Helium isotopes in Lake Mashu, 2017

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Helium-3 is one of the most sensitive geochemical tracers which reflects addition of mantle components to volcanic hydrothermal systems, and temporal changes of $^3He/^4He$ ratios may reflect activation of the systems leading to eruptions (e.g., Kagoshima et al., 2016). Therefore He isotopes may be useful to assess hydrothermal activity at volcanic lakes. Lake Mashu is a caldera lake which formed around 7000 years ago in Hokkaido, the northernmost island in Japan. Igarashi et al. (1992) measured He and Ne isotopes in water of Lake Mashu, and concluded that they reflect injection of mantle-derived He due to hot spring activity at the lake bottom. After that, there is no subsequent study reporting He isotope data. The lack of observational data may be due to difficulty of water sampling at caldera lakes. Igarashi et al. (1992) collected water samples into copper tubes. However this method requires heavy and large sampling tools, and well-trained people to seal the tubes.

In May and September 2017, we investigated Lake Mashu in order to check volcanic activity and practical sampling methods for caldera lakes. We collected water using a Niskin bottle at several depths (surface to 210 m) around the deepest point (211 m). Collected water was immediately transferred into lead-glass containers with vacuum valves at both ends. In Atmosphere and Ocean Research Institute, dissolved gases were extracted by a head space method, and introduced into a purification vacuum line. In the line, He and Ne were refined for isotope analyses. $^3He/^4He$ and $^4He/^{20}Ne$ ratios were measured using Helix-SFT and QMS, respectively. The highest $^3He/^4He$ ratios were observed at 205-210 m depth. The values were 2.70 ± 0.03 R_a (error: 1σ) (R_a is the atmospheric $^3He/^4He$ ratio of 1.38×10^{-6}) and 3.95 ± 0.04 R_a (1σ) in May and September, respectively. The increase of $^3He/^4He$ ratios may reflect accumulation of fluids with high $^3He/^4He$ ratios injected from the bottom. A linear correlation ($R^2 = 0.89$) between $^4He/^{20}Ne$ and $^3He/^{20}Ne$ ratios in 20 samples indicated mixing of two components: injected fluids and the atmosphere. The fitting provides a fluid end-member with the $^3He/^4He$ ratio of 6.52 ± 0.53 R_a (1σ). This value is indistinguishable from 6.74 ± 0.12 R_a calculated by Igarashi et al. (1992), indicating a possibility that there was no significant change in volcanic activity at Lake Mashu in the past 30 years.