

Reaction rind formation in Mèlange in the Catalina Schist, California

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Reaction rinds between differing lithologies are commonly thought to have formed due to fluid-assisted metasomatic alteration, however, enrichment in relatively fluid-immobile elements such as Cr and Ni suggests an additional process may be responsible for their formation. Eleven samples along a 17cm transect through one amphibolite grade block and a reaction rind with an ultramafic-rich matrix from the Catalina Schist, CA show distinct changes across the block-rind contact in mineral abundance and whole rock major and trace element and Li isotope composition. Whole rock rind concentrations of SiO₂, K₂O, Rb, Ba, MgO, Cr and Ni are enriched in the rind relative to the core and FeO is depleted. Lithium concentrations are enriched in the rind (10-16ppm) relative to the core (8-11ppm) with $\delta^7\text{Li}$ ranging from -3 to +1‰. The distribution of Li concentrations and isotope compositions is consistent with diffusion on the scale of almost the entire 17-cm profile. Garnets in the core and rind are similar in FeO content, however whole-rock FeO of the core and rind differs significantly, suggesting garnet growth before the depletion in whole-rock FeO. Rind garnets are pseudomorphed extensively by decussate chlorite, suggesting that infiltration by H₂O-rich fluid occurred after garnet growth. Rind concentrations of Cr, Ni, Al₂O₃ and CaO can be most simply explained by mechanical mixing of mafic block (50-70%) with melange matrix (30-50%). Mixing cannot explain the increases in SiO₂, K₂O, Li, Rb and Ba or the depletions in FeO, and we propose that the concentrations of these elements in the rind are due to relatively late-stage fluid infiltration. We propose an early episode of mechanical mixing where mixing of mafic block and melange matrix produced rind-like material which was then accreted onto the outside of basaltic blocks. Garnets likely grew in both block core and rind after mechanical mixing. Fluid infiltration in the rind occurred after peak metamorphism of the block. The source of this fluid was likely metasedimentary rocks within the subduction zone, as has been proposed based on O isotope compositions of this amphibolite-facies mèlange unit.

Serpentinization and hydrogen generation

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Much of the current scientific interest in serpentinites revolves around the production of molecular hydrogen (H₂) during serpentinization, which can serve as a source of metabolic energy for autotrophic microbial communities, or as the reductant for abiotic formation of organic compounds. While it has been known for some time that fluids generated during serpentinization can be highly reducing and enriched in H₂, the processes responsible for producing these conditions remain poorly understood. Serpentinization of ultramafic rocks is commonly portrayed by the simple generalized reaction: olivine + water → serpentine + brucite + magnetite + H₂, where production of H₂ occurs as a result of oxidation of ferrous Fe [FeO] from the mineral components of the original rock (olivine and pyroxene) to ferric Fe [FeO_{1.5}] in the reaction products, especially magnetite. However, petrologic studies and laboratory experiments make it increasingly evident that the process is much more complex than this simple expression would indicate. For instance, rather than going directly into magnetite, Fe from the reactant minerals is partitioned among all solid products including serpentine and brucite, so that the relative distribution and oxidation state of Fe among these minerals determines the amount of H₂ generated. Petrologic, lab-oratory, and theoretical studies indicate that the proportions and oxidation state of Fe in the product minerals is highly variable, and appears to be dependent on a number of factors including temperature, bulk rock composition, extent of reaction, and 'openness' of the system. To complicate matters further, the Fe components of serpentine and brucite may become unstable as the reaction progresses, so that Fe-rich minerals formed during the initial stages of serpentinization may decompose over time in favor of more Fe-poor compositions and magnetite. We will present results from ongoing laboratory experiments and modeling studies that are an attempt to unravel the sequence of reactions controlling Fe distribution and H₂ formation during serpentinization, and their dependence on reaction conditions.