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Source of the Rhyolitic Ash Layer in Basaltic Ash Layers on Izu-Ōshima

By

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Abstract Chemical compositions of volcanic glass, plagioclase and biotite in the rhyolitic ash layer intercalated in the basaltic ash layers of the Younger Ōshima Group in Izu-Ōshima are compared with those in ash from Mukaiyama (Niijima) and Tenjōsan (Kōzushima) volcanoes erupted in A.D. 838 and 886, respectively. High ΣFeO and Na_2O contents of volcanic glass and high Mg* values and low ΣFe contents of biotite in the rhyolitic ash from Ōshima are features closer to those from Niijima than from Kōzushima, suggesting the origin from Mukaiyama volcano in Niijimza.

Introduction

Izu-Ōshima island, the northernmost island in the seven Izu islands running from east off Izu Peninsula south to Marianas. The major part of the island consists of material erupted from Ōshima volcano, an active basaltic stratovolcano. Recent products of Ōshima volcano called the Youjnger Ōshima Group are devided into three formations, i.e. Yuba, Nomashi and Sashikiji Formations in descending order (NAKAMURA, 1960). A basaltic ash layer N_3 in Nomashi Formation is conspicuous for intercalation of rhyolitic ash layer supplied from a volcano other than Ōshima volcano. This rhyolitic ash lalyer had been recognized in N_3 throughout the island (NAKAMURA, 1964), though it varies from <0.1 cm to 1 cm or more in thickness. NAKAMURA (1964) inferred the date of eruption produced N_3 member as ninth century from historical documents and pottary remains. Based on the result of mechanical analyses of the rhyolitic ash, he further referred the source of the rhyolitic ash to Kōzushima or Niijima where Tenjōsan and Mukaiyama volcanoes erupted in 838 and 886 A.D., respectively. Since then, it remains unsettled either of the above two volcanoes is the source volcano of this rhyolitic ash, for both volcanoes provided rhyolitic lavas and pyroclastics almost identical in chemical composition and constituting minerals.

In this paper, the auther intended to specify the source volcanoes of this rhyolitic ash by putting chemical data of ash contituents such as volcanic glass, plagioclase and biotite together.

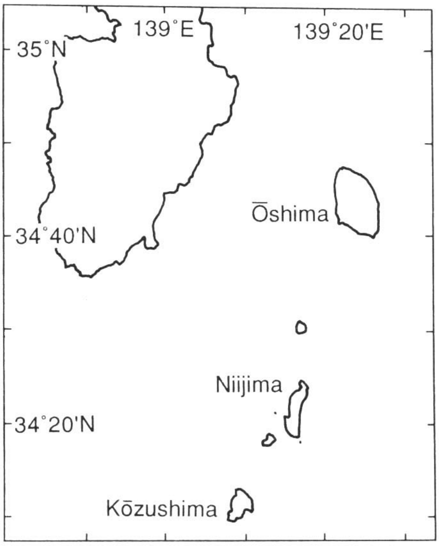

Fig. 1. Index map of Ōshima, Niijima and Kōzushima.

Samples and Analytical Method

On Ōshima island, rhyolitic ash samples are collected from several exposures on northern slope outside the caldera wall. Ash samples of 838 A.D. eruption of Tenjōsan volcano in Kōzushima (ISSHIKI, 1982) and 886 eruption of Mukaiyama volcano in Niijima (ISSHIKI, 1987) are taken from the eastern coast of the islands closer to Ōshima island (Fig. 1). Common constituents of the ash samples are volcanic glass, quartz, plagioclase, biotite and magnetite. Ash from Niijima contains olivine, clinopyroxene and orthopyroxene provided by basaltic volcanism occurred possibly on Miyakejima.

The ash samples are washed in distilled water and dried in the room temperature. Volcanic glass fragments, plagioclase grains and biotite flakes for analysis are hand picked under the binocular microscope. Those fraction are fixed on slide glass with epoxy resin and polished. Chemical analysis of the samples was done by using Link Systems energy dispersive X-ray sepctrometer.

