ON SOME SODA-PYROXENE AND -AMPHIBOLE BEARING QUARTZ SCHISTS FROM HOKKAIDO

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With 5 Text-Figures

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INTRODUCTION

The so-called Kamuikotan System,[1] which forms the foundation of the whole of Hokkaidô, extends over a comparatively large area along the western side of the central mountain range. It stretches from the province of Tesio to that of Hidaka, as a narrow belt in a direction approximately north to south, though it is locally covered by younger sedimentaries and volcanics. The rocks of the system have undergone severe deformation by dynamo-metamorphism and have usually been folded and cleaved, showing a noticeable banded texture in the field.

The rocks are, as a rule, composed mostly of recrystallized products despite the fact that some parts contain less metamorphosed grains of the primary minerals showing a distinctly palimpsest texture. The system consists of various kinds of metamorphics differing largely in character. The essential types in the system are classified as follows: green schist, black schist, quartz schist and

(1) Formerly the System was correlated, from its outward appearance, to the Sambagawa or Mikabu System in Japan proper; it is, however, at present distinguished from the above-cited two system and is called the "Kamuikotan System," from the characteristic petrographical and geological points of view. The name of the system is given on account of its typical occurrence in the Kamuikotan valley of the province of Isikari. (J. SUZUKI: Petrography of the Kamuikotan System (in Japanese). Jour. Geol. Soc. Tôkyô, Vol. XLI (1934), p. 392).

crystalline limestone. The best section for studying the relations of these rock types is to be found in the Kamuikotan valley.

In the field of the metamorphic complex of the system we found the lenses or masses of ultra-basic and basic rocks, now represented by serpentine and metamorphosed dolerite. It is believed that these igneous rocks intruded subsequent to the regional metamorphism connected with the great orogenic movement. It is noticeable that various contact rocks develop between the crystalline schists and the above-mentioned igneous bodies, which are attract special attention because of the presence of some interesting sodium bearing silicates, such as glaucophane, riebeckite, aegirite-augite and albite, as essential constituents.[1] In some places, albite-, pectolite-[2] or soda-zeolite-veins penetrate the contact rocks and igneous mass themselves.

It seems probable that the occurrence of the minerals in the special contact zone was effected by the soda-rich hydrothermal solution derived from the ultra-basic intrusive masses.[3][4]

The most remarkable outcrops of these contact rocks are seen at the Uryû and Kamikawa districts in central Hokkaidô, especially in the environs of Horokanai-pass, Etanbetu and Kamuikotan.

The rocks in the contact facies in these districts may be roughly classified into two main types: acidic and basic. To the former belong all siliceous schists such as glaucophane-quartz-schist, glaucophane-epidote-quartz-schist, aegirite-augite bearing glaucophane-quartz-schist, aegirite-augite bearing riebeckite-quartz-schist, etc., and to the latter type, actinolite-schist, hornblende-schist, glaucophane bearing hornblende-schist, glaucophane-schist, etc.

A detailed account of the petrography of the crystalline schists in the Kamuikotan system including the above-mentioned contact rocks will be given on another occasion. This paper deals with some

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(1) J. Suzuki: Localities of Glaucophane Scists in Hokkaidô (in Japanese). Jour. Geol. Soc. Tôkyô, Vol. XXXIX (1932), p. 132 and Some New Facts on Glaucophane Schists in Japan (in Japanese). Jour. Japanese Assoc. Min., Petro., & Econ. Geol., Vol. VIII (1932), p. 237.

(2) Z. Harada: On Pectolite from Hokkaidô (Preliminary Note in Japanese). Jour. Japanese Assoc. Min. Petro. & Econ. Geol., Vol. VIII (1932), p. 249.

(3) S. Yamaguchi: Geological and Petrological Studies of the Uryû and Kamikawa Districts, Hokkaidô. MS. (1933).

(4) J. Suzuki and S. Yamaguchi: On the Contact Metamorphic Effect of Basic Intrusions at the South-western Mountain District of Asahikawa, Hokkaidô (Preliminary Note in Japanese). Jour. Geol. Soc. Tôkyô, Vol. XL (1933), p. 387.

soda-pyroxene bearing soda-amphibole quartz schists, with special reference to their mode of occurrence and to the petrographical properties.

