Across-arc variation in noble gas isotopes of volcanic products from the Izu-Ogasawara arc

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Noble gases are considered to be ideal geochemical tracers to trace volatile behavior during subduction processes because of their chemical inertness. Under natural environment, variation in their isotopic compositions caused by physical processes, so that the isotopic ratios are different among several reservoirs, such as upper mantle, atmosphere and continental crust.

The Izu-Ogasawara arc is located along the boundary of two oceanic plates, the Pacific plate and the Philippine Sea plate, parallel to the Izu-Ogasawara trench in the Pacific Ocean. This arc is suitable to investigate the recycling of the volatile materials concurrent with the subduction process, because the contribution of continental components in arc magma can be negligible.

Hot spring gases, steams, hot spring waters and volcanic rocks were collected from the volcanic front and the back-arc region in the northern part of the Izu-Ogasawara arc. In case of water samples, dissolved gas was extracted for analysis. Olivine phenocrysts were separated from the volcanic rock samples, and noble gases were extracted by a combination of step heating (600C, 1200C and 1800C) and in vacuo crushing. Then, noble gas abundances and their isotopic compositions were measured for these gas and rock samples.

The gas samples have different maximum 3He/4He ratio between in the volcanic front region (6.3-7.0Ra, where Ra denotes the atmospheric ratio, 1.4x10E-6) and in the back-arc region (7.0-8.0Ra), while rock samples have similar 3He/4He ratio of about 8.0Ra in both regions, which is in the range of the MORB value.

The 40Ar/36Ar ratios of rock samples from the back-arc region is about 620 at highest, whereas those from the volcanic front region is about 320 at highest. Both ratios are significantly lower than the MORB value (40000) indicating that the contribution of slab-derived atmospheric component is very large in the mantle wedge.

Based on noble gas data, a model of volatile behavior during subduction process in the Izu-Ogasawara arc is proposed. Helium transported with subducting materials (including sediments and altered oceanic crust) is degassed from subducting plate at shallow depths in the fore-arc region, and so the magma chamber beneath the volcanic front is not influenced by the subducting helium. While heavy noble gases (Ar, Kr, Xe and probably Ne) subduct with subducting materials to a greater depth than helium, and degassed with dehydration of subducting materials. Therefore, heavy noble gases in the magma beneath the volcanic front are severely influenced by those gases from subducting materials. Based on 40Ar/36Ar difference of rock samples between volcanic front and back-arc regions, it is suggested that the contribution of heavy noble gases from subducting materials in the back-arc side is smaller than that in the volcanic front.