A Drift Pumice from the 2021 Eruption of Fukutoku-Oka-no-Ba Found in Koura Beach, Shimane Prefecture, San'in Region

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Abstract

We found a pumice clast from the 2021 eruption of Fukutoku-Oka-no-Ba (FOB eruption) in Koura beach, eastern Shimane Prefecture. The pumice clast shows a chocolate chip cookie-like appearance, with a gray matrix and black-colored spots, which are clear characteristics of the products of the FOB eruption. Petrographic and geochemical analyses evidence the pumice is product of FOB eruption: The phenocryst assemblage of the pumice is plagioclase, clinopyroxene, and olivine. The groundmass glass of the pumice has trachytic composition with SiO_2 content of ~65.8 wt.% and alkali (Na_2O+K_2O) of 10.6 wt.%. The mineral chemistry of the pumice is similar with that of FOB pumice. These all characteristics are identical with that of the eruptive product of FOB. The findings of FOB pumice in this study marks the second report in the San'in region. This suggests that the arrival of FOB pumice in San'in region may have been widespread. The pumice drifted westward from Fukutoku-Oka-no-Ba, reached the Ryukyu Islands, traveled northward through the Japan Sea by the Tsushima Warm Current, and eventually reached the San'in region.

Key words: Fukutoku-Oka-no-Ba, Drift pumice, Petrological characteristics, Geochemical characteristics, San'in region

1. Introduction

Fukutoku-Oka-no-Ba (FOB) is a submarine volcano belonging to Ogasawara islands, Japan, and located in 1300 km south from Tokyo. The volcano experienced phreatomagmatic eruption at Aug 13th, 2021, and generated volcanic column with height of 16 km in maximum. The eruptive volume was estimated to ~0.1 km^3 in DRE (dense rock equivalent) [1].

The FOB eruption produced a large amount of drift pumice on the sea. The pumice drifted across the Pacific Ocean and, about two months later, washed ashore in large quantities along the coast of the Ryukyu Islands[2-7]. In the following months, it reached the Pacific coast of Kyushu and Honshu, as well as the Japan Sea coast and Hokkaido[8-10]. The pumice drifted not only within Japan but also further southwest from the Ryukyu Islands, washing ashore in the Philippines, Taiwan, Thailand, and Malaysia[11].

Drift pumice has frequently occurred during submarine eruptions in the sea around Japan, and impacted ocean-based work such as fishing and shipping[12-13]. Detailed data on the stranding sites of drift pumice from the recent FOB eruption could serve as valuable information for predicting the drift paths of pumice in future submarine eruptions. However, reports of FOB pumice stranding in the San'in region have been limited to a single location: Torii coast, Oda City, central Shimane Prefecture[14]. Imai (2024) found a maximum of 364 FOB pumices per day along transect of ~1.5 km on this coast in September 2022 to June 2023[14]. The present study reports the findings of FOB pumice at Koura Beach located in eastern Shimane Prefecture, to show the arrival of FOB pumice was widespread in San'in region.

2. Methods

2.1 Field survey

Field survey was conducted in Aug 20, 2024, at Koura Beach, eastern Shimane Prefecture, San'in region (**Fig. 1**: N35.5203, E132.9745). The beach faces the Japan Sea, is located eastern Shimane Prefecture, and approximately 50 km east from the Torii coast. Drift materials, mainly consisting of wooden fragments and small plastic pieces, was deposited as strandline. During the survey, a 20-minute walk along the beach was conducted, focusing on the area near the strandline

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(**Fig. 2**). The identification of possible FOB pumice was based on the visual characteristics described by Yoshida *et al.* (2022)[6] and actual specimen of FOB pumices collected in main island of Okinawa (N26.4360, E127.7883). During the field survey, we found one possible FOB pumice clast in the strandline.

