Geochemistry of the Timberville Zn-Pb District, Rockingham County, VA

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Introduction

The Timberville Zn-Pb district, located in Rockingham County, VA, contains about 10 deposits of carbonate sediment-hosted sulfide mineralization. The district is approximately 30 km by 15 km and located in the Great Valley Region of the Appalachians in the Eastern United States. Sulfide mineralization is strata-bound in the Upper Beekmantown dolomite, which is interpreted to be a paleokarst breccia in the Timberville district (Hoagland, 1971). Sulfide mineralization in the Timberville Zn-Pb district is thought to occur after brecciation of the host rock. The primary sulfide mineral present in the Timberville district is sphalerite (ZnS), followed by pyrite (FeS_2), and minor occurrences of galena (PbS), chalcopyrite ($CuFeS_2$), and fluorite (CaF_2) (Herbert and Young, 1956). Sphalerite is common to all locations, but pyrite, galena, fluorite, and chalcopyrite are reported to occur in varying amounts. Appold et al. (1995) suggested, based on sulfur isotope compositions of samples within the district, that sulfide mineralization occurred in two different stages. The presence of zoned sphalerite in at least one location in the Timberville Zn-Pb district is consistent with multiple stages of mineralization.

Hypothesis

- The salinity of fluid inclusions in sphalerite can be correlated to the chemical composition of the host sphalerite.

Sphalerite grains are visibly zoned, on a macroscopic level, within samples from the Bowers-Campbell mine. If the chemical composition or fluid inclusion properties differ between the core and the rim of zoned sphalerite grains, the observed variation could be indicative of a correlation between the chemical composition of the host sphalerite and the salinity of fluid inclusions. This potential variation may support the idea that the regional mineralization of sulfides occurred in multiple stages.

Samples

Four samples were obtained from Stephen Kesler of University of Michigan and used for this study. Two samples originate from the Bowers-Campbell mine (BC-4 and BC-11) (Figure 1), while the other two samples originate from the Weatherholz mine (TW-5 and TW-7.1). Appold et al. (1995) conducted sulfur isotope analyses and fluid inclusion microthermometry on each of the four samples.

