Research for multiple fluids trapped in subcontinental mantle based on noble gas isotopes

Junji Yamamoto[1], Ichiro Kaneoka[1], Hiroyuki Kagi[2], Shoji Arai[3]

[1] ERI, Univ. Tokyo, [2] Lab. Earthquake Chem., Grad. School Sci. Univ. Tokyo, [3] Dept. Earch Sci., Kanazawa Univ.

Spectroscopical and petrographical observation suggest that there are at least two compositionally distinct fluids in subcontinental mantle-derived xenoliths from far eastern Siberia. One consists predominantly of liquid CO2. The other is melt inclusion involving blebs. The inclusions of liquid CO2 were rarely seen in the samples showing the low 3He/4He ratios. Therefore it is speculated that the inclusions of liquid CO2 has a high 3He/4He ratio similar to that of MORB, and the component with the low 3He/4He ratio is derived from blebs in melt inclusions. Furthermore, low 40Ar/36Ar ratios were shown in the melt inclusions. Hence, the melt inclusion showing atmospheric property and significantly low 3He/4He ratio may have been derived from a component related to the old subducted slab.

To reveal the geochemical characteristics in the subcontinental mantle and obtain some additional constraints for the influences of the subducted components, I have analyzed noble gas compositions of subcontinental mantle-derived ultramafic xenoliths from far eastern Siberia. In the far eastern Siberia area, oceanic crusts have been subducting underneath the Eurasian plate since about 100 Ma. Hence, the mantle beneath the far eastern Siberia might have been influenced by the components derived from the crustal materials.

By applying both methods of vacuum crushing and stepwise heating for extraction of noble gases, I have revealed the occurrence of 3He/4He ratios extremely lower than the atmospheric ratio in olivine separates for some of subcontinental mantle-derived xenoliths from far eastern Siberia. Since He with the low 3He/4He ratio was extracted by the crushing method, it is expected to be located mostly in fluid inclusions of minerals. While, MORB-like high 3He/4He ratios have also been observed for some samples in gases extracted by the crushing method. Hence, at least two kinds of fluid sources with the low 3He/4He ratio and the MORB-like value should exist in the upper mantle underneath the far eastern Siberia area. Furthermore, the orthopyroxene and clinopyroxene of two samples show fairly similar helium compositions to those of olivines. It may indicate that those minerals might have trapped the same fluid in fluid inclusions.

For gases extracted by the heating method, the 3He/4He ratios observed in gases extracted by the crushing method would approximately correspond to the total 3He/4He ratios, in particular for samples with low 3He/4He ratios.

The crushing method is effective to selectively detect the components trapped in fluid inclusions. Spectroscopical and petrographical observation suggest that there are at least two compositionally distinct fluids in these xenoliths. One consists predominantly of liquid CO2, which is isolated from alignment of the inclusion arrayed in neighboring minerals. The other is melt inclusion involving blebs, which intrude through minerals, indicating a following intrusion. However, reaction rim was not observed in the contacted part with the melt inclusions. Thus the melt inclusions would not be derived from the host magma. Although the melt inclusions were observed throughout the mantle-derived xenoliths from far eastern Siberia, the inclusions of liquid CO2 were rarely seen in the samples showing the low 3He/4He ratios. Therefore it is speculated that the inclusions of liquid CO2 has a high 3He/4He ratio similar to that of MORB, and the component with the low 3He/4He ratio is derived from blebs in melt inclusions.

In the present study, all 40Ar/36Ar data obtained with the crushing method are less than 1000, which are significantly low compared to those found in MORB. The most likely source to have caused the low 40Ar/36Ar ratio is the material with the atmospheric compositions. Since the low 40Ar/36Ar ratios were observed irrespective of the occurrence of CO2 inclusions, it is likely that the atmospheric component would exist in melt inclusions.

Since the far eastern Siberia area had been located at the subduction zone, the melt inclusion showing atmospheric property and significantly low 3He/4He ratio may have been derived from a component related to the old subducted slab. On the other hand, the 3He/4He ratios observed in the CO2 inclusion are assumed to be similar to the MORB-like value, which might reflect more ubiquitous character of the upper mantle as a whole. Hence, the far eastern Siberian mantle with the initially MORB-like source might have been infiltrated by subduction-related fluids at least partly.