Thermal observations of Unzen volcano and estimation of its conduit cooling condition

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Some thermal observations of Unzen Volcano were conducted as a part of the Unzen Scientific Drilling Project (USDP). The heat discharge rates from the lava dome by the infrared imagery observation decrease gradually. The 1-m depth temperatures near the summit of Mt. Fugen decrease compared with those near the lava dome fumaroles. In some remote observation of volcanic gases by an FT-IR spectrometer, CO and CO2 were detected, and the equilibrium temperature of over 900 deg. C was estimated from the CO/CO2 ratio. Some intensity anomalies of 214Bi and 208Tl were detected at the stations just near the estimated conduit location by the Gamma-ray intensity investigation. The result of the numerical simulation using a simple topography 3-D convective model showed high temperature of the conduit.

Since 1999, the Unzen Scientific Drilling Project (USDP) has been conducted by the Science and Technology Agency (STA). During the first phase (from April 1999 to March 2002), there are three main topics for the investigation. These are 1. Conduit and eruption mechanism, 2. Structure and evolution of volcano, and 3. Technical development and optimizing of drilling and downhole measurement. We participate in a group investigation category "Cooling of the conduit and the geothermal system" in Topic 1. In this project, we are aiming at quantitative explaining for development of hydrothermal system in Unzen Volcano by compiling the results of the investigations and by constructing a conceptual and a numerical model. Now we are conducting some kinds of observations and investigations at Unzen Volcano. The following are the principal results of four of the thermal observations in 1999 and 2000.

There is only one observation point for the infrared imagery observation, therefore the measured heat discharge rate doesn't show that from the whole of the lava dome. From August 1999 to December 2000, the heat discharge rates from the lava dome were decreasing gradually, however the thermal anomaly area was increasing.

The 1-m depth temperatures near the lava dome and the summit of Mt. Fugen are lower than an extrapolated line of the temperatures at the stations on the flank of Unzen Volcano. And from August to December in 2000, the 1-m depth temperatures near the summit of Mt. Fugen decreased compared with those near the lava dome fumaroles.

In some remote observation of volcanic gases by an FT-IR (Fourier Transform Infrared) spectrometer, CO and CO2 were detected from an observation point about 1.5 km away from the lava dome. Although the reliability of quantitative analysis is not so high because of the long distance between the target (a fumarole) and the observation point and low temperature of the infrared source, the equilibrium temperature of over 900 deg. C was estimated from the CO/CO2 ratio.

Some intensity anomalies of 214Bi and 208Tl were detected at some stations by the Gamma-ray intensity investigation. Almost all of these stations are on the western side of the summit of Mt. Fugen and just near the estimated conduit location. Because the anomalous stations are not so many and are limited in the narrow area, we don't think this result was caused by extensive hydrothermal activity. And this result may mean the influence of existence of the conduit.

From these results, we constructed a conceptual model in which the lava dome and the summit of Mt. Fugen are cooled by precipitation except some points where high temperature gases are spouting out. And we tried to explain this conceptual model quantitatively by numerical modeling. In 1999, we constructed a simple two dimensional conductive model of Mt. Fugen area as a simplified model for the cooling process of the magma in the conduit. This 2-D conductive model showed that non-conductive effects are associated with conduit cooling. Therefore, we constructed a simple topography three dimensional convective model in 2000. The result of the simulation showed that the lava in the conduit still keeps high temperature (over 700 deg. C), however the high temperature zone is limited in the conduit and surroundings. This 3-D model also showed that the prevailing flows are the up-current of high temperature gases in the conduit and the down-current of groundwater from the ground surface, and that there is little possibility of extensive hydrothermal activity near the lava dome.