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Drill core texture as geometallurgical indicator for the Mont-Wright iron ore deposit (Quebec, Canada)

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A B S T R A C T

Ore texture has been traditionally used by geologists during geological mapping and logging for mine planning. However, using textural information for mineral processing prediction has been rarely explored. In this paper, the correlation between the ore texture (as observed from the surface of drill cores) and the core samples response to lab scale mineral processing operations was studied for the Mont-Wright iron ore deposit (Quebec, Canada). The potential of drill core textures as a geometallurgical indicator was assessed.

Through the mineralogical characterization of the Mont-Wright textures, differences were observed in the iron oxides liberation and grain size distribution, and in the iron-by-size pattern associated to each drill core texture. These differences were reflected in the samples processing performance: different trends were observed in the comminution response and iron oxides separability by heavy liquid separation. According to these results, a classification of ore textures calibrated to mineral processing performances was established for the Mont-Wright deposit. This classification is intended to serve as geometallurgical indicator.

1. Introduction

Traditionally, the primary assessment of “how well” or “how poorly” the ore will respond to mineral processing has been based on mine geologists’ experience and visual assessments of drill cores. However, in the current context of the mining industry, with challenging lower ore grades and more texturally complex ores, traditional assessments need to be supported by a more accurate characterization of the ore resources.

Geometallurgy has emerged in recent years to achieve this higher level of knowledge in a way to provide models for mineral processing prediction (Dunham et al., 2011, Lamberg, 2011; Williams, 2013; Bradshaw, 2015). By means of extensive -and often expensive- characterization programs, geometallurgy populates block models with suitable parameters to predict the ore processing behavior (Walters, 2008; Powell, 2013; Koch et al., 2015). Since each particular deposit carries its own challenges, each mining project may adopt a different geometallurgical approach (Lishchuk et al., 2015) and develop its own geometallurgical indicators.

The ore meso- and macro- texture is used by geologists on a regular basis during geological mapping and logging. In the past, there have been few attempts to explore the information carried by the ore texture in relation to mineral processing (Bojcevski et al., 1998; Frangomeni et al., 2005). But recently, it was when some attention has been drawn to the study of this feature and its potential application to geometallurgy (Bonnici, 2012; Wightman et al., 2014; Lund et al., 2015).

In this paper, the use of the ore mesotexture (i.e. texture observable with the naked eye) as a geometallurgical indicator is evaluated for the Mont-Wright iron ore deposit (Québec, Canada). At this deposit, the geometallurgical model is under development and different approaches are being considered in order to define the most suitable geometallurgical indicators. At Mont-Wright, geologists and metallurgists have long suspected a link between texture (as observed in drill cores) and ore processing performance. In a previous work, Pérez-Barnuevo et al. (2016) carried out a preliminary evaluation of the potential correlation between the drill core textures and processing performances at Mont-Wright. Results obtained in that work suggested the existence of such a correlation. This work aims at evaluating this potential link and establishing a drill core texture classification correlated to mineral processing performances. If this link can be confirmed, a particular behavior would be associated to a specific drill core texture. Hence, whenever this texture is detected in the deposit, its processing behavior might be inferred from the previously established link.

The paper consists of seven sections. After the introduction given in the first section, the second section describes the six main drill core textures identified at Mont-Wright. Section three provides information

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on samples preparation for characterization and processing stages applied to the samples. Section four shows sample response to mineral processing, namely size reduction and separability of the valuable minerals, and links this response to ore texture. The fifth section contains the mineralogical characteristics of each texture obtained through Mineral Liberation Analyzer (MLA). Finally, in the last two sections, results are discussed and conclusions presented.

2. The Mont-Wright iron deposit

Mont-Wright is an iron ore deposit occurring in the Labrador Trough, located in Northeastern Quebec, Canada. It is the largest open-pit mine in Quebec with an ore having iron content varying between 25% and 35%, and low contents of aluminium, manganese and phosphorus (Neal, 2000). Exploited by ArcelorMittal Mines Canada, Mont-Wright produces annually 25 million tonnes of iron ore concentrate by spirals, grading 66% Fe. More than 90% of the iron ore at Mont-Wright occurs as hematite. The most important unit consists of granular recrystallized specular hematite and minor amounts of magnetite normally found as small inclusions in hematite (Neal, 2000; Petruk, 2000). The main gangue mineral is quartz, which usually presents a sugary texture, with less than 3% of other gangue minerals (especially muscovite, biotite and hornblende, but also Ti oxides, such as ilmenite and Ti-magnetite, and garnet). At the eastern part of the deposit, an amphibole quartz iron formation with higher magnetite content is found (Neal, 2000). Amphibolite (which is a highly altered gabbro) occurs commonly adjacent to or within the iron formation (Neal, 2000).

