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Cu- and Zn-isotope systematics of seafloor hydrothermal vent fluids from a back-arc setting (Manus Basin)

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Unique seafloor hydrothermal processes combine in back-arc basins (BAB) to produce a wide range of vent fluid chemistry and mineral deposits, which are generally considered as critically important for the genesis of volcanogenic massive sulfide ore deposits. While it has become apparent that volatile-rich magmatic fluids play a crucial role in many BAB hydrothermal systems, the source of metals to the vent fluids, including ore-forming metals such as Cu, Zn and precious metals such as Ag and Au, has been a matter of debate [1]. Here, we applied coupled Cu and Zn stable isotopes to delineate if metal enrichment patterns in back-arc hydrothermal systems reflect (1) water-rock reactions with felsic host rock at low pH, (2) direct input of metal-rich magmatic volatiles, (3) remobilization from previously deposited sulfide or enriched source rock compositions.

We measured Cu and Zn isotope composition of hydrothermal fluids from ten vents located in the eastern Manus BAB, Papua New Guinea (cruise MLGN06MV, R/V Melville, ROV Jason II). Purified samples were measured by MC-ICP-MS (Neptune) at IFREMER and data were corrected from instrumental mass bias using internal normalization [2], with an overall precision of 0.03‰ (2s). Cu isotopic ratios were reported relative to the NIST SRM 976 standard while Zn isotopic ratios were reported relative to IRMM 3702, having a δ66Zn value of 0.3‰ relative to Lyon-JMC standard.

For the first time, Cu isotope composition of seafloor hydrothermal fluids were investigated and results show systematic enrichment in heavy Cu isotopes relative to basalt values (δ65CuNIST976= 0.3‰ +/- 0.2‰ n=30). In general, the variations of δ65Cu values in hydrothermal fluids are consistent with δ65Cu values in chalcopyrite lining hydrothermal chimneys. In some case, heavier δ65Cu values of Cu-sulfides related to Cu in the fluids are interpreted to result from Cu-isotope fractionation during Cu oxidation and precipitation within local chimney environments. Zn isotope compositions are also heavier than basalt values (δ66ZnJMC ranging from -0.04 to 0.94‰ but lack any correlation with δ65Cu values. Those values are in the same range of the East Pacific Rise vent fluids (δ66ZnJMC=0.00 – 1.04‰ [3]) and show a similar negative correlation with the fluid temperature. Overall, the variability of both δ66Zn and δ65Cu are interpreted to result mostly from sub-seafloor precipitation/redissolution processes, rather than evaporation/condensation of metal-rich magmatic fluid at depth.

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