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Metasomatism in eclogite and omphacitite xenoliths from the Navajo Volcanic Field (USA) and its impact on Mg-Fe-Zn-S isotopes

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Oceanic slabs release fluids in the deep forearc and subarc (≤120 km depth) that influence the composition and properties of the mantle wedge, but samples that directly interacted with these fluids are tectonically exhumed only from ≤80 km depth. This gap in the record can be closed using eclogite and omphacitite xenoliths from the Navajo Volcanic Field (NVF) that provide a detailed record of processes in the subducting Farallon plate. After initial eclogitization at ~50 Ma (2.4-3.3 GPa, 400-540°C), these xenoliths were subjected to at least two distinct episodes of UHP fluid metasomatism, which we investigate in more detail by studying their Mg-Fe-Zn-S isotope and Fe^{3+}/SFe systematics.

The first metasomatic episode, likely related to metasediment-derived fluids in the deep forearc, triggered new omphacite and pyrite growth at the expense of garnet and zoisite, thereby turning eclogites into omphacitites. The bulk rocks reveal a coupled increase of Na-Si-S-Li-LREE-Th contents, $Fe^{3+}/\Sigma Fe$ ratios, and $\delta^{26}Mg$, $\delta^{56}Fe$ and $\delta^{66}Zn$ values, but a decrease of Ca-Mg-Fe-Zn contents. This suggests loss of isotopically light Mg, Fe^{2+} and Zn from garnet to the fluids. Mass balancing of the coupled pyrite precipitation and bulk rock Fe oxidation reveals Fe-S redox interaction and points to the presence of both oxidized and reduced S in the metasomatizing fluid, corroborated by positive $\delta^{34}S$ values (mostly +1 to +5‰) in newly grown pyrite.

The second metasomatic episode is less obvious in the bulk chemical composition, but evident from Mg-rich garnet rims with mantle-like oxygen isotope compositions indicative of serpentinite-derived fluid in the subarc. These Mg-rich garnet rims have lower $\delta^{56}Fe$ values and Fe^{3+}/SFe ratios, but mostly higher $\delta^{26}Mg$ values than the pre-metasomatic garnet cores, while all omphacite generations have much higher $\delta^{26}Mg$ and $\delta^{56}Fe$ values than both garnet generations. This suggests that instead of (or in addition to) Mg-Fe supply by consumption of older garnet or omphacite generations, the serpentinite-derived fluids added Mg and isotopically light Fe^{2+} to the rocks. Our results reveal how UHP fluids in the deep forearc and subarc drive and undergo chemical and isotopic modifications while traveling through subducted metabasites before reaching the mantle wedge.