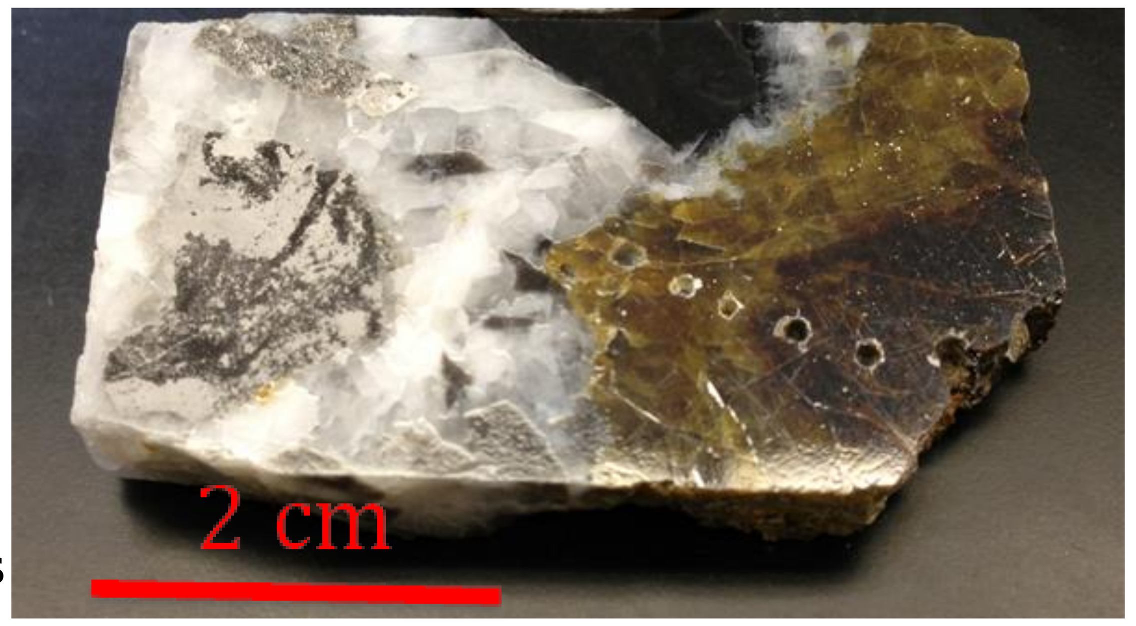

Figure 1: Sample BC-4 from the Bowers-Campbell mine.

Analytical Methods

Analysis	Instrument
Fluid inclusion microthermometry: Freezing point depression	USGS-type gas-flow fluid inclusion stage attached to an optical microscope
Major and minor element concentrations	JEOL JXA-8900 electron probe microanalyzer
Trace element concentrations: . ^{33}S, ^{43}Ca, ^{47}Ti, ^{49}Ti, ^{55}Mn, ^{57}Fe, ^{59}Co, ^{61}Ni, ^{62Ni}, ^{63}Cu, ^{65}Cu, ^{69}Ga, ^{71}Ga, ^{73}Ge, ^{75}As, ^{77}Se, ^{82}Se, ^{85}Rb, ^{88}Sr, ^{95}Mo, ^{97}Mo, ^{107}Ag, ^{111}Cd, ^{115}In, ^{118}Sn, ^{121}Sb, ^{125}Te, ^{137}Ba, ^{197}Au, ^{205}Tl, ^{208}Pb, ^{209}Bi, ^{232}Th, and ^{238}U.	New Wave Nd-YAG 213 nm laser ablation unit coupled to a Thermo-Finnigan Element2 single–collector ICPMS

Fluid Inclusion Salinity

The salinity of the fluid inclusions (FIs), in wt% NaCl equivalent, was calculated from the freezing point depression by using the following equation from Bodnar (1993):

Equation 1: $Salinity = 1.78\theta - 0.0442\theta^2 + 0.000557\theta^3$

where θ is the depression of the freezing point in degrees Celsius. Equation 1 is based on experimental results (Hall et al., 1988).

The salinities of fluid inclusions in Fe-rich yellow-brown sphalerite were found to be distinct, outside of the margin of error, from fluid inclusions in Fe-poor yellow sphalerite (Figure 2).

Minor Element Variation in Sphalerite

Iron is the only element found to vary in sphalerite on a weight percent level, which is reflected in the color of the crystal; thus, it is useful to compare the iron concentration of a grain of sphalerite to the salinity of fluid inclusions in the grain. Figure 2 shows that the two different types of sphalerite are distinct based on salinity and Fe concentration, at the 2σ margin of error.

