Evolution possibility of hydrothermal system in Unzen Volcano

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We participate in the Unzen Scientific Drilling Project to evaluate the possible evolution of a hydrothermal system caused by the conduit filling with lava and acting as the heat source over a short period after the 1990-95 eruption.

We have conducted several kinds of geothermal observations and investigations, mainly on heat discharge and ground temperature, on Unzen Volcano since 1999.

The heat discharge rates from the lava dome that are obtained by the infrared imagery observations show a trend of decrease from 1999 to 2002 although the heat anomaly area increased during the same period. These results show the cooling process of the lava dome.

The 1-m depth temperatures near the summit of Mt. Fugen are lower than an extrapolated line of the temperature-altitude relation of the stations on the flank of the volcano. And the 1-m depth temperatures near the summit of Mt. Fugen show seasonal changes, but those near the fumaroles on the lava dome keep their values.

Gamma-ray intensity anomalies of 214Bi and 208Tl were detected at the stations that exist western side of Mt. Fugen. Those are near the estimated location of the conduit by seismic and geodetic data. Therefore, the result of Gamma-ray investigation may give us some information on horizontal location of the conduit.

The results of repeat gravity measurements show that the gravity values near the lava dome decreased while those in a valley between the summit of Mt. Fugen and the caldera's rim, which shapes Mt. Kunimi and Mt. Myoken, increased from 1999 to 2000, but indicate the opposite trend during 2 years from 2000.

Remote observations of volcanic gases by an FTIR spectrometer detected CO and CO2, and the equilibrium temperature of about 800 degrees C was estimated from the CO/CO2 ratio. We inferred from this result that the lava in the conduit still maintains a high temperature.

Using our previous numerical model study by using vertical two-dimensional thermal conduction models and the results of our geothermal surveys, we constructed a conceptual model for the hydrothermal system in Unzen Volcano. This model shows that permeating rainwater cools the lava dome except for the conduit which is the pathway of high temperature gas, and that there is no strong hydrothermal circulation in the volcano near the lava dome.

In order to explain our conceptual model, we constructed a simplified three-dimensional numerical model by using a computer code called HYDROTHERM Version 2.2 (Hayba and Ingebritsen, 1994) that calculates multiphase flow of water and heat over a temperature range of 0 to 1200 degrees C. The lava dome was set at the center of an analytical area that has a horizontal extension of 5 km (E-W) by 4.6 km (N-S) and a vertical extension of -3 km sea level to the ground surface. The result of the simulation showed that the downflow of permeating rainwater is dominant in the body of Unzen Volcano, and the upflow of gas is limited in the conduit. And no remarkable hydrothermal circulation has occurred during 13 years from the commencement of the 1990-95 eruption. This result means that there is little possibility of extensive hydrothermal activity near the lava dome and the lava in the conduit is still hot as of 2003.

Hayba, D. O. and Ingebritsen, S. E. (1994). The Computer Model HYDROTHERM, a Three-dimensional Finite-difference Model to Simulate Ground-water Flow and Heat Transport in the Temperature Range of 0 to 1,200 degree Celsius. USGS Water-Resources Investigations Report 94-4045.