Geophysical Research Abstracts, Vol. 8, 05110, 2006
SRef-ID: 1607-7962/gra/EGU06-A-05110

Metamorphic structures along the slab-mantle interface: Reactive pathways for fluids or melts

R. King and G. Bebout

Earth & Environmental Sciences, Lehigh University, Bethlehem, PA, 18015, USA (robbie@lehigh.edu)

Identification of a fluid or melt signature affecting arc volcanic centers is critically dependent upon both our assumption of a source composition for the metasomatic agent(s), as well as an understanding of the reaction pathways experienced by an agent as it traverses from its source to the sub-arc mantle. A body of emerging research indicates the metamorphic structure of the slab-mantle interface is dominated by mélange and metasomatic zones bridging the depleted mantle of the wedge with the evolved components present within the subducting slab. Our comprehension of the petrology and geochemistry of this system is poor, but this system must exert a significant influence upon the composition of any mobile agent progressing to the wedge interior. Here, we present data for two Mesozoic subduction complexes of California (USA) that record aspects of the slab-mantle interface.

Foremost are the effects of novel bulk compositions produced by mélange formation. The Catalina Schist is dominated by mélange zones consisting of hybridized bulk compositions formed during subduction by mechanical mixing of peridotites, basalts, and sediments, accompanied by fluid-related element mobility (primarily Si). Major element compositions are transitional between all realistic protolith compositions, but are dominantly Mg-rich (>10-15% MgO). Trace element signatures often considered diagnostic of a particular ocean floor subduction input are heterogeneously recorded by mélange zones. Therefore, while a particular mélange zone may bear a strong "sediment" signature, the phase equilibria of the mélange composition will be dramatically different as mélange zones are dominantly ultramafic in composition. Mixing behavior is also recorded by isotope systematics, where mélange compositions span large ranges in Sr-Nd isotope ratios that dominantly reflect mechanical mixing. In contrast, measured Pb isotope ratios do not preserve mixing relationships, but are consistently

more radiogenic than any subduction input and suggest 50 to $>$95% Pb loss during subduction to $\sim$60-70km depths (probably via desulfidation reactions). Despite this massive processing of the U-Th-Pb system, mélange Pb ratios are as equally successful in explaining Pb signatures of modern arcs as are calculations employing unfractionated input compositions. These data suggest that mélange-forming processes may invalidate many assumptions regarding the bulk composition of the metamorphic system, impacting our ability to confidently employ specific geochemical signatures to trace sediments or altered oceanic crust, as fluids or melts may either be directly derived from mélange, or will likely re-equilibrate within mélange zones of the slab-mantle interface.

While mechanical mixing along the slab-mantle interface probably plays an important role in all subduction zones, metasomatic reactions within the mantle wedge itself are also capable of fractionating initial "slab" fluid/melt compositions during metasomatism. A representative series of metasomatic reactions preserved within exotic metaperidotite blocks of the Franciscan Complex, record the equilibration of subduction-zone fluids with a depleted peridotite. Through a series of predominantly Si-metasomatic reactions, the peridotite protolith progressively evolved through the reaction series serpentinite/talc schist/tremolite schist. Within these metasomatic zones, trace element compositions are highly dependent upon metasomatic mineralogy. Within serpentinites, Li, B, Cs, and Pb increase in concentration with reaction progress, while many other elements not compatible in serpentinite (i.e., Ca) are simultaneously stripped by fluid flow. The serpentinite-compatible elements are not compatible in talc and are dramatically depleted by the talc-in reaction; this reaction progresses by the influx of Si-bearing fluids, but is a dehydration reaction, indicating mobility of a "new" fluid potentially bearing a distinct signature. Within tremolite zones formed after talc, numerous neoblastic accessory minerals are present, including zircon, apatite, clinozoisite, and rutile. The formation of these phases attests to the presence of constitutive elements in solution, but their formation impacts nearly all trace element systematics so that tremolite-zone rocks record significantly enriched trace-element compositions. This suggests that the buffering reactions that accommodate progressive Si metasomatism of the mantle wedge may selectively retain, ignore, or remobilize key tracers used to infer either fluid or melt, as well as sediment or altered oceanic crust.