Evaluation of volcanic activity by geochemical observation of hydrothermal fluids

*Muga Yaguchi[1], Takeshi Ohba[2]

1. Meteorological Research Institute, JMA, 2. School of Science, Tokai University

The volatiles degassed from magma are composed of various components such as H_2O, CO_2, SO_2, HCl, and He, some of which are released to the surface as volcanic fluids such as volcanic gases, hot spring water, and crater lake water. Since degassing of volatiles is a driving force of various volcanic activities such as magma viscosity change, ascent, and eruption, we can withdraw useful information for evaluating volcanic activities through chemical and isotope analyses of volcanic fluids (e.g., Ohba, 2022). In this presentation, we report an effort to evaluate volcanic activity by chemical and stable isotope analyses of thermal waters, using the example of Ebinokogen Iwoyama volcano located in the northern part of the Kirishima volcanic group, which recently erupted in 2018.
Ebinokogen Iwoyama volcano is the most geothermally active area in the Kirishima volcanic group (Kagiyama et al., 1979), and various volcanic activities such as earthquake swarms, thermal water/fumarolic discharge can be observed. Many visible activities have been observed recently alone, such as; a decline since the late 1990s and a temporary cease around 2007 of fumarolic activity that had been active since at least the Meiji era and its resumption in 2015; temperature increase of spring water and sediment discharge near the summit area in 2017; phreatic eruptions at the summit and foot of this volcano in 2018.

The content of this presentation is based on the analytical results of spring water at the foot of Iwoyama volcano, water discharging at the site of the sediment discharge in 2017, and crater water at the site of the 2018 eruptions. These thermal waters are characterized by a temperature of 15-97˚C, low pH of 0.5-2.8, and SO_4・Cl type or Cl・SO_4 dominated composition. The hydrogen and oxygen isotope ratios are widely distributed between δD=-51‰ and δ^{18}O=-7.9‰ of the spring water at the foot of the mountain and δD=-0.4‰ and δ^{18}O=+10.1‰ of the thermal water in sediment discharge site at the summit. These isotopic characteristics imply that the thermal waters originated from mixing with the local meteoric water (δD = -48±2‰, δ^{18}O = -7.6±0.3‰; Ide et al., 2016) and magmatic water (δD = -20±10‰, δ^{18}O =+10±2‰; Giggenbach, 1992). However, it is difficult to explain the origin of thermal waters only by simple mixing of meteoric and magmatic water because most of the thermal waters have a δD/δ^{18}O slope of about 3.2 on the δD—δ^{18}O diagram, and some crater waters with particularly heavy isotopic ratios show a δD/δ^{18}O gradient of about 5. Assuming that the slope of δD/δ^{18}O is due to isotope fractionation during the gas-liquid separation of water, and using the isotope fractionation coefficient by Horita and Wesolowski (1994), δD/δ^{18}O=3.2 and δD/δ^{18}O=5 are close to the ratio of isotope fractionation associated with gas-liquid separation at about 160˚C and at about 100˚C, respectively. That is, the thermal waters in this area are the liquid phase of the gas-liquid separation at about 160˚C of the mixture of local meteoric water and magmatic gases, and heavy isotopic ratios of some crater waters are due to evaporative enrichment of D and ^{18}O at craters at near-boiling temperatures.

In general, the HCl/SO_2 ratio can be used as an indicator of volcanic activity (Hirabayashi et al., 1982) because this ratio increases as the temperature of volcanic gases increase with volcanic activity (e.g., Iwasaki et al., 1966). Since HCl is easily soluble in water and SO_2 provides SO_4 when oxidized and dissolved, the Cl/SO_4 ratio in thermal water is a proxy for the HCl/SO_2 ratio of volcanic gases. In spring water at the foot of Iwoyama volcano, where we started observations in August 2016, we were able to capture significant increases and decreases in the Cl/SO_4 ratio before and after the sediment discharge in April 2017 and the eruption in 2018, providing a good example of the effectiveness of thermal water analysis in the evaluation of the volcanic activity. Even after the 2018 eruption, seismic activity and crustal deformation have been observed at Iwoyama volcano; the latest trends in volcanic activity insight through thermal water analysis will be discussed.

A part of this research was supported by the Integrated Program for Next Generation Volcano Research and Human Resource Development of the Ministry of Education, Culture, Sports, Science and Technology (MEXT), Japan.

Keywords: Evaluation of volcanic activity, thermal water, δD･δ18O, Cl/SO4 ratio, Ebinokogen Ioyama volcano

