Experimental constraints on the composition of subduction zone fluids

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The nature of the slab-derived mobile phase that metasomatizes the mantle wedge and causes melting in volcanic arcs is still poorly understood. Recent models argue that a transport mediated by aqueous fluids is too inefficient to produce the observed trace element enrichment in arc magmas. Instead, sediment melts were proposed as the main metasomatizing agents [1-5].

In a series of piston cylinder experiments conducted at 4 GPa and 700-800 ˚C, we studied the effect of NaCl on the partitioning of trace elements between aqueous fluids and an eclogitic residue. The investigated fluid compositions ranged from pure water to 15 wt. % NaCl, covering the most common fluid salinities in subduction zones. In our experiments, fluid/eclogite partition coefficients for a set of 25 trace elements were determined by laser-ablation ICP-MS analyses using the diamond trap technique. We demonstrate attainment of equilibrium by reversed experiments.

The results show that the partitioning of the light rare earths, alkalis, alkaline earths, Pb, and U into the fluid is enhanced by several orders of magnitude upon addition of a few wt. % of Cl. For some of these trace elements, the solubility increase is comparable to that for a temperature increase by several hundred ˚C. On the other hand, the partitioning of the heavy rare earths and high field strength elements seem to not be affected by fluid salinity, thus enhancing features typically observed in arc magmas such as the negative Nb-Ta anomaly.

Overall, our data indicate that the trace element enrichment observed in typical arc magmas is entirely consistent with hydrous fluids being the main trigger for melting in subduction zones. Sediment melting is likely a phenomenon of only local importance for arc magmatism.

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