上越教育大学研究紀要　第19巻　第2号　平成12年3月
Bull. Joetsu Univ. Educ., Vol. 19, No. 2, Mar. 2000

Note on rock-forming minerals in the Joetsu district, Niigata Prefecture, Japan. (14) Hornblende in the volcanic rocks from the Yoneyama and Myoko volcanos

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(Received October 29, 1999)

ABSTRACT

The volcanic rocks of the Myoko in Quaternary and the Yoneyama in late Pleiocene are distribed in the Nishikubiki region, Niigata Prefecture. In the Myoko volcanoes, pyroxene and hornblende andesites are common, and basalt is accompanied in subordinate amount. The majority of volcanic rocks from the Yoneyama are two pyroxene andesite, they are the rock types as follows: olivine-clinopyroxene-orthopyroxene basalt with or without hornblende, clinopyroxene- orthopyroxene andesite and hornblende clinopyroxene-orthopyroxene andesite. Hornblende gabbro occurs in these volcanic rocks. The amphiboles from the Yoneyama are magnesiohornblende to pargasite, on the other hand, the amphiboles from the Myoko except for the Maruyama lava are magnesiohornblende.Amphiboles in the Maruyama lava are pargasite.

Amphiboles in the volcanic rocks from both the Myoko and Yoneyama in this study are near the tremolite-pargasite join in the field of hornblende from gabbroic inclusions from the Yoneyama.

KEY WORDS
Ca-amphibole, Hornblende gabbro, Magnesiohornblende, Myoko volcano group, Pargasite, Yoneyama

Introduction

The hornblende gabbros are found in the volcanic rocks of the Myoko in Quaternary and the Yoneyama in late Pleiocene in the norther Fossa magna region. Many investigators reported that the horblende gabbros occur in calc-alkali andesites of the Fossa magna region and the surrounding of the Japan sea (Aoki 1970, 1971; Yamasaki et al., 1977; Shimazu et al., 1979; Yagi and Takeshita, 1987). They suggested on the basis of coexisting clinopyroxene with high Al_2O_3 content that the hornblende gabbro is derived by the lower crust and the upper mantle. However, some hornblende gabbros may be the cumulate rocks in the magma chamber. I attempt to clarify the origin of hornblende in the gabbro.

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Table 1. Chemical compositions of volcanic rocks from the Myoko and Yoneyama volcanos.

	1	2	3	4	5	6	7	8	9	10	11
SiO2	60.60	56.99	60.01	63.22	58.81	60.67	52.58	55.34	53.25	62.36	59.38
TiO2	0.62	0.9	0.58	0.54	0.89	0.72	0.76	0.87	0.76	0.56	0.61
Al2O3	16.83	18.01	17.30	16.25	17.50	17.26	17.74	18.62	18.05	17.40	18.11
Fe2O3	7.04	8.52	7.23	6.23	7.72	6.92	10.29	8.92	9.90	6.42	6.82
MnO	0.13	0.15	0.14	0.13	0.13	0.13	0.18	0.09	0.17	0.16	0.12
MgO	2.94	3.07	3.09	2.42	3.22	2.78	4.45	3.32	4.22	1.82	2.49
CaO	6.56	7.55	6.71	5.73	6.74	6.33	9.39	7.45	8.84	5.61	7.16
K2O	3.02	3.04	3.02	3.17	2.91	3.10	2.27	2.75	2.31	3.22	3.06
Na2O	2.08	1.63	1.77	2.15	1.92	1.95	1.98	2.31	2.15	2.18	2.02
P2O5	0.18	0.14	0.15	0.16	0.16	0.14	0.36	0.33	0.35	0.27	0.23
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

1 Otani pyroclastic rock from the Yakeyama: Hbl-Opx andesite
2 Maruyama lava from the Myoko: Hbl-Cpx-Opx andesite
3 Akakura pyroclastic rock from the Myoko: Hbl-Opx andesite
4 Otagirigawa pyroclastic rock from the Myoko: Hbl-Opx andesite
5 Kaname lava from the Myoko: Hbl-Cpx-Opx andesite
6 Myokosan lava from the Myoko: Hbl-Cpx-Opx andesite
7 Lava (H-2) at Haraigawa route from the Yoneyama: Hbl-Cpx-Opx-basalt
8 Lava (Yo-12) at Yoshiodani route from the Yoneyama: Hbl-Cpx-Opx-andesite
9 Agromarate (S-40) at Saruge route from the Yoneyama: Hbl-Cpx-Opx-basalt
10 Kuroiwa dyke from the Yoneyama: Hbl-Opx andesite
11 Shirokoshi dyke from the Yoneyama: Hbl-Opx andesite

