GEOLOGY OF THE MINAMI-YAMATO NUNATAKS, EAST ANTARCTICA

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Abstract: The Minami-Yamato Nunataks are situated at 71.9°–72.1°S latitude and 35.1°–35.3°E longitude, 40 km southwest of the Yamato Mountains.

The basement rocks exposed in this area are classified as follows: (1) Granitic gneiss, (2) Hornblende-biotite gneiss, (3) Clinopyroxene-biotite gneiss, (4) Basic dikes, (5) Acidic dikes. The gneissic rocks subjected to amphibolite facies metamorphism were intruded by various dike rocks, which are subdivided into basic dike I, acidic dikes, basic dike II in order of their emplacement. Basic dike rocks were also metamorphosed. On the basis of their modes of occurrences and petrographic features it can be concluded that the rocks composing the Minami-Yamato Nunataks are correlated with those of Massifs B and C in the Yamato Mountains.

1. Introduction

The Minami-Yamato Nunataks are situated at 71.9°–72.1°S latitude and 35.1°–

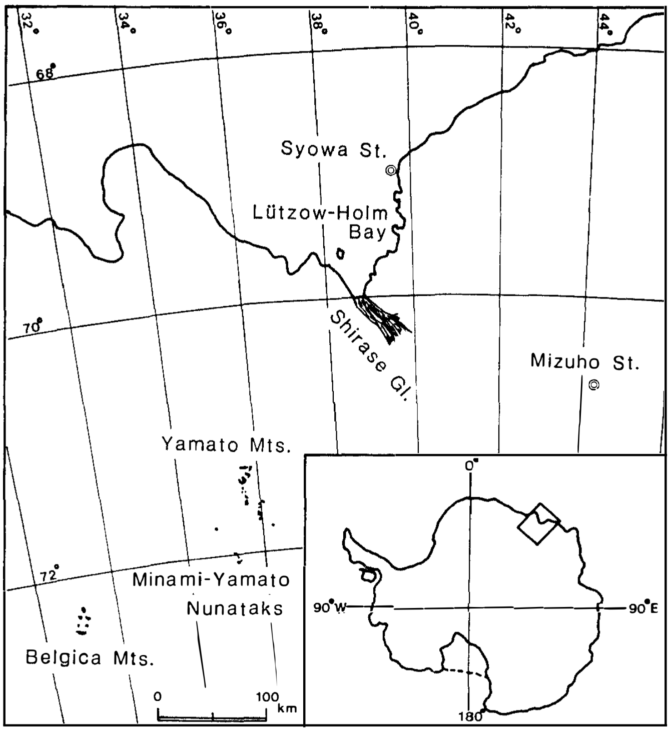

Fig. 1. Location map of the Minami-Yamato Nunataks.

