

Key parameters for low-grade fine-grained iron ore valorization: lower environmental impact through reduced waste.

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In low-grade banded iron formations (BIFs), a large part of the iron is related to micro- and nano- metric iron-bearing inclusions within quartz and/or carbonates, mainly dolomite (~ 20 to $50 \mu\text{m}$). Low-grade fine grained iron ore present two types of environmental risks: a) they are often stocked as tailings. For example, the recent disaster (5th of November 2015) in the Minas Gerais district, Brazil, was caused by the collapse of the Fundão tailings dam at an open cast mine; b) during beneficiation significant amounts of dust are generated also leading to metal loss.

A laminated BIF studied from a drill core at Àguas Claras Mine, Quadrilátero Ferrífero, Brazil, contains 26.71 wt. % total iron, 0.2 wt. % SiO_2 , 0.32 wt.% MnO , 15.46 wt. % MgO , 22.32 wt.% CaO , 0.09 wt. % P_2O_5 , < 0.05 wt. % Al_2O_3 , 0.15 wt. % H_2O and 34.08 wt. % CO_2 . Environmental hazardous elements are present as traces (As: 3-20 ppm, Cd: 0-0.7 ppm; Cr: 0.05-60 ppm, Pb: up to 55 ppm; U: up to 8 ppm). Dolomite and quartz bands alternate with hematite bands. Raman spectroscopy, X-ray diffraction and FIB-TEM analyses reveal that the micro- and nano- metric inclusions in dolomite are hematite and minor goethite, partly occurring as clusters in voids. Curie Balance analyses were carried out at different heating steps and temperatures on whole rock samples and a synthetic mix of decarbonated sample and pure dolomite. X-ray diffraction on the products of the heating experiments shows that that hematite is stable and new phases: magnesioferrite (MgFe_2O_4), lime (CaO), periclase (MgO), portlandite ($\text{Ca}(\text{OH})_2$) and srebrodoskite ($\text{Ca}_2\text{Fe}_2\text{O}_5$) were formed between 680°C and 920°C .

These findings promote the economic use of low grade ores rather than their stockpiling as tailings. The presence of OH-bearing goethite reduces the sintering temperature. After having separated coarse hematite from barren dolomite and quartz, a low temperature sintering of the inclusion-bearing dolomite/quartz leads to transformations into phases with higher magnetic susceptibilities (such as hematite and magnesioferrite). The entire Fe and Fe/Mg oxide feed can then pass through wet-high intensity magnetic separation after crushing. Intelligent processing of these ore types can minimize the two above mentioned risk factors.