Heat discharge, water level and geomagnetic changes of the crater lake, Aso Volcano, Japan

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Crater lakes of active volcanoes are considered to be condensers of heat and volatiles from the underlying magmatic systems. Thus, monitoring of physical and chemical parameters such as the temperature, water level and chemical concentrations of a lake is an essential part of surveillance programs at active volcanoes with crater lakes. Nakadake, one of the cones of Aso Volcano which is located in central Kyushu, southwest Japan, has a high temperature crater lake on its flank. We investigated the relationship between water level, surface temperature, and geomagnetic changes of the crater lake during the period 1991-2000. The activity of Nakadake was relatively calm during this period except for some small-scale phreatic activity during the end of 1991 and the middle of 1994.

We estimated the variation of water level and surface area of the crater lake using video images taken by monitoring cameras of the Aso Volcano Museum. Then the variation of heat discharge from the lake surface was calculated in combination with surface temperature which was remotely measured by Japan Meteorological Agency.

In addition, we have operated continuous monitoring of geomagnetic total force in the vicinity of the crater lake for these 12 years. Tanaka (1993) has already reported the geomagnetic changes of an earlyer period and proposed a thermal (de/re)magnetisation model with special attention to the activity of 1989-1990. One of the essential conclusions of Tanaka (1993), an equivalent magnetisation source at a depth of 100-200 m beneath the crater related to rapid heat transport by the circulation of shallow ground water, is basically valid also in the following decade. Hence, we regard here the geomagnetic changes as an indicator of the temperature just beneath the crater lake and investigate the relationship between the heat discharge from the crater surface. Following results have been obtained from our analysis.

1. The water level of the crater lake has shown a remarkable change exceeding 70 m during 1991-2000. The consequent surface area change of the lake surface amounts to 150 %, which cannot be ignored in estimation of heat discharge.
2. The main features of the level change can be quantitatively explained by surface evaporation of lake water.
3. The amount of heat discharge from the lake surface (mostly by evaporation process) has been in a range of 50 to 150 MW, whereas the thermal energy concerning the geomagnetic variations has been in a range of 5 to several tens of MW. Thus, roughly one tenth of the total discharge contributes to the heating/cooling of the shallow subsurface region.
4. Long-term variation of geomagnetic intensity has been well correlated with the heat discharge from the crater surface (increasing heat discharge during demagnetisation period). This fact strongly suggests an effective heat transport in vertical direction between the equivalent magnetisation source and the bottom of the crater lake.