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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 (SF_6) has been produced industrially since 1950s, and used as a tracer for dating young groundwater. In addition, $SF_6$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 SF_6 in groundwater in the Nakano-shima Island, Oki-dozen, were observed, and it was suggested that the geogenic SF_6 could be the reason for the high SF_6 concentration. In this paper, we discuss the origin of water, dissolved 3He and SF_6 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^+, Ca^{2+}, Mg^{2+}, Cl^-, HCO_3^-, SO_4^{2-}, NO_3^-), CFCs, ^3H, SF_6, 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 SF_6

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. SF_6 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 SF_6 concentrations should be geogenic. It should be noted that the sample obtained from the hot spring showed lower concentrations of both CFCs and SF_6.

3-2. Stable isotopic ratios of water

Delta D and delta ^{18}O 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 SF_6, and those from two wellsprings and the hot spring, containing low concentrations of SF_6, 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 ^{18}O 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 ^{18}O 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 SF_6 and shows higher $^3He/^4He$ value than that of air, while groundwater at W4 contains higher concentrations of SF_6 and shows $^3He/^4He$ value close to that of air. These results suggest that SF_6 added to groundwater of W4 and W7 are not originated from mantle.

4. Summary

Delta D and delta ^{18}O 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 $^{3}He/^{4}He$ value and high concentrations of SF_6, SF_6 added to groundwater in W4 and W7 is considered not to be originated from mantle. Identifying the origin of added SF_6 also needs further consideration by analyzing concentration of SF_6 trapped in rocks in the island.