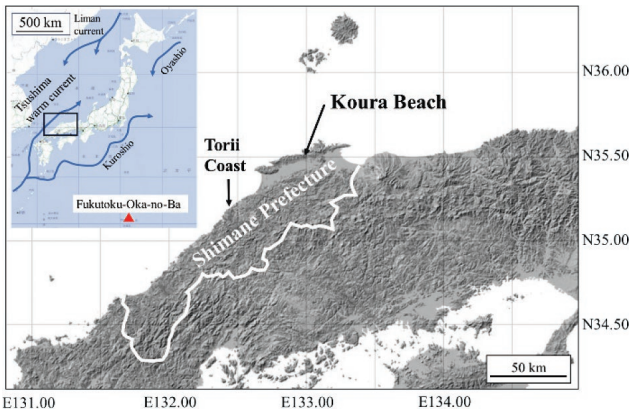

Fig. 1 Location of Koura Beach. The location of Torii coast is also plotted in the map. White line surrounds Shimane Prefecture. Rectangle in inlet indicates San'in region. Triangle and arrows in inlet indicate FOB and ocean currents, respectively. The location map is based on the Digital Topographic Map published by the Geospatial Information Authority of Japan and processed by the Japan Volcanological Data Network (https://jvdn.bosai.go.jp/portal/en/).

Fig. 2 Koura Beach, eastern Shimane Prefecture.

2.2 Petrological and geochemical analyses

We conducted petrological and geochemical analyses on the possible FOB pumice clast collected during the field survey in the Koura Beach.

Digital stereoscopic microscope (Keyence VHX-7100) at the National Institute for Earth Science and Disaster Resilience (NIED), Tsukuba, Japan, was used to detailed observation of the surface texture of pumice.

After the observation of surface texture under the digital stereoscopic microscope, we made a polished section of the pumice. The pumice was embedded in epoxy resin (Petropoxy; Burnham Petrographics), followed by grinding on wrapping film under running water, and subsequently polished with 1 μm diamond powder.

The petrography of pumice was conducted using polished sections observed under the stereoscopic digital microscope, a polarized microscope and a Scanning Electron Microscope (SEM: JEOL IT-500), NIED. For the SEM observations, a carbon coating was applied to the polished sections.

The chemical compositions of groundmass glass and minerals were analyzed using the SEM equipped with an energy-dispersive X-ray spectrometer (EDS; Oxford X-Max detector and the INCA software) at the NIED. The measurements were carried out with an accelerating voltage of 15 kV and a beam current of 0.5 nA, using a cobalt standard for calibration. Major elements (Si, Ti, Al, Fe, Mn, Mg, Ca, Na, K, and P) were quantified as oxides. The beam size was approximately 5 μm.

3. Results

We conclude the pumice clast found in Koura Beach is originated from the FOB eruption, evidenced by surface texture of clast, and petrological and geochemical characteristics.

We found the pumice clast with size of ~1.2 cm during the field survey in Koura beach. The pumice exhibits Choco chip cookie-like appearance with gray matrix and black-colored spots (**Fig. 3**). Detailed observation on surface of pumice by the digital microscope show us the following characteristics: The pumice shows rounded shape. Phenocrysts and the black-spots often protrude from a vesiculated matrix. The black-colored spots are crystal clot or phenocryst surrounded by a brown-colored glass. The appearance of the pumice clast is consistent with that of FOB pumice[6].

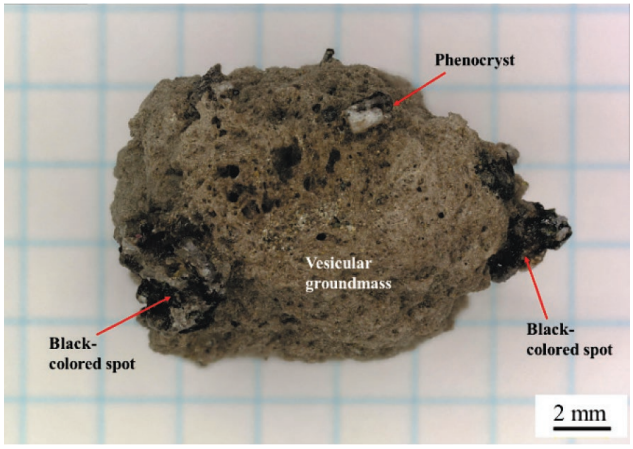

Fig. 3 Image of the pumice clast collected in Koura Beach, obtained by the digital stereoscopic microscope.

