CHEMICAL COMPOSITIONS OF COEXISTING BIOTITES AND HORNBLENDES FROM OKUEYAMA GRANODIORITE, KYUSHU, JAPAN

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Chemical compositions of coexisting biotites and hornblendes and their host rocks of the Shishigawa-type of the Okueyama granodiorite batholith were investigated. Compositional difference which can be seen between granitic rocks of the southern part and those of the northern part in the batholith indicates that the rocks of the latter were affected by a residual liquid due to differentiation of magma of the main body of the Okueyama granodiorite. Both biotites and hornblendes are poor in Al, and low in Mg/Fe⁺² ratio. The distribution coefficient for Mg and Fe⁺² of the coexisting biotite and hornblende pairs is 0.75 in average. Comparing with chemical compositions of coexisting biotite and hornblende pairs from granitic rocks in Kitakami and Ryoke regions, those of coexisting biotite and hornblende pairs from the Okueyama granodiorite suggest that rocks of the Okueyama main body would have been formed as a volcano-plutonic complex.

INTRODUCTION

Many bodies of Tertiary granitic intrusives are distributed in South Kyushu. Granitic rocks carrying both biotite and hornblende are, in general, exposed in the northern belt of the Shimanto terrain. It is known that these granitic rocks were formed in a state of the volcano-plutonic activities at relatively shallow depths. Therefore, it is interested to investigate the physical and chemical natures of the coexisting biotite and hornblende pairs.

The Okueyama granodiorite batholith is located in the northern belt of the Shimanto terrain, Miyazaki Prefecture, Japan (Fig. 1). Geological and petrological studies of this batholith and the surrounding area have been reported by Toriyama (1936),

Kuroda (1948), Hashimoto and Miyahisa (1959), Nozawa and Takahashi (1960), and Ōba (1961). This paper presents physical and chemical natures of coexisting biotites and hornblendes from the Shishigawa-type granitic rocks which occupy the southwestern part of the batholith. An attempt is made to compare chemical compositions of the coexisting biotite and hornblende pairs from rocks of this batholith to those of coexisting biotite and hornblende pairs from Kitakami and Ryoke granitic rocks.

GEOLOGIC RELATIONS OF THE OKUEYAMA GRANODIORITE BATHOLITH

Geology of the Shishigawa district is shown in Fig. 1. The Okueyama granodiorite batholith intrudes the geosynclinal

Fig. 1. Index and geologic maps of the southwestern part of the Okueyama granodiorite, Miyazaki Prefecture. Map showing the distribution of the granodiorite and the collected points of the analysed samples.

Stratigraphic sequence: 1. Aso welded-tuff. 2 and 3. Okueyama granodiorite (2. Shishigawa-type granodiorite 3. granite porphyry). 4. Mitate conglomerate. 5, 6 and 7. Shiiba formation (5. Sandstone, 6. Clayslate, 7. Alternation of sandstone and clayslate). 8, 9 and 10. Hinokage formation (8. Sandstone, 9. Clayslate, 10. Alternation of sandstone and clayslate). 11, 12, 13 and 14. Togawa formation (11. Sandstone, 12. Clayslate, 13. Limestone, 14. Chert).

Faults 15. Fault. 16. Inferred fault.

Location a. Hinokage-gawa. b. Aminoshe-gawa.

sedimentary rocks of the Chichibu and Shimanto terrains. In the Chichibu terrain, only the Togawa Formation of the Permian age, which is composed mainly of sandstone, clayslate and chert with lenses of limestone and thin layers of conglomerate, is distributed in the northern part of the district. In the Shimanto terrain of the district, the Shimanto Group of the certain age (probably Jurassic to Cretaceous) is divided into the following two formations by a fault: one is the Hinokage Formation composed mainly of sandstone and alternation of sandstone and clayslate, and the other is the Shiba Formation consisting of sandstone with alternation of sandstone and clayslate (Imai

et al. 1971). The Chichibu and the Shimanto Groups are geologic members widely distributed in the Outer Zone of Southwest Japan. Both Groups are bounded by the Butsuzo tectonic line from each other, and show a conspicuous zonal arrangement of rocks with northeast-southwest trend.

