Bull. Natn. Sci. Mus., Ser. C (Geol.), 3 (3), September 22, 1977

Metasomatic Titan-biotite in Quartz Syenite Porphyry from Dōzen, Oki Islands

By

Tokiko Tiba

Department of Geology, National Science Museum, Tokyo

Three islands of Dōzen (Oki Islands) are made up mainly of alkaline rocks yielded by Pliocene volcanism on the basement Neogene sedimentary rocks. On Nishi-no-shima, the largest island of Dōzen, quartz syenite is found as two masses at the northern foot of the central cone in the southward projection from the middle of the island (Tiba, 1975). The both masses are bounded on the north by the Neogene sedimentary rocks and on the south by the central cone glassy trachyte lava. Occurrences of sandstone hornfels around the northeastern mass (Kôzu, 1913; Shimoma, 1928; Tiba, 1975) and quartz syenite blocks as volcanic breccia at the western foot of the central cone suggest that intrusion of quartz syenite had taken place prior to Pliocene volcanism.

The principal rock of the both masses is hornblende quartz syenite. In the northeastern mass, hornblende quartz syenite gradually passes into titan-biotite quartz syenite porphyry near the contact with the central cone lava. Such a transition is restricted to the case mentioned above. Any noticeable changes of mineralogy are not observed near the contact with the sedimentary rocks.

Hornblende quartz syenite, the principal rock of the both masses, is megascopically medium-grained and compact. Dark green hornblende is scattered in the light gray matrix. Microscopically the rock shows even-grained mosaic texture. It consists chiefly of various-shaped alkali feldspar with exsolved patches, subhedral brownish green hornblende, plagioclase, irregular-shaped magnetite and interstitial quartz. A small amount of reddish brown titan-biotite and secondary calcite are also present. Accessory minerals are zircon, allanite, apatite and limonite.

Bulk of the titan-biotite quartz syenite porphyry is compact and pale green in color. Sporadic thick clusters of dark brown titan-biotite characterize the rock. In thin sections, the rock is rather porphyritic and finer in grain size than the hornblende quartz syenite. Major constituent minerals are alkali feldspar, titan-biotite, plagioclase, quartz and magnetite. All these minerals but titan-biotite occur in forms similar to those in the hornblende quartz syenite Aggregates of granular apatite, magnetite and calcite are often found Calcite grains of various sizes stain the rock ubiquitously.

Chemical analyses and CIPW norms of the hornblende quartz syenite and the titan-biotite quartz syenite porphyry are set in Table 1. Each rock contains nearly identical amounts of Na_2O and K_2O. The hornblende quartz syenite is richer in SiO_2 and alkalies than the titan-biotite quartz syenite porphyry. Al_2O_3 content is almost identical in the both rocks. All the orther oxides are richer in the titan-biotite quartz syenite porphyry. As for the CIPW norms, the hornblende quartz syentite is

Table 1. Chemical analyses and CIPW norms of quartz syenites

	1	2		1	2
SiO_2	63.88	53.90	Q	2.07	—
TiO_2	0.47	1.85	or	35.45	26.55
Al_2O_3	17.56	17.47	ab	50.23	36.75
Fe_2O_3	0.32	2.02	ne	—	1.39
FeO	2.96	4.60	an	3.56	13.55
MnO	0.12	0.18	di wo	0.80	3.09
MgO	0.15	2.28	di en	0.06	1.74
CaO	1.18	5.02	di fs	0.83	1.23
Na_2O	5.94	4.65	hy en	0.31	2.76
K_2O	6.00	4.49	hy fs	3.79	2.17
H_2O+	1.02	2.06	mt	0.46	2.94
H_2O-	0.24	0.59	il	0.90	3.52
P_2O_5	0.06	0.61	ap	0.13	1.44
Total	99.90	99.72			

Analyst: T. Tiba
1. Hornblende quartz syenite.
2. Titan-biotite quartz syentite porphyry.