MINERAL COMPOSITION OF THE ROCKS

(a) Aegirite-augite bearing riebeckite quartz schist

Riebeckite bearing quartz schists are found in the environs of Kamuikotan, Etanbetu and Takadomari, in the mountain district

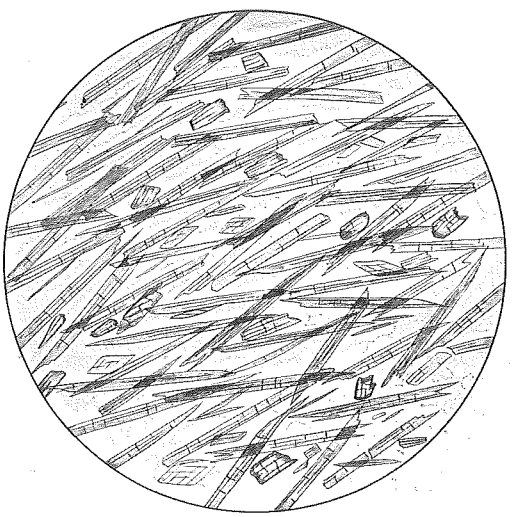

Fig. 1. Aegirite-augite bearing riebeckite quartz schist from Kamuikotan. ×70. Section parallel to schistosity plane.

west of Asahikawa city[1]. In the first cited locality, the rock occurs as a thin layer between a light greenish quartzose schist and a small mass of decomposed serpentine at the railroad cutting, 3 km. northeast of the Kamuikotan Station. The rocks from the two latter localities are found as pebbles in the fluvial deposits of the Uryû and

(1) J. SUZUKI: Aegirite-augite Riebeckite Quartz Schist from Kamuikotan and Some Other Localities in Hokkaidô. Proc. Imp. Academy, Vol. IX (1933), p. 617 and Jour. Japanese Assoc. Min., Petro., & Econ. Geol., Vol. XII (1934), p. 55.

Etanbetu rivers. We were unable to study *in situ* their geological characters and relations to the enclosing rocks, though they suggest that unknown out-crops of these rocks may be widely distributed in the regions along the upper courses of the rivers. The rocks from these localities show, as usual, a highly schistose or gneissose texture, and are dark bluish in colour, though often consisting of dark bluish and light grayish layers in alternation. They are commonly very fine and compact rocks and no individual constituents are discernible in them with the naked eye, except in some blocks found at Kami-etanbetu, which show a medium grained structure containing comparatively large prisms of riebeckite as an essential component.

Under the microscope, the rocks from those localities prove to be chiefly composed of quartz, albite, riebeckite and a subordinate amount of aegirite-augite, but are sometimes partly characterized by the presence of a minute amount of garnet, rutile, epidote and magnetite, and the absence or poorness of aegirite-augite and albite. The schistose character and dark bluish colour of the rocks are produced entirely by a parallel orientation of riebeckite prisms (Figs. 1–3).

The proportion of mineral constituents in the representative types from every locality is schematically as follows:

Kamuikotan (K11): quartz > riebeckite > aegirite-augite

Takadomari (U1): quartz > albite > riebeckite > garnet > aegirite-augite > rutile

Kamietanbetu (EI2): quartz > riebeckite > albite > magnetite > garnet

Kamietanbetu (E19): quartz > albite > riebeckite > aegirite-augite > garnet > epidote

Quartz, the predominant constituent in every rock, occurs usually as a very fine rounded equidimensional grain, 0.02 to 0.1 mm. in diameter showing a granoblastic structure. It is very fresh and often shows undulatory extinction.

Albite occurs also as a fine rounded grain mingled with the quartz grain, showing similar dimensions to that of quartz in diameter, though it is generally less in amount than the latter and is almost absent in rock from Kamuikotan. The mineral is colourless and usually fresh, and is sometimes twinned after the albite law but zonal structure is rarely seen. According to the determination

on Fedrow's universal stage the mineral is seen to be of the composition of $Ab_{97}An_3$.