The Mitate conglomerate of the Paleogene age which is distributed in the north-western part of the batholith, is unconformably overlain by the Shimanto Group, and comprises gravels of chert and sandstone with partly pelitic rocks. The Pleistocene Aso welded tuff derived from the Aso caldera occurs in small areas along the Aminoshe and the Hinokage rivers, and unconformably

overlain by the Togawa Formation and the Shimanto Group.

THE OKUEYAMA GRANODIORITE BATHOLITH

The Okueyama granodiorite batholith is exposed in 10 km in the length diameter, and intrudes the Togawa Formation, the Shimanto Group and the Mitate conglomerate. Roof pendants of the Shimanto Group occur in some places. Ring dikes and satellitic bodies, composed of granite porphyry and quartz porphyry, occur around the batholith. The boundaries between the batholith and the adjacent surrounding sedimentary rocks show sharp and discordant contacts, and indicate that the initial form at the time when the batholith was formed is considerably preserved well up to the present time. Greisen and tourmaline deposits are found in the contacts in the northern part of the batholith. In the adjacent areas surrounding the batholith, biotite and cordierite as contact minerals are contained in thermally metamorphosed pelitic rocks, and garnet in thermally metamorphosed calcareous rocks of the Togawa Formation. Skarn minerals such as garnet and pyroxene are found within the Chichibu terrain. Many ore deposits can be observed in the contact aureoles. Data of K-Ar and zircon ages (Miller *et al.*, 1962 and Miyahisa *et al.*, 1953) indicate that the batholith was formed in the Miocene age (21 ± 1 m.y.).

Hashimoto and Miyahisa (1959) reported that the batholith was emplaced just after the activity of the Sobosan acidic volcanic rocks in the northwestern part of this district, and that the volcanic rocks can be correlated to the Ishizuchiyama acidic igneous complex in North Shikoku. They concluded that the Sobosan-Okueyama

acidic volcanic and intrusive bodies are products of volcano-plutonic complex activities.

PETROGRAPHY AND PETROCHEMISTRY OF THE GRANITIC ROCKS

The Okueyama granodiorite is lithologically divided into two types of Shishigawa and Horigawa (Ōba, 1961). The rocks of Shishigawa-type, which are leucocratic and medium grained granodiorite with slightly porphyritic texture, intrude both the Shimanto Group and Mitate conglomerate (see Fig. 1). The rocks of this type consist mainly of biotite, green hornblende, orthoclase, plagioclase and quartz, and a small amount of zircon, magnetite and apatite are accompanied as accessories. Xenoliths of pelitic rock and basic rock origin are found throughout the batholith. Xenoliths measuring about 50 cm in diameter can be found in the northern part of the batholith, but those present abundantly in the southern part are less than 5 cm in size.

Plagioclase occurs as euhedral grains with commonly twinned on albite and Carlsbad laws and rarely on pericline law. Zoned plagioclase range in composition from An_{20} to An_{35} from the refractive indices (see Table 1). Myrmekite is sometimes observed in the margin of plagioclase grains. Quartz occurs as large porphyritic crystals or assemblage of small grains. Orthoclase occurring as anhedral to subhedral grains is commonly twinned on Carlsbad and rarely perthite.

Biotite occurs as euhedral independent flakes with ragged edges. Sometimes, biotite which occurs together with hornblende shows glomeroporphyritic texture, in which their grain boundaries are sharp or intertongued of biotite. Biotite is more than 3 mm in size and has pleochroism with

X = light yellow and Z = deep brown to reddish brown. It is sometimes altered to chlorite. Zircon and magnetite are commonly found within biotite grains as inclusions. Biotite in xenoliths is much smaller, about 0.1 mm in length.

