Cobalt released from stratiform sulfides by metamorphic remobilization: sources of orogenic sediment-hosted Cu-Co deposits

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Sediment-hosted copper deposits (SCDs) within Paleoproterozoic graphite schist and marble units in the south section of Tran-North China Orogen are important Co and Cu producers in China. The uncertainty of ore genesis models, including low-temperature stratiform sulfide diagenesis, a seafloor exhalative formation origin, and a metamorphosed sedimentary ore model, is primarily due to poor constrains regarding the mineralization timing and ore-forming process. In the graphite schist (protolith of sulfidic shale), the deformed stratiform pyrite (Py I) have high $\delta^{34}S$ values (SIMS: 22.75 ± 0.57 ‰), indicating a complete bacterial sulfate reduction in the Paleoproterozoic sulfate-limited seawater. Lightly heavy iron isotope (*in-situ* $\delta^{56}Fe$ 0.90 ± 0.16 ‰) and cobalt-rich in Py I, suggest metal elements, including Fe, Co, Ni, Cu, preliminarily trapped in sulfidic ocean post great oxygenation event. Some Co-poor euhedral pyrite newly formed in metamorphic veinlets have slightly lighter $\delta^{34}S$ valuesand heavier $\delta^{56}Fe$ values than Py I, indicating cobalt is mobilized from Co-rich Py I through deformation and dissolution during orogenic fluid infiltration. recrystallized from Py I. The great variable of sulfur isotope in hydrothermal pyrite (Py-III) from mineralized veins, implies a thermochemical reduction of sulfate. Methane, from hydrothermal alteration of graphite, acted as a reducing agent for the thermal reduction of sulfate at high temperatures. New metamorphic apatite U-Pb age (1844 ± 25 Ma) from meta-evaporite is consistent with the molybdenite Re-Os isochore age (1819 ± 10 Ma) from sulfides bearing veins, further supporting a coincidence of orogenesis and mineralization. This study highlights the importance of metal pre-enrichment in the sulfidic ocean and upgrading through orogenic mobilization for the formation of SCDs hosted in the metamorphic terrance. Furthermore, it demonstrates the diverse styles of orogenic ore mineralization.

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