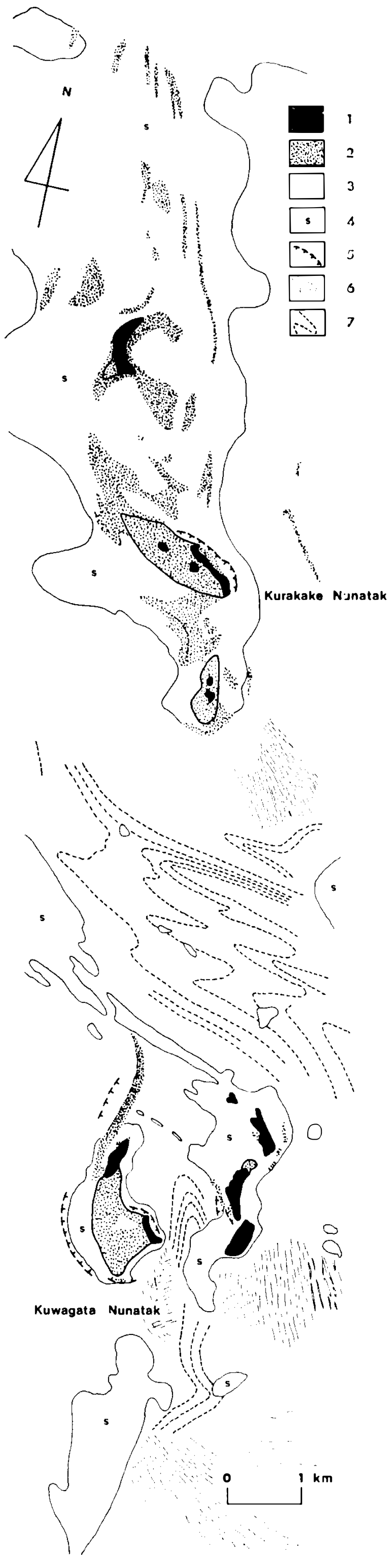

Fig. 2. Brief topographic map of the bare ice field around the Minami-Yamato Nunataks. 1. Bedrocks. 2. Moraine. 3. Bare ice area. 4. Snow-covered area. 5. Wind scoop. 6. Crevasse. 7. Dirt bands.

35.3°E longitude, 40 km southwest of the Yamato Mountains (Fig. 1). The nunataks are composed of two large nunataks, Kurakake Nunatak in the north (2218 m in height) and Kuwagata Nunatak in the south (2282 m in height), and associated smaller nunataks. They range from north to south. Morainic debris is distributed mainly in the northwest of the nunataks. The nunataks are surrounded by the bare ice area where meteorites have been found (Fig. 2).

The inland traverse party of the 14th Japanese Antarctic Research Expedition (JARE-14) visited the Minami-Yamato Nunataks and the surrounding area for the first time in 1973 and surveyed the geology of the nunataks (SHIRAISHI, 1975). Since then no geological investigation has been done, although several parties carried out searches for meteorites and geomorphological investigations in this area. The author, one of the members of the inland traverse party of JARE-23, surveyed the geology of this area for 5 days from December 25, 1982 through January 3, 1983. The investigation was carried out mainly in the southern area of the Minami-Yamato Nunataks and also in some parts around Kurakake Nunatak in the north. The geology of some parts in the southern area has not yet been reported by SHIRAISHI (1975). Since topographic maps of this area are not available, field data are plotted on the conventional map compiled from the aerial photographs taken by JARE-16 on a scale of approximately 1 : 23500.

This paper presents the geology of the nunataks with special reference to the intrusive relations of the igneous rocks. The relationship between the Minami-Yamato Nunataks and the Yamato Mountains is briefly described.

2. Geology

The investigated area is divided into two parts, the southern part around Kuwagata Nunatak and the northern part around Kurakake Nunatak. The nunataks are named for convenience' sake A to F from south to north.

Fig. 3. The southern Minami-Yamato Nunataks around the Kuwagata Nunatak.

