

Mineralogical Characterization of Low-Grade Goethitic Iron Ores from Central India: Enabling Sustainable Beneficiation

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Mineralogical characterization plays a crucial role across the mining value chain, from exploration and mine development to waste management and mine rehabilitation. This task becomes particularly challenging when ores are strongly altered and dominated by secondary minerals. In the current industrial scenario, where the demand-supply balance is severely skewed, there is an urgent need either to discover new deposits or to make low-grade ores economically viable.

Mineralogical characterization provides a scientific basis for designing mineral beneficiation strategies. The iron ore deposits of central India are Precambrian in age (2.6-2.7 Ga) and have been significantly affected by tectonic activity. As a result, they contain abundant secondary alteration phases, such as goethitic ore.

In this study, low-grade goethitic iron ore samples were collected from central Indian iron ore mines. Using gravity separation, magnetic separation, and their combination, it was observed that these low-grade ores can be upgraded from 55 wt% Fe to about 58 wt% Fe without substantial size reduction. The samples were first screened, and the +1 mm fraction was treated using an air classifier followed by a Wet High-Intensity Magnetic Separator (WHIMS). In a parallel route, the same sample was ground to $-45\ \mu\text{m}$, identified as the optimum liberation size from mineralogical studies, and these fines were also processed with an air classifier followed by WHIMS. The magnetic fraction of the finer material exhibited consistent quality improvements over the 5000–9000 Gauss range: Fe_2O_3 increased by approximately 4% on average, while SiO_2 and Al_2O_3 each decreased by 2-3 wt%, and LOI decreased by about 2 wt%. Overall, this flowsheet upgraded the finer fraction from 55 to 58 wt% Fe, demonstrating its potential as an effective dry beneficiation route for low-grade goethitic iron ore with significant cost benefits.