Experimental Constraints on Trace Element Fluxes from Slab to Wedge

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The characteristic trace element signature of arc magmas is a consequence of the chemical flux from subducted slab to mantle wedge. The nature of this flux is determined by the different subducted lithologies, the subduction geotherm and the partitioning behaviour of trace elements between fluids, melts and slab residues. In an attempt to constrain the trace element flux that can be derived from subducted basalt we carried out H_2O-saturated experiments on a trace element-doped MORB composition at 2.5 GPa, 750-900 °C and fO_2=NNO.

Garnet, omphacite and rutile occur at all temperatures. Amphibole, staurolite and epidote disappear above 750 °C; allanite appears above 750 °C. The tronjhemitic glass present at all temperatures was quenched from supercritical fluid. Trace element analyses of glasses demonstrate the control exerted by residual minerals on fluid chemistry: garnet controls HREE; rutile controls Ti, Nb and Ta; and allanite buffers LREE contents of fluids to low levels and preferentially holds back Th and, to a much lesser extent, U. We agree with previous experimental [1] and metamorphic [2] studies that residual allanite has a key role in selectively retaining trace elements during subduction.

Experiments and allanite-bearing rhyolites are used to derive a model for allanite solubility in melts or fluids as a function of *P*, *T*, composition and LREE (La-Sm) content. Our model reproduces LREE concentrations in allanite-saturated melts and fluids to within a factor of 1.4 from 650-1100°C, 0-4 GPa. The extreme *T*-dependence of allanite solubility is very similar to that of monazite [3]. Silicic fluids from basaltic (or sedimentary) protoliths will be saturated in allanite (or monazite) except at very high temperatures. For conventional subduction geotherms the low solubility of LREE (+Th) in allanite-saturated fluids raises questions about the mechanism of LREE+Th transport from slab to wedge. We suggest either that (i) locally temperatures experienced by the slab are appreciably higher than normal, e.g. by mechanical incorporation of thin slivers of sediment into the mantle wedge, or that (ii) substantial volumes of H_2O-rich fluids must pass through the mantle wedge prior to melting. The solubility of accessory phases in fluids derived from subducted rocks clearly provides important geochemical constraints on subduction zone thermal structure.

References

[1] Hermann (2002), *Chem Geol*, **192**, 289-306
[2] Sorensen & Grossman (1993), *Chem Geol*, **110**, 269-297
[3] Montel (1993), *Chem Geol*, **110**, 127-146