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The Large Gap of Mercury Isotopic Compositions in the Ocean

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As an important reservoir of mercury (Hg) on earth, ocean plays a crucial role in mediating global Hg cycling. Mercury undergoes complex migration and transformation processes (e.g., adsorption/desorption, deposition/resuspension, oxidation/reduction, and methylation/demethylation) between multiple interfaces (e.g., atmosphere-seawater, land-seawater, seawater-sediment, and seawater/sediment-biota) of the ocean. Recently, Hg stable isotope approach has shown great advantages in studying the biogeochemical cycling of oceanic Hg, from tracing sources and processes to reconstructing paleoenvironment and paleoclimate. Herein, we overviewed the accurate analytical methods for Hg isotopes in different marine samples, summarized the reported Hg isotope dataset in seawater, sediment/particulate, and biological samples from different oceans of the world, and comprehensively analyzed the fractionation mechanisms of Hg isotopes and their potential applications in tracing marine Hg cycling. We found that i) Hg isotope data in seawater and suspended particles, and in important sources like marine volcanic hydrothermal are very limited, ii) marine Hg isotope fractionation mechanisms, especially mass-independent fractionation mechanisms remain unclear, and (iii) studies on Hg transfer in marine food chain and Hg exchange between interfaces are constricted by limited Hg isotope data in single Hg species (e.g., Hg of different chemical forms in sediment and methylmercury in seawater/sediment/biota), and reconstruction of paleo-marine environment using Hg isotopes is still in its infancy. As a result, systematics of Hg in oceanic environment and the global Hg cycling model could not be accurately established using current marine Hg isotope data, and it is difficult to precisely verify and restrict key processes and corresponding fluxes of global Hg cycling. More work is needed in the future to i) further establish and improve isotope method for single Hg species and in-situ or real-time measurement of seawater and important sources like marine volcanic hydrothermal and submarine groundwater, ii) well investigate mechanisms of Hg isotope fractionation in seawater matrix (e.g., organic and inorganic media, particulate matter, microorganism), and iii) deeply explore Hg (especially MeHg) enrichment and transfer in marine food chain, and Hg exchange between ocean-atmosphere and seawater-sediment, and further reconstruct ancient ocean evolution, to provide basic data and theoretical support for controlling marine Hg pollution and understanding global Hg cycling.