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The autosem ore characterisation of conglomeratic and banded iron formations

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ABSTRACT

Image processing is applied in the calculation of clast sizes for conglomeratic type ore and band width mineral distributions/compositions for banded iron formation (BIF) type ores. Hematite band widths are defined according to hematite mass percent thresholds and were developed to act as a bridging concept between microscopic hematite band widths and macroscopic hand specimen band widths. The difficulties of defining clasts against matrices through automated mineralogy include the occurrence of hematite clasts in a hematite matrix making clast boundaries indistinguishable in a QEMSCAN system. Defining clasts according to size is also problematic since hematite can either form matrix when associated with quartz granules or clasts when associated with clay. After mineralogical classification the ores are crushed to determine liberation and grind size characteristics. The correlations between hematite clast size/hematite band width with liberated grind sizes are compared for use in predictive models.

1. Introduction

The Minerals and Process Research division of the Research department of Anglo American's Technical Solutions developed a methodology for the characterisation of low grade iron ores through the use of its QEMSCAN (EDS–SEM) instruments, supplemented with X-Ray Diffraction (XRD) techniques and Mineral Liberation Analyzer (MLA) instrumentation. EDS–SEM instruments are energy dispersive spectrometers attached to scanning electron microscopes and, in the case of MLA and QEMSCAN instrumentation, are largely automated (Sutherland and Gottlieb (1991), Gottlieb et al (2000), Pirrie et al (2004) and Figueroa et al (2011)). This involved the use of image processing techniques to calculate clast sizes for conglomeratic type ores and band width mineral distributions/compositions for banded iron formation (BIF) type ores. A comprehensive description of BIF textures can be found in Beukes and Gutzmer (2008).

Low grade ore is defined differently according to commodities and the ability to beneficiate the ore into concentrates that are sufficiently valuable for sale (as determined by economics), products or smelting. In the case of iron ore, low grade iron ores are generally defined as presently having an iron content of between 65% and 55% Fe (lower for certain taconite ores) – see: www.exxaro.com/pdf/icpr/a/geology/iron.htm and www.kumba.co.za/reports/kumba_afs_08/res_minerals.php. This generally restricts low grade iron ores to banded iron formations, conglomerates and ferruginous shales, with massive hematite ore being excluded.

The characterisation of lower grade iron ores is becoming more complicated owing to the depletion of world lump iron ore stocks (Geerdes et al., 2009). It is important since pre-treated agglomerates of fine ore (sinters and pellets) are making up a growing proportion of blast-furnace feedstock (currently ~80%) and invariably come from the concentration/processing of iron oxides from lower grade iron ores.

The understanding of lower grade iron ore mineralogy and the subsequent characterisation of lower grade iron ore will allow for the efficient processing of the ores and the optimisation of downstream smelting.

2. Methodology

2.1. Sample preparation

The initial low grade ore samples were cut into rock slabs of 9 cm by 4 cm. The area for cutting was selected to maximise textural features and, where possible, to be in profile across the bedding planes. An area of 8 cm by 3 cm was subsequently analysed.

For liberation analyses, crushed particulates were mounted in 30 mm resin blocks. Sub 1 mm particulates were prepared for

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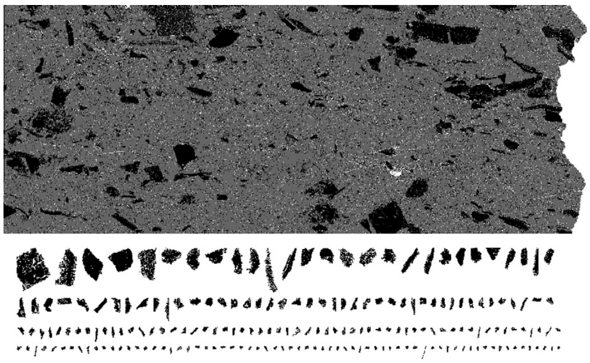

Fig. 1. Image of originally measured slab and subsequent granulation of dark grey/black hematite clasts with erosion and dilation operations having subsequently been applied. White represents (vugular) macro-porosity. Light grey represents clay minerals. Slab is approximately 9 cm × 4 cm.

and measured in MLAs, whilst + 1 mm particulates were prepared for and measured in QEMSCANs.

