

Chemical composition of volcanic gases from Mt.Unzen, Japan: Implication to the magma degassing process

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INTRODUCTION

The driving force of lava effusion is the degassing of volatile dissolved in magma. The chemical composition of volcanic gases which contains the degassed volatile could be related to the lava effusion rate. In this study, the degassing process of Unzen volcano is discussed based on the correlation between the chemistry of volcanic gas and the lava effusion rate.

OBSERVATION

During the eruption of Unzen volcano in 1991 to 95, the direction of growth and collapse of lava dome at the summit is limited on the east flank. The lava dome did not collapse on the west flank, and a discharge of volcanic gas was observed at the basement of lava dome. We had successfully sampled a high temperature volcanic gas at the west side basement of lava dome six times on May 1992 to Oct. 1995.

RESULT

The outlet temperature of volcanic gas was 535 to 818C. The δD and $\delta^{18}O$ of H_2O in the gas was -36 to -28 and +7.4 to +9.5 permill to SMOW, respectively. The apparent equilibrium temperature estimated from the chemical composition of gas was 850 to 890C (Ohba et al., 1994), being consistent to the lava temperature based on Fe-Ti-oxide thermometer (Nakada and Motomura, 1999; Venezky and Rutherford, 1999). The components strongly soluble to water, such as HCl and SO_2 were contained in the gas with high concentration. The CO_2/H_2O ratio of gas showed a minimum on Sep. 1992 and increased in 1993. The pattern of CO_2/H_2O change was similar to the change in the lava effusion rate, however the minimum of lava effusion rate occurred on Dec. 1992. The change of CO_2/H_2O ratio anticipated the lava effusion rate change at least one month. The HCl/ H_2O and $(SO_2+H_2S)/H_2O$ ratios were much stable relative to the change in CO_2/H_2O ratio.

DISCUSSION

The chemical composition of volcanic gas is the relative concentration of gases species. The change in the concentration of a component in gas, for example A does not always means the change of A's flux. The change of A could be made by the changes of flux of other components. For the above reason, the CO_2/H_2O change observed in the volcanic gas can be explained with the following different models.

MODEL-1. The evolution of volcanic gas is controlled by the growth of bubbles in magma. The CO_2/H_2O ratio in bubble depends on the diffusion rate and solubility of CO_2 and H_2O molecules in magma. As the solubility of CO_2 gas is low, the most CO_2 in magma is distributed into the bubbles in magma when the magma ascended to shallow level. On the other hand, due to the high solubility of H_2O in magma, substantive H_2O is still remained in magma even when the magma reached a shallow level. If the time scale of magma ascend is competitive with the time scale of H_2O diffusion in magma, the low lava effusion, namely, slow ascending of magma offers a enough duration for H_2O diffusion, then the CO_2/H_2O ratio in bubble could be decreased. Although the above model would explain qualitatively the correlation between CO_2/H_2O of volcanic gas and magma effusion rate, it hardly explain the constancy in the HCl/ H_2O and $(SO_2+H_2S)/H_2O$ ratios.

MODEL-2 The volcanic gas sampled beside the lava dome is assumed to be a mixture of a CO_2 rich and a CO_2 depleted gas. The CO_2/H_2O change is attributed to the change in the mixing ratio. The CO_2 rich gas was evolved at deep magma reservoir and transported along the conduit of magma. The CO_2 depleted gas was degassed and evolved from magma at shallow level. The above two gases was mixed and discharged as volcanic gas. The transient stop of lava effusion in Dec. 1992 and the following onset of lava effusion on Feb. 1993 could be attributed to the restart of CO_2 degassing at a deep magma reservoir. The stable HCl/ H_2O and $(SO_2+H_2S)/H_2O$ ratios could be explained with the time scale of H_2O , HCl, SO_2 , and H_2S diffusion in magma, limited relative to the long time scale of magma ascending.