PROCESS MINERALOGY STUDIES OF LOW GRADE IRON ORES USED IN THE PRODUCTION OF PELLET FEED

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Abstract

The study was conducted on low grade Brazilian iron ores to determine the liberation of iron oxides and their associations to the gangue minerals, especially silica, aluminum, and phosphorus bearing minerals. The mineralogical composition of the sample, the degree of liberation and the phase associations of the iron minerals as well as the partition of the main elements and the potential iron recovery were assayed by size fractions through automated image analysis paired with a scanning electron microscope.

Despite the variations in iron distributions in the minerals of interest (29 to 61 wt%, or up to 95 wt% if goethite is considered), the results indicated the possibility of attaining products with Fe-total grades higher than 65 wt% associated with potential recoveries of around 80 to 85 wt%.

Using this approach, the characterization studies proved to be important in predicting metallurgical recovery related to the ore mineral processing and in identifying factors that may interfere with the quality of the final product.

Keywords: low grade iron ore, process mineralogy, automated image analysis

1 INTRODUCTION

The growth of iron ore production due to the strengthening steel market has led mining companies to expand their reserves by improving the technological knowledge of their mineral resources. Moreover, the exhaustion of high grade iron ores (from friable to compact), which usually require only a correct size adjustment, stimulates the study of lower grade iron ores such as banded iron formations (BIF) with high SiO2 grades[1]. These ore types are characterized by intercalations of milimetric to submilimetric iron oxyhydroxides, silicates and/or carbonate layers, and often present complex textures that demand comminution to liberate and separate the gangue minerals. Brazilian iron ores have mostly demonstrated different degrees of weathering, which results in significant modifications in the mineralogical composition, especially regarding the content of goethite and clay minerals.

Depending on the amount of goethite in the concentrate, the Fe-total grade may decrease substantially while the levels of silica, alumina, and phosphorus may be enriched, and these are critical for metallurgical specifications. Furthermore, recent studies have demonstrated changes in ore behavior in mineral processing, especially in the flotation and pellet agglomeration steps [2, 3].

This article presents the process mineralogy studies of three low grade iron ore samples, with distinct alteration degree and complex mineralogy, targeted for the production of pellet feed.

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2 MATERIALS AND METHODS
Experimental procedures for the characterization studies are shown in Figure 1 and described below:
- homogenization and sampling;
- grinding of representative samples below 0.21 mm in a rod mill;
- size analysis through wet screening at 0.15, 0.10, 0.074, 0.044, 0.037, and 0.020 mm sieve apertures;
- desliming of material passing at 0.020 mm, trough 25 mm hydrocyclone (d_{100} 7–10 µm);
- chemical analyses of Fe-total, SiO_2, Al_2O_3, P_2O_5, CaO, and MgO (XRF on fused beads), loss on ignition (LOI) at 1050 °C, Fe^{2+} by titration;
- chemical compositions of mineral phases were determined by scanning electron microscope (SEM) paired with an energy dispersive spectrometer (EDS), including several microanalyses for the major minerals (Quanta600F, FEI & Quantax4030, Bruker). Blocks from each fraction size were mounted, with carbon spheres and a vertical cut for the finer fractions; monolayer sample preparation was adopted for fractions above 0.074 mm;
- mineral identification was supported by SEM/EDS and X-ray diffraction (XRD) through the powder method by XPert MPD diffractometer (PANalytical);
- mineralogical composition, mineral liberation and associations of iron oxyhydroxides were conducted by MLA image analysis system (FEI). Phase discriminations were done in XBSE mode considering the average atomic number contrast as well as the chemical composition of each mineral phase. Goethite discrimination was conducted by considering the BSE threshold (gray level segmentation). Magnetite and hematite discriminations were not determined due to system limitations; therefore, magnetite content was estimated by stoichiometric calculations using FeO grades;
- mineral separations were conducted by heavy liquid (tetrabromethane, 2.95 g/cm^3) and Frantz barrier magnetic separator.

3 RESULTS

3.1 Chemical composition
The chemical compositions of the samples are presented in Table 1. Fe-total grades vary from 26 to 35 wt%, SiO_2 from 41 to 54 wt%, Al_2O_3 from 1.8 to 3.2 wt%, and P from 0.06 to 0.09 wt%. FeO grades range from 0.67 to 24 wt%.

3.2 Mineralogical composition
The mineralogical composition of the samples (total +0.020 mm), highlighted in Figure 2, was determined by MLA and supported by XRD and SEM/EDS analyses. Validation of these results was done by comparing the chemical composition calculated by MLA to the chemical analyses results by FRX.

The alteration degree increases from sample A to B and finally to C, leading to a notable difference in mineralogical composition. Sample A presents magnetite and hematite as ore minerals and a high content of amphibole (principally grunerite). In Sample B, there is an increase in hematite and quartz content while the magnetite tends to zero. Sample C is basically made up of quartz, hematite, and goethite. Residual magnetite is eventually found in Samples B and C as part of the martitization process.

3.3 Particle size analysis
Cumulative distribution curves for weight, Fe-total, FeO, SiO_2, Al_2O_3, and P are presented in Figure 3. The distributions in Sample A were very similar, except for phosphorus, which tends to concentrate in the fines. In Sample B, the only difference was that Al_2O_3 also became finer, similar to the behavior of the