Molecular Controls on the Concentration, Speciation and Isotopic Composition of Trace Elements in Marine Sediments

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In many cases marine sediments provide the ultimate sink for a wide variety of trace elements in the marine environment, including those that are redox sensitive. Within the sediments, despite their relatively low abundance, iron and manganese minerals, through coupled sorption and redox reactions, provide an important host phase for trace elements. Marine sediments, and in particular iron and manganese minerals, are therefore used as sedimentary archives, storing a wealth of trace element chemical information that can be used to reflect on past environmental conditions at the time of sediment deposition. In order to fully exploit these abundant sedimentary repositories, we must understand the processes that control the initial drawdown of trace elements from seawater into the host mineral phases – do sedimentary archives directly reflect seawater chemistry or do the processes of drawdown superimpose a secondary chemical signature? – and we must understand subsequent diagenetic alteration of the primary mineral hosts in order to evaluate the robustness of sedimentary archives over time – do these repositories still reflect original seawater chemistry and thus the contemporaneous environmental conditions? Our group uses a combination of advanced, high resolution analytical techniques, including X-ray absorption spectroscopy and microscopy, coupled with sorption and isotopic fractionation experiments, to investigate the reactivity and cycling of trace elements in the marine environment, focusing on the processes that control elemental concentration and isotopic composition in seawater and marine sediments. We are applying these techniques to understand the cycling of micronutrient trace metals, and the sequestration and preservation of redox sensitive metals in marine sediments, and in this talk we will highlight the power of these microanalytical approaches to shed light on trace element behaviour, exemplified with case studies investigating nickel, copper, chromium and molybdenum drawdown and preservation in marine sediments. We will show that molecular level processes during elemental drawdown and sedimentary diagenesis provide a first order control on the global cycling of trace elements in the marine environment, and thus the record of this cycling in sedimentary archives.