minerals

Editorial

Editorial for Special Issue "Mineral Liberation"

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The mineral liberation studies are fundamental for mineral processing and metallurgy. Mineral resources are non-renewable, and it is expected that the ore grades available to the mining industry will decrease in the future [1]. Thus, mineral processing must meet sustainability criteria, that is, to recover the greatest amount of materials possible from the resources we have. This requires a deep understanding of the characteristics of ore and gangue minerals. Mineral liberation data is essential for designing the optimal mineral processing and also for estimating the efficiency that can be achieved by a separation process.

In relation to mineral liberation, two aspects must be addressed: (1) the characterization of the raw materials to be processed, and (2) the variation of the liberation characteristics according to the treatment to reduce the particle size. This issue covers both topics: techniques of mineral liberation characterization of ores before treatment [2,3], and the relationships between comminution and mineral liberation, taking into account the energy consumption [4–8].

Currently there are several quantitative techniques to characterize mineral liberation. These techniques include the Mineral Liberation Analyser (MLA), Quantitative Evaluation of Materials by Scanning Electron Microscopy (QEMSCAN), Tescan Integrated Mineralogical Analyser (TIMA), and x-ray microtomography (µCT). The use of automated mineralogy analysis provides valuable information on mineral liberation, such as the chemistry, mineral composition, shape, and size of particles, and the mineral association [9]. However, the correct use and interpretation of them requires a mineralogical understanding of the materials [10].

X-ray microtomography shows a 3D image that allows estimation of size and shape of particulates and also cracks and pores [11] without the stereological error typically produced by 2D techniques [12]. Guntoro et al. [2] evaluate the data analysis methods involved in processing µCT datasets and thoroughly discuss various µCT data analysis methods, their limitations, as well as their application in mineral characterization. They concluded that the establishment of µCT as a rapid, standalone, and automated mineralogical analysis is challenging, as the result of this study indicates that additional information (Scanning Electron Microscopy with energy-dispersive spectral analysis, X-ray fluorescence, calibration with pure minerals, dual energy) are required to effectively differentiate between different mineral phases in the µCT dataset.

In mineral processing, the mineral liberation size is a determining parameter for defining the optimal comminution process in order to obtain the maximum grade during the separation process with the lowest energy consumption. The comminution method selected is essential for achieving good results in the liberation of the particles, as well as the most suitable morphology for the following processing steps [13,14]. This is the case of flotation, where the dimensions and shape of the particles play an important role [15]. This is shown by Rong et al. [3], who analyse the effect of the shape of particles obtained from different comminution methods on low-rank coal flotation. They investigate the length–diameter ratio, wrap angle, and bubble–particle attachment/detachment of rod-milled and crushed coal particles. Their results show that the floatability ratio of crushed products was higher than that of rod-milled products and coal particles from the crushed method with a larger length–diameter ratio had higher a floatability ratio than those obtained by the rod-milled method.

During comminution, breakage can be random and not random. Random breakage has been defined as the independence of breakage from ore and mechanical properties [16]. The knowledge about whether an ore is undergoing random or non-random breakage during comminution is useful, as non-random breakage may enhance the liberation properties that influence the behaviour of particles in the subsequent separation process [16]. The non-random breakage indicates that it is necessary to know the mineralogical and textural characteristics of the materials to predict their liberation [14]. Mirzaei et al. [5] developed a 2D a simulator, based on the Voronoi tessellation method, to model the liberation spectrum resulting from random and non-random breakages. The simulations were validated using artificial ore samples crushed using different energy levels. The simulator predicts the changes in the proportion of the intergranular breakage with the grade and particle size of fragmented material. In this case, the proportion of intergranular breakage was dependent on the ore grade and independent of the size of the fragmented particles. However, the material used had a simple texture.

Three articles from this issue report results of the Increasing yield on Tungsten and Tantalum ore production by means of advanced and flexible control on crushing, milling and separation process (OPTIMORE) European project [3,6,7]. The main objective of OPTIMORE was to optimize the crushing, milling, and separation ore processing technologies for tungsten and tantalum mineral processing. This was accomplished by means of improved fast and flexible fine tuning production process control based on new software models, advanced sensing, and deeper process physical study, with results showing an increase in yields by 7–12% on the current best production processes, and an increase in energy savings by 5% compared to the best available techniques [17].

The tantalum ore selected was that of the Penouta Sn-Ta deposit, Ourense (Spain), which was constituted by an open pit and tailings to be reprocessed. The mineralogical characteristics of the liberation of these ores were presented before in a Special Issue of *Minerals* devoted to the process mineralogy of critical raw materials [13,14,18]. Alfonso et al. [3] determine the liberation characteristics of Penouta tailings and compare the results with those from outcroppings of leucogranite low-grade tantalum ore. The characteristics of mineral liberation were quantified for columbite-group minerals and cassiterite. To characterize the mineral liberation, several techniques, such as X ray diffraction and microprobe analyses, were utilised to select minerals to use in the Mineral Liberation Analyzer database. The mineral associations and relationships among the ore content, size of particles, and grade class were determined. These data are necessary to select the particle size that must be reached according to the recovery to be obtained.

Guldris et al. [6] used the open pit granitic rocks from Penouta to develop a test protocol to characterize the tantalum grade by size variation during compression breakage using relatively low-cost techniques. They considered a non-random breakage and proposed to analyse the mineralogy and texture of the crushing products according to the particle size. They demonstrate that the proposed characterization can facilitate the rejection of part of the gangue material after this stage. They recommend doing compression tests and grade-by-size analysis for coarse-grained ores or ores with heterogeneous textures.

Hamid et al. [7] determine the mineral liberation modelling of a scheelite ore obtained from a processing plant, using quantitative mineralogy and simulation to complete the characterization. The liberation modelling was obtained using a back-calculation method in MATLAB with the grade/size distribution un order to produce a predictive liberation model. The grade of scheelite liberation in the size fractions allowed for a good estimation of the mineral distribution in the concentration feed. The energy consumption of the comminution process was also provided. The conjunction of both data allowed an optimum balance to be selected for the processing parameters.

Finally, Saramak and Saramak [8] present advantages for mineral liberation with the use of a new high-pressure grinding crusher (HRC). They observed that HRC operating pressure significantly affects the level of mineral liberation in crushing products and that the utilization of a HRC press provides a measurable effect with a decrease in the Bond work index Wi, which closely correlates with operating pressure value. They observed more intense generation of the finest particle size fractions during the ball mill grinding processes, a shorter required grinding time, and a micro-crack formation during the high-pressure comminution process.

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