Advantages of combined high precision MC-ICPMS and high spatial resolution techniques in Earth Sciences

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Isotopic measurements of geological material have enhanced our understanding of the timing and chemical evolution of the Earth and its ocean. Over the last decade, geochemists have in particular benefited from technical advances in multiple collector ICP-MS facilitating the precise measurement of a wide range of radiogenic and stable isotopes with relevance to planetary evolution, environmental change and archaeology. Despite the precise determination of isotope ratios, the data achieved by wet chemical bulk analysis represent an average of the sample in the range of micrograms. This can limit the significance of the information obtained if the composition and/or geochemical information or the sample material is heterogeneous in the micrometre scale and hence outside the preparative and analytical resolution. The advent of micro-analytical in situ techniques and recent innovations in high-resolution laser ablation ICP-MS and secondary ionization mass spectrometry (SIMS) has greatly improved our capabilities to gain insight into Earth and environmental process operating down to micro-scale e.g. on mineral surfaces or boundaries. The strength of high spatial resolution analysis is often achieved at the cost of a reduced precision of isotopic data due to short analysis times or small element abundance in the sputtered material.

Here we illustrate the opportunities offered by the integration of datasets obtained from MC-ICP-MS bulk analyses and micro-analytical in situ techniques of LA-MC-ICPMS and SIMS, focusing on applications to problems in Earth and ocean science, including geochronology, petrology and environmental change. For example, we will demonstrate how integrated bulk- and micro-analytical studies of U-Pb, Hf, O, B and Li isotope analyses of minerals and melt inclusions enabled spatial and temporal insights in subduction zone processes and continental crust formation. Further examples include how our understanding of past seawater pH, ocean temperature and continental weathering improves by combining B and Ca isotope data obtained from biogenic carbonates on a range of temporal and spatial scales.