Helium measurements by passive diffusion samplers hanged in a borehole in Beppu, Japan

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Helium concentrations and its isotopic ratios in spring water are potentially powerful tools for crustal tectonic and thermal events, and could serve as tracers in resolving contribution of mantle-derived fluid. However, helium gas in spring water is directly sampled on sites and often collected with its coexisting water. A new passive diffusion sampler, which is just set up at any sites, can collect only helium gas dissolving in water (Dame, 2015). The sampling devices allow gas exchange between the head space in the sampler volume and the dissolved gases in the water though gas permeable silicon tubing. Here, we measured helium concentrations and its isotopic ratios in a borehole in Beppu, Japan, and obtained their depth profile.

Beppu is located on east end of subsidence of the Beppu-Shimabara Graben in Kyushu Island, southwest Japan (Matsumoto, 1979), and is a famous area as a geothermal system. The geothermal system is situated on the eastern flanks of the Tsurumi-Garandake volcanic center and spread until the coastline to the east. The geothermal activity is mostly concentrated in two areas, on the northern and southern sides of the fan deposit. These two areas are known as the Kamegawa and Beppu thermal zones, which are along with two faults, the Kamegawa and Asamigawa faults, respectively (Allis & Yusa, 1989). Therefore, it is worthwhile to attempt to find depth profile of helium signal in this area.

The sampling devices were installed every 50 m from near bottom of the well to the surface in the periods of July 13th-15th, August 21st-24th, 2015 and May 31st-June 3rd, 2016. The collected gases were measured by a noble gas mass spectrometer (Helix SFT; GV Instrument) installed at Atmosphere and Ocean Research Institute, University of Tokyo.

Helium concentrations and isotope ratios ($^{3}He/^{4}He$) are gradually lower, as setting depth becomes shallow. The $^{3}He/^{4}He$ ratios ranges from 1.0-2.2 R_a under water surface to 6.3-7.1 R_a (R_a=1.4×10^{-6}) at the bottom of a borehole. The high $^{3}He/^{4}He$ ratios are within range reported for mantle-derived magma at subduction zones (e.g., Hilton et al., 2002). The MORB-type helium could enter the borehole with hot spring water around the bottom. The observed variation in the $^{3}He/^{4}He$ ratios are the result of binary mixing of magma and air components.

References

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