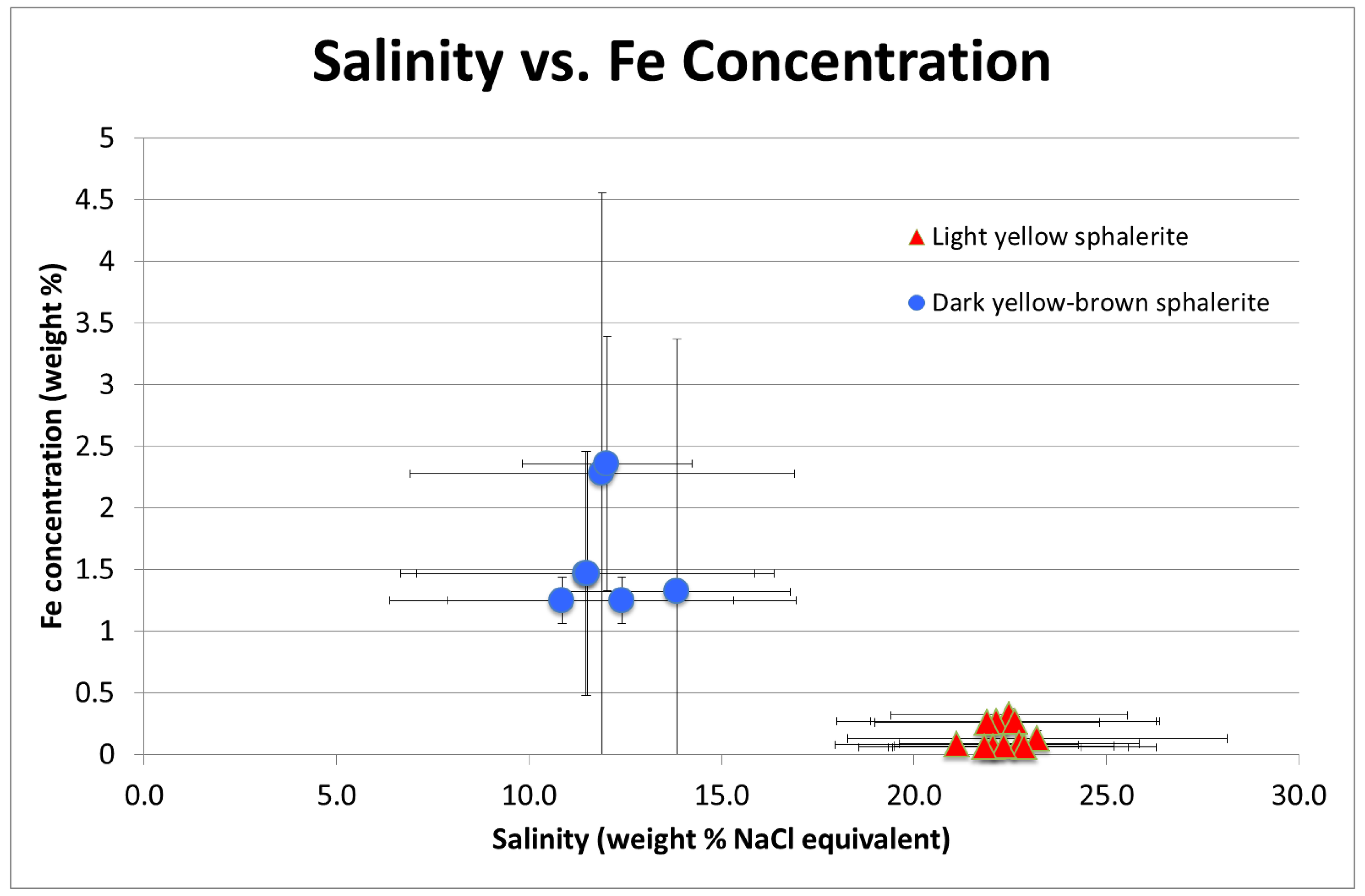

Figure 2: Salinity, in weight % NaCl equivalent, vs. concentration of Fe in grains of sphalerite from the Timberville Zn-Pb district. The error bars represent the standard deviation within a set of analyses.

Trace Element Variation in Sphalerite

Gallium is the only element, of those measured, found to vary between high-Fe and low-Fe sphalerite outside of the 2σ variation within each data set (Figures 3 & 4).

