Goldschmidt 2023 Abstract
https://doi.org/10.7185/gold2023.18422

Southern Ocean Hydrothermal Iron and Manganese Supply from the Pacific Antarctic Ridge

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The Southern Ocean is the largest high-nutrient low-chlorophyll region with significant concentrations of unused surface macronutrients because of a dearth of bioavailable Fe. Major sources of iron (Fe) to most of the surface ocean are dust and sediments. However, as the remote Southern Ocean is situated far from continental sources, low Fe inputs result in Fe supply limiting phytoplankton growth. Recently, hydrothermal sources have been proposed as a possible source of bioavailable Fe to the surface of Southern Ocean. Hydrothermal Fe can travel laterally on the scale of thousands of kilometers, and when this is combined with sustained bathymetrically-guided upwelling across isopycnals in the Southern Ocean, vents become a potential source of Fe to Southern Ocean phytoplankton. Models have previously shown that hydrothermal emissions of Fe from Southern Ocean ridge axes, compared to other ocean basins, have the greatest impact on export production in the Southern Ocean; however, to date there is little evidence of Fe supply from Southern Ocean vents. One prior study showed elevated concentrations of the hydrothermal fluid tracer ^{3}He near the Pacific-Antarctic Ridge (PAR) in the Pacific sector of the Southern Ocean, raising the likelihood that hydrothermal Fe could be found in the area, although no Fe data is available to test this hypothesis. Here, we show dissolved Fe and Mn data from the U.S. GEOTRACES GP17-OCE expedition to the South Pacific and Southern Oceans, where we documented elevated dissolved Fe and Mn concentrations over and around the PAR, confirming a hydrothermal metal source from PAR venting. Our metal data are corroborated by elevated sensor turbidity signals, indicating enhanced particles loadings associated with this hydrothermal plume. However, the absence of corresponding anomalies in oxidation-reduction potential, which are characteristic of reduced species found in near-field hydrothermal plumes, suggests that the sampled plume was some distance from its source. We conclude that the PAR is a significant source of hydrothermal Fe and highlight the need for further research to constrain the magnitude of this flux and its potential to sustain phytoplankton production in Southern Ocean surface waters.