Hydrogen isotopic composition, water content, and color of hydrous phenocrysts from Japanese Quaternary volcanoes.

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Abstract

This report provides hydrogen isotopic compositions (δD), chemical compositions, and color of separated hornblende and biotite phenocrysts from Japanese Quaternary volcanoes. Figure 1 shows location of the volcanoes studied. Table 1 shows chemical composition of the hornblende phenocrysts. Table 2 shows δDvalue, water content, and color of separated hydrous minerals (hornblende and biotite).

Samples analysed

Volcanic rock samples were collected throughout the Japanese arc (see Figure 1 and Volcanoes of Japan by GSJ, Ono et al., 1981). The samples comprise lavas, lava domes, pyroclastic flow deposits related with lava dome collapse, air-fall pumices and pumice flow deposits. A brief description of rock specimens follows (Numbers correspond with Figure 1 and Table 1-2) :

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1. Dacitic lava dome and lava flow of Unzen (Watanabe and Hoshizumi, 1995);

2. Dacitic lava dome of Tsurumi (Ohta et al., 1990);

3. Dacitic lava flow and intrusive rocks of Himejima (Itoh, 1989);

4. Pumice flow, pyroclastic flow, and dacitic lava dome of Sambe (Matsui and Inoue, 1971);

5. Pumice fall and pyroclastic flow associated with dacitic lava dome collapse of Daisen (Tsukui, 1984; Saji *et al.,* 1975);

6. Andesitic and dacitic lava flows of Kurohime (Hayatsu, 1972);

7. Andesitic lava flows, pumice flows, and dacitic pyroclastic flow of Myoko (Hayatsu, 1972);

8. Dacitic lava flows and lava domes of Gassan (Nakazato et al., 1996);

9. Pumice flows and pumice falls of Hijiori (Murakami and Kawaguchi, 1994);

10. Andesitic lava flows of Chokai (Hayashi, 1984; Nakano and Tsuchiya, 1992);

11. Pumice flow of Takahinata (Abe, E. 1990 Pers. Comm.);

12. Andesitic lava flows of Kanpu (Maruyama et al., 1988);

13. Pumice flow (Aoki and Fujimaki, 1982) and hornblendite xenoliths (Aoki, 1971) of Ichinome-gata;

14. Andesitic lava dome of Nanashigure (Ishikawa et al., 1985);

15. Pumice flows and dacitic lava dome of Osorezan (Togashi, 1977);

16. Pumice fall of Oshima-Ooshima (Yamamoto, 1984).

Mineral separation techniques

Hornblende and biotite phenocrysts in the volcanic rock specimens were separated by conventional ways. A rock specimen of a few kg was crushed, ground, screened (between 0.06 and 0.13 mm), and separated with magnetic and heavy liquid techniques. The final purity of the separates was almost 100 % for those from air-fall pumice fragments or pumiceous fragments from pyroclastic flows, and about 20 vol. % for lava samples. This impurity for the lava samples, however, may not give a serious error to the δD measurements because of small amount of water in contaminants, mainly pyroxenes. For example, reported hydrogen concentrations in ppm H_2O for minerals from mantle xenoliths are 100-1300 ppm H_2O for clinopyroxene, 60-650 ppm H_2O for orthopyroxene, 0-140 ppm H_2O for olivine and 1-200 ppm H_2O for garnet (Ingrin and Skogby, 2000).

D/H and H_2O analyses

Stoichiometric water in hydrous phenocrysts was extracted from about 200 mg. of separated hydrous phenocrysts by heating in vacuum (Friedman et al., 1964). The heating has three major phases. First phase is a steady heating at 300 °C for a few to several hours to remove the absorbed water. Second phase is an escalation of heating temperature up to 1000 °C in 3 to 4 hours. Final phase is a steady heating at about 1200 °C. Usually in the second heating phase, hornblende and biotite release a mixture of H_2O and H_2 gas. The H_2 gas was converted into H_2O with a CuO furnace. All the trapped water was purified and finally reduced to H_2 gas with a hot Uranium metal (or Chrome metal) and pumped into a manometer with a Töepler pump. Hydrogen isotopic analyses were carried out with a Finnigan MAT-250 mass spectrometer. Typical reproducibility of the water content and δD analysis on our hornblende working standard is better than

0.1 % and 3 $^o/_{oo}$, respectively.

