Water chemistry of fluid supplied from subaqueous fumaroles of Yugama crater lake, Kusatsu-Shirane volcano, inferred from geochemical heterogeneities of lake water

*Leona Suzuki[1], Akihiko Terada[1], Muga Yaguchi[2], Masanori Takahashi[1], Takeshi Ohba[3]

1. Tokyo Institute of Technology, 2. Meteorological Research Institute,JMA, 3. Department of chemistry,School of Science,Tokai University

Yugama crater lake at Kusatsu-Shirane volcano is classified as a high-activity crater lake with a diameter of 200 - 300 m. Water temperatures are 10 –15 degrees Celsius higher than the ambient air temperature because of fluid emissions from subaqueous fumaroles on the lake floor at a depth of 30 m. The lake water has a pH of around 1.0 and contains high concentrations of Cl and SO_4 ions, which show marked changes in response to volcanic activity. Therefore, regular sampling of lake water by hand has been performed at the shore of Yugama crater lake for 50 years, providing valuable data including early warning of an eruption. However, geochemical properties of hydrothermal fluid emitted from subaqueous fumaroles is altered because of mixing with existing lake water and diluted by precipitation input. Surface evaporation cause kinetic fractionation of water stable isotope rate as well as condensation of chemical concentration including Cl and SO_4. To evaluate water chemistry of fluid emitting from subaqueous fumaroles around the center of Yugama crater lake, we have sampled lake water from various depth around the subaqueous fumaroles by a drone (unmanned aircraft system). Our drone (DJI MATRICE 600 PRO) with a winch enables to descend sampling bottles from a drone to the lake surface, without descending a drone itself to lake surface, meaning reduction of the risk of a loss of radio communications between the drone and the operator at a site due to topographic effects. Remote water sampling using a drone have been repeatedly performed from a site located at 1 km southeast from the center of Yugama crater lake in 2019. Isotope compositions of water differ from that of water sampled at the lake shore, while temperature recorded by thermistor attached to a sampling bottle is only 1-2 degrees higher than that of ambient lake water. Our numerical simulation, which takes into account isotope fractionation during surface evaporation, precipitation input and seepage through the lake bottom, indicates the relation between water stable isotope composition of fluid emitted from subaqueous and that of lake water sampled at the shore. Comparing numerical simulation and drone observations, we found that water stable isotope sampled by a drone is consistent with numerical evaluation. Data on temporal changes in lake water chemistry are useful for identifying and predicting volcanic activity. However, it takes enough time to detect temporal changes in lake water chemistry due to large volume of lake relative to mass flux of subaqueous fumaroles. In the case of Yugama crater lake, the residence time is over 1 year indicated by numerical simulation. Therefore, water sampling from subaqueous fumaroles by a drone is useful to evaluate temporal changes in volcanic activity such as changes in hydrothermal reservoir supplying hot water to crater lake.

Keywords: Drone, Unmanned aircraft system, Kusatsu-Shirane volcano, Crater lake, Water stable isotope ratio, Volcano monitoring

©2020. Japan Geoscience Union. All Right Reserved.