Analysis of evolution of the hydrothermal system of Aso volcano from 2014 to 2015 using multiphase flow simulation and 3-D resistivity variation model

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Understanding hydrothermal systems and their evolution is essential to trace and predict volcanic activity. Electrical resistivity is an important proxy for the subsurface hydrothermal systems; low resistivity zones in a volcanic body correspond to the presence of hydrothermal fluids, magma, or hydrothermally altered rocks. Furthermore, monitoring electrical resistivity may help to constrain movement and/or increase and decrease of hydrothermal fluids and magma. For example, our previous work (Minami et al. 2018) provided a temporal resistivity variation model of Aso volcano between August 2014 and August 2015. These results were obtained from several controlled-source electromagnetic surveys (ACTIVE; Utada et al. 2007), and they revealed the increase of the resistivity 400 m beneath the crater bottom, coinciding with the starting of the magmatic eruptions in November, 2014. This resistivity variation implies that a magmatic intrusion enhanced the temperature of hydrothermal fluids in the system which created a vapor-rich boiling zone. Recently, Minami et al. (2019, SGEPSS) also provided a higher temporal resolution version of the resistivity variation model at a 3-month interval, which illustrates effects of the rainy season on the system and recovery of the fluid amount before the phreatomagmatic eruption in September, 2015. Although resistivity changes have been understood by the previous works, quantitative interpretation, e.g. understanding of the change in temperature, fluids amount and pressure remains missing. Such information is crucial in order to properly assess the volcanic risk.
In this study, we propose to address this issue, by using a dynamic multiphase flow simulation from which we calculate its synthetic electrical resistivity values using Archie's law. We performed an axisymmetric 3-D multiphase flow simulation to interpret the enhanced resistivity just before the starting of Aso magmatic eruptions in November 2014. In the simulation, we temporarily increase an input of magmatic source beneath the first Nakadake crater, which reaches the crater bottom through a high permeable conduit of 120 m in diameter. Our preliminary result shows that the enhanced resistivity 400 m beneath the crater bottom can be caused by the prescribed magmatic source and the presence of a low permeability layer, several hundred meters below the crater bottom. This implies the possibility that an impermeable cap rock traps hot hydrothermal fluids where part of them exists in gas phase. In the presentation, we will report details of our multiphase flow and discuss the temporal variation model of Minami et al. (2019, SGEPSS).

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