Observation of the polished section under the stereoscopic microscope, polarized microscope, and SEM show the pumice clast contains phenocrysts of plagioclase, clinopyroxene, and olivine within a vesicular glassy groundmass, along with minor amounts of apatite and opaque minerals (**Fig. 4** and **5**). The groundmass glass has colorless to brown color. There are two types of crystal clots: Type-A clots consist of euhedral phenocrysts of plagioclase (size of < 1.5 mm), clinopyroxene (size of < 1.5 mm), and olivine (size of < 0.2 mm) with brown-colored interstitial glass (**Fig. 5b**), which forms the black-colored spot. Type-B clot is polycrystalline material which is comprised from plagioclase and clinopyroxene in which the sizes of these crystals (size of < 0.1 mm) are smaller than those in Type-A clots (**Fig. 5d**).

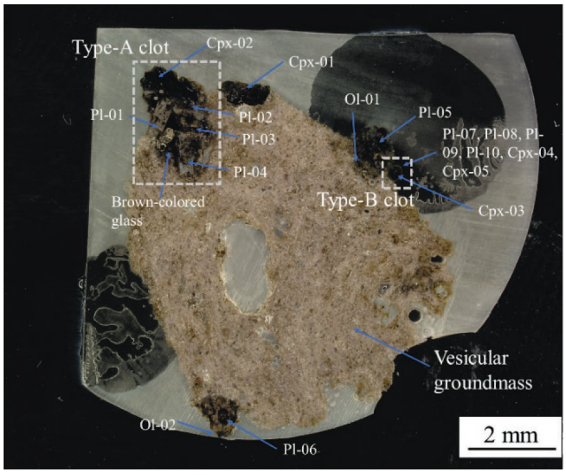

Fig. 4 Image of the polished section obtained by the digital stereoscopic microscope. Cpx, Pl, and Ol indicate clinopyroxene, Plagioclase, and Olivine, respectively. Rectangles of dash line indicate the crystal clot.

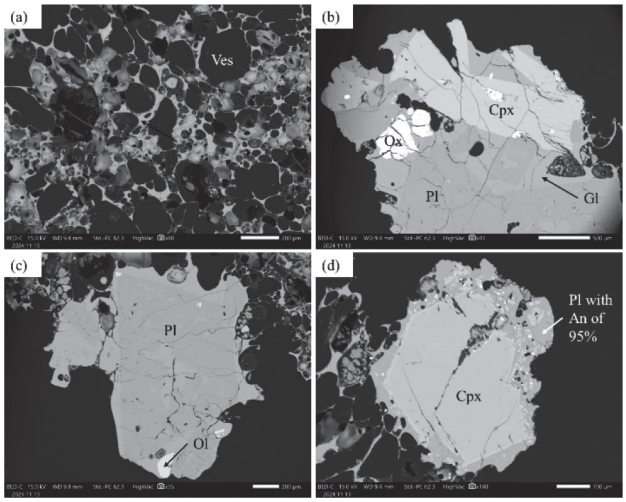

Fig. 5 Back scattered electron (BSE) images on the polished thin section obtained by the SEM. Cpx, Pl, Ol, Ox, and Ves indicate clinopyroxene, Plagioclase, Olivine, Oxide, and vesicle, respectively. (a) Vesicular groundmass. (b) A part of Type-A clot. (c) Plagioclase phenocryst. (d) Type-B clot.

These petrographic characters are similar with pumice clast of the FOB eruption[4), 6)].

