Notes on Rock-Forming Minerals (11) Jadeite and Hornblende from the Kamuikotan Metamorphic Belt

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I. Introduction

Jadeite occurs in some parts of the Kamuikotan metamorphic belt as was briefly reported before (SEKI and SHIDÔ, 1959). In the present paper, we intend to make a more detailed description on the modes of occurrence and mineralogy of jadeite from the Kamuikotan gorge within the belt. Chemical data on a typical common hornblende from an epidote-hornblende-schist with biotite in a part of this belt are also given here. The data indicate that the belt involves a fairly large range in metamorphic grade.

The Kamuikotan metamorphic belt, less than 30 kilometers in width, lies north and south to the west of the central mountain range of Hokkaido. The belt contains a great variety of rocks; it is composed mainly of mafic green schists and siliceous black schists, locally intercalated with quartzites, crystalline limestones, and weakly metamorphosed mafic intrusive rocks with poorly developed schistosity, if any. At places ultramafic masses, now mostly represented by serpentinite, are also exposed, and they are considered to have intruded roughly simultaneously with the regional metamorphism. The metamorphosed sediments of the belt were deposited in pre-Cretaceous time and the regional metamorphism is considered to be late Mesozoic (HUNAHASHI, 1958; SUZUKI and SUZUKI, 1958). We found jadeite from the Kamuikotan gorge, which is well known for a fine landscape and good exposures of Kamuikotan metamorphic rocks.

II. Jadeite in the Kamuikotan Gorge

SUZUKI and SUZUKI (1958) made a geological and petrographical study on the crystalline schists of the Kamuikotan gorge. The distribution of various rock types in the gorge is shown in Fig. 1, which is taken from their paper. We made a trip on the southern bank of the gorge in early October of 1958. Glaucophane, lawsonite, and pumpellyite occur widely in this area. Glaucophane occurs not only in the neighborhood of serpentinite masses, but also in many other parts. The distribution of glaucophane is quite independent of that of serpentinite. Probably, the schists of the Kamuikotan gorge represent the lawsonite-pumpellyite-epidote-glaucophane subfacies of the glaucophane-schist facies (MIYASHIRO and SEKI, 1958).

We found jadeites in the low grade metamorphic rocks of the following three places in this gorge: (1) the southern foot of the Kamuikotan bridge, (2) 1 kilometer southwest of Ino, and (3) Meoto-iwa. These localities are marked by open circles in Fig. 1.

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Fig. 1 Geological map of the Kamuikotan gorge, somewhat simplified from the original (SUZUKI and SUZUKI, 1958).

1=alluvium; 2=terrace deposits; 3=Neogene sediments; 4=green schists (containing incompletely recrystallized diabase and diabase tuff); 5=chert and red quartzite; 6=psammitic metamorphic rocks; 7=black siliceous schists; 8=welded tuffs; 9=serpentinite.

(1) Kamuikotan bridge area

About 30 per cent of the specimens of psammitic and mafic schists brought from the neighborhood of the southern foot of the bridge carry jadeite. The following mineral assemblages were observed in these jadeite-bearing rocks.

- a* : Pumpellyite-chlorite-quartz-jadeite with or without albite and stilpnomelane.
- b* : Lawsonite-chlorite-sericite-quartz-jadeite-albite with or without stilpnomelane.
- c* : Epidote-stilpnomelane-sericite-jadeite-albite.
- d* : Calcite-stilpnomelane-sericite-jadeite-albite.

The assemblages *a* and *b* are common and the other two are rare. Jadeite occurs in sub-radiating acicular sheaves or in rounded forms. In some cases, the mineral occurs as sutured aggregates of small grains filling the interspaces between lawsonite prisms or pumpellyite clusters. The jadeite with this feature shows characteristically fine polysynthetic twinning.

(2) Southwest of Ino

Two specimens with jadeite were hitherto found from metagreywacke of the Kamuikotan series. The mineral assemblage of these two specimens is lawsonite-jadeite-quartz-albite with or without sericite. In both specimens, jadeite occurs in sub-radiating acicular sheaves in association with quartz and albite.