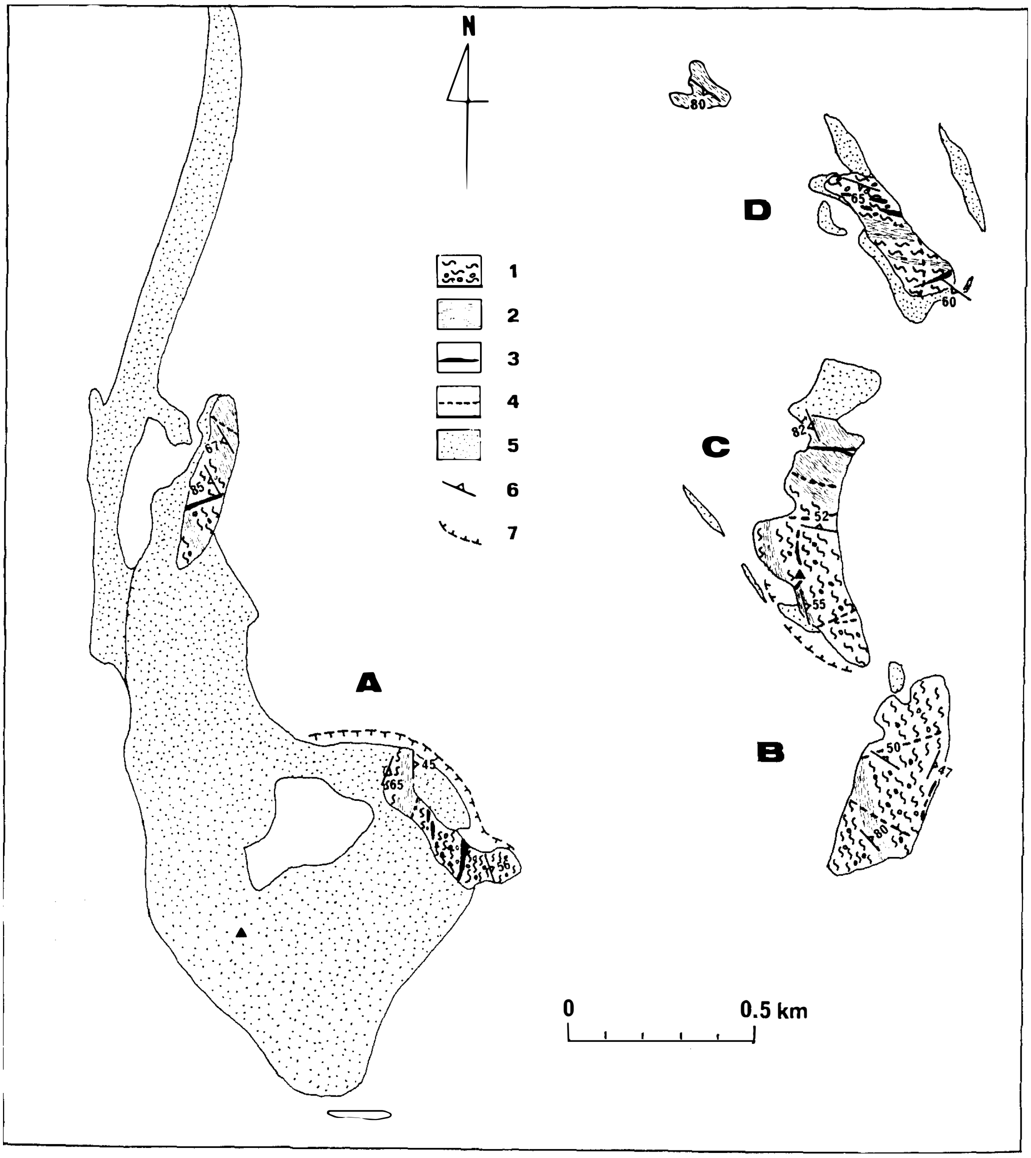

Fig. 4. Geologic map of the southern Minami-Yamato Nunataks. 1. Granitic gneiss, ellipsoidal parts bearing potash feldspar porphyroblasts. 2. Hornblende-biotite gneiss. 3. Basic lenticular bodies and layers and basic dikes. 4. Acidic dikes. 5. Moraine. 6. Strike and dip of foliation. 7. Wind scoop.

2.1. Southern area

Figure 3 shows the southern area viewed from Kurakake Nunatak. The geology of the area is presented in Fig. 4. The east side of Kuwagata Nunatak (Nunatak A) and the west side of Nunatak C form steep cliffs facing each other. The crystalline basement rocks in this area are well exposed in contrast to those of the northern area, except for the central to the western parts of Nunatak A, which are covered with morainic debris.

The basement rocks are composed mainly of granitic gneiss and associated interbedded hornblende-biotite gneiss. The modes of their occurrences are well ob-

Fig. 5. The mode of occurrence of granitic gneiss and interbedded hornblende-biotite gneiss. Locality: West cliff of Nunatak C.

