Phase equilibria controls on mass transfer reactions in the rainbow hydrothermal system

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In July 2008, high temperature hydrothermal fluids (~365°C) were sampled from the Rainbow vent field (36°13.8'N at 2300 m depth) on the Mid-Atlantic Ridge during cruise *KNOX18RR*. Rainbow, located at the intersection of non-transform and ridge-related faults, is characterized as an ultramafic system. Considering the temperature and reducing nature of the Rainbow fluids, end-member dissolved sulfate concentrations must be near zero. Extrapolation of dissolved Mg data to zero sulfate suggests Mg values as high as 1.5-2 mmol/kg. Measureable concentrations of Mg provide new insight into the mineral phases that buffer fluid chemistry in ultramafic systems. In combination with other select species (Fe, Si, Al, Ca and H_2), these data permit calculation of the pH and redox dependent solubility of minerals. We speculate that the moderate (measured) dissolved silica values result from alteration of plagioclase and olivine to chlorite + magnetite ± talc. The available data for activity-composition relations of chlorite solid solutions indicates that in spite of the high Fe/Mg ratio in the vent fluids, the mole fraction of chamosite is ~0.22. The coexistence of chlorite solid solutions with magnetite provides a redox buffer that helps to maintain the characteristically high H_2 concentrations in Rainbow fluids. Furthermore, the pH of chlorite saturation is similar to that required for both magnetite and talc. These data strongly suggest the existence of gabbroic intrusions within the Rainbow system and the existence of talc may influence strain localization with implications for the tectonic evolution of detachment fault shear zones.

Linking temperature to time in retrograde metamorphism: Ti-in-quartz + Rb/Sr of muscovite in preserved Ms + Qtz symplectite

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Symplectites are arrested metamorphic reaction textures that are preserved when falling temperature and/or other factors limit grain boundary diffusion rates such that the transport of chemical components to the reaction interface cannot keep pace with the rate of grain boundary migration. Analysis of symplectites provides a unique opportunity to use preserved phase relationships to better assess how crustal conditions evolved after the formation of peak-grade mineral assemblages. For example, in batholithic settings, symplectites can be analyzed to determine the timescales for re-equilibration of the geotherm following the heat input associated with massive intrusion. To answer first-order questions of this type, both temperature (T) and time (t) data must be extracted from symplectites.

Muscovite + quartz and plagioclase + quartz symplectites (myrmekite) that form at the expense of K-feldspar + sillimanite-bearing assemblages are widespread phenomena in deeply exhumed arc crust that provide the essential mineralogy to constrain T-t history. We have performed Ti-in-quartz thermometry with the ion microprobe and have used back-scattered electron (BSE) imaging to guide focussed ion beam (FIB) sampling of the symplectites to perform Rb/Sr geochronology via TIMS and ICP-MS methods. Previous muscovite, biotite, and K-feldspar $^{40}Ar/^{39}Ar$ results revealed that the 15 km deep exposures we have studied cooled from > 600°C to 450-400°C over a 15 m. y. interval that followed massive intrusion at 95-91 Ma. Preliminary Rb/Sr results from the symplectites indicate that the geotherm decreased from > 40°C/km to ca. 30°C/km over a < 2 m. y. interval post-intrusion. These results demonstrate our ability to collect data directly from μm-scale metamorphic textures to determine the timing and rates of tectonic processes. It also highlights the rich record that symplectites preserve regarding the retrograde evolution of orogens.