Petrography of the Yoneyama and Myoko volcanic rocks

The geology and petrochemistry of the Myoko volcanos are reported by Hayatsu (1977) and Sakuyama (1981). Hayatsu (1977) reported that the Myoko volcano is divided into four active eruption stages. He found many inclusions in lavas and pyoclastic flow deposits of andesite, especially hornblende andesite. Sakuyama (1981) concluded on the basis of zoning patterns of plagioclase and disequilibrium phenocryst assemblages of hornblende or quartz and olivine that a normal zoning type plagioclase bearing magma mixed with a reverse zoning type plagioclase bearing magma. Pyroxene and hornblende andesites are common, and basalt is accompanied in subordinate amount.

The Yoneyama formation is the Pliocene volcanic sequence composed of alternating beds of lava, pyroclasic and sedimentary rocks intruded by dykes (Sato et al., 1975; Kobayashi et al., 1989; Oba and Miyagawa, 1998). The majority of volcanic rocks are two pyroxene andesite, they are the rock types as follows: olivine-clinopyroxene-orthopyroxene basalt with or without hornblende, clinopyroxene-orthopyroxene andesite and hornblende clinopyroxene-orthopyroxene andesite.

We selected one hornblende andesite from the Yakeyama and six hornblende andesites from the Myoko, and two hornblende basalts and three hornblende andesites. The

