The Mount Tom Price Iron Ore Deposit (Hamersley Province, Western Australia)—3D Structural Evolution and Implications for the Formation of High-Grade Iron Ore

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The banded iron-formation (BIF)-hosted Mount Tom Price iron ore deposit is the second largest known high-grade hematite deposit in the Hamersley Province, Western Australia, and is one of the largest worldwide. With estimated resources of close to 1 Bt of high-grade iron ore (>64% Fe), it has been mined for more than half a century. The formation of these extraordinary resources has been debated since their discovery and various origins have been proposed, ranging from syngenetic, diagenetic, synorogenic, supergene/metamorphic, and hypogene to combined supergene/hypogene models. Although folds and faults are now widely accepted to exert a fundamental control on the location and formation of iron ore bodies, the temporal and spatial relationship of such structures and mineralization often remains ambiguous.

The Mount Tom Price deposit is an ideal location to study the structural framework of a high-grade, BIF-hosted iron ore deposit because of its complexity and the availability of vast amounts of geological data collected over 50 years of mining operations. The deposit is located at the eastern end of the Turner syncline in the extensively deformed central part of the Hamersley Province, which has been affected by multiple compressional and extensional events. Several faults (e.g., Southern Batter, Box Cut, and Southeast Prongs faults) in the deposit have been described and interpreted as fluid pathways for ascending and descending fluids.

Our approach to study the 3D geometry and 4D evolution of the deposit is to visualize the geological structure using 3D implicit (Leapfrog; AranzGeo Ltd.) and explicit (Move; Midland Valley Exploration Ltd.) modelling based on drill hole data provided by Rio Tinto Ltd. The 3D modelling is supported by fieldwork and petrographic and microtectonic studies in order to link deposit- and outcrop-scale deformation to microscale processes.

Our multiscale approach indicates that the development of key structures is controlled by rheological heterogeneities within a banded iron-formation, which comprises multilayers of chert and iron oxides, intercalated with layers of shale and carbonate rocks. Such heterogeneity accounts for complex relationships between brittle and ductile structures and constrains areas of possible mineralization. Faults in the deposit occur as relay or splay faults with normal movement and curved fault planes and are often parallel to steep fold limbs, coincident with shale layers. Folds are strongly noncylindrical, disharmonic, and their geometry depends on layer thickness variations and layer-specific rheological behavior. Our observations indicate that folding is accompanied by faulting due to the strong rheological contrasts between BIF and shales, which are available for reactivation during later deformation. On a microscale, these deformation events are manifested in deformation-induced dissolution-precipitation creep, which leads to significant removal of silica and prepares the rock for later mineralizing fluids possibly circulating along higher permeable fault zones. Comparable structural relationships may be inferred within other structurally controlled deposits of the Hamersley Province.