New approach to evaluating the mass flux of volcanic fluids using the electrical conductivity structure of a volcano: application to Unzen volcano, SW Japan

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The efficiency of degassing of volcanic fluids in magma is one of the key parameters controlling the explosive potentiality of the eruption and the diversity of the volcanic activity. Therefore, to evaluate the mass flux of volcanic fluids is important in considering the constraint conditions of these phenomena. When volcanic fluids are dissolved into the pore water of the aquifer, the aquifer has a high electrical conductivity; this is because that the pore water conductivity is increased due to the high- salinity and temperature, and that the surface conductivity of matrix is also increased due to hydrothermal alteration. The spatial extent of the high conductivity region could be related to the abundance of the flux of volcanic fluids. Therefore, the electrical conductivity structure of a volcano has a potentiality for estimating the volcanic fluid mass flux by groundwater flow.

The authors developed the simple steady state model of volcanic fluids dissipation inside the aquifer, to investigate the factors controlling the spatial extent of the high electrical conductivity region. Firstly, the model of the groundwater flow was developed, to estimate the salinity and temperature distributions of the aquifer. Some simplification were used with respect to the groundwater flow; a simple geometry and physical properties of the aquifer, and relatively little contribution of the groundwater flow from the buoyancy force. Secondly, the simple model of the electrical conductivity was developed, to estimate the bulk electrical conductivity distribution using the temperature and salinity distributions. This model assumes that the pore water conductivity and the surface conductivity of matrix can be represented simply as a function of temperature and salinity of pore water.

Results showed that the spatial extent of the high electrical conductivity region is essentially controlled by the volcanic fluids flux, rainfall recharge and aspect ratio of the aquifer, regardless of the many uncertainties of the parameters used. The above results were applied to the electrical conductivity structure at Unzen volcano, SW Japan, obtained from TDEM surveys. The estimated volcanic fluids flux from magma by groundwater flow was $10^{5.3\pm0.5}$ t/yr. This value is quantitatively consistent with the other petrology, geochemical and geophysical evidences; which are the spatial change of water content of magma by melt inclusion analysis, CO_2 flux by groundwater and soil analysis, and magma input rate by GPS and leveling surveys.

Recent Unzen volcano (150Ka-present) has the dome-forming eruptions; that means non-explosive activities are dominant during recent Unzen. Our result suggests that the magma is steadily releasing the volcanic fluids at the underground prior to eruptions. This effective degassing might lead to the decrease of water content of magma, and be one of the reason of the non-explosive volcanism.

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