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Hydrothermal system at Tatun Volcano Group, northern Taiwan, inferred from resistivity structure

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Tatun Volcano Group is composed of over twenty volcanoes, which were formed within faults at the northern tip of Taiwan. So far, these volcanoes were regarded as extinct because of no historical record of eruption. However, recent studies have found the relatively young ejecta (Chen and Lin, 2002; Belousov et al., 2010), high 3He/4He ratio (Yang et al., 1999; Ohba et al., 2010), and hypocenter distribution suggesting the fluid flow and the high temperature condition (Konstantinou et al., 2007); that suggest the presence of potentially eruptive magma beneath TVG. Further, active heat discharge from fumaroles and springs also suggests a large amount of the volcanic fluids released from magma beneath Chishinshan volcano. Focusing on this phenomenon, Utsugi et al. (2012, JPGU) conducted AMT surveys at the volcano for a better understanding of this magma degassing, and showed the preliminary resistivity structure suggesting the low resistivity region at the depths of 1-2km.

On the basis of their work, the authors conducted further AMT surveys around Matsao hot spring and Da-you-keng fumarole areas, about 2 km northeast of the volcano. Time series of the electric and magnetic fields were acquired for about 4 hours at each site. Totally 10 observation sites were configured to cover the areas. After data acquisition, the frequency domains were obtained from the time series, using FFT processing. The impedances were estimated for each frequency. The obtained frequency range was between 1 and 10400 Hz. The authors used not only the data of the present study but also those of Utsugi et al. (2012, JPGU).

This study categorized the study area into two areas, mainly from the characteristics of the main axes of the impedance phase tensor ellipse by the method of Caldwell et al. (2004): 1) Mt. Chishinshan area and 2) Matsao and Da-you-keng areas. In this study, two-dimensional resistivity structure was estimated for each area, using the inversion code of Ogawa and Uchida (1996). By incorporating them with the evidences from geochemistry and geophysics (MRSO, 1969, 1970, 1971, 1973; Ohba et al., 2010; Ohsawa et al., 2013; Murase et al., 2013, IAVCEI), the following features of the hydrothermal system was inferred.

Beneath Mt. Chishinshan two-phase fluids are supplied; which is represented by the extremely-low resistivity column (less than 3 Ohm-m) and the deflation pressure source below 1 km depth. As the fluids ascend, their phase is changed into vapor-phase, leading to low to relatively-low resistivities (6-30 Ohm-m) at the depths of 0.3-1 km. The vapor-rich region is covered by the low-permeability cap represented by the extremely-low resistivity layer near the surface (less than 3 Ohm-m). A portion of the vapors is mixed with shallow groundwater, and flows along a topographical relief to form Matsao hot spring; whose area is represented by resistivities less than 10 Ohm-m.

On the other hand, Da-you-keng area has intense fumaroles; whose vapor-dominated fluids are supplied from the region beneath Cing-tian-gang, represented by the low to low-resistivity region (3-30 Ohm-m) and the inflation pressure source below 1 km depth. This vapor-bearing region is covered by the overlying low-permeability cap represented by the extremely-low resistivity region (less than 3 Ohm-m).

This study estimated the horizontally-extending vapor-rich region beneath Mt. Chishinshan, Da-you-keng, and Cing-tian-gang. Actually, this area has experienced a phreatic eruption ca. 6 Ka (Belousov et al., 2010). These suggest that the vapors have been maintained for at least several thousands years, and that there is still a possibility of phreatic explosions.

Keywords: Tatun Volcano Group, Hydrothermal system, Two-phase region, Vapor-dominated region, Pressure sources