Riebeckite is the important member in every sample after quartz. In general it occurs as a fine narrow prism, 0.5–1 mm. in length and 0.01–0.02 mm. in width, arranged subparallel to the schistosity of the rock. It is noticeable that the mineral in some blocks from Kami-etanbetu reaches 2–3 mm. in length and 0.2–0.3 mm. in width, while, on the other hand, the mineral in the rock from Kamuikotan, which shows a fibrous or acicular form, is rather narrow that it may better

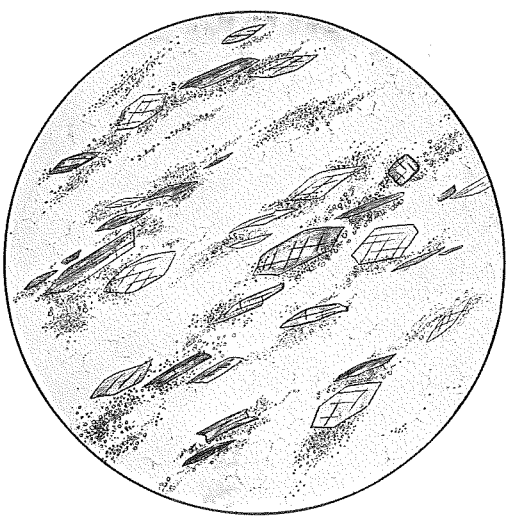

Fig. 2. Aegirite-augite bearing riebeckite quartz schist from Takadomari. ×65. Section normal to schistosity plane.

be called crocidolite. The terminal part of the prism generally shows a tassel-like form. In the section normal to the principal axis of the mineral, it shows exact rhombs in which perfect cleavage parallel to (110) is well developed. The extinction angle is c:X=0°—3° on (010). The indices of refraction[1] are usually high, but double refraction is comparatively low. The dispersion is commonly very large.

(1) The writer takes here the opportunity of expressing his sincere thanks to Ass. Prof. T. SUENO at the Techn. University of Tôkyô who kindly determined for him the indices of refraction of the mineral.

Riebeckite in (K11) from Kamuikotan:
n_1=1.700–1.706, n_2=1.712–1.719,
„ in (U1) from Takadomari:
n_1=1.678–1.682, n_2=1.683–1.686,
„ in (E12) from Kamietanbetu:
n_1=1.689–1.699, n_2=1.697–1.705,
„ in (E19) from Kamietanbetu:
n_1=1.680–1.687, n_2=1.686–1.690.

The pleochroism of the mineral is characteristic and the axial colours and absorption relation are as follows: X=dark prussian blue, Y=grayish violet blue and Z=light yellowish brown,

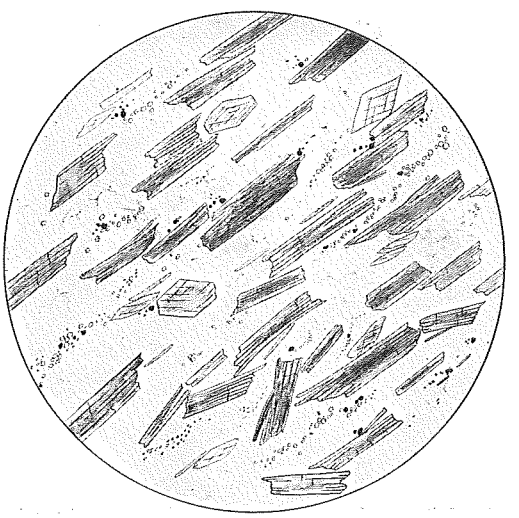

Fig. 3. Riebeckite quartz schist from Kamietanbetu. ×50.
Section parallel to schistosity plane.

$X > Y > Z$. In general the inner part shows a darker tint than the outer portion of the crystal. From the above-cited optical data the mineral is clearly distinguished from glaucophane in the contact rock of the same localities. The paragenesis of riebeckite and glaucophane is not yet found in the same samples from these districts, though that of aegirite-augite and glaucophane is known in the rock from Obirasibe and Horokanai.

Aegirite-augite is an unusual constituent in the rocks, though it is contained in large amount in some parts. The mineral occurs

in short prismatic form, 0.1–0.2 mm. on the average. Cleavage parallel to (110) is comparatively distinct. The maximum extinction angle of the pyroxene in the rock (K11) from Kamuikotan is c:X=14° on (010) but that of the mineral in the block (U1) found at Takadomari is c:X=32°. The peochroism in the mineral from the former locality shows the following relation: X=light yellowish green, Y=pale green and Z=pale yellowish brown, and that in the latter X=deep grass green, Y=light greenish yellow and Z=light yellowish brown. The absorption formula is in both cases as follows: $X > Y > Z$. The indices of refraction of the mineral are comparatively high though the exact value is as yet undetermined. Double refraction is much higher than that of riebeckite. Zonal structure and undulatory extinction are often recognizable in the mineral.

