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New insights into the behaviour of Cu and Zn isotopes in ore-forming systems from the Alexandrinka VHMS deposit, S. Urals

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New analytical protocols for high-precision Cu and Zn isotope measurements of silicate and sulphide samples using multiple-collector inductively coupled plasma mass spectrometry (MC-ICP-MS) have been validated using ore materials from the Alexandrinka Volcanic-Hosted Massive Sulphide (VHMS) deposit, Southern Urals. The Alexandrinka ores show significant spatial and mineralogical isotope heterogeneity, with a spread in Cu and Zn isotopic compositions of 0.36 and 0.44 ‰ per atomic mass unit (amu^{-1}), respectively, relative to the long-term reproducibility of 0.035 ‰ amu^{-1} (2SD).

For Cu, samples from the stockwork zone and the paleo-hydrothermal vent complex show no significant isotopic variability, suggesting bulk isotopic fractionation of Cu during the genesis of primary Cu minerals was negligible, or that such fractionation effects were easily homogenised by continued fluid flow. By contrast, Zn isotopic compositions in the stockwork show a dependency on mineralogy, with sphalerite-bearing samples yielding isotopically heavy compositions of ca. +0.2 ‰ amu^{-1} relative to chalcopyrite. This behaviour is tentatively linked to equilibrium isotopic partitioning of Zn between sphalerite and chalcopyrite during primary mineralisation. Zinc isotopes also show a trend towards heavier compositions from core to periphery across a preserved hydrothermal chimney wall by up to +0.13‰ amu^{-1}. The exact cause of this variation remains unclear, although it may indicate a temperature and/or compositional dependence on Zn isotopic discrimination effects associated with sulphide precipitation. Secondary Cu sulphides in clastic ores derived from the degradation of the hydrothermal vent system exhibit a range of Cu isotopic compositions that are skewed towards isotopically light values relative to primary chalcopyrite by up to –0.29 ‰ amu^{-1}. No similar trend occurs with Zn isotopes. This behaviour is consistent with Cu isotopic fractionation associated with the reduction of Cu(II) to Cu(I) during secondary supergene mineralisation within the clastic sulphide pile.

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Lead isotope investigation of MVT Pb-Zn deposits in Kangdian area, China: Implication for ore genesis

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Although previous studies emphasized a significant difference in Pb isotope values between each individual deposit, this study utilizes more than 115 isotope data including new data plus published values from eight typical deposits of the most typical in order to identify Pb-Zn sources and flow paths for MVT ores in the Kangdian region of Southwest China. The data characterize the isotope systematics of both ore samples and Pb hosted by sedimentary rocks away from ore districts.

Data of Pb isotope from the region have these characteristics: 1)rocks higher in the stratigraphic section contain ores with more radiogenic Pb, eg. Jingshachang ores ($^{208}Pb/^{204}Pb$, 41.972~38.746, $^{207}Pb/^{204}Pb$, $^{207}Pb/^{204}$ Pb,16.140 ~15.385; $^{206}Pb/^{204}Pb$, 21.350~18.925), hosted in upper Dengying formation, and Qilingchang ores($^{208}Pb/^{204}$ Pb, 39.487~38.749, $^{207}Pb/^{204}$ Pb, 15.855~15.664; $^{206}Pb/^{204}$ Pb, 18.530~18.251) , hosted in Carboniferous carbonate rocks, contains lead that is more radiogenic than that in galena and sphalerite from Tangjia mine ($^{208}Pb/^{204}Pb$, 38.066~37.729, $^{207}Pb/^{204}Pb$, 15.677 ~ 15.567;$^{206}Pb/^{204}Pb$,17.916~17.831) and Tuangbaoshan ores ($^{208}Pb/^{204}Pb$, 39.191~38.469, $^{207}Pb/^{204}$ Pb, 15.820~15.776; $^{206}Pb/^{204}Pb$, 18.647~18.369), hosted in middle and lower Dengying formation and nearly uncomformit between Dengying formation and metamorphic basement. 2) data from Jingshachang are notable for having a higher ^{208}Pb and ^{206}Pb for a given^{207}Pb compared to the other districts ores, and similar to its host rocks (phosphorite); 3) data from the Dalingzi and Tianbaoshan deposits plot in an arrays ($^{208}Pb/^{204}$ Pb, 41.810~37.274, $^{207}Pb/^{204}Pb$, 17.18~15.217; $^{206}Pb/^{204}Pb$, 19.880~17.587). The two deposits are typical fault control and the largest scale deposits in the Kangdian district. 4) except Qilingchang, all the other deposits have the overlapped Pb isotope values ($^{208}Pb/^{204}$ Pb, 39.050~38.032, $^{207}Pb/^{204}Pb$, 15.803~15.514, $^{206}Pb/^{204}Pb$, 18.596~17.831) which are characterized by having a relative lower Pb isotope values, similar to those of rocks from Dengying and basement.

This study suggests that the main Pb-Zn sources are derived from lower Dengying dolomite or/and the metamorphic rocks of the basement and upper Dengying phosphorite, and that the fluids paths are these two unconfromits: the lower one between Dengying formation and the basement, and the upper one between Dengying formation and Cambrian. the mixing of fluids traveling along separate aquifers results in the precipitation of ore

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