Q normative but the titan-biotite quartz syenite is *ne* normative. Contradiction between appearances of modal quartz and normative *ne* in the titan-biotite quartz syenite porphyry may have been brought about by crystallization of titan-biotite which is poorer in SiO_2 and richer in alkalies than the hornblende. Noted difference of chemical compositions in these two rocks implies that the glassy trachyte gave not only thermal but also metasomatic effect on the quartz syenite mass. Metasomatic effect on the quartz syenite is represented by extraction of SiO_2 and alkalies or addition of TiO_2, Fe_2O_3, FeO, MnO, MgO, CaO, H_2O+ and P_2O_5.

Titan-biotite

The titan-biotite in the titan-biotite quartz syenite porphyry occurs as planar clusters of subhedral flaky crystals up to 1.5 mm across. It includes minute granules of magnetite and apatite. Irregular-shaped, fine grains of magnetite are scattered sparsely around the ragged outlines of titan-biotite crystals.

Titan-biotite has a pleochroic nature, peculiar to titan-biotite, from light copper red or light vermilion to pale brown or straw-yellow. The X-ray powder patterns of the mineral give the unit cell parameters: a=5.35 Å, b=9.25 Å, c=10.19 Å, $\beta=$

100.2°.

Chemical analysis and atomic ratios on an anhydrous basis of O=22 are given in Table 2. The present titan-biotite is considerably poor in Si and Al. The high Ti content is common with the titan-biotites in the tristanites and trachytes (TIBA, 1972) or titan-phlogopite in the trachybasalt (TIBA, 1976) of the Dōzen volcano. Slightly low $Fe^{3+}/(Fe^{3+}+Fe^{2+})$ ratio distinguishes this titan-biotite from those in the tristanites and trachytes. From the atomic ratios, following molecular proportions (TIBA, 1976) are gained: margarite 6.0%, phlogopite 77.1%, Ti_4-mica 9.1% and Ti_3-mica 7.8%.

Table 2. Chemical analysis of titan-biotite

	wt%	atomic ratios on O=22		
SiO_2	36.41	Si	5.400	8.000
TiO_2	6.79	Al	2.400	
Al_2O_3	13.73	Fe^{3+}	0.200	
Fe_2O_3	2.54	Fe^{3+}	0.083	5.445
FeO	15.85	Ti	0.757	
MnO	0.22	Fe^{2+}	1.965	
MgO	11.82	Mn	0.028	
CaO	0.75	Mg	2.612	
Na_2O	1.00	Ca	0.119	1.992
K_2O	8.38	Na	0.287	
H_2O+	2.38	K	1.586	
H_2O-	0.25			
Total	100.12	$\beta_{max}=1.667$		

Analyst: H. Ônuki

The present titan-biotite has a quite similar chemistry to those of titan-biotite phenocrysts in the volcanic rocks of Dōzen. This implies that crystallization of titan-biotite favorably occurs both in a SiO_2-undersaturated environment (represented by titan-biotite quartz syenite porphyry) at a near surface level and SiO_2-oversaturated environment (represented by titan-biotite tristanites and trachytes) at slightly deep levels, as it is expected that crystallization of this metasomatic titan-biotite must have proceeded under lower P-T conditions than those when phenocrystic titan-biotites were formed.

Acknowledgments

The author is greatly indebted to Dr. Mitsuo HASHIMOTO for critical reading of the manuscript. She also thanks Dr. Hitoshi ŌNUKI for chemical analysis and Dr. Akira KATO and Mr. Satothi MATSUBARA for X-ray study of the titan-biotite.

References

KōZU, S. 1913. Petrological notes on some igneous rocks of the Oki Islands. *Sci. Rep. Tohoku Univ., Ser. II*, **1**; 25–59.

SHIMOMA, T. 1928. On alkali trachyte dikes in Dozen, Oki Islands. *Chikyu* [*Globe*], **9**: 433–439 [in Japanese].

TIBA, T. 1972. Titaniferous biotites and associated phenocrysts in dike rocks from Dozen, Oki Islands. *Japan. Assoc. Min. Pet. Econ. Geol.*, **67**: 357–369.

TIBA, T. 1975. Geology of Dōzen, Oki Islands. *Bull. Natn. Sci. Mus., Ser. C*, **1**: 137–145 [in Japanese with English abstract].

TIBA, T. 1976. Amygdale titan-phlogopite from Dōzen, Oik Islands. *Ibid.*, **2**: 145–150.