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WALL ROCK ALTERATION IN THE KANOKO VEIN SWARM, HOSOKURA MINE, MIYAGI PREFECTURE, NORTH-EAST JAPAN

By

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Introduction

Hosokura mine, enumerated as exploiting one of the big four lead-zinc deposits in Japan, is located in Uguisuzawa Machi, Miyagi Prefecture, northeastern part of Honshu island. Its mining field is composed exclusively of huge Neogene Tertiary volcanic materials corresponding to a part of the long continued belt extending along the whole inner zone of the Japanese islands arc. "Green tuff region" is the name proposed for that prominent Neogene Tertiary effusive terrain, which has recently become an attractive field for the Japanese geologists as having resulted from epoch-making events in the history of the development of the Japanese islands arc. Various metalliferous deposits are also associated with those volcanic activities forming a peculiar ore province that has an important role in respect to the Japanese mining industry.

Epithermal types of deposits, such as chlorite copper veins, lead-zinc veins and so-called black ore etc. are the characteristic representatives of the province. Besides, gold-silver deposits also accompany and they all are associated intimately forming a peculiar zonal arrangement that surrounds the effusive centres. In many instances, the disposition of those ore deposits suggests that their formation was possibly related to the extrusion of propylite. But, in other cases, there are some evidences that dacitic and liparitic activities also took an important role in their formations.

Propylite, the leading product of Miocene volcanic activities of the whole green tuff region, is represented in every effusion centre as lava, sheets or basement masses; some of them form funnel shaped intrusive bodies among the pyroclastic pilings. The greenish tint of the rock appearances suggesting the deeply altered character is the distinctive feature of those propylites. Several types of alteration are discriminated in every propylite body. Further, these altered appearances are more complicated because of the alterations related to the ore formations of

the region.

The Hosokura mine which works the typical ore deposits of such a Miocene green tuff region; the deposits comprise three main vein swarms, namely, the Kanten, Fuji and Nikanme districts. All of them are disposed in a propylite mass that branches in a deep level into some separated mass as a result of the insertion of tuff formations between them. The altered state of those propylites that are represented in and around the vein swarm are of very great interest for the study of ore genesis and for the exploration of deposits. In the present paper the writer deals exclusively with the characters of alteration that are revealed around the Kanoko vein swarm which is developed at the south-western most part of the Nikanme district as one of its sub-swarms. Although the examined materials were obtained from a narrowly limited sphere amidst the widely developed Hosokura mining field, the examined results may be applied to the whole field, without any basic corrections.

There are discriminable two kinds of alteration around the Kanoko vein swarm. The one is so widely represented through the whole propylite body that it seems properly referable to autometasomatism which succeeded immediately after the formation of propylite; the other alteration is revealed in a limited sphere around the vein with sulphide impregnation, and so it is presumed to be related to the vein formation. In the following both types of such alteration are examined from the viewpoint of chemistry.

The geology and ore deposits of the Hosokura mine have hitherto been studied by K. INOUE (1903)¹¹⁾, Y. OINOUE (1908)²⁰⁾, K. TUBOYA (1933)²⁸⁾, H. IMAI (1942, 1948, 1955, 1956)^{7),8),9),10)}, T. MIYAKE (1950, 1951)^{18),19)}, S. ITO (1954)¹²⁾, K. TOGARI (1954, 1959)^{26),27)}, K. OMORI and K. YAMADA (1954)²¹⁾ and N. KATAYAMA and K. UMEZAWA (1958)¹⁴⁾. The present writer also has been engaged in a study on the geology and mineral deposits of the "mineralized zone of Hosokura-Onikobe". That zone stretches NW-SE including the mining field of Hosokura mine.

General Geology

In the region including the Hosokura mining field the green tuff formation develops widely, in general, with N-S trend and with intercalating siltstone, sandstone and conglomerate of Miocene age; in trend the upper member in east and the lower in west. The large mass of propylite in which the deposits of the Hosokura mine are disposed is covered discordantly by these members. But around the propylite mass those

sedimentary members form a large dome structure which was shifted by the central propylite mass. All those members are discordantly overlain by the Pliocene pyroclastics and dacitic tuffaceous sediments that chiefly burry the south-eastern flank of the mining field. Pre-Tertiary basement complexes which usually crop out here and there in the Miocene-green tuff region are not found in this district. Other than propylite, there are such igneous rocks as felsic andesite, quartz bea. hornblend hypersthene augite andesite and dacite, which occur as dikes and intercalating lava flows.

The green tuff group is divided into five parts, Shimohata formation, the lower, Hosokura formation and Nakayama formation as the middle, and Tozawa formation and Himematsu formation, the upper member. The Pliocene groupe is Kawaguchi formation. Their spatial arrangement as well as the distribution of altered rock facies are represented in Fig. 1 and 2.

