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Mineralogical controls on trace metal micronutrient cycling: Towards coupling mineral, organic carbon and micronutrient biogeochemistry.

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Determining the geochemical controls on the chemistry of the oceans is fundamentally important for understanding the modern and ancient Earth system. Concentrations of micronutrient metals in modern oceans control photosynthesis and thus modern climate, whilst concentrations and isotopic compositions of these micronutrients recorded in ocean sediments can reflect contemporaneous ocean chemistry at the time of sediment deposition and can thus shed light on micronutrient cycling in ancient oceans and links between ocean chemistry and evolution of Earth's atmosphere and biosphere. Currently the controls on ocean chemistry are typically considered within a top-down framework, in which metals are sourced largely from rivers and recycled within the water column. Assuming a top-down ocean however, it is difficult to explain recently observed elevated micronutrient concentrations in deep waters and benthic fluxes are now well-established for iron. A bottom-up ocean implies that processes within sediments and at the interface between sediments and seawater are key in controlling ocean chemistry, yet these processes are poorly understood. Here we present the results of recent mineral-water interface studies in which iron and manganese minerals exert an important control on the cycling of micronutrient trace metals, including nickel and zinc, between ocean sediments and overlying seawater, helping to control their oceanic concentrations and isotopic compositions. We discuss how recent work on the interactions between iron and manganese and organic carbon, might couple the carbon and micronutrient cycles, and the implications for these mineralogical processes on the modern and ancient Earth system.

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