Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.37797

Predicting Metal Deportment in Granulite-Facies Rocks: A Case Study from the Somerset Trough, Nunavut

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The Paleoproterozoic Somerset Trough on Somerset Island, Nunavut, is a granulite-facies volcano-sedimentary rift basin within the Boothia Terrane on the western margin of the Rae craton. These granulite-facies rocks preserve mineral assemblages that equilibrated at high pressure–temperature conditions and provide a natural laboratory for evaluating how high-temperature metamorphism governs the redistribution of metals in the continental crust. This study examines a representative suite of lithologies including pegmatite, psammite, paragneiss, tonalite, diorite, rhyolite, mafic litharenite, to quantify mineralogical controls on metal deportment across contrasting protoliths. The facies concept, in equilibrium thermodynamics, predicts that rocks of fixed bulk composition stabilize predictable mineral assemblages at defined pressure and temperature conditions. Because metals partition among coexisting phases according to crystal-chemical constraints, systematic relationships between metamorphic grade, mineral assemblage, and metal distribution are expected. Bulk compositions are reconciled with quantitative mineral modes obtained from automated SEM-based X-ray mapping and Mineral Liberation Analysis (MLA), establishing a statistically robust and texturally constrained phase inventory for each sample. Trace-element concentrations in major rock-forming minerals (garnet, pyroxene, feldspar, amphibole, olivine) and accessory phases (sulfides, oxides, phosphates, zircon) are determined by in situ laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS), enabling direct quantification of critical and chalcophile element distribution at the mineral scale. Comparison between mineral-scale trace-element data and bulk-rock compositions identifies the major and minor hosts of metals, resolves discrepancies in elemental budgets, and highlights accessory phases that exert disproportionate control on whole-rock metal inventories. Empirical mineral–mineral partition coefficients derived from coexisting phases are integrated with pseudosections calculated using THERIAK-DOMINO to evaluate how variations in pressure, temperature, and bulk composition influence predicted metal distribution. By linking quantitative mineralogy, in situ trace-element geochemistry, and thermodynamic modeling within a single granulite-facies terrane, this work establishes a systematic and predictive framework for understanding metal deportment in high-grade crust and for assessing the mineralogical conditions that concentrate economically significant elements.