Element transfer through the Kurile convergent margin

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We have recently conducted a detailed geochemical investigation (including selected trace elements and Sr-Nd-Pb-Hf- and Be-isotope ratios) of the incoming crust (sediments and AOB) and across the wide (volcanoes ~115-200km above slab depth), active Kurile arc in the NW Pacific to address 1) the changing nature of the slab component with depth and 2) element cycling via the subduction "factory." Initial results indicate the pre-subduction mantle is a mixture of Pacific and Philippine Sea Plate types and melting processes largely explain systematics of immobile, incompatible trace elements in VF and BVF lavas. The behaviour of highly fluid-mobile trace elements is contradictory and is better explained by multistage processes operating beneath the arc.

The agent of mass transfer appears to change from aqueous fluid beneath the volcanic front to melt-like and solute-rich fluid beneath the deeper regions of the arc, which is demonstrated by: 1) the strong VF→BVF decline in highly soluble fluid mobile elements when melting effects are minimized (e.g., B/Be, B/Nb, Cs/Th, Pb/Ce), 2) these ratios are often higher in the VF than the bulk incoming crust, and 3) enrichments in sediment-derived cosmogenic ^{10}Be ($t_{1/2}$=1.5My) in BVF lavas that are equal to those in the VF- despite longer transit times. ^{10}Be recycling (flux out / flux in) is estimated at ~17%, to which additional elements are compared. Cross-arc trends coupled with previously well-characterized Wadati-Benioff zone and mineral stability studies allow inferences about the pressure and temperature conditions at the slab-surface (e.g., exploiting the contrasting fluid and melt partitioning behaviours of Be and B in primary sedimentary host white mica) with extensions to thermal and geodynamic models. Geochemical flux estimates clarify longer-term evolution of the crust-mantle system.

Fluid properties at high P and T – What are they good for?

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The knowledge of accurate physical and chemical fluid properties at high pressures and temperatures is the key to a quantitative understanding of many geochemical processes. Recent simulation studies have demonstrated that the *physical evolution* of hydrothermal systems is largely controlled by the non-linear dependence of fluid properties such as viscosity, density and heat capacity on temperature, pressure, and composition. Using simplified fluid properties in a simulation will obscure and sometimes completely surpress important phenomena observed in natural systems. Typical examples from mid-ocean ridge type hydrothermal systems and ore-forming magmatic-hydrothermal systems will be discussed.

A major problem for understanding the *geochemical evolution* of these systems is the lack of accurate, experimentally determined thermodynamic data for many geochemically important fluid systems at high temperatures and pressures. Moreover, for the near-critical region as well as for phase-separating complex fluids, no thermodynamic formalism is currently available that allows the accurate description or even prediction of thermochemical properties. Current models for standard (infinite dilution) thermodynamic properties such as HKF/Supcrt fail in this region as do Gibbs Free Energy-based activity models for solutions with finite concentrations. To overcome these limitations, geochemists have more recently moved into theoretical and experimental fields that have little to do with a traditional view of geochemistry including combined quantum chemical calculations and mass spectrometric stability determinations of cluster ions, combined molecular dynamics simulations and EXAFS determinations of ion solvation, and theoretical studies linking these molecular-scale determinations to macroscopic thermodynamic fluid properties. The presentation reviews a few of these recent studies and gives an outlook how these approaches may eventually lead to a quantitative formalism for fluid properties at high temperatures and pressures.