

Evaluating the sensitivity of siderophile metals during seafloor sulfide mineralization and plume formation along Earth's hydrothermal systems: Constraints from the osmium system

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Hydrothermal alteration of oceanic crust and sulfide mineralization are fundamental geochemical processes that collectively contribute to the global carbon cycle, regulate seawater chemistry, and lead to the genesis of ore deposits. Understanding of how these geochemical processes regulate the flux of essential nutrients and metals to seawater is essential but still remains largely unconstrained. This is especially true for the ultra-trace metal osmium (Os), which is becoming an emerging geochemical proxy to decipher seafloor alteration and sulfide mineralization processes. However, few vent fluid Os concentration – isotopic data currently exist [1, 2], effectively limiting our ability to decipher globally on how seafloor hydrothermal systems contribute or limit the flux of highly siderophile trace metals to seawater. Here we triple the currently existing Os concentration – isotopic database of low- and high-temperature fluids from seafloor hydrothermal systems by characterizing fluids sampled from the basalt-hosted Piccard mid-ocean ridge (MOR) vent field, the sediment influenced basalt-hosted Guaymas MOR vent field, and the Tui Malila, Tahī Moana, and Mariner back-arc hydrothermal systems within the Lau Basin. These novel data combined with past observations [1, 2] provide a global and diverse perspective on how the flux of Os to seawater and metals differ from seafloor hydrothermal systems.

¹⁸⁷Os/¹⁸⁸Os values of low- and high-temperature hydrothermal fluids indicate that radiogenic seawater Os does slightly contaminate the end-member composition of subseafloor hydrothermal fluids prior to venting to seawater. The comparison of the Os concentration of dregs and residual Os concentration of hydrothermal fluids sampled by gas-tight titanium samplers indicates that Os partitions strongly into sulfide minerals. This observation suggests that the majority of end-member dissolved Os derived from the alteration of oceanic crust is removed through sulfide mineralization upon venting and mixing with seawater during the formation of buoyant hydrothermal plumes overlying active seafloor hydrothermal systems. These Os concentration and isotopic data also suggest that sulfide mineralization at the seafloor and plume formation also scavenge dissolved seawater Os, revealing an unknown and potentially significant sink within the marine Os cycle.