Paragenesis to processing: Structural and geochemical constraints on gold supply chain optimisation in the Archean Terranes of Western Australia

Mikaela G. Tannert Podesta1

1. Honours Student, The University of Western Australia, Perth, WA, 6009, email: mikahtannert@gmail.com

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# ABSTRACT

The gold supply chain does not begin at the haul road or enterprise dashboard; it starts at the thin section. In the Archean terranes of Western Australia, gold deposits exhibit paragenetic and metallurgical behaviour distinct from other metals. Gold commonly forms during late-stage deformation, often associated with telluride-rich assemblages and micro-inclusions in phosphate minerals, challenging conventional resource modelling and characterisation methods.

To reduce risk and enhance throughput, supply chains must build on an accurate and comprehensive understanding of the geological and metallurgical characteristics, rather than on administrative abstraction. Traditional block models and homogenised scheduling frameworks often fail to capture the complex spatial and temporal variability of gold mineralisation. This gap between geological reality and operational assumptions introduces inefficiencies across mining, processing, and value recovery.

This study reconstructs mineral paragenesis and fluid evolution using high-resolution geoscientific tools, including backscattered electron scanning electron microscopy (BSE-SEM), the TESCAN Integrated Mineral Analyser (TIMA), micro–X-ray fluorescence (μXRF), and laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) for uranium–lead dating of accessory minerals such as monazite and xenotime. It integrates these datasets with structural mapping to generate paragenetic chronologies and fluid pathway models.

Results reveal spatial and temporal compartmentalisation of gold-hosting assemblages that remain undetected by conventional domaining and estimation methods. Incorporating this detail into resource models supports selective mining unit (SMU)-scale scheduling, enhances feed blending strategies, and improves metallurgical performance forecasting, as well as predictability and economic return.

Embedding microstructural and paragenetic data into resource modelling workflows improves ore–waste classification, reduces dilution, and strengthens throughput reliability. Recommendations include integrating in-situ geochronology and structural analysis into estimation models and using this geological intelligence to reconcile model outputs with plant performance. This approach redefines the gold supply chain as an integrated system, where detailed geological insights enhance downstream efficiency, resilience, and value recovery, starting at the thin section.