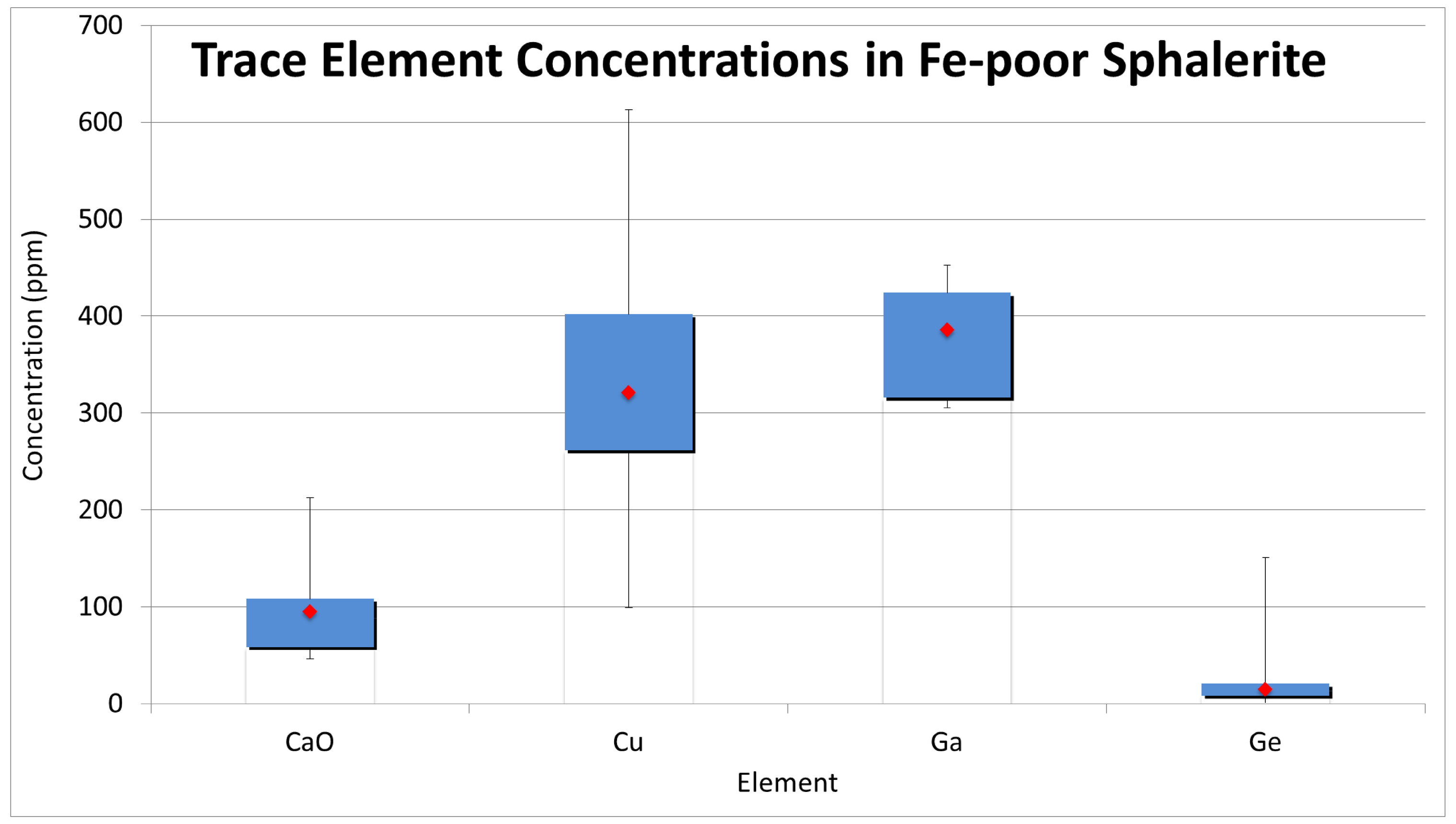

Figure 3: Trace element concentrations of CaO, Cu, Ga, and Ge in dark yellow-brown, Fe-rich sphalerite grains from samples BC-4 and BC-11.

