Crystal Structure of Sulfide Minerals in Hydrothermal Vents at Mid-Cayman Rise

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Approach

•Samples were collected in January 2014 along the *Atlantis*. Collection was completed using the Suspended Particulate Rosette V2.
• Allowed for collection along different elevations within the plume.
•Samples were analyzed for geochemistry and mineralogical phase.

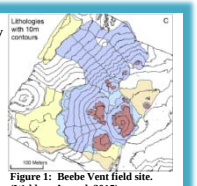


Figure 1: Beebe Vent field site. (Webber, A. et al, 2015)

Methods

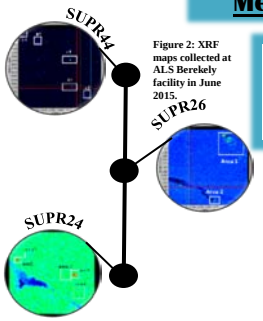


Figure 2: XRF maps collected at ALS Berekely facility in June 2015.

←Step 1: X-Ray Fluorescence mapping.
→Step 2: Spot-and- grid based analysis with Laue diffraction.

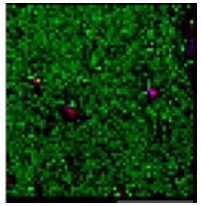
Spot Analysis

Grid Analysis

Figure 3: Visual example of diffraction spot- and grid workflow.

Figure 4: Advance Light Source , University of California, Berkeley.

←Step 3: Curate the usable file list by the → clarity and density of diffraction.
•Files with evidence of strain were noted.



"Fe(II)sulfide" "Fe(III)silicate"
"Fe(III)oxyhydroxide"

Figure 5: Results of Fe Chemmap analysis of SUPR44. (Brandi K, 2015)

←Step4: Curate the list of possible minerals present based on previously observed minerals via XANES and Chemmap analysis.

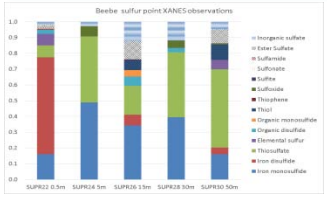


Figure 6: Results of S XANES analysis of Beebe vent samples. (Brandi K., MMI, 2010).

Step 5 :
Analyze files in XMAS program.

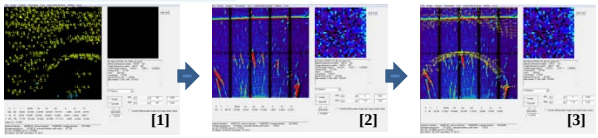


Figure 7: Typical XMAS workflow. [1]: Load calibrant file and index to determine appropriate geometry. [2]: Load file of unknown species, [3] Identify unknown species according to list of possible species present and correspondence of diffraction pattern.

Introduction

• Hydrothermal vents are important portions of ocean biogeochemical cycles and are essential sources of Fe and Mn.
•The Beebe vent in the Mid Cayman Rise is a high temperature vent with high concentrations of Fe-sulfides.
•The goal of this study is to observe the geochemical changes with plume height, and note any patterns in crystallography, elemental distribution, and strain, if present.
•Alternate goal is to become familiar with XMAS software, and pass knowledge onto others in Toner Lab for future use.
•Our main hypothesis is the decrease in crystallinity with rising plume height, as well as a change in geochemistry from sulfides near the plume source to oxides near the top of the plume.

Results

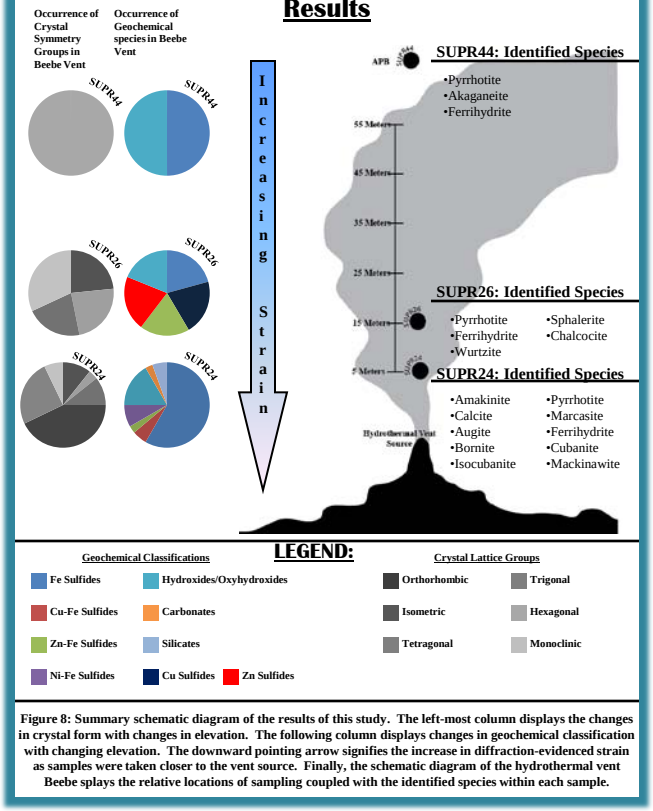


Figure 8: Summary schematic diagram of the results of this study. The left-most column displays the changes in crystal form with changes in elevation. The following column displays changes in geochemical classification with changing elevation. The downward pointing arrow signifies the increase in diffraction-evidenced strain as samples were taken closer to the vent source. Finally, the schematic diagram of the hydrothermal vent Beebe splays the relative locations of sampling coupled with the identified species within each sample.

Discussion

•There is a general trend of increasing crystal strain with decreasing distance from the vent source. This is to be expected, due to the high temperature conditions of the chimney orifice.
•There is a geochemical trend towards decreasing sulfides with increasing distance from the vent source. This could be due to precipitation out of the plume or chemical changes due to microbial activity.
•There is no discernible pattern concerning crystal symmetry in relation to distance from the vent source.
•Certain species seem to survive throughout the entire height of the plume, such as ferrihydrite and pyrrhotite. Both of these minerals are not highly crystalline and diffract very little. May either be error in analysis or property of the crystal habit that these minerals were able to survive.

Conclusion

•Hydrothermal vents are chemically dynamic zones, and as a result of this study, two distinct patterns were determined:
  •A decrease in sulfides and an increase in oxyhydroxides with increasing distance from the vent source.
  •Increasing strain with decreasing distance from the vent source.
•The overall goal of this study was completed: familiarization with the XMAS software. This software will be an immense asset for future studies of Beebe and other hydrothermal vents.

Further Work

•Certain samples, most notably SUPR44, did not receive a complete analysis due to the sheer amount of diffraction files present.
  •Goal: Analyze these samples on XMAS on a supercomputer so they may be tested against all possible mineral species.
•Other samples from past years were collected without calibrant files, and therefore could not be included in this study.
  •Goal: Run these samples at the ALS facility once more and analyze those minerals in the same manner as stated above.
•XMAS is a versatile program with many different functions. XMAS is able to observe and calculate mineral strain based on the peak shape and orientation.
  •Goal: Continued work on analyzing these minerals under these functions.
•The Toner Lab will continue to work with this program, with the ultimate goal of producing a paper to be submitted to a peer-reviewed journal article within the next year, co-authored by Brandi Kammermans and Aubrey Dunshee.

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