Goldschmidt 2024 Abstract
https://doi.org/10.46247/gold2024.21355

Quantifying the role of Fe-oxide mineral adsorption on the marine Os geochemical cycle

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Osmium (Os) is redox-sensitive, highly siderophilic (iron loving), and responds acutely to environmental changes and global geologic events [1], as reflected by the elemental and isotopic composition of Os preserved in the geologic record. We investigated the geochemical behavior of dissolved Os (dOs) during the formation of hydrothermal plumes when seawater mixes with high-temperature fluids venting from Earth's mid-ocean ridge (MOR) system. The experiment examined the adsorption of dOs onto well-characterized hematite (Fe2O3), which is ubiquitous to hydrothermal metalliferous sediments and serves as a proxy for Fe-oxy-hydroxide minerals [1] formed within plumes on- and off-axis of MOR hydrothermal environments. Specifically, we employed a distinct Os-bearing synthetic seawater solution to quantify the rate and degree of dOs adsorption onto hematite at pH conditions relevant to modern Earth. Subsequently, an enriched 190Os-bearing solution was introduced to test for elemental exchange between adsorbed-Os and dOs. Time-series samples of solution were recovered to monitor the change in the dOs concentration as the solution reached adsorption equilibrium. Experimental results revealed a high affinity for Fe-oxide minerals to adsorb and effectively remove dOs derived from seawater and vent fluids. In addition, the dissolved 190Os-tracer added to the experimental solution indicates minimal elemental exchange between dOs and adsorbed-Os after hematite-fluid adsorption equilibrium has been reached. This study provides the first experimental constraints on the unexplored role MOR hydrothermal plumes may have as a significant sink for dOs derived from seawater and MOR high-temperature vent fluids. Overall, our novel results indicate Fe-oxide minerals forming within metalliferous sediments and hydrothermal plumes [2] can function as a significant sink in the marine Os cycle, and that the magnitude of this Os sink is likely sensitive to changes in ocean chemistry, especially dissolved oxygen content, throughout Earth's history [3,4].

References

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