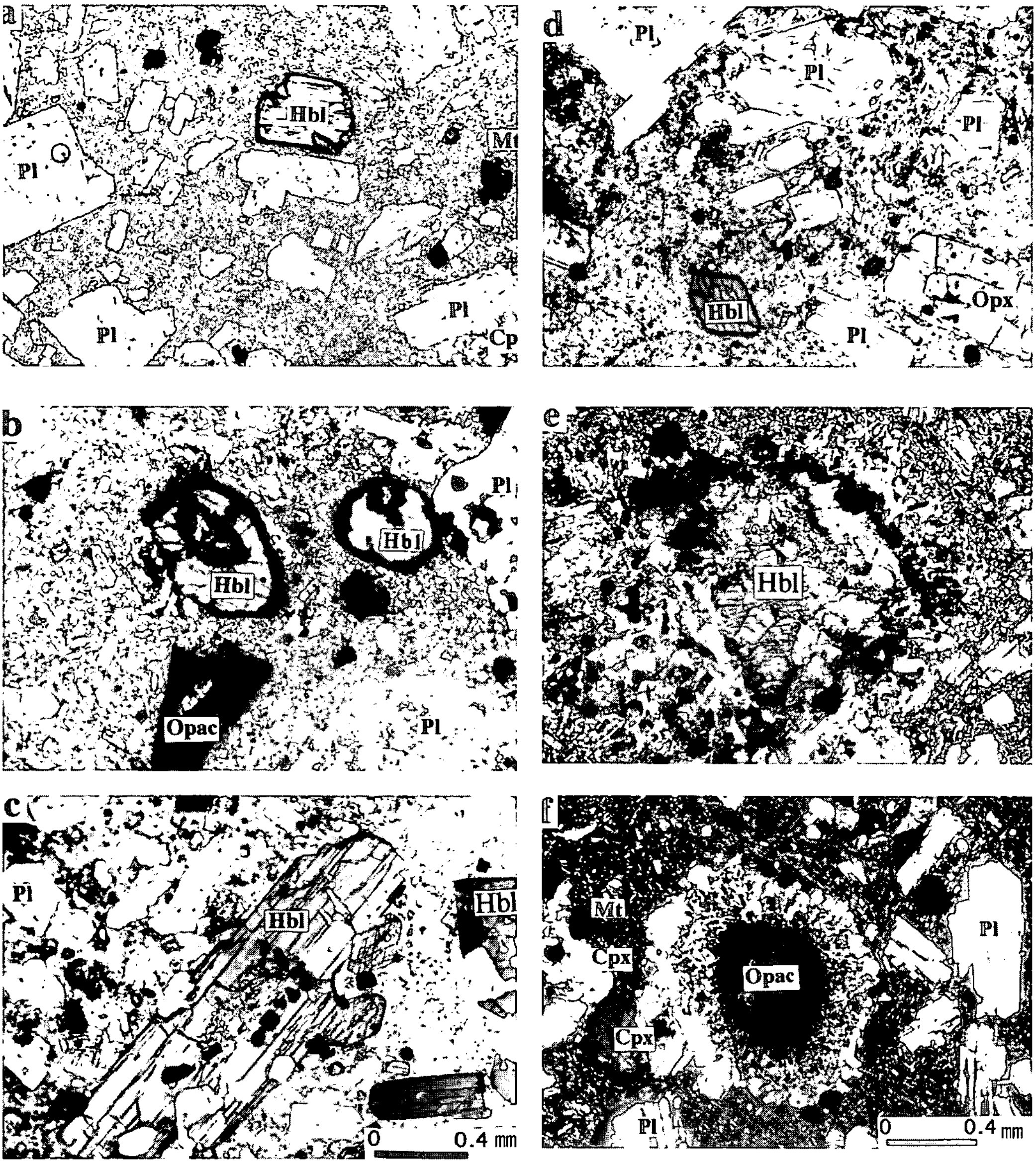

Figure 1. Photomicrographs of Ca-amphiboles in the volcanic rocks from the Myoko and Yoneyama volcanic rocks.

a: Brown hornblende with thin opacitized margin in lava along the Harai river, Yoneyama.

b: Red oxyhornblende in the Akakura pyroclasic rock, Myoko.

c: Hornblende in andesite from the Kuroiwa dyke, Yoneyama.

d: Brownish yellow hornblende with reaction rim in Myokosan lava.

e: Brownish yellow hornblende sorrounded by opacitized margin in the Maruyama lava, Myoko.

f: Opacite in the Ohtaki lava, Myoko.

Abbreviation: Cpx: clinopyroxene, Hbl: hornblende, Mt: magnetite, Opac: opacite, Opx: orthopyroxene, Pl: plagioclase.

Table 2. Chemical compositions of amphiboles in volcanic rocks from the Yoneyama and Myoko volcanos