Garnet occurs in a subordinate amount in the rocks from Takadomari and Kamietanbetu and shows minute colourless grains, 0.01 mm. in average diameter, and often of a fine rhombic dodecahedral form.

Epidote is very occasionally found in some parts in the sample collected at Kamietanbetu, showing a fine light yellowish crystal, 0.02 mm. in length. The minute rounded grains of magnetite are uniformly distributed in the riebeckite schists though usually in small quantity.

Chemical analyses of the rocks from Kamuikotan and Kamietanbetu are shown in Table I.

(b) Aegirite-augite glaucophane quartz schist

It has been well known for a long time that the gravel deposits on the river beds of certain rivers in Hokkaidô occasionally have a fairly large number of pebbles of metamorphic rocks, mostly crystalline schists in great variety[1]. The writer has had an opportunity, through the favour of Professor H. YABE at the Tôhoku Imperial University, to examine microscopically the various river pebbles of glaucophane schists from the province of Tesio. The samples were all collected by Mr. K. NISHIKAWA from the middle course of the river Obirasibe, which empties into the Japan Sea at a little north of

(1) K. JIMBÔ: General Geological Sketch of Hokkaidô with Special Reference to the Petrography. Hokkaidô-chô (1892), p. 5.
H. HACHIYA: Glaucophane Rocks from Obirasibe, Tesio, Hokkaidô. (in Japanese) Jour. Geol. Soc. Tokyo, Vol. IX (1902), p. 98 & 147.

the town of Rumoe. During his study of these samples, the writer found a small block of quartz schist which is especially interesting in having aegirite-augite and glaucophane as essential components.

In his previous paper[1] the writer made a preliminary note on the petrography of the block, but till that time we had nothing beyond an account of its original provenance. In the course of subsequent studies of the geology and petrography of the Uryû and Kamikawa districts, central Hokkaidô,[2][3] it became clear that the pebble in question and, likewise, those of other glaucophane bearing schists had been broken off from a conglomeratic layer in the Neogene Tertiary formation. As a result of the further investigation of the metamorphic region in these districts, the original localities of the glaucophane bearing rocks were found *in situ* by the writer and Mr. S. YAMAGUCHI in the area of the Kamuikotan System.

The aegirite-augite bearing glaucophane quartz schists now to be described occur as a thin layer in the quartzose schist at the roadside near the northern entrance of the Horokani Tunnel. The rocks show quite the same petrographical properties as the rock, which is a pebble found as float on the fluvial bed of the Obirasibe river, and no characteristic feature can be seen in any of them. The rocks from both localities, Horokanai pass and the Obirasibe river, are, as usual, distinctly schistose in texture and appear, as a whole, dark bluish grey in colour, though, more in detail, they consist of dark bluish grey and light grey layers in alternation. Being fine and compact, individual minerals are not discernible by the naked eye. Under the microscope, it is found that the schistosity, the rocks reveal is due to successive layers of different mineralogical composition:— thin layers composed in most part of quartz and feldspar grains which are somewhat elongated in one direction, and those rich in glaucophane and aegirite-augite, which are arranged subparallel to the plane of schistosity (Fig. 4).

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(1) J. SUZUKI: Aegirite-augite Glaucophane Quartz Schist from the Province of Tesio, Hokkaidô, Japan, Proc. Imp. Acad., Vol. VII (1931), p. 283 and Jour. Japanese Assoc. Min., Petro., & Econ. Geol., Vol. VII(1932), p. 11.

(2) S. YAMAGUCHI: Geological and Petrological Studies of the Uryû and Kamikawa Districts, Hokkaidô. MS. (1933).

(3) J. SUZUKI: Some New Facts on Glaucophane Schists in Japan (in Japanese). Jour. Japanese Assoc. Min., Petro., & Econ. Geol., Vol. VIII(1932), p. 237.

