BIOTITE CRYSTALS FROM THE MYŌGŌ-HŌ, MIYAGI PREFECTURE, JAPAN*

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ABSTRACT

The biotite crystals described in this paper are found as an ingredient mineral of hornblende biotite granite exposed on Myōgō-hō, Kawasaki-machi, Shibata-gun, Miyagi Prefecture. They are also contained abundantly in the sand derived from the weathered rock. These crystals occur as six-sided short prisms or plates. Hardness: 2.5~3. Colour: brownish black with brownish streak. Indices of refraction: $\alpha=1.620\sim1.621$, $\beta=1.658$, $\gamma=1.658\sim1.659$. Further, they are characterized by the small optic angle [$(-)\angle 2V\approx 0^\circ$] and weak dispersion ($v > \rho$). A chemical analysis gave the following result for this mineral: SiO₂ 33.92, TiO₂ 2.91, Al₂O₃ 13.88, Fe₂O₃ 3.39, FeO 26.66, MnO 1.35, MgO 4.86, CaO 0.75, K₂O 7.46, Na₂O 1.70, H₂O (+) 3.53, H₂O (-) 0.16, total 100.57%. Moreover, the X-ray powder diagram of this specimen agrees with that of biotite rich in ferrous iron on its octahedral layer.

Introduction

In the summer of 1950, some biotite crystals were obtained by one of the writers (H.M.) from Myōgō-hō, Kawasaki-machi, Miyagi Prefecture** (Fig. 1). Some specimens from this locality do not expand by heating and appear fresh under the microscope. They have

* Dedicated to Dr. S. Tsuboi, Emeritus Professor of the University of Tokyo, on the occasion of his sixtieth birthday.

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Fig. 1. Map showing the locality of biotite (x).

of this biotite crystal, is situated in the outer zone of the northeastern part of the Zaō volcanic area and is accessible from the Shiroishi or Oogawara station of the Tōhoku Railway Line *via* the Gaga hot spring. It is built up, at the western part of the area, of hornblende biotite granite which is covered by the olivine-bearing two-pyroxene andesite and its ejecta erupted from the Zaō volcano.³⁾ Biotite crystals are found on the summit where the granite is disintegrated into sands and gravels. They are found together with feldspar and hornblende which are also component minerals of the granite.

been investigated by the optical and chemical as well as by the X-ray powder method.

This paper is dedicated to Emeritus Professor Seitaro Tsuboi who has carried out interesting investigations on the biotite in the granitic rocks in Japan.⁵⁾

Occurrence

Myōgō-hō, the locality

Fig. 2. Photograph of the biotite crystals from Myōgō-hō.

Petrography of hornblende biotite granite

It shows a granular texture, with a porphyritic appearance due to the presence of large microcline crystals ($2 \times 0.7 \times 0.7$ cm). Main

component minerals are biotite, orthoclase, with sporadic microcline structure, plagioclase and granular quartz; and they are associated by a small amount of hornblende and minute crystals of iron oxide mineral, zircon, allanite, etc.. The chemical analysis (by Minato in 1954) follows, SiO_2 69.48, TiO_2 0.61, Al_2O_3 15.35, Fe_2O_3 1.97, FeO 2.68, MnO 0.39, MgO 0.77, CaO 3.09, K_2O 2.99, Na_2O 1.54, P_2O_5 0.22, H_2O (+) 1.03, H_2O (−) 0.29, total 100.41%. Hence, the mother rock is rather rich in iron and calcium but poor in alkalis as compared with normal granites; this may be due to the abundance of biotite and plagioclase.

General characters

The biotite crystals from Myōgō-hō, brownish black in colour, have a six-sided short prismatic or platy form, occurring frequently together with quartz and feldspar which are attached to the surface of the samples and also found as inclusions. In addition, there are minor inclusions of magnetite and zircon. Observed forms are $c(001)$, $b(010)$ and $m(110)$, with a perfect cleavage parallel to (001) and a parting parallel to (010) . The hardness is 2.5~3. Their cleavage flakes have a brownish gray colour and are very flexible.

Optical properties

Seven crystals were optically investigated. Of these, six crystals used for chemical analysis gave the following indices of refraction:

$$\alpha=1.620, \beta=1.658, \gamma=1.658, \gamma-\alpha=0.038 \text{ and } (-)2V \text{ nearly } 0^\circ.$$

The refractive indices β and γ were measured on six crystals and α was determined on two of the large crystals, and all of them gave the same results. The similar indices of refraction are also shown by the other remaining crystal, viz.,

$$\alpha=1.621, \beta=1.658, \gamma=1.659.$$

Dispersion ($v > \rho$) is weak. They are strongly pleochroic, viz., $X=$

pale brown or yellow, Y=dark brown, Z=dark brown. X is nearly normal to (001).

Chemical composition

Material for chemical analysis was obtained by a hand sorting method from the thin cleavage flakes under the binocular microscope. Before the chemical analysis was carried out, they were examined under the petrographic microscope with high-power objective. The examination showed that the material contained no appreciable amount of impurity. Moreover, six crystals, as mentioned above, have the same optical properties. They were chemically analysed by means of semi-micro methods. The results are given in Table 1, and the atomic ratio was calculated from the weight

Table 1. Chemical analysis and atomic composition of the biotite crystal from Myōgō-hō.

