Trace of mantle plume beneath southwest Japan revealed by noble gas isotopes

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Since Cenozoic alkaline basalts distributed around the Sea of Japan have geochemical characteristics distinct from typical island-arc basalts, they are considered to be mantle plume origin. We have analyzed mantle-derived xenoliths contained in alkaline basalts from southwest Japan to investigate the contribution of the plume (Nagao and Takahashi, 1993, Sumino et al., 2000). We will present new data of noble gas isotopic compositions of mantle xenoliths and alkaline basalts from southwest Japan to discuss the origin of the volcanism.

Olivine and pyroxene separates from alkaline basalts collected from Higashi-matsuura and Kita-matsuura districts in northwestern Kyushu were used for analysis. Mantle-derived xenoliths were collected from Takashima (Karatsu bay), Kurose (Genkai-jima) and Hukue-jima (Goto Islands). Noble gases were extracted by in-vacuo crushing and heating methods.

3He/4He ratios of Higashi-matsuura basalts and xenoliths from Kurose were comparable to the MORB-value (8+/-1Ra), and 40Ar/36Ar ratios (300-800) were low with respect to mantle-derived materials. These data can be explained by addition of slab-derived noble gases to wedge mantle isotopically similar to the MORB source mantle. 3He/4He ratios of xenoliths from Takashima varied from 6.1 to 16.6Ra, indicating that plume-type helium was contained in some parts of the samples.

Stepwise crushing method was applied for two helium-rich samples. The sample with low 3He/4He ratios with replicate bulk analyses showed relatively constant 3He/4He ratios during the stepwise crushing. Meanwhile 3He/4He ratios of the sample with high 3He/4He ratios in bulk analyses varied from 8.5 to 11.8Ra independently with progress of the crushing. The crushing method is effective to selectively extract noble gases from fluid inclusions. Fluid inclusions which were aligned along planes of healed fractures were observed in the sample with constant 3He/4He ratios. On the other hand, not only the planner inclusions but also randomly-scattered, large fluid inclusions were contained in the sample with variable 3He/4He ratios. Thus helium with low and high 3He/4He ratios are trapped in the planner and the scattered fluid inclusions, respectively. Since alkaline basalts erupted around Takashima show similar 3He/4He ratios to that of the planner inclusions, helium with the low 3He/4He ratios in xenoliths might be acquired from their host magma.

The high 3He/4He ratio of the scattered inclusions indicates that plume-type helium had been trapped in uppermost mantle beneath northwestern Kyushu before eruption of Higashi-matsuura basalts. There were no intra-plate volcanisms in northwest Kyushu before the alkaline basalt activity, which had started 11 million years ago. Yanagi and Maeda (1998) suggested that mantle upwelling beneath this region started at about 40 million years ago and continued until just before the alkaline basalt activity. It is possible that plume-type helium was inherited from incipient melts carrying noble gases with plume signature during the mantle upwelling, and when alkaline basalt magmas erupted in Higashi-matsuura were generated, 3He/4He ratio of the plume had decreased owing to dilution by MORB-like helium in surrounding mantle.

Noble gases analysis of alkaline basalts which erupted in the early stage will constrain this model. However, it is difficult to get samples containing fresh olivine suitable for analysis. Large amounts of Fe-rich black pyroxenite xenoliths which might be precipitated from incipient alkaline basalt melt are observed in southwest Japan (Arai et al., 2000). Analysis of these pyroxenites is ongoing because they are expected to contain noble gases inherited from early alkaline basalt magma.

References

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