Metamorphic Chemical Geodynamics of Subduction Zones

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Study of metamorphic suites directly representing the deep subduction of altered oceanic crust and sediments can help elucidate the geochemical evolution of the forearc-to-subarc slab-mantle interface and the chemical processing of slabs and sediments entering the deeper mantle. Hypotheses regarding the geochemistry of "fluids" generated in deeply subducted oceanic lithosphere and sediment, mostly from study of arc lavas and ocean-island basalts (OIB, thought to sample the deeper mantle), provide direction for focused study of high-pressure (HP) and ultrahigh-pressure (UHP) metamorphic suites and a better merging of field geochemical studies with knowledge of mineral chemistry and reactions, kinetics and disequilibrium, prograde and exhumation-related P-T paths, fluid flow and fluid-rock interactions, and experiments bearing on the physical and chemical properties of "fluids" at HP and UHP metamorphic conditions.

Many HP and UHP metamorphic suites contain the metamorphic equivalents of seafloor sediment and oceanic crust, but they are commonly fragmented and probably biased lithologically. High-pressure and UHP metamorphic suites show variable, in many cases extensive, overprinting of assemblages representing prograde and peak metamorphism by assemblages stabilized during their protracted exhumation histories. Despite these obstacles, recent geochemical study of HP and UHP metamorphic suites has provided some tantalizing compatibilities with the records from study of arc lavas (including cross-arcs) and OIB, helping us reconcile the seafloor subduction input budget with arc geochemistry and the evidence for deep mantle geochemical heterogeneity.

Increasingly high-resolution thermal models, employing variable upper mantle viscosity and associated subduction-induced "corner flow", indicate that the slab-mantle interface and shallowest portions of the subducting oceanic crust may be warmer than predicted in earlier models, perhaps at or near temperatures required for partial melting of both sedimentary and mafic rocks. Emphasis of the field metamorphic studies should in part be placed on UHP suites representing peak metamorphism at depths greater than 100 km that potentially experienced partial melting, with the goals of better characterizing subarc additions from the slab and sediments and the compositions of dehydration and melting residues entering the deeper mantle.