Chemical Composition

Volcanic glass: Major oxide analyses of volcanic glasses are given in Appendices 1–3. Rhyolitic glass JR-2 is used to inspect the validity of the analyses. The analyses are plotted on oxide-K_2O diagrams (Fig. 2) after conversion to anhydrous total=100%. In Fig. 2, K_2O content is taken as absissa, for K is the sole incompatible element analysed that tends to enrich in high silica fluid

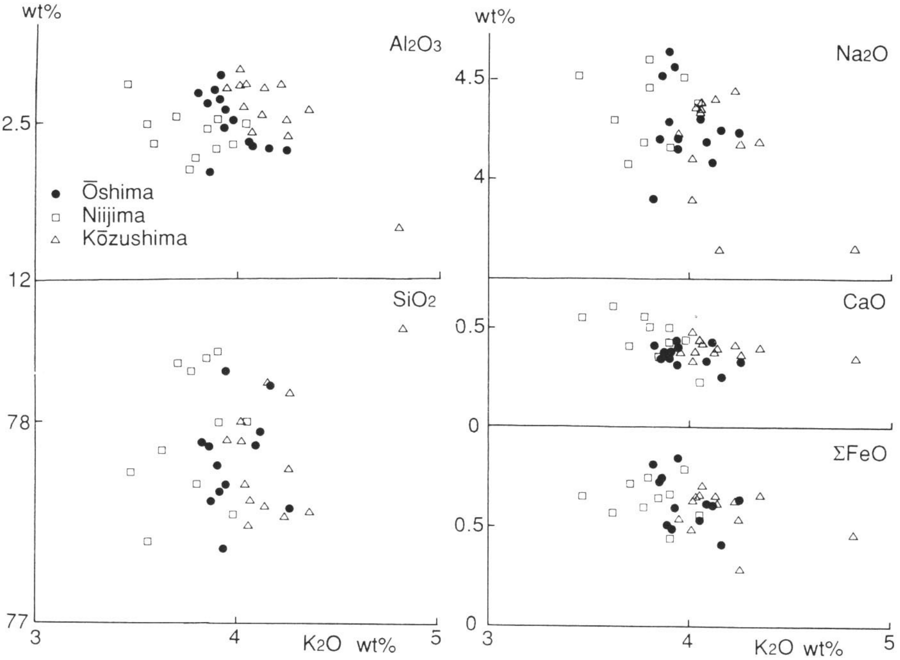

Fig. 2. Plots of volcanic glass analyses on SiO_2, Al_2O_3, ΣFeO, CaO and Na_2O contents vs. K_2O diagrams.

phase till potash feldspar begins to crystallize.

As seen in Fig. 2, plots of volcanic glasses from Niijima fall on the lower K_2O side, those from Kōzushima on the high K_2O side and those from Ōshima on intermediate area between them. As far as the major oxide contents concerned, volcanic glasses with somewhat high ΣFeO and Na_2O are found both ash samples from Niijima and Ōshima.

Plagioclase : Chemical analyses of plagioclase grains are shown in Appendix 4 and plotted on An–Ab–Or system (Fig. 3). Plagioclase in ash from Niijima covers the widest compositional rnage from An_{34} to An_{16}. On the other hand, plagioclase from Kōzushima shows a limited compositional variation from An_{22} to An_{17}. Some plagioclase grains from Ōshima are much sodic than those from Niijima and Kōzushima.

Biotite : Biotite flakes in ash from Ōshima are usually more or less altered, presenting paler color than those from Niijima and Kōzushima. This must have been caused by meteoric water preserved more abundantly in basaltic ash layers that overlay and underlay the rhyolitic ash layer. Major element analyses of biotite (Appendix 5) reflect the effect of alteration, i.e. compositions of biotite from Ōshima are characterized by low ΣFe and higher Mg contents than those from Niijima and Kōzushima. Plots of the analyses on atomic ratios-1 Mg*

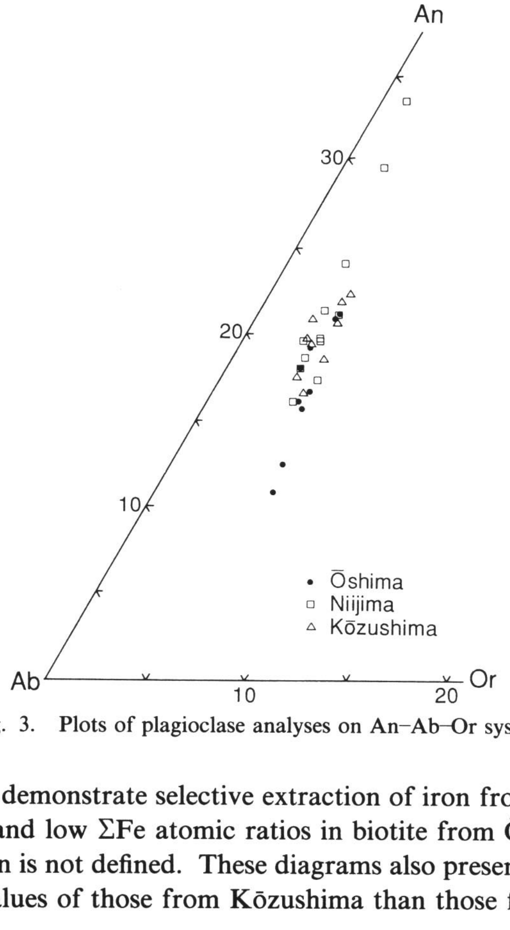

Fig. 3. Plots of plagioclase analyses on An–Ab–Or system.

