Slab-derived halogens and noble gases in mantle peridotites from subduction zones

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Halogens and noble gases are expected to provide complementary information as tracers on the origin and behavior of water in the mantle. This is because both of these groups of elements are strongly partitioned into fluids and have distinct elemental and/or isotopic compositions depending on their origin. Seawater-like noble gases in the convecting mantle are carried into the mantle via subduction of seawater or sedimentary pore fluids [1]. Halogens in mantle wedge peridotites also have a signature suggesting an origin involving sedimentary pore fluids [2]. The pore fluid-like halogens and noble gases would be incorporated into serpentine minerals in the oceanic plate derived from pore fluids in overlying sediments, and then carried into the mantle during the subduction process [2,3]. Here, we present the halogen and noble gas compositions of mantle peridotites from subduction zones to better constrain how far the influence of subducted pore water extends into the mantle.

We applied the noble gas method which converts halogens (Cl, Br and I) and other elements (K, Ca, Se, Te, Ba and U) to isotopes of Ar, Kr and Xe by neutron irradiation in a nuclear reactor [4]. This method has detection limits that are from two to five orders of magnitude lower than alternative methods and is required to determine the relatively low halogen abundances in mantle samples.

The samples studied are harzburgitic xenoliths from Avacha volcano in Kamchatka and Pinatubo volcano in the Philippines, and alpine-type peridotite from Horoman massif in Japan. Water-rich fluid inclusions have been found in mineral phases in all of these rocks [5,6,7]. The Br/Cl and I/Cl values show a contribution of subduction fluids [2] to a mantle-like component [7] with different proportions of subduction fluid in each sample locality. Noble gas compositions are also dominated by slab-derived noble gases with atmosphere-like isotopic compositions as previously reported [9,10].

The signatures of subducted halogens and noble gases observed in the mantle peridotites are strong evidence that the sedimentary pore water signature is preserved through the subduction process and survives in the mantle wedge. Transport of some of this material into the deep mantle then accounts for the same signature observed in mantle-derived gases [1].

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