The effects of hydrodynamic sorting on the Ti isotope composition of sediments

Martijn Klaver1, Pieter Vroon2, and Marc-Alban Millet1

1School of Earth and Ocean Sciences, Cardiff University, United Kingdom (klaverm@cardiff.ac.uk)
2Faculty of Science, Vrije Universiteit Amsterdam, Netherlands

Detrital sediments provide a useful tool to investigate the composition of the continental crust through time. Mass-dependent (“stable”) isotope variations in Archaean to present-day sediments (shales, diamictites) have recently received much attention and Ti, in particular, holds significant promise as a novel tracer of crustal composition [1, 2, 3]. This approach is based on i) the contrasting Ti isotope composition of mafic versus felsic rocks as a result of the removal of isotopically light oxides during igneous differentiation; and ii) the chemical behaviour of Ti, a refractory and biologically inert element that should not fractionate during weathering and sedimentation. Hence, current interpretations of the Ti isotope detrital sediment record rely heavily on the assumption that it reflects the integrated composition of the source(s), and thus provides a record of the proportion of felsic to mafic rocks in that source.

A potential caveat, however, is the hydrodynamic sorting of dense minerals in coarse, more proximal sediments [4]. This effect is well-known for zircon; coarser sediments tend to have higher Zr/Al2O3 and a less radiogenic Hf isotope composition due to the concentration of zircon grains [e.g., 5, 6]. Shales form the complementary zircon-depleted reservoir characterised by lower Zr/Al2O3 and a more radiogenic Hf isotope composition relative to the source. Common Ti-rich phases such as ilmenite and rutile are also resistant against physical and chemical weathering and could be concentrated together with zircon in coarse sediments.

We examined a suite of Eastern Mediterranean passive margin sediments with well-constrained provenance [7] and found that Ti indeed behaves like Zr. Fine-grained samples have lower TiO2/Al2O3 compared to coarser, proximal deposits of identical provenance. The removal of Ti-rich phases with a light Ti isotope composition into coarse-grained sediments could thus bias the Ti isotope composition of shales towards isotopically heavier values. We will report on the δ49/47Ti isotope composition of these sediment samples, but a TiO2/Al2O3 mass balance suggests that a bias of more than 0.05 ‰ in the δ49/47Ti of shales is possible. Understanding the consequences of hydrodynamic sorting for Ti isotopes in sediments is crucial for their use as a quantitative proxy of crustal composition and for reconciling the shale and diamictite Ti isotope records.