	Wt. %	Mol. prop.	Atom. ratio
SiO ₂	33.92%	.565	Si 2.76 } 4.00
TiO ₂	2.91	.036	Al 1.24 }
Al ₂ O ₃	13.88	.135	
Fe ₂ O ₃	3.39	.021	Al 0.08 }
FeO	26.66	.371	Ti 0.18 }
MnO	1.35	.019	Fe ⁺³ 0.21 } 2.96
MgO	4.86	.121	Fe ⁺² 1.81 }
CaO	0.75	.013	Mn 0.09 }
K ₂ O	7.46	.079	Mg 0.59 }
Na ₂ O	1.70	.027	Ca 0.06 }
H ₂ O (+)	3.53	.196	K 0.77 } 1.09
H ₂ O (-)	0.16	.010	Na 0.26 }
Total	100.57		

Analysed by H. Minato. (1954)

percentage. Chemical formula is given as (Ca_{0.06} Na_{0.26} K_{0.77}) (Ti_{0.18} Mn_{0.09} Mg_{0.51} Fe⁺²_{1.81} Fe⁺³_{0.21} Al_{0.08}) (Al_{1.24} Si_{2.76}) O₁₀ (OH)_{2.00}. It shows fair agreement with the chemical analysis of some

biotite crystals contained in granitic rocks from Nada-mura, Yamaguchi Prefecture and Sanage-yama, Aichi Prefecture, as reported by Tsuboi, Sugi and Iwao.⁵⁾

X-ray investigation

Carefully hand-sorted material of this biotite was used for the experiment of X-ray powder method by means of Philips "Norelco" X-ray spectrometer. The observed intensities and measured spacings are listed in Table 2 together with those by Nagelschmidt⁴⁾ for comparison. The values are also compared with the indices and calculated values, and a close agreement was found between them. The facts that the spacing of (060) is observed in 1.529 Å and not in 1.50 Å, and the intensity of (002) reflection appears weak, suggest the specimen to be a trioctahedral mica such as biotite^{2) 6)}. Furthermore, that the intensity of (003) reflection is stronger than that of (005) is one of the characteristics of the high ferriferic type of octahedral layer in mica mineral²⁾. According to the consideration on the order of the intensities (Cu K α) observed on (00 l) reflections, such as (001), (003), (005), (002) and (004), the biotite specimen of this locality has the ratio of Mg/Fe between 1/2 and 1/5 in the octahedral layer. The result agrees fairly well to the value of 1/3 obtained by the chemical analysis. The correlation between the intensity of (00 l) reflection and the ratio of Mg/Fe has been attempted by Grim, Bradley and Brown.¹⁾

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Table 2. X-ray powder data of biotite.

Myōgō-hō				after Nagelschmidt ⁴⁾		Calculated value	
I(CuK α)*	d	I(FeK α)**	Q obs.	I(FeK α)**	Q obs.	Q calc.	(hkl)
18	14.17 Å	55	0.0047				
25	11.81	63	0.0081				
100	10.16	100	0.0096	vs	0.0098	0.0098	(001)
26	5.01	24	0.0386			0.0392	(002)
		24	0.0464	w	0.0477	0.0480	(110)
		26	0.0642				
24	3.72	42	0.0729				
		31	0.0797				
100	3.75	31	0.0884	vs	0.0886	0.0880	(003)
23	3.20	28	0.0989	vw	0.1008		
21	2.95	26	0.1166	vw	0.1181	0.1144	(103)
22	2.65	38	0.1426	s	0.1424	0.1448	(200)
37	2.519	37	0.1576	w	0.1587	0.1564	(004)
21	2.447	34	0.1654	s	0.1666	0.1664	(211)
		26	0.1924	vv	0.1920	0.1920	(220)
		(28	0.2024				
20	2.184	30	0.2079	s	0.2099		
29	2.013	36	0.2463	s	0.2495	0.2450	(005)
18	1.920	24	0.2548	vw	0.2738		
18	1.830	26	0.2912				
		23B	0.3146	vw	0.3257		
23	1.677	(27	0.3452				
		37	0.3551	s	0.3577	0.3528	(006)
20	1.550	37	0.4083		0.4156		
20	1.529	26	0.4283	s	0.4288	0.4248	(060)
		24	0.4535	vw	0.4577		
20	1.438	28	0.4824	vw	0.4904		
17	1.418						
17	1.409	24	0.5074				
		26	0.5252				
		30	0.5337	w	0.5399		
17	1.314	27	0.5741	w	0.5618		
17	1.304	25	0.5862	w	0.5827		
17	1.258	26	0.6309				
		(24	0.7418				
		24	0.7457				
		23B	0.7599				
		24B	0.7722				
		23B	0.7764				
		23B	0.7776				
		23	0.7930				
		23	0.7974				

B: Broadly spreading band

*) "Norelco" X-ray spectrometer CuK α_1 , $\lambda=1.54050$ Å. No filter. slit 1°, 0.006", 1° Scanning speed 2°/min. Scalefactor 4. Multiplier 1. Time constant 4 sec.

**) "Norelco" X-ray spectrometer FeK α_1 , $\lambda=1.93597$ Å. No filter. slit 4°, 0.006", 4° Scanning speed etc. are the same as above.

REFERENCES

- 1) Bradley, G. W.: X-ray Identification and Crystal Structures of Clay Minerals (London), 163 (1951).
- 2) Grim, R. E.: Clay Mineralogy (New York), 93 (1953).
- 3) Ichimura, T.: Bull. Earthq. Res. Inst., **29**, 327 (1951).
- 4) Nagelschmidt, G.: Zeit. Krist., **97**, 514 (1937).
- 5) Tsuboi, S., K. Sugi and S. Iwao: Jour. Geol. Soc. Jap., **45**, 453 (1938).
(in Japanese)
- 6) Walker, G. F.: Miner. Mag., **28**, 73 (1953).

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