Variety in the chemical composition of volcanic gas discharged at the geothermal area in Hakone volcanic caldera

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1. INTRODUCTION

Giggenbach (1987) studied the chemistry and evolution of fumarolic gas discharged from White Island, NZ, based on thermodynamics. Iwasaki et al. (1963) classified volcanic gases into four types, I, II, III and IV. The volcanic gas of type-I is a high temperature gas, corresponding to the vapor phase directly degassed from magma. The volcanic gas of type-IV is a gas characteristic to geothermal system. On the point o view of volcanic activity, the transition from I to II, III and IV is parallel to the retrograde process of volcano. The volcanic gas studied by Giggenbach (1987) corresponds to the type-I and II. Although the gas of type-III contains magmatic composition, they are poor in SO_2 and HCl, and rich in CO_2 and H_2S. The number of studies on this type of gas is limited. The fumarolic gases similar to the type-III are discharged at the geothermal areas on Mt. Hakone volcano, Japan. In this study, the fumarolic gases are sampled and analyzed. The process on the change in chemistry of the gases are discussed.

2. SAMPLING and ANALYSIS

The sampling of fumarolic gas was carried out at the geothermal areas of Owakudani, Sounjigoku and Yunohanazawa in 2005 and 2006. Eleven fumarolic gases and two gases from bore holes were sampled. The gas samples was analyzed for the chemical composition, stable isotope ratios and rare gas composition.

3. RESULT and DISCUSSION

The main composition of the sampled fumarolic gas was water vapor. The secondary major component was CO_2 or H_2S. The SO_2 was contained in the gas from bore hole with high concentration. The SO_2 concentration in natural fumarolic gas was in the level of trace. The sampled gases were classified into the following four group based on the R_H and $\log(CH_4/CO_2)$. Here R_H is $\log(H_2/H_2O)$ introduced by Giggenbach (1987) as an index of redox state of volcanic gas. We define R_C for $\log(CH_4/CO_2)$ hereafter.

1) Magmatic oxidized gas

The R_H and R_C are both low. The gas discharged from the deep bore hole at Owakudani (GB) is classified into this type. The gas may represent a source fluid prevailing the hydrothermal system of Mt. Hakone.

2) Magmatic reduced gas

The R_H is high and R_C is low. A fumarolic gas located close to GB is classified into this type.

3) Equilibrated reduced gas

The R_H and R_C are both high. Most of the fumarolic gas was included in this type of gas. Some gases in this type have a composition for which the reaction, $CH_4+2H_2O = CO_2 + 4H_2$ is equilibrated.

4) Hybrid gas

The R_H and R_C shows the value intermediate between the values for 1) and 3). This type of gas could be the mixture of gases 1) and 3).

The above classification suggest that two different type of fluid are prevailing in the hydrothermal system, one is a magmatic fluid, another is a reduce fluid characteristic to geothermal system. The magmatic gas is mainly distributed in the deeper level of hydrothermal system. The only portion where the fluid is penetrating the surface is Owakudani geothermal area. The reduced gas is probably distributed surrounding the magmatic fluid at shallow level. The magmatic gas could be invaded by the surrounding reduced gas. The hybrid type gas may be generated under the above environment.

On the point of view for volcano monitoring, primarily the concentration of magmatic component should be noticed. And also the monitoring of component originating in the reduced fluid, such as CH_4 is important because the detection suggest the retrograde of magmatic fluid.