Monitoring of hydrothermal system under active volcanic vents using hot crater lake of Aso volcano

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Nakadake in Aso caldera, central Kyusyu, Japan is one of the most active volcanoes in Japan in terms of the persistent release of volatiles and thermal energy. The 1st Crater of Nakadake has a hot lake, locally called Yudamari, of over 200 meters in diameter. During the recent calm period, heat discharge from Yudamari is almost constant at approximately 200 - 300 MW (Terada et al., 2008). Some old documents describe that such a hot crater lake has repeatedly appeared/disappeared since at least 1,500 years ago, suggesting a particular mechanism of the volcano to prefer to have a crater lake.

Observations made at Yudamari crater lake clearly demonstrate that substantial changes in water level and temperature are related to volcanic activity. The water level rapidly falls preceding an active period. Sometimes disappearance of lake water is followed by the emergence of incandescence at the crater bottom or wall, then by phreatic or phreatomagmatic explosions and finally by Strombolian activity which typically lasts for several months. The lake re-forms with the return of a calm period of volcanic activity. These drastic changes in lake water are probably caused by changes in the input of volcanic fluid to the crater bottom.

Therefore, precise observation and analysis enables us to reveal the variation of volcanic fluid input originated from the underlying hydrothermal system.

Recently, precise and continuous monitoring has been performed at Yudamari (Terada et al., 2008). We apply our numerical model to the observation data obtained at Yudamari, and evaluate mass m and specific enthalpy H of the volcanic fluid supply from the lake bottom.

The precise monitoring data enable us to access time variations of H and m. The bottom input enthalpy H of 1.4 - 2.2 $*10^6$ J/kg estimated at Yudamari in calm period are much smaller than that of 6 $*10^6$ J/kg obtained at Ruapehu Crater Lake. It suggests that the heat pipe (Hurst et al., 1991) may not play important role in persist of Yudamari.

Here we regard physical properties of bottom input fluid as that of H_2O. Assuming pressure to be atmospheric condition, calculated bottom input enthalpy is smaller than that of dry vapor of 100 degree C but exceed to that of liquid water of 100 degree C, suggesting both liquid water and vapor emission.

What is emitting from lake bottom? The bottom input enthalpy linearly decreases with mass flux, suggesting that mixtures of low- and high-temperature fluids are supplied from lake bottom. Moreover, the flux of low-temperature fluid changes. Emissions of high-temperature volcanic gas from subaqueous fumaroles are a suggested by the south-wall fumaroles (SWF) located at the 1st Crater whose temperature is approximately 800 degree C, while low-temperature groundwater inflow was observed when crater bottom was deeply bored due to the eruption (Ikebe et al., 2008).

We assume that both liquid water and high-temperature volcanic gas are emitting from lake bottom, and estimate mass fluxes of each it. High-temperature volcanic gas and liquid water are 800 and 10 degree C in temperature, then specific enthalpy of high-temperature volcanic gas, H^v, is 4.15 $*10^6$ J/kg and that of liquid water H^w, is 4.18 $*10^4$ J/kg under the ambient pressure of 1 $*10^5$ Pa.

Based on mass and energy conservation, we estimate time-variation of mass flux of high-temperature volcanic gas m^v and liquid water m^w. As a result, magnitude of mass fluxes of high-temperature volcanic gas is comparable to that of liquid water. Larger mass fluxes of liquid water are estimated in the period from November to January; it is corresponding to the variation of bottom input masses that increase in winter season.