D/H FRACTIONATION OF COEXISTING BIOTITE AND HORNBLende IN TABITO COMPOSITE MASS, ABUKUMA PLATEAU, JAPAN

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Tabito composite mass consists of two groups of intrusions, e.g. the older (Myōjin-ishi quartz-diorite and gabbro) and the younger (Komuro quartz-diorite and Iritabyūto granodiorite). The equilibrium relationship is recognized on $\delta D-X_{F_2}$ plots of coexisting biotite-hornblende pairs. δD value of water in magma coexisted with biotite and hornblende in the younger group is estimated to be almost similar to that for the granitic masses in the Kitakami mountainous district (-29 to -37 ‰), while that in the older group is clearly lighter (-40 to -55 ‰).

INTRODUCTION

Kuroda *et al.* (1974) found that coexisting pairs of biotite and hornblende from the Cretaceous granitic rocks in the southern Kitakami mountainous district are in equilibrium with respect to hydrogen isotope exchange. On this basis δD value of the ambient water equilibrated with biotite and hornblende in these rock masses was estimated to be -29 to -37‰. Further investigation on the Cretaceous granites in the northern Kitakami mountainous district revealed that δD values of most of biotite were slightly higher than those of coexisting hornblende. Although this fact was accounted for the incomplete quenching of biotite-water equilibrium, δD value of the water in magma of the granites was estimated to be almost similar to that of the southern Kitakami granitic rocks (Kuroda *et al.* 1975 a).

On the other hand, the δD value of the

water in the Paleogene granitic magma of the Miyazu mass in Southwest Japan was estimated to be -60 to -65‰, which is quite different from that of the Kitakami mountainous district Kuroda *et al.* 1975 b).

In the Abukuma plateau there are many granitic masses as in the Kitakami mountainous district. Those of both districts have been called Cretaceous granites in northeast Japan. Their K-Ar ages are the same each other, ranging 90 to 110 m. y. (Kawano and Ueda 1965 a, b). Our interest extended to investigate D/H fractionation of coexisting biotite and hornblende and to estimate δD value of water in magma of the Abukuma granitic masses in relation to the Kitakami granitic masses.

OUTLINE OF GEOLOGY

In the Gosaisho-Takanuki district of the Abukuma plateau there are various kinds of granitic rocks. Among them the

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Tabito mass has a relatively simple construction and is situated at the boundary of Area I and II of the Gosaisho-Takanuki metamorphic rocks (Kano *et al.* 1973). Rb-Sr age for biotite of the mass was reported to be 92 m.y. (Ueno 1968) and Rb-Sr isochron age of whole rocks was given to be 150 m.y. (Maruyama 1972).

Tabito composite mass is composed of four rock types with the following succession of intrusion; Myōjin-ishi quartz-diorite, gabbro, Komuro quartz-diorite and Iritabyūto granodiorite (Fig. 1) (Tanaka 1974).

Myōjin-ishi quartz-diorite is composed of biotite, hornblende, plagioclase and quartz, and often contains cummingtonite and clinopyroxene. K-feldspar is found in an about half of the collected specimens. Gabbro has a wide variation in constituent minerals and texture. It often shows cordilleritic texture and composition, but in any facies biotite and hornblende are included. Komuro quartz-diorite consists of biotite, plagioclase and quartz. Hornblende is often found, but K-feldspar, cummingtonite, clinopyroxene and orthopyroxene are never found. Iritabyūto granodiorite, which is the main facies of the Tabito mass, is composed of biotite, hornblende, plagioclase, K-feldspar and quartz. In the Iritabyūto granodiorite dark inclusions (several *cm* to several *m* in size) of various shapes are found and they are similar to the Komuro quartz-diorite in petrographical characters. The intrusion of Iritabyūto granodiorite is followed by the intrusion of aplite and pegmatite.

RESULTS AND DISCUSSION

Three pairs of hornblende and biotite from Myōjin-ishi quartz-diorite, a pair from

gabbro, three pairs from Komuro quartz-diorite, two pairs from Iritabyūto granodiorite, two of biotite from Iritabyūto granodiorite and aplite, and three pairs from dark inclusions were separated and analyzed (Tanaka 1975). The locality of these specimens is shown in Fig. 1 and the analytical result is listed in Table 1.

Fig. 1. Geological sketch map and locality of specimens studied.

1: country metamorphic rocks, 2: Myōjin-ishi quartz-diorite, 3: gabbro, 4: Komuro quartz-diorite, 5: Iritabyūto granodiorite. Numbers are the same as those in Table 1.

As seen in tie-lines on $\delta D-X_{Fe}$ plots in Fig. 2, all the mineral pairs except No. 3 show nearly equilibrium relationship with respect to D/H fractionation given by Suzuoki and Epstein (1970, 1972), as was previously found in southern Kitakami mountainous district (Kuroda *et al.* 1974).

Table 1. Analytical results and pertinent chemical informations of biotite and hornblende from the Tabito composite mass.

