Effects of equilibrium crystallization on conduit flow dynamics during the 1986 eruption at Izu-Oshima volcano

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A diversity of eruption styles has been mainly studied in silicic volcanism, in which the competition between vesiculation of hydrous magma and gas escape from the magma in conduit flow is one of the main factors controlling eruption styles (explosive or effusive). In basaltic magmatism, diverse eruption styles are also been observed especially in island arc volcanoes with hydrous magma. In this study, we investigated the origin of the diverse eruption styles during the 1986 eruption of Izu-Oshima volcano, Japan, using a 1-D steady conduit flow model. Ishibashi and Oida (2018) proposed that a variety of equilibrium crystallization paths during magma ascent caused by a difference in magma temperature is a key factor controlling the eruption styles which range from lava flow to sub-Plinian eruptions. We assessed the effects of the equilibrium crystallization on conduit flow dynamics during the 1986 Izu-Oshima eruptions. In the conduit flow model, magmatic properties of the Izu-Oshima eruptions were properly set based on petrological observations and thermodynamic modeling. We also applied various models for magma fragmentation (expansion, shear-induced, and stress) and gas escape (permeable flow and bubble segregation) because information about these processes in basaltic magma is limited. We obtained two distinct patterns of conduit flow depending on equilibrium crystallization path and magma temperature as expected in the previous study: a low (or high) temperature and high (or low) crystallinity magma induces a flow with high (or low) magma viscosity. When a shear-induced or stress fragmentation is applied, the flow with high viscosity leads to fragmentation and explosive eruption, whereas that with low viscosity leads to effusive eruption without fragmentation. We also found that expansion fragmentation is promoted for the flow with high viscosity when gas escape due to bubble segregation is applied because the high viscosity prevents the bubble segregation. Our results revealed that due to the above relationship between the crystallinity or viscosity and the explosivity of basaltic eruptions, there exist the conduit flow solutions corresponding to the lava flow and sub-Plinian eruptions at Izu-Oshima volcano. Although crystallization kinetics has been recognized as an important process controlling the eruption dynamics, our results indicate that the equilibrium crystallization process is also strongly controlling the eruption styles in basaltic volcanism.

Keywords: Basaltic eruption, Conduit flow, Eruption style, Crystallization, Fragmentation, Gas escape

