Porosimetry of pumice sinking into the sea: an example from the Fukutoku-Oka-no-Ba 2021 eruption

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The Fukutoku Oka-no-Ba 2021 eruption has inspired interest in drifting pumice phenomena in various scientific and engineering fields. Takeuchi et al. (2022) conducted a porosimetric study on floating pumice from the Fukutoku Oka-no-Ba 2021 eruption sampled in the main island of Okinawa using pseudo-fluid replacement and gas replacement methods to measure total porosity, connected porosity, and isolated porosity. The results show that the floating pumice with mm to cm in diameter mostly has high isolated porosity, which enables the pumice to continue to float even if the connected pore is saturated with seawater (hereafter, referred to as unsinkable floating pumice) and that as the grain size decreases, the unsinkable floating pumice has lost phenocryst.

This study investigated the porosimetric and petrological characteristics of pumice that settle in seawater using the same method as Takeuchi et al. (2022). Among floating pumice stored in containers with seawater, a few grains of pumice settled after a while. This type of pumice is referred to as post-sampling settling pumice and was examined in this study. The post-sampling settling pumice is thought to float as long as sufficient air is trapped within the connected pore and settles if the trapped air escapes and is reduced in the connected pore (Fauria et al., 2017). This type of pumice probably occurs in nature but is difficult to sample. Although it is difficult to quantify the proportion of post-sampling settling pumice among floating pumice, all but one of the 26 randomly selected as floating pumice with measured porosity were unsinkable pumice (Takeuchi et al., 2022). This suggests that the proportion of post-sampling settling pumice was small.

The unsinkable floating pumice and post-sampling settling pumice have total porosity of 73—84%, 71—85%, respectively. The connected porosity of the unsinkable floating pumice is 22—52%, whereas those of the post-sampling settling pumice is 33-83%. The post-sampling settling pumice tends to have higher connected porosity than the unsinkable floating pumice. Maximum wet density, at which the connected pore is saturated with seawater, was calculated based on the porosity data. The unsinkable floating and the post-sampling settling pumices have the maximum wet density lower and higher than seawater density, respectively. For the post-sampling settling pumice with 0.1—0.5 cm^3 in grain volume, we measured floatation time, defined as the time for the initially dry pumice to begin to settle in seawater. The minimum floatation time is 52 days. At this time, five months after the start of the experiment, some grains are still floating.

The post-sampling settling pumice also originated from Fukutoku-Oka-no-Ba and drifted over more than 1,000 km. Some grains of post-sampling settling pumice have floatation times shorter than the eruption-to-Okinawa arrival timescale (about two months). Because the sampling of floating pumice was conducted near the seashore of Okinawa, the sampled pumice has probably stranded on the beach and again returned to the sea several times. Some post-sampling settling pumice with short floatation time suggests that split and abrasion of floating pumice occurred during post-eruption drifting and stranding on the beach. The split and abrasion processes could produce the post-sampling settling pumice with lower isolated porosity. These processes are important in understanding how the unsinkable floating pumice becomes settling pumice over time and disappears from the sea surface.

Skeletal density (density corresponding to the combined portion of solid phase and isolated pore) of unsinkable floating and post-sampling settling pumices is divided into values lower and higher than the seawater density, respectively. The skeletal density has been measured in previous studies of drifting pumice (Manga et al., 2018; Mitchell et al., 2021) but has yet to be explicitly stated. In this study, we emphasize that the skeletal density is the primary measure of pumice floatability.

Keywords: Fukutoku-Oka-no-Ba 2021 eruption, drifting pumice, porosimetry, pumice floatability