Hornblende occurs as subhedral grains and has pleochroism with X = light green and Z = green. Twinning is sometimes found. Apatite and magnetite are common

Table 1. Chemical compositions of granitic rocks of the Shishigawa-type of the Okueyama batholith.

No.	Oks-1	Oks-2	Oks-3	Oks-4	Oks-5	Oks-6
Modal analyses						
Quartz	23.9	30.3	21.7	29.5	37.1	32.8
K-feldspar	22.3	22.6	26.9	25.0	28.4	23.9
Plagioclase	37.3	31.4	36.6	37.2	28.2	33.7
Biotite	8.5	12.7	12.9	7.7	6.4	7.7
Hornblende	7.5	2.1	1.0	0.2	-	1.8
Chlorite	0.2	0.9	1.0	0.2	tr.	0.1
Others	tr.	tr.	tr.	tr.	tr.	tr.
Total	99.7	100.0	100.1	99.8	100.1	100.0
Chemical analyses*						
SiO ₂	61.82	66.10	65.96	70.46	71.46	71.58
TiO ₂	0.44	0.33	0.36	0.19	0.29	0.15
Al ₂ O ₃	15.01	14.37	14.85	14.74	13.46	12.48
Fe ₂ O ₃	1.73	1.85	1.77	0.84	0.80	0.51
FeO	4.59	1.99	2.33	0.52	0.85	1.00
MnO	0.13	0.06	0.03	0.06	0.08	0.10
MgO	1.91	1.59	1.59	1.03	0.46	1.16
CaO	3.62	3.16	3.03	2.73	1.13	3.13
Na ₂ O	4.60	3.30	2.40	3.40	2.20	4.01
K ₂ O	3.40	3.50	4.00	3.20	5.60	3.70
H ₂ O ⁺	1.46	1.96	2.10	1.56	1.98	1.22
H ₂ O ⁻	0.78	1.58	1.38	1.84	1.28	0.52
P ₂ O ₅	0.15	0.06	0.15	0.05	0.06	0.01
Total	99.67	99.85	99.85	99.92	99.63	99.57
CIPW norms						
Q	9.8	23.4	26.5	30.0	33.3	27.8
C	-	-	1.6	1.0	2.2	-
Or	20.7	21.7	24.9	19.6	35.0	22.5
Ab	42.4	31.0	22.7	31.5	20.9	36.9
An	10.0	14.7	15.0	13.7	5.4	3.1
Mt	4.1	1.9	1.9	1.0	0.9	0.5
Il	0.6	0.5	0.5	0.3	0.4	0.2
Ap	0.3	0.1	0.3	0.1	0.2	0.03
Di	5.6	0.8	-	-	-	8.3
Hyr	8.3	5.7	6.7	3.0	1.9	0.3
D.l.	72.9	76.1	74.1	81.1	89.2	87.2
mg	0.35	0.44	0.42	0.58	0.33	0.57
Plagioclase						
Index n ₁	1.546	1.545	1.540	1.538	1.540	1.538
n ₂	1.556	1.555	1.545	1.548	1.547	1.549
An content	35	32	23	20	23	21

inclusions in hornblende.

Calcite is rarely found as accessory mineral within granitic rocks. The mode of occurrence of calcite indicates that calcite is not a product of hydrothermal alteration, but a primary mineral crystallized at the latest stage during the formation of the batholith.

Modal and chemical analyses of six rock samples of the Shishigawa-type, Nos. Oks-1, 2 and 3, collected from the southern part of the batholith at the elevation of 600 m above sea level, and three rock samples from the northern part at the elevation of 1000 m (see Fig. 1) were made. These analytical data and CIPW norms are given in Table 1.

