The continent-ocean flux of transition metals and their isotopes

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Some transition metals (e.g. Fe, Zn) are important micronutrients that support phytoplankton growth and carbon sequestration in the ocean. Others (e.g. Mo) are increasingly being used as tools to understand ocean redox in Earth history. The modern oceanic budgets of these elements, and the likely controls on those budgets through Earth history, need to be quantified and understood. For many of these metals the riverine input to the ocean is an important, sometimes dominant, source. The focus of this contribution is the controls on the size and isotopic composition of this input, in terms of the processes occurring during chemical weathering, soil development and riverine transport.

A clear and consistent feature of many transition metals in rivers is that their stable isotopes are heavy in the conventionally-defined dissolved (<0.4micron) load. Thus the estimated isotope composition of the global riverine flux of Mo, Ni and Cu are all about 0.6-0.7‰ heavier than the likely value for the upper continental crust. If representative of the long-term riverine input to the dissolved pool of the oceans, this gives rise to budgetary problems that either require additional fractionation into the oceanic sinks or non-steady-state behaviour in the oceans. Efforts to understand the export of heavy isotopes from the weathering environment, and to locate the complementary light reservoir, are beginning to focus on trace metal mobility and isotope fractionation in soils. Soils do preserve evidence of isotope fractionation during their development, including retention of a light pool, but they are also complicated by the impact of multiple processes, such as aerosol deposition, biological cycling and redox transformations. In addition, the soil pool can only be a transient storage reservoir over the long term. In this context, export of an isotopically light signature in riverine particulates is potentially significant. Moreover, a large portion of the particulate reservoir of metals may be stored in labile phases (grain coatings, organic material), whose fate on reaching the oceans is of key importance to oceanic budgets.

Overall, the investigation of the transition metals and their isotopes has the potential to identify and quantify the importance of key processes during soil development and riverine transport, as well as to shed light on the relative importance of oceanic sources and sinks.