ON THE OCCURRENCE OF THE SO-CALLED TSUBOSAWA GNEISS IN THE KITAKAMI DISTRICT, JAPAN

by

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(with 17 Figures)

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Introduction

The geology of the Kitakami mountain region in the outer zone of north-eastern Japan has been well studied from many years ago. For it affords a most admirable field for the study of Paleozoic and Mesozoic formations, and of various kinds of intrusives and their associated normal contact metamorphosed rocks. The existence of any gneissose rock had, however, not been noted in any part of the region, before the writer, K. ITO and Y. YAMASHITA, each and separately found the gneissose rocks in 1949 in the areas along the western foot of Mt. Hikami*. They named the rock the "Tsubosawa gneisses". In the Tsubosawa Valley, 4 km north of the city of Takata, the Tsubosawa gneisses show excellent outcrops where they occur in irregular narrow lenticular forms running in NNW

*) SUZUKI, Y. (1952): On the Structure of the Granodioritic Rocks in the Takata District of the Kitakami-Mountainland Northeastern Japan. Jour. Geol. Soc. Japan, Vol. 58, No. 676, pp. 1–16.

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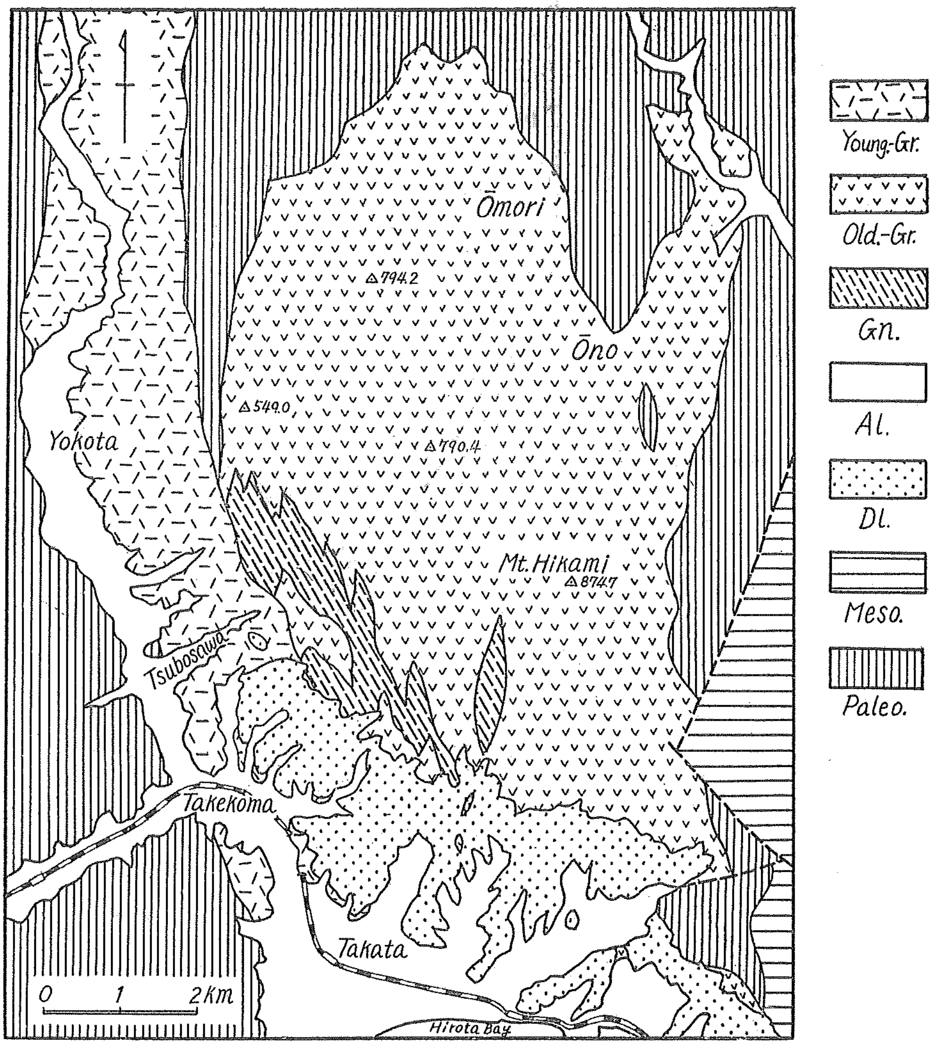


Fig. 1. Geological map of the vicinity of Mt. Hikami in southern part of the Kitakami mountain region.

