Stable Isotope Evidence for Subduction Fluid Metasomatism in UHP Rocks

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Metasomatic selvages have been observed around gneiss-hosted mafic eclogite blocks in both the North Qaidam, China and Tso Morari, India UHP terranes. Stable isotope (O, B and Fe) analyses of the metasomatic rocks suggest they formed in near ultrahigh-pressure (UHP) conditions in the presence of subduction zone fluids.

In China, O isotope data from the selvage indicate a fluid/rock ratio >1 during regional-scale infiltration by high $\delta^{18}O$ (ca. 14‰) fluids. Heavy $\delta^{18}O$ overgrowths of metamorphic zircon over isotopically-lighter detrital grains indicate that the gneiss was similarly affected. Starkly contrasting B and $\delta^{11}B$ values for the host gneiss and the metasomatic selvage also cannot be explained by local-scale devolatilization of the gneiss. Instead, the B systematics are best attributed to two distinct phases of fluid infiltration. (1) Low-B, high-Cs selvage phengite with high $\delta^{18}O$ (14‰) and low $\delta^{11}B$ from -9 to -30‰ grew under near-UHP conditions. (2) High-B, low-Cs muscovite with generally positive $\delta^{11}B$ values crystallized in the host gneiss under subsequent epidote-amphibolite facies conditions as the terrane was exhumed past shallower portions of the subduction channel.

In India, measured whole rock and inter-mineral Fe fractionation between omphacite and garnet in samples collected from an eclogitic block varies with distance from the outer metasomatized edge of the boudin. The sample near the center plots within the range of equilibrium values determined by the ionic model (0.45‰), and the sample closer to the eclogite-gneiss metasomatized contact plots outside of the range of equilibrium values (0.08‰). The change in $\Delta^{56}Fe_{Omp\text{-}Grt}$ with proximity to the lithologic contact is interpreted to reflect an open system process that has perturbed the $\delta^{56}Fe$ value of omphacite, but not garnet, resulting in a disequilibrium fractionation. We hypothesize that the perturbing agent was a low $\delta^{56}Fe$ slab-derived, high-pressure metasomatic fluid, causing spuriously small omphacite-garnet fractionation in the metasomatic contact zone.