

Hydrothermal Chimney Weathering Time Series, Endeavour Segment, Juan de Fuca Ridge: The view from the sulfur edge

SARAH L NICHOLAS¹, EURIPIDIS ALEXANDER PAPANICOLAOU², RYAN V TAPPERO¹, BRANDY M TONER³ AND JOHN JAMIESON⁴

¹Brookhaven National Laboratory

²Memorial University

³University of Minnesota - Twin Cities

⁴Department of Earth Science, Memorial University of Newfoundland

Presenting Author: snicholas@bnl.gov

We used synchrotron micro X-ray fluorescence (μ XRF) imaging, micro X-ray absorption near-edge structure (μ XANES) and micro X-ray diffraction (μ XRD) to analyze a transect of hydrothermal chimney samples from the Endeavour Ridge segment of the Juan de Fuca Ridge tectonic spreading center.

Hydrothermal chimneys form when hot, reduced, metal-rich hydrothermal fluids reach cold, oxygen-rich seawater. The new structures are extreme environments with distinct microbial communities. As tectonic spreading centers expand, these chimneys move with the crust away from the fluid source and become extinct. Mineral weathering of the extinct chimneys in cold, oxygen-rich seawater transforms them. As they weather, they continue to provide a source of metal ions and a substrate for microbial life.

The chimney samples were collected on a ~1km transect, and range in age from ~5.7 kya to an actively forming sample collected in 2012 from the active vent. If we assume a similar initial composition, the time series samples show that as the chimney samples weather they lose Cu, Zn, S and Fe and develop iron oxide weathering rinds. The morphology of the oxide weathering structures suggests that they are microbial exudates.

Analysis of the sulfides using sulfur spectroscopy and X-ray diffraction allowed us to avoid the overabsorption or self-absorption effects that can be a problem for XAS analysis of sulfide and other mineral samples measured at the metal edge. This approach may be useful for other geochemical samples where transition metal concentrations are high.

Sulfide mineral standards for comparison and analysis were provided by the American Museum of Natural History. Synchrotron μ XRF, μ XAS, and μ XRD measurements were collected at the National Synchrotron Light Source II, Brookhaven National Lab.

Figure 1: μ XRF map of hydrothermal chimney sample dating to ~5.7kya. Iron fluorescence is shown in red, sulfur in green, and zinc in blue. The weathered surface is on the left. Location of μ XANES spectra (Figure 2) are marked.

Figure 2: Sulfur 1-s μ XANES spectra collected at sample locations shown in Figure 1. In the weathering rind, left, we see

S mostly as sulfate, moving right into the interior we see mixed sulfate and sulfide (pyrite/marcasite, chalcopyrite, sphalerite).