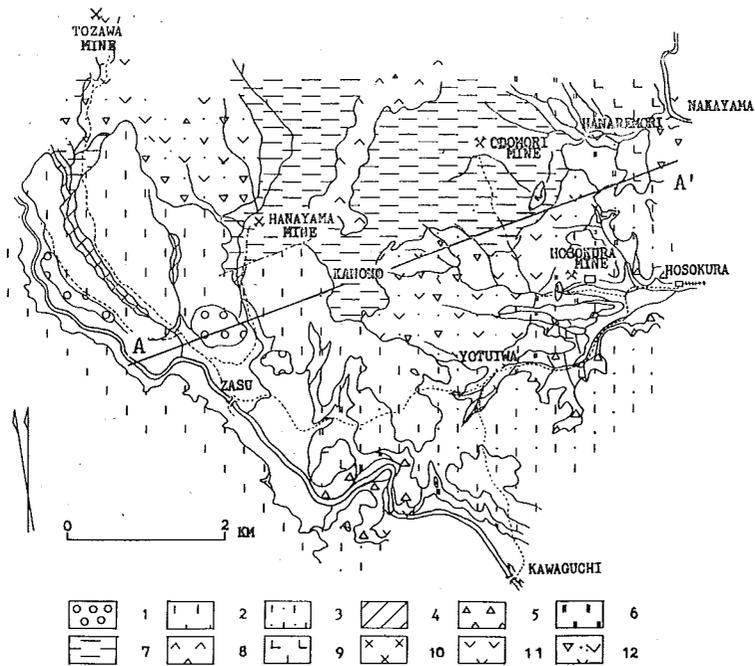


Fig. 1. Geological map of the Hosokura Mine.

- 1. Terrace deposit,
- 2. Kawaguchi form.,
- 3. Himematsu form.,
- 4. Tozawa form.,
- 5. Nakayama form.,
- 6. Hosokura form.,
- 7. Shimohata form.,
- 8. Q bea. andesite,
- 9. Felsic andesite,
- 10. Dacite,
- 11. Hypersthene augite andesite,
- 12. Propylite

All the members of those sedimentary formations are composed mainly of pyroclastic materials, even sandstone and siltstone are tuffaceous; further confused facies changes are as usually. The pyroclastic materials are dacitic in some horizons, but in others they are liparitic or andesitic. Occasionally, different rock characters are found in one horizon interfingering with each other, especially in the rocks of the Hosokura and Nakayama formations. Generally those tuffaceous materials and volcanic breccias of each formation, especially those of the Miocene members, are more or less coloured a green tint, a sign of chloritic alteration which is granted the name of "green tuff".

Ore Deposits

General features:—Although the workable mines are not numerous in the neighbourhood of the Hosokura mine, there are several metal mines such as the Odomori, Hanayama, Kawaguchi, Ikezuki, Ginkaseki, Suginomori, Kanizawa and Motoyama, which are arranged in the NW-SE trend Hosokura—Onikobe belt that coincides with the general trend of the other Miocene mineralized zones of the green tuff region. Gold, silver, copper, lead, zinc and iron sulphide are chief products of those deposits.

The Hosokura mine occupies the eastern most part of this mineralized belt. The deposits comprise many swarms of lead-zinc veins developed mainly in the propylite mass. The fracture system that controlled the deposits, is a comparatively systematic one. It is a combination of the direction NE, NS, EW and NW. The mineral components of those veins are the same through the swarms; the components comprise both gangue and ore minerals. In the former group are included chlorite, quartz, sericite, kaolinite, saponite, calcite, manganocalcite and fluorite. In the later group are galena, sphalerite, so-called wurtzite, chalcopyrite, tetrahedrite, freibergite, pyrargyrite, stibnite, marcacite, pyrite, pyrrotite, magnetite and hematite. Further, chalcocite, covellite, native copper and native silver are noted as supergene secondary minerals.

Kanoko vein swarm:—There are three main groups of vein swarms in the Hosokura mining area, the Kanten, Fuji and Nikanme districts from north-east to south-west, as shown in Fig. 2 and 3. Although it seems to be included in the Nikanme district, the Kanoko vein swarm, now under consideration, is detached from its main group, and is disposed absolutely in the westernmost part of the mine separated from those of Nikanme district by a prominent fault.