The Optical properties of jadeite from the above two places are as follows: $\alpha=1.653$, $\beta=1.659$, $\gamma=1.668-1.671$, $2V_z=72^\circ$, and colorless in thin sections. The X-ray powder diffraction patterns of the jadeite is practically identical to that given for pure jadeite by YODER (1950). Some characteristic peaks are shown in Fig. 2a,

(3) Meoto-iwa

The rock containing jadeite is massive and presumably derived from a mafic intrusive rock. It is mainly composed of jadeite and relic augite with very small amounts of chlorite, calcite, and albite (An_3). Jadeite occurs either as a rim surrounding relic augites or as fine-grained matrix over which relic augites are scattered. The boundaries between the jadeite and augite in zoned crystals are always sharp with a distinct Becke line and abrupt change in birefringence. A part of the X-ray powder diffraction pattern of this rock is shown in Fig. 2b, where the peaks of both pyroxenes are clearly separated as is expected from the microscopic observation. This indicates the existence of a compositional gap between the jadeite and augite. The optic properties of the jadeite are: $\alpha_{(Min.)}=1.665$, $\gamma-\alpha_{(Max.)}=0.020$, $2V_z=75^\circ-85^\circ$ and $v>r$ strong, $c\wedge Z=42^\circ-63^\circ$ for Na-light and $c\wedge Z_r < c\wedge Z_v$ showing abnormal interference color; pale green to the unaided eye and colorless in thin sections. Relic augite has $2V_z=48^\circ-52^\circ$. As shown in Fig. 2b, the peaks of the jadeite are slightly shifted toward the smaller angle than the corresponding peaks of pure jadeite. The shifts of peaks as well as the optical properties show that this jadeite contains about 10 per cent of acmite molecule.

It is noteworthy that the stable association of almost pure jadeite with quartz is commonly present in crystalline schists of the Kamuikotan gorge, although sodic plagioclase also exists in most specimens. The result of experimental and

Fig. 2 X-ray powder diffraction patterns of jadeite from the Kamuikotan gorge, compared with that of aegirine.

(a) = Jadeite from 1 kilometer south west of Ino (see text). (b) = Jadeite-relic augite rock from Meoto-iwa (Jd=jadeite; Ag=augite; see text). (c) = Aegirine (ca. $Ag_{90}Hd_{10}$) from aegirine-riebeckite-quartz syenite (MIYASHIRO and MIYASHIRO, 1956, Table 27, column 6).

The corresponding peaks of augite, diopside-hedenbergite, and aegirine appear in similar positions in the powder patterns, but the peaks of jadeite appear in very different positions.

thermochemical studies shows that the assemblage of jadeite and quartz in equilibrium requires pressures higher than 9 kilobars in room temperature, and still higher pressures in higher temperatures (ROBERTSON et al., 1957). As the jadeite that we found may be considered to be practically pure, the pressures that prevailed during metamorphism in the Kamuikotan gorge were higher than 9 kilobars, which roughly corresponds to the load pressure at the depth of 30 kilometers. Jadeite is probably a stable mineral in parts of the glaucophane-schist facies (probably in the lawsonite-pumpellyite-epidote-glaucophane subfacies).

III. Epidote-Hornblende Schist from Mituisi

The Kamuikotan series is exposed near the town of Mituisi in the province of Hidaka, as an isolated small mass completely surrounded by Tertiary formation. The mass consists mainly of crystalline schists and serpentized ultramafic rocks. ISIBASI (1939) published a petrographical investigation of this mass and stated that the schists appeared to be metamorphosed in a higher grade than in the ordinary schists of the Kamuikotan series. We made a detailed observation along the Mituisi river in this region in early October of 1958. The exposed schists are epidote-hornblende schists with or without garnet and biotite, actinolite schists, and spotted magnetite-quartz-garnet schists. The latter two groups occur generally within or near the serpentinite. Some of hornblende crystals have a thin rim of glaucophane or riebeckite.

A blue-green hornblende from one of the epidote-hornblende schists collected by SHIDÔ was separated and chemically analysed, with the result shown in Table 1. The host rock has the following mineral assemblage: blue-green hornblende $\gg$ epidote ($2V_x=79^\circ$) $>$ quartz, albite (An_3) $>$ rutile, sphene $\gg$ brown biotite ($\gamma=1.640$, $\beta=1.639$; $2V_x=7^\circ-10^\circ$).