This map is compiled from the maps made by the auther and the public works division of the Iwate Prefectural Office (1954).

Numerous faults are observed in this area, however for the simplification, only indispensable faults have been shown as broken line.

Abbreviations.

Young.-Gr.	Kesengawa plutonics.	Meso.	Mesozoic formation. (Cretaceous)
Old.-Gr.	Hikami granite.		
Gn.	Tsubosawa gneiss group.	Paleo.	Paleozoic formation. (Gotlandian, Devonian, Carboniferous and Permian formations.)
Al.	Alluvial deposits.		
Dl.	Terrace deposits and debris.		

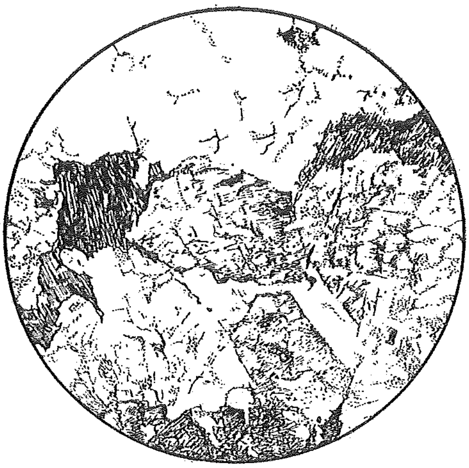


Fig. 2. Granitic rock of the Hikamiyama type. Northern part of Mt. Hikami. Diam. 4mm. Glomeroporphyritic aggregation of quartz, highly chloritized biotite with intercalating epidote and altered felspars.

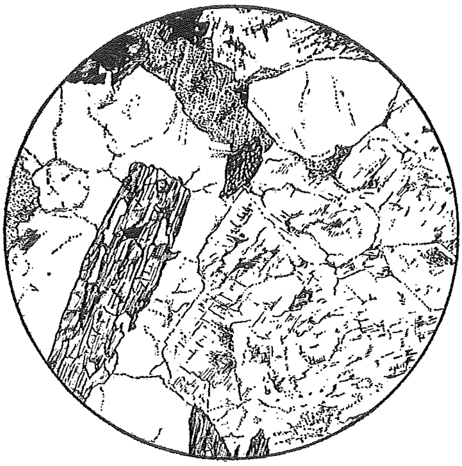


Fig. 3. Acid plutonic rock of the Kesengawa type. Eastern margin of the Tsubosawa Valley. Diam. 4mm. Granodioritic rock containing euhedral plagioclase, green hornblende and biotite with interfilling quartz and orthoclase.

direction in the acid plutonic mass. (Fig. 1)

The acid plutonic masses in this district are roughly divided into two, the Hikamiyama or Hikami type (Fig. 2) and the Kesengawa or Takekoma type (Fig. 3). The relation between these two types has been known from the field occurrence that the former is clearly cut by the latter and the effect of the metamorphism by the latter is obviously observed on the former. The lenticular masses of the Tsubosawa gneiss are always enclosed as xenoliths on a large scale in the Hikami plutonic mass; this fact indicates probably that the gneiss has partly at least been rendered crystalline by the Hikami intrusives. The relation between the gneisses and the plutonics of the Hikamiyama type is observed not only in the neighborhood of the Tsubosawa Valley but also in the Hirasawa area, distant 20 km north from this area.

As is shown in Figure 1, the northern and eastern margins of the Hikami granitic rock mass come directly in contact with Paleozoic and Mesozoic (mainly Cretaceous) formation, though the latter and the Hikami mass are bounded by faults. The Paleozoic group is formed of Gotlandian, Devonian, Carboniferous and Permian formations, each of which is respectively classified into subordinate subdivisions. There is no stratum of younger age than Cretaceous, if one excludes terrace and detrital deposits of Pleistocene developing along the southern margin of the Hikami mass, and covering the older sediments and plutonics.