The swarm consists of those veins that are named respectively as the

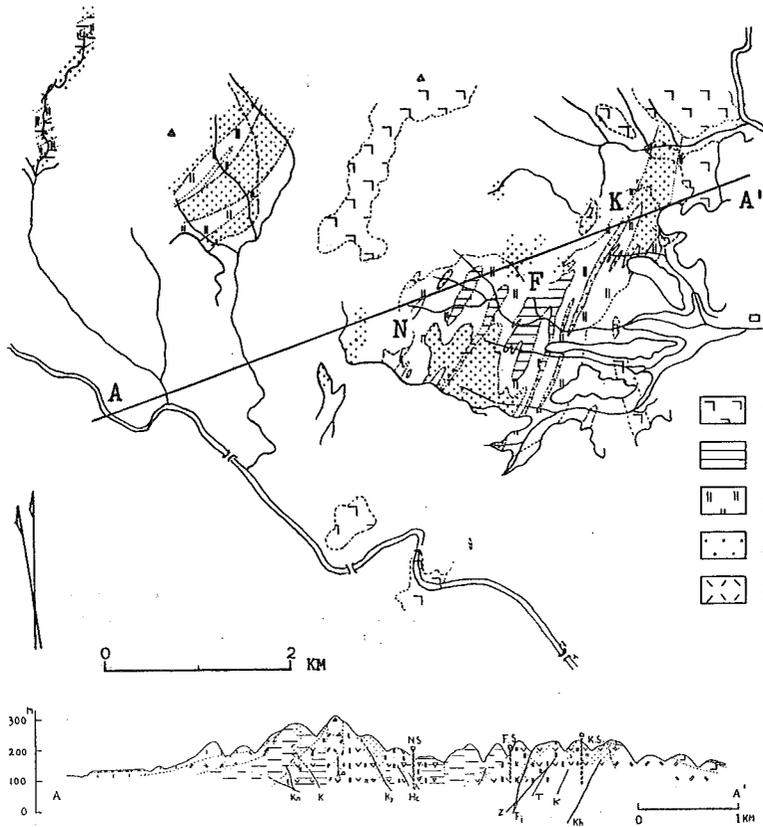


Fig. 2. Alteration map of the Hosokura Mine.

1. Propylite-1, 2. Propylite-2, 3. Propylite-3, 4. Silicified rock, 5. Argillic rock, Kn: Kanoko-hi, K: Kakurei fault, Ky: Kyukanme-hi, Hc: Hachiwari-hi, Z: Zuicho fault, Fj: Fuji-hon-hi, T: Kyoiei-hi, Kh: Kanten-hon-hi, K. S. Kanten shaft, F. S. Fuji shaft, N. S. Nikanme shaft.

Hanza-minami-hi (NEE), the Ichigo-hi (EW), the Monji-hi (EW), the Mae-hi (NEE), the Hon-hi (NEN) and the Oku-hi (NEE) as represented in Fig. 4.

Mae-hi. This vein is an important member among the Kanoko swarm as well as Hon-hi and Oku-hi. It extends to the NEE and attains to the length of 280 m, but rapidly diminishes in the upper levels. The width of the vein and grade of ore are rather smaller and poorer than those of Hon-hi and Oku-hi. In the western part of the vein, the ore is enriched with chlorite.

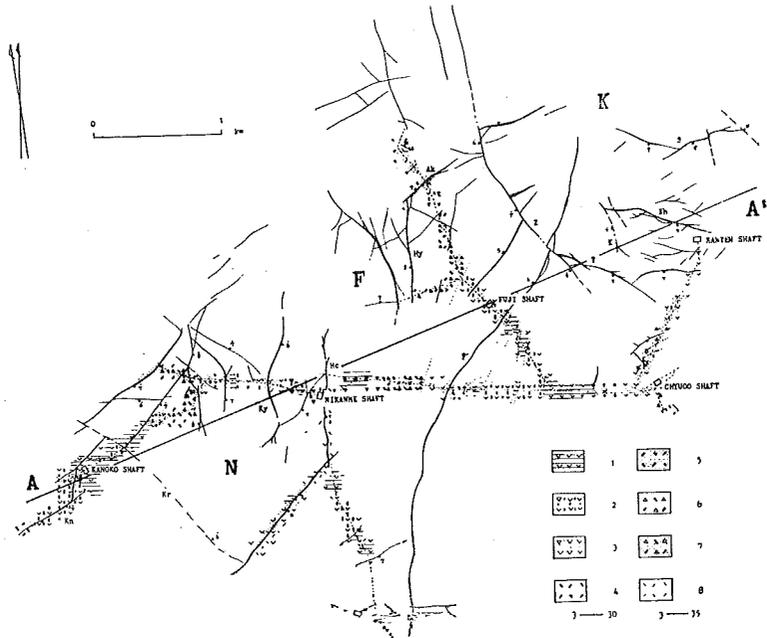


Fig. 3. Schematic diagram of veins and altered rocks on 0 meter level, Hosokura Mine.

1. Propylite-2, 2. Propylite-3, 3. Silicified propylite, 4. Tuff,
5. Silicified tuff, 6. Tuff breccia, 7. Silicified tuff breccia, 8. Argillic rock.

Ichigo-hi. The vein runs E-W, as a foot wall side branched vein of Mae-hi. At the 0 m level, it stretches only in for a limit of 150 m forming a lense-like body, but in the upper level, it forms a continuous vein spreading to the west. In the western part of the vein, the ore is enriched with chlorite, but, it is rather quartzose in the east. In the higher levels, the ore becomes poorer, and associates much with kaolinite.

Hon-hi. The width of this vein reaches to 3 m in some parts, but extremely it swells and pinches extremely with irregular windings. It contains a some of the best ore among the Kanoko vein swarm. Generally, the ore of those shoots is associated with rich chlorite, but it grades to a poorer quartzose ore in the upper level.

