Petrological Constraints on the Magma Fragmentation Pressure on the Hoei Eruption (AD 1707) of Fuji Volcano - Implications for the dynamics of Basaltic Plinian Eruptions

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Basaltic volcano systems erupt in various ways, from weak effusive to explosive Plinian eruptions. However, the magma ascent dynamics and fragmentation mechanism of basaltic Plinian eruptions have remained unclear. One feasible explanation is that the crystallization and rheological transition of magma during the ascent could induce brittle fragmentation and Plinian-style basaltic eruptions. Furthermore, the temperature, initial water content, crystallization timescale, and final equilibrium pressure are critical for crystallization. In this regard, this study adopted the petrological method of estimating magma temperature and final equilibrium pressure using analyses of natural scoriae from the Hoei eruption (AD 1707), which is a basaltic sub-Plinian eruption and the last large eruption of the Fuji volcano. Furthermore, a numerical conduit flow model was used to test the possibility of reaching the fragmentation criteria and the effect of conduit geometry. The Hoei scoria has a microlite content of 51%-60%, which can increase the apparent viscosity of the Hoei magma by several orders of magnitude more than the melt viscosity. Most of the crystal phase (~90%) is composed of plagioclase, and the presence of olivine, augite, and Fe-Ti oxide implies a final equilibrium pressure-temperature condition. High-temperature experiments were performed within a temperature range of 1060 ℃-1120 ℃ under low pressure (< 20 MPa) to test the equilibrium pressure-temperature condition of the Hoei scoriae. We used two oxidation buffers (Ni-NiO and Re-ReO_2) because the chemical equilibrium phase of a mineral is also related to the oxidation condition. We established the final equilibrium condition of the Fuji Hoei eruption as 1080 ℃ - 6 MPa - ΔNNO + 1.0~1.5 in terms of equilibrium crystallinity and the chemical equilibrium phase of pyroxene. Direct evidence for the conduit geometry of the Hoei eruption is limited. However, as this study shows, the appropriate conduit geometry can be estimated by the geological constraints of the discharge rate and final equilibrium pressure. The crystallization during the basaltic magma ascent significantly changes the viscosity, and this effect can also be tested using the conduit flow model.

Keywords: Basaltic Plinian eruption, Fuji Volcano, Crystallization, Fragmentation, Hoei eruption