The Hikami plutonics show particular granitic features and have pretty different nature from the common acid plutonics widely distributed in the Kitakami province**. The chief constituents of the rocks are coarser than those of common plutonics and the most of them are, as a rule, altered due to chloritisation, saussuritisation, epidotization, and albitisation which are considered to be auto-metasomatism in the plutonics. Though the rocks show local variation in petrographical character, most of them are usually composed of quartz, felspars and biotite.

The quartz grains frequently aggregate together forming a glomero-porphyritic structure, and the diameter of the aggregations often exceeds 1 cm. The potash felspars are orthoclase and microcline, which are locally pink-colored, and in some cases reach 3 cm or more in length. They are abundantly contained in the rock of the southern part of the Hikami granite mass, but are dificient in the north-western part of the mass. The plagioclase is albite to oligoclase in composition, and usually shows albite polysynthetic twinning but almost no zonal structure. It reaches about 3 to 4 mm in length. Most of the plagioclase is sericitized and albitized. Biotite generally is embedded in chlorites; rarely relics of hornblende are observed.

The western part of the Hikami granite mass is bounded by the Kesengawa plutonics, though the contact boundary is mostly covered by young detrital deposits, and the eastern part of the mass makes contact directly with Paleozoic formations.

It is noticeable that the effect of the contact metamorphism due to the intrusion of the Hikami granite mass is almost lacking on the adjacent sedimentaries which are not altered being still well bedded and frequently fossiliferous. In the eastern part of the Hikami granite, there are many large xenolithic blocks of limestone and sandstone which show also almost no trace of alteration. Despite the fact that a limestone is usually fairly sensitive to the changes in temperature and pressure condition, almost no evidence of thermal influence has been regarded on the limestones developing at the immediate vicinity of the granite contact and occurring

**) KANO, H. (1954–55): Preliminary Notes on Tectonic Relations between the Granitic and Their Country Rocks in the Kitakami-Central Zone, Northeastern Japan. (I) Jour. Geol. Soc. Japan, Vol. 60, No. 705, pp. 241–254. (II) Ibid. Vol. 61, No. 714, pp. 124–139.

SENDO, T., Y. UEDA, Y. YAMASHITA, T. WATANABE and K. ISHII, (1954): Granitic Rocks in the Vicinity of Hikami Mountain. (abstract). Jour. Geol. Soc. Japan, Vol. 60, No. 706, p. 317.

as xenolith within the granite mass.

In the marginal part, especially that of the north-eastern and south-western areas of the Hikami granite mass, special brecciated facies are developed, where the rocks are crushed and sheared, forming some mylonitic structure (Fig. 4). It has been noticed that the brecciated parts are restricted only to the granitic mass itself and do not extend to the adjacent sedimentary rocks.

The western marginal part of the Hikami granite mass, which occupies the narrow area between the Tsubosawa gneiss and the Kesengawa plutonic mass is fairly metamorphosed by the Kesengawa plutonics. The rock at the part in question shows as a rule, distinct gneissose texture characterized mainly by lenticules of aggregations of recrystallized minor biotite flakes, though its original texture is roughly preserved. (Fig. 5) The margin of plagioclase and quartz grains in the above rock are crushed and the aggregations of fine flakes of biotite are scattered in the crushed part of plagioclase. Moreover in this part garnet sometimes occurs. Large garnet is mostly crushed, especially when it is surrounded with chlorite. Also muscovite is contained; the flakes of which sometimes reach a diameter of 1 mm or more. Some muscovites replace biotite, while others occur in company with chlorite.

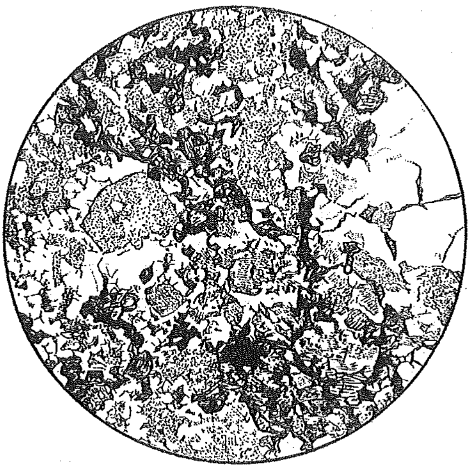


Fig. 4. Brecciated part of granitic rock of the Hikamiyama type. North eastern margin of the plutonic mass. Diam. 4mm. Brecciated qnartz and felspars, with epidote and chlorite.

