Cu isotope fractionation by Cu–PGE mineralizing processes in the Eastern Gabbro, Coldwell Complex, Canada

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Equilibrium isotope fractionation factors are expected to be small for heavy elements at high temperatures. Chalcopyrite from the Cu–PGE sulfide deposits in the Eastern Gabbro of the Coldwell Complex, Canada, however, exhibit δ^{65}Cu values that range over 2‰. In the Marathon deposit, the values range from -1.49 to 1.07‰, with Footwall Zone having the lightest values and W Horizon the heaviest. Mineralization in the Four Dams and Area 41 occurrences (N of the Marathon deposit) largely have mantle δ^{65}Cu values (0.06 ± 0.20‰) [1]. Numerical modelling of δ^{65}Cu–Cu/Pd–S/Se of mineralization in these deposits suggests that i) sulfide segregation exhibits no measurable control on the δ^{65}Cu of sulfides at reasonable degrees of segregation (<0.3%) [2], ii) contamination by Archean sedimentary rocks can modify Cu isotopes from typical mantle values, and iii) R factors <100,000 can exhibit significant control on the δ^{65}Cu of sulfides.

The range of δ^{65}Cu–S/Se–Cu/Pd in the Marathon deposit is attributed to the addition of Archean sedimentary Cu to a pool of sulfide liquid located at depth, followed by progressive dilution of the contaminated signature and decrease in Cu/Pd ratio by influxes of uncontaminated pulses of magma (i.e., increasing R factor). Some of the magma pulses had Cu isotope compositions heavier than the mantle resulting from their variably metasomatized mantle source. Variably contaminated and enriched (with respect to Pd) sulfides from this pool were entrained in these pulses and emplaced to form the Footwall Zone (most contaminated), Main Zone, and W Horizon (least contaminated) of the Marathon deposit. The largely mantle δ^{65}Cu, but lower- and higher-than-mantle S/Se and Cu/Pd, respectively, observed at Four Dams and Area 41 were likely the result of sulfide segregation at depth and contamination by S-depleted igneous rocks. This demonstrates that Cu isotopes can be used to characterize mineralizing processes in Ni–Cu–PGE sulfide deposits and for identifying zones of PGE enrichment

[1] Liu *et al.* (2015) *EPSL* **427**, 95–103, [2] Barnes & Ripley (2015) *RiMG* **81**, 725–774.