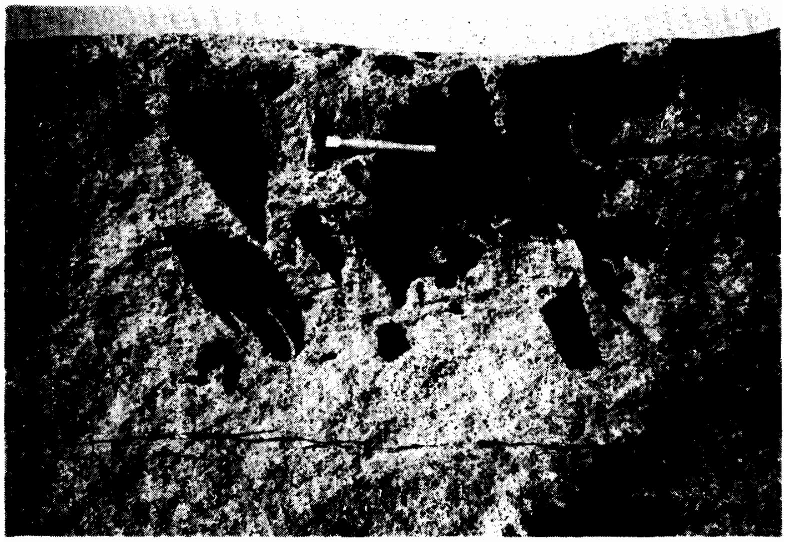

Fig. 6. The agmatitic structure of granitic gneiss. Locality: Nunatak D.

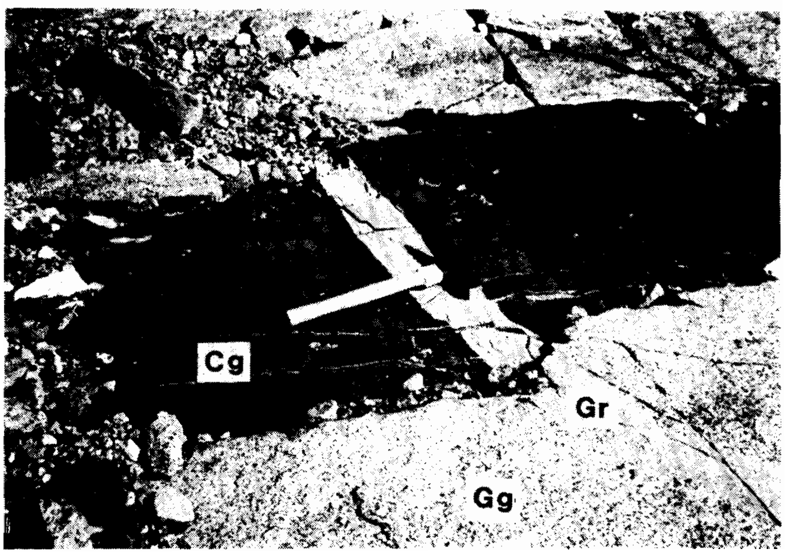

Fig. 7. Clinopyroxene-biotite gneiss (Cg) and surrounding granitic gneiss (Gg) intruded by granite vein (Gr). Locality: Nunatak D.

