

Sulfide Mineralization in the Franklin Marble at Sterling Mine, New Jersey

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Abstract

The Franklin Marble of Sterling Hill and Franklin Mine, New Jersey is host to a stratiform hypogene nonsulfide zinc deposit (Hitzman et al., 2005). It is unusual compared to other Zn orebodies in that it has a relatively low abundance of sulfide minerals. We have measured the sulfur isotopes of the rare sulfide minerals hosted in the ore deposit and the sulfur isotopes of the trace sulfate hosted in the gangue calcite. The study of these stable isotopes yields important insights into the thermodynamic environment of the Franklin Marble during periods of metamorphism.

We tested the hypothesis that the sulfur in the sulfide minerals is sourced from a thermo-chemical reduction of trace sulfate. We were unable to isolate any trace sulfate in our samples, so this study is inconclusive. Secondly this investigation is concerned with understanding the depositional environment of the Franklin Marble, through the study of carbon, oxygen, and sulfur isotopes. Data from organic carbon $\delta^{13}\text{C}$ values may suggest that the rock experienced a late stage metamorphic fluid.

Hypothesis

The sulfide minerals are the product of a thermochemical reduction reaction with the carbonate-associated sulfate (CAS) in the host carbonate

- H_0 : There is no correlation of $\delta^{34}\text{S}$ between CAS and sulfide minerals.
 H_1 : $\delta^{34}\text{S}$ of CAS and sulfide minerals correlate.