2.1. The Mont-Wright textures

To identify the most frequent textural patterns at Mont-Wright, eighteen complete drill cores 50 mm in diameter (≈100 m deep for a total of 1500 m) from different representative areas of the deposit were visually examined. Six textural patterns were identified: massive (Ms), bright banded (BBd), dark banded (DBd), mottled (Mo), layered (Ly) and amphibolite (Amp).

The texture nomenclature proposed in this work is intended to describe the visual appearance of minerals in drill core surfaces at the particular deposit under evaluation. Therefore, it is site-specific and does not necessarily correspond to the traditional definition of lithology or mineralogical classes established for BIF deposits.

Fig. 1 shows images of the identified textures taken with and RGB digital camera from the round surface of drill cores. These images cover a 3 × 4 cm drill core surface. According to geologists from the mine, textures (a)–(e) represent around eighty percent of the material feeding the concentrator. The other twenty percent corresponds mostly to gangue or has no recognisable textural pattern. As revealed by Neal (2000), it is not unusual to find the amphibolite within the iron formation, like in Fig. 2b. Hence, its geometallurgical assessment is also important and the amphibolite (Fig. 1f) is considered in this work among the Mont-Wright textures. Fig. 2 shows the variability of textures in drill cores. Normally, as much as three different textures are present in a 6 m drill core sample.

2.2. Polished-thin sections examination

Polished-thin sections were examined under optical microscopy. For each texture, two drill core portions from different samples were randomly selected to prepare polished-thin sections. The objective of this examination was purely qualitative and intended to identify differences in the micro-textures associated to each macro-texture. Special attention was drawn to the grains morphology, relative size and grain boundary relationship between iron oxides and quartz.

Table 1 contains the description of polished-thin sections, along with images taken under optical microscopy in reflected light (RL) and transmitted light (TL). A more detailed mineralogical characterization of the samples is provided in Section 5.

From this examination, some general remarks can be made. Hematite was the dominant iron ore mineral, except for the layered samples where magnetite was more abundant. Quartz grains were of finer size than the iron oxides grains for all samples, except the layered ones; in general, grain boundaries between iron oxide and quartz grains were not intricate, indicating an expected good liberation after grinding.

3. Samples and characterization methods

To characterize each particular textural pattern and its unique metallurgical response, a set of twenty two samples was characterized. These samples were selected after visual examination of six complete holes (≈600 m). Each sample was composed of drill core portions chosen from a continuous 6 m long core, showing the same textural pattern. The selection was manual and strictly based on visual inspection of drill cores. Those portions in the 6 m long drill core with only quartz or with no textural pattern were rejected, as well as altered or not competent portions. This selection criterion was intended to provide samples for the characterization of the individual textures, without interference of other factors (such as alteration or porosity).

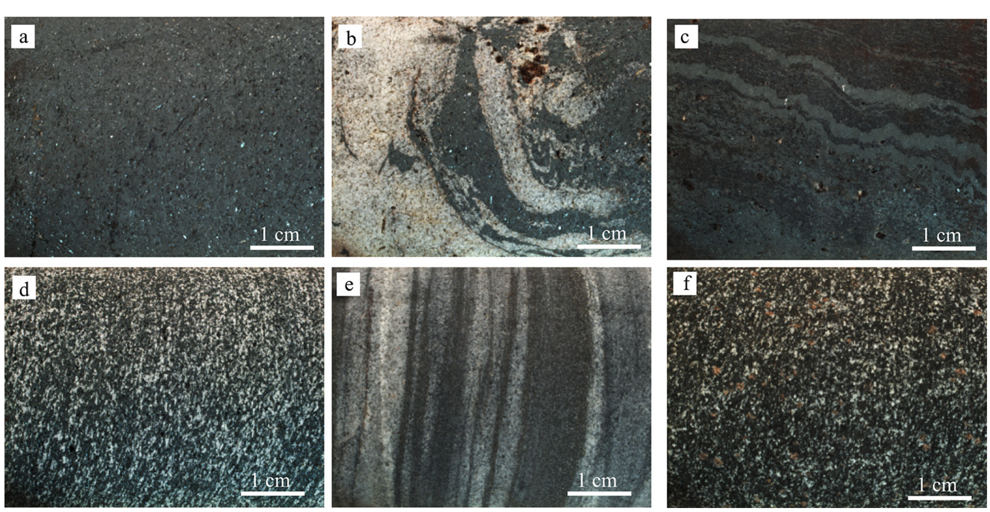

Fig. 1. Most frequent drill core textural patterns identified at Mont-Wright: (a) Massive (Ms). (b) Bright banded (BBd). (c) Dark banded (DBd). (d) Mottled (Mo). (e) Layered (Ly). (f) Amphibolite (Amp).