Noble gas and halogen recycling at the Izu-Ogasawara subduction zone

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Recent findings of subducted halogens and noble gases with seawater and sedimentary pore-fluid signatures in exhumed mantle wedge peridotites and eclogites from the Sanbagawa-metamorphic belt, southwest Japan [1,2], as well as seawater-derived heavy noble gases (Ar, Kr, and Xe) in the convecting mantle [3], challenge a popular concept that the water flux into the mantle wedge is controlled only by hydrous minerals in altered oceanic crust and sediment. Serpentinized lithosphere of the subducting oceanic plate may transport noble gases and halogens acquired from pore-water in the overlying sediment [1,2,4]. To verify whether and how such subduction fluids modify the composition of the mantle beneath subduction zones, we determined noble gas and halogen compositions of olivines in arc lavas collected from 10 localities of the northern Izu-Ogasawara subduction zone and 11 IODP sediments and basalts recovered from northwestern margin of the Pacific plate.

MORB-like $^{3}He/^{4}He$ and halogen ratios of the Izu olivines indicate insignificant contributions to the mantle wedge of radiogenic ^{4}He and pore fluid-like halogens, both of which are observed in the subduction fluids in the Sanbagawa samples exhumed from a depth ranging from 40 to 100 km [1,2]. On the other hand, a systematically higher contribution of atmospheric Ar in volcanic front lavas relative to rear-arc lavas suggests progressive decrease in the flux of subducted Ar from the slab with increasing distance from the Izu-Ogasawara Trench. The distinct halogen and heavy noble gas elemental ratios of altered oceanic basalts indicate their minor contributions to the Izu arc magma and the Sanbagawa subduction fluids. In contrast the I/Cl ratios of the Sanbagawa subduction fluids are elevated above sedimentary pore fluid values [1] and can most simply be related to the high I/Cl ratios of pelagic clays and radiolarian cherts.

The significantly smaller contributions of subducted noble gas and halogen in the Izu-Ogasawara arc relative to those in the Sanbagawa belt may result from a difference in the P-T condition of the subducted slabs. A hotter mantle wedge than those characteristic of mature subduction zones is proposed for the Sanbagawa subduction system [5], in contrast the Izu subducting slab is relatively cold and would therefore lose relatively little water at equivalent depths to other slabs [6]. This implies a relatively small amount of the pore water subduction fluids would be released from the Izu slab at a sub-arc depth (150-200 km) resulting in further subduction of halogens, heavy noble gases and potentially water, to great depths in the mantle.

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