

Mass budgets of hydrothermal water beneath hot crater lakes at Kusatsu-Shirane volcano evaluated by ground deformation and changes in thermal activities

*Akihiko Terada¹, Yuri Sakamoto¹, Wataru Kanda¹, Yasuo Ogawa¹

1.Volcanic Fluid Research Center, Tokyo Institute of Technology

Kusatsu-Shirane volcano is one of the most active volcanoes in Japan in terms of persistent heat-release of approximately 150 MW. Mt. Shirane which is one of the pyroclastic cone contains a hot crater lake, locally referred to as Yugama, showing interesting variations of water temperature and chemical concentrations. We detected intense earthquake swarms located at shallow depth around the Shirane pyroclastic cone between March and August 2014. The seismic activity was accompanied by a ground deformation, increase in water temperature of Yugama crater lake, changes in geomagnetic field and chemical concentration of volcanic gas emitting around the cone.

Volcanic Fluid Research Center, Tokyo Institute of Technology have deployed three continuous bore-hole type tilt meters, enabling evaluation of changes in volume at shallow depth of the cone. In addition to them, we have monitored thermal activities on the cone. Temperatures of Yugama crater lake have been continuously recorded at an interval of 1 minute. Repeated aerial infrared surveys observe changes in ground surface temperatures around the cone. Using these data we evaluate changes in mass-budgets of hydrothermal water which cause earthquake swarms in 2014.

Records of tilt meters indicate that gradual increase in pressure occurred at shallow depth of the cone. Applying the Mogi model we find the inflation source at a depth of only 500 meters from the bottom of Yugama crater lake. A volume change of the inflation source during the period from March 2014 to November 2015 is estimated to be 110,000 cubic meters.

To evaluate changes in thermal activities on Kusatsu-Shirane volcano, repeated aerial infrared survey were carried out between 2012 and 2015. The observation of 2014 and 2015 were done in the nighttime because even slight changes in ground surface temperature can be detected. Comparing IR records obtained in 2015 and that in 2015, surface temperatures of steaming ground located at northern flank of the cone increased significantly, indicating increases in volcanic gas flux. Water temperature of Yugama crater lake rose several degree Celucius from May 2015.

We evaluate evaporation mass by use of atmospheric conditions obtained at the cone, water evaporation rate in 2014 is estimated approximately to be 5 kg/s, which is 2.5 times higher than that of the value in 2012. Rapid decreases in water level were detected by photographs of bars installed near the shore of Yugama crater lake. There results suggest increases in enthalpy of fluid emitting from the lake bottom have occurred since May 2014. We believe that increases in flux of hydrothermal fluid from depth have been maintained although the inflation detected by tilt meters has almost stopped since November 2015.

Keywords: ground deformation, mass budget, tilt meter, hot crater lake, fumarole, Kusatsu-Shirane volcano