

S and O isotopic systematics of the 2000 eruptions of Miyakejima volcano

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Sulfur and oxygen isotope geochemical investigations were carried out in order to elucidate the origin of high-concentration SO₂ of the 2000 eruption of Miyakejima Volcano. Calculated oxygen isotopic temperature based on olivine and groundmass gave 1135 degC, and on lithic fragments of chert and anhydrite gave 380 degC, which implies possible interaction between magma body and overlying hydrothermal system. The S-O isotopic systematics suggest that the eruption had proceeded in the followed processes: (1) separative derivation of H₂O-SO₂, (2) formation of hydrothermal system involving silica and sulfate depositions, (3) H₂O-SO₂ emission by magma eruption, and (4) formation of sulfate and systematic depletion of H₂O by distillation.

1.Introduction

In July 2000, active eruptions of Miyakejima Volcano ejected large quantities of SO₂ gas with a considerably large flux (40000 t/day). According to petrologic study by Saito et al. (in this abstract), volcanic bombs injected on August 18, 2000 could have been derived from CO₂ and SO₂ saturated high temperature magma (1100 degC). In order to elucidate the origin of high-concentration SO₂, we carried out S and O isotope geochemical investigations on ejecta (volcanic ash and bomb) and ash leachates. Such an approach, has already been reported by Rye et al. (1984) for the 1982 eruption of El Chichon Volcano, is important tool for monitoring and prediction for the activity of on-going eruption.

2.Analyses

S and O isotope analyses were performed on leachates of (1) adsorbed sulfate on ash surface, anhydrite scattered in groundmass, and residual S remained in leached volcanic bomb. Oxygen isotopic analysis was made on individual separates of phenocrysts (olivine, plagioclase, and pyroxene) and groundmass in volcanic bombs. Whole-rock chemical and isotopic compositions were determined on fused samples with use of electron and CO₂-laser microprobes.

3. Isotopic compositions of ash leachates

S and O isotopic compositions for August 18 to September 22 ash leachates vary from +8.0 to 5.5 permil and +7.9 to 9.3 permil, respectively. The ash with higher sulfate adsorption (3 wt%, SO₄) showed the higher d₃₄S and the lower d₁₈O values. Leachate as anhydrite fraction showed S and O isotopic compositions of +4.1 and +11.3 permil, respectively. Residual S in completely leached whole-rock powdered sample gave an S content of 200 ppm and d₃₄S of +3.8 permil.

4. Oxygen isotopic composition of volcanic bomb

Fusion-treated whole volcanic bomb showed SiO₂ = 50 wt% and d₁₈O = 5.6 permil. This data fall on primitive member of differentiation trend of Miyakejima magma. The d₁₈O values of separates of olivine, plagioclase, pyroxene, groundmass, and lithic fragment of chert showed 4.9, 5.9, 5.1, 5.7 and 10.0 permil. Calculated O-isotope temperature based on olivine-groundmass (Kyser et al., 1981) and quartz-anhydrite (Lloyd, 1968; Matsuhisa, 1979) were 1135 and 380 degC, respectively, suggesting igneous and hydrothermal temperature.

5.Discussion

Isotopically, the d₃₄S order of adsorbed S (= 8-5.5 permil) > anhydrite S (= 4.1 permil) = residual magma S (= 3.8 permil) is consistent with fractionation relationship between SO₂ and SO₄ produced by a redox reaction (3SO₂ + 2H₂O = 2H₂SO₄ + H₂S). The d₃₄S decrease in adsorbed sulfate may have been caused by SO₄-H₂S fractionation (e.g., Ohmoto and Rye, 1979) during low to high temperature process. Besides, similar d₃₄S values between residual magma S and anhydrite may indicate that pre-built hydrothermal system was controlled by pre-eruptive magmatic S system. Oxygen isotopic compositions of ash-leachate sulfate may also reflect H₂O in hydrothermal system in which production of sulfate and distillation were proceeded.

We infer that the 2000 eruption could have been proceeded in the followed processes: (1) separative derivation of H₂O-SO₂, (2) formation of hydrothermal system involving silica and sulfate depositions, (3) H₂O-SO₂ emission by magma eruption, and (4) formation of sulfate and systematic depletion of H₂O by distillation.