

On the source characteristics of ground deformation and demagnetization in inter-eruptive periods

*Takeshi Hashimoto¹, Mitsuru Utsugi², Takahiro Ohkura², Wataru Kanda³, Akihiko Terada³, Satoshi Miura⁴, Masato Iguchi⁵

1. Institute of Seismology and Volcanology, Graduate School of Science, Hokkaido University, 2. Aso Volcanological Laboratory, Institute for Geothermal Sciences, Graduate School of Science, Kyoto University, 3. Volcanic Fluid Research Center, Tokyo Institute of Technology, 4. Research Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University, 5. Sakurajima Volcano Research Center, Disaster Prevention Research Institute, Kyoto University

1. Introduction

Phreatic eruptions are generally poor in obvious preceding seismicity or deformation, which makes it relatively difficult to predict their onset rather than in the case of magmatic eruptions. On the other hand, volcanoes with shallow hydrothermal system often exhibit repeated unrest during inter-eruptive periods (years to decades), such as microseismic swarm, shallow inflation and magnetic field changes. It is easy to imagine that such anomalies reflect some pressure/temperature changes in the hydrothermal system as a source of, in particular, hydrothermal or magmatic-hydrothermal eruptions. Meanwhile, it still remains difficult to link them to practical evaluation of eruption imminence or size. We aim to find a clue for the problem by comparing anomalous events at several long-monitored Japanese volcanoes with hydrothermal feature. Here we look at collective characteristics of deformation and magnetic change among these events.

2. Method

We collected source information for deformation and magnetic changes with relatively long duration (months to years) from literatures based on GNSS, tilt, leveling, and magnetic total field observations. Here we dealt with the simplest and most commonly-applied model, i.e., Mogi model for deformation and the single dipole model for magnetism. Source depth and changes in volume or magnetic moment were investigated. For some events we newly estimated source parameters from the records obtained in the "Earthquake and Volcano Hazards Observation and Research Program" and their related researches.

3. Results

We plotted the rate of change in source volume or magnetic moment against the source depth in Fig. 1. In the deformation plot, the Kuchi-no-Erabujima 2014-15 event was based on the precise leveling by Kyoto University and its volume rate was calculated from the period between the two surveys. Three events in 2014-16 at Aso were estimated from GNSS baseline changes by assuming a fixed source location to the deflation source that was previously estimated from the repeated precise leveling by Kyoto University (Ohkura et al., 2009). Strong positive correlation was found between source depth and rate of change both in deformation and magnetism.

4. Discussion and summary

Generally, there is a trade-off between source depth and intensity, and it is intrinsically natural that a deeper source tends to be stronger. However, most of the source parameters shown here are estimated using the records of multiple observation sites, and therefore, it is unlikely that the source depth is significantly erroneous and the above-mentioned correlation is merely arose from the error of the model estimation. Besides the correlation, we emphasize another important feature that no events are plotted in

the upper-left region of the scatter diagram. This fact suggests that extremely shallow and intense sources cannot be realized in spite that they are detectable. Though it may seem paradoxical, such a source may immediately be erupted, if it does exist. This idea leads us to a possibility to delineate a danger line to an eruption by further accumulating the number of similar observations. We here assumed a point source both for deformation and magnetic changes. However, it should be noted that uniqueness of the model is not guaranteed. Additional care must be taken that the source parameters do not necessarily correspond to physical reality such as mass or heat, since properties such as compressibility or magnetization of the source material are not considered here. We believe that researches that can link geophysical observations to subsurface state such as hydrothermal simulations will play one of the key roles in the future to solve this problem.

Acknowledgment: H. Aoyama and R. Tanaka at Hokkaido Univ. and M. Ichiki at Tohoku Univ. are greatly appreciated for valuable discussion and suggestions. This study was supported by MEXT, under its Earthquake and Volcano Hazards Observation and Research Program.

Keywords: volcano, hydrothermal system, ground deformation, geomagnetic change

