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三波川変成帯のカンラン岩とエクロジャイトに捕獲されたスラブ起源ハロゲンと希ガス
Slab-Derived Halogens and Noble Gases Preserved in Peridotite and Eclogite from the 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 (Staudacher and Allegre, 1988, Earth Planet. Sci. Lett. 89, 173-183). Nevertheless, subduction of sediment and seawater-dominated pore fluids to the deep mantle has been proposed to account for heavy noble gas (Ar, Kr and Xe) non-radiogenic elemental abundance and isotopic pattern of the convecting mantle (Holland and Ballentine, 2006, Nature 441, 186-191). To verify whether and how subduction fluids preserve a seawater signature, we have determined noble gas and halogen compositions of the Higashi-akaishi peridotite and Western Iratsu and Seba eclogite bodies in the Sanbagawa metamorphic belt, southwest Japan, in which relicts of slab-derived water are contained as hydrous mineral inclusions in wedge mantle rocks exhumed from depths in excess of 100 km (Mizukami et al., 2004, Nature 427, 432-436) and aqueous fluid inclusions in associated slab-derived eclogites and quartz veins/lenses (Endo et al., 2009, J. Metamorphic Geol. 27, 371-384; Endo, 2010, Isl. Arc 19, 313-335; Hirajima et al., 2010, Geophys. Res. Abst. 12, EGU2010-6343).

The striking similarities of the observed noble gas and halogen compositions of the Higashi-akaishi peridotite with marine pore fluids (Sumino et al., 2010, Earth Planet. Sci. Lett. 294, 163-172) challenge a popular concept, in which the water flux into the mantle wedge is only by hydrous minerals in altered oceanic crust and sediment (e.g., Schmidt and Poli, 1998, Earth Planet. Sci. Lett. 163, 361-379). The Western Iratsu eclogite also exhibits non-radiogenic noble gas and halogen elemental ratios well explained by a mixing between seawater-derived and sedimentary components. These results indicate that subduction and closed system retention of marine pore fluid occurs up to depths of at least 100 km. Two mechanisms of subduction of unfractionated pore fluid-derived noble gas and halogens are proposed: one is that a portion of pore-fluid in sediments and/or crust subducts to a depth deeper than the overlying crust and is liberated and incorporated into grain boundaries of the mantle peridotite that is dragged down by flow in the mantle along with the downgoing slab. The other is that hydrated lithospheric mantle, resulting from penetration of pore-fluid along bending-related faulting of the oceanic plate entering subduction zones, preserves unfractionated noble gases and halogens of pore-fluid origin and transports them to the deep mantle.

The subducted halogen and noble gas compositions are clearly distinct from those of arc volcanic gases. This implies that the subduction-related metamorphic rocks of the Sanbagawa belt appear to have frozen-in and preserved a previously unseen part of the deep water recycling process whereby noble gases and halogens (and probably other volatiles) are injected into the wedge mantle just above the subducting slab, requiring a reassessment of the dominant transport mechanism and source of water in subduction zones. A small proportion of marine pore fluid, preserved in the downgoing hydrous peridotite and/or eclogite, can account for the heavy noble gas composition observed in the convecting mantle.

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