

Self-potential surveys and monitoring on Sakurajima Volcano, Japan

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A self-potential (SP) anomaly of about a few hundreds to more than a thousand mV was observed on many active volcanoes. Electrokinetic effect associated with subsurface fluid upflows is considered to be the most probable cause of such a large anomaly, so that the SP data are often used as an indicator of the hydrothermal activity of volcanoes. Therefore, continuous measurement of SP will bring knowledge of hydrothermal activity inside the volcano associated with volcanic activities.

We have conducted repeated SP surveys at Suwanosejima and Satsuma-Iwojima volcanoes in order to detect the time variation of the SP distribution associated with the volcanic activity. Repeated surveys of the same traverse to the summit of those volcanoes showed that difference in the SP profiles between volcanically active period and inactive period was not obvious at the summit area while a slight but significant difference was seen at the flank area where SP profile was shifted from topographic effect to the central positive anomaly (Kanda and Mori, 2003).

SP surveys on Sakurajima volcano were conducted by Hashimoto et al. (1998, 1999). The survey was restricted to the flank area because of frequent volcanic explosion. According to their results and our additional measurements, a central positive anomaly is not obvious at Sakurajima. Increasing tendency was seen towards the summit around the western edge of the profile for eastern flank of Minamidake (MD), while SP did not increase for southern flank though the topographic effect terminated. It may be interpreted that the hydrothermal system is not sufficiently developed because the repeated explosions exclude the fluids from the vicinities of the vent.

Explosive eruptions have been repeatedly occurred at the summit crater of MD since 1955. The number of explosive eruptions exceeded several hundreds per year during the most active period from the late 1970's to 1980's. In recent years it shows decreasing tendency. Explosions were observed just about 10 times per year during 2003-2005. If the flow pattern of the hydrothermal system changes corresponding to the volcanic activity, the present low active state would be convenient to find its relation to the SP variations.

We started the continuous measurements of SP on Sakurajima in March 2003. Electrodes were installed at 6 locations with 150-200 m intervals on the southern flank of MD (Arimura district) where we can access closer location to the MD crater. Voltage differences between electrodes were measured at an interval of 1 min. The electrode installed at the closest position to MD is located at about 1200 m south from the crater rim and at about 460 m altitude. The electrode used was hand-made Pb-PbCl₂: a Pb electrode was coated by a mixture of bentonite and PbCl₂ considering stability. The SP data were recorded to an internal memory (2Mb) of the CR-10X data logger (Campbell Scientific Inc.) and retrieved every 40 days. In December 2005, we replaced the data logger with CR-1000X that can accommodate CF card as data storage. This replacement enables us to collect SP data with 1 sec. sampling rate synchronized by GPS.

We applied the MT method, which utilizes the ratio between the inducing geomagnetic field and the induced electric field, to the observed voltages. Since we have just 1 component of the electric field, we can not estimate resistivity by the analysis. Then, a transfer function (TF) between the magnetic field and voltage was estimated for each voltage difference. Three components of the geomagnetic field data observed at Kanoya Magnetic Observatory of JMA were used for estimation. Since TF includes information on the subsurface resistivity, the time variation of TF is considered to reflect mainly the variation of electric structure of volcanic edifice. In this study, we analyzed voltage data for about 2 years and the relation to the volcanic activity was discussed.