Quartz is the dominant mineral in the rocks, occurring as irregular minute grains with rugged outlines in a mosaic aggregate. The grains are 0.1 mm. in average length and have their longer diameter generally parallel to those of glaucophane and aegirite-augite. Most of the quartz grains are clear and in places they show more or less undulatory extinction.

Glaucophane is the next important constituent to quartz; the crystals assume minute prismatic forms and are usually arranged, together with aegirite-augite prisms, parallel to the rock flowage. Larger crystals are 0.1–0.3 mm. long. Extinction angle c : Z is nearly

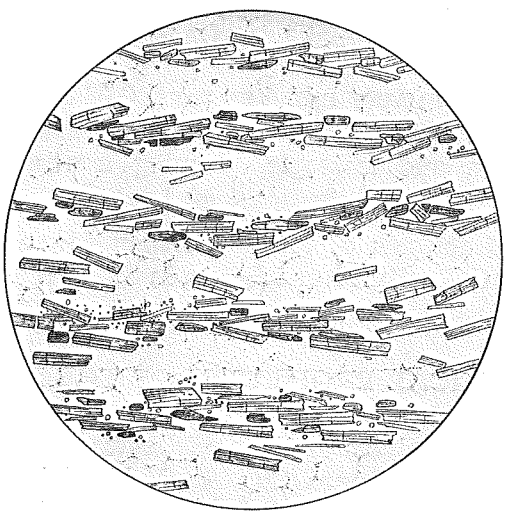

Fig. 4. Aegirite-augite glaucophane quartz schist from Horokanai-pass. ×70. Section parallel to schistosity plane.

5°. It is characterised by its comparatively strong pleochroism, X=light yellowish violet, Y=light bluish violet and Z=blue; $Z > Y > X$. The refractive index of the mineral from the Obirasibe river is as follows:

Glaucophane in (Ob4) from the Obirasibe river:

n_1=1.664–1.666, n_2=1.665–1.668.

Aegirite-augite has a short prismatic form, the average length of the crystals being 0.1 mm. Prismatic cleavage is well developed and there are very occasionally traces of imperfect cracks generally at right angles to the c-axis. The crystals are frequently broken

and irregular in outline. Maximum extinction angle measured from the prism axis, c:X is 25°. The mineral generally shows slightly darker axial colours than those in the force-cited riebeckite quartz schists, as can be seen from the following data: X=grass green, Y=yellowish green and Z=yellowish brown; absorption is $X > Y > Z$. The crystals are usually arranged parallel to the glaucophane prisms.

Feldspar is found interstitially in a comparatively small amount among the quartz grains; it is distinguished from quartz by its optical biaxiality and lower refringence. 2V is nearly 75° and optical character positive; hence albite is to be assumed. It frequently shows multiple twinning after the albite law; zonal structure is not prominent in most crystals.

Garnet occurs in very minute grains, 0.01 mm. on the average, and is usually well shaped after a rhombic dodecahedral form. It is almost colourless and isotropic, showing a very high index of refraction.

A chemical analysis of the aegirite-augite glaucophane quartz schist from the Obirasibe river is given in Table I.

CHEMICAL PROPERTIES OF THE ROCKS

The chemical analyses of the aegirite-augite bearing riebeckite-quartz-schists from Kamuikotan and Kamietanbetu, and the aegirite-augite bearing glaucophane-quartz schist from the Obirasibe river, which were made by Mr. A. KANNARI, of the Geological and Mineralogical Department of the Hokkaidô Imperial University, are given in the following table. The chemical composition of the glaucophane quartz schist from the Horokanai pass is cited in the parallel column for comparison.

The chemical analyses of the aegirite-augite bearing riebeckite- and glaucophane-quartz-schists in the above table include several criteria available for determining the sedimentary origin of the rocks, closely approaching those of chert or siliceous shale.

A remarkable thing is that all rocks have much higher value of silica. As has been said before, glaucophane occurs in both types, acid- and basic-schists, in the district, however, riebeckite is, so far as the writer knows, found, as usual, only in a high siliceous type.

TABLE I.