Oku-hi. This vein, running parallel to the Mae-hi, is well developed in lower levels, and presents similar characters to those of Hon-hi. It stretches into the tuff formation, in the western side.

Throughout the swarm, the veins are generally composed of the following minerals, which are grouped into five facies.

Primary hypogene minerals

- 1) banded quartz, galena, sphalerite, pyrite.

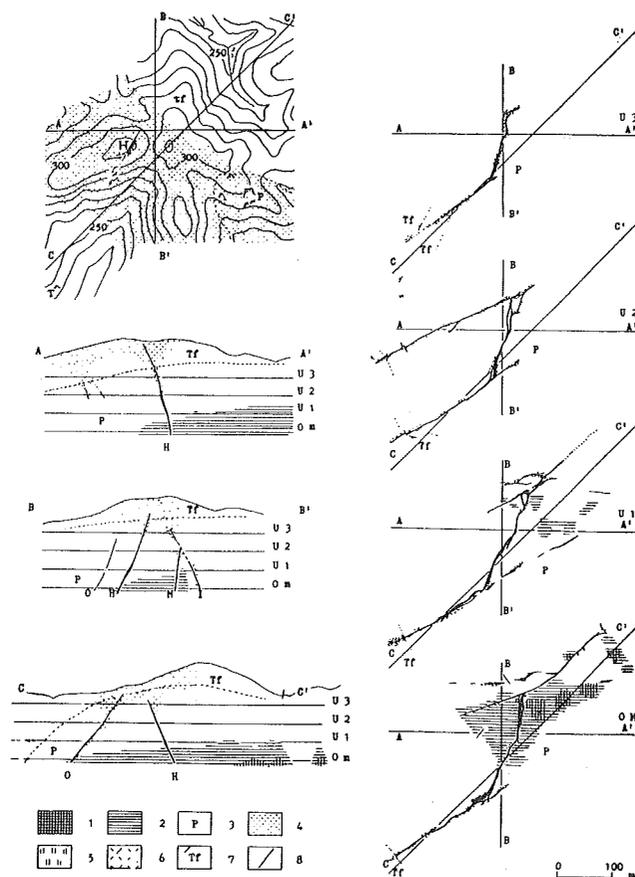


Fig. 4. Plane of Kanoko vein swarm and altered rocks, by levels and cross sections.

1. Propylite-1, 2. Propylite-2, 3. Propylite-3, 4. Silicified rock,
 5. Chloritized rock, 6. Argillic rock, 7. Tuff, 8. Veins I: Ichigo-
 hi, M: Mae-hi, H: Hon-hi, O: Oku-hi, O m: 0 meter level,
 U 1: upper 1 level, U 2: upper 2 level, U 3: upper 3 level

- 2) chlorite, montmorillonite, kaolinite, quartz, galena, sphalerite, so-called wurtzite, chalcopryrite, tetrahedrite, freibergite, marcacite, pyrite, pyrrhotite, hematite and magnetite.
- 3) quartz, kaolinite, galena, sphalerite, so-called wurtzite, chalcopryrite, marcacite, pyrite, stibnite and hematite.
- 4) marcacite, pyrite, galena and sphalerite.
- 5) massive quartz, kaolinite, galena, sphalerite, marcacite and pyrite.

Secondary supergene minerals

chalcocite, covellite, native copper and native silver.

1) banded quartz facies. Banded appearance is a characteristic of this type, a minor amount of pyrite, sphalerite and galena is always accompanies. It is disposed mainly in barren parts of the vein, such as interspaces between of sulphide shoots or as remnants of earlier formed parts intersected by succeeding mineralizations; it is presumed to be the earliest formation of deposits.

2) chlorite-sphalerite facies. The main part of this facies is a felted mass of chlorite and quartz, and is accompanied by impregnated pyrite, sphalerite, so-called wurtzite and galena. Often, these sulphides aggregate themselves among the chloritic base to form a minor scale vein that runs parallel to the main trend.

Generally, it is predominant in the deeper level, and had a meaning of primordial zone of vein formation, the so-called "hinouchi".¹⁾ On occasion, at the part of least impregnation of galena and sphalerite, a special mineral assemblage is markedly noticed. Of the assemblage, chalcopyrite, almost lacking in other parts, is predominant accompanied with hematite partly converted into magnetite. Dots of pyrrhotite are always included within such chalcopyrite.

3) quartz-sphalerite facies. The mineral assemblage of this facies is similar to that of the above mentioned 2), though the amount of quartz is exceedingly high. It is arranged, in some part, with the above described facies in discontinuous relation. When it appears side by side with chlorite facies, it exerts a bleaching effect upon the adjoining facies, but in other cases, gradual transition is also observed. In general, this facies is rather predominant in the upper level.

4) iron sulphides facies. Although this is well represented in Kantén district, it is rather of minor scale in the Kanoko vein swarm. The chief component is a loose aggregation of pyrite and marcacite associated with some galena and sphalerite. Its spatial disposition is always at the innermost part of the main zone of sulphide mineralization that is represented as facies 2) or 3) above. Often, such pre-existing sulphide parts are replaced irregularly by this pyritic facies.

