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Multiple isotopes trace volatile recycling through subduction zone metasomatism

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Subduction zone metasomatism is a key mechanism for recycling of crustal materials into the mantle wedge. Traditionally, the composition of mafic arc magmas is linked to normal metasomatism at subarc depths by subducting oceanic crust-derived fluids. Recent studies indicate geochemical contributions of mantle wedge serpentinite-derived fluids to both normal and reverse metasomatisms during subduction of oceanic slab to different depths. At forearc depths, subducting crust-derived Mg-poor fluids hydrate the mantle wedge peridotite to form serpentinite, resulting in the first stage of normal metasomatism. Afterwards, the serpentinite was offscrapped from the mantle wedge bottom and carried along subduction channels into subarc depths, where it breaks down to liberate Mg-rich fluids for both normal and reserve metasomatisms in the second stage. The normal metasomatism is indicated by some arc basalts with serpentinite-derived geochemical signatures, whereas the reverse metasomatism is recorded by coesite-bearing whiteschist. While a great deal of studies has devoted to normal metasomatism by subducting crust-derived Mg-poor fluids, less attention has been paid to both normal and reverse metasomatisms by serpentinite-derived Mg-rich fluids.

The coesite-bearing whiteschist from the Dora-Maira Massif in Western Alps provides an excellent target to investigate the reverse metasomatism in the composite oceanic and continental subduction zone. It shows high δ^{26}Mg values of -0.07 to +0.72‰ and high tourmaline δ^{11}B values of mostly -2 to +1‰. Based on the Mg-B isotope systematics in terrestrial reservoirs, the metasomatic fluids were demonstrated to originate from the mantle wedge serpentinite. In addition, the whiteschist exhibits low $Fe^{3+}/\sigma Fe$ but high δ^{56}Fe values, indicating significant Fe mobility and the loss of Fe^{2+} in the form of Fe^{2+}-Cl and Fe^{2+}-(HS) complexes in reduced fluids. In this regard, mantle wedge serpentinite-derived fluids have high δ^{26}Mg and δ^{11}B values but low δ^{56}Fe values. This has great bearing on the composition of arc magmas, accounting for both high δ^{11}B and δ^{26}Mg values for arc basalts from South Sandwich Islands. Although detailed processes remain to be investigated, the incorporation of serpentinite-derived fluids into both crustal and mantle rocks at subarc depths can be deciphered by an integrated study of Mg-B-Fe-O isotope systematics in the metamorphic and magmatic products.