diagrams (Fig. 4) demonstrate selective extraction of iron from biotite, resulting high Mg^* values and low ΣFe atomic ratios in biotite from Ōshima, though the degree of alteration is not defined. These diagrams also present higher ΣFe ratios and lower Mg^* values of those from Kōzushima than those from Niijima.

Considerations

The ninth century eruptions on Niijima and Kōzushima yielded rhyolitic lavas almost identical in bulk chemistry (see ISSHIKI, 1987 & 1982), together with rhyolitic ash. The present dasta, however, allow to regard rhyolitic ash from Tenjōsan volcano (Kōzushima) is derived from much evolved magma than those of Mukaiyama volcano (Niijima), since rhyolitic ash from Kōzushima includes K rich volcanic glass, less calcic plagioclase and biotite with low Mg^* values. Judging from low ΣFe ratios in biotite and high ΣFeO and Na_2O contents of volcanic glass in rhyolitic ash from Ōshima, Mukaiyama volcano on Niijima is the likely source supplied the rhyolitic ash layer in the Younger Ōshima Group in Ōshima.

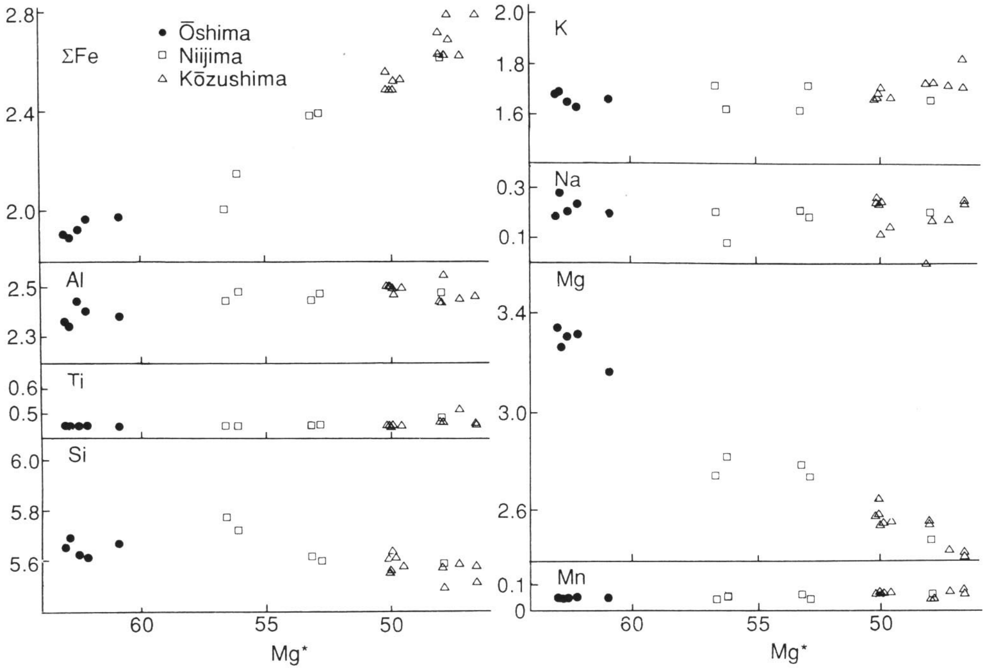

Fig. 4. Plots of biotite analyses on Si, Ti, Al, Fe, Mn, Mg, Na and K atomic ratios (on anhydrous basis of O=22)-Mg* diagram. A bulk analysis of biotite phenocrysts (Mg*=53, ISSHIKI, 1987) in the rhyolite lava extruded contemporaneously with the volcanic ash studied is also plotted together for comparison.
* 100Mg/(Mg+ΣFe+Mn)

Acknowledgment

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Appendix 1. Major oxide analyses of volcanic gasses from Ōshima.