No	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Point No	64	69	76	81	117	118	112	114	1	6	241	249	431	444	36	43	81	83	19	33	68	71
	Otani Pyr.		Maruyama L.		Akakura Pyr.		Otagirigawa Pyr.		Kaname L.		Myoko		Haraigawa		Yoshiodani		Saruge route		Kuroiwa dyke		Shirokoshi dyke	
	core	rim	core	rim	core	rim	core	rim	core	rim	core	rim	core	rim	core	rim	core	rim	core	rim	core	rim
SiO2	46.20	45.06	39.25	38.92	45.59	45.34	47.44	47.59	46.94	46.22	45.95	46.43	40.03	40.68	43.00	43.44	39.78	40.30	46.01	46.42	41.30	42.19
TiO2	1.54	1.77	2.2	2.13	1.67	1.52	1.3	1.16	1.3	1.79	1.91	1.74	1.80	1.83	1.96	2.06	1.78	1.65	1.61	1.39	2.08	1.28
Al2O3	7.22	7.83	14.32	14.3	8.00	8.34	6.66	6.62	7.12	8.67	8.68	7.85	15.34	15.06	11.86	12.48	15.16	15.11	10.07	9.74	12.57	11.01
Cr2O3	0.01	0.03	0.02	0.03	0	0.01	0	0.01	0	0.01	0	0	0.11	0.08	0.16	0.11	0	0.01	0.01	0.06	0.02	0
FeO	14.34	14.92	10.75	11.04	15.22	14.88	14.13	15.13	14.85	14.22	14.81	14.5	10.11	9.56	14.51	13.85	10.72	10.64	14.8	16.65	12.47	15.50
MnO	0.36	0.35	0.14	0.09	0.27	0.34	0.3	0.35	0.24	0.31	0.23	0.32	0.05	0	0.25	0.24	0.02	0.15	0.54	0.68	0.27	0.92
MgO	13.67	12.8	13.8	14.03	12.72	12.89	13.81	14.13	13.71	13.37	13.25	13.18	14.51	14.83	13.48	13.91	13.98	14.03	13.27	12.69	13.13	11.90
CaO	10.67	10.87	11.84	11.89	10.99	10.64	11.1	11.11	11.07	10.96	10.29	10.87	12.23	12.28	11.14	11.19	12.44	12.60	10.31	9.88	12.54	11.16
Na2O	1.32	1.45	2.51	2.23	1.49	1.53	1.23	1.43	1.25	1.47	1.45	1.18	1.97	2.00	2.20	2.41	1.86	1.89	1.57	1.51	2.02	1.81
K2O	0.52	0.57	0.72	0.57	0.47	0.5	0.39	0.46	0.53	0.43	0.52	0.46	1.71	1.61	1.18	1.12	1.39	1.24	0.34	0.35	0.77	0.71
Total	95.85	95.65	95.55	95.23	96.42	95.99	96.36	97.99	97.01	97.45	97.09	96.53	97.86	97.93	99.74	100.81	97.13	97.62	98.53	99.37	97.17	96.48
Si	6.936	6.822	5.923	5.895	6.841	6.822	7.058	7.006	6.97	6.815	6.809	6.913	5.893	5.957	6.285	6.255	5.908	5.947	6.712	6.761	6.165	6.409
AlIV	1.064	1.178	2.077	2.105	1.159	1.178	0.942	0.994	1.030	1.185	1.191	1.087	2.107	2.043	1.715	1.745	2.092	2.053	1.288	1.239	1.835	1.591
AlVI	0.213	0.219	0.47	0.448	0.256	0.301	0.226	0.155	0.216	0.321	0.325	0.290	0.554	0.557	0.328	0.373	0.561	0.575	0.444	0.433	0.376	0.380
Ti	0.174	0.202	0.250	0.243	0.188	0.172	0.145	0.128	0.145	0.198	0.213	0.195	0.199	0.202	0.215	0.223	0.199	0.183	0.177	0.152	0.233	0.146
Cr	0.001	0.004	0.002	0.004	0	0.001	0	0.001	0	0.001	0	0	0.013	0.009	0.018	0.013	0	0.001	0.001	0.007	0.002	0
Mg	3.059	2.888	3.104	3.168	2.845	2.891	3.062	3.101	3.034	2.938	2.927	2.925	3.184	3.237	2.937	2.985	3.094	3.086	2.886	2.755	2.921	2.694
Fe2+	1.800	1.889	1.357	1.398	1.910	1.872	1.758	1.863	1.844	1.753	1.835	1.805	1.245	1.171	1.774	1.668	1.331	1.313	1.806	2.029	1.557	1.969
Mn	0.046	0.045	0.018	0.012	0.034	0.043	0.038	0.044	0.030	0.039	0.029	0.040	0.006	0	0.031	0.029	0.003	0.019	0.067	0.084	0.034	0.118
Ca	1.716	1.763	1.914	1.930	1.767	1.715	1.769	1.752	1.761	1.731	1.634	1.734	1.929	1.927	1.744	1.726	1.979	1.992	1.612	1.542	2.005	1.816
Na	0.384	0.426	0.734	0.655	0.434	0.446	0.355	0.408	0.360	0.420	0.417	0.341	0.562	0.568	0.623	0.673	0.536	0.541	0.444	0.426	0.585	0.533
K	0.100	0.110	0.139	0.110	0.090	0.096	0.074	0.086	0.100	0.081	0.098	0.087	0.321	0.301	0.220	0.206	0.263	0.233	0.063	0.065	0.147	0.138
Toal	15.493	15.544	15.989	15.966	15.525	15.537	15.427	15.538	15.492	15.484	15.477	15.418	16.013	15.971	15.891	15.896	15.966	15.943	15.498	15.493	15.861	15.795
Mg/Mg+Fe	0.629	0.605	0.696	0.694	0.598	0.607	0.635	0.625	0.622	0.626	0.615	0.618	0.719	0.734	0.623	0.642	0.699	0.702	0.615	0.576	0.652	0.578

