Notes on Rock-Forming Minerals (18) Zoisite in Altered Hornblende Gabbro of the Miyamori District, Iwate Prefecture

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Outline of Geology

The Miyamori ultramafic and mafic complex which intruded into the upper Permian formation consists of the following two groups:

I Peridotites and their serpentinized facies,

II Diopside hornblendite, hornblendite and hornblende-gabbro.

Peridotites are composed of dunite, enstatite-dunite, diopside(diallage)-olivine rock and diallagite. These rocks gradually pass into each other and no intrusive relations were found between them. All of these rocks are always sheared and serpentinized or chloritized.

Diopside-hornblendite, hornblendite and hornblende-gabbro are always closely associated and gradually pass into each other. These rocks are intruded into the above-mentioned peridotites. As the peridotites near the contact with hornblendite and hornblende-gabbro were remarkably sheared and serpentinized, it is probable that these hornblende-bearing rocks have emplaced into the almost copmletely solidified peridotites as late differentiation products of the mafic magma from which peridotites were derived.

In hornblendite and hornblende-bearing gabbro, gneissosity and lineation represented by parallel arrangements of constituent minerals, especially of hornblende, are very remarkable in most cases. These structures are probably due to flow movements of partly crystallized magma.

The chief constituents of hornblende-gabbro are light-brown or greenish-brown hornblende and plagioclase. Besides these, augite is often observed as partly replaced relics within hornblende crystals. In some cases, plagioclase and hornblende show texture closely similar to ophitic texture of plagioclase and pyroxene. Porphyritic structure is quite lacking. The grain-size of these minerals is variable from 1 mm to 3 mm. Though rarely, pegmatitic facies composed of large crystals of hornblende, plagioclase, mica and tourmaline (maximum length of these minerals is about 3.5cm) is observed as lenticular or sheetlike bodies in gneissose hornblende-gabbro.

Chemical composition of a hornblende separated from diopside-hornblendite associated with hornblende-gabbro is as follows (Seki, 1957) :

$(Ca_{1.98}Na_{0.44}K_{0.02})(Mg_{2.55}Mn_{0.08}Fe''_{1.57}Fe''_{0.39}Ti_{0.11}Al_{0.39})(Al_{1.67}Si_{6.33})O_{23}(H_2O)_{1.05}$

Optical examination show that the greenish-brown hornblende usually found in hornblende-gabbro is almost the same as this analysed hornblende.

The plagioclase in hornblende-gabbro usually has moderately An-rich composition ($An_{45\sim48}$). Carlsbad twin is common. Albite and albite-carlsbad twin are not rare.

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The hornblende-gabbro often suffered secondary alteration accompanied by moderately strong shear. In such altered gabbro, original light-brown or greenish-brown hornblende usually shows distinctly wavy extinction and is replaced by pale green or colorless actinolite and chlorite along its marginal part and cleavage planes. Pseudomorphs chiefly composed of actinolite, chlorite and titanite after hornblende were often observed. As the alteration of hornblende proceeds, plagioclase in hornblende-gabbro is also replaced by sodic plagioclase ($An_{11\sim38}$), calcite and epidote-group minerals (zoisite, clinozoisite and pistacite). Plagioclase with zonal structure composed of calcic core ($An_{45\sim48}$) and sodic margin ($An_{11\sim38}$) is usually observed in sheared hornblende-gabbro.

The secondary alteration is almost limited to the hornblende-gabbro facies. In diopside-hornblendite and hornblendite facies closely associated with the hornblende-gabbro, no distinct secondary alteration can be seen except weak replacement of hornblende and diopside by actinolite and chlorite even when the rocks were strongly sheared. Thus, above-mentioned secondary alteration of hornblende-gabbro is believed to be due to deuteric action that took place in the latest differentiation products rich in hydrous and other volatile substance.

Zoisite and Associated Minerals in Altered Gabbro

Zoisite was separated from a pink segregation mass chiefly composed of zoisite and plagioclase, within a specimen of altered hornblende-gabbro (VI-B-220) (Figure 1).

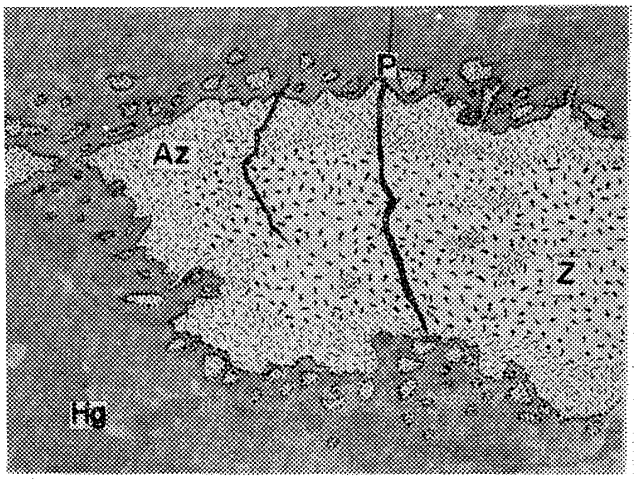

Figure 1. Mode of occurrence of zoisite in altered hornblende-gabbro of the Miyamori district, Iwate Prefecture.
Hg: Hornbelnde gabbro
Az: Actinolite-zoisite part
Z : Zoisite segregation part
P : Vein chiefly composed of sodic plagioclase