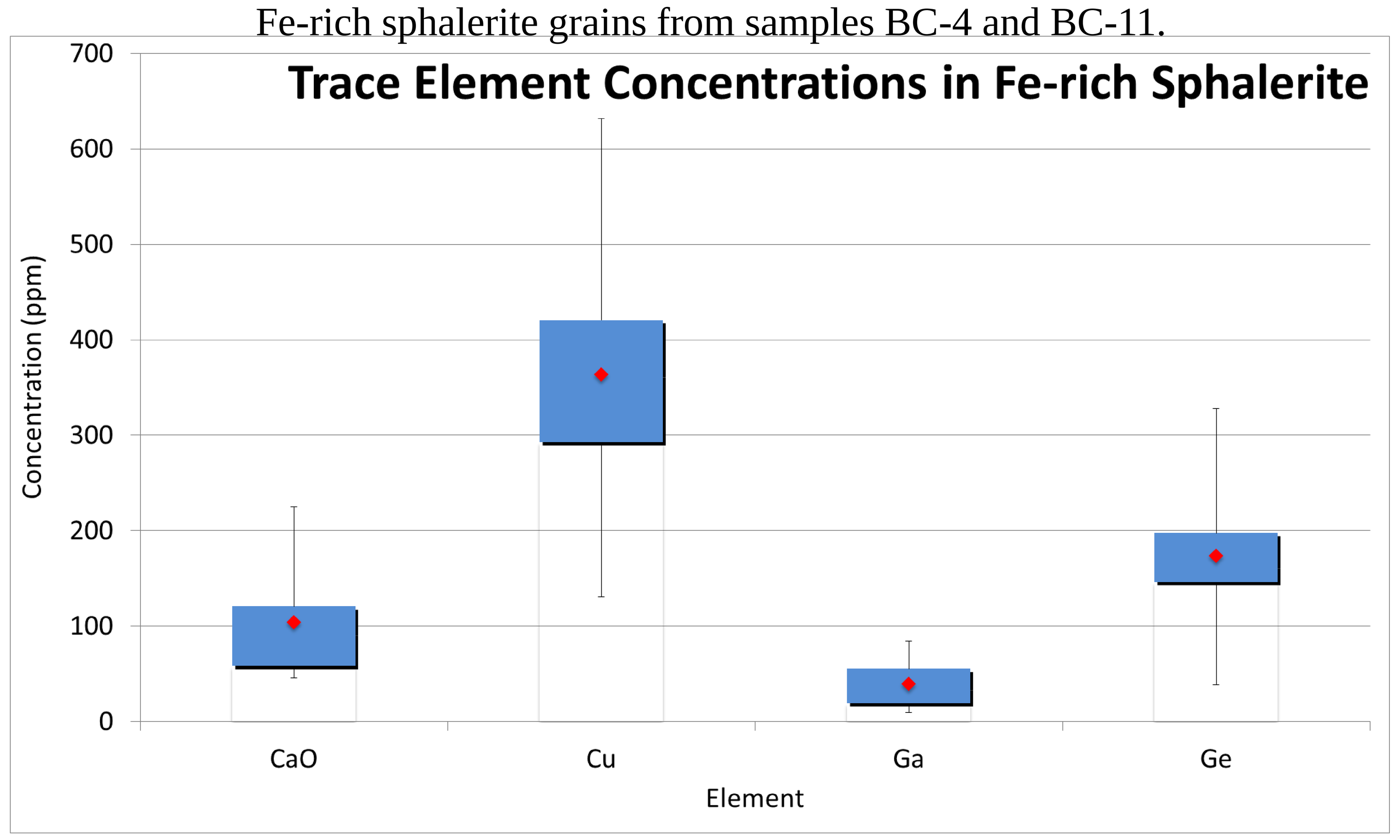

Figure 4: Trace element concentrations of CaO, Cu, Ga, and Ge in light yellow, Fe-poor sphalerite in the set of samples from BC-4, BC-11, TW-5, and TW-7.1

Conclusions

The concentrations of iron and gallium in sphalerite grains from the Bowers-Campbell mine and the Weatherholz mine in the Timberville Zn-Pb district are correlative with the salinity of fluid inclusions in the host sphalerite. Sphalerite with a higher concentration of iron, and therefore a darker color, hosts fluid inclusions with a lower freezing point depression than sphalerite with a lower Fe concentration. The relationship of the concentration of gallium with respect to salinity is conversely proportional to that of iron. This finding supports the conclusion that regional sulfide mineralization occurred in multiple stages, suggested by Appold et al. (1995). This finding also may suggest that two formational fluids, from which sphalerite precipitated, experienced different degrees of mixing during the time periods that light and dark sphalerite were formed.

References

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