The chemical composition of vesiculated glass measured by the SEM-EDS indicates trachyte with SiO_2 content of 65.8 ± 0.3 wt.% and total alkali ($Na_2O + K_2O$) content of 10.6 ± 0.1 wt.%, being similar with those of the pumice of FOB eruption[6)] (**Fig. 6**). The chemical compositions are not different between groundmass glasses with colorless and brown-color. The plagioclase phenocryst in groundmass and Type-A clot show anorthite content (An% = Ca/[Ca + Na + K] × 100) of 41 ± 6 % and 40 ± 4 % in the core and the rim, respectively. The plagioclases in Type-B clot have An# of 42-95%. The phenocryst of clinopyroxene has an magnesium number (Mg# = Mg/[Mg + Fe^{2+}] × 100) of 85 ± 6 % and 82 ± 6 % in the core and rim, respectively. The olivine phenocrysts have the Mg# of 65%. These geochemical characteristics are identical to those in the FOB pumice[6)]. The results of chemical analyses are summarized in supplementary **Tables A1-A3**.

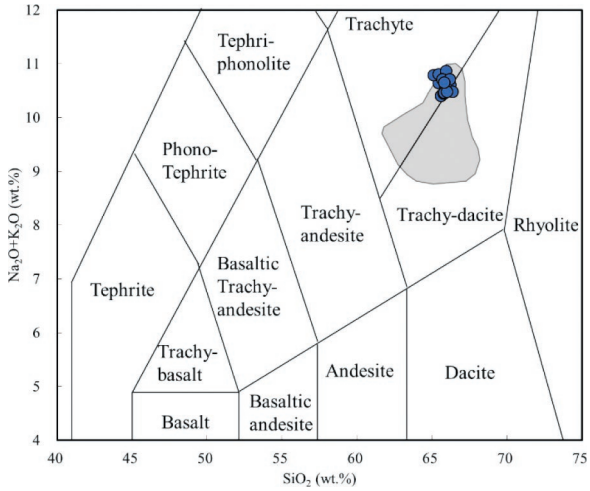

Fig. 6 SiO_2 and Alkali ($Na_2O + K_2O$) contents of groundmass glass. Blue filled circles indicate the chemical composition of groundmass glass of the clast of possible FOB pumice found in Koura beach. Gray shade represents the chemical composition of groundmass glass of FOB pumice[6)]. Classification of rock is based on Middlemost (1994)[15)].

4. Implications

This study has given second case of finding of FOB eruption's drift pumice in San'in region, which follows the first observation in Torii coast, Oda City, central Shimane Prefecture by Imai (2024)[14)]. The fact that drift pumice from FOB eruption were found further east of Torii coast suggests that their arrival was widespread in San'in region. The amount of pumice washed ashore on Koura Beach is smaller compared to that of Torii coast, which is thought to reflect the timing of observation and the local situation including variations in topography and nearshore current. The FOB

pumice which stranded the coast of Japan Sea are considered to have been transported by the Tsushima Warm Current[9), 10)]. The FOB pumice found in Koura Beach is also considered to have been carried by the Tsushima Warm Current. It is likely that the drift pumice found in this study washed ashore at the timing of between August and October 2022[9), 14)], based on the report of timing of stranding of FOB pumice along the coast of Japan sea from Kyushu to Hokkaido[9), 10), 14)]. The detailed stranding sites of drift pumice can provide fundamental data for predicting the drift paths of pumice from future submarine eruptions, which is expected to help reduce the impact on the ocean-based work from drift pumice.

