Hydrothermal system beneath the Jigokudani valley, Tateyama volcano

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The mechanism of phreatic eruption has not been well understood yet, although we observed phreatic eruptions many times. Phreatic eruption is known to occur in the hydrothermal system developed within a volcanic edifice because the ejecta of phreatic eruptions often contain the hydrothermally altered minerals originated from the hydrothermal system. Therefore, an understanding of the hydrothermal system is essential to clarify the mechanism of phreatic eruption.
The Jigokudani valley, Tateyama volcano located in the Hida Mountains, has an active solfatara field, and was formed by repeated phreatic eruptions some 40,000 years ago. Recently the Jigokudani valley showed the increased volcanic activity, for example, a sulfur outflow and temporal changes in the composition of fumarolic gases. These situations make us expect the presence of a well-developed hydrothermal system which is in preliminary stage of a phreatic eruption.
The objective of this study is to reveal the hydrothermal system beneath the Jigokudani valley by resistivity exploration and hot spring water analysis. In general, hydrothermal fluids or hydrothermally altered minerals are electrically conductive, whereas gases or rocks are resistive. Therefore, a resistivity imaging by using an audio-frequency magnetotelluric (AMT) method is suitable for structural investigation of the hydrothermal system. We estimated where the hydrothermal system developed by AMT survey. In addition, we discussed what has happened in the hydrothermal system by hot spring water analysis. We compared the inferred resistivity structure with the results of hot spring water analysis, which enabled us to estimate more realistic hydrothermal system.
The 3D resistivity structure showed that the Jigokudani valley has a cap structure that is composed of upper hydrothermally altered layer (called cap rock), which shows electrically conductive and rock) and hydrothermally low-permeable, and lower gas reservoir which shows relatively high resistivity. A highly conductive layer is found in a depth of around 500 m and it seems to extend eastward as the depth becomes large. These features were interpreted as the hydrothermally altered pyroclastic flow deposit and a fluid path from the deep magma, respectively.
We measured an electrical conductivity, temperature and pH of hot spring water on the spot. The ion concentration and isotope ratio of hot spring water samples were analyzed at 27 locations. The hot spring water in the Jigokudani valley was classified into three types based on Cl^-/SO_4^{2-} concentration ratio. Considering both the chemical composition and the isotope ratio, three types of hot spring water were derived from condensation of volcanic gases, a mixing of meteoric water and vapor phase separated at a shallow depth and the surface water supplied with volcanic gases consisting of mainly H_2S.
An integrated view of the resistivity structure and geochemical analysis suggests that the hydrothermal system develops in the depth to 500 m and a common parental fluid of all hot springs is there. In addition, a gas reservoir estimated from the resistivity survey corresponds to the vapor phase inferred from the geochemical analysis. The concentration of Cl^- in the hot spring water derived from the vapor phase is a measure of the temperature condition beneath the cap rock, which implies that the monitoring of Cl^- could be useful to know the physical state of the cap

structure.

Keywords: hydrothermal system, phreatic eruption, AMT, hot spring water analysis, cap structure

