Mantle-derived xenoliths with hot-spot type helium in Cenozoic alkali basalt, northwestern Kyushu, Japan

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The $^3He/^4He$ ratio of mantle-derived material is not uniform and the distinct $^3He/^4He$ signatures are found in association with different tectonic environments. Helium isotopic signature of hot-spot regions such as Hawaii, Iceland, and Réunion range from 9 to 30 Ra, where Ra is $^3He/^4He$ of the atmosphere = 1.4×10^{-6}, which indicates that the hot-spot volcanisms tap a deeper region of the mantle enriched in ^3He than MORB reservoir.

Cenozoic alkaline basalts from back-arc region of the Japanese island-arc system are less depleted in Ta, Nb and Ti and less enriched in K, Sr, Ba and Rb compared with samples from northeastern Japan. These geochemical features lead to Nakamura *et al.* (1985) to suggest that the alkali volcanisms of this area were not directly related with subduction processes but were triggered by plumes originated from greater depth. Furthermore, it was suggested that the alkali basalt magmatism may represent the final stage of a mantle diapirism which was most active in the Miocene and caused the opening of the Sea of Japan (Iwamori, 1991). We measured noble gas isotopic compositions of xenoliths in Cenozoic alkali basalt, Takashima, northwestern Kyushu to investigate possible contribution of deep mantle plume.

Samples and experiments

There are many localities of Cenozoic volcanics which carry mantle-derived xenoliths in the Japan island arcs. Takashima (33°28′25″N, 129°59′26″E) is one of the numerous Cenozoic monogenetic alkali basalt volcanoes of the Southwest Japan arc. The Takashima alkali basalt is 3.0 Ma in age (Nakamura, *et al.*, 1986) and erupted on the rim of the Southwest Japan arc adjacent to the Sea of Japan, a back-arc basin for the Japan island arc (Fig. 1). It contains many ultramafic xenoliths and pyroxene megacrysts. Olivines separated from dunite xenoliths and pyroxene megacrysts were used for noble gas analyses. Gases were extracted from mineral separates by *in vacuo* crushing and heating. Noble gas analyses were carried out in two laboratories. Crushing experiments were done using a sector-type mass spectrometer (VG-5400, Micromass) in the Laboratory for Earthquake Chemistry of the University of Tokyo. A detailed procedure of the noble gas isotopic ratio measurement has been described by Nakai *et al.* (1997). Air standards were measured frequently for correction of mass discrimination factors of the mass spectrometer. Heating experiments and a few crushing experiments were performed by modified VG-5400 at the Institute

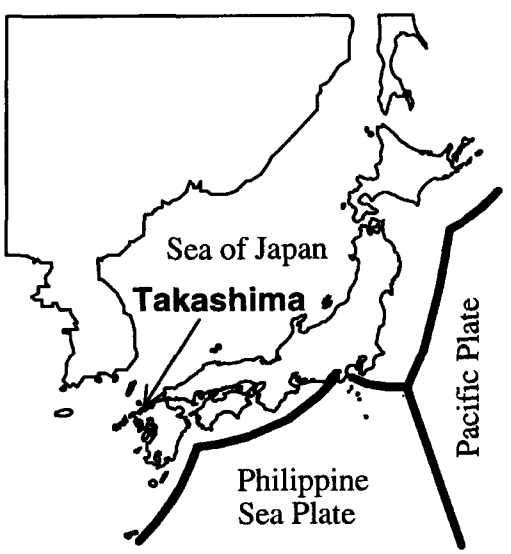

FIG. 1. The location of Takashima. Thick solid lines represent plate boundaries.

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Details of the mass spectrometric technique at ISEI were described by Nagao *et al.* (1996).

Results and discussion

Most of olivines contain helium with $^{3}He/^{4}He$ ratios of MORB (8 $\pm$ 1 Ra). However, three samples of olivine showed significantly higher $^{3}He/^{4}He$ ratios of 9.9 $\pm$ 0.3, 11.8 $\pm$ 0.7, 15.3 $\pm$ 1.3 Ra. The first two ratios were obtained with crushing extraction method, which releases little cosmogenic component. The highest value was obtained with heating extraction method. However, $^{21}Ne/^{22}Ne$ ratio of the sample was almost atmospheric (0.033 $\pm$ 0.005), indicating little cosmogenic contribution. Lower limit of $^{3}He/^{4}He$ ratio after cosmogenic component correction with this $^{21}Ne/^{22}Ne$ ratio is 13.9 Ra, and this value is still higher than MORB. The results indicate that the alkaline volcanism in northwestern Kyushu contain hot-spot type helium. $^{3}He/^{4}He$ ratios of pyroxenes obtained with crushing extraction method were in the range of those of MORB, however $^{3}He/^{4}He$ ratios obtained with heating method showed lower value, indicating the post-eruptive addition of radiogenic ^{4}He.

The $^{40}Ar/^{36}Ar$ ratios (300–1100) of these samples are generally lower than that assumed for MORB-type argon (>20000). These low $^{40}Ar/^{36}Ar$ ratios are considered as a result from mixing of hot-spot type argon and MORB-type argon or, contamination by atmospheric argon in the suducting slab. Isotopic compositions of other noble gases were not significantly different from those of atmosphere.

Our helium isotopic results clarified contribution of hot-spot type material to the alkali volcanisms. There are a few previous noble gas studies of xenoliths in alkaline basalts from back-arc region of the Japanese island-arc system (e.g. Nagao and Takahashi, 1993). The $^{3}He/^{4}He$ ratios obtained in these previous studies were the same as MORB. Therefore, this is the first case that hot-spot type helium were found in this region.

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