論文内容の要旨

論文題目　Noble gas geochemistry of the Izu-Ogasawara subduction system

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The Izu-Ogasawara volcanic arc is located along the boundary between two oceanic plates, the Pacific plate and the Philippine Sea plate, parallel to the Izu-Ogasawara trench. This arc is suitable to investigate the origin of the slab-derived fluid, which plays an important role in arc magma generation. This is because we don't have to consider the contribution of the continental crustal component in arc magma genesis. How noble gases transport to the deeper place and are recycled to Earth's surface via arc volcanism in the subduction system is an important issue in the understanding of the evolutional history of the Earth's interior.

I measured noble gas isotopic composition of gas and rock samples from the Izu-Ogasawara arc, in order to evaluate which is more preferable, gas or rock sample, to identify the inherent noble gas features of arc magmas. Subducting sediments, basalts collected from ODP Leg 185, Sites 801 and 1149 and gabbros in the Pacific plate were also analyzed to know the isotopic nature of subducting noble gases. Serpentinites in the Izu-Ogasawara fore-arc, which are formed by hydration of mantle wedge materials with subduction-related fluids, containing noble gases of fluid origin, were also analyzed. Then the noble gas behaviors during the subduction processes were discussed using both input (subducting materials) and output (volcanic products) data.

Volcanic products show $^{3}He/^{4}He$ ratios of 8.0 R_A, which are in the range of the MORB value (8 ± 1 R_A). The $^{40}Ar/^{36}Ar$ ratios of these samples range from 300 to 620, which are significantly lower than that of the MORB source (up to 32000). On the other hand, subducting gabbros show a similar $^{3}He/^{4}He$ ratio of the MORB value, while the $^{40}Ar/^{36}Ar$ ratios for the gabbros range from 420 to 800, some of which are higher than those of the volcanic products. These observations reveal that pore water dissolving atmospheric argon ($^{40}Ar/^{36}Ar$ = 296) in the subducting slab significantly affects the noble gas signature in arc magma rather than the input materials measured in this study.

Considering that no difference in $^{3}He/^{4}He$ ratios between the volcanic front and the back arc regions is observed, it is indicated that the contribution of helium in the subducting materials to the mantle wedge beneath the Izu-Ogasawara arc is considerably low. On the other hand, there was an obvious difference in $^{40}Ar/^{36}Ar$ ratios of rock samples between the volcanic front and the back arc regions. Since the $^{3}He/^{4}He$ ratio of the mantle wedge beneath the Izu-Ogasawara arc is similar to that of MORB, its $^{40}Ar/^{36}Ar$ ratio must have been originally the same as that of the MORB source mantle. However, the $^{40}Ar/^{36}Ar$ ratios of the volcanic front region and back arc regions were shown to be significantly lower than the MORB value, indicating the considerable addition of atmospheric argon to the arc magma derived from the subducting slab. A simple mass balance calculation of argon isotopes revealed that at least 7% of the subducting pore water dissolving atmospheric argon in the slab is recycled back to the atmosphere through arc volcanism.

Helium is the most mobile noble gas, hence helium in the subducting materials may be degassed before the slab reaches to the depth of generation of arc magma. As a result, the $^{3}He/^{4}He$ ratio of arc magma is similar to the MORB value, which is an original value of the mantle wedge. Heavy noble gases (argon, krypton, xenon and probably neon) may be able to subduct with the slab to a deeper place than the depth of helium release. As shown in $^{40}Ar/^{36}Ar$ ratio, contribution of slab-derived noble gases to magma generated at the back arc is considered to be smaller than that of magma at the volcanic front region due to continuous degassing from subducting slab with depth. Consequently, argon isotopic ratio of magma at the back arc region is higher than that of the volcanic front region.

It is not evident at present whether heavy noble gases in subducting materials are completely degassed beneath the back arc region. However, since the $^{40}Ar/^{36}Ar$ ratio of basalts from the Mariana trough, a back arc basin, is still much lower than that of the MORB source mantle, it is speculated that a part of pore water dissolving atmospheric noble gases carried in the serpentine may be transported into a greater depth to the deeper mantle.