1, 2: Otani pyroclastic rock from Yakeyama: Hbl-Opx andesite
3, 4: Maruyama lava from Myoko: Hbl-Cpx-Opx andesite
5, 6: Akakura pyroclastic rock from Myoko: Hbl-Opx andesite
7, 8: Otagirigawa pyroclastic rock from Myoko: Hbl-Opx andesite
9, 10: Kaname lava from Myoko: Hbl-Cpx-Opx andesite
11, 12: Myokosan lava from Myoko: Hbl-Cpx-Opx andesite
13, 14: Lava (H-2) at Haraigawa route from Yoneyama: Hbl-Cpx-Opx-basalt
15, 16: Lava (Yo-12) at Yoshiodani route from Yoneyama: Hbl-Cpx-Opx-andesite
17, 18: Agromarate (S-40) at Saruge route from Yoneyama: Hbl-Cpx-Opx-basalt
19, 20: Kuroiwa dyke from Yoneyama: Hbl-Opx andesite
21, 22: Shirokoshi dyke from Yoneyama: Hbl-Opx andesite

chemical compositions of the volcanic rocks from the Myoko and Yoneyama are listed in Table 1. Major elements were determined by X-ray fluorescence spectrometry (Rigaku S3030 type) at the Joetsu University of Education. Total amounts recalculated as 100 %. Total Fe is expressed as Fe_2O_3. As compared to the volcanic rocks from the Yoneyama, hornblende andesite in the Myoko volcano is acidic.

Hornblende is commonly observed as phenocryst in the Myoko and Yoneyama volcanic rocks. No hornblende is observed in the groundmass. The color of hornblene is mostly brownish yellow and brown, sometimes green or red. The brown and red hornblendes are sorrounded by opacitized margin (Figs. la, lb, ld le). The hornblende in the Ohtaki lava of the Myoko volcano is completely replaced by aggregate of a fine grained-crystal such as pyroxene and magnetite (Fig. lf). The hornblende crystals in the Kuroiwa dyke are generally 5 to 10 mm in size, and sometimes attain to 20 mm in length. They are bigger than hornblendes (0.2 mm in length) in other lavas and pyroclastic rocks. The boundary of the hornblende and groundmass is sharp, and is not attack by opacitization (Fig. lc).

Mineralogical data and discussion

The chemical compositions of minerals were analyzed with a JEOL 8060 superprob at Niigata University, and EDS (Link Isis 300) at the Joetsu University of Education. The selected spot analyses of amphibole at rim and core parts are given in Table 2 together with their structural formulae. Total Fe is expressed as FeO. Fe^{3+} content is not calculated.

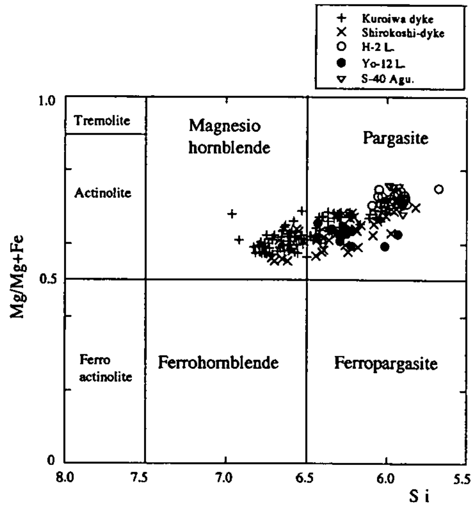

Figure 2. Classification of the calcic amphiboles from the Yoneyama volcanic rocks.