Figure 1: Microdrill



Figure 2: CAS leaching

Materials and Methods

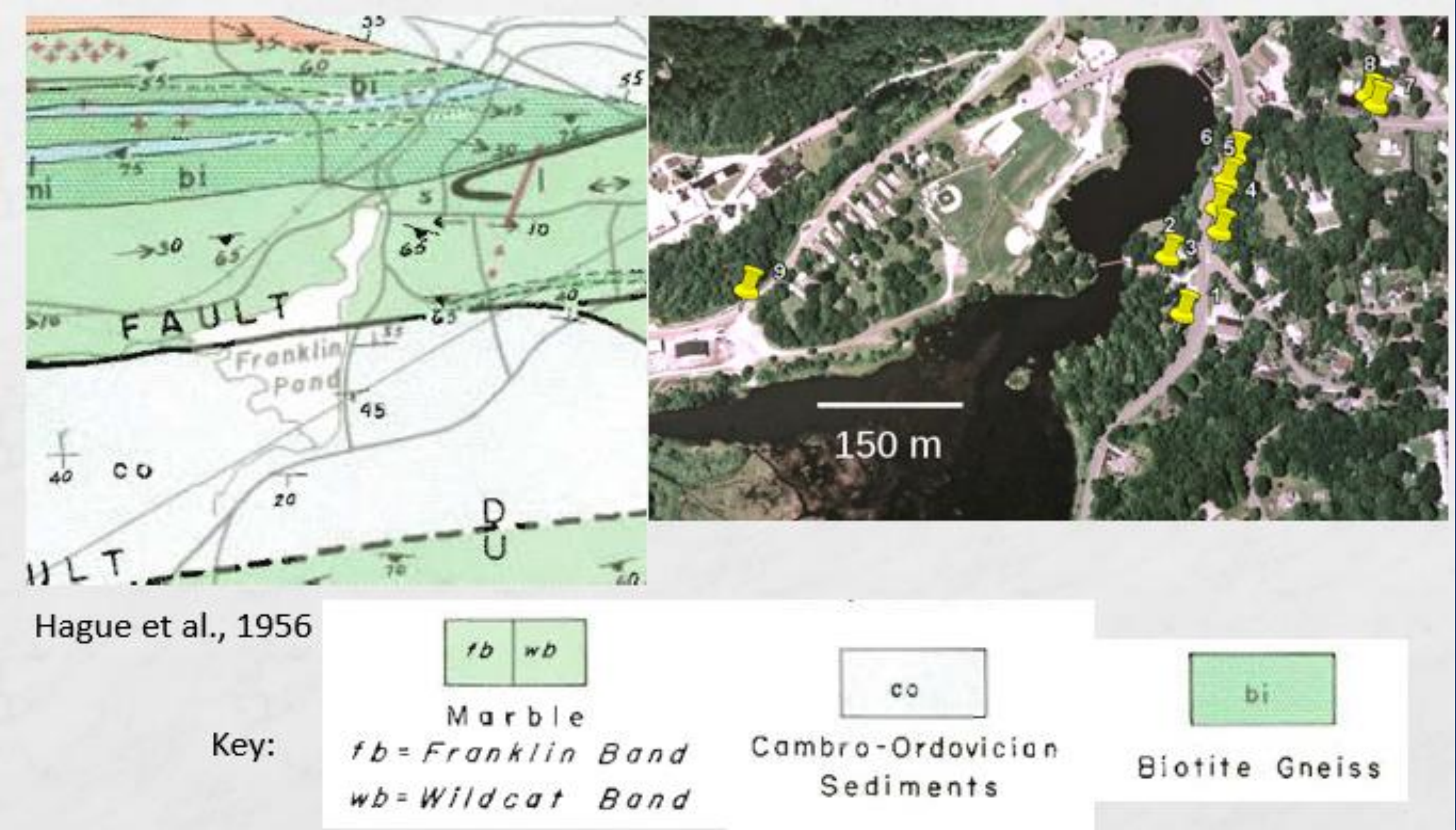


Figure 3: Location of the 9 samples collected along strike, with accompanying geologic map

In September 2012, twenty-four samples were collected at the Sterling Hill Mine in Ogdensburg, NJ. Dr. Rich Volkert of the New Jersey Geological Survey and Dr. Earl Verbeek of the Sterling Hill Mining Museum assisted with the collection.

Nine of these samples are marbles that were collected along strike along Franklin Ave. Eight of these samples were analyzed for their $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ levels in the carbonate carbon (CC), $\delta^{13}\text{C}$ levels in the organic carbon (OC), and $\delta^{34}\text{S}$ levels in the carbonate associated sulfate (CAS).

The remaining thirteen samples are of various composition and were collected from the mine. When cut and polished, four of these revealed macroscopic sulfide minerals that were micro-drilled and analyzed for $\delta^{34}\text{S}$ values.

All mass-spectrometer measurements were done in the Stable Isotope Laboratory (Chemistry 1216), which is supervised by Drs. Evans and Kaufman, and managed by Rebecca Plummer. Carbon and oxygen isotope abundances of the marble samples were analyzed with the MultiFlow peripheral carbonate reaction device in-line with an Isoprime IRMS. Sulfur isotopes in the sulfides and sulfates were analyzed with a Eurovector EA and an Isoprime IRMS. Samples were weighed using a Mettler Toledo AT21 scale.

CAS extraction procedures followed those outlined in Wotte et al. (2012).

