Goldschmidt 2025 Abstract
https://doi.org/10.7185/gold2025.29155

# Sulphur Isotope and Trace Element Evidence for Mineralisation Traits in the Raja Au-Co Deposit, Peräpohja Belt, Northern Finland

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The Raja Au-Co prospect in the Peräpohja Belt, Northern Finland, represents an orogenic gold deposit with atypical metal association. The deposit formed through multi-stage ore forming processes with partial remobilisation of the primary ore [1]. This study integrates sulphur isotope data, trace element analyses, and textural observations of sulphide minerals to develop a detailed genetic model for the deposit.

The development of the Raja deposit initiated by early high-temperature, cobalt-rich metamorphic fluids sourced from the Petäjäkoski formation, which deposited euhedral pyrite (type A) enriched in Co, As, Se, Te, Bi, and Au, with $\delta^{34}S$ values ranging from +2.5‰ to +5.9‰. Subsequent regional metamorphism caused partial desulphidation of pyrite A to pyrrhotite, releasing Au, Co, and other trace elements, leading to the formation of massive pyrrhotite, chalcopyrite, cobaltite, and granoblastic pyrite (type B) as well as Au and Bi-Te phases. Late hydrothermal overprint introduced Au-enriched fluids that precipitated relatively heavy pyrite (type C) enriched in Ni, Zn, Cu, Pb ± W, with $\delta^{34}S$ values of +2.3‰ to +7.9‰. Altered pyrite A and pyrite B with intermediate $\delta^{34}S$ and trace element characteristics mark a transitional stage and a shift in fluid composition. Heavier $\delta^{34}S$ values and distinct trace element composition together with inter-mineral variations of pyrite C suggest a change to more oxidising conditions, potentially driven by fluid mixing involving granitic fluids and local crustal assimilation.

Our results suggest that orogenic gold deposits with atypical metal associations could form when base metal systems are subsequently affected by Au-rich fluid activity. This revised genetic model contributes to a better understanding of gold mineralisation in metamorphic belts and should be considered for similar deposits in northern Finland and other regions.

[1] Raicˇ, Molnár, Cook, O'Brien & Lahaye (2022), *Solid Earth* **13**, 271–299.