Color measurements

Color of the minerals was measured because this provides useful information for evaluating the degree of mineral dehydrogenation (Miyagi *et al.,* 1998). We used a Minolta spectrophotometer CM-1000 and Minolta chromameter CR-300. Details about the method are reported in Nakashima *et al.,* (1992). The result of the color measurement is expressed quantitatively as L*, a* and b* units in the CIE1976 L*a*b* color space proposed by the Commission Internationale de l'Eclariage. The L* value is the psychometric lightness and ranges from 0 (black) to 100 (white). Positive and negative values of a* and b* correspond to red and green color, and yellow and blue, respectively.

Chemical composition

Chemical composition of the minerals was measured with an EPMA (JEOL JXA-733 and JXA-8800) with a 15 kV accelerating voltage and 12 nA beam current. The analytical results were reported in the formula "$A_{0-1}X_2Y_5Z_8O_{22}$", assuming that Z site is filled with Si^{4+} and a part of Al^{3+}, and that the excess Al^{3+}, Mg^{2+}, Fe^{2+}, Ca^{2+}, and Ti^{4+} occupy X and Y sites.

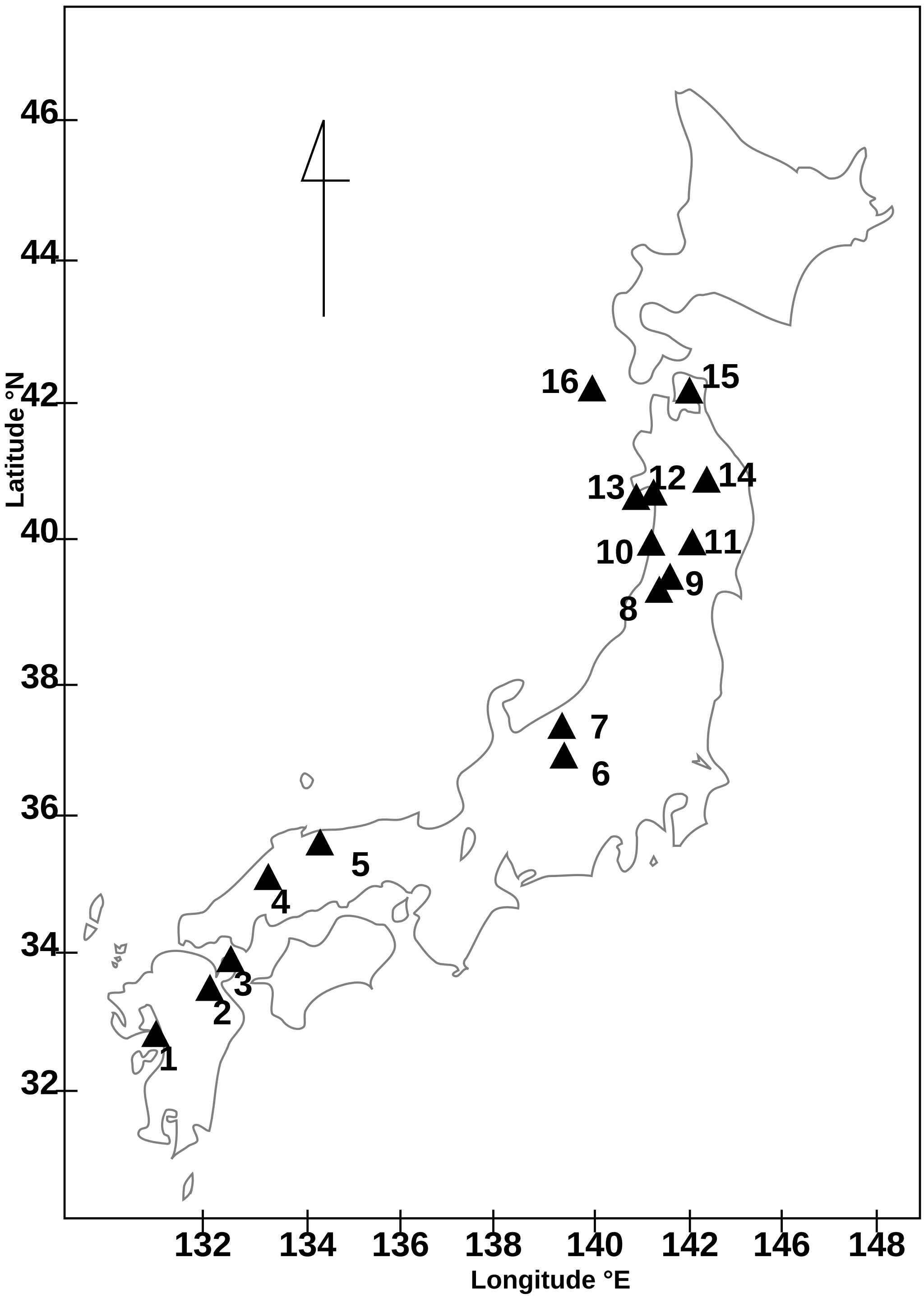

Fig. 1. Map showing the locations of the Japanese arc volcanoes studied. 1 Unzen, 2 Tsurumi, 3 Himejima, 4 Sambe, 5 Daisen, 6 Kurohime, 7 Myoko, 8 Gassan, 9 Hijiori, 10 Chokai, 11 Takahinata (Onikobe caldera), 12 Kanpu, 13 Ichinome-gata, 14 Nanashigure, 15 Osorezan, 16 Oshima-Ooshima.

Table 1

