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A study for the volcanic hydrothermal system of Mt. Kusatsu-Shirane with the use of stable isotope

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1. INTRODUCTION

Mt. Kusatsu-Shirane is a typical active volcano brings steam explosions. The cause for the steam explosion is the break of a hydrothermal reservoir. For the prediction of steam explosion, the physical and chemical condition of the reservoir should be estimated. On the north side of the summit of Mt. Kusatsu-Shirane, a lot of fumaroles are distributed. The fumarolic gas is the leakage of the vapor phase in hydrothermal reservoir. In this study, temporal change of fumarolic gas is observed and we propose a geochemical model for the hydrothermal system developed in Mt. Kusatsu-Shirane.

2. OBSERVATION

Three fumaroles (N4, N10 and N12) were selected for a short term observation. Eleven samplings were carried out on July 2001 to Nov. 2001. The chemical composition and D/H, 18O/16O ratios of H2O in gas were measured. A long term observation was carried out at N10 where the gas had been sampled every month over 1997 to 2000.

3-1. RESULT(short term)

The discharging pressure of gas from N10 was significantly strong with a noisy sound. The discharge of gas from N4 and N12 were weak. The outlet temperature of N10 was 103 to 104C. The outlet temperature of N4 and N12 were 93 to 94C. An inverse correlation was observed between the CO2/H2O ratio of N10 and N12. However, a positive correlation was observed between the 18O/16O of H2O from N10 and N12.

3-2. RESULT(long term)

The outlet temperature of N10 was 101 to 105C over 1997 to 2000. The CO2/H2O ratio was 0.006 to 0.013, the 18O/16O ratio was d18O=-8 to 0 permil to SMOW. Those ratios correlated with the precipitation at Mt.Kusatsu-Shirane, namely, the CO2/H2O ratio increased and the 18O/16O ratio decreased with one month delay after the large precipitation in September of every year.

4. DISCUSSION

The long term change in the CO2/H2O and 18O/16O ratios can be explained with a change in the hydrothermal reservoir where a vapor and a liquid phases are coexisting. Assuming that the reservoir is a mixture of high temperature magmatic fluid and a cool ground water with meteoric origin, and the enthalpy and the amount of isotope are kept at the mixing, when the mixing ratio of ground water increases the fraction of vapor phase decreases, the CO2/H2O ratio increases and the 18O/16O ratio decreases. A part of the vapor phase leaks out to the surface as the N10 fumarolic gases. The correlation between the precipitation and the gas composition with a delay suggests that the surface meteoric water infiltrates and affects the hydrothermal reservoir. The observed CO2/H2O variation is larger than the variation expected from the change of hydrothermal reservoir. Also a temporal change in the CO2/H2O ratio of the magmatic fluid should be considered.

The variation in the composition of N10 can be explained by the change in the hydrothermal reservoir, however, the change of N12 can not by explained. The change of N12 could be explained assuming that N12 is a mixture of a gas similar to N10 (=N12-precursor) and a water vapor with meteoric isotope ratios. If the addition of the vapor to N12-precursor is large when the ground water contribution to hydrothermal reservoir is large, because of the low isotope ratio of the meteoric vapor, the decrease in 18O/16O for vapor phase in reservoir overlaps the decrease of 18O/16O for N12-precursor by meteoric vapor addition. As the meteoric vapor does not contain CO2, the addition of meteoric water cancels or reverses the CO2/H2O ratio increase by the addition of ground water to reservoir, resulting in the reverse correlation between the CO2/H2O ratio of N10 and N12.