Estimation of carbon dioxide emission from Kuju Volcano, Japan, and its numerical modeling

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Kuju Volcano is located in Kyushu and one of the active volcanoes in Japan. In order to infer the mass balance and energy balance of the hydrothermal system in the Kuju volcanic area, we tried to estimate volcanic CO_2 emission and to construct a numerical model of the hydrothermal system of Kuju Volcano.

We considered four forms of volcanic CO_2 emission; from the fumaroles, the bare area around the fumaroles, the flank by the soil gas, and some hot springs at the foot of the volcano. We adopted the value of about 166 t/day from the plumes of Kuju Volcano estimated by Ehara et at. (1981). On the other hand, Itoi (1993) shows the distribution of soil gas CO_2 concentration in the bare area around the fumaroles. In our previous study (Araragi et al., 2008), the relationship between soil gas CO_2 concentration measured by the Kitagawa Gas Detector Tube System and CO_2 flux measured by a CO_2 flux meter in Kuju Volcano was found. Therefore, the CO_2 concentration values shown by Itoi (1993) were converted into the CO_2 flux values, and about 0.8 t/day of the volcanic CO_2 emission was estimated. We measured soil gas CO_2 concentration at 60 points on the flank of the volcano by the Kitagawa Gas Detector Tube System and collected 15 soil gas samples to conduct the carbon isotope analysis to identify the origin of the CO_2. As a result, we concluded that the volcanic CO_2 emission from the flank was 0 t/day. And for the CO_2 emission from the hot springs at the foot of the volcano, the hot water discharge rate and the average CO_2 concentration in the carbonated water of the Nagayu Hot Springs area was adopted. Then about 5.0 t/day of the volcanic CO_2 emission from Nagayu Hot Springs was estimated. These results show that the volcanic CO_2 emissions by the plumes from the fumaroles and by the carbonated water from a hot springs area are dominant in Kuju Volcano.

In order to construct a numerical model of the hydrothermal system of Kuju Volcano, we used a geothermal simulator STAR Version 9 (Pritchett, 1989) that can treat the components of H_2O and CO_2 but has the limitations of temperature from 0 to 350 deg. C and pressure from 1 to 600 bars. The modeling area has a horizontal extension of 25 km (E-W) and 15 km (N-S), and a vertical extension from -500 m asl to the ground surface. Finally, we constructed a numerical model, which explains the heat discharge rate and CO_2 emission rate by the plumes from the fumaroles and the CO_2 emission rate from the Nagayu Hot Springs area, by trial and error. This numerical model also indicates that the volcanic CO_2 emission is dominated by the gas from the fumaroles and hot water from Nagayu Hot Springs.