Fig. 5. Hikamiyama granite metamorphosed by the intrusion of the Kasengawa plutonics. Somewhat north of the Tsubosawa Valley. Diam. 4mm. Aggregation of fine biotite flakes developing along the boundary among relict grains of quartz and felspars.

Fig. 6. Hornblende diabase dike cutting the Hikamiyama granite. Middle part between Mt. Hikami and Takata city. Diam. 4mm. Partly ophitic aggregation of andesine, hornblende and opaque minerals.

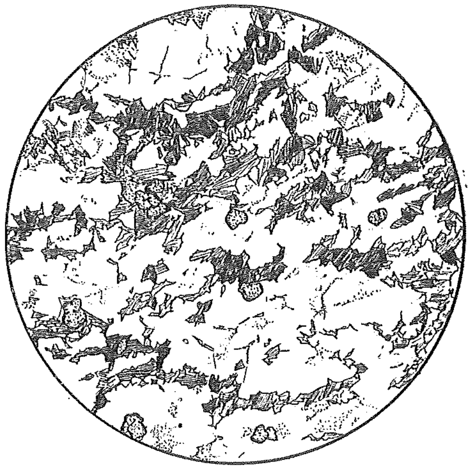


Fig. 7. Tsubosawa biotite gneiss. Tsubosawa Valley. Diam. 4mm. Quartz, plagioclase, biotite and sericite flakes arranged in a band, and garnet with a small amount of sphene, zircon and apatite.

The Hikami granite mass is penetrated in places by a few dikes of porphyrite and diabase. Both rocks are comparatively fresh and are chiefly composed of plagioclase, hornblende and pyroxene. (Fig. 6).

The Tsubosawa gneiss group

The main body of the Tsubosawa gneiss occurs in an irregular lensoidal form extending in NNW direction in the Hikami granite mass. An isolated large lenticle and numerous patches of the similar gneiss are found in the eastern side of the main lens of the gneiss. The gneiss usually contains fine foliation planes, which run approximately parallel to the elongated trend of the gneiss bodies.

The boundary between the gneiss and the Hikami granitic rock is generally rather sharp; the former is easily distinguished from the latter in respect to petrographical features. The numerous thin layers of the Hikami granitic rock are often intercalated in the gneiss mostly along the foliation planes at the marginal parts of the latter. In the gneiss body at the Tsubosawa Valley, occurs a small mass of meta-porphyrite, which has been metamorphosed from the basic dike rock.

The Tsubosawa gneiss group is roughly divided into two main types, biotite gneiss and amphibolite, though some local differences in the petrographical character of the respective types can be observed.

a) Biotite gneiss

Biotite gneiss is the commonest type occupying the most part of the gneiss area. It consists chiefly of quartz, plagioclase, biotite associated with subordinate amount of muscovite, garnet and others, and bears no trace of the original materials. The rock generally shows typical gneissose structure (Figs. 7 and 8), but sometimes granoblastic or rather hornfels structure. (Fig. 9).

Quartz and plagioclase, the principal constituents of the rock, are present in irregular coarse grains, 0.1 mm in size. Quartz is generally fresh and clear showing weak undulatory extinction. Most of the plagioclase belonging to oligoclase to andesine is rich in dusty inclusion and shows polysynthetic twinning after albite or pericline law. Recognizable potash felspars are sometimes seen in the rock. In the normal biotite gneiss, minute flakes of biotite, about 0.1×0.01 mm, with a pleochroism of reddish brown to yellow ochr, aggregate forming thin layers in the bases of quartz and felspars, and they impart a marked gneissose feature to the rock. In the rock with the hornfels texture, biotite occurs rarely

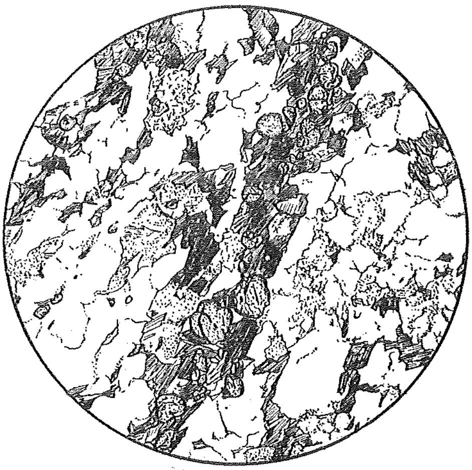


Fig. 8. Tsubosawa biotite gneiss. Northern part of Takata city. Diam. 1.5mm. The rock character is same to that of Fig. 7.