Results and Discussion

Sulfide Sulfur

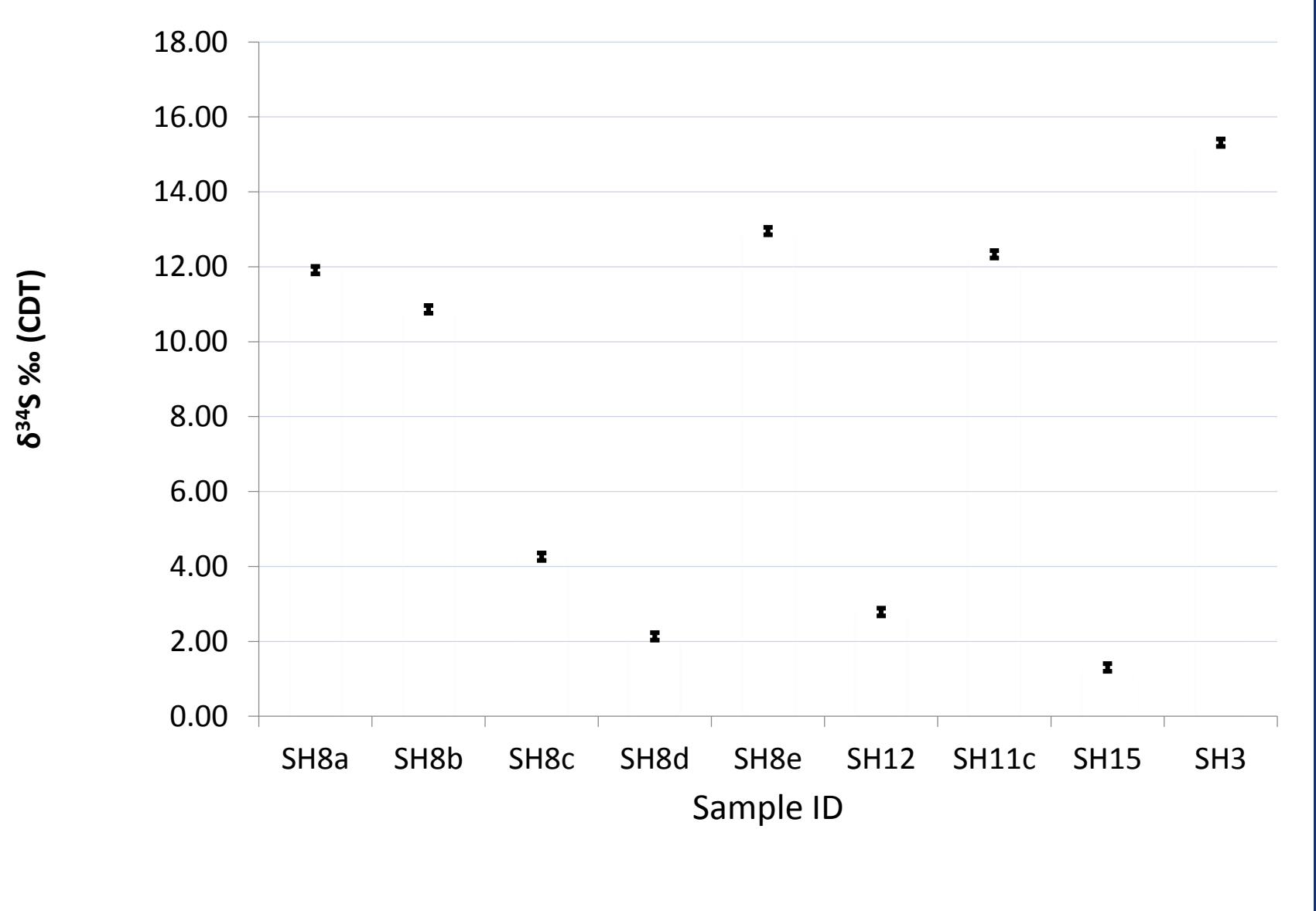


Figure 4: $\delta^{34}\text{S}$ of sulfide minerals

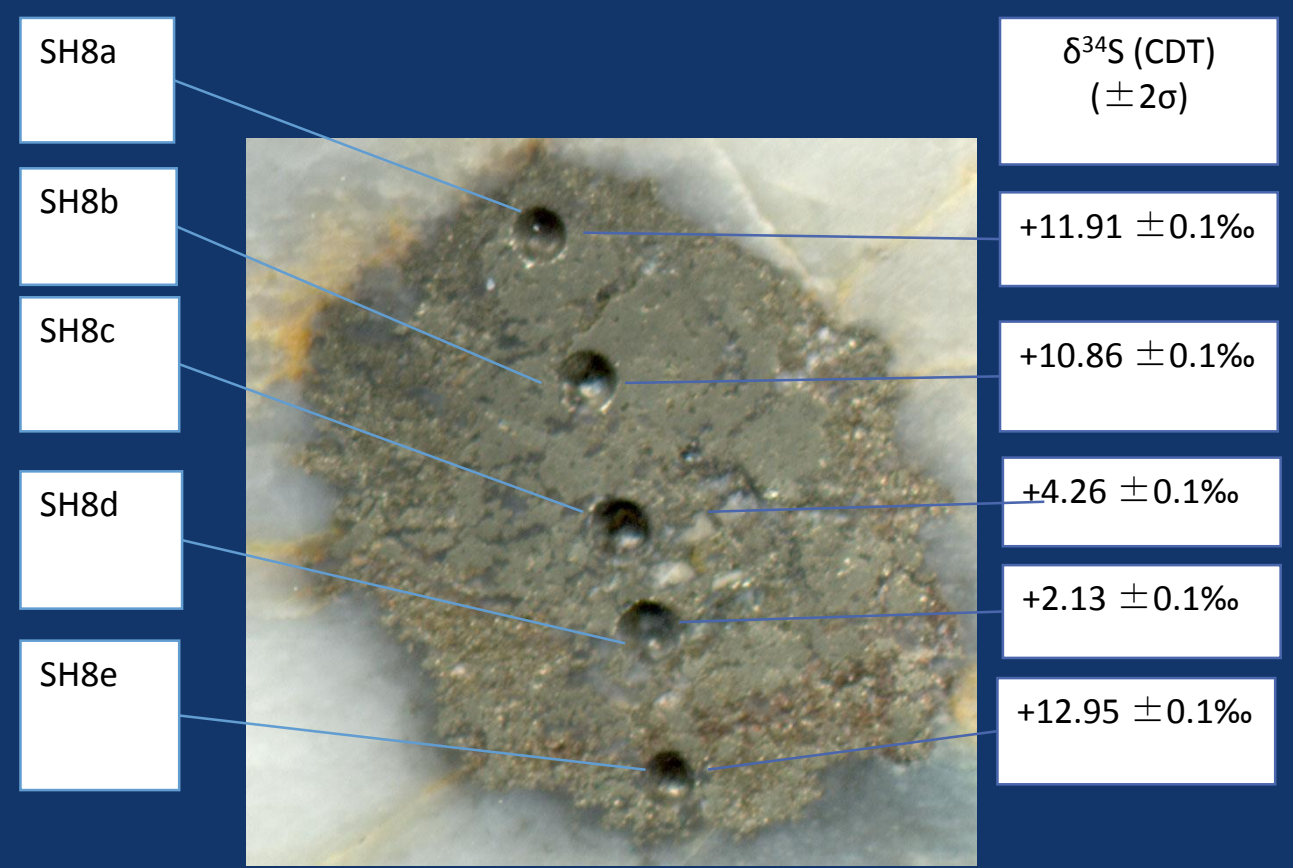


Figure 5, Sample SH8, showing core-rim variation, Field of View: 8.8mm

A total of five sulfide samples were measured for $\delta^{34}\text{S}$. Sample SH8 was measured in 5 different places and shows variation across the grain. Lower $\delta^{34}\text{S}$ values were found in the core than on the rims, suggesting that these sulfide minerals precipitated in a closed system and/or the reaction consumed all of its reactants. Smaller-sized crystals (SH12) seem to have lower $\delta^{34}\text{S}$ values than larger crystals, with the exception of SH15 (galena).

Because the $\delta^{34}\text{S}$ values of the crystals seem to be dependent on size, this suggests that the sulfides precipitated in a closed system with sulfur as the limiting reactant. Alternatively, this could be the result of multiple injections of sulfur-rich fluid, with each injection progressively more enriched in ^{34}S . Correlation with CAS fraction was inconclusive because CAS was absent or not present in a large enough quantity to perform meaningful measurements.

Conclusion

The original hypothesis that the sulfide minerals present at Franklin and Sterling Hill mines are the product of a thermochemical reduction reaction with the carbonate-associated sulfate (CAS) in the host carbonate cannot be adequately answered at this time. No CAS was extracted from the four samples we performed the CAS extraction on. It is still possible that sulfide minerals were sourced from TSR of CAS, and that all of the original CAS has reacted away. To adequately test this hypothesis, many more samples over a wide range must be tested for CAS, as CAS has been elusive so far.