5) massive quartz facies. The barren zone of the upper level is exclusively composed of massive quartz. Occasionally, brecciated banded quartz facies is caught in the massive quartz. It has milky translucent appearance and is accompanied by minor amounts of pyrite, marcacite, sphalerite and galena. In some druses, partly pseudo-hexagonal marcacite is obtained.

As above stated, the 1) banded quartz facies is arranged in the barren parts of deeper levels of the vein just as it seems an earliest formation. An equivalent formation of rich parts at the deeper levels is represented in 2) chlorite-sphalerite facies, though its stage is slightly more delayed than facies 1). The concentration of ore minerals in facies 2) proceeded after the formation of felted base of chlorite and quartz. On the other hand, at the upper level, the situation of chlorite-sphalerite facies seems to be represented in the quartz-sphalerite 3) facies, and its representatives in the lower level are arranged side by side with the chlorite-sphalerite facies, though evidences of slight delay are obvious. Iron sulphide facies are represented as the products of a succeeding mineralization continuous to the mineralizations of sphalerite, galena etc. Latest phase showing in the barren part of the upper level is represented in the massive quartz facies 5).

Wall rock alteration

The propylite mass that received the Kanoko vein swarm suffered a weak alteration as a whole, so fresh andesitic state is never found in any places. According to their altered natures, three types of alteration are discriminated among them. Generally speaking, a weakly altered facies is disposed in the deeper level of the central part of the mass, while the most strongly altered type is found in the marginal part of the propylite body. Their spatial arrangement that takes such an incomplete zonal disposition as represented in Fig. 4 never agrees with arrangement of the vein systems. A vein runs through different zones of such altered types, that the arrangement is rather discordant. Other kinds of alteration are distinguishable along the wall of every vein. As a rule, they are represented in strong chloritic alteration in the deep level, but, emerge into broad silicified zones in the upper level accompanied by some small scale argillic part. The spatial relation of them is also represented in Fig. 4.

Petrographical description of each altered facies is given as follows.

1) Propylite; As above stated, three kinds of altered facies are distinguished according to their grade of alteration. The original rocks of those propylites is two-pyroxene andesite, which carries a medium amount of phenocrysts of plagioclase, hypersthene and augite. Plagioclase (An_{65}), of short prismatic phenocryst, attains to 2~4 mm in size and presents heavy zonal structure. The pyroxenes of euhedral or subhedral are smaller size and in minor amount than plagioclase, and when hypers-

there is present it reveals weak pleochroism. They are often altered, especially in hypersthene, into clear green~greenish brown chlorite. The ground mass is composed of a small lath of plagioclase and granular pyroxenes together with inter-filling glass and chloritic material.

a) Propylite-1 This type of propylite still holds the original nature of two-pyroxene andesite. However the crystals of pyroxene are almost entirely chloritized. The other signs of alteration are shown by slightly sericitization and carbonitization of plagioclase and pyroxene. Though the change is a minor one, the alteration is revealed equally through this rock type. Viewed from the aspect of alteration, it is characterized by an assemblage of *chlorite-sericite-calcite*. (Pl. 1)

b) Propylite-2 The distinction between phenocrysts and ground mass in appearance is obscured in this type of propylite. Under the microscope, the original structure is so far well preserved, but each rock forming mineral is wholly converted into an aggregation of altered minerals. The plagioclase is albitized and the pyroxene is chloritized, further, an aggregate of chlorite and albite is produced from the glass of the ground mass. Among the newly-formed minerals, sericite takes a much more important role than those of propylite-1, so a separated assemblage of *chlorite-albite-sericite-calcite* is characteristic in this type of propylite. (Pl. 2)

c) Propylite-3 This type is distinctly contrasted to the two above described in its strongly bleached appearance. The original propylitic structure is obliterated by the growth of newly-formed minerals. Sericite and calcite are almost absent from the assemblage, and its chlorite is a lighter coloured type of faint pleochroism. Many pools of albite and quartz appear in the ground mass. The mineral assemblage of *chlorite-quartz-albite* is characterized in this type of propylite. (Pl. 3)

The above described propylites transit gradually to each other, so no sharp separated boundary can be mentioned there. Often intermediate types are widely developed between them.

2) Wall rock alteration developed immediately close to the veins has a rather different nature than the above described propylites. As already mentioned, every vein is mantled by silicified rocks, strongly chloritized rocks and, in part, by argillic rocks. In those altered rocks, the original state of the rock structure has almost vanished to be replaced by a closely packed mosaic aggregate of altered minerals.

