

Groundwater flow system of Unzen volcano (2): Results from He isotopes in groundwater

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We are studying groundwater system of the volcano using geochemical and hydrological techniques in order to estimate flux of magmatic volatiles through the groundwater. Forty-eight groundwater samples were collected for helium isotope analyses from eastern and western part of the Unzen Graben and northern part of Shimabara Peninsula (outside the graben). Helium isotopes and Ne concentrations were determined using a static mass spectrometer, Mass Analyzer Products 215, at CNRS-LSCE, France. The results indicate that all samples show nearly atmospheric value ($1R_a = 1.4 \times 10^{-6}$) or higher than atmospheric value. The feature of isotopic result is distinct in each region.

In the eastern part of the Unzen graben, the $3\text{He}/4\text{He}$ ratios in groundwaters are generally high, especially in the eastern foothill of Mayuyama (5.2-7.2 Ra), but some groundwaters in the southern part of Shimabara City and Fukae Town show relatively low $3\text{He}/4\text{He}$ ratio. The hydrogen isotopic results indicate that groundwaters recharged at the slope of Fugendake are well-mixed in the course of flow, while non-uniform HCO_3 distribution as well as high HCO_3 concentration in the groundwater in this region was observed. He isotope distribution combined with HCO_3 results may result from the addition of magmatic gases ascending along the faults. In the western part of the graben, all of the groundwater except carbonate spring show relatively low $3\text{He}/4\text{He}$ ratio (1-2 Ra). On the $3\text{He}/4\text{He}$ versus $4\text{He}/20\text{Ne}$ ratio diagram, the helium isotopic signature which is incorporated into the groundwater is different between the eastern and western part of the graben. $3\text{He}/4\text{He}$ ratios of hot spring gases around Unzen volcano show an increase from west to east in the Unzen Graben [1, 2]. The groundwater from the inside of the Unzen Graben seems similar trend to the adjacent hot spring, although it is not so clear in the western side because of low He concentration.

High $3\text{He}/4\text{He}$ ratios in groundwaters are also shown in the outside of the Unzen graben, north side of Shimabara Peninsula. From ten data points analyzed in this study, $3\text{He}/4\text{He}$ ratio increase with increasing the distance from the Unzen Graben. There seems to be some possibilities for the high $3\text{He}/4\text{He}$ ratio in the groundwater from the outside of the graben, such as the advection of high $3\text{He}/4\text{He}$ component from the recharge area of the groundwater, addition of magmatic gases ascending along the faults.

References: [1] Kita et al. (1993) *Geochem. J.* 27, 251-259, [2] Notsu et al. (2001) *J. Volcanol. Geotherm. Res.* 111, 89-98