2.2. Instrumentation

QEMSCAN instrumentation uses computer grey-scale backscatter electron (BSE) imaging in conjunction with a custom-designed X-ray spectral window database to identify phases of interest. MLA instrumentation uses a best-fit model to compare collected EDS X-ray spectra with a spectral library.

For both systems, potential difficulties in analysis occur when phases of similar chemistry have similar average atomic numbers (i.e. similar back-scatter electron intensities) making distinctions difficult. For illustrative purposes, whilst albite and quartz have similar average atomic numbers they are readily distinguishable due to their unique chemistries. Similarly, (also for illustrative purposes) whilst pyrite and pyrrhotite have similar chemistries they are distinguishable due to their unique average atomic numbers. Problem minerals therefore encountered in analysis (and these are specific to this study) may include hematite and magnetite since they share similar chemistries and similar average atomic numbers. It is therefore important to note that QEMSCAN and MLA distinctions between magnetite and hematite are dependent on a number of factors, specifically the surface characteristics of the iron oxides being measured (scratching, plucking, dipping beneath mounting media, porosity, carbon coating thickness etc.) and the degree of ionic substitution being encountered in the iron oxides (in particular Mg, Ca and Mn). The MLA technique tends to produce X-ray centroid measurements, whereby single EDS X-ray spectra are collected for common BSE grey-scale levels, at higher magnifications/lower field sizes (and also at lower working distances resulting in superior resolution). It is thus a preferred

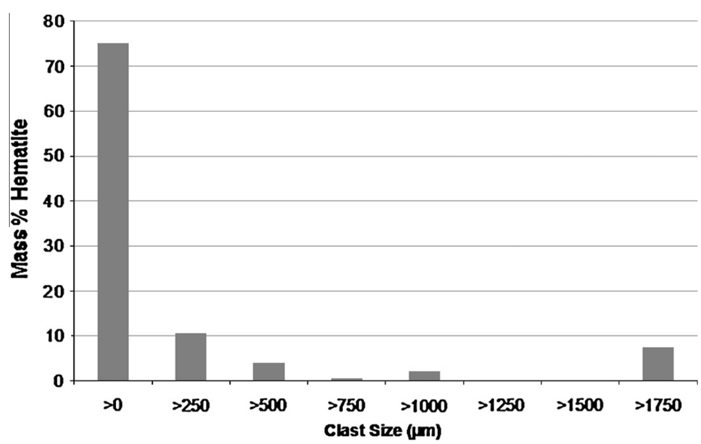

Fig. 2. Example of a clast size distribution histogram for a conglomeratic ore.

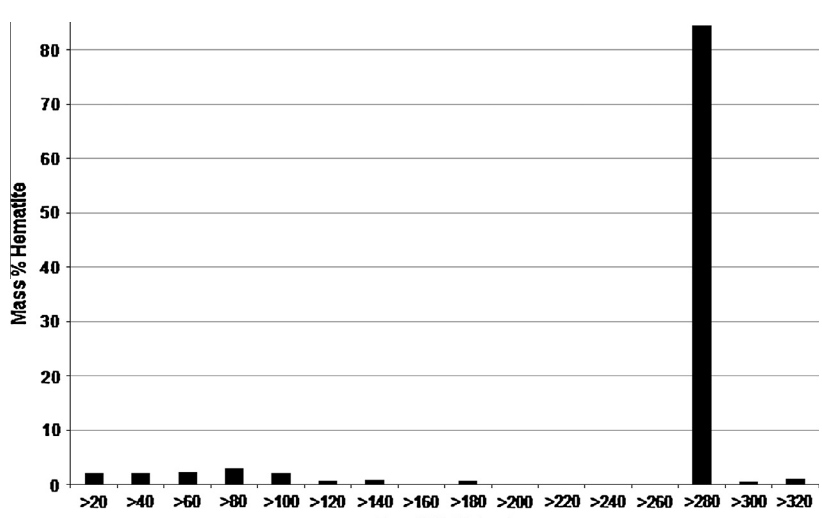

Fig. 3. Example of a micro-band size distribution histogram for a BIF-type ore.