	Z=8		Y+X					A	
	Si	Al	Al	Mg	Fe	Ca	Ti	Na	K
1: Unzen									
1-1	6.96	1.04	0.31	3.10	1.67	1.78	0.19	0.23	0.03
1-3	7.08	0.92	0.33	3.18	1.67	1.73	0.14	0.17	0.04
1-4	7.05	0.95	0.41	2.91	1.76	1.76	0.16	0.20	0.04
2: Tsurumi									
2-1	6.97	1.03	0.34	3.37	1.41	1.78	0.17	0.20	0.03
2-2	7.14	0.86	0.35	3.29	1.46	1.76	0.15	0.13	0.04
3: Himejima									
3-1	6.74	1.26	0.36	3.30	1.44	1.80	0.20	0.29	0.04
3-4	6.65	1.35	0.42	3.30	1.40	1.80	0.19	0.31	0.04
3-5	6.62	1.38	0.47	3.12	1.45	1.83	0.20	0.32	0.05
3-6	6.40	1.60	0.54	2.93	1.76	1.76	0.18	0.33	0.04
4: Sambe									
4-1	6.78	1.22	0.45	3.37	1.44	1.74	0.12	0.25	0.02
4-2	6.92	1.08	0.52	3.11	1.52	1.76	0.12	0.24	0.03
5: Daisen									
5-1	6.45	1.55	0.44	3.61	1.01	1.85	0.22	0.35	0.05
5-4	6.64	1.36	0.42	3.32	1.45	1.76	0.18	0.28	0.03
5-5	6.80	1.20	0.48	3.21	1.49	1.69	0.17	0.28	0.03
5-9	7.02	0.98	0.37	3.40	1.49	1.67	0.13	0.19	0.02
5-11	6.92	1.08	0.39	3.36	1.57	1.64	0.14	0.20	0.02
5-12	6.90	1.10	0.41	3.25	1.56	1.72	0.13	0.23	0.04
5-13	7.00	1.00	0.36	3.26	1.69	1.71	0.09	0.19	0.03
5-16	6.77	1.23	0.43	3.43	1.34	1.73	0.16	0.28	0.03
6: Kurohime									
6-1	6.11	1.89	0.71	3.39	1.14	1.85	0.16	0.33	0.03
6-2	6.10	1.90	0.72	3.31	1.19	1.85	0.17	0.33	0.03
7: Myoko									
7-1	7.03	0.97	0.31	3.03	1.82	1.71	0.18	0.18	0.03
7-2	6.98	1.02	0.29	3.04	1.78	1.78	0.19	0.20	0.03
7-9	6.88	1.12	0.33	3.14	1.67	1.77	0.18	0.22	0.02
7-10	7.01	0.99	0.27	3.03	1.79	1.79	0.18	0.19	0.03
7-11	6.97	1.03	0.31	3.00	1.80	1.77	0.19	0.20	0.03

