Goldschmidt 2024 Abstract
https://doi.org/10.46247/gold2024.23641

Thallium and copper isotope compositions for Norilsk sulfide ores

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Non-traditional stable isotopes are increasingly being used to characterize the genesis of metal deposits as they provide new insights into the sources of metals, the chemistry of fluids, and the mechanisms of metal enrichment. Some isotopic systems are more common, such as copper (Cu), whereas others have seen only recent application. Here, we present new whole-rock thallium (Tl) isotope compositions of sulfide ores for the Norilsk Cu–Ni–platinum-group element (PGE) magmatic sulfide deposit and combine them with Cu isotope data of sulfides. The samples represent disseminated (n = 6) and massive sulfide ores (n = 7), with the former comprising silica matrix and 2-10 % of sulfides (pyrrhotite, chalcopyrite and pentlandite in sum) and the latter comprising ~ 98% sulfides (pyrrhotite, chalcopyrite and pentlandite in sum). Sulfides from disseminated and massive ores exhibit δ^{65}Cu values of 0 ± 0.3 ‰ (shown as δ^{65}Cu, which is the ^{65}Cu/^{63}Cu ratio relative to SRM NIST 976), whereas bulk-rock ε^{205}Tl values vary between -3.9 ± 1.1(n = 6) and -5.3 ± 3 (n = 7) for disseminated and massive ores, respectively (shown as ε^{205}Tl, which is the ^{205}Tl/^{203}Tl ratio relative to SRM NIST 997). These variations cannot be explained by post-magmatic alteration, contamination, or fractional crystallization. No correlation exists between δ^{65}Cu values of sulfides, and bulk-rock trace-element and PGE contents. Bulk-rock Tl contents strongly correlate with S contents and Cu/Ni ratios (r^2 = 0.93) for disseminated ores, whereas no correlation exists in the massive ores. We interpret this as Tl being preferentially concentrated in chalcopyrite that formed from an immiscible sulfide liquid and not fractionating significantly during the evolution of this sulfide liquid (i.e., between Fe-rich monosulfide solid solution and Cu-rich intermediate solid solution). No correlation exists between δ^{65}Cu and ε^{205}Tl, but a moderate (r^2 = 0.45) correlation is evident between ε^{205}Tl and Pd/Pt. These wide ranges of δ^{65}Cu and ε^{205}Tl may reflect heterogeneity of the mantle source or indicate a metasomatically altered mantle source.