F and Cl in peridotite minerals: analytical development, partitioning, and applications to fluid cycling in the Earth's mantle

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The subduction factory plays a major role in recycling volatiles into the deep Earth. Fluids contained in the subducted slab are released during dehydration reactions and percolate through the mantle wedge. Fluorine (F) and chlorine (Cl) measurements in arc magmas have been increasingly popular in the last few years because of their potential to track subduction-derived components, and because of their effect on the properties of melts and magmatic systems. However, F and Cl concentrations in nominally anhydrous and hydrous mantle minerals remain scarce, because measuring F and Cl at low concentrations (< 1 ppm) is challenging. In order to understand the range of variability of F and Cl contents of arc magmas, and how F and Cl partition during mantle wedge melting, it is critical to obtain high-precision measurements of F and Cl directly in the source of arc magmas, i.e. in nominally anhydrous and hydrous mantle minerals from supra-subduction ophiolites that represent analogs of the mantle wedge. Here we have developed analytical methods to measure F and Cl at low concentrations by secondary-ion mass spectrometry in mantle minerals from various supra-subduction ophiolites, orogenic peridotites and mantle xenoliths world-wide.

F and Cl can be added to the mantle wedge through fluid and melt percolation, and can be removed from the mantle wedge through melting. During those processes, F and Cl fractionation is tightly linked to their solubilities in aqueous fluids, and their partitioning behavior between melts, anhydrous minerals, and potentially stabilized hydrous phases. Using F and Cl concentrations of peridotite minerals, partition coefficients between minerals, fluids and melts, as well as fluid-melt compositions, we identify processes that connect F-Cl sub-arc source variability to F-Cl variability in arc magmas. F and Cl contents of mantle minerals provide a direct record of fluid metasomatism, melt percolation and melting processes in the mantle source. Preliminary data show that those measurements have the potential to contribute significantly to our understanding of mantle metasomatism and melting in subduction zones.