Clumped Isotope Thermometry in MVT Carbonates: Insights into Ore-Forming Temperatures and Fluid Evolution

Hashindra Herath[1], Bryce Barney[2], Zeyang Sun[2], Phillip Hays[1], Ethan Grossman[2], Adriana Potra[1]
[1]Department of Geoscience, University of Arkansas, Fayetteville, United States, [2]Department of Geology & Geophysics, Texas A&M University, College Station, United States

Carbonate clumped isotope (Δ47) thermometry is a novel technique that allows for the determination of carbonate mineral precipitation temperatures independent of the oxygen isotopic (δ18O) composition of the precipitating fluid. The Δ47 temperatures coupled with the measured δ18O of the carbonate allow for the calculation of the δ18O composition of the precipitating fluid. The application of this method in ore geology, particularly in the context of Mississippi Valley-type (MVT) Pb-Zn deposits, is an area of research that could answer several long-standing questions on basin evolution and these deposits.

Twenty-two carbonate samples from six MVT districts in the US midcontinent (Northern Arkansas, Tri-State, Southeast Missouri, East Tennessee, Central Tennessee, and Upper Mississippi Valley) have been analyzed to constrain the ore fluid composition and the ore-formation temperatures. This study is the first application of the novel clumped isotope thermometer to these deposits. Typically hosted by platform carbonates, these hydrothermal deposits form from hot, saline basinal fluids. Secondary carbonates form at different stages throughout the paragenetic sequence and can vary between ore districts. All the dolomite (11 samples from Northern Arkansas and East Tennessee) and two calcite samples (Central Tennessee) recorded temperatures comparable with published fluid inclusion data, suggesting ore-stage formation. Cooler Δ47 temperatures measured in the remaining calcites suggest precipitation during the post-ore stage (32-80 °C). Northern Arkansas samples representing multiple mines in the district recorded precipitation temperatures between 118 °C and 141 °C. East Tennessee samples collected from a single mine recorded temperatures ranging from 155 to 173 °C, suggesting a cooling trend in mineralizing fluids migrating from southeast to northwest. Our results provide insights beyond fluid inclusions or 18O thermometry, enhancing our understanding of ore formation in carbonate-hosted hydrothermal systems.