

# XAFS INVESTIGATIONS OF TRANSITION METAL TRANSPORT IN TWO-PHASE (LIQUID + VAPOR) HYDROTHERMAL FLUIDS

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## Introduction

The physical separation of brine and vapor in boiling hydrothermal systems has a profound influence on ore metal transport and deposition. Fluid inclusion data from hydrothermal systems associated with silicic magmatic intrusions indicate strong segregation of metals between a hypersaline brine and a lower-salinity vapor. It is speculated that in porphyry systems, Cu, Au and As preferentially partition into a sulfur-rich vapor phase which may then ascend to form high sulphidation epithermal deposits. Strong partitioning of Cu into a vapor phase is supported by experimental studies employing synthetic fluid inclusions [1]. An understanding of the chemical controls of Cu and Au transport in vapor-dominated ore-forming systems requires knowledge of the stability and structural properties of their complexes in a vapor at elevated temperatures. However, metal speciation in a magmatic vapor is essentially unexplored because the importance of a vapor phase for transporting metals in these environments may have been overlooked in previous work.

In the present study we assess the feasibility of determining the structure of Cu complexes in a boiling hydrothermal system by using the XAFS technique to separately analyze synthetic brine and vapor-rich fluid inclusions in quartz at elevated temperatures. In situ analysis of synthetic fluid inclusions has the advantage of providing direct information on the structural properties of fluids at actual ore-forming temperatures.

## Methods and Materials

The inclusions were manufactured by simultaneously trapping a two phase fluid in the system, brine-vapor-haplogranitic melt-intermediate solid solution-pyrrhotite-quartz at elevated temperatures and pressures and at an oxygen fugacity buffered by Ni-NiO. The synthetic fluid inclusions function as transparent, micro autoclaves which effectively segregate samples of the brine and vapor present at a given hydrothermal condition. Cu K-edge XAFS spectra were collected in the fluorescence mode up to the temperature of inclusion formation (450 °C) from individual inclusions situated less than 15 micrometers from the surface of the host quartz. A beam spot size of 7  $\mu\text{m}$  was used to analyze the inclusions which varied in size from 10 to 17  $\mu\text{m}$  in diameter. A single element Ge detector was used to collect the XAFS signal and a modified Linkam THMSG 600 heating stage was used to control the temperature of the inclusion (Figure 1).

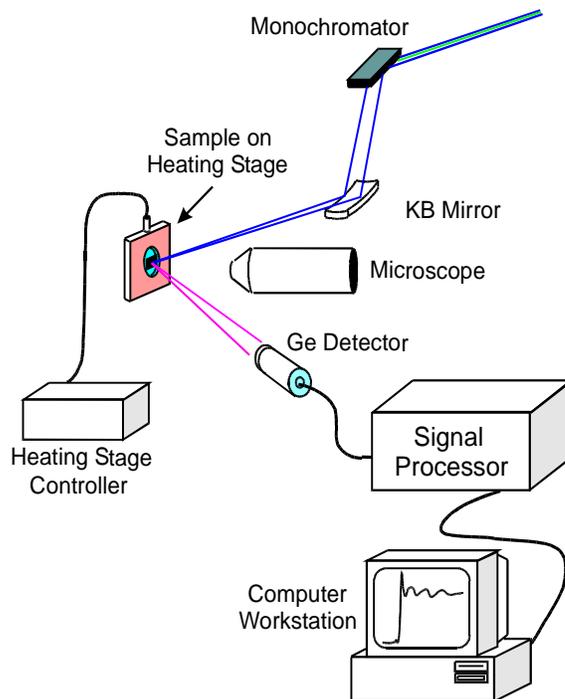


Figure 1: The Experimental Setup.

## Results and Discussion

Figure 2. shows typical Cu K-edge XAFS spectra collected from a vapor-rich inclusion at 25 and 440 °C. The noise in these spectra is attributed to the small size, low Cu concentration and heterogeneous nature of the inclusions. Although the quality of these initial spectra precludes reliable data analysis, the synthetic inclusion method shows promise for the investigation of dissolved metals in high temperature vapors. In order to enhance the XAFS signal in future experiments a 13-element Ge detector will be used to collect spectra from larger, homogeneous synthetic inclusions.

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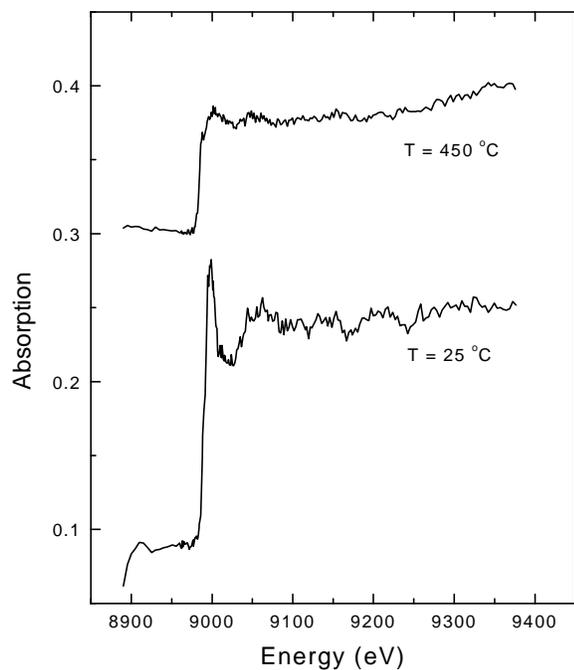


Figure 2: Cu K-edge XAFS spectra obtained from a synthetic vapor-rich inclusion in quartz.

#### References

- [1] M.R. Frank, P.A. Candela, and P.M. Piccoli, "Estimated copper concentrations in magmatic vapor and brine, in a sulfur-bearing brine-vapor-haplogranitic melt-intermediate solid solution-pyrrhotite system at 800 degrees C and 100 MPa." Geological Association of America Annual Meeting, Toronto. Abstract. (1998)