Distinguishing Shallow and Deep Sources of Halogens in Submarine Volcanic Systems

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Defining the primary volatile composition of submarine basalts from mid-ocean ridges, back-arc basins and arc-front volcanoes are key to understanding volatile cycling and the influence of volatiles on melting in the upper mantle. The volatile and halogen geochemistry of submarine volcanic glasses and melt inclusions has been the subject of an increasing number of studies that have made progress in distinguishing between secondary seawater contamination of magmas, and true melting and mantle-source variations, thus enabling observed magma compositions to be used to study the time-integrated cycling of volatiles through the upper mantle. But fewer studies have examined in detail the local-and segment-scale variations of volatiles together with trace elements and radiogenic isotopes, so that it can be understood how and where in the oceanic crust submarine magmas are contaminated by seawater-derived components.

Mid-ocean ridge basalts (MORB) are significantly affected by secondary seawater assimilation processes due to their low volatile contents. From combined CO2-H2O-Cl systematics, it is apparent that addition of seawater-derived components is enhanced in magmas that ascend more slowly through the crust, and/or erupt away from the ridge axis. Highly depleted magmas that erupt in extensional zones within transform faults (e.g. Siqueiros) show little evidence for seawater addition, due to the near absence of thick crust and hydrothermal systems in such environments. At the same time, there also exists a second tier of more subtle seawater addition that is evident as a function of the extent of differentiation in MORB, pointing to combined assimilation and fractional crystallization as an important process operating in MORB petrogeneis. In detail the geochemistry of the assimilants can vary substantially from simple seawater compositions.

Discerning seawater contamination in arc and back-arc magmas is more difficult, not only because of higher volatile concentrations but because addition of deep slab-derived fluids can often produce geochemical signatures that mimic the shallow assimilation of seawater-derived components in the crust. In these tectonic environments, deeply-trapped melt inclusions can often reveal compositions that permit distinguishing deep from shallow processes that influence the geochemistry of arc-related submarine basalts.