Color index ranges from 16 in rocks of the southern part to 6 in rocks of the northern part of the batholith, and the amount of hornblende decreases from the

Fig. 2. Modal relation of plagioclase, alkali-feldsaps and quartz. Showing classification of the IUGS subcommittee. A: Granite, B: Granodiorite 1; Hornblende biotite granite. 2; Hornblende biotite granite. 3; (augite bearing) hornblende biotite granite. 4; Hornblende bearing biotite granite. 5; Biotite granite. 6; Hornblende bearing biotite granite.

former to the latter. Calcite was found only within the sample No. Oks-3, which has the highest chlorite/(biotite+hornblende) ratio in mode as compared to the other samples. Fig. 2 shows modal composition of analyzed rock samples. Almost all of the analyzed samples are plotted within the granite field.

Differentiation indices range from 73 in rocks of the southern part to 89 in rocks of the northern part of the batholith. From the former to the latter, the contents of MgO and CaO regularly decrease, whereas those of SiO_2 increase. Normative Di ranging from 5.6 to 0.8 in amount was calculated in rock samples, Nos. Oks-1, 2 and 6, which indicate that the rocks of the southern part of the batholith are not rich in Al_2O_3 . The $\text{K}_2\text{O}/\text{Na}_2\text{O}$ ratios range from 0.74 to 2.5, and the FeO/CaO ratios from 1.3 to 0.2, which are consistent with the general petrological features of granitic rocks in the western district of the Shimanto terrain reported by Ōba (1967). On the evolution trend diagram, $(\text{FeO} + \text{Fe}_2\text{O}_3) - (\text{Na}_2\text{O} + \text{K}_2\text{O}) -$

Fig. 3 Evolution-trend diagram, $(\text{FeO} + \text{Fe}_2\text{O}_3) - (\text{K}_2\text{O} + \text{Na}_2\text{O}) - \text{MgO}$. Solid line; Variation trend curve showing the Southwestern Outer Zone granites. ●; Nozawa and Takahashi, 1960. ○; This papers.

MgO, Fig. 3, solid curve represents a variation trend-curve showing the Southwestern Outer Zone granites (Ōba, 1961). The plotted points of the analyzed rocks in this paper fall on the solid curve.

CHEMICAL COMPOSITION OF BIOTITES

Five biotites were separated from the pulverized rock samples by means of a magnetic separator and heavy liquid. Their chemical compositions are listed in Table 2 together with structural formulas calculated on the basis of 24 (O, OH) and optical properties.

Table 2. Chemical compositions of biotites from granitic rocks of the Shishigawa-type of the Okueyama batholith.

No.	Oks-1	Oks-2	Oks-3	Oks-4	Oks-5
Chemical analyses*					
SiO_2	35.98	34.96	35.02	35.36	35.72
TiO_2	3.66	3.66	3.58	3.56	2.32
Al_2O_3	12.29	12.98	12.68	12.74	14.19
Fe_2O_3	4.36	4.98	5.56	5.73	3.48
FeO	20.48	19.22	19.31	19.94	22.82
MgO	7.24	7.66	8.31	8.30	5.91
MnO	0.35	0.29	0.30	0.29	0.75
CaO	1.26	1.03	0.50	0.41	0.35
Na_2O	0.30	0.50	0.20	0.30	0.70
K_2O	7.20	8.00	7.50	6.70	7.15
H_2O^+	4.76	4.46	4.52	4.62	4.28
H_2O^-	1.53	2.32	2.37	1.66	1.65
P_2O_5	0.04	0.01	0.02	0.03	0.09
Total	99.45	100.07	99.87	100.64	99.40
Structural formulae.					
Si	5.589	5.473	5.481	5.488	5.626
Al^{IV}	2.249	2.398	2.331	2.329	2.374
Fe^{+3}	0.162	0.129	0.188	0.183	-
Z	8.000	8.000	8.000	8.000	8.000
Al^{VI}	-	-	-	-	0.255
Ti	0.438	0.437	0.427	0.422	0.278
Fe^{+3}	0.351	0.454	0.470	0.488	0.416
Fe^{+2}	2.659	2.520	2.519	2.590	3.007
Mg	1.680	1.787	1.937	1.910	1.390
Mn	0.047	0.038	0.038	0.037	0.104
Y	5.175	5.236	5.391	5.447	5.450
Ca	0.205	0.169	0.075	0.065	0.057
Na	0.093	0.150	0.066	0.093	0.217
K	1.428	1.599	1.485	1.322	1.437
X	1.726	1.918	1.626	1.480	1.711
OH	4.936	4.664	4.719	4.780	4.501
mg	0.345	0.365	0.378	0.370	0.285
Mg/Fe^{+2}	0.63	0.71	0.77	0.74	0.46
index 8	1.649	1.658	1.647	1.660	1.652