Chemical composition of hornblende phenocrysts measured with an EPMA, reported in the formula "$A_{0-1}X_2Y_5Z_8O_{22}$", assuming that the Z site is filled with Si^{4+} and partially with Al^{3+}, and that the excess Al^{3+}, Mg^{2+}, Fe^{2+}, Ca^{2+}, and Ti^{4+} occupy the X and Y sites.

Table 1 continued

	Z=8		Y+X					A	
	Si	Al	Al	Mg	Fe	Ca	Ti	Na	K
8: Gassan									
8-1	7.01	0.99	0.32	3.16	1.63	1.76	0.17	0.20	0.03
8-2	7.03	0.97	0.37	3.14	1.65	1.72	0.16	0.20	0.03
8-4	7.02	0.98	0.42	3.01	1.67	1.76	0.15	0.21	0.03
9: Hijiori									
9-1	7.24	0.76	0.33	3.36	1.62	1.60	0.12	0.16	0.01
9-3	7.24	0.76	0.30	3.34	1.60	1.65	0.13	0.17	0.02
10: Chokai									
10-8	6.52	1.48	0.43	3.01	1.59	1.84	0.24	0.30	0.05
Takahinata									
10-1	7.10	0.90	0.30	3.12	1.68	1.74	0.18	0.16	0.01
12: Kanpu									
12-1	6.07	1.93	0.68	3.17	1.24	1.90	0.21	0.32	0.08
13: Ichinome-gata									
13-1	6.39	1.61	0.58	2.87	1.82	1.69	0.19	0.32	0.02
13-6	6.13	1.87	0.68	3.05	1.28	1.84	0.27	0.36	0.04
15: Osorezan									
15-2	7.15	0.85	0.28	3.20	1.65	1.73	0.17	0.17	0.01
16: Oshima-oshima									
16-1	6.22	1.78	0.52	3.23	1.36	1.91	0.21	0.30	0.10

Table 2

δD value, water content, and color of hydrous minerals from Japanese Quaternary volcanoes.

Sample locality	Mineral	Occurrence	H_2O	δD	color L*	a*	b*
1: Unzen							
1-1	Ho	LAFL	1.6	-57	48.4	0.3	7.2
1-1	Bi	LAFL	5.8	-66	-	-	-
1-2	Bi	LAFL	1.0	-72	44.8	0.3	6.2
1-3	Ho+Px	LAFL	0.8	-39	-	-	-
1-3	Bi	LAFL	0.8	-42	50.0	0.2	7.4
1-3	Ho	LAFL	1.2	-55	-	-	-
1-4	Ho	LAFL	1.0	-49	54.7	-0.1	8.9
1-4	Bi	LAFL	2.0	-40	44.1	0.2	6.4
1-5	Ho	LADM	0.8	-60	-	-	-
2:Tsurumi							
2-1	Ho+Px+Gl	LAFL/LADM	0.8	-70	-	-	-
2-1	Ho+Px	LAFL/LADM	0.9	-61	-	-	-
2-2	Ho+Px	LAFL/LADM	0.6	-36	-	-	-
2-2	Ho+Px	LAFL/LADM	0.5	-34	53.3	0.6	8.6
3: Himejima							
3-1	Ho	LAFL	1.4	-80	50.9	-0.1	8.1
3-2	Ho	LAFL	1.2	-84	-	-	-
3-3	Ho	INTL	1.5	-75	53.6	-0.9	8.0
3-4	Ho	LAFL	1.6	-61	51.2	-0.6	7.8
3-5	Ho	LAFL	1.7	-78	53.5	-0.6	9.0
3-6	Ho	LAFL	1.5	-81	48.3	-0.9	7.4
3-7	Ho	LAFL	1.5	-83	-	-	-
4: Sambe							
4-1	Bi	PCFL	2.6	-53	45.7	0.3	7.6
4-1	Ho	PCFL	1.6	-55	50.8	-0.5	8.1
4-2	Ho	PMFL	1.7	-56	58.0	-1.8	7.0
4-3	Bi	PMFL	3.1	-67	54.3	-0.5	10.2
5: Daisen							
5-1	Ho+Px	PCFL	0.5	-59	55.4	0.7	7.9
5-1	Ho	PCFL	1.2	-61	48.4	1.1	9.6
5-1	Ho	PCFL	0.4	-51	59.1	1.0	10.8
5-2	Ho+Px	PCFL	0.1	-67	-	-	-
5-3	Ho+Px	PCFL	0.9	-76	-	-	-
5-3	Bi	PCFL	1.7	-66	-	-	-
5-4	Ho	PMFA	1.6	-53	60.2	-1.5	8.3
5-5	Ho	PMFA	1.6	-49	54.3	-1.3	7.2
5-6	Ho	PMFA	1.7	-54	54.4	-1.6	6.9
5-7	Ho	PMFA	1.8	-50	54.5	-1.7	6.9
5-7	Ho	PMFA	1.6	-49	-	-	-

