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Review

Fluids and trace element transport in subduction zones

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Abstract

Melt inclusion data from primitive arc basalts from Mexico and Kamchatka show clear positive correlations of "fluid mobile element"/H_2O ratios with the Cl/H_2O ratio, suggesting that the trace element content of subduction zone fluids is strongly enhanced by complexing with chloride. This effect is observed for large-ion lithophile (LILE) elements, (e.g., Rb and Sr), but also for the light rare earth elements (REE, e.g., La and Ce) as well as for U. The correlations of these elements with Cl/H_2O cannot be explained by the addition of sediment melts or slab melts to the mantle source, since Cl has no effect on the solubility or partitioning of these elements in silicate melt systems. On the other hand, the observed relationship of trace element abundance with Cl is consistent with a large body of experimental data showing greatly enhanced partitioning into aqueous fluid upon addition of chloride. Accordingly, it appears that a dilute, Cl-bearing aqueous fluid is the main carrier of LILE, light REE, and U from the slab to the source of melting in arcs. Moreover, elevated Ce/H_2O ratios clearly correlate with fluid salinity and therefore are not suitable as a "slab geothermometer." From a synopsis of experimental and melt inclusion data, it is suggested that the importance of sediment or slab melting in the generation of arc magmas is likely overestimated, while the effects of trace element scavenging from the mantle wedge may be underestimated. Moreover, establishing reliable data sets for the fluid/mineral partition coefficients of trace elements as a function of pressure, temperature, and salinity requires additional efforts, since most of the commonly used experimental strategies have severe drawbacks and potential pitfalls.

Keywords: Subduction zones, trace elements, halogens, chlorine, fluid flow, percolation, mantle wedge, slab geothermometer, arc magmas, Invited Centennial article, Review article