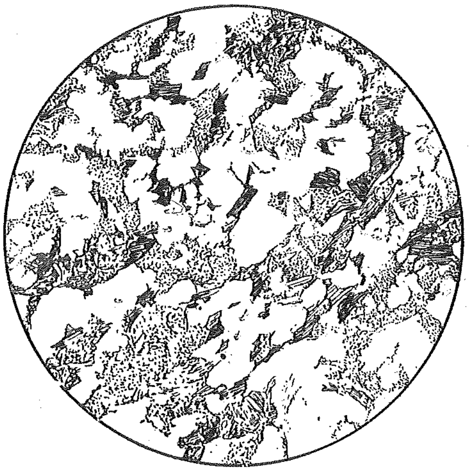


Fig. 9. Tsubosawa gneiss showing hornfels texture. Northern part of Takata city. Diam. 4mm. Principally quartz, plagioclase, biotite and muscovite.

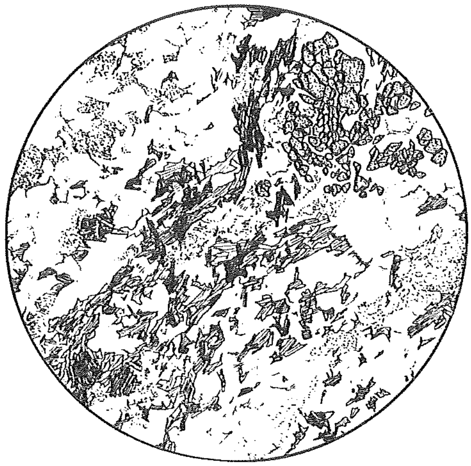
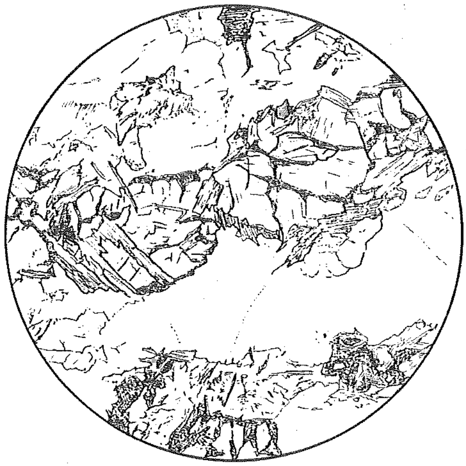


Fig. 10. Tsubosawa gneiss containing large garnet grains which were crushed by post action. Tsubosawa Valley. Diam. 4 mm.



F.g. 11. Cordierite, andalusite gneiss in the Tsubosawa gneiss. North of the Tsubosawa Valley. Diam. 1.5 mm. Cordierite surrounded with yellowish chlorite, which mingles with sericite, and euhedral andalusite: groundmass is mainly composed of quartz and plagioclase.

in isolated flake and is partly chloritized. Flakes of sericite, chlorite and comparatively large muscovite up to 0.4 mm in size are seen mingling with biotite flakes in the biotite layers. Many of them are considered to have replaced biotite or plagioclase grains.

Besides the above-mentioned minerals, garnet, andalusite and cordieritie are frequently found, generally in or near the biotite layers. Of these minerals, garnet is widely distributed all around, while the latter two are comparatively scanty. Garnet occurs usually as minute crystals, occasionally it reaches 1 mm in maximum diameter; most of the layer crystals are crushed into small irregular fragments. (Fig. 10) It is always colorless or very pale brown, almost isotropic, indicating that it may belong to an almandine type. Cordierite is present in irregular grains, 0.5 mm in size and is often characterized by trilling form. (Fig. 11) It is noted that most of those grains are always surrounded by yellowish chlorite, such chlorite, however, is not observed around biotite, even when the latter mineral comes in contact with cordierite.