Table 2. continued

Sample locality	Mineral	Occurrence	H_2O	δD	color L*	a*	b*
5-8	Ho	PMFA	2.0	-58	57.4	-1.9	7.7
5-9	Ho	PMFA	1.9	-51	54.4	-1.7	7.4
5-10	Ho	PMFA/PMFL	1.6	-53	55.8	-1.1	7.9
5-11	Ho	PMFA	1.9	-48	59.2	-2.0	6.8
5-12	Ho	PCFL	1.5	-89	47.3	-0.3	5.6
5-12	Bi	PCFL	2.7	-72	-	-	-
5-13	Ho	PCFL	1.2	-50	56.6	-0.5	8.3
5-13	Bi	PCFL	2.7	-48	-	-	-
5-14	Ho	PCFL	1.3	-42	55.2	-0.5	8.1
5-14	Bi	PCFL	2.5	-39	-	-	-
5-15	Bi	PCFL	0.8	+71	47.7	0.2	5.9
5-16	Bi	PCFL	1.5	-69	-	-	-
5-16	Ho	PCFL	0.7	-74	-	-	-
5-17	Bi	PCFL	1.5	-75	49.9	0.5	8.5
5-18	Bi	PCFL	1.8	-10	45.9	1.1	9.3
6: Kurohime							
6-1	Ho+Px	LADM	0.2	-60	-	-	-
6-2	Ho+Px	LADM	0.4	-44	-	-	-
Sadoyama							
6-3	Ho+Px	LAFL	0.3	-75			
7: Myoko							
7-1	Ho	PCFL/PMFL	1.2	-25	48.9	0.2	8.4
7-2	Ho	PCFL/PMFL	1.3	-57	47.5	-0.4	5.7
7-3	Ho	PCFL/PMFL	1.2	-39	49.5	0.1	6.8
7-4	Ho	PCFL/PMFL	1.0	-44	46.9	0.4	7.5
7-5	Ho	PCFL/PMFL	1.2	-33	51.1	0.1	7.4
7-6	Ho	PCFL/PMFL	1.1	-38	53.7	-0.4	7.1
7-7	Ho+Px	PCFL/PMFL	0.9	-41	-	-	-
7-8	Ho	LAFL	1.2	-1	47.5	0.7	7.2
7-9	Ho	LAFL	0.3	+103	51.2	3.6	12.7
7-10	Ho	LAFL	1.3	-54	51.0	-0.4	7.1
7-11	Ho	LAFL	0.6	-79	58.4	-0.7	7.8
7-12	Ho		1.4	-48	36.0	0.2	1.3
8: Gassan							
8-1	Bi	LAFL	2.1	-81	-	-	-
8-1	Ho	LAFL	1.4	-91	52.7	-0.9	7.9
8-2	Ho	LAFL	1.4	-82	-	-	-
8-3	Bi	LAFL	2.8	-74	-	-	-
8-4	Ho	LADM	1.5	-93	51.7	0.4	8.9