	SiO ₂ % w.r.	biotite			hornblende		
		H ₂ O wt.%	δD ‰	X _{Fe}	H ₂ O wt.%	δD ‰	X _{Fe}
No.1	54.61	3.70	-84.7	0.50	2.09	-77.6	0.43
3	55.53	3.83	-66.2	0.45	1.96	-66.2	0.38
4	56.82	3.15	-74.0	0.49	1.85	-63.1	0.44
13	49.74	3.85	-73.9	0.49	1.95	-71.0	0.45
19	55.98	3.70	-63.4	0.45	2.17	-55.8	0.38
20	56.76	3.38	-60.7	0.51	1.99	-49.7	0.45
21	58.07	4.09	-68.8	0.53	2.10	-64.1	0.48
23	59.92	4.53	-74.4	0.52	1.91	-73.1	0.49
26	63.98	3.11	-70.5	0.57	1.79	-65.1	0.52
32	69.38	3.44	-70.3	0.57			
34	71.60	4.61	-72.4	0.60			
37	46.98	4.12	-71.5	0.50	2.03	-51.9	0.48
41	61.97	3.31	-72.2	0.57	1.88	-62.3	0.53
42	55.56	3.40	-66.0	0.52	1.96	-60.0	0.48

Nos. 1: 7281409 (Myōjin-ishi), 3: 7272011 (Myōjin-ishi), 4: 7272613 (Myōjin-ishi), 13: 80204 (gabbro), 19: 7272216 (Komuro), 20: 7272315 (Komuro), 21: 51505 (Komuro), 23: 7272307 (Iritabyūto), 26: 51506 (Iritabyūto), 32: 72017 (Iritabyūto), 34: 7281506A (aplite), 37: 7281511A (dark inclusion), 41: 7331402B (dark inclusion), 42: 7372404B (dark inclusion).

The tie-lines of biotite and hornblende pairs observed are comparatively parallel to the equilibrium line or show slight shift

toward relative depletion of deuterium in biotite. The latter case can be reasonably expected as a result of crystallization of biotite in later stage (lower temperature) than that of hornblende.

However, specimens of Nos. 3 and 37 (Table 1) are far from equilibrium relationship. These two examples can be attributed to the locality of No. 3 being at the very contact with country metamorphic rocks and the xenolithic occurrence for No. 37.

As reported by Tanaka (1974), the main

Fig. 2. Relationship of δD and X_{Fe} of biotites and hornblendes.

1: hornblendes from Komuro quartz-diorite and Iritabyūto granodiorite, 2: hornblendes from dark inclusions, 3: hornblendes from Myōjin-ishi quartz-diorite and gabbro, 4: biotites.

Broken line is Suzuoki-Epstein's experimental line (see Kuroda et al. 1975a).

facies of the Tabito mass is Iritabyūto granodiorite. The tie-line of pairs in Iritabyūto mass is apparently in low δD range of Komuro mass and/or high δD range of Myōjin-ishi quartz-diorite. As seen in Fig. 2, the δD of pair of specimen No. 23 is almost the same as δD of biotites from Nos. 34 and 32 which are separated from aplite and biotite-granite in this mass. On this basis, it can be rather inferred that the pairs of Iritabyūto granodiorite were equilibrated under comparatively low temperature with the same water as that of Komuro quartz-diorite.

Regarding the tie-line of pairs from dark inclusions in Iritabyūto granodiorite, the hornblendes are found to be the same region as those of Komuro quartz-diorite, while biotites are in the same region as those of Iritabyūto granodiorite. This finding is quite consistent to petrological similarity in Komuro quartz-diorite and dark inclusion pointed by Tanaka (1974). On the other hand, biotite could be relatively depleted in its deuterium content as a result of reequilibration of these inclusion with the host rock (Iritabyūto granodiorite) after their xenolithic situation was attained, when it is taken into account that the biotite is subject to follow the change in ambient chemical and thermal condition.

There is no petrological evidence to indicate definitely a difference in temperature of formation among these rocks (Iritabyūto, Myōjin-ishi and gabbro). Providing that the highest temperature of formation of these rocks is the same as that of Kitakami granitic masses, δD of the water in magma of Komuro and Iritabyūto rocks can be estimated to be -29 to -37‰ which is fairly agreed with that of Kitakami masses, and the formation temperature of biotite and hornblende in Iritabyūto rocks

can be also estimated to be as low as $450\sim 550^{\circ}\text{C}$.

On the other hand, as seen in Fig. 2, the observed over-all range of δD variation for hornblendes is too large to attribute only to the variability in temperature of equilibration with an ambient water with same δD . Providing also the same formation temperature as Komuro quartz-diorite δD of the water in magma of Myōjin-ishi quartz-diorite and gabbro can be estimated to be -43 to -51‰ .

The result of D/H fractionation study on Tabito composite mass presented here shows that δD of coexisting water in crystallization process of the older rocks Myōjin-ishi quartz-diorite and gabbro is lower than that of younger rocks—Iritabyūto granodiorite and Komuro quartz-diorite of Cretaceous age.

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阿武隈山地、田人複合岩体中の共存する黒雲母と角閃石の D/H

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田人複合岩体は明神石石英閃緑岩 (1), はんれい岩 (2), 小室石英閃緑岩 (3), 入旅人花崗閃緑岩 (4) の4つの岩相からなる。共存する黒雲母、角閃石の D/H から考察すると、4岩相のうち、1と2、3と4の2つに区分され、後者はほぼ完全な平衡型で、そのマグマの水は北上山地の場合と同じく、-29~-37‰と考えるとさしつかえない。前者もほぼ平衡型と見なしてよいが、その

場合のマグマの水は -43~-51‰と、はるかに低い値を示す。このことは、後者は東北日本の白亜紀の花崗岩の一連のものであることを示し、前者はそれよりも古い別の花崗岩であったことを示すものであろう。また、平衡型でない対をもつ岩石は、それぞれ捕獲岩であるか、変成岩に直接接触する特別なものとして解釈される。