Reconstructing ocean-atmosphere processes over Earth's history using zinc and cadmium isotopes

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The zinc (Zn) and cadmium (Cd) stable isotope systems are emerging as powerful tools for reconstructing the evolution of the ocean-atmosphere system throughout Earth's history. This is because of their intimate coupling as important micronutrients for marine primary producers that modulate the efficiency of the ocean's biological pump, and in turn, global carbon and climate cycles. Furthermore, the association of Zn and Cd with sulfide formation under anoxic and sulfidic ocean conditions has led to growing interest in the use of Zn and Cd isotopes as tracers of evolving ocean oxygenation in 'deep-time'. These ocean-atmosphere processes are archived within marine sediments. However, the accuracy of sedimentary Zn and Cd isotope records is impacted by a lack of robust calibration between Zn and Cd cycling in the ocean and their transfer to sediments.

To address this knowledge gap, we report paired Zn and Cd isotope datasets for eight Holocene era carbonate-dominated core-top sediments, collected using techniques in double-spiking and MC-ICPMS. Samples are spatially distributed around the sub-tropical frontal zone bordering the Southern Ocean to evaluate the effect of contrasting oceanographic settings with sampling depth. The bulk sediment Zn and Cd isotope signatures reflect the average seawater composition at the time and depth of formation. This demonstrates both the power of paired isotope analysis and the viability of this approach for reconstructing nutrient utilisation on longer timescales providing the faunal assemblage is well characterised. Furthermore, the Cd and Zn isotope signatures of zooplankton physically separated from the bulk sediment records seawater processes below the euphotic zone. This is ideally suited to oceanic circulation reconstruction on more recent timescales where the zooplankton and phytoplankton components can be isolated. In contrast, the separated phytoplankton mode faithfully records euphotic zone Zn and Cd isotope values and are a viable archive for micronutrient reconstruction. These findings significantly extend the utility of the Zn and Cd isotope systems as tracers of ocean-atmosphere processes throughout Earth's history.