a) Silicified rock This rock type is scarcely developed near the 0 m level and is completely wanting in the deeper level. But, with upper level, it spreads out as a broad zone replacing the tuffaceous formation that covers the propylite mass. Greyish white to greyish green coloured

and hard granulitic appearance with nets of quartz stringers are the distinct features of those silicified rocks. Under the microscope, such rock is composed of mosaic *quartz-adularia-chlorite*. The last named is a light coloured variety different from those of propylite; it is almost colourless or light green and gives abnormal blue interference colour. (Pl. 4)

b) Argillic rock As a whole, this rock type is very narrowly developed such as along a vein side or a sheared zone or a stratification of silicified tuff. It is composed of assemblage of *sericite-kaolinite-montmorillonite* of propylite origin, but it is a kaolinitic yellowish white argillic rock that contains the remnants of quartz and adularia at the corresponding horizon of tuff formation. (Pl. 5)

c) Chloritic rock This type of rock is developed along the vein of deeper level, as a comparatively broader primordial zone of vein formation. Generally, it is stained by hematite, and is more or less impregnated with pyrite. In some part, grains of sphalerite and galena are scattered in those chlorite bases. (Pl. 6)

Chemistry of Altered Rocks

As above stated, several types of alteration are discriminable respecting the country rocks which surround the Kanoko vein swarm. Each alteration facies is characterized by a peculiar assemblage as list in follows.

TABLE 1. Mineral association of altered rocks.

alteration facies	mineral assemblage
propylite-1	<i>chlorite-sericite-calcite</i>
propylite-2	<i>chlorite-sericite-albite-calcite</i>
propylite-3	<i>chlorite-quartz-albite</i>
silicified rock	<i>chlorite-quartz-adularia</i>
argillic rock	<i>kaolinite-montmorillonite</i> <i>kaolinite-halloysite-sericite</i>
chloritic rock	<i>chlorite-montmorillonite</i> <i>chlorite-sericite</i>

The chemical characters of each alteration facies were examined. The compositions of each representative altered rock are represented in Table 2 and 3. For the examination of the chemical exchanges, calculated number of cations in analysed rocks, on standard cell are listed in Table 4.

Although the chemical composition of the propylite group, as a whole, coincides with that of Quaternary pyroxene andesite, detailed differences are rather distinct. It is mentioned as a prominent feature of propylite that it has slightly higher ferric oxide than does Quaternary andesite. In some cases, it exceeds the ferrous oxides, which are never met with in the Quaternary pyroxene andesite group. Further, the amount of lime is notably lower in the propylite group, its high content of water is also a characteristic feature. Richness of potassium does not occur in Quaternary pyroxene andesite. Among the propylite group, the grade of alteration seems to be represented by increasing of water and ferrous oxide, and by decreasing of alumina.

The silicified rock (K-91, K-19) properly has a distinct silica, and the relative amount of alumina is similar to that of propylite. In the alkalis, the absolute amount of potassium is the highest, which corresponds to the formation of adularia. Also, strong bleaching of lime and soda seems to be a feature of this type of alteration.

TABLE 2. Chemical composition of propylite and Quaternary pyroxene andesite

	Q	K-43	K-96	K-92
SiO ₂	54.79	54.72	53.27	55.42
TiO ₂	.83	.84	.71	.64
Al ₂ O ₃	17.63	16.08	15.18	14.50
Fe ₂ O ₃	3.17	5.55	4.88	2.75
FeO	5.94	3.07	4.20	5.82
MnO	.17	.21	.41	.23
MgO	4.15	4.21	1.96	5.60
CaO	8.53	4.58	6.17	3.61
Na ₂ C	2.75	2.51*	1.58*	3.96*
K ₂ O	.90	3.64*	6.50*	1.42*
P ₂ O ₅	.16	tr	tr	tr
H ₂ O (+)	.66	2.91	3.61	4.84
H ₂ O (-)	.56	.94	.62	.77
CO ₂		.28	.36	.03
FeS ₂		.96	.66	1.06
Total	100.24	100.50	100.11	100.65

Q: Quaternary pyroxene andesite. Mean value of group II and III, after S. TANEDA (1952).²⁵⁾

K-43: Propylite-1 of Kanoko cross cut at Om level.

K-96: Propylite-2 of foot-wall-side (5 m) of Kanoko-mae-hi at U 1 level.

K-92: Propylite-3 of foot-wall-side (1 m) of Kanoko-mae-hi at U 1 level.

* Analyst, Y. NASU

TABLE 3: Chemical compositions of silicified, argillic and chloritic rocks

	K-91	K-19	K-157	K-66
SiO ₂	55.77	61.32	58.33	49.57
TiO ₂	.65	.79	.90	.50
Al ₂ O ₃	13.74	14.41	18.44	12.94
Fe ₂ O ₃	5.60	4.48	.70	1.74
FeO	4.25	1.30	tr	12.39
MnO	.24	.30	tr	.82
MgO	2.66	1.52	1.41	11.40
CaO	.29	.20	.23	1.70
Na ₂ O	.22*	.24*	1.82*	.25*
K ₂ O	8.96*	8.01*	8.05*	.07*
P ₂ O ₅	.24	tr	tr	tr
H ₂ O (+)	5.03	3.40	6.88	4.50
H ₂ O (-)	1.07	.81	1.65	2.27
CO ₂	.08	.03	.03	.05
FeS ₂	1.61	3.23	1.55	1.35
Total	100.41	100.04	99.99	99.55

K-91: Silicified rock of foot-wall-side (0.5 m) of Kanoko-mae-hi at U 1 level.

