Nd-Pb-Os and Cu-Zn isotope systematics of Urals VHMS deposits

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Coupled radiogenic (Sm-Nd, Pb-Pb, Re-Os) and stable (Cu, Zn) isotope systematics have been performed within ore facies, host rocks and sediments from the Paleozoic VHMS deposits in Southern Urals, Russia.

Lead isotope composition is constant within a single ore deposit but shows a progressive increase from early fore-arc environments to intra-arc and back-arc settings. The unradiogenic lead values of the VHMS deposits in fore-arc setting may be due to the lead input from the subducted MORB-like oceanic crust and overlaying depleted mantle in Orovician – Early Devonian. About 380 Ma ago (Middle Devonian), subduction of sediments and continental fragments has provoked a metasomatism of the depleted mantle wedge, expressed in LREE enrichment, low εNd values and radiogenic lead isotope composition. Devonian VHMS deposits in rifted-arc and back-arc settings display the highest radiogenic lead composition, reflecting a metasomatized mantle wedge signature.

Re-Os isotope data for three studied deposits defines a best-fit line corresponding to a Late Devonian age of 366 ± 5 Ma. This age could indicate a late Os isotope reequilibration associated with long living hydrothermal processes attending formation and closure the Urals paleo-ocean. In each deposit, the Re/Os ratio and initial $^{187}Os/^{188}Os$ isotopic compositions decrease from early stage sub-seafloor hydrothermal ore facies to reworked clastic sulphides and metalliferous sediments deposited at the top of the deposit. This range of Os isotopic values reflects variable degrees of mixing between hydrothermal fluid ($^{187}Os/^{188}Os \sim 1.3$) and Devonian seawater ($^{187}Os/^{188}Os \sim 0.2$).

The role of mineralogy, temperature and redox conditions on the Cu and Zn transition metals stable isotopes fractionation processes has been evaluated locally using hand sample specimens of sulphide assemblages collected in a single hydrothermal vent chimney, stockwork and reworked clastic sulphides from the Alexandrinka Deposit. Results show the equilibrium partitioning of isotopically light Zn into chalcopyrite during sub-seafloor hydrothermal-metasomatic ore formation. The local enrichment in zinc heavy isotopes toward the rim of the chimney is best interpreted in terms of a temperature gradient controlled fractionation factor and/or local distillation fractionation exaggerating a small inherent mineralogical fractionation. Post-depositional seafloor oxidative dissolution and re-precipitation in the clastic sediments led to systematic negative shifts in Cu and Zn isotope compositions relative to primary sulphides.