Pore fluid-derived halogens and noble gases preserved in exhumed mantle wedge rocks from the subduction-type Sanbagawa metamorphic belt

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Subduction volcanism is generally considered to form a 'subduction barrier' that efficiently recycles volatile components contained in subducted slabs back to the Earth's surface [1]. Nevertheless, subduction of sediment and seawater-dominated pore fluids to the deep mantle has been proposed to account for the non-radiogenic elemental and isotopic compositions of heavy noble gases (Ar, Kr, and Xe) in the convecting mantle [2]. To verify whether and how subduction fluids preserve a seawater signature, we determined noble gases and halogens in the Higashi-akaishi peridotite and Western Iratsu and Seba eclogite from the subduction-type Sanbagawa metamorphic belt, southwestern Japan, in which relicts of slab-derived water are contained as hydrous mineral inclusions in wedge mantle rocks exhumed from depths of more than 100 km [3] and aqueous fluid inclusions in associated slab-derived eclogites and quartz veins and lenses [4,5].

The observed noble gas and halogen compositions of the peridotite [6] and eclogite samples show striking similarities with sedimentary pore fluids, involving a minor contribution from altered oceanic crust in the case of halogens in eclogites. The almost constant noble gas and halogen elemental ratios with depths of slab-derived fluid entrapment ranging from 30 to 100 km indicate flux of pore fluid-derived water is extensive in the mantle wedge, challenging a popular concept that the water flux into the mantle wedge is dominantly controlled by hydrous minerals in altered oceanic crust and sediment [e.g., 7]. These results indicate that subduction and closed system retention of marine pore fluid occurs to depths of at least 100 km, necessitating a reassessment of the dominant transport mechanism and source of water in subduction zones. Further subduction of a small amount of marine pore fluid can account for the heavy noble gas composition observed in the convecting mantle [1].

The mechanism by which the seawater-like noble gases are delivered to the convecting mantle remains to be elucidated. Serpentinized lithosphere of subducting slab is probably the best candidate, because serpentine contains significant amounts of Cl (up to 0.5 wt%). If the hydration of the lithosphere by pore fluids is operating in a closed system, subduction of the serpentinized lithosphere can transport pore-fluid derived noble gases and halogens into the deep mantle [6]. This is supported by a recent observation of pore fluid-like noble gases and halogens in exhumed serpentinites [8].

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