Metal isotope tracers of the redox and productivity states of the past oceans: Refining modern calibrations

C.H. STIRLING[1,*], J.M. ROLISON[1,2], E. GEORGE[1], R. MIDDAG[1,3], M.O. CLARKSON[1,4] AND S.K. GANGL[1]

[1] Dept. Chemistry, Univ. Otago, Dunedin, New Zealand *cstirling@chemistry.otago.ac.nz

[2] Lawrence Livermore National Laboratory, U.S.A.

[3] Royal Netherlands Institute for Sea Research, The Netherlands

[4] Dept. Earth Sciences, ETH Zürich, Switzerland

Trace metals play many important roles in the biogeochemistry of the oceans, and via connections with the carbon and sulfur cycles, are intrinsically linked to global climate. The oceanic distributions of trace metals are significantly influenced by the concentration of dissolved oxygen, as well as the intensity and efficiency of the ocean's biological pump. Therefore, metal stable isotope systems have recently emerged as powerful tracers of the redox evolution and productivity status of the past and present oceans. A growing inventory of data provide (1) important boundary conditions for modelling future climate scenarios, and (2) reconstructions of the evolution of the ocean-atmosphere system throughout Earth's history, as recorded in marine sediments. However, both applications rely on robust calibration of metal isotope cycling in the modern marine environment.

In the modern oceans, a wealth of trace metal isotope datasets are now available for many oceanic regions, facilitated by the GEOTRACES programme, the advent of multiple-collector inductively coupled plasma mass spectrometry (MC-ICPMS) using double spiking techniques for metal isotope analysis, as well as combined experimental, observational and modelling approaches. Despite these advances, there remains an incomplete knowledge regarding how trace metals are cycled through the oceans and how their dissolved isotopic signatures are transferred to the sedimentary record.

Here, we discuss the biogeochemical cycling of the iron, cadmium, and uranium isotope systems in underconstrained regions of the world's oceans. We address the current limitations of these systems, especially where dissolved trace metal levels are exceedingly low. We also examine approaches for improving the calibration of these systems in the modern ocean to enable their robust application to sedimentary records in 'deep time'.