wt%	1	2	3	4	5	6	7	8	9	10	11	12	13
SiO_2	75.77	74.86	75.56	76.13	75.98	75.26	77.07	75.52	75.47	75.09	76.75	75.53	77.03
TiO_2	–	–	–	–	–	–	–	–	–	0.24	–	–	–
Al_2O_3	12.32	12.27	12.70	12.38	12.56	12.22	12.46	12.51	12.52	12.44	12.37	12.33	12.72
ΣFeO*	0.58	0.59	0.59	0.52	0.71	0.60	0.40	0.47	0.48	0.78	0.74	0.62	0.84
MnO	–	–	–	–	–	0.23	–	–	–	–	0.26	0.29	–
CaO	0.31	0.41	0.43	0.43	0.35	0.31	0.26	0.37	0.33	0.39	0.38	0.32	0.41
Na_2O	4.02	3.92	4.46	4.20	4.10	4.05	4.18	4.52	4.14	3.76	4.47	4.12	4.18
K_2O	3.81	3.96	3.84	3.96	3.77	3.95	4.11	3.81	3.77	3.68	3.83	4.15	3.91
Cl	–	–	0.09	–	0.12	–	0.09	0.07	0.10	–	0.10	–	0.07
	96.81	96.01	97.67	97.62	97.59	96.62	98.57	97.27	96.81	96.38	98.90	97.36	99.16
O≡Cl	–	–	–0.02	–	–0.03	–	–0.02	–0.02	–0.02	–	–0.02	–	–0.02
total	96.81	96.01	97.65	97.62	97.56	96.62	98.55	97.25	96.79	96.38	98.88	97.36	99.14

* total iron as FeO

Appendix 2. Major oxide analyses of volcanic gasses from Niijima.

wt%	1	2	3	4	5	6	7	8	9	10	11
SiO_2	76.44	75.04	77.94	75.21	76.03	74.44	75.25	74.83	77.12	78.00	75.98
TiO_2	–	0.25	–	–	–	–	–	–	–	0.24	–
Al_2O_3	12.75	12.21	12.63	12.04	12.44	12.26	12.33	12.07	12.59	12.74	12.35
ΣFeO*	0.65	0.56	0.76	0.59	0.55	0.73	0.65	0.42	0.80	0.71	0.63
MnO	–	–	–	–	–	0.26	–	–	–	–	0.26
CaO	0.55	0.59	0.50	0.54	0.22	0.47	0.41	0.48	0.44	0.41	0.35
Na_2O	4.44	4.14	4.61	4.03	4.26	4.29	4.01	3.97	4.48	4.06	3.89
K_2O	3.41	3.49	3.82	3.62	3.95	3.66	3.76	3.72	3.96	3.70	3.73
Cl	0.07	0.10	0.07	0.09	–	0.07	0.07	–	0.07	–	0.09
	98.31	96.38	100.33	96.12	97.45	96.18	96.48	95.49	99.46	99.62	97.02
O≡Cl	–0.02	–0.02	–0.02	–0.02	–	–0.02	–0.02	–	–0.02	–	–0.02
total	98.29	96.36	100.31	96.10	97.45	96.16	96.46	95.49	99.44	99.62	97.00

∗ total iron as FeO

Appendix 3. Major oxide analyses of volcanic gasses from Kōzushima.

wt%	1	2	3	4	5	6	7	8	9	10	11	12	13
SiO_2	75.04	74.79	76.03	74.25	75.58	75.22	74.69	75.79	74.68	75.27	75.92	75.51	74.31
TiO_2	0.21	–	–	–	–	–	–	–	–	–	–	–	–
Al_2O_3	12.28	12.38	12.36	12.41	12.51	12.42	12.24	12.54	11.65	12.52	12.48	12.63	12.43
ΣFeO	0.52	0.59	0.27	0.46	0.64	0.63	0.68	0.63	0.44	0.61	0.52	0.64	0.60
CaO	0.37	0.38	0.35	0.46	0.39	0.37	0.41	0.37	0.33	0.32	0.33	0.44	0.40
Na_2O	4.08	3.49	4.07	3.71	4.07	4.27	4.21	4.24	3.47	3.96	4.13	4.22	4.26
K_2O	3.80	3.96	4.14	3.83	4.25	4.00	3.92	3.93	4.59	3.88	4.15	3.95	3.80
Cl	–	0.07	0.07	0.06	0.03	0.06	0.09	0.07	–	0.06	0.09	0.06	0.07
	96.30	95.66	97.29	95.18	97.47	96.97	96.24	97.57	95.16	96.62	97.62	97.45	95.87
O≡Cl	–	–0.02	–0.02	–0.01	–0.01	–0.01	–0.02	–0.02	–	–0.01	–0.02	–0.01	–0.02
total	96.30	95.64	97.27	95.17	97.46	96.96	96.22	97.55	95.16	96.61	97.60	97.44	95.85

∗ total iron as FeO

Appendix 4. Major oxide analyses of plagioclases.