	A		B		C		D	
	Per-cent.	Mol. Prop.	Per-cent.	Mol. Prop.	Per-cent.	Mol. Prop.	Per-cent.	Mol. Prop.
SiO_2	76.77	1273	84.19	1396	85.80	1423	87.96	1459
TiO_2	—	—	0.20	3	tr.	—	0.60	8
Al_2O_3	0.59	6	4.11	40	2.73	27	2.43	24
Fe_2O_3	9.40	59	2.77	17	1.70	11	0.69	4
FeO	7.19	100	3.59	50	2.60	36	1.68	23
MnO	—	—	0.85	12	0.28	4	—	—
MgO	1.50	37	1.85	46	3.00	74	3.33	83
CaO	—	—	0.47	8	1.20	21	0.47	8
Na_2O	2.78	45	1.12	18	1.90	31	1.59	26
K_2O	0.08	1	—	—	0.86	9	—	—
P_2O_5	0.26	2	—	—	0.31	2	—	—
H_2O	1.14	—	0.97	—	—	—	1.21	—
Ignition loss	—	—	—	—	0.10	—	—	—
Total	99.71		100.12		100.48		99.96	
s	425		663		632		850	
al	2		19		12		14	
fm	83		68		61		66.5	
c	0		4		9		4.5	
alk	15		9		18		15	
k	0.02		0		0.23		0	
mg	0.14		0.32		0.54		0.73	
al-alk	-13		10		-6		-1	
c/fm	—		0.06		0.15		0.07	
Sp. gr.	2.83		2.82		2.70		2.70	

(A) Aegirite-augite riebeckite quartz schist. Kamuikotan. (A. KANNARI, anal.)

(B) Aegirite-augite and garnet bearing albite riebeckite quartz schist. Kami-etanbetu. (A. KANNARI, anal.)

(C) Aegirite-augite bearing glaucophane quartz schist. The Obirasibe river. (A. KANNARI, anal.)

(D) Glaucophane quartz schist. Horokanai pass. (A. KANNARI, anal.)

This coincides with the fact that riebeckite of igneous origin forms only in the relatively most acid magmas and especially under the influence of a mineralizer(1).

It is noticeable that the rocks are comparatively rich in soda and poor in kali and lime. It is also characteristic that except the riebeckite quartz schist (B) from Kamietanbetu, they show a higher value of alkali in molecular number than that of alumina. The high proportion of soda in these rocks may be due to the high content of soda-rich mineral constituents. The comparatively high amount of alumina in the rock from Kamietanbetu, however, may be responsible for the presence of garnet grains in it.

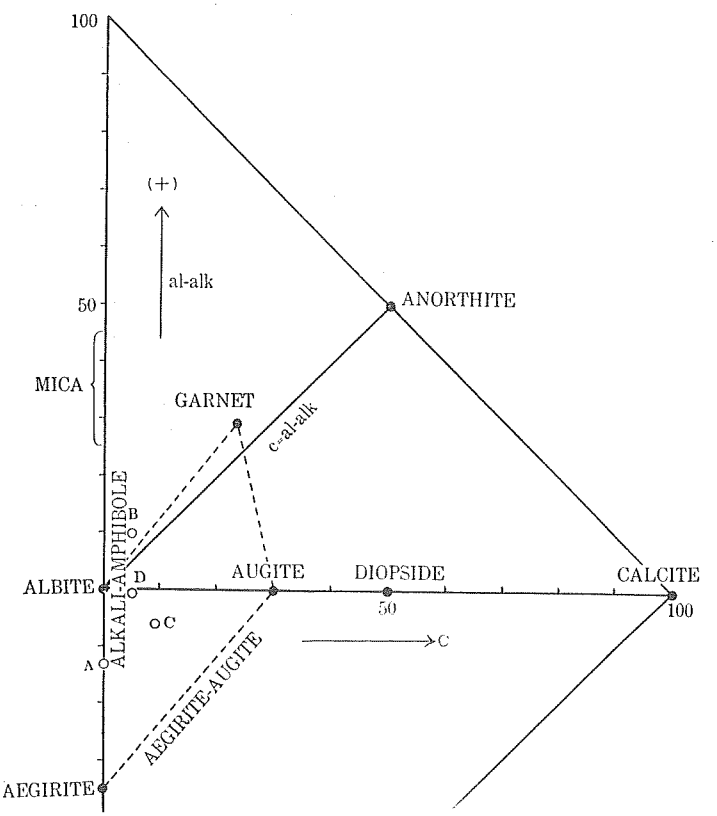

Fig. 5. c-(al-alk) diagram.

