Helium isotope ratios in fumarolic and hot spring gases in Kirishima volcanic group, Japan

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In Kirishima volcanic group in Southwest Japan, Shinmoe-dake is an active volcano and erupted in 2008, 2011, 2017 and 2018, and Iwo-yama also erupted in 2018. It is known that the temporal variations of helium isotope ($^3He/^4He$) in volcanic gases are useful to evaluate the present state of volcanic activity [1]. We report spatial and temporal variations of $^3He/^4He$ ratios of fumaroles and hot spring gases collected from 10 sites in Kirishima volcanic group during 2016 to 2019.

The obtained air-corrected $^3He/^4He$ ratios ranged from 4.3 Ra to 7.6 Ra, where 1 Ra denotes atmospheric $^3He/^4He$ ratio of 1.4×10^{-6} [2]. The $^3He/^4He$ ratios decrease with the increase of the distance from the magma reservoir, location of which is estimated as pressure source of crustal deformation associated with the 2011 Shinmoe-dake eruption [3], to each sampling site. This trend reflects that the contribution of radiogenic ^4He accumulated in old groundwater increases with migration distance of the gas.

The $^3He/^4He$ ratios of fumaroles in Iwo-yama slightly increase before Shinmoe-dake eruptions, and decrease after each eruption. This variation results from the change in mixing ratio of gases derived from two reservoirs having high and low $^3He/^4He$ ratios. Assuming that the magma chamber has the high $^3He/^4He$ ratio, the increase of $^3He/^4He$ ratios before the eruption would result from increase of the supply of the gas from the magma chamber to the Iwo-yama fumaroles. On the other hand, the decrease of $^3He/^4He$ ratios reflect the decrease of the magmatic gas supply. Thus, the temporal variation of $^3He/^4He$ ratios in volcanic gases in this region may reflect the pressure variation of the magma chamber.

References: [1] Padrón et al. (2013) Geology; [2] Ozima and Podosek (2002) Noble Gas Geochemistry; [3] Nakao et al. (2013) Earth Planets Space.