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Regulation of hydrothermal vent contribution to ocean chemistry by hydrothermally influenced sediments, the Rainbow field case study

ZVI STEINER[1], ZHOULING ZHANG[1], CHRISTOPHER GALLEY[2], LINBIN ZHOU[1,3], NETTA SHALEV[4], NICOLAAS GLOCK[5], XUE-GANG CHEN[1,6] AND ERIC P. ACHTERBERG[1]

[1]GEOMAR Helmholtz Centre for Ocean Research Kiel
[2]University of Ottawa
[3]South China Sea Institute of Oceanology
[4]ETH Zürich
[5]University of Hamburg
[6]Zhejiang University

Presenting Author: zsteiner@geomar.de

Hydrothermal fluids are potentially a major source of many trace elements to the ocean following enrichment during circulation in the ocean crust. Whether this translates to a significant contribution to ocean biogeochemistry at distances beyond a few hundred meters from the vents depends on buffering and removal processes in the plume. There are two components to the biogeochemically relevant hydrothermal flux, the first one is composed of ions and small particles that remain in solution or suspension over long distances from the vents, the second component contains elements that are removed from the plume but released back to the water. We investigated the particulate and sedimentary components of the hydrothermal flux along a series of stations at a distance of 200 m to 60 km from the Rainbow hydrothermal vent field on the Mid-Atlantic ridge to examine the return flux from hydrothermally influenced sediments. We find that magnesium is released from particles and lithium removed from solution by interactions of seawater within the hydrothermal plume. Thereby the contribution of major elements is modified by the hydrothermal activity compared to predictions based on the composition of the hydrothermal end-member. Within the first two km from the vent, the sediments release large quantities of copper, nickel and cobalt to the bottom water. Therefore, the hydrothermal contribution of these elements is larger than calculated based on their concentrations in the non-buoyant plume. From a distance of ten km from the vent, we measure an increase in the flux of vanadium, phosphate and arsenic from the sediment to the bottom waters. These oxyanions are transferred from seawater onto iron oxides in the buoyant part of the plume, and are released when iron oxides precipitate from the plume and recrystallize in the sediment to more stable mineral phases. This means the hydrothermal sink of oxyanions may be smaller than previously assumed. Overall, these results indicate that sediments deposited downstream from a hydrothermal vent are an active interface that modifies the hydrothermal contribution to ocean chemistry.