A: Aegirite-augite riebeckite quartz schis (Kamuikotan).
B: Aegirite-augite and garnet bearing albite riebeckite quartz schist (Kamietanbetu).
C: Aegirite-augite bearing glancophane quartz schist (the Obirasibe river).
D: Glancophane quartz schist (Horokanai pass).

(1) G. M. Murgoci: On the Genesis of Riebeckite and Riebeckite Rocks. Am. Jour. Sci. 488, Vol. XX(1905), p. 133.

The absence or poorness of mica, and plagioclase or epidote in the rocks is shown by the fact that they have extremely low values of potash and lime. In Fig. 5 the calculated values of the four rocks in question are plotted. It is obvious that most of their loci fall into or near the soda-pyroxene-soda-amphibole-albite-garnet-field in the c-(al-alk) diagram.(1) The riebeckite-quartz-schist and the glaucophane-quartz-schist show a general similarity in their chemical composition, but, strictly speaking, the former shows a much lower value of mg, than in the latter; mg in riebeckite-quartz-schist=0.14–0.32 and mg in glaucophane quartz schist=0.54–0.73. It is interesting to notice that this fact may be comparable to the difference in their theoretical composition of riebeckite and glaucophane themselves. In chemical composition, the aegirite-augite riebeckite-glaucophane-quartz schist is similar to normal sericite quartz schist and normal glaucophane quartz schist of the Sambagawa (Crystalline schist) System(2) in Sikoku and other parts of Japan. In the latter rocks, however, the relative amount of alkali and alumina is usually reversed.

The above-cited characters of the rocks which are now in question indicate us that they may belong, chemically and mineralogically, to Grubenmann's group of so-called "Alkaligneis."(3)

THE ORIGIN OF THE ROCKS

It is accepted from the chemical composition as well as from the mode of occurrence that the rocks now in question are clearly derived from a high siliceous schist of sedimentary origin by means of contact action of the ultra-basic igneous rocks intruded in relation with regional metamorphism.(4)-(7)

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(1) P. NIGGLI: Grundprinzipien der Gesteinsmetamorphose. Die Naturwissenschaften, Ht. 14, 18 Jahrgang (1930), S. 295.

(2) J. SUZUKI: Petrological Study of the Crystalline Schist System of Shikoku, Japan. Jour. Fac. Sci. Hokkaidô Imp. Univ., Series IV, Vol. I(1930), p. 86.

(3) U. GRUBENMANN: Die kristallinen Schiefer. (1910), S. 230.

(4) J. SUZUKI: Localities of Glaucophane Schists in Hokkaidô. Jour. Geol. Soc. Tôkyô, Vol. XXX(1932), p. 132 and Some New Facts on Glaucophane Schists in Japan, Jour. Japanese Assoc. Min. Petro. & Econ. Geol., Vol. VIII(1932), p. 237.

(5) S. YAMAGUCHI: Geological and Petrological Studies of the Uryû and Kamikawa Districts, Hokkaidô. MS.(1933.)

(6) J. SUZUKI and S. YAMAGUCHI: On the Contact Metamorphic Effect of Basic Rocks at the Southwestern Mountain District of Asahikawa, Hokkaidô. Jour. Geol. Soc. Tôkyô. Vol. XL(1933), p. 387.

(7) J. SUZUKI: On the Petrography of the So-called Kamuikotan System. Jour. Geol. Soc. Tôkyô, Vol. XLI(1934), p. 392.

It may safety be asserted that the origination of the soda-rich minerals, such as riebeckite, glaucophane, aegirite-augite and albite, stands in close causal relationship with the so-called "Natronzufuhr"[1] which was derived from the igneous mass, because these minerals usually occur in the field only in the contact facies along the igneous bodies. The riebeckite quartz schist and glaucophane quartz schist show a similar occurrence in the same contast zone in the district, however, no paragenesis of riebeckite and glaucophane in the same rock mass has been seen and the relation betwen them is still unknown. As has been said, the aegirite-augite occurs either with riebeckite or with glaucophane; nevertheless, there is no evidence of metamorphic transition between the two minerals, and their genetic relation is not clear in the thin section of rocks from the district examined by the present writer.

