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The role of mid-ocean ridge hydrothermal plumes on the marine osmium cycle

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The osmium (Os) isotope composition of seawater reflects a balance between isotopically distinct sources, such as through continental weathering and hydrothermal alteration of oceanic crust, providing a unique perspective on understanding various Earth surface processes [1-3]. In particular, the application of Os isotope stratigraphy of marine sediments has received considerable interest as a key tool for tracking changes in global weathering/alteration regimes and perturbations to the global carbon cycle throughout Earth history. However, our knowledge of the processes controlling the net flux of Os delivered from mid-ocean ridge (MOR) hydrothermal systems to seawater remains limited [2, 3]. Constraints on this particular unradiogenic Os hydrothermal source to seawater could provide critical information on our interpretation of past geological events and their connection to the seawater Os isotope composition.

This study focuses on the effect of hydrothermal plume formation on the fate of dissolved Os in seawater and from hydrothermal fluids venting at the seafloor of active MOR hydrothermal systems. In particular, this study provides novel experimental-modeling constraints on dissolved Os adsorption onto and exchange with the Fe-oxide mineral, hematite, which is used as a proxy for Fe-oxide minerals that form within buoyant hydrothermal plumes rising above the seafloor. The experimental observations demonstrate that dissolved Os is effectively scavenged onto hematite grains, suggesting that hydrothermal plume Fe-oxide minerals likely act as a significant sink of seawater- and vent fluid derived-Os. The experimental results are used to refine the net flux of Os delivered from vent fluids to seawater and are implemented into a global mass balance model to evaluate the imbalance of sources and sinks of Os in the marine Os cycle. Further, geochemical modeling simulations of hydrothermal plume formation indicate that the residence time of dissolved Os in seawater along Earth's MOR system is likely sensitive to secular changes in seafloor spreading and ocean chemistry.

[1] Peucker-Ehrenbrink and Ravizza, 2000 (Terra Nova)
[2] Sharma et al., 2007 (GCA)
[3] Syverson et al., 2021 (GCA)