simulated liberation obtained from crushed particles. The simulated liberation both from the slabs and crushed particles was also assessed with measured liberation from ground particles that have undergone actual breakage.

2. Method

2.1. Sample preparation

Two HQ half-core with evident veining structure were selected to generate the samples. One core was further cut to semicircular slabs (63.5 mm diameter and 1 cm thickness) using a high precision diamond saw. The slabs were prepared and analysed in the MLA according to the method adopted by Wightman et al. (2014). The classified images of the slabs were imported into Microsoft Paint to create images showing only the vein structures. The processed images were used in the breakage simulation to generate liberation. An example of the original and processed classified images are shown in Fig. 1a and b, respectively.

The other half-core was stage-crushed to −4000 μm to minimise the generation of fines using a laboratory jaw crusher and a 4 mm standard sieve. The 4000 μm was chosen based on Gy's safety line (Lotter, 2012; Pitard, 1993). The crushed particles were split into representative subsamples using a laboratory rotary splitter. A subsample was taken to undergo particle size distribution using laboratory standard sieves. Each particle size fraction was analysed by X-ray backscattered electrons (XBSE) method in the MLA particularly to determine the modal mineralogy for each size fraction. The coarse particle size fractions (−4000/+2800, −2800/+2000, −2000/+1400, −1400/+1000 μm) were selected based on liberation spectrum (Tungpalan et al., 2015; Tungpalan, 2016). These coarse size fractions were expected to provide the intact microtextural features in the ore. Classified

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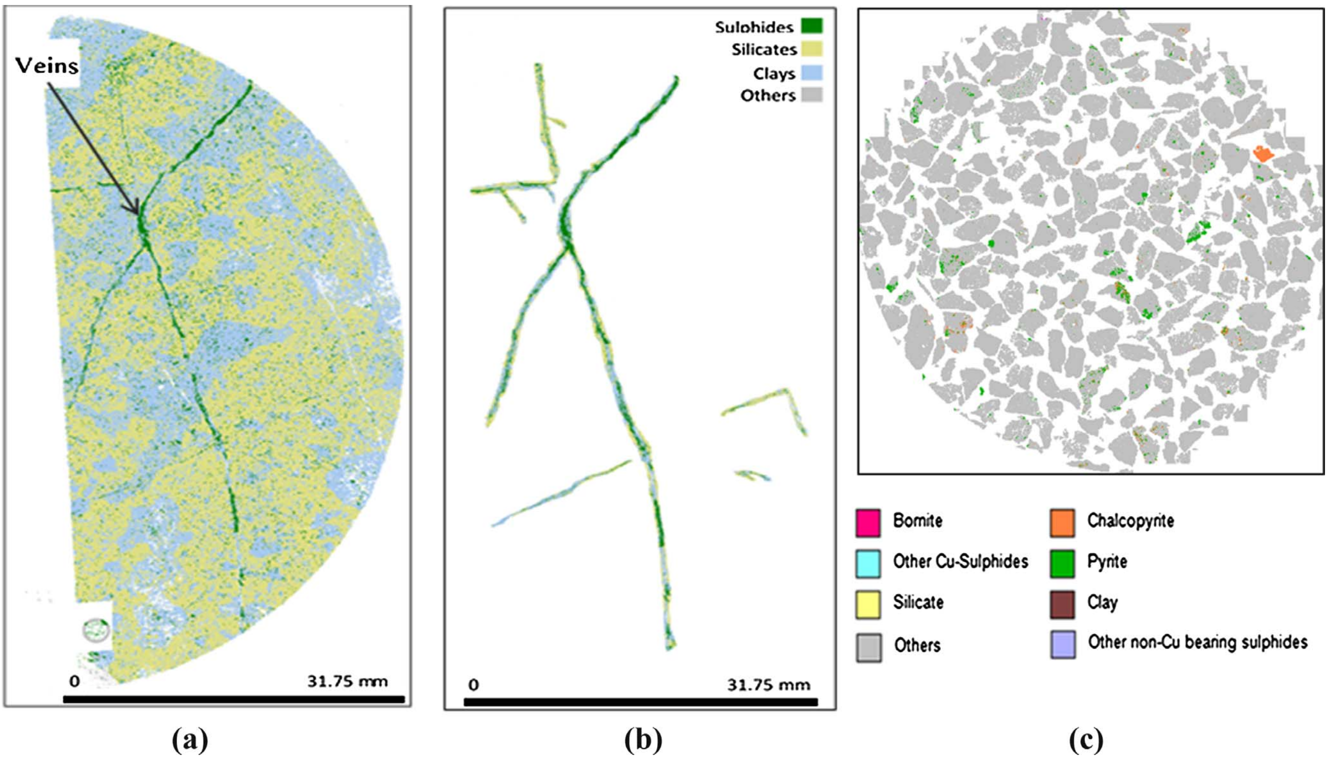