Up to the end of the nineteenth century, aegirite (acmite) and aegirite-augite were known as constituent minerals of igneous rocks only[2], and had never been recorded as a component of metamorphic rocks. Since C. PALACHE[3] found aegirite in a granulite of Gloggnitzer Berg, Austria, and M. A. LACROIX[4] acmite in a calcareous schist of Polycandros, Greece, the minerals have become known as one of the constituent minerals in several metamorphic rocks. Thenceforth aegirite bearing schists or gneisses have been recorded from time to time from several places, though their occurrence is by no means common, and it is indeed the first time to find a similar rock in Japan.

Of aegirite or aegirite-augite and riebeckite bearing rocks as metamorphic products we have some records as in Switzerland,[5]

(1) V. M. GOLDSCHMIDT: Ueber einen Fall von Natronzufuhr bei Kontaktmetamorphose. Neues Jahrbuch. BB. XXXIX(1914), S. 193.

(2) F. ZIRKEL states in his Text Book: Den kristallinischen Schiefern fehren diese Mineralien (Aegirin und Akmit), soweit bekannt, gäzlich. (Lehrbuch der Petrographie, 3 Aufl. 3, Leipzig, (1894), S. 293, and C. HINTZE says: Akmit auf Eruptivgesteine beschräkt; in Elaeolithayenit, in natronreichen Syenit und Graniten. (Handbuch der Mineralogie, Zweiter Band, (1897), S. 1129).

(3) C. PALACHE: Ueber ein neues Vorkommniss des Riebeckites. Neues Jahrbuch, (1895), I, S. 100.

(4) M. A. LACROIX: Sur la constitution minéralogique de l'ile de Polycandros (Archipel). Compte Rendu, 124 (1897), p. 628. LACROIX says in his paper: Cést la premiere fois qu'un pyroxéne du groupe de l'aegyrine est trouvé dans un schiste metamorphique.

(5) H. P. CORNELIUS: Petrographische Untersuchungen in den Bergen zwischen Septimber-und Julierpass. Neues Jahrbuch, BB. XXXV (1913), S. 373.

Norway,[1] Austria,[2] Portugal,[3] etc. It is noteworthy that some of the rocks in these localities occur in the contact metamorphic facies around the basic igneous mass as in Hokkaidô.

The aegirite bearing siliceous metamorphic rocks which bear a close analogy in their petrological properties to those from Obirasibe and Horokanai are found also in two circum-Pacific regions, Java and South California. According to G. NIETHAMMER,[4] the rock from Java is aegirite quartzite and was found as pebbles between Loh Kidang and Karang Samboeng. The rock from South California, reported by A. O. WOODFORD,[5] is quartz-crossite-garnet-aegirite schist and was found also as pebbles in a conglomerate, a member of the Lower Miocene Temblor Formation in San Onofre facies, exposed at the vicinity of San Onofre. In both cases, remarkably to say, the pebbles of the aegirite bearing rocks are stated to be in association with other pebbles of various kinds of glaucophane rocks, just as in the case of Hokkaidô.

In general, aegirite and aegirite-augite in metamorphic rocks, as in igneous rocks, are usually accompanied by sodic amphibole such as riebeckite and arfvedsonite, while it is interesting to notice that they are intimately associated with glaucophane in the metamorphic rocks from the above mentioned circum-Pacific regions and also from Polycandros in Greece.[6]

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(1) V. M. GOLDSCHMIDT: Ueber einen Fall von Natronzufuhr bei Kontaktmetamorphose, Neues Jahrbuch, BB. XXXIX (1914), S. 193.

(2) C. PALACHE: Ueber ein neues Vorkommniss des Riebeckits. Ibid. I (1895), S. 100.

(3) V. de SOUZA-BRANDAO: Ueber einen portugiesischen Alkaligranulit. Centralblatt f. Min. (1902), S. 49.

(4) G. NIETHAMMER: Die Eruptivgesteine von Loh Ooels auf Java. Min. Petr. Mitt. (1909), S. 205.

(5) A. O. WOODFORD: The San Onofre Breccia, its Nature and Origin. Bull. Depart. Geol. Sci. Univ. California, Vol. XV. No. 7 (1925), S. 197.

(6) M. A. LACROIX: Op. cit.