Thermal processes in the body of Unzen Volcano

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High temperature volcanic gasses have been discharging from the fissures of existing domes of Unzen volcano since the 1990-95 eruption. The observed maximum fumarolic temperature was near 700 deg C just after the cessation of the lava dome forming and the temperature higher than 300 deg C was still observed even in the end of 2003. On the other hand, the observed temperature of the conduit for the 1990-95 eruption by the conduit drilling in Phase II of the Unzen Scientific Drilling Project was lower than 200 deg C, which is much lower than that (higher than 700 deg C) expected before the drilling. In this study, the reason for the low temperature of the conduit was interpreted by numerical simulation, and also a numerical thermal model beneath Unzen Volcano, where four active hydrothermal systems exist, was constructed.

1. Observed Lower Temperature of the Drilled Conduit

Numerical studies were conducted in order to understand the thermal state in and around the conduit. We calculated the temperature distribution in and around the conduit after the settlement of the conduit. A higher temperature than 700 deg C is expected if there is a conduit of which thickness in N-S direction is about a few hundreds meters. The thickness of the conduit was estimated to be 300m by the seismic reflection technique. However, the thickness of 300m was reinterpreted in terms of the zone of dike swarms including many old dikes in the conduit drilling. The thickness of each dike was a few tens meters. Then we changed the thickness of the newly formed conduit to 25m. As the result, the calculated temperature at the central part of the conduit becomes lower than 200 deg C. Accordingly, the observed lower temperature is interpreted in terms of the thinner conduit and dominating down flow of cold groundwater. This result also shows that active circulation of hydrothermal water is not realized accompanying with such a small heat source.

2. Comprehensive thermal model beneath Unzen Volcano

The most active hydrothermal system is the Unzen fumarolic field (Unzen jigoku). And there is another high temperature geothermal system of which underground temperature at 1km deep exceeds 200 deg C about 4km west of Mt. Fugen. We call this hydrothermal system as 'West Unzen High Temperature Body, WUHTB'. At 7km deep of WUHTB, a most important pressure source called C-source was determined by the geodetic data during the 1990-95 eruption. C-source is considered to be a magma reservoir of which high temperature has been maintained for a long period by replenishment of new magma such as the 1990-95 eruption. Then we tried to construct a model of hydrothermal system with a heat source around C-source. We assumed that the high temperature heat source has been maintained during recent 20,000 years based on the volcanic history. We simulated the hydrothermal system of WUHTB by changing the size of the heat source. The size of the heat source for the good fit model is 1km x 1km x 8km of which center is 7km depth. This model also produces the two upflow zones of geothermal fluid near the western and eastern coasts where the Obama hot springs and the Shimabara hot springs are located, respectively. However, C-source explains only a part of the heat discharge rate from the Obama hot springs. Then we must consider the heat supply from another heat source such as the magma reservoir beneath Tachibana Bay. C-source also explains the heat discharge rate from the Shimabara hot springs. However, high concentration of magmatic gas in the hot spring waters may show the contribution of the other magma.

It is difficult to interpret the heat discharge rate from the Unzen fumarolic field by C-source. Then we must set another heat source beneath the Unzen fumarolic field. The heat source of which depth is a few km and of which age is a few thousands year roughly explains the heat discharge rate and the horizontal extent of the high temperature zone.