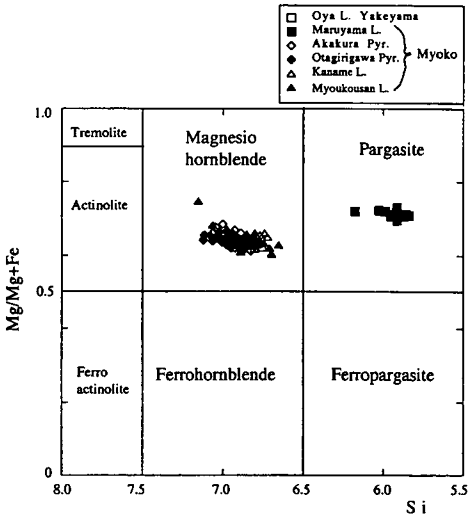

Figure 3. Classification of the calcic amphiboles from the Myoko volcanic rocks

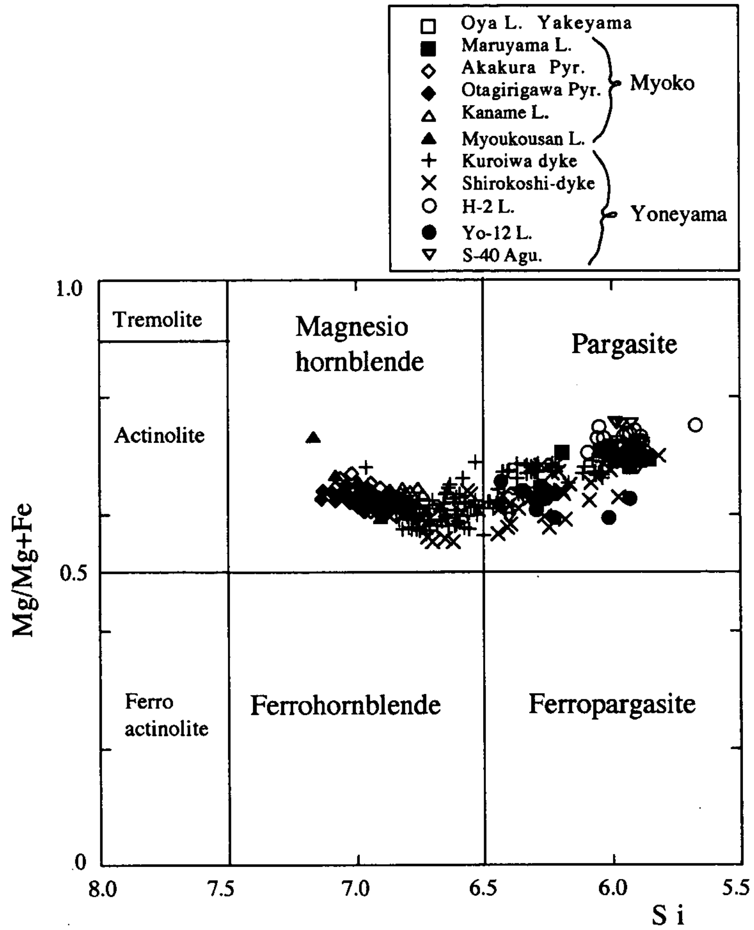

Figure 4. Classification of the calcic amphiboles from the Myoko and Yoneyama volcanic rocks.

According to the classification of Leake et al. (1997), the amphiboles from the Yoneyama are magnesiohornblende to pargasite in Fig. 2. The chemical variations of the amphiboles from the Kuroiwa and Shirokoshi dykes are wider than those of the lavas (H-2, Yo-12) and a agglutinate (S-40). Mg/(Mg+Fe) ratios of amphiboles increase with decreasing Si content in tetrahedra site. On the other hand, the amphiboles from the Myoko except for the Maruyama lava were plotted in magnesiohornblende field (Fig. 3). Amphiboles in the Maruyama lava are pargasite.

Mg/(Mg+Fe) ratios of amphiboles in magnesiohornblende field decrease with decreasing Si content in tetrahedra site. The whole variation trend of amphiboles from both areas is concave wrve, and decreases once and then increases with decreasing Si content in tetrahedral site, as shown in Fig. 4. Amphiboles from both areas are plotted on and near the join tremolite-pargasite in Fig. 5. The major variation in the chemical

