Zn Isotopes as a Tracer of Magma-Assisted Ore Mobilization at the Balmat, NY Sedex Zinc Deposit

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The large, carbonate-hosted Sedex sulfide deposit in the Adirondack Lowlands at Balmat, NY, was remobilized during amphibolite facies metamorphism associated with the Shawinigan orogeny, ~1160 Ma. Unusually large distances of ore remobilization, up to 700 m laterally across stratigraphy in shear zones, and up to 2000 m down plunge, are reported from underground mapping. These distances are conservative in that some ore bodies cannot be connected to a specific point of origin. Remobilization at this scale is believed to be possible only with the assistance of fluids.

Micropetrographic analysis of ores from Balmat has identified As-bearing polymetallic mineral assemblages that must have been molten under regional metamorphic temperatures (ca. 650°C). The As-rich sulfide magma migrated along crystal boundaries within the ore, scavenged metals from primary ore minerals, and migrated to low-stress settings where it crystallized.

The zinc isotopic composition of 38 sphalerite samples from 6 different ore bodies was measured, with samples chosen to monitor changes with increased distance of remobilization along plunge. Our results show that overall, there is significant fractionation within the deposit, with $\delta^{66}Zn$ ranging from -0.7‰ to +0.6‰. Two ore bodies that exhibit little to no remobilization across stratigraphy show little fractionation of Zn, and display no systematic trend in $\delta^{66}Zn$ with position within the orebodies. The four ore bodies displaying extensive cross-stratigraphic remobilization show a greater degree of Zn fractionation; three show a linear decrease in $\delta^{66}Zn$ with increasing remobilization distance. The 4th remobilized orebody has uniform $\delta^{66}Zn$, but all samples are fractionated toward lighter isotopic enrichment.

These results indicate that low-percentage partial melting of sulfides along grain boundaries facilitated solid state flow, leading to the large degree of ore remobilization at Balmat. This process also led to measurable Zn isotopic fractionation that correlates with distance of remobilization. As such, variations in $\delta^{66}Zn$ may provide a new means of exploring for parent orebodies at Balmat.