K-19: Silicified rock of hanging-wall-side of Kanoko-hon-hi at O m level.

K-157: Argillic rock of foot-wall-side of Kanoko-oku-hi at U 2 level.

K-66: Chloritic rock in Kanoko-hon-hi at O m level.

* Analyst, Y. NASU

Argillic rock too, has a peculiar composition. Due to the formation of clay minerals, the amount of alumina is the highest among the altered rocks now under consideration, and the water content is also the highest of all. The bleaching of magnesia, lime and iron is considerable, thus, the argillic alteration also shows a unique style different to the other ones.

The chemical composition of chloritic rock (K-66) corresponded to the chemical character of chlorite, characterized by its low silica, distinct high content of ferrous oxide and magnesia and minimum alkalies. The bleaching of lime and alkalies, soda as well as potash, and the decrease of ferric iron are not in conformity with the style of alteration of propylite or silicification.

The chemical behaviour of each alteration facies display respectively a unique one as described above. Corresponding to each mineral assemblage and to respective dispositions in the region, characteristic chemical compositions were brought about. In view of those alterations as a whole, the enrichment of water is a prominent feature, and further the

high concentration of potash contrasted to the decrease of soda except in chloritic alteration is another distinct feature. Also, bleaching of lime is almost predominant in each type of alteration.

The nature of the alterations were so discontinuously changed according to the time and space of formation that widely different chemical compositions were induced.

TABLE 4. Calculated number of cations in the analysed rocks, on basis of 0=160

	K-43	K-96	K-92	K-91	K-19	K-157	K-66
Si	53.7	52.6	54.0	58.2	65.4	61.1	50.6
Ti	.6	.5	.5	.5	.6	.7	.4
Al	18.6	17.6	16.6	16.9	18.1	22.7	15.6
Fe	7.1	7.4	7.2	8.9	6.5	1.4	12.5
Mn	.2	.4	.2	.2	.3	.0	.7
Mg	6.2	2.9	8.2	4.2	2.4	2.2	17.5
Ca	4.8	6.5	3.8	.3	.2	.3	1.9
Na	4.8	3.0	7.4	.4	.5	3.7	.5
K	4.6	8.2	1.8	11.6	10.9	10.8	.1
P	.0	.0	.0	.2	.0	.0	.0
H	(12.6)	(13.9)	(19.3)	(21.2)	(15.0)	(29.8)	(23.1)
C	(.4)	(.5)	(.0)	(.1)	(.0)	(.0)	(.1)
S	(.9)	(.7)	(1.0)	(1.7)	(3.4)	(1.6)	(1.4)

Considerations

Concerning the problem of wall rock alteration^{3),4),13),15),17)} and propylitization,^{1),2),6),16),23)} discussions have been carried on for a long time. An opinion proposed by COATS, J. W. (1940) designates the propylitization as an autometasomatic hydrothermal action which succeeded immediately after the effusion of propylite. It is merely reduced to an igneous phenomenon proper. On the other hand, in some discussions it is exclusively considered as a problem of alteration caused by ore forming fluids. Such conflicting understandings could base on observations made in different localities.

In the green tuff region, also, various modes of propylite which may lead to such opposed opinions are mentioned in every discussion. In some instances, a widely developed propylite mass which is separated far from ore deposits has suffered a type of alteration uniformly. According to the mode of occurrence of the mass and altered facies, it is adequate to apply the theory of hydrothermal autometasomatic alteration for explain-

ing the cause of such type of propylite.

It is well worth while to give careful attention to the alteration facies appearing to only a limited extent which includes a vein swarm. The idea of "local propylite" or "epipropylite" confronted to the regional alteration (or propylitization) which means the hydrothermal autometasomatic character has been proposed by T. AKIBA¹⁾ or J. W. COATS²⁾ for such a limited alteration aureole surrounding an ore deposits. Pyritization is a prominent feature of such local alteration, which is rather considered as a related phenomenon of the action of ore fluids.

It is considered as needful to discriminate the style of alteration represented in the propylite mass which is so far treated collectively as a single phase of propylitization. One type of alteration might be represented as regional in character, properly ascribed to the autometasomatism of igneous rocks. Another type might be distinguished as resulting in a limited aureole of smaller scale and display a more intimate relation to the formation of ore deposits. Unfortunately, in the Kanoko vein swarm, the propylite mass is rather smaller compared to the scale of development of the vein swarm, so that the whole mass is included in the aureole of the vein swarm. So the precise distinction of regional or local character is not clearly determinable.

Of both types of alteration, similar mineral assemblages of alteration would be expected, but they should be treated separately according each to the mode of occurrence. Around the Kanoko swarm, although propylite-3 is mainly disposed in the marginal part of the mass, similar rock character is also to be noted as the outer sheath of every vein.