	Ōshima								
wt%	1	2	3	4	5	6	7	8	9
SiO_2	65.42	64.52	63.98	64.01	63.43	63.70	66.10	63.91	66.45
Al_2O_3	22.00	22.28	21.29	23.1	22.68	22.48	21.09	22.05	20.73
ΣFeO	–	0.40	0.31	–	0.33	0.35	–	0.29	–
CaO	3.32	4.00	3.23	4.27	4.23	3.94	2.25	3.29	2.54
Na_2O	8.64	8.95	9.04	8.42	8.12	9.40	9.63	9.03	9.23
K_2O	0.81	0.62	0.83	0.66	0.67	0.62	1.03	0.76	0.94
total	100.19	100.78	98.69	100.48	99.46	100.49	100.10	99.34	99.89
Ab	78.5	77.3	79.5	75.1	74.5	78.5	83.4	79.6	82.1
An	16.7	19.2	15.7	15.7	21.4	18.1	10.8	16.0	12.4
Or	4.8	3.5	4.8	4.8	4.1	3.4	5.9	4.4	5.5

	Niijima											
	1	2	3	4	5	6	7	8	9	10	11	12
SiO_2	64.16	64.44	60.78	63.69	64.05	61.35	64.40	63.75	63.48	64.16	63.94	62.55
Al_2O_3	22.44	22.07	20.08	22.21	21.57	24.71	22.24	22.58	22.57	22.53	22.54	22.53
ΣFeO	–	–	–	–	–	–	–	–	–	–	–	–
CaO	3.70	4.00	6.08	3.71	3.25	6.95	3.62	4.13	4.17	4.11	3.97	4.96
Na_2O	8.93	8.68	7.77	8.59	8.88	7.44	8.96	8.08	8.10	8.91	8.64	8.40
K_2O	0.63	0.53	0.35	0.62	0.75	0.21	0.85	0.67	0.55	0.65	0.64	0.53
total	99.86	99.72	99.06	98.82	98.50	100.66	100.07	99.21	98.87	100.36	99.73	98.97
Ab	78.4	77.3	68.4	77.8	79.5	65.1	77.8	74.8	75.3	76.7	76.8	73.1
An	17.9	19.6	29.6	18.5	16.1	33.6	17.3	21.1	21.4	19.6	19.5	23.9
Or	3.7	3.1	2.0	3.7	4.3	1.2	4.9	4.1	3.3	3.7	3.7	3.0

	Kōzushima								
	1	2	3	4	5	6	7	8	9
SiO_2	63.95	64.82	64.72	64.32	63.67	64.20	64.10	63.92	63.33
Al_2O_3	23.20	22.70	22.19	23.13	22.76	22.19	23.13	21.90	22.65
ΣFeO	–	–	0.38	–	–	–	–	–	–
CaO	4.22	3.91	3.44	4.31	4.45	3.71	4.36	3.62	4.24
Na_2O	9.07	8.54	9.02	8.75	8.14	9.26	8.23	8.33	8.60
K_2O	0.55	0.62	0.78	0.48	0.63	0.65	0.64	0.75	0.72
total	100.99	100.59	100.53	100.99	99.65	100.01	100.46	98.52	99.54
Ab	77.1	77.0	78.9	76.4	73.9	78.8	74.4	76.9	75.3
An	19.8	19.4	16.6	20.8	22.3	17.5	21.8	18.5	20.5
Or	3.1	3.6	4.5	2.8	3.8	3.7	3.8	4.6	4.2

Appendix 5. Major oxide analyses of biotites.

