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Tracing fluid-induced metasomatism across a blueschist-facies shear zone (Sesia-Lanzo zone, Western Alps) using boron isotopes

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Boron (B) is a useful tracer for slab-mantle-arc fluid transport and recycling processes in subduction zones due to its high mobility in hydrous fluids and its significant isotope fractionation by fluid-rock interaction. Although B isotope geochemistry provides key evidence for slab to arc transfer by aqueous fluids, B isotope data on natural high-pressure metamorphic rocks are still scarce and the effects and extent of fluid-rock interaction remain poorly studied. Secondary ion mass spectrometry (SIMS) analyses generally confirm that slab dehydration significantly lowers δ^{11}B of subducted oceanic crust and sediments, but the lack of a systematic relationship with peak metamorphic conditions suggests additional processes have affected the exhumed rocks.

Here, we evaluate the effects of deformation and fluid flux on the B isotopic composition of phengitic mica along a structural profile with strain- and recrystallization gradient across a major crustal shear zone that separates two tectonometamorphic units in the Sesia-Lanzo Zone (SLZ), Western Alps. Weakly deformed, eclogite-facies samples contain phengites that show significant major element compositional differences between pristine cores and overprinted rims. Samples from the blueschist-facies shear zone contain fine-grained, mylonitic phengite with a major element composition similar to the rims. Lithium (Li) and B concentrations show a slight decrease in the overprinted rims (38-50 ppm Li, 30-33 ppm B) compared to the cores (55-69 ppm Li, 44-48 ppm B), and a significant drop to $<$10 ppm B and $\sim$20 ppm Li in the mylonitic phengite. These data point to increasing retrograde fluid influx from weakly deformed samples towards highly deformed mylonites.

Boron isotope compositions of phenigte cores and rims from the weakly deformed samples are highly negative (average δ^{11}B = -10 to -18) and overlap within uncertainty. These data confirm the postulated general trend of decreasing δ^{11}B values with increasing metamorphic grade, but the variability in δ^{11}B of samples that have experienced the same peak P-T conditions is considerable. In the shear zone, however, δ^{11}B is significantly higher (δ^{11}B = 0 to -5), an effect that is attributed to equilibration with an external high-δ^{11}B fluid during deformation. In contrast to B, Li isotope data of phengite and glaucophane from a shear zone sample (δ^{7}Li = +0.8 to +2.6) broadly overlap with the weakly deformed eclogitic micaschist (δ^{7}Li = +0.7 to +4.6), whereas both minerals in a weakly deformed metabasite show much lighter Li isotopic compositions (δ^{7}Li = -4$\pm$2). Lithium isotope systematics are decoupled from the B isotope signature and possibly more dependent on the precursor rock composition. These data will be combined with in situ Ar isotope analyses to systematically evaluate the effects of fluid-rock interaction on the Ar isotope system.

In summary, fluid-induced resetting of B isotopes in phengitic mica is controlled by mylonitic deformation and associated fluid flux during exhumation and juxtaposition of two tectonometamorphic segments in the SLZ.