

FORMATION PROCESS OF VOLCANIC GASES FROM MEAKANDAKE VOLCANO, JAPAN

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INTRODUCTION

Volcanic gases contain the volatile emitted from a degassing magma. The chemical and isotopic composition of volcanic gases, therefore, bring us some information on the magma. The fumarolic gas sampled at surface is modified from the gas emitted from magma mainly due to the interaction with groundwater. In this study, we sampled and analyzed fumarolic gases at Meakandake volcano, where the activity has increased recently. The process of formation was investigated for the fumarolic gases.

VOLCANIC GAS

The sampling of gas was carried out in June and July 2008. There were two main craters, Ponnmachineshiri (P-crater) and Nakamachineshiri (N-crater), on the summit area of Meakandake volcano. Two fumarolic gases (p1 and p2) were sampled within P-crater. One fumarolic gas (p3) was sampled on the northwest outer wall of P-crater. The fumarole of p3 is the location where a phreatic eruption took place in 2006. The discharging pressure of p3 gas was strong so that a loud noise was generated. The temperature of gas at P-crater was 96 to 98 degC close to the boiling temperature of water. Two fumarolic gases (n1 and n2) were sampled within N-crater. The temperature of n1 and n2 was 214 and 116 degC, significantly higher than the boiling temperature of water.

CHEMICAL and ISOTOPIC COMPOSITION

The fumarolic gas, n1 and n2 contained HCl with high concentration. The d18O of H2O in those gases was -0.2 and +1.3 permil, respectively, significantly higher than -11.8 permil, the value for local meteoric water. The d18O of H2O in p3 was also high (-1 permil), however p3 did not contain HCl. CH4 was detected in p3 with high concentration. The chemical composition of p1 and p2 was similar to p3 although the d18O was lower than that of p3. The CO2/H2O ratio of n1 and n2 was around 0.007. The ratio of p3 was 0.04, much higher than that of n1 and n2. The ratio of p1 and p2 was 0.014 and 0.011. The d13C of CO2 in the sampled gases were all concentrated within the range, -9.7 to -7.0 permil.

FORMATION PROCESS OF FUMAROLIC GAS

Because n1 and n2 contains HCl with high concentration, the gases was transported to surface with little interaction involving groundwater. Based on the d18O of H2O, n1 and n2 is thought to be formed after the direct mixing between a high temperature magmatic gas and a cold groundwater with meteoric origin. The mixing ratio between the magmatic gas and the groundwater was estimated to be 6 : 4. If the CO2/H2O ratio of magmatic gas is 0.012, the observed CO2/H2O ratio for n1 and n2 could be consistently explained. Although the formation of p3 can be explained by the mixing between a magmatic vapor and cold groundwater, a high value, 0.06 is necessary for the CO2/H2O ratio of magmatic vapor. The composition of p1 and p2 could be the modification of a gas similar to p3 with addition of a vapor with meteoric origin.

One characteristic feature of fumarolic gases from Meakandake volcano is the high concentrations in CH4 and H2. The chemical composition of p3 can be apparently equilibrated at 170 degC in terms of the following reaction, $\text{CO}_2 + 4\text{H}_2 = \text{CH}_4 + 2\text{H}_2\text{O}$. Although the CH4/CO2 and H2/H2O ratios of n1, n2, p1 and p2 is less than those of p3, a positive correlation is found between the those ratios. Those gases are thought to be on the transitional way starting from a slightly oxidized state to the reduced state represented by the composition of p3.

There is a significant difference between the CO2/H2O ratios of magmatic gas for P- and N-craters. The ratio for N-crater is relatively lower than that of P-crater, suggesting the depletion of volatile in the magma beneath N-crater. A magma depleted in volatile should be enriched in Cl relative to CO2 and H2O. The high concentration of HCl in n1 and n2 supports the depletion of volatile in the magma beneath N-crater.