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Elucidating hydrothermal vent particulate contributions to global marine iron cycling using a multi-modal XAS and XRF approach

BRANDY STEWART[1], ADRIAN WACKETT[2], TUCKER ELY[3] AND BRANDY M TONER[4]

[1]SLAC/University of Minnesota
[2]Stanford University
[3]University of Minnesota-Twin Cities
[4]University of Minnesota - Twin Cities

Presenting Author: stewarb@umn.edu

Processes active within buoyant hydrothermal plumes are expected to modulate the flux of biologically-limiting metals, such as Fe, to ocean waters. However, these processes have yet to be described in a comprehensive manner through observations or models. Here we collected vent plume particles and assessed particulate Fe (pFe) speciation across a global network of hydrothermal vent systems (Eastern Lau Spreading Center, Mid Cayman Rise, East Pacific Rise, etc.) that differ in temperature, depth, and fluid chemistry. Particles were collected from vertical transects within the buoyant hydrothermal plume at each site using *in situ* filtration with a Remotely Operated Vehicle. Filter bound particles were then analyzed using a suite of synchroton-based analytical techniques (micro-probe X-ray fluorescence mapping (XRF), X-ray diffraction (XRD), XRF spectroscopy, X-ray absorption near edge structure (XANES) spectroscopy at the Fe 1s edge, and XRF-based chemical speciation mapping) to measure composition and chemical speciation of pFe. This meta-analysis reveals new insights on the controls driving mineralogical diversity and pFe speciation in buoyant vent plumes, and also highlights particularly complex and dynamic vent fields that may be of interest for further study. For example, our findings reveal a high diversity in solid-state chemistry and prevalence of poorly crystalline, meta-stable phases in buoyant vent plumes of the Eastern Lau Spreading Center. We also demonstrate the need for a multi-modal XRD-XANES analytical approach to fully describe and characterize the crystalline-to-noncrystalline character of plume particulate Fe. The work described here has important implications for understanding both sources and transport potential of particulate Fe within ocean waters and sediments.