Imaging technologies to understand grinding at particle scale in a UG-2 processing plant

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Motivation and objectives

This study is part of research program for ball milling optimisation undertaken by Magotteaux Belgium and the University of Liege. Many macroscopic parameters, such as the slurry density, are known to be related to grinding efficiency, but, the links between those and particle size distribution (PSD) are still unclear.

Case study : the Upper Group 2 (UG-2)

This reef of the Bushveld Intrusive Complex (RSA) is ~4g/t rich in Platinoids (PGE) but accounts for around 54 per cent of the global reserves (Cawthorn, 1999). UG-2 mineralization consist of minute base metal sulphide (usually ~0,1 per cent) that can be or not associated with PGE. The main gangue minerals are chromite (up to 90 per cent), orthopyroxenes and plagioclases (Fig.1). Chromite contains minor proportions of PGM, while silicates contain fine (<10 µm) grain disseminated PGE (McLaren and DeVillers, 1982). Thus, the trend is to very finely ground silicates to enhanced PGE recovery. However, chromite constrain the fine grinding because if it is too finely ground it is entrained in the concentrate and can cause troubles in the pyrometallugical process. (Hay and Roy, 2009).

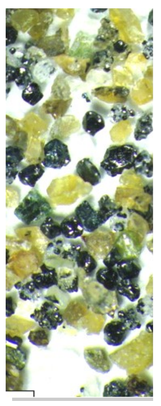


Fig.1

Research main objectives

To get a deep understanding of chromite particles behaviour in a ball mill and to see how this could be monitored by image analysis techniques.

Material & Methods

Sampling campaign

In 2009, Magotteaux conducted a series of surveys at a UG-2 plant equipped with a Sensomag®. Each survey lasts one hour during which densifier underflow (DU) and mill discharge (MD) are both continuously sampled to obtain one-hour composites. At the same time the output data of the Sensomag® are recorded. The assays were conducted at controlled and stable per cent solids and ball filling degree (FD).

All the samples underwent a four-class sieving procedure (sieving size : 106µm, 75µm and 38µm). Chrome and PGM content were assayed for each size fraction.

Occhio FC200

A pilot installation based on the standard version of the Occhio Instruments FC 200 is used to acquire images of diluted pulp samples from the surveys (Fig.2). The FC200 device is equipped with a high pressure peristaltic pump that flushes the samples into a thin glass chamber. The imaging operation consist in a brief back-lighting of the chamber at each pump stops. Hundreds of thousands of particles can be imaged this way in a few minutes.

