Estimation of viscosity of erupting magma from lava flow morphology

*Taketo Okazaki[1], Tsuneomi Kagiyama[1]

1. Graduate School of Science, Kyoto University

Eruption types of volcanoes depend on magma viscosity. For example, in the case of magma with much volatiles, viscous magma causes Plinian eruption, and conversely magma with low viscosity causes Hawaiian eruption which forms lava fountain. Thus, in studying volcanic eruptions, it is meaningful to investigate viscosity of erupting magma.
Viscosity of lava flow varies according to various factors like temperature (Minakami et al., 1951) and petrologic compositions (Shaw, 1972). In this study, we focus on lava flow morphology formed by volcanic eruptions, and aim to establish a method for estimating viscosity and to calculate viscosity of erupting lava flow from various volcanoes. The merit of this morphological method is that it requires no direct observation data such as flow rate or temperature, so it can apply to various lava flows erupted in the past.

The method of calculating viscosity from morphological parameters of lava flow such as thickness and width is presented by Stevenson et al. (1994). Firstly, we used lava flow simulation offered by Earthquake Research Institute (Yasuda et al., 2013) to evaluate the utility of this method. This simulation uses the method presented by Ishihara et al. (1990). We determined morphological parameters from the simulation results, calculated viscosity using Stevenson’s formula, and then compared with original value calculated from erupting temperature using Minakami’s formula. As a result, values obtained from Stevenson’s method showed different distribution from the original values’. Also, it proved that this method cannot calculate because of error when assumed viscosity was too high.
We used a new method to estimate viscosity in order to solve the above problem. This time, we adopted aspect ratio which can be obtained by dividing lava flow thickness by the square root of its area size. We calculated aspect ratio from the simulation result, and then derived a relation among the ratio, gradient of the ground, and original viscosity calculated from erupting temperature. We also applied this relation to real lava flow topography and ascertained its usefulness. Although the verification is not enough, this method of aspect ratio is expected to be applied to various places because it can obtain significant results regardless of lava flow characteristic or gradient of the ground.

Keywords: lava flow, magma, viscosity, aspect ratio