Fig. 4 Relation between Mg, Fe^{2+} (+ Mn^{2+}), R^{3+} (Al, Fe^{3+} and Ti) in trioctahedral micas after M.D. Forster (1960).

Relations among octahedral members in the structural formulas of analyzed biotites are shown in Fig. 4, $\text{Mg}-\text{R}^{3+}$ ($\text{Al}^{\text{VI}} + \text{Ti} + \text{Fe}^{3+}$)—($\text{Fe}^{2+} + \text{Mn}$) (Foster, 1960). All the biotites fall within the Fe^{2+} -biotite field, and are plotted in parallel to the $\text{Mg}-(\text{Fe}^{2+} + \text{Mn})$ line, indicating the compositional variation between Mg and Fe^{2+} . The Mg/Fe^{2+} ratios range from 0.46 to 0.77. No Al^{VI} or only small amount of Al^{VI} was calculated in biotites from rocks containing both biotite and hornblende unaffected by residual liquid. This fact is consistent with chemical composition of some host granodiorite in which normative Di appears. On the other hand, Al^{VI} of 0.26 per formula unit was calculated in biotite from rock free from hornblende affected by the residual liquid.

CHEMICAL COMPOSITION OF HORNBL-ENDES

Four hornblendes separated from the host rocks were chemically analysed. The chemical analyses, structural formulas calculated on the basis of 24 (O, OH), and

Table 3. Chemical compositions of hornblendes from granitic rocks of the Okeuyama batholith.

No.	Oks-1	Oks-2	Oks-3	Oks-4
Chemical analyses*				
SiO_2	44.97	45.98	45.84	47.97
TiO_2	2.31	1.67	2.02	0.94
Al_2O_3	6.40	6.65	5.86	4.85
Fe_2O_3	4.20	3.64	2.85	3.21
FeO	19.58	18.05	19.22	18.53
MgO	9.14	9.81	9.15	10.13
MnO	0.71	0.59	0.74	0.77
CaO	9.30	9.32	11.37	10.85
Na_2O	1.28	1.40	1.02	0.91
K_2O	0.57	0.95	0.47	0.33
H_2O^+	1.96	1.76	1.94	1.88
H_2O^-	0.12	0.32	0.06	0.16
P_2O_5	0.02	0.03	0.02	—
Total	100.56	100.17	100.56	100.53
Structural formulae				
Si	6.830	6.977	6.942	7.214
Al^{IV}	1.149	1.023	1.046	0.786
Fe^{+3}	0.021	—	0.012	—
Z	8.000	8.000	8.000	8.000
Al^{VI}	—	0.161	—	0.072
Ti	0.264	0.191	0.227	0.108
Fe^{+3}	0.462	0.419	0.316	0.361
Fe^{+2}	2.489	2.286	2.438	2.330
Mg	2.070	2.213	2.065	2.266
Mn	0.091	0.073	0.091	0.099
Y	5.376	5.343	5.137	5.236
Ca	1.512	1.505	1.820	1.716
Na	0.374	0.410	0.291	0.262
K	0.109	0.182	0.091	0.063
X	1.995	2.097	2.202	2.041
OH	1.988	1.785	1.965	1.887
<i>mg</i>	0.406	0.446	0.422	0.451
Mg/Fe^{+2}	0.83	0.97	0.85	0.97
<i>index</i> α	1.659	1.658	1.660	1.660
γ	1.678	1.676	1.677	1.677
$\chi^{\text{Bi-Hor}}$	0.76	0.73	0.91	0.75

optical properties are tabulated in Table 3.