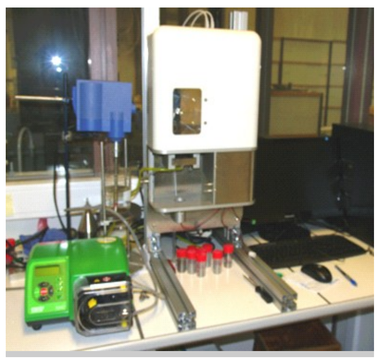


Fig.2

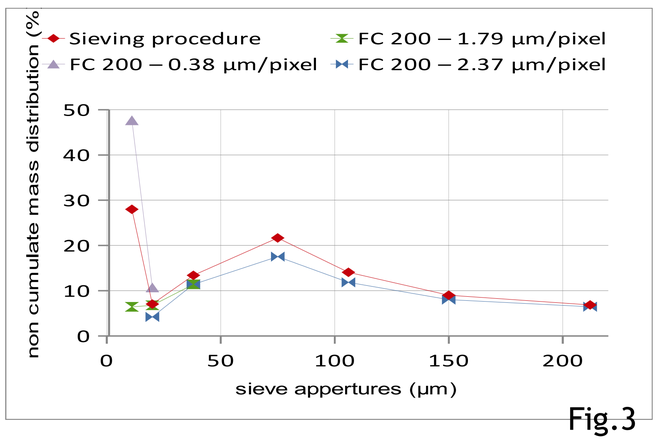


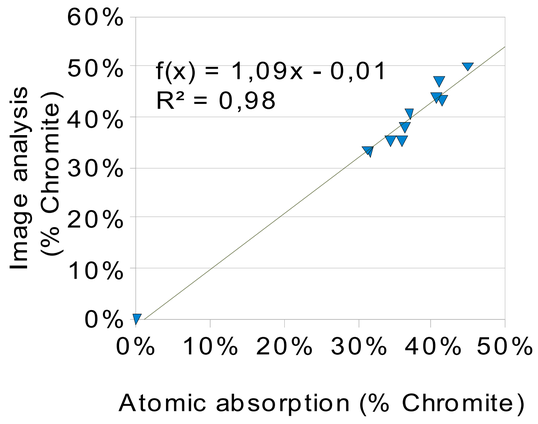
Fig.3

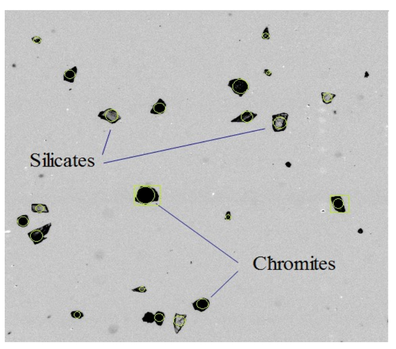
Particle size

The drawback of image based analysis is that for wide particle size distributions it become difficult to image the coarser and the finer particles at the same time. To tackle this problem a methodology based on multi-scale image acquisition was developed. The principle is to image each particle at its optimal magnification. The particle size resolution results obtains at different magnification are then recombined little by little thanks to the coherence that exists for two close size fractions (Fig.3). So, it is not the global proportion of one size fraction which is measured but the ratio between two adjacent size fractions. Figure 3 shows that three magnifying scales are enough to fit the curve obtain with a six-class sieving procedure.

Particle nature

The feasibility to recognize chromite from silicates minerals in a UG-2 ore was demonstrate previously (Leroy et al., 2011). The use of a specular panel allow to enhance silicates translucency and to achieve a high confidence level for chromite identification in the bulk pictures (Fig.4).





Occhio FC200 image

Fig.4

Results & Perspectives

Chromite content analysis

In view of the variations of chromite head grade at the feed, the difference between the feed and the discharge grade must be normalised by the feed grade in order to compare the surveys with each other. So comes the definition below :

$$Accumulation_i = \frac{(\%Cr_{(DU,i)} - \%Cr_{(MD,i)})}{\%Cr_{(DU,i)}}$$

Where *i* stands for the number of the survey.

This definition is first applied to the head grades (Fig 5a), a linear correlation appears between accumulation and percentage solids. This correlation confirms that segregation occurs in the mill. Then, the same definition was applied for separate size fractions. Accumulation phenomenon is size dependant and mainly affect >106µm particles (Fig 4). In fact, particles >100 µm do not behave like water in a ball mill (Napier et al.,1996).Complete analysis of chomite distribution is shown at fig. 5b.

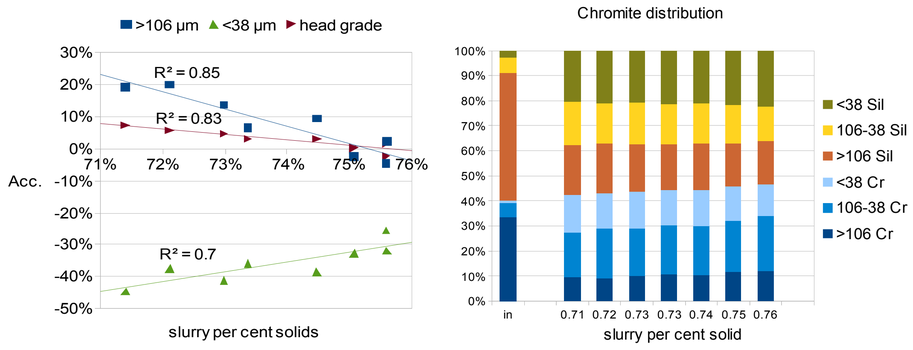


Fig.5

Conclusion & Perspectives

Optical methods could serve for particle characterization in mineral processes. Their interested would be reinforced if more minerals become discernable.

References

❍ *Cawthorn, R G, 1999. The platinum and palladium resources of the Bushveld Complex. South African Journal of Science 95 (November/December), 481*

❍ *Napier-Munn, T J, Morrell, S, Morrison, R D, and Kojovic, 1996. Mineral Comminution Circuits: Their Operation and Optimisation. . JKMRC, The University of Queensland.*

❍ *Leroy, S. et al., 2011, Optical analysis of particle size and chromite liberation from pulp samples of a UG2 ore regrinding circuit, Minerals Engineering*

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