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Title: Ball milling control: the reconciliation of macroscopic SensoMag<sup>®</sup> data with microscopic optical information.

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Abstract: In the mineral processing of metallic ores, grinding allows the fragmentation of rocks into fine particles which then can be further process to separate valuable from non-valuable particles. Traditionally, milling is performed in large tumbling mills in which the ore is crushed together with water thanks to the rotation and falling of a grinding media, either ceramic or steel balls. Ideally, the mill discharge materials should have stable characteristics in terms of particle size distribution and mineral composition. However, the behavior of particles in the mill is related to their mineral composition, to the parameters of the pulp (% solids) and to the motion of the grinding media. All these parameters can eventually vary due to operating strains and thus the grinding operation is impacted.

Mill performances are usually daily measured at the mill discharge, on the basis of a mass percentage passing a certain sieve. Some other macroscopic parameters (pulp density, power input, etc.) are sometimes monitored too. Nevertheless, as the reaction time of a mill is approximately 15 min, these measurements are meaningless and the need for real-time monitoring seems obvious. Moreover, the mill discharge materials should be described more accurately. Indeed, the current approach does not reflect at all what happen to the fines particles through milling, and, despite of the current trends towards extra-fine grinding, getting too many fines at mill discharge is still a waste of energy.

For several years Magotteaux has been developing the SensoMag<sup>®</sup>: an electrical sensor capable of measuring the position of the charge within a mill in operation. Up to now, these data haven't been related to milling performances in terms of particle size distribution (PSD). Here we compared macroscopic data from the SensoMag<sup>®</sup> to optical measurements at the particle scale. We studied the particular case of a UG2 platinum ore concentrator equipped with a SensoMag<sup>®</sup> device. Due to the very low grade of sulfide and PGM in UG2, grinding mechanisms are entirely control by gangue minerals. The UG2 gangue is a mixed of silicate minerals with chromite. Chromite is barren while silicates contain finely disseminated platinoid grains (<10 µm). Thus, there is usually a trade-off to enhance PGM recovery while keeping the chromite coarse enough to limit its entrainment in the concentrate. Indeed, chromite is penalizing for UG2 pyrometallurgical process. In this study, the grindability of both gangue minerals was studied on a size by size basis. The results were linked to real-time measurable macroscopic SensoMag<sup>®</sup> measurements. The specific behaviors of chromite and silicate particles were demonstrated.

These results give new bases for real time control of grinding process with the SensoMag<sup>®</sup>. In the specific case of the UG2 ore, it could help to better predict chromite entrainment in platinum concentrate and to easily value chromite as a by-product of UG2 platinum ore.