Andalusite forms irregular colorless short prisms with distinct cleavage plane, scattering among the grains of the other minerals. (Figs. 11, 12 and 13) It occurs rather in the crushed part of the matrix, and always alters to minute flakes of sericite.

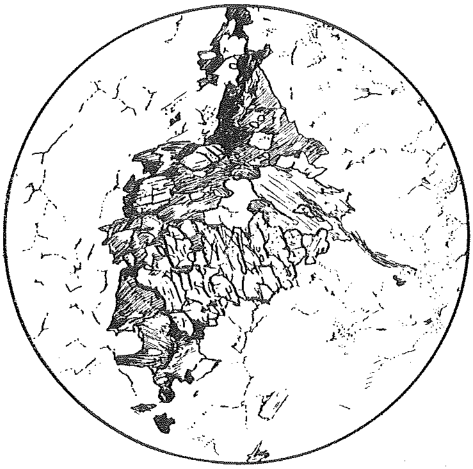


Fig. 12. Tsubosawa gneiss. The north part of Takata city. Diam. 1.5mm. Composed of andalusite, sillimanite after muscovite, biotite, quartz, and felspars.

Fig. 13. Tsubosawa gneiss. North of the Tsubosawa Valley. Diam. 1.5mm. Composed of sillimanite after biotite, andalusite, muscovite, quartz, and felspars.

Zircon and apatite are common accessory components of the biotite gneiss though in very small amount. The former shows pleochroic halo when it is included in the biotite flake. In rare cases, fine green hornblende occurs also.

The normal biotite gneiss includes numerous leucocratic layers of various sizes, mostly parallel to the foliation planes of the former. But the above layers are hardly distinguished from the gneiss, when they are very thin. When they are very thick, they look like a dike or sill penetrating the gneiss, though they are found to intermingle frequently with small patches of the gneiss, upon close examination. The leucocratic layers are chiefly composed of quartz and potash felspar; they are deficient in plagioclase, muscovite and biotite, showing an aplitic appearance. (Fig. 14)

Potash felspar are microcline and orthoclase, and often form myrmekite with the plagioclase. In most cases the leucocratic parts contain irregular grains of tourmaline, 5 cm or more in length, with pleochroism of bluish green to pale green. The gneiss is locally characterised by a content of a pretty large amount of garnet, andalusite and sillimanite. (Figs. 12 and 13) The last-mineral seems to have originated from andalusite, muscovite and sometimes biotite. It is uncertain whether the leucocratic parts were materials derived from the Hikami intrusive and

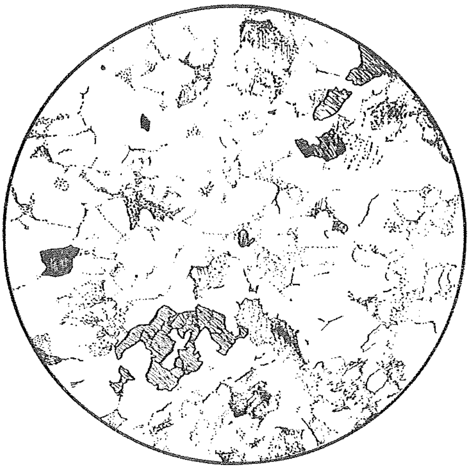


Fig. 14. The aplitic part in the Tsubosawa gneiss. Tsubosawa Valley. Diam. 4mm. Composed essentially of quartz and potash felspar with accessory plagioclase and tourmaline.

Fig. 15. Amphibolite. Tsubosawa Valley. Diam. 4mm. Green hornblende, diopside, plagioclase and sphene.

injected into the gneiss, or those segregated from the adjacent rock during the metamorphism.

b) Amphibolite

Amphibolite occurs as a small patch or in dike-like form in the biotite gneiss; it is negligible in volume as compared with the surrounding biotite gneiss. It is only several decametres in average length and the axis of elongation is arranged nearly parallel to the foliation of the adjacent gneiss. Generally the amphibolite come in sharp contact with the neighboring biotite gneiss.

