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Metal Stable Isotopes in the Marine Realm

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The field of marine metal stable isotope geochemistry has expanded dramatically since the last edition of the Treatise on Geochemistry. In this chapter, we examine the marine stable isotope cycling of nine transition metals: V, Cr, Fe, Ni, Cu, Zn, Mo, Cd and W. We classify the metals into three groups according to their oceanic residence time and degree of internal cycling. This approach enables comparison between isotope systems and, in each case, to draw out the importance of one or more key controlling processes. Long residence time elements with homogeneous seawater elemental and isotopic distributions (V, Mo, W) exhibit limited internal cycling in the ocean; their behavior is driven by chemical properties that govern their slow removal to sedimentary sinks. Elements that display marine variability despite long residence times (Cr, Ni, Zn, Cd) are subject to strong internal cycling by either biological or chemical processes, which repartition the whole-ocean inventories of these elements and their isotopes on short timescales. This group of elements is most affected by the physical ocean circulation, which acts to transport as well as erode the elemental and isotopic fingerprint of biogeochemical processes. Short residence time elements (Fe, Cu) are affected considerably by both biological and chemical internal cycling processes, leading to significant spatial variability in the ocean. Finally, the isotopic oceanic mass balance of each metal is reviewed and, in some cases, updated, providing revised oceanic residence times estimates. These estimates will continue to be refined as efforts to constrain oceanic metal sources and sinks progress.