Silica metasomatism of oceanic serpentinites

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Both dynamic and static recrystallization of serpentinite to soapstone have been reported from ultramafic massifs in the oceans. While the development of talceous schists is common in detachment faults that are loci of large time-integrated fluid fluxes, static replacement of serpentine by talc is more difficult to explain. We report on observations made in ODP drill core from Leg 209, Hole 1268, at the Mid-Atlantic Ridge (MAR) 15°N, where soapstone is abundant. Talc appears in blackwalls at the contact to small (<10 m) gabbroic units, but the majority of soapstone is not formed diffusively at mafic/ultramafic contacts. Static replacement of serpentinite by talc starts along anastomosing vein networks and continues to pervasive steatitization, during which the serpentine hourglass texture is preserved. To transform magnesian serpentine (Mg/Si=1.5) to talc (Mg/Si=0.75) massive removal of Mg or addition of Si is required. As the solubility of Mg is very low in fluids with pH>3, metasomatic enrichment of silica seems the most likely explanation. It appears that, except for obvious blackwalls, this metasomatism was facilitated by ingress of aqueous fluids. Serpentinite in Hole 1268 does not contain any brucite, suggesting that even the serpentinite has undergone silica metasomatism, as the precursor harzburgites and dunites had <15-20% orthopyroxene so that brucite would be expected to form during isochemical serpentinization. Gabbros in Hole 1268 do also show evidence for interactions with fluids with high silica activities since they are not rodingized but instead show common greenschist alteration to chlorite, albite, and actinolite. This is unlike other drill holes in the MAR 15°N area and elsewhere, where brucite-bearing serpentinites host rodingitized gabboic dikes.

We propose two possible explanations for the variability in aqueous fluid silica activity suggested by the phase assemblages of oceanic metaperidotites. (1) They are a result of the variable distribution of mafic units in a composite mafic/ultramafic crust, or (2) they are a consequence of the temperature-dependent reaction sequences taking place along the fluid flow path. To further explore the second possibility, we conducted isobaric (500 bar) geochemical model calculation. At temperatures >350°C, olivine is stable and hydration of pyroxenes imposes high silica activities to the fluids. Low aqueous silica activities can only develop at temperatures <<350°C, in particular when fluid pH is high due to the hydrolysis of olivine. Brucite-bearing serpentinite as well as rodingite are expected to form under those conditions. Steatitization, in contrast, requires two condi-tions: high fluid flux and high silica activities. Sulfide assemblages in Hole 1268 suggest that oxygen and sulfur fugacities were high during silica metasomatism, which is consistent with our geochemical model predictions of coupled decreases in H_2 fugacity and pH with increasing fluid flux.

Hydrothermal systems in the eastern Manus Basin: Effects of phase separation and fluid mixing

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The number of factors affecting metal fluxes within hydrothermal systems is large and the evolution of magmatic-hydrothermal system is complex and often difficult to reconstruct from the fossil record. Studying active submarine hydrothermal systems has a tremdous advantage: one can directly link fluid chemistry with deposits composition and rock alteration. Hydrothermal vents in arc/backarc settings are particularly intriguing as these systems are considered modern analogues for VHMS deposits.

The eastern Manus Basin reveals variable basement composition, ranging from depleted mid-ocean ridge basalt to basaltic andesite to rhyodacite with pronounced island-arc geochemical affinity. In August 2006, hydrothermal activity within the eastern Manus Basin was investigated using a combination of mapping and sampling (using AUV ABE and ROV Jason2). Objectives included identifying geological settings, examining interactions of seawater with felsic rocks, and determining the extent of volatile magmatic inputs into these systems. At the PACMANUS area five previously discovered vent fields were mapped and sampled, and a new very active field, Fenway, was located. The core of the Fenway field is a 40 m diameter two-tiered mound with active black smokers. The mound features exposures of anhydrite-sulfide stockwork. At the DESMOS caldera and at North Su vent field within the SuSu Knolls area acidic, sulfate-rich white smoker fluids were sampled. North Su also features black smoker acitvity with anhydrite stockwork. The abundance of massive anhydrite at Fenway and presence of anhydrite cement at North Su is consistent with significant local entrainment and heating of seawater.

Fluids sampled from felsic-hosted hydrothermal systems in the eastern Manus Basin exhibit great compositional variability within an individual vent field. Degassing of magmatic volatiles is evident in almost every vent field. Degassing of CO_2 is ubiquitous, while SO_2 degassing is obvious only in the Desmos and North Su hydrothermal fields. Excess fluorine in vent fluids is another indication of magma degassing. Evidence for past SO_2 degassing, in the form of native sulfur and advanced argillic rock alteration, exists in the South Su and PACMANUS areas. The majority of fluids exhibit salinities lower or higher than seawater, consistent with phase separation below the seafloor. Fluid boiling at the seafloor is evident in parts of the PACMANUS area (356°C, 1710 mbsl) and at North Su (325°C, 1180 mbsl).