The amphibolite is mostly composed of recrystallized green hornblende, plagioclase, clinopyroxene and small amounts of quartz, sphene, apatite and zircon, and has almost no relict minerals. (Fig. 15) The rock is as a rule distinctly schistose, and its recrystallized minerals are generally elongated in a certain direction, along the planes of foliation.

Plagioclase varies in amount, though it is always an essential ingredient of the rock. It shows irregular shape smaller than 0.1 mm, being rich in dust. Hornblende grains are generally larger than those of plagioclase. They occur in short prismatic form about 1 mm in average length and these prism on the whole show orientated arrangement. Hornblende shows strong pleochroism, bluish green to pale brownish yellow, or dark green to pale yellow. Its interference color is yellow of first order, but it becomes lower, if the hornblende grain is sheared. In many cases the hornblende surrounds the plagioclase. Pyroxene is idioblastic, and arranges in a zone. According to the optical properties, it seems to be diopsidic pyroxene. Sometimes it is included in plagioclase and hornblende, and is frequently surrounded by a hornblende mantle.

In addition to the above minerals, sphene, apatite, zircon and a very small amount of biotite are contained. Especially it is noted that sphene also is arranged along the foliation plane of the rock. In a particular type of the amphibolites, small grains of quartz, 0.2 to 0.3 mm in size, are abundantly distributed in association with the orientated aggregation of fine flakes of green hornblende. (Fig. 16)

c) Other associated rock, meta-porphyrite

In the middle course of the Valley Tsubosawa, there is a special porphyritic green rock which occurs as a small lenticular intrusive body in the biotite gneiss. It extends nearly parallel to the foliation of the gneiss and shows sharp contact with the surrounding rock.

The rock bears apparently some resemblance to the common porphyrite which occurs at various places in the Kitakami district. It is however characterized by the fact that the rock has partly recrystallized, as a

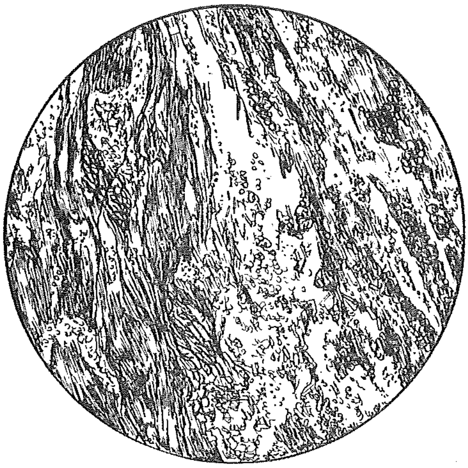


Fig. 16. Amphibolite of particular type. Tsubosawa Valley. Diam. 1.5mm. Fibrous green hornblende developed from green hornblende which partly remains; basement is mainly composed of quartz which includes minor epidote.

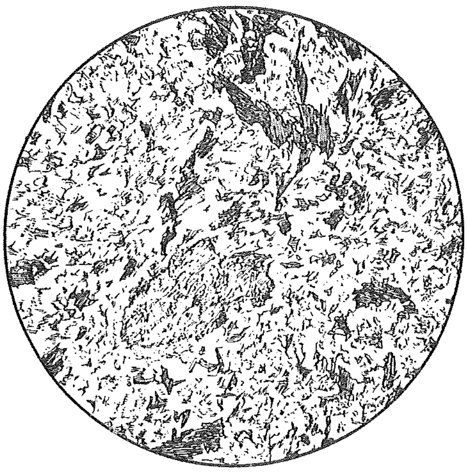


Fig. 17. Meta-porphyrite. Tsubosawa Valley. Diam. 4mm. Relict plagioclase and green hornblende surrounded by recrystallied groundmass composed of plagioclase, green hornblende and biotite.

result of slight thermal metamorphism. Accordingly it may rather be called a meta-porphyrite. (Fig. 17) The rock shows blastoporphyritic texture characterized by large crystals of plagioclase and green hornblende; the fine-grained groundmass consists of the small grains of plagioclase, green hornblende mingled with numerous minute flakes of biotite, smaller grains of apatite and opaque minerals.