As shown in the analysis, the hornblende is an ordinary common hornblende very rich in Al^{IV} and Na. In the atomic ratios calculated from the analysis on the anhydrous basis of $O=23$, the amount of Al^{IV} is nearly equal to that of ($Al^{VI}+Fe^{+3}$), and the amount of $(2-Ca)$ to that of $1/2(Na+K)$. Then, in this hornblende the bulk of the Al^{IV} is in tschermakite molecule and the bulk of the $(Na+K)$ is in sodatremolite molecule. The very high ferric iron content in this amphibole may be attributed to high water pressures that prevailed.

Table 1. Chemical composition of blue-green hornblende from biotite-bearing epidote-hornblende schist (Specimen No. FS58-130).

Wt. %		Atomic Ratios (O=23)			Optical Properties
SiO ₂	42.89	Si	6.380	8.000	$\alpha=1.669$ $\gamma=1.691$ $2V_Z=56^\circ$ Disp. distinct; $r>v$
Al ₂ O ₃	13.95	Al ^{IV}	1.620		
TiO ₂	0.75	Al ^{VI}	0.826		
Fe ₂ O ₃	6.07	Ti	0.084	1.599	
FeO	13.39	Fe ⁺³	0.689		
MgO	7.41	Fe ⁺²	1.665	3.341	X=yellow Y=dull green Z=blue-green Y=Z>X $c\wedge Z=25^\circ$ All values determined in Na-light.
MnO	0.27	Mg	1.642		
CaO	9.75	Mn	0.034		
Na ₂ O	2.83	Ca	1.554	2.532	
K ₂ O	0.85	Na	0.817		
H ₂ O (+)	1.68	K	0.161		
H ₂ O (-)	0.00				
P ₂ O ₅	0.01				
Total	99.85				

Analysed by H. HARAMURA.

The coexisting biotite is quite ordinary in its optical properties. These schists may be considered to belong to the albite-epidote-amphibolite facies.

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References Cited

- HUNAHASHI, M. (1958): The Kamuikotan tectonic zone: *Jubilee Publication in Commemoration of Professor Jun Suzuki*, pp. 37—52, (in Japanese).
- ISHIBASHI, M. (1939): On the rocks in the vicinity of Hôrai-san, Mituisi in the province of Hitaka: *Hokkaido-chisitu-chosakai, Hokoku*, No. 10, pp. 7—35, (in Japanese).
- MIYASHIRO, A. and MIYASHIRO, T. (1956): Nepheline syenites and associated alkalic rocks of the Fukushin-zan district, Korea: *Jour. Fac. Sci., Univ. Tokyo*, Sec. II, Vol. 10, pp. 1—64.
- MIYASHIRO, A. and SEKI, Y. (1958): Mineral assemblages and subfacies of the glaucophane-schist facies: *Japanese Jour. Geol. Geogr.*, Vol. 29, pp. 199—208.
- ROBERTSON, E. C., BIRCH, F., and MACDONALD, G. J. F. (1957): Experimental determination of jadeite stability relations to 25,000 bars: *Amer. Jour. Sci.*, Vol. 255, pp. 115—137.
- SEKI, Y. and SHIDÔ, F. (1959): Discovery of jadeite from the Sanbagawa and Kamuikotan metamorphic belts, Japan: *Proc. Japan Acad.*, Vol. 35, pp. 137—138.
- SUZUKI, J. and SUZUKI, Y. (1958): *Guide book for the geological excursion at the Kamuikotan gorge: 1958 Meeting of Geol. Soc. Japan in Hokkaido*, (in Japanese).
- YODER, H. S., Jr. (1950): The jadeite problem: *Amer. Jour. Sci.*, Vol. 248, pp. 225—248.

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(11) 神居古潭変成帯からの Jadeite と Hornblende

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(摘 要)

北海道神居古潭峡谷に露出する変成岩には jadeite が広く出現する。しかもそれはしばしば quartz と伴っている。

三石町附近の神居古潭変成岩に属する epidote-hornblende schists の1つから hornblende を分離・分析したところ、これは Al とアルカリの多い common hornblende であった。この岩石は biotite をも含み、したがって、この schists は albite-epidote-amphibolite facies を表している。

このように神居古潭変成帯形成の時の物理条件の巾はかなり広く、jadeite+quartz の産出で特徴づけられる glaucophane-schist facies の中のある subfacies (多分 lawsonite-pumpellyite-epidote-glaucophane subfacies) から epidote-amphibolite facies にわたっている。