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Geographical distribution of helium isotope ratios in northeastern Japan and its origin

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A helium isotope ratio (^{3}He/^{4}He ratio) is a good indicator to distinguish the origin of fluid as a carrier, because the ratios in the mantle and crust are quite different each other. We decompose the helium from samples obtained in northeastern Japan into three components originated from the mantle, crust and atmosphere using ^{3}He/^{4}He ratios and ^{4}He/^{20}Ne ratios.

Geographical distribution of helium isotope ratios in northeastern Japan is characterized by high values of 4 to 8 R_A (where R_A is the atmospheric ^{3}He/^{4}He ratio of 1.40x10^{-6}) in the back-arc regions and low ratios less than 1 R_A in the fore-arc regions. This reflects that the major parts of helium in the back-arc regions are originated from the mantle and those in the fore-arc regions are from the crust. The ^{3}He/^{4}He ratios vary along the volcanic front. In Miyagi prefecture [38-39N], the ratios range from 2 to 5 R_A. On the other hand, the ratios are less than 1 R_A in and around the southern border between Iwate and Akita prefectures [39-39.5N] (Horiguchi et al., 2007). This difference is caused by the difference in mixing ratios of mantle component and crust component of helium. In the former region, mantle components are dominant, but crust components dominate in the latter region.

Comparing the distribution of helium isotope ratios to some results of recent geophysical studies, we find that the features in geographical distribution of helium isotope ratios are similar to those of low-velocity zone distributions and high $Q_p{}^{-1}$ distributions in the uppermost mantle. It is also noteworthy that contributions of mantle component of helium decrease with distances from Quaternary volcanoes or active faults.

These observations strongly suggest that the geographical distribution of helium isotope ratios reflects that of melts in the uppermost mantle. Mantle-derived helium is thought to be transported to the ground surface with magmatic fluids at volcanoes and transported with aqueous fluids along active faults in non-volcanic regions.