Fig. 5 shows the relation between Al^{IV} and ($\text{Al}^{\text{VI}} + \text{Fe}^{3+} + \text{Ti}$) of analyzed hornblendes. The hornblendes fall within the common hornblende field. Following to decrease of Al^{IV} , the plotted points are aligned from the common hornblende field toward the tremolite end member. No Al^{VI} or only small amount of Al^{VI} was calculated in the hornblendes, as the same as the case in the coexisting biotites. Mg/Fe^{2+} ratio ranges from 0.83 to 0.97, and is larger than

Fig. 5 Chemical variation of the calcium-rich amphiboles expressed as the numbers of $(\text{Al}^{\text{VI}} + \text{Fe}^{3+} + \text{Ti})$ and Al^{IV} atoms per formula unit.

that of the coexisting biotites. $\text{Fe}^{3+}/\text{Fe}^{2+}$ ratio (0.13–0.19) of the hornblendes is approximately similar to that (0.14–0.26) of the coexisting biotites. This fact may suggest that no change had occurred in the oxygen partial pressure in the magma during crystallization of coexisting hornblende and biotite.

DISTRIBUTION OF Fe^{3+} AND Mg IN COEXISTING BIOTITES AND HORNBLENDES

Most of granitic rocks of the Okueyama granodiorite batholith have coexisting biotite and hornblende pairs. The distribution coefficients of Fe^{3+} and Mg , $K_D = (X^{\text{Bt}}/1 - X^{\text{Bt}})/(X^{\text{Hbl}}/1 - X^{\text{Hbl}})$, in the analyzed biotite and hornblende pairs are listed in Table 3. Here, X^{Bt} and X^{Hbl} are $\text{Mg}/(\text{Mg} + \text{Fe}^{2+})$ mole fractions of biotite and hornblende, respectively.

The distribution coefficient of the biotite and hornblende pair from the rock containing calcite, No. Oks-3, indicates a relatively

higher value, but that of the other three pairs ranges from 0.73 to 0.76. Kanisawa (1972) has shown that the distribution coefficient of Fe^{2+} and Mg in the biotite and hornblende pairs from granitic rocks in the Kitakami Mountainland, northeast Japan, is uniform in respective intrusive bodies. Judging from this, most of the Okueyama granodioritic rocks were equilibrated during formation of the batholith. The distribution coefficients of the analyzed biotite and hornblende pairs are similar to those from the Kitakami granitic rocks (Kanisawa, 1969, 1972; Kato, 1972, 1974; Kato and Tanaka, 1973, Kato *et al.* 1977, and Tanaka, 1975), but are smaller than those from the Ryoke granitic rocks of the Takato district, Central Japan (Kanisawa, 1975).

The Mg/Fe^{2+} ratios of the analyzed biotites and hornblendes from the Okueyama granitic rocks are smaller than those from the Kitakami granitic rocks, while, those of the analyzed hornblendes are similar to those from the Ryoke granitic rocks (Kanisawa, 1975). The Al^{IV} -content of the analyzed hornblendes is smaller in amount than that of hornblendes from the Ryoke granitic rocks, but similar to that of hornblendes from the Kitakami granitic rocks. The Niggli's *mg* values of the analyzed host granodiorites are higher as compared to those of the Kitakami and Ryoke rocks (Fig. 6). These facts indicate that either Mg/Fe^{2+} ratio or Al^{IV} -content or both in the hornblendes is not only affected by bulk composition of their host rocks, but also by physical conditions during crystallization of hornblende.

Fig. 6 shows a relationship between the *mg* values of the coexisting biotites and hornblendes and those of their host granitic rocks. In the Kitakami granitic rocks, biotites rather than hornblendes are plotted

Fig. 6 Relationship between *mg* values of coexisting biotites and hornblendes and those of their host granitic rocks.

