

## Analysis of Mineralizing Fluids Trapped in Single Fluid Inclusions From the Middle Valley Hydrothermal System, Juan de Fuca Ridge by Synchrotron X-Ray Fluorescence Microprobe

J. Peter (Geological Survey of Canada), A. Lanzirotti and S. Sutton (U. of Chicago)

Abstract No. Pete6673

Beamline(s): X26A

**Introduction:** Middle Valley is a hydrothermally active sediment-covered oceanic rift situated about 9 km off-axis in sediments overlying 300 Ka crust on the northern Juan de Fuca Ridge. During Leg 169 of the Ocean Drilling Program, an actively forming, 15 to 20 million tonne seafloor massive sulphide deposit with both high grade Zn and Cu zones was drilled (Zierenberg et al., 1998). Fluid inclusions (FI) provide the only samples of ancient fluids and allow us to examine the evolution of the hydrothermal system through time since its initiation some 350,000 years ago. We performed a scoping study of single FI to evaluate the feasibility of analyzing these dilute fluids and solids trapped in various minerals. The aim is to determine actual concentrations of mineralizing fluid constituents in order to constrain hydrothermal circulation and precipitation models.

**Methods and Materials:** Several carefully selected FI samples were prepared and analyzed over the two day run period. The beam size was  $\approx 15 \mu\text{m}$  diameter, which is similar to, or larger than, many of the FIs. Regions of interest corresponding to the elements analyzed for were: S K alpha; Ba L alpha; Mn K alpha; Ni K alpha; Cu K alpha; Zn K alpha; As K alpha or Pb L alpha; As K beta; Pb L beta; Rubidium K alpha; Strontium K alpha. 25 spectra were collected from a variety of samples, including cleavage plates of anhydrite and barite mounted on ultra pure silica glass rounds with cyanoacrylate adhesive, standard doubly polished FI sections mounted with acetone soluble adhesive to standard glass slides, and doubly polished FI chips removed from the glass slide. Runs included spot analyses of the background host mineral, spot analyses of FI, line scans over host mineral and FI, and raster scans over host mineral and FI. Steps varied from 5 to  $13 \mu\text{m}$ . Live times varied from 5 seconds to 3600 seconds, current varied from 450 to 250 mA. The positioning of the monochromator was also varied to test different configurations (e.g., binding energy of Cu, Cr).

**Results:** The FI glass slides contain significant As contamination. Fe, Mn, Ni, Rb, and S are present either in the glass slide and/or the host quartz. Inclusions in small quartz crystals within isocubanite and/or chalcopyrite could not be analyzed because of the intense scattering of x-rays from these sulfides and Cu and Fe in the resultant spectra. Cleavage plates of barite were the best of the samples analyzed. However, barite FI samples could not be run with the monochromator set to the Cu binding energy due to the massive (100%) dead time generated from Ba. For such samples, the monochromator was set to below the binding energy of Ba L lines. Line scans show "lows" or troughs of Sr over an inclusion, with higher values in the host barite, and these lows correspond to "highs" of Fe in the inclusion. Cu, Pb, and Zn were detected in the inclusions. Monochromatic mode does not allow for the analysis of Na, Cl, and other light elements. The actual concentrations of elements in the inclusion fluids is presently being determined by a number of corrections for the host mineral composition and trace element concentrations, and FI depth and shape.

**Conclusions:** Our scoping study found that: only large ( $> 40$  microns) FI are useable; smaller FI may be amenable to the technique if they are hosted by a trace-element free mineral (not found to date); sample chips cannot be adhered to standard FI glass mounts which are contaminated with As, Fe, Mn, Ni, Rb, and S; samples must be mounted on pure silica rounds or Kapton<sup>®</sup> tape; only FI that are shallow (i.e., within 10 microns of the upper surface) can be analyzed. Na and Cl could not be analyzed. Further work at NSLS may involve the use of "white beam" rather than "monochromatic mode" to achieve a smaller beam ( $\approx 8 \mu\text{m}$  diam.) and higher fluxes, but concomitantly higher background levels and greater scatter which may be unacceptable for high sulfide samples. Also, as rhodium mirrors are not used, and because Rh peaks overlap with the Cl peak, there is a far greater likelihood of analyzing for Cl, a major anion in the FI fluids. The analysis of FI by SXRF microprobe is in its early infancy. Indeed, there are only a handful of papers, which report actual concentrations of elements in inclusion fluids, and all of these reports on highly saline and concentrated fluids such as from porphyry copper deposits. Thus, more development work is required to determine optimal analytical conditions needed for the quantitative analysis of dilute fluids (3-10 eq. wt.% NaCl) in FI from most seafloor hydrothermal systems.

**Acknowledgments:** Peter thanks the Natural Resources Canada Synchrotron Steering Committee for funding to do this work.

**References:** Zierenberg, R. A., Fouquet, Y., Miller, D. J., Bahr, J. M., Baker, P. A., Bjerksgarden, T., Brunner, C. A., Duckworth, R. C., Gable, R., Gieskes, J. M., Goodfellow, W. D., Groeschel, B. H. M., Guerin, G., Ishibashi, J., Iturrino, G. J., James, R. H., Lackschewitz, K. S., Marquez, L. L., Nehlig, P., Peter, J. M., Rigsby, C. A., Schultheiss, P. J., Shanks, W. C., III, Simoneit, B. R. T., Summit, M., Teagle, D. A. H., Urbat, M., and Zuffa, G. G., The deep structure of a sea-floor hydrothermal deposit: *Nature*, **392**, 485-488, 1998.