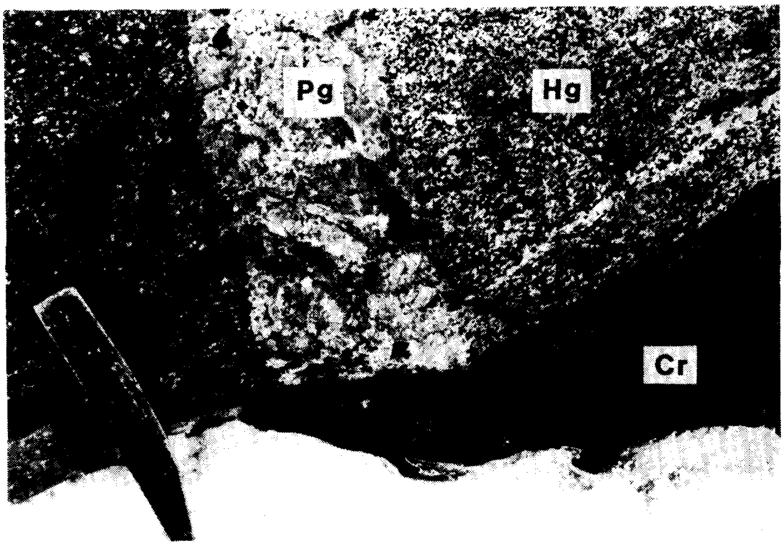

Fig. 8. Clinopyroxene-biotite rock (Cr) of basic dike II intruding into hornblende-biotite gneiss (Hg) and pegmatite (Pg). Locality: Nunatak D.

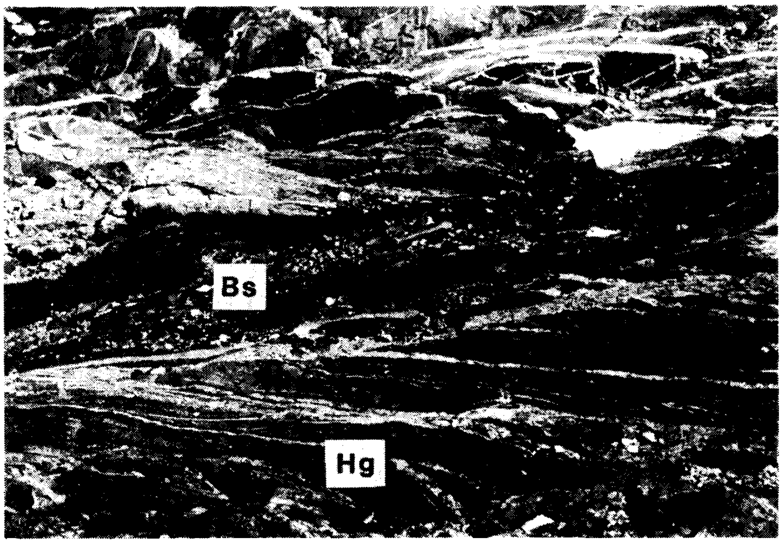

Fig. 9. Biotite schist (Bs) of basic dike II intruding into hornblende-biotite gneiss (Hg) and acidic dikes. Locality: Nunatak C.

Fig. 10. The northern Minami-Yamato Nunataks around Kurakake Nunatak.

served in the west cliff of Nunatak C (Fig. 5). Their relations are generally gradational, and migmatitic and agmatitic structures appear in part of their contact in Nunatak D (Fig. 6). Biotite gneiss and biotite amphibolite occur as mafic lenses enclosed within the gneissic rocks. Broken layers of clinopyroxene-biotite gneiss, 70 cm in width, are observed within granitic gneiss in Nunatak D (Fig. 7). Although these layers are often obliquely disrupted, their entire outlines are continuous and the foliation is parallel to that of the surrounding gneisses. Therefore, the clinopyroxene-biotite gneiss seems to be one of the dikes which intruded during or before the metamorphism, from which the foliation resulted. The basic dikes discordant to the gneissic rocks are classified into two types based on their relation to acidic dikes. Basic dike I is represented by hornblende-biotite gneiss distributed in the east cliff of Nunatak A and the west cliff of Nunatak C, and is intruded by acidic dikes. Clinopyroxene-biotite rock, several tens of centimeters in width, in Nunatak D (Fig. 8) and biotite schist, 1 to 2 m in width, in Nunatak C (Fig. 9) are grouped in basic dike II,

