Laboratory Experiments of Streaming Potential Aiming for Quantitative Evaluation of Self-Potential Data

Takeshi Hashimoto[1]; Annamaria Vicari[2]

[1] Inst. Seismol. Volcanol., Hokkaido Univ.; [2] INGV, Italy

Introduction:

It is well-known that fluid flow in a porous media produces the streaming potential. An application of this phenomenon to estimating subsurface fluid flow in volcanoes has been increasingly attempted in recent years. It is theoretically possible to assess hydrothermal system and to evaluate thermal energy within a volcanic edifice by means of self-potential mapping on the ground surface. However, in reality, ambiguities of electrical conductivity, hydraulic conductivity, and streaming potential coupling coefficient (or the zeta-potential) often prevent us from even rough estimations of them. Regarding the electrical conductivity, it would be possible to some extent to obtain a realistic subsurface structure by means of geophysical explorations such as the magneto-tellurics. For the hydraulic conductivity, constraint in some orders would be possible in cases that borehole data is available. There are some problems for the estimation of the zeta potential as shown later.

The primary aim of this study is to elucidate whether self-potential is really useful in estimating the thermal energy of a volcano, and if so, to enable the quantitative evaluation in a precision within a few orders.

Implication from field data:

Many previous studies have reported positive SP anomalies centered at active craters of volcanoes (e.g. Zablocki, 1976; Hashimoto and Tanaka, 1995), in which those positive anomalies are interpreted as the streaming potential due to a subsurface hydrothermal system. Numerical modeling of such a process has also been achieved by some previous studies (e.g. Ishido and Pritchett, 1999). However, field data from some volcanoes, such as Rishiri and Kusatsu-Shirane, seem controversial: The former has a notable positive SP anomaly towards the summit, though it is considered to have almost finished its volcanic lifetime from geological viewpoint. The latter conversely shows low SP towards the summit, nevertheless it has a remarkable hydrothermal system within the edifice. Another controversial example is that SP in the very vicinity of small-scale fumaroles or steaming ground, nevertheless they have remarkable upward flow of fluid, does not always accompany positive anomalies. We should have a consistent model that is also applicable to these observations. We consider that further understanding of the behavior of the zeta-potential in rock-water systems is necessary.

Zeta-potential measurements:

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