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The variation in the chemical and isotopic composition of fumarolic gases at Kusatsu-Shirane volcano and the implication

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Introduction

At Mt Kusatsu-Shirane the number of volcanic earthquakes have increased since Mar 2014. The inflation of volcanic body occurred simultaneously (HP of Japan Meteorological Agency). In Mar 1976, a steam explosion happened at Mizugama crater at Mt Kusatsu-Shirane. Ossaka et al (1980) detected an increased SO2/H2S ratio in the fumarolic gas composition of Kitagawa geothermal area 8 months prior to the eruption. In 1982 and 1983, steam explosions happed within Yugama crater bringing a significant change in the chemical composition of the lake water in Yugama crater (Ohba et al 2008). Steam explosion is the break of a hydrothermal reservoir. The volatiles in the reservoir is supplied to fumarolic gas and crater lake. For the understanding and prediction of steam explosion, the observation of fumarolic gas and the lake water is important. In this study, fumarolic gases were sampled after the unrest on Mar 2014. An ongoing process at the depth of Mt Kusatsu-Shirane is discussed.

Sampling and analysis of fumarolic gas

Fumarolic gases were sampled in July 2014 at two points (K1 and K2) in the Kitagawa geothermal area 500m north of Yugama crater, at one point (M1) in the Manza geothermal area 2.4km northwest of Yugama crater, and at one point (S1) in the Sesshou geothermal area 3km southeast of Yugama crater.

The fumarolic gases were sampled and analyzed along the method by Ozawa (1968). The fumarolic gas was cooled by use of a double glass tube to obtain condensed water for the determination of isotopic ratios by use of an IR laser cavity ring down analyzer (Picarro).

Result

The fumarole K1 discharged gas with the presser highest in the Kitagawa geothermal area. The feature of discharge was common to the K1 in 1999. The outlet temperature of K1 was 92.4C slightly lower than the temperature 104C in 1999. The outlet temperature of K2, M1 and S1 was 94.1, 96.2 and 94.5C, respectively, close to the boiling temperature of water at the local altitude. The SO2/H2S molar ratio of K1, K2, M1 and S1 was low as 0.013, 0.013, 0.019 and 0.011, respectively. Eight months prior to the Mizugawa eruption in 1976, Ossaka et al (1980) detected the SO2/H2S ratio as high as 0.29 in fumaroles in the Kitagawa geothermal area. The current CO2/H2O ratios of K1 and K2 were 0.044 and 0.042, respectively. The value of K1 is about 8 time larger than 0.0052, which is the ratio of K1 in 1999. Ossaka et al (1980) detected similar large ratio, 0.059 8 months prior to the Mizugama eruption in 1976. The H2/H2O molar ratios of K1 and K2 was 2.7E-7 and 2.6E-7. In 1999, the ratio of K1 was 2.6E-7, almost same as in the current value. The isotopic ratio of H2O in fumarolic gases was similar to the ratios in 1999 and 2000.

Discussions

The high CO2/H2O ratio found in K1 and K2 might be explained two ways. If the condensation of water vapor happened in the channel of volcanic gas, CO2 will be enriched relative to H2O resulting in the increase in the CO2/H2O ratio. However such a condensation is possible at the fumaroles with a low discharging pressure. The strong discharging pressure of K1 in Jul 2014 is inconsistent to the condensation for the explanation. Another straightforward explanation for the high CO2/H2O ratio is the enrichment of CO2 at the magmatic gas source. Beneath the Yugama crater a depleted solidifying magma is expected, based on the chemistry of lake water (Ohba et al 2008). Such a magma cannot emit CO2, suggesting another new CO2 enriched magma is now degassing. The low SO2/H2S and H2/H2O ratios of K1 and K2 suggest the temperature of hydrothermal reservoir beneath the Kitagawa geothermal area is not increased recently. The ongoing process at Mt Kusatsu-Shirane is limited in the deep region. A steam explosion at Mt Kusatsu-Shirane is not likely.

Keywords: Kusatsu-Shirane volcano, Hydrothermal system, Volcanic gas, Steam explosion, Magma, CO2/H2O