Goldschmidt 2024 Abstract
https://doi.org/10.46247/gold2024.23726

Carbon matrices support transport of nanoparticulate iron from hydrothermal vents to open ocean waters

SARICK L MATZEN[1], ZVI STEINER[2], TUCKER ELY[1], JOHN BREIER[3], JESSICA N. FITZSIMMONS[4], ERIC P. ACHTERBERG[2], CHRISTOPHER R GERMAN[5] AND DR. BRANDY M TONER, PH.D.[1]

[1]University of Minnesota - Twin Cities
[2]GEOMAR Helmholtz Centre for Ocean Research Kiel
[3]University of Texas Rio Grande Valley
[4]Texas A&M University
[5]Woods Hole Oceanographic Institution

Presenting Author: smatzen@umn.edu

Iron (Fe) is a necessary but limiting nutrient for life on Earth. Supply by sediments and dust deposition are typically considered the main sources of iron to Earth's oceans. Recent work suggests hydrothermal vents could also be an important source of bio-essential iron over the length scales of ocean basins. Dissolved iron concentrations in hydrothermal fluids are a million times those of surrounding ocean water. Most iron (>90%) precipitates close to vent sources, but in a major breakthrough, the international GEOTRACES program revealed signatures of hydrothermally-derived iron transported across deep ocean basins worldwide. Models show that through density-controlled upwelling, this iron could support up to 10% of primary production in the North Pacific Ocean and up to 30% in the Southern Ocean. It remains unclear how this iron persists in dissolved form in the water column rather than being sequestered into sinking particles. The fate of iron could depend on plume chemistry, including iron, sulfur (S) and oxygen (O) content, iron speciation, and aggregate size. Critical processes constraining the export of iron from vent sources to open ocean waters occur within the first ~100 km of plume evolution.

We compare hydrothermal plume particulate matter collected from the first 100 km of plumes in the low-sulfur, high-oxygen Rainbow vent system (Mid Atlantic Ridge) and high-sulfur, low-oxygen Endeavour vent field (Juan de Fuca Ridge). We characterize particulate chemistry and morphology with synchrotron-based methods (bulk extended X-ray absorption fine structure spectroscopy, X-ray fluorescence spectromicroscopy, scanning transmission X-ray microscopy, and ptychography) and electron microscopy. We show that plume chemistry affects the mineral phase of iron, with pyrite and mixed iron(II/III) phases persisting longer in the high-sulfur, low-oxygen Endeavour plume. Nevertheless, the morphology of suspended particulate iron is similar in both environments, with nanoparticulate iron embedded within "fluffy" carbon matrices persisting in each plume, regardless of plume chemistry. We explore carbon matrix chemistry and potential links to vent microbial communities and/or other sources of ocean carbon. Co-located iron and carbon within marine particles drives export of iron from hydrothermal vents to open ocean waters and is a signature of nutrient-rich hydrothermal activity in Earth's oceans.