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References

1) Maeno, F., Kaneko, T., Ichihara, M., Suzuki, Y. J., Yasuda, A., Nishida, K., and Ohminato, T. (2022): Seawater-magma interactions sustained the high column during the 2021 phreatomagmatic eruption of Fukutoku-Oka-no-Ba. Communications Earth & Environment, **3**, 260. https://doi.org/10.1038/s43247-022-00594-4
2) Okuno, M. and Torii, M. (2022): Occurrences of drifting pumice (originated from the August 2021 Fukutoku-Okanoba eruption in Ogasawara Islands) in Okinawa Island: A preliminary report. Chikyu monthly/special, **71**, 42-49.
3) Ishimura, D., Hiramine, R., and Aoki, K. (2022): Tracing the pumice from the 2021 Fukutoku-Oka-no-Ba eruption—Distribution and characteristics of drifted Pumice— (福徳岡ノ場 2021 年噴火による軽石を追いかけて—軽石の漂着状況とその特徴 —), Monthly Geography (月刊地理), **67**, 23-32.
4) Konoo, T., Naruo, H. and Miyabuchi, Y. (2022): Drifting Situation of Pumices Discharged from the 2021 Eruption of Fukutoku-Oka-no-Ba Volcano: Cases at Osumi Peninsula in Kagoshima Prefecture, Southern Part of Miyazaki Prefecture, Tanegashima and Amami Oshima Islands. Bulletin of the Volcanological Society of Japan, **67**, 401-408. https://doi.org/10.18940/kazan.67.3_401
5) Usami, K. and Shinjo, T. (2022): Drifted pumice stones at Okinawa Prefecture derived from the 2021 August eruption at Fukutokuokanoba submarine volcano. Bulletin of the Museum, Okinawa Prefectural Museum and Art Museum, **15**, 1-16.
6) Yoshida, K., Tamura, Y., Sato, T., Hanyu, T., Usui, Y., Chang, Q., and Ono, S. (2022): Variety of the drift pumice clasts from the 2021 Fukutoku-Oka-no-Ba eruption, Japan. Island Arc, **31**, e12441. https://doi.org/10.1111/iar.12441
7) Takeuchi, S., Ishige, K., Uesawa, S., and Suwa, Y. (2024): Unsinkable, long-drifting, millimeter-sized pumice of the 2021 eruption of Fukutoku-Oka-no-Ba submarine volcano. Progress in Earth and Planetary Science, **11**, 47. https://doi.org/10.1186/s40645-024-00652-9
8) Shiihara, M., Ichihara, T., Hiramine, R., and Ishimura, D. (2021): Distribution of drift pumice from the 2021 Fukutoku-Oka-no-Ba eruption in the vicinity of Fukuoka city (福岡市近郊における福徳岡ノ場 2021 噴火由来軽石の漂着状況), Donburako (どんぶらこ), **73**, 11.
9) Yoshida, K., Maruya, Y., and Kuwatani, T. (2022): Chocolate-chip cookie-like pumice from the 2021 Fukutoku-Oka-no-Ba eruption: views from SNS-related geology. Ganseki Kobutsu Kagaku, **51**, 220412. https://doi.org/10.2465/gkk.220412
10) Enya, T., Hirose, W., Takahashi, R., and Suzuki, A. (2024): Stranding record of the pumices from the 2021 Fukutoku-Oka-no-Ba eruption on the coast of the Japan Sea side, southwestern Hokkaido, Japan. Journal of Japan Driftological Society, **21**, 25-27. https://doi.org/10.57279/driftological.21.0_25
11) Yoshida, K., Tamura, Y., Sato, T., Sangmanee, C., Puttapreecha, R., and Ono, S. (2022): Petrographic characteristics in the pumice clast deposited along the Gulf of Thailand, drifted from Fukutoku-Oka-no-Ba. Geochemical Journal, **56**, 134-137. https://doi.org/10.2343/geochemj.GJ22011
12) Hiramine, R., Aoki, K., Ishimura, D., and Suzuki, T. (2023): Characteristics of drift pumice clasts along the coast of the Japanese Islands: The AT tephra, representative source of drift pumice clasts. Geographical reports of Tokyo Metropolitan University, **58**, 87-94.
13) Oikawa, T., Ikegami, F., and Watanabe, S. (2023): Eruption Styles and Source Volcanoes for Drifting Pumice Deposited along the Nansei Islands, Southwest Japan. Bulletin of the Volcanological Society of Japan, **68**, 171-187. https://doi.org/10.18940/kazan.68.3_171
14) Imai, S. (2024): Drift and temporal changes of pumice from the 2021 Fukutoku-Oka-no-Ba eruption at Torii Coast, Ōda City, Shimane Prefecture (島根県大田市鳥井海岸における福徳岡ノ場 2021 年噴火起源軽石の漂着とその時間変化), Journal of the Geoscience Society of Shimane Prefecture (島根県地学会誌), **39**, 17-22.
15) Middlemost, E. (1994): Naming materials in the magma/igneous rock system. Earth-Science Reviews, **37**, 215-224. https://doi.org/10.1016/0012-8252(94)90029-9

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Table A1 Normalized chemical composition of groundmass glass.

