Linking petrological and geophysical observations: A case study of the 2011 eruption of Shinmoedake volcano

*Satoshi Okumura[1], Tomofumi Kozono[2], Takehiro Koyaguchi[3], Masashi NAGAI[4]

1.Division of Earth and Planetary Materials Science, Department of Earth Science, Graduate School of Science, Tohoku University, 2.Department of Geophysics, Graduate School of Science, Tohoku University, 3.Earthquake Research Institute, The University of Tokyo, 4.National Research Institute for Earth Science and Disaster Prevention

Three sub-plinian eruptions were observed during the 2011 eruption of the Shinmoedake volcano, which were well monitored by tiltmeter, GPS, and weather radar (e.g., Shimbori and Fukui 2012; Kozono et al., 2013). To link petrological information to geophysical observations and understand the evolution of magma ascent processes during sub-plinian eruptions, we investigated pumices from these eruptions. At the Nakadake volcano, we observed deposits of the 2011 eruption and collected pumice samples. We primarily investigated gray pumice although two types of pumice (gray and white pumice) were found in the deposits, because this type of pumice reflects major eruptive magma (Tomiya et al., 2013). Two to four pumice lapilli for each subunit were polished, and bulk groundmass and matrix glass compositions were measured. The analytical results showed that the bulk groundmass composition was almost constant for all three sub-plinian eruptions, whereas the composition of the matrix glass changed systematically. Considering that the matrix glass composition reflects the degree of microlite crystallization, we obtained the variation in microlite crystallinity during the three sub-plinian eruptions. The microlite crystallinity decreased from the early stage of the first eruption to the end of the second eruption. The final eruption showed microlite crystallinity similar to that of the first sub-plinian eruption. The porosity obtained from image analyses showed good correlation with microlite crystallinity, i.e., the samples with high and low porosity had low and high microlite crystallinity, respectively.
The petrological data above indicate the following scenario. During the first sub-plinian eruption, magma experienced outgassing and microlite crystallization, resulting in the formation of relatively low porosity magma with high microlite crystallinity. The degree of outgassing decreased during the second sub-plinian eruption and the microlite crystallinity decreased. The magma erupted by the final sub-plinian eruption experienced outgassing and crystallization similar to that of the first sub-plinian eruption. The variation in microlite crystallinity can be explained by considering the change in magma decompression rate and/or the change in the final pressure at which the magma is quenched (e.g., Riker et al., 2015).
Linking the petrological and geophysical observations allows us to understand more details of temporal evolution of explosive eruptions. Geodetic data indicated that the magma fluxes were almost constant during the three sub-plinian eruptions, whereas the pressure in the magma chamber monotonically decreased corresponding to the eruptions (Kozono et al., 2013). These observations are counterintuitive because it is commonly expected that the flux decreases in response to the decrease in the pressure of the magma chamber under the assumption of magma chamber of constant volume. However, these paradoxical observations (at least those from the first and second sub-plinian eruption) may be qualitatively explained by considering that magma fragmentation pressure increased, as recorded in the groundmass of pumices, i.e., the decrease in microlite crystallinity observed from the first to the second sub-plinian eruption. According to the steady conduit flow model (Kozono and Koyaguchi, 2009; Koyaguchi, 2016), even when the magma chamber pressure decreases, the magma flux can be kept constant if the fragmentation pressure slightly increases so that the length of gas-pyroclastic flow regime in the conduit increases, i.e., the

level of the fragmentation surface descends.

Keywords: Eruption dynamics, Magma fragmentation, Petrological and geophysical observations

