Stable isotope labelling and imaging mass spectrometry as a tool to investigate mineral-fluid interaction

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The micron- to sub-micron scale interaction between fluids and minerals is key to understanding large-scale geological phenomena such as metasomatism, element transport, and the deposition of ore bodies. Yet the processes occurring at the mineral-fluid interface are not well understood. Stable isotope labelling has been used to track the movement of molecules within biological systems for many years. The technique involves replacing atoms in the starting material with their rare isotopic counterpart (e.g., ^{13}C or ^{15}N) and using mass spectrometry to monitor their movement, behaviour and ultimate fate. The development of high spatial resolution imaging mass spectrometry techniques, such as NanoSIMS, allows this investigation to be carried out of the sub-cellular scale. The same technique can be readily applied to experimental petrology systems involving water, CO_2 or other volatile species. We have conducted experiments to investigate the feasibility of studying the interaction between minerals and hydrous melt, using ^{2}D- and ^{18}O-labelled water in the starting composition. NanoSIMS was used to isotopically image the mineral-melt interface, revealing the intricate processes occurring at the nano-scale. This presentation will introduce the concept of stable isotope labelling in experimental petrology, and discuss the technical advantages of SIP + NanoSIMS to investigate element exchange processes at the sub-micron scale.