This altered hornblende-gabbro is chiefly composed of hornblende, plagioclase and zoisite. The hornblende is partly replaced by pale green actinolite ($\alpha=1.643$, $\beta=1.656$, $\gamma=1.664$) and by almost colorless actinolite ($\alpha=1.629$, $\beta=1.643$, $\gamma=1.650$) along its cleavage planes and crystal margin. The zonal texture showing retrogressive replacement of original hornblende by light green actinolite and colorless actinolite is quite distinct. The plagioclase generally having a lot of dusty inclusions is andesine. More calcic plagioclase was rarely seen as a relic core in these dusty plagioclase. More sodic plagioclase usually associated with calcite is quite rare. Minute crystals of zoisite are found intimately associated with or enclosed within andesine and colorless actinolite.

Minerals stably associated with zoisite in a segregation part are as follows:
Actinolite: This mineral is usually acicular with maximum length of 0.2mm, and has the following optical properties;

$\alpha=1.629$, $\beta=1.644$, $\gamma=1.650$, $(-)$ $2V=87°$, $r>v$

X : Colorless, Y : Colorless, Z : Pale yellowish green

Plagioclase: This mineral does not show any zonal structure and is always clear. Granular texture is general. Optical properties of the plagioclase ($\alpha=1.647$, $(-)$ $2V=89.5°$) show that its composition is almost $An_{35}Ab_{65}$. Veinlets, 1.1mm or less in width, composed chiefly of plagioclase of the same composition are often observed. The veinlets penetrate also the host sheared hornblende-gabbro.

Other minor constituents of the pink segregation mass are apatite, calcite and sphene.

Zoisite has an acicular or tabular form and is associated with above mentioned actinolite and plagioclase. Radial aggregates of zoisite are often observed in the pocket. Twinning on (010) is not rare. The maximum length and width of the zoisite are 3mm and 0.6mm respectively. Pink color of this segregation pocket is due to the pink color of zoisite to the unaided eye.

Mineralogical Description of Zoisite

(1) Chemical composition

Practically pure zoisite sample separated from the above-mentioned segregation mass was chemically analysed by the present writer and S. Kuriyagawa. The results are given in Column A of Table 1. Under Column B of this Table are shown the atomic ratios of the zoisite calculated on the anhydrous basis: O =25. The zoisite is approximately represented by the formula $Ca_4Al_5Si_6O_{25}(H_2O)$.

(2) X-ray powder data

The x-ray powder diffraction data of the zoiste were obtained by means of the Philips Geiger counter X-ray diffractometer using CuKα-radiation. Peaks were indexed on the basis of an orthorhombic unit-cell with the following dimensions: 16.19Å, 5.57Å, 10.05Å. Quartz powder was used as an internal standard. The results are listed in Table 2. These results are in good harmony with those obtained previously for zoisite from other

Table 1. Chemical composition and atomic ratios of a zoisite in altered hornbelnde-gabbro of the Miyamori district, Iwate Prefecture.

A		B		
SiO_2	40.31	Si	6.05	
Al_2O_3	33.86	Al	6.00	
Fe_2O_3	0.09	Fe'''	0.01	
FeO	1.05	Fe''	0.13	
MnO	0.36	Mn	0.05	3.89
MgO	0.70	Mg	0.16	
CaO	22.00	Ca	3.54	
Na_2O	n. d.	O	25	
K_2O	n. d.	H_2O	1.05	
H_2O^+	2.10			
H_2O^-	0.48			
Total	100.95			

Table 2 X-ray powder diffraction data of a zoisite in altered hornblende-gabbro of the Miyamori district, Iwate Prefecture (CuKα_1)

Indices	2θ (degrees)	Intensity
002	17.64	w
400	21.93	m
401	23.53	w
302	24.19	w
402	28.31	w
501	28.92	m
013	31.21	s
020	32.20	w
502	32.88	m
600	33.21	vs
313	35.47	w
204	37.51	m
611	38.12	w
420	39.30	w
304	39.52	w
702, 603	43.03	w
521	43.75	m
800	44.73	w
504	45.66	w
124	49.20	w

a : 16.19 Å
b : 5.57 Å
c : 10.05 Å

Note : The values of 2θ are for CuKα_1 so far as the peak for CuKα_1 can be distinguishes from that for CuKα_2.
w : weak, m : medium, s : strong, vs : very strong

districts (SEKI, 1959).

(3) Optical properties and density.

The optical properties of the zoisite are as follows:

$\alpha=1.701$, $\beta=1.703$, $\gamma=1.709$ $\pm$ 0.002 $\quad \gamma-\alpha=0.008$

(−) $2V=40-41°$ $\quad r>v$

Colorless in thin sections. Optical plane normal to 010.

Density of the zoisite is 3.31.

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造岩鉱物ノート (18) 岩手県宮守地方の変質角閃石斑れい岩の Zoisite

関　　陽太郎

(摘　　要)

変質角閃石斑れい岩の中に，緑閃石，斜長石 ($An_{35}Ab_{65}$) と共存して zoisite がある．この変質斑れい岩の中にはほとんど zoisite のみからなる淡紅色のレンズ状部分もできている．このノートでは，zoisite の産状，化学成分，光学的性質および X線データを記した．