Relationship between phreatic eruptions and the active hydrothermal system of Kusatsu-Shirane volcano, Japan

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Mount Kusatsu-Shirane, central Japan, is an active andesitic volcano that is associated with fumaroles, hyper-acidic hot waters, and other signs of vigorous thermal activity (Ohba et al., 2000; Terada and Hashimoto, 2017). Yugama crater lake is located at the top of the volcano and forms part of the beautiful scenery of the area. The lake water has high concentrations of Cl^- and SO_4^{2-}, which change markedly in response to volcanic activity. The thermal activity is most obvious at the famous spa town of Kusatsu, where the flow rate of hot water is ~32,000 L min^{-1}. Four million people visit the town of Kusatsu each year to see the volcano and enjoy the hot spring, so understating the hydrothermal system associated with phreatic eruptions is critical.

Geochemical data indicate that the hot springs are supplied by a tow-phase reservoir of hot water produced by the condensation of magmatic gases. The fumarolic gases are characterized by high H_2S and CO_2 concentrations, and separated from the reservoir (Ohba et al., 2008). Magnetotelluric surveys show clay layers below Yugama crater lake, and these control the subsurface flow of hot water (Nurhasan et al., 2006; Ogawa et al., in prep.).

In 2014, unusual volcanic activity included changes in seismic activity, ground deformation, and the compositions of fumarolic gases and lake water, providing insights into the hydrothermal system. It is inferred that a horizontal body of a source of over-pressure exists 1,000 m below the bottom of Yugama crater lake. Precise measurements of the hypocenters of microearthquakes show that they are distributed from depths to the bottom of a bell-shaped impermeable clay layer that underlies Yugama crater lake. A source of low-frequency earthquakes (Nakano et al., 2003) and demagnetization/magnetization (Takahashi and Fujii, 2014) is located close to the over-pressure source. On the basis of these observations, I infer that a hydrothermal reservoir exists below the clay layer that underlies Yugama crater lake. Phreatic eruptions are related to the growth of fractures that connect the reservoir to the ground surface or the bottom of the lake.

Identification of the precursors to phreatic eruptions at Kusatsu-Shirane volcano remain challenging (Terada, 2018). Geophysical and geochemical parameters have been monitored

continuously at Kusatsu-Shirane volcano since the 1970s, providing an effective record of changes in volcanic activity. Geochemical observations were used to predict a phreatic eruption in 1976 (Ossaka et al., 1980), however, such proxies for volcanic activity are not correlated with ejecta mass, location, or timing of eruptions. Although obvious changes in geochemical and geophysical data were detected around Yugama crater lake in 1990 and 2014, then no eruptions occurred at Yugama.

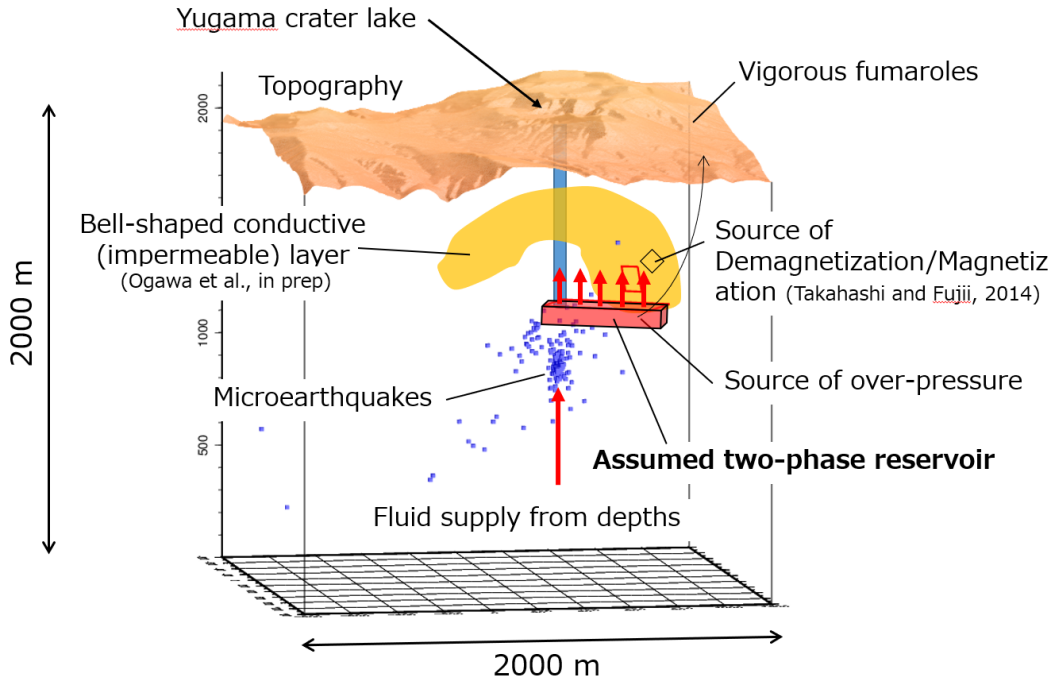

Fig. 1. Schematic illustration of water flow and storage near Yugama crater lake at Kusatsu-Shirane volcano.

Main References

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