Study on the origin of He and non-anthropogenic sulfur hexafluoride in groundwater in the Nakano-shima Island, Oki Dozen

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1. Introduction
Sulfur hexafluoride (SF6) has been produced industrially since 1950s, and used as a tracer for dating young groundwater. In addition, SF6 is known to be trapped in silicic igneous rocks with high concentration, and is also estimated to be contained in deep fluid (Busenberg and Plummer, 2000). High concentrations of SF6 in groundwater in the Nakano-shima Island, Oki-dozen, were observed, and it was suggested that the geogenic SF6 could be the reason for the high SF6 concentration. In this paper, we discuss the origin of water, dissolved 3He and SF6 in groundwater.

2. Method
Water samples were collected from twelve wellsprings and a hot spring well in June 2009, February and September 2010. All samples were analyzed for major dissolved components (Na+, K+, Ca2+, Mg2+, Cl−, HCO3−, SO42−, NO3−), CFCs, 3H, SF6, and stable isotopic ratios of water. Samples from four wellsprings and the hot spring were analyzed for isotopic ratios of He.

3. Results and discussion
3-1. Concentrations of CFCs, 3H, and SF6
Concentrations of major dissolved components of water samples from deep wells tend to increase, and those of CFCs and 3H tend to decrease. These trends suggest that groundwater of deeper part has longer residence times. CFCs and 3H concentrations of groundwater from two wellsprings, W4 and W7, were much lower than those of other samples. SF6 concentrations of these samples were higher than that of pond water which is assumed to be saturated with modern air. Considering that CFCs concentrations of these samples were lower, high SF6 concentrations should be geogenic. It should be noted that the sample obtained from the hot spring showed lower concentrations of both CFCs and SF6.

3-2. Stable isotopic ratios of water
Delta D and delta 18O values of groundwater were plotted parallel to the meteoric water line. These of the hot spring and W7 were smaller than other groundwater samples.

3-3. Isotopic ratio of He
Groundwater samples from W4 and W7, containing high concentrations of SF6, and those from two wellsprings and the hot spring, containing low concentrations of SF6, were analyzed for He isotopic ratios. 3He/4He values of the hot spring and W7 were higher than that of air, suggesting that mantle-derived 3He is added. Other three samples showed 3He/4He values close to that of air.

3-4. Origin of groundwater and dissolved gases
Because delta D and delta 18O values of groundwater were plotted parallel to the meteoric water line, groundwater is considered to be mainly meteoric water origin. Higher 3He/4He values of the hot spring and W7 samples indicated that the mantle-derived 3He are added to these samples. delta D and delta 18O values of magmatic water are estimated to be in the range between -80 and -50 per mill, and +6 and +10 per mill, respectively (Hoefs, 2007). These values are much different from those of groundwater in the island. Therefore, the contribution of magmatic water is considered to be quite small. The hot spring water contains little SF6 and shows higher 3He/4He value than that of air, while groundwater at W4 contains higher concentrations of SF6 and shows 3He/4He value close to that of air. These results suggest that SF6 added to groundwater of W4 and W7 are not originated from mantle.

4. Summary
Delta D and delta 18O values of groundwater suggest that groundwater is mainly originated from meteoric water. Higher 3He/4He values of the hot spring and W7 indicated that mantle-derived 3He is added to groundwater. As the hot spring water
contains low concentration of SF₆, and W4 shows low $^{3}\text{He}/^{4}\text{He}$ value and high concentrations of SF₆. SF₆ added to groundwater in W4 and W7 is considered not to be originated from mantle. Identifying the origin of added SF₆ also needs further consideration by analyzing concentration of SF₆ trapped in rocks in the island.