The larger crystals of plagioclase and hornblende, which are easily recognized by the naked eye, show irregular margins; most of them are probably the relics of phenocrysts in the original rock. The relict felspar phenocryst is as a rule cloudy and contains numerous inclusions such as epidote and sericite, though it often shows Carlsbad and albite polysynthetic twin as well as zonal structure. However, fine grained plagioclase forming the groundmass is generally fresh and clear, and it shows almost no twinning. The hornblende always occurs as short greenish prism, but its terminal part is usually broken up into fine fibers; often the large prism reaches 2 mm in length, but it is not certain whether the mineral is a relict or not.

The fine minerals which form the groundmass of the rock, are randomly arranged, showing hornfels structure. Most of them show fresh and clear appearance in comparison with the relict phenocrysts, consequently they are considered to be recrystallized products.

Consideration on the formation of the Tsubosawa gneiss group

To sum up the above-mentioned observations, the Tsubosawa gneiss occurs always as enclosure in the Hikami granite mass and is partly injected by the latter along its foliation. The gneiss itself in this field may be considered to be confined at most to the amphibolite facies, however some parts of it are further affected by contact metamorphism which accompanied the younger Kesengawa plutonics. Thus the gneisses are characterized by containing often such special minerals as garnet, cordierite, andalusite and sillimanite besides the essential constituents, but no relict mineral.

Most of the sedimentaries and their xenolithic blocks at the immediate vicinity of the contacts in the northern and eastern parts of the Hikami granite mass, show almost no evidence of thermal effect or hornfels structure, and some of the former are even fossiliferous. In the marginal portion, especially in the north-eastern part of the Hikami granite mass, there is developed a particular brecciated facies which is restricted only to the granite mass itself and does not extend to the areas of the adjacent

Paleozoic sedimentaries.

The above-cited facts show that the geological mechanics in the area are very complicated, and offer some problems especially on the genesis of the Hikami granite and the accompanying Tsubosawa gneiss. For instance, the Hikami granite mass includes comparatively highly metamorphosed gneisses as enclosures on one side, while it comes in contact with sediments with very slight or no trace of contact effect on other side.

As above noted, certain brecciated or crushed facies develop in the marginal part of the Hikami granite mass. From their features and modes of occurrence, these special facies are assumed to be distinct autoclastic products which may be ascribed to the upward movement of the granitic material. This may suggest the question whether the granitic material contained little fluidal portion or whether its movement was comparatively rapid. It seems that those facts suggest the probably plastic nature of the Hikami granite mass at its intrusion stage.

It is noticeable that the Hikami granitic rocks bear special characteristics in model composition and in structure, and they are especially characterized by the fact that the plagioclases are almost wanting in zonal structure. This fact indicates that the Hikami granitic rocks are different from normal magmatic plutonics and that they may be rather regarded as a kind of metamorphosed products.

Despite the relatively abundant development of the plutonic rocks of the Kesengawa type near the Hikami granite mass and the Tsubosawa gneiss, the contact metamorphism can be recognized only in limited area, and no distant migration of material appears to have taken place among them.

As already mentioned, the Tsubosawa gneisses are divided into biotite gneiss, and amphibolite, with associated meta-porphyrite. From the mineral compositions and the modes of occurrence, the biotite gneiss and the amphibolite are considered to be respectively the products of recrystallization of argillo-siliceous sediments and associated basic pyroclastic rocks, probably schalsteins, though their original structures have been completely obliterated by metamorphism. The occurrence of the meta-porphyrite may be considered as a basic dike, since the origin of the rock is clearly indicated by the presence of relict phenocrysts which are retained even in completely recrystallized groundmass. Then the characteristic features of the gneisses will mainly depend on their original chemical composition.

It is best conceivable that the gneissic rocks intercalated in the southwestern part of the Hikami granite mass may be the highly metamorphosed products of the large blocks enclosed in the granitic materials at great depths. It may be considered that the gneiss occurred merely in company with the uprising of the Hikami granite from the depth. On the other hand, the sedimentaries and xenoliths come directly in contact with the border of the intrusive mass. They are considered to have been scarcely effected by the intrusion since they had come into contact with the low temperature portion of the intrusives of the last stage. It is conceivable that that contact occurred in a somewhat uneven manner in places.

The writer wishes to express his sincere thanks to Professors T. ISHIKAWA and M. MINATO, for their valuable suggestions and kind guidance during this investigation.