Fig. 1. Classified MLA images used in random masking simulation of breakage to predict liberation (a) original slab image, (b) processed slab image showing only the veins, (c) block of crushed ore particles.

images of blocks of the coarse particle size fractions (as shown in Fig. 1c) were used in the simulation of breakage to generate liberation.

Another subsample underwent grinding in a laboratory rod mill to flotation feed size (P_{80} 150 µm). The ground products were subjected to particle size distribution using laboratory standard sieves. Each particle size fraction was also analysed in the MLA by XBSE method. In particular, the liberation of the copper sulphides was measured by liberation by particle composition in the MLA. This data was used to cross-check the simulated liberation from the slabs and from the crushed particles.

2.2. Generation of liberation by simulated breakage

The random masking approach was applied to the MLA images to simulate the breakage of the slabs and the crushed particles. Random masking approach involves overlying square grids on the images and breaking into progeny particles along the grids of the mask (Bonifazi and Massacci, 1995; Evans, 2010; Hunt et al., 2011). The size of the grids represents the fragmentation size and a square grid represents a progeny particle. The characteristics of the progeny particles were obtained from which the liberation was determined. The random masking procedure was performed in eCognition Developer 64, commercially available image processing software (eCognition, 2014).

In this work, masking was done at four sizes of square grids to simulate fragmentation to approximately 150, 100, 75, and 50 µm. For the crushed particles, the liberation for all copper sulphide minerals were combined (chalcopyrite + bornite + other copper sulphide minerals) to obtain the total liberation for copper sulphides. For the slabs, due to the limitation of the software to process substantial file sizes, it is the liberation of sulphides (all copper sulphides minerals + pyrite) that was obtained. MLA analyses of the slabs, the crushed and ground particles provided an indication of a strong association of copper sulphides with pyrite. The simulated liberation of sulphides in the slabs could therefore be linked with the liberation of copper sulphides in the crushed and ground particles. The results from the simulation on the slabs was used to explain the difference between the simulated liberation in the crushed particles and the measured liberation in the ground particles.

3. Liberation data

3.1. Simulated liberation from the veins (slabs)

The liberation was plotted as cumulative curves of the liberation distributions. Particles in the 90–100% liberation class are referred to as the high grade particles and highly liberated sulphides in this work while those in the 0–10% liberation class are the highly unliberated.

The simulated liberation of sulphides from the veins is illustrated in Fig. 2a. The figure showed that even at 150 µm, there is already 12% sulphides that occur as highly liberated sulphides. As the fragmentation size decreases to 100 µm, 75 µm and 50 µm, the proportion of highly liberated sulphides increases to 18%, 27% and 38% respectively.

3.2. Simulated liberation from crushed particles

The simulated liberation of copper sulphides from crushed particles for all simulated fragmentation sizes is shown in Fig. 2b. A similar trend was observed in that the proportion of copper sulphides occurring in the higher grade particles increased as the fragmentation size becomes finer. This indicates increasing liberation of copper sulphides at decreasing particle size. However it can be seen that considerable proportion of highly liberated particles start to occur only at 100 µm with about 8% sulphides. The proportion increases to about 12% and 18% at 75 µm and 50 µm respectively.

3.3. Measured liberation from ground particles

The liberation of copper sulphides in each size fraction from the ground particles as measured by the MLA is shown in Fig. 2c. The distribution was observed to follow similar trend with increased liberation as the fragmentation size decreases. This confirms the trend