Table 2. continued

Sample locality	Mineral	Occurrence	H_2O	δD	color L*	a*	b*
9: Hijiori							
9-1	Ho	PMFL	1.2	-93	-	-	-
9-2	Ho	PMFL	1.5	-82	55.2	-1.3	7.4
9-3	Ho	PMFL	1.4	-86	-	-	-
9-4	Ho	PMFL	1.6	-78	57.3	-1.1	8.2
9-5	Ho	PMFL	1.2	-83	-	-	-
9-6	Ho+Px	PMFA	1.1	-58	-	-	-
9-7	Ho+Px	PMFA	1.0	-62	-	-	-
9-8	Ho+Px	PMFA	1.1	-59	-	-	-
9-9	Ho+Px	PMFA	1.0	-64	-	-	-
10: Chokai							
10-1	Ho+Px	LAFL	0.1	-80	-	-	-
10-2	Ho+Px	LAFL	(0.04)	-108	-	-	-
10-3	Ho+Px	LAFL	(0.04)	-86	-	-	-
10-4	Ho+Px	LAFL	0.1	-88	-	-	-
10-5	Ho+Px	LAFL	0.1	-95	-	-	-
10-6	Ho+Px	LAFL	0.1	-98	-	-	-
10-7	Ho+Px	LAFL	0.1	-101	-	-	-
10-8	Ho+Px	LAFL	0.1	-49	-	-	-
10-9	Ho+Px	LADM	0.1	-98	-	-	-
10-10	Ho+Px	LAFL	0.1	-93	-	-	-
10-11	Ho+Px	LAFL	0.1	-95	-	-	-
11: Takahinata							
11-1	Ho	PMFL	-	-57	54.6	-0.8	8.3
12: Kanpu							
12-1	Ho+Px	LAFL	0.2	-76	-	-	-
12-2	Ho+Px	LAFL	0.1	-67	-	-	-
13: Ichinome-gata							
13-1	Ho	IHBD 3)	1.5	-49	-	-	-
13-2	Ho	IAMP 4)	1.1	-46	48.0	-0.6	4.8
13-2	Ho	IAMP	1.6	-32	-	-	-
13-3	Ho	IAMP	1.8	-34	53.5	-1.4	7.0
13-4	Ho	IAMP	1.7	-31	37.3	0.0	2.2
13-5	Ho	IHBD	1.7	-36	37.8	0.1	2.7
13-6	Ho	IHBD	1.7	-32	-	-	-
13-7	Bi	PMFA	2.4	-57	48.0	-0.1	7.6
13-7	Bi	PMFA	2.0	-41	-	-	-
13-7	Ho+Px	PMFA	0.7	-44	52.0	-0.5	7.9
14: Nanasigure							
14-1	Ho+Px	LAFL/LADM	0.3	-79	-	-	-

Table 2. continued

Sample locality	Mineral	Occurrence	H_2O	δD	color L*	a*	b*
15: Osorezan							
15-1	Ho	PMFL	1.4	-38	51.0	0.3	9.2
15-2	Ho	LADM	0.9	-39	47.5	1.4	9.6
15-3	Ho+Px	LADM	0.8	-70	-	-	-
15-4	Ho	PMFL	1.8	-51	-	-	-
16: Oshima-Oshima							
16-1	Bi	PMFA	2.9	-56	-	-	-
16-1	Ho	PMFA	1.2	-53	53.9	-1.0	7.4

1) Ho = Hornblende; Bi = Biotite; Px = Pyroxene; Gl = Matrix glass

2) PMFA = Pumice fall deposit; PMFL = Pumice flow deposit; PCFL = Pyroclastic flow deposit; LAFL = Lava flow; LADM = Lava dome; INTL = Intrusive rock;

3) IAMP = Ichinome-gata amphibolite xenolith;

4) IHBD = Ichinome-gata hornblendite xenolith;

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