The alteration character of those members closely allied with the vein has prominent difference from the characters of propylitic alterations. Corresponding to each peculiar mineral assemblage which has undergone the development of a special alteration mineral as a stable form of its environment of alteration, characteristic chemical compositions are induced. The enrichment of potassium in silicified rocks will be ascribed to the development of adularia as a component of a stable assemblage of quartz-adularia. With the chloritic alteration which includes characteristic increase of chlorite, the chemical composition of it approaches to that of chlorite itself. Argillic alteration too, denotes a similar trend of chemical change.

As already stated, distinct differences according to the nature of vein facies are displayed between the deeper and upper level or along one level. It will be concluded that the mineral assemblage of vein facies remarkably differentiated according to the time and space relation of each successive

mineralization. It is considered similarly that the wall rock alteration has an intimate relationship to such various vein facies and analogous time and space relation amongst the facies themselves.

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Explanation of
Plate 1

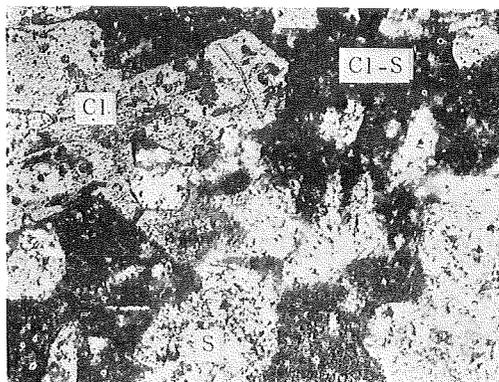
Explanation of Plate I

Plate

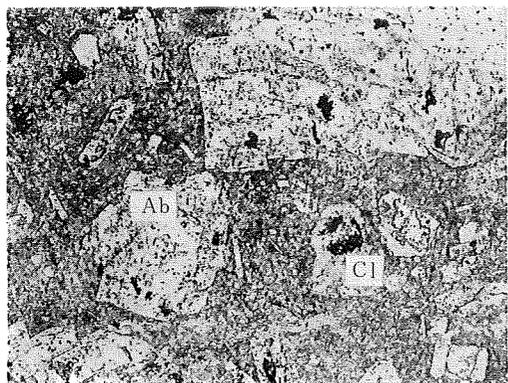
1. K-43 Propylite-1 Pl: plagioclase, Cl: chlorite after pyroxene, C: calcite.
2. K-96 Propylite-2 S: sericite and albite after plagioclase, Cl: chlorite after pyroxene, Cl-S: aggregates of chlorite, sericite and albite.
3. K-92 Propylite-3 Cl: chlorite after pyroxene, Ab: albite after plagioclase.
4. K-19 Silicified rock Q: aggregation of quartz, Ad: adularia, Cl: chlorite, P: adularia and chlorite after plagioclase.
5. K-20 Argillic rock after silicified rock, K-S: fine aggregation of kaolinite, halloysite and sericite, Ad: remnant adularia, Q: remnant quartz.
6. K-66 Chloritic rock Cl-M: fine aggregates of chlorite and montmorillonite, Cl: chlorite after plagioclase, Q: quartz.



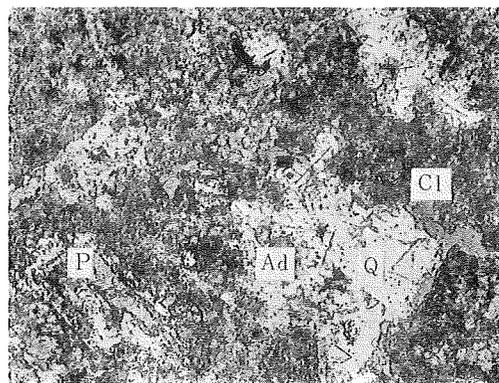
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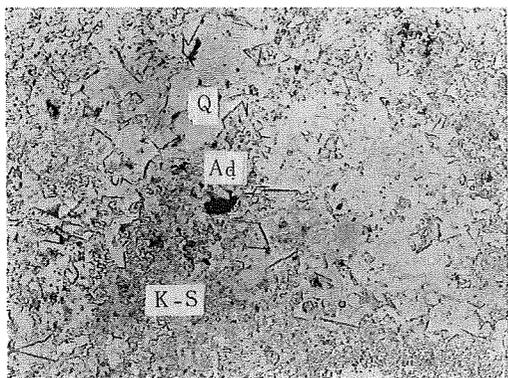
2



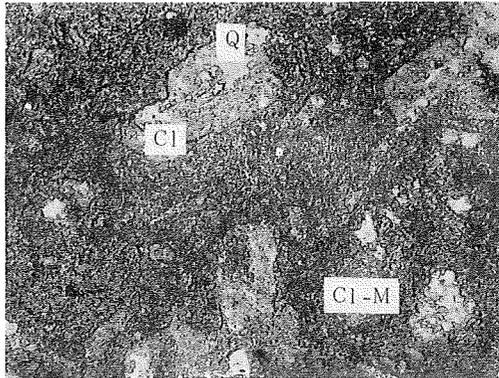
3



4



5



6