Analytical point	Fk-Gl01	FK-Gl02	FK-Gl03	FK-Gl04	FK-Gl05	FK-Gl06	FK-Gl07	FK-Gl08	FK-Gl09	FK-Gl10	FK-Gl11	BG01	BG02	BG03
Color of glass	Colorless	Colorless	Colorless	Colorless	Colorless	Colorless	Colorless	Colorless	Colorless	Colorless	Colorless	Brown	Brown	Brown
wt.%														
SiO_2	65.62	65.47	65.12	65.89	65.47	66.25	66.38	65.96	65.72	65.82	65.83	66.21	66.02	65.83
TiO_2	0.63	0.61	0.69	0.61	0.57	0.54	0.43	0.67	0.76	0.68	0.50	0.48	0.68	0.65
Al_2O_3	16.26	16.47	16.55	16.64	16.65	16.29	16.41	16.27	16.20	16.37	16.66	16.37	16.61	16.30
FeO	3.68	3.87	3.79	3.39	3.60	3.69	3.53	3.43	3.78	3.70	3.75	3.54	3.67	3.75
MnO	0.25	0.17	0.18	0.14	0.16	0.21	0.03	0.02	0.05	0.22	0.00	0.25	0.06	0.28
MgO	0.91	0.84	0.90	0.75	0.86	0.85	0.86	0.83	0.87	0.89	0.85	0.71	0.72	0.73
CaO	2.12	1.86	1.96	1.98	1.78	1.57	1.78	1.93	1.91	1.79	1.93	1.65	1.65	1.78
Na_2O	5.17	5.41	5.48	5.39	5.54	5.44	5.36	5.41	5.39	5.14	5.30	5.47	5.25	5.37
K_2O	5.23	5.23	5.29	5.19	5.26	5.16	5.11	5.45	5.31	5.29	5.16	5.23	5.23	5.28
P_2O_5	0.13	0.08	0.02	0.01	0.11	0.00	0.10	0.02	0.00	0.10	0.03	0.07	0.10	0.02
Total	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Original total	100.00	100.03	99.90	99.79	100.83	98.74	98.93	99.44	100.68	100.51	100.03	98.08	98.51	98.59
Alkali (Na_2O+K_2O)	10.40	10.64	10.78	10.58	10.80	10.60	10.47	10.86	10.71	10.44	10.46	10.70	10.48	10.65

Table A2 Chemical compositions of plagioclase.

