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Chromium isotope systematics of ferromanganese nodules: Implications for the marine chromium cycle

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Ferromanganese nodules are important carriers of trace metal elements, and their trace element composition intricately linked to the depositional environment. Chromium (Cr) isotope compositions of ferromanganese nodules have the potential to reflect the Cr isotope compositions of seawater and provide insights into the oceanic redox states. Previous studies have demonstrated that Cr isotope fractionation occurs between ferromanganese nodules and seawater, with seawater exhibiting significantly heavier Cr isotope compositions. However, the geochemical processes controlling the Cr isotope compositions of ferromanganese nodules remains controversial and require further investigation. In this study, we analyzed the Cr isotope compositions of ferromanganese nodules from the Pacific ocean and conducted Cr adsorption experiments to explore the mechanism of Cr isotope fractionation.

The results show that the δ^{53}Cr values of ferromanganese nodules range from –0.82‰ to -0.20‰, with an average of -0.48‰, which are lower than the reported Cr isotope compositions of global seawater. Additionally, the adsorption experiment results confirm that manganese (Mn) oxides readily adsorb Cr, with the adsorbed Cr being isotopically lighter than dissolved Cr by approximately 0.90‰. However, this fractionation cannot fully account for the isotopic difference between seawater and ferromangnese nodules. EPMA analysis combined with selective leaching experiments reveal that Cr is likely predominantly hosted within detrital components of ferromanganese nodules. Furthermore, the significantly lower Cr/Al and Cr/Ti ratios of the samples compared to UCC suggest potential post-depositional Cr loss from the detrital components in ferromanganese nodules. This finding suggests that rather than acting as a sink for Cr in the ocean, ferromanganese nodules may serve as a source of Cr, akin to terrestrial weathering products and soils. The findings highlight the necessity of isolating authigenic components of ferromanganese nodules when reconstructing seawater Cr isotope compositions.