Magnetite Ores and the Green Steel Revolution: A Global Outlook on Resources and Future Prospects

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The drive to decarbonise the steel sector has led to renewed focus on high-grade magnetite ores (≥68% Fe) as a suitable feedstock for Direct Reduced Iron (DRI) production. These ores present a viable pathway to lower-emission steelmaking. However, their economic competitiveness hinges on several key factors, including deposit tonnage, head grade, recovery potential, mineralogical properties, comminution performance, and beneficiation requirements.

This study compiles and analyses global data on magnetite ore deposits to evaluate their suitability and constraints in the context of low-carbon steel production. Banded Iron Formation (BIF)-hosted magnetite systems represent the principal global source, with major operations across Canada, Western Australia, and South Australia. These deposits are typically fine grained and require substantial grinding to achieve mineral liberation—an energy-intensive step that elevates processing costs. However, certain BIFs that underwent high-grade metamorphism, such as Scully (Canada) and Warramboo (South Australia), contain coarser-grained magnetite, improving comminution efficiency and reducing energy consumption.

Other important sources include Iron Oxide-Apatite (IOA) deposits (e.g., Kiruna, Sweden; El Laco, Chile), with high Fe grades but requiring phosphorus removal, and Iron Oxide-Copper-Gold (IOCG) deposits (e.g., Marcona, Peru) associated with sulphur-rich gangue. Skarn-hosted deposits, such as Savage River (Tasmania), produce high-grade magnetite concentrates despite smaller scale. Layered mafic-ultramafic intrusions (e.g., Balla Balla, Western Australia) provide coarse-grained magnetite with potential for vanadium and titanium by-product recovery.

Processing magnetite ores involves energy-intensive crushing, grinding, and magnetic separation, with grain size critical to beneficiation efficiency. High-grade metamorphosed BIFs hold a significant advantage due to coarser grains, larger resource volumes, and lower deleterious element contents. While magnetic separation remains the main beneficiation method, selective flotation is sometimes necessary to meet concentrate quality targets. Optimising geological understanding and processing strategies is crucial to ensure the economic and environmental sustainability of magnetite ores in supporting the transition to green steel.