Sample	Pl01-rim	Pl02-rim	Pl03-rim	Pl04-rim	Pl05-rim	Pl06-rim	Pl08-rim	Pl01-core	Pl02-core	Pl03-core	Pl04-core	Pl05-core	Pl06-core	Pl07-core	Pl08-core	Pl09-core	Pl10-core
Occurrence	In Type-A clot	In Type-A clot	In Type-A clot	In Type-A clot	Indivisual phenocryst	Indivisual phenocryst	In Type-B clot	In Type-A clot	In Type-A clot	In Type-A clot	In Type-A clot	Indivisual phenocryst	Indivisual phenocryst	In Type-B clot	In Type-B clot	In Type-B clot	In Type-B clot
wt.%																	
SiO_2	58.09	58.00	57.34	57.55	59.38	59.53	57.70	57.32	56.79	55.88	58.29	59.94	59.52	44.95	56.10	53.32	52.29
TiO_2	0.01	0.00	0.11	0.04	0.10	0.12	0.00	0.00	0.13	0.12	0.08	0.12	0.23	0.00	0.06	0.15	0.12
Al_2O_3	26.98	27.23	27.55	27.27	25.97	26.32	27.41	27.69	27.97	27.88	26.95	25.65	26.10	35.55	28.55	27.98	30.16
FeO*	0.48	0.42	0.49	0.46	0.58	0.44	0.41	0.50	0.40	0.50	0.40	0.42	0.47	0.97	0.88	2.87	1.55
MnO	0.05	0.16	0.00	0.04	0.00	0.06	0.04	0.09	0.01	0.12	0.01	0.00	0.01	0.00	0.08	0.00	0.21
MgO	0.01	0.01	0.01	0.04	0.04	0.10	0.01	0.00	0.09	0.08	0.06	0.04	0.08	0.10	0.09	0.31	0.22
CaO	8.23	8.37	8.96	8.56	6.94	7.43	8.66	9.15	9.12	9.76	8.45	6.86	7.21	18.45	10.06	11.03	13.06
Na_2O	6.12	6.13	5.92	6.00	6.79	6.65	6.06	5.69	5.61	5.39	6.15	6.91	6.84	0.56	5.37	4.13	3.41
K_2O	0.72	0.72	0.68	0.69	1.04	0.89	0.71	0.69	0.66	0.61	0.80	1.04	1.01	0.02	0.49	1.07	0.63
P_2O_5	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	100.69	101.04	101.06	100.65	100.84	101.54	101.11	101.13	100.78	100.40	101.19	100.98	101.47	100.60	101.68	100.86	101.65
Number of cations for O=8																	
Si	2.59	2.58	2.55	2.57	2.64	2.63	2.56	2.55	2.53	2.51	2.59	2.66	2.63	2.07	2.49	2.43	2.36
Ti	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.00
Al	1.42	1.43	1.45	1.43	1.36	1.37	1.44	1.45	1.47	1.48	1.41	1.34	1.36	1.93	1.50	1.50	1.60
Fe	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.02	0.01	0.02	0.02	0.04	0.03	0.11	0.06
Mn	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Mg	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.01	0.00	0.00	0.01	0.01	0.01	0.02	0.01
Ca	0.39	0.40	0.43	0.41	0.33	0.35	0.41	0.44	0.44	0.47	0.40	0.33	0.34	0.91	0.48	0.54	0.63
Na	0.53	0.53	0.51	0.52	0.58	0.57	0.52	0.49	0.49	0.47	0.53	0.59	0.59	0.05	0.46	0.36	0.30
K	0.04	0.04	0.04	0.04	0.06	0.05	0.04	0.04	0.04	0.03	0.05	0.06	0.06	0.00	0.03	0.06	0.04
P	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	4.99	4.99	5.00	4.99	5.00	4.99	4.99	4.99	4.99	5.00	4.99	5.00	5.00	5.00	5.00	5.03	5.01
An	40.82	41.19	43.75	42.29	33.91	36.20	42.30	45.15	45.47	48.22	41.16	33.30	34.68	94.68	49.41	55.77	65.36
Ab	54.93	54.59	52.30	53.65	60.04	58.63	53.57	50.80	50.61	48.19	54.20	60.69	59.54	5.20	47.73	37.79	30.88
Or	4.25	4.22	3.95	4.06	6.05	5.16	4.13	4.05	3.92	3.59	4.64	6.01	5.78	0.12	2.87	6.44	3.75

FeO* is total iron as FeO; An= Ca/(Ca+Na+K) × 100; Ab=Na/(Ca+Na+K)×100; Or=K/(Ca+Na+K)×100

Table A3 Chemical compositions of clinopyroxene and olivine.

