# Drift paths and dispersion of pumice raft ejected by the Fukutoku-Oka-no-Ba 2021 eruption.

*Kosuke Ishige[1], Shingo Takeuchi[1], Shimpei Uesawa[1], Kiyoshi Toshida[1], Yukiko Suwa[2]

1. Central Research Institute of Electric Power Industry, 2. CERES, Inc.

The Fukutoku-Oka-no-Ba 2021 eruption ejected large amounts of pumice raft associated with an explosive eruption equivalent to VEI4 (Maeno, et al, 2022), which drifted towards the coasts of Japan and Southeast Asia. Understanding the phenomenon of pumice raft is important for disaster management because pumice raft can not only cause navigational hazards for ships, but also water intake hazards for power generation and industrial facilities. Therefore, satellite imagery monitoring, and numerical model drift simulations were attempted for the Fukutoku-Oka-no-Ba 2021 eruption, and the results were used by various agencies in their disaster prevention measures (e.g., Miyama et al. 2022). Verification based on detailed drift history data is important for the sophistication of such emergency response and the accuracy of simulations.
Ishige et al. (2022) observed and analyzed pumice raft using optical satellite images taken from the early stages of the eruption until late October 2021. We found that the pumice raft consisted of three groups (1-3) corresponding to the eruptive phases and drifted sequentially to the Nansei Islands, and that the composition of the pumice raft was different for each group. In this study, we have extended the observation period until December 2021, when the observation limit based on the resolution of the two main satellites (Sentinel-3 and Sentinel-2) is reached, in order to clarify the details of the drift path and dispersion process of pumice raft, and to quantify the amount of pumice raft. All dates below are for 2021.
The pumice raft group separated early after its formation and moved westwards in the Pacific Ocean until early September. The pumice group then made a semi clockwise rotation along the warm eddy, and the order of westward movement of the groups changed, with the pumice group moving westward again when the typhoon passed at the end of September.
Group 1 approached off the east coast of Okinawa Island in late October, but most of them moved southwest without drifting. Most of them remained in a weak cold eddy off the east coast of Miyakojima, but some continued southwest and reached the Philippines in late November. The pumice remaining in the cold eddy dispersed in the same area, mixed with the previous Group 3, and moved southwest again after the cold eddy disappeared in late November, reaching the Philippines and Taiwan in early to mid-December, reaching the observation limit.
Group 2 split into three subgroups (2-A, 2-B, and 2-C) when it approached the Nansei Islands in mid-October. 2-A moved southwestward toward Okinawa Island and drifted to the north to west coasts of Okinawa Island in late October. 2-B drifted north off the east coast of the Amami Islands from late October and reached the far offshore of Shikoku in early November. 2-C drifted to the Amami Islands in mid-October and stayed there until early November, then started moving north from mid-November and reached the far offshore of Shikoku. Satellite observations of both 2-B and 2-C were difficult from far offshore Shikoku, but they are thought to have been carried by the Kuroshio Current and drifted successively to the Izu Islands during November.
Group 3 drifted to Okinawa Island and Yoron Island in mid-October, then some of them moved southwest and stayed in the cold eddy off the east coast of Miyakojima in late October. They then mixed with group 1, which arrived in the same area.
Thus, it is clear that pumice raft from the Fukutoku-Oka-no-Ba 2021 eruption dispersed through the ocean under the influence of the extinction of the oceanic medium-scale eddy and typhoons.
For each pumice raft in the satellite images, the distribution area was enclosed by polygons and the area

 

was calculated using QGIS. In addition, a drift area concentration index was developed using the shading of the pumice raft in the True color images and estimated for each pumice raft. The results showed that the maximum drift area converted to 100% concentration for each group was 280 $km^2$ for group 1 (32 days after the eruption), 170 $km^2$ for group 2 (2 days after the eruption) and 35 $km^2$ for group 3 (24 days after the eruption), with group 1 being the largest pumice raft group. Assuming a drift layer thickness of 1 cm, which is close to the lower limit, the total volume is 0.005 $km^3$. The estimated amount of pumice recovered by Okinawa Prefecture is approximately 100,000 $m^3$, or about 2% of the total.
Thus, the Fukutoku-Oka-no-Ba 2021 eruption is a valuable case in which pumice raft were tracked for four months at high resolution due to a combination of the availability of a high-performance public satellite and good weather conditions.

Keywords: Fukutoku-Oka-no-Ba, pumice raft, Satellite Image Analysis, ocean current

 