	Ōshima					Niijima				Kōzushima										
wt%	1	2	3	4	5	1	2	3	4	1	2	3	4	5	6	7	8	9	10	11
SiO_2	37.43	37.43	37.67	38.08	37.50	38.24	37.55	36.99	37.76	36.57	36.62	36.81	36.89	37.27	37.15	35.40	35.56	36.19	35.00	35.93
TiO_2	4.00	4.04	4.06	4.1	4.28	4.02	4.29	4.09	4.03	4.05	4.00	4.15	4.15	4.27	4.27	4.17	4.08	4.35	4.30	4.39
Al_2O_3	13.78	13.64	13.34	13.31	13.38	13.80	14.17	13.70	13.89	13.98	13.77	13.85	13.98	14.21	13.98	13.96	13.36	13.42	13.30	13.30
ΣFeO*	15.38	15.72	15.25	15.44	15.63	16.74	21.08	18.86	17.07	20.22	19.45	19.48	19.58	20.30	20.17	20.52	20.52	21.10	20.43	20.24
MnO	0.37	0.42	0.40	–	0.40	0.34	0.60	0.52	0.36	0.63	0.55	0.50	0.55	0.61	0.42	0.42	0.58	0.38	0.71	0.65
MgO	14.70	14.81	14.97	14.63	14.02	12.25	11.21	12.34	12.51	11.75	11.19	11.19	11.40	11.55	11.60	10.80	10.36	11.15	10.41	10.60
CaO	–	–	–	–	–	0.16	0.08	–	0.19	–	–	–	–	–	–	–	–	–	–	–
Na_2O	0.72	0.81	0.63	0.97	0.68	0.70	0.70	0.73	0.29	0.79	0.81	0.37	0.82	0.83	0.90	0.89	0.78	–	0.84	0.57
K_2O	8.55	8.49	8.76	8.86	8.60	8.92	8.75	8.35	8.36	8.65	8.69	8.63	8.61	8.72	8.93	8.74	8.62	8.75	8.98	8.65
Cl	0.10	0.08	0.07	0.08	–	0.10	0.11	0.12	0.10	0.11	0.11	0.16	0.11	0.10	0.11	0.13	0.13	0.13	0.14	0.18
	95.03	95.44	95.15	95.47	94.49	95.27	98.54	95.70	94.56	96.75	95.19	95.14	96.09	97.86	97.53	95.03	93.99	95.47	94.11	94.66
O≡Cl	–0.02	–0.02	–0.02	–0.02	–	–0.02	–0.02	–0.03	–0.02	–0.02	–0.02	–0.03	–0.02	–0.02	–0.02	–0.03	–0.03	–0.03	–0.03	–0.04
total	95.01	95.42	95.13	95.45	94.49	95.25	98.52	95.67	94.54	96.73	95.17	95.11	96.07	97.84	97.51	95.00	93.96	95.44	94.08	94.62
atomic ratios on anhydrous basis of O=22																				
Si	5.621	5.608	5.561	5.692	5.667	5.774	5.589	5.613	5.722	5.541	5.619	5.638	5.602	5.571	5.577	5.491	5.579	5.574	5.511	5.582
Ti	0.451	0.455	0.458	0.461	0.487	0.456	0.480	0.466	0.459	0.462	0.462	0.478	0.474	0.480	0.482	0.487	0.482	0.504	0.509	0.513
Al	2.440	2.409	2.360	2.344	2.383	2.456	2.486	2.449	2.480	2.496	2.492	2.502	2.502	2.504	2.474	2.552	2.470	2.438	2.467	2.463
Fe	1.931	1.969	1.913	1.930	1.976	2.067	2.623	2.394	2.163	2.563	2.496	2.495	2.487	2.537	2.532	2.663	2.692	2.717	2.690	2.630
Mn	0.047	0.053	0.050	–	–	0.440	0.076	0.067	0.046	0.081	0.071	0.065	0.071	0.077	0.053	0.056	0.077	0.049	0.095	0.086
Mg	3.291	3.308	3.348	3.260	3.159	2.757	2.488	2.792	2.826	2.654	2.561	2.556	2.580	2.573	2.597	2.498	2.422	2.561	2.443	2.452
Ca	–	–	–	–	–	–	-0.013	–	0.030	–	–	–	–	–	–	–	–	–	–	–
Na	0.209	0.235	0.184	0.282	0.198	0.205	0.202	0.213	0.086	0.233	0.240	0.110	0.243	0.241	0.263	0.268	0.238	–	0.257	0.172
K	1.639	1.624	1.676	1.690	1.658	1.718	1.662	1.618	1.617	1.673	1.700	1.686	1.668	1.663	1.711	1.730	1.725	1.719	1.803	1.716
Mg**	62.5	62.1	63.0	62.8	60.9	56.6	48.0	53.2	56.1	50.1	49.9	50.0	50.2	49.6	50.1	47.9	46.7	48.1	46.7	47.3

* total iron as FeO

** 100Mg/(Mg+ΣFe+Mn)