Estimation of magma ascent process during the 2021 eruption of Fukutoku-Oka-no-Ba based on bubble texture.

*Tatsuki Mizuno[1], Fukashi Maeno[1]

1. Earthquake Research Institute, Department of Earth and Planetary Science, University of Tokyo

Large-scale explosive eruptions often affect extensively by the spreading of pyroclasts. To predict volcanic activities, it is necessary to improve understanding of their magmatic processes. Generally, explosive eruptions are caused by the process of bubble formation and magma fragmentation. When the volcano is underwater, highly explosive eruptions are caused by the interaction of magma and external water, known as phreatomagmatic explosions. The explosiveness of underwater eruptions is related to the discharge rate and water depth. In the shallow-water environment, explosive eruptions can be caused by low discharge rates such as often observed Surtseyan eruptions. Phreatoplinian eruptions have been proposed for large-scale phreatomagmatic explosions, but the phenomena and mechanisms are poorly understood because they have not been observed.
On August 13-15, 2021, a large-scale explosive eruption occurred at Fukutoku-Oka-no-Ba submarine volcano in the Izu-Ogasawara arc. The column reached 16 km height and a large amount of pyroclasts was discharged as a pumice raft. This eruption is a valuable example for revealing the process of explosive eruptions in a shallow sea-water environment. Although the observed column was high, it was possibly mainly composed of vapor and is different from the columns often observed in a Plinian eruption. Therefore, it is important to unravel the magma ascent process of this eruption and compare the key parameters such as magma discharge rate and decompression rate with those of Plinian eruptions.
In this study, we estimate the magma ascent process in this eruption by analyzing the bubble texture of the pyroclasts. Drifted pumice clasts collected from Nagahama, Yomitan Village, Okinawa Prefecture were used for observation and analysis. Since the drifted pumice clasts show various characteristics, they were classified in terms of color and texture. The most common type of pumice is white, characterized by gray matrix glass which includes a large number of circular to elliptical bubbles. Most bubbles are about 50-100 μm in size and each of which is either independent or weakly bound to the other. Microlites are not included.
We assumed that the white pumice was ejected at the time of the formation of a large column, and quantified the bubble texture by image analysis. The bubble number density (BND) is 2.8×10^{13} m^{-3}, which is 1-2 orders lower than that of Plinian eruption’ s pyroclasts. (usually 10^{14}-10^{15} m^{-3}). Decompression rate can be estimated from BND and some other chemical conditions using the theoretical methods (Toramaru, 2006; Fiege and Cichy, 2015; Shea, 2017; Hajimirza et al., 2021). The melt SiO_2 composition is 65 wt%, and temperature and pressure conditions were set in a range of possible values according to Yoshida et al. (2022). The highest value of 8.8×10^{6} Pa/s was calculated by the method of Toramaru (2006), which seems to reflect the highest decompression rate at the peak of bubble nucleation. The value of 5.5×10^{4} Pa/s was calculated by Fiege and Cichy (2015). Although the estimate values range 10^{4} -10^{6} Pa/s depending on the methods, they may be lower than the decompression rate of about 10^{6} Pa/s in Plinian eruptions estimated by a steady conduit flow model. The estimated column height is 3.6-13 km by using the method of Toramaru (2006), which is lower than the observed column height in this eruption. The results suggest that the observed column was not driven by high discharge rate.

Keywords: Fukutoku-Oka-no-Ba volcano, Phreatomagmatic explosion, Bubble texture analysis, Decompression raterate