○; Hornblendes from the Okueyama granodiorite ●; Biotites from the Okueyama granodiorite ⊙; Hornblendes from the Kitakami granitic rocks ⊙; Biotites from the Kitakami granitic rocks ●; Hornblendes from the Ryoike granitic rocks.

in an area near the 1:1 line, suggesting that the biotites are compositionally affected by the bulk composition. In the Ryoike granitic rocks, hornblendes are closely plotted on the same line, suggesting that the hornblendes are compositionally affected by the bulk composition. In the case of the Okueyama granodiorite, both the analyzed biotite and hornblende pairs fall in an area near the line, except for a pair No. Oks-4 which was affected by the residual liquid. These facts suggest that the chemical composition of both the biotites and hornblendes was controlled on the bulk composition of host rocks in an earlier stage during the formation of the Okueyama batholith.

Kanisawa (1971) has reported that the Al^{IV} - and Al^{VI} -contents of hornblendes from granitic rocks associated with volcanic rocks in the Kitakami Mountainland are

smaller in amount than those unassociated with volcanic rocks in other regions. Those of the analyzed hornblendes of the Okueyama batholith are also small. It is suggested, that hornblendes from granitic rocks which were formed in a state of the volcano-plutonic complex are poorer in the Al^{IV} - and Al^{VI} -content as compared to those from granitic rocks without the activity of the volcano-plutonic complex.

CONCLUSION

Chemical compositions of coexisting biotite and hornblende pairs and their host granitic rocks of the Shishigawa-type of the Okueyama granodiorite batholith were investigated in the present study. The batholith is apparently one which was formed by a volcano-plutonic complex activity, as reported by Hashimoto and Miyahisa (1959). The difference in chemical composition between granitic rocks of the southern part and those of the northern part in the batholith is characterized by the fact that the granitic rocks in lower elevation of the southern part are poorer in SiO_2 than those in higher elevation of the northern part. It is suggested that the latter was affected by the residual liquid which was derived throughout differentiation of magma of the Okueyama granodiorite.

Chemical compositions of analyzed biotites and hornblendes indicate that both minerals are poor in Al, and Mg/Fe^{+2} ratios of these minerals are low in spite of the host granitic rocks have high Niggli's *mg* value. The average distribution coefficient for Mg and Fe^{+2} of the coexisting biotite and hornblende pairs is 0.75.

Chemical compositions of the analyzed biotites and hornblendes from the Okueyama granitic rocks were compared to

those from the Kitakami and the Ryoke granitic rocks. As compared to the Kitakami granitic rocks, the analyzed biotites and hornblendes have the lower Mg/Fe^{2+} ratios, and the host rocks have the higher mg value. On the other hand, as compared to the Ryoke granitic rocks, the analyzed hornblendes have the lower Al^{IV} -content, and the host rocks have the higher mg value. The compositional features of the analyzed biotites, hornblendes and host granitic rocks suggest that the Okueyama grandiorite would have been a product by a volcano-plutonic complex activity. Similar studies are expected to clarify the genesis of many granitic intrusive rocks containing both biotite and hornblende in the Outer Zone of Southwest Japan.

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大崩山花崗閃緑岩中の共存する黒雲母・角閃石の化学組成について

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大崩山花崗閃緑岩体の鹿川地域における花崗岩とそこに共生する黒雲母と角閃石を化学分析し考察をおこなった。

この地域の花崗閃緑岩の化学組成は SiO_2 量において 10% に及ぶ変化を示し、この変化はマグマの結晶分化作用によって生じたものである。

花崗閃緑岩中の黒雲母と角閃石とも Al が少なく、 Mg/Fe^{+2} 比が小さい。 Mg と Fe^{+2} の平衡定数 $K_D^{\text{Bi-Hor}} = 0.75$ である。黒雲母、角閃石を領家、北上の花崗岩質岩類中のものと比較すると、その化学組成は、火山-深成岩複合火成作用によってできた花崗岩質岩類中のものに近い。