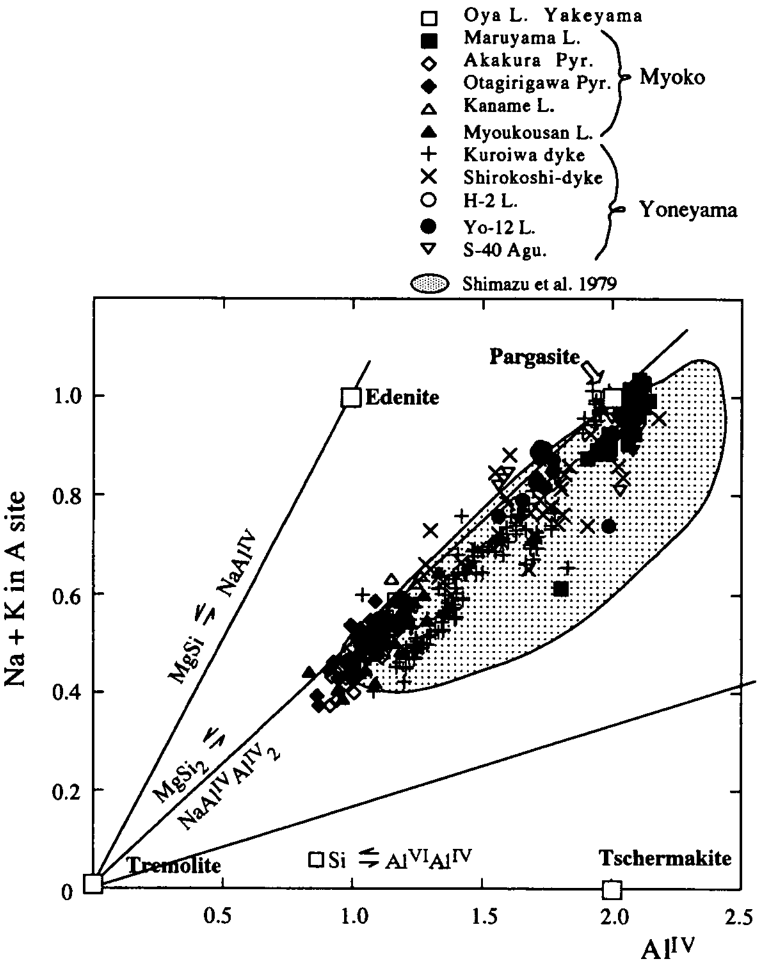

Figure 5. Plots of amphiboles in AlIV versus Na + K in A site diagram

compositions of the amphiboles can be explained pargasite substitution in the tremolite formula. Oba (1980) reported that the composition of amphibole becomes rich in pargasite with increasing temperature. In addition, the composition of amphibole is affected with the bulk composition. Fig. 6 shows that Si in tetrahedral site in amphibole increases with increasing SiO_2 contents of the host rocks except for the Maruyama lava, the Kuroiwa and Shirokoshi dykes. The fact suggests that Si contents in tetrahedral site from amphibole are effected on SiO_2 contents of the host rocks. Amphiboles from the Kuroiwa and Shirokoshi dykes are variable in composition. Amphibole in the Maruyama lava is rich pargasite in spite of SiO_2 rich bulk composition. In this case, amphibole in the Maruyama lava crystalized at higher temperature than other amphiboles.

The area bounded by a circle indicates hornblendes in gabbroic inclusions from the Yoneyama reported by Shimazu et al. (1979). As compered to hornblende in gabbroic

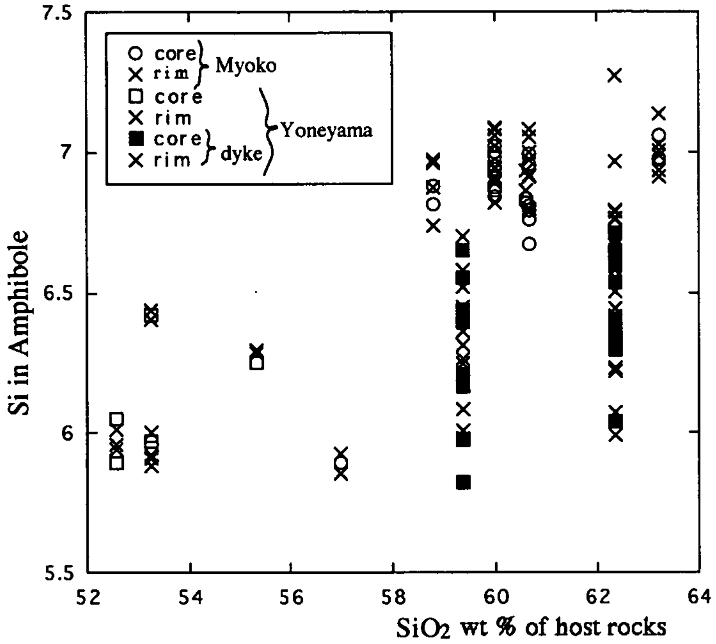

Figure 6. Plots of amphiboles in Si in amphibole versus SiO2 wt % of host rocks diagram.