Mineral spieces	Clinopyroxene								Olivine			
Analytical points	Cpx01-rim	Cpx02-rim	Cpx03-rim	Cpx01-core	Cpx02-core	Cpx03-core	Cpx04-core	Cpx05-core	Ol01-rim	Ol02-rim	Ol01-core	OL02-core
Occurrence	Indivisual phenocrst	In Type-A clot	In Type-B clot	Indivisual phenocrst	In Type-A clot	In Type-B clot	In Type-B clot	In Type-B clot	Touching with Pl	Touching with Pl	Touching with Pl	Touching with Pl
wt.%												
SiO_2	50.86	53.23	50.91	50.30	53.27	50.88	47.67	46.18	37.13	38.22	37.47	38.10
TiO_2	0.53	0.46	0.39	0.59	0.19	0.31	0.61	0.70	0.00	0.00	0.00	0.00
Al_2O_3	5.12	1.50	4.58	5.16	1.94	4.74	8.17	11.01	0.05	0.00	0.00	0.01
FeO*	7.95	8.94	6.14	6.47	8.63	6.42	9.75	9.57	30.14	31.04	30.20	30.79
MnO	0.22	0.72	0.25	0.26	0.62	0.16	0.06	0.18	1.43	1.45	1.75	1.67
MgO	14.72	15.60	15.63	15.04	15.81	15.58	13.48	11.95	31.72	32.51	31.96	32.37
CaO	20.27	19.39	22.45	22.69	20.12	22.35	19.27	20.46	0.13	0.11	0.22	0.16
Na_2O	0.44	0.42	0.21	0.22	0.33	0.23	0.41	0.37	0.00	0.00	0.00	0.10
K_2O	0.32	0.05	0.00	0.00	0.00	0.02	0.08	0.00	0.00	0.03	0.00	0.01
P_2O_5	0.06	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.02
Total	100.49	100.31	100.56	100.79	100.91	100.69	99.50	100.42	100.60	103.38	101.60	103.23
	Number of cations for O=6								Number of cations for O=4			
Si	1.87	1.97	1.87	1.85	1.96	1.87	1.79	1.72	1.00	1.00	1.00	1.00
Ti	0.01	0.01	0.01	0.02	0.01	0.01	0.02	0.02	0.00	0.00	0.00	0.00
Al	0.22	0.07	0.20	0.22	0.08	0.20	0.36	0.48	0.00	0.00	0.00	0.00
Fe^{3+}	0.04	0.01	0.06	0.06	0.02	0.06	0.07	0.06				
Fe^{2+}	0.18	0.27	0.10	0.11	0.24	0.11	0.21	0.20	0.68	0.68	0.68	0.68
Mn	0.01	0.02	0.01	0.01	0.02	0.00	0.00	0.01	0.03	0.03	0.04	0.04
Mg	0.81	0.86	0.86	0.82	0.87	0.85	0.75	0.66	1.28	1.27	1.27	1.27
Ca	0.80	0.77	0.88	0.89	0.79	0.88	0.77	0.82	0.00	0.00	0.01	0.00
Na	0.03	0.03	0.01	0.02	0.02	0.02	0.03	0.03	0.00	0.00	0.00	0.01
K	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
P	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	3.00	3.00	3.00	3.00
Mg#	81.47	76.40	89.18	88.05	78.42	89.02	78.37	76.79	65.23	65.12	65.36	65.21

FeO* is total iron as FeO; Mg# = $Mg/(Mg+Fe^{2+})\times100$; Fe^{3+}/Fe^{2+} of clinopyroxenes were calculated so that total cation = 4 (O = 6 basis).

山陰地方島根県古浦海水浴場で発見された福徳岡ノ場 2021 年噴火由来の軽石

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要　旨

2021 年の福徳岡ノ場（Fukutoku-Oka-no-Ba: FOB）の噴火に由来する軽石を島根県東部の古浦海水浴場において発見した．この軽石は灰色の基質に黒色の斑点が散在する特徴的な外観を有し，FOB 噴火の産物の特有の産状を示す．岩石学および地球化学的分析により，この軽石が FOB 噴火由来であることが明らかになった．軽石中の斑晶は斜長石，単斜輝石，カンラン石で構成されている．また，石基ガラスは SiO_2 含有量が約 65.8 重量 %，アルカリ元素（Na_2O+K_2O）濃度が 10.6 重量 % を有する粗面岩質組成を示す．さらに，鉱物化学組成も FOB 軽石の特徴と一致している．すなわち，この軽石の岩石学的特徴と地球化学的特徴はすべて FOB 噴火の噴出物と整合する．本研究での FOB 軽石の発見は山陰地域における報告として 2 例目である．このことは FOB 軽石が山陰地域に広範囲に分布している可能性を示唆している．軽石は福徳岡ノ場から西方へ漂流し，琉球列島に到達後，対馬暖流により日本海を北上し，最終的に山陰地域に到達したと考えられる．

キーワード：福徳岡ノ場，漂流軽石，岩石学的特徴，地球化学的特徴，山陰地方