inclusions by Shimazu et al. (1979), amphiboles from both the Myoko and Yoneyama in this study are plotted near the tremolite-pargasite join. It is known that the substitution of tschermakite increases with increasing pressure. Most hornblende from both the Myoko and Yoneyama is magnesiohornblende to pargasitic with a small portion of tschermakite. Al_2O_3 content of coexisting clinopyroxene is about 1 ~ 3 wt. %. Aoki (1971) concluded on the basis of the mineral assemblages of the mafic inclusions from Itinome-gata and the compositions of their minerals that the mafic inclusions recrystallized or crystallized in 600-110 and 6-9 kb. $CaAl_2SiO_6$ molecule in clinopyroxene is about 4.5~10.5 (Al_2O_3: 3.27~ 6.7wt. %). Shimazu et al. (1979) reported that Al_2O_3 content of clinopyroxene in hornblende gabbros is about 2 ~ 8 wt. %. The fact suggests that some hornblende gabbros may be the cumulate rocks in the magma chamber. After hornblende phenocryst cumulated in magma chamber, the cumulate inclusions are carried by new magma derived from the lower crust.

Acknowledgnents

I am very much indebted to Professor S.Miyashita at the Niigata University for the electron probe micro-analysis. I wish to thank Prof. T.Watanabe for his suggestion and interest in this work.

References

Aoki, K. 1970. Petrology of kaersutite-bearing ultamafic inclusions in Iki island Japan. Contrib. Mineral.Petrol., **25**, 270-283.

Aoki, K. 1971. Petrology of mafic inclusions from Itinome-gata, Japan. Contrib.Mineral. Petrol., **30**, 314-331.

Deer, W. A., Howie, R. A. and Zussman J. 1963. Amphibole group. 203-374. in "Roch-forming minerals." Vol. 2, Longman.

Hayatsu, K. 1977. Geologic study on the Myoko volcanos, central Japan. -Part2. Petrography-. Mem. Fac. Sci., Kyoto Univ., Ser. Geol. Mineral., XL III, 1-48.

Kobayashi, I., Tateishi, M., Kurokawa, K., Yoshimura, T. and Kato, H. 1989. Geology of the Okanomachi district. with geological sheet map at 1: 50,000, 112p. (in Japanese with English abstract)

Leake, B. E., Woolley, A. R., Arps, C. E. S., Birch, W. D., Gilbert, M. C., Grice, J. D., Hawthorne, F. C., Kato, A., Kisch, H. J., Krivovichev, V. G., Linthout, K., Laird, J., Mandarino, J. A., Maresch, W. V., Nickel, E. H., Rock, N. M. S., Schumacher, J. C., Smith, D. C. Stephenson, N. C. N., Ungretti, L., Whittaker, E. J. W. and Youshi, G. (1997): Nomenclature of amphiboles: Report of the subcommittee on amphiboles of the International Mineralogical Association commission on new minerals and mineral names. Am. Mineral. **82**, 1019-1037.

Oba,T. (1990) Experimental study on the tremolite-pargasite join at variable temperatures under 10kbar. Proc. Indian Academy Sci. **99**, 81-90.

Oba, T. and Miyagawa, K. 1998. K-Ar age and chemical variations of Tertiary Yoneyama volcanic rocks, Niigata Prefecture. Annual Meeting Japan. Min. Petr. Econ. Geol., 185. (in Japanese)

Sakuyama, M. 1981. Petrological study of the Myoko and Kurohime volcanos, Japan: Crystallization sequence and evidence for magma mixing. Jour. Petrol., **22**, 553-583.

Sato, T. and Yoneyama Research group 1975. Volcanic rocks in the Yoneyama district, Niigata Prefecture, Japan. Earth Sci. (Chikyukagaku), **29**, 211-226. (in Japanese with English abstract)

Shimazu M., Yano, T. and Tajima, M. 1979. Gabbroic inclusions in calc-alkali andesites of the Fossa magna region central Japan. Sci.Rept. Niigata Univ., Ser. E, Geol.Mineral., **5**, 63-85.

Yagi, K. and Takeshita, H. 1987. Impact of hornblende crystallization for the genesis of calcalkalic andesites. Geochem. Soc., Spec. Publ. **1**, 183-190.

Yamasaki, M., Onuki, H. and Tiba, T. 1966. Significance of hornblende gabbroic inclusions in calc-alkali rocks. Jour. Japan. Assoc. Min. Petr. Econ. Geol., **55**, 87-103.