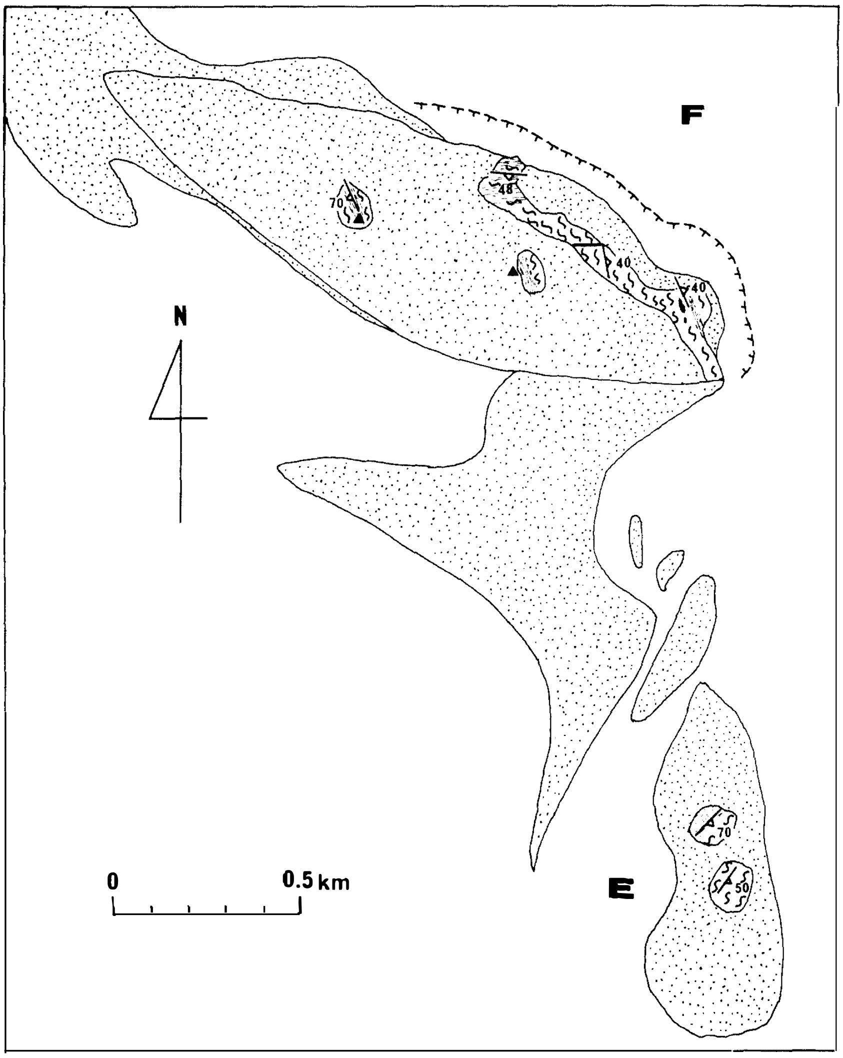

Fig. 11. Geologic map of the northern Mimani-Yamato Nunataks. Legend is the same as in Fig. 4.

which intruded into acidic dikes with sharp contact. Basic lenticular bodies and layers within the gneisses and basic dikes I and II are all marked as metabasite in the geologic map. The acidic dikes; *i.e.*, granites, pegmatites and aplites, are distributed throughout the nunataks, but only major dikes are shown in the geologic map.

The foliation of the gneisses is generally conspicuous. It is nearly constant within each nunatak, but the structural relation between the nunataks is unknown. Generally the foliation strikes north to northwest and dips steeply to the west or east.

2.2. Northern area

Figure 10 shows Kurakake Nunatak (Nunatak F) viewed from south. The geologic map of the northern area, Nunataks E and F, is shown by Fig. 11. Due to the wide extension of moraine field, the basement rocks are exposed only in restricted parts, *i.e.*, the east cliff of Nunatak F and several smaller parts.

The rocks in this area are composed mainly of granitic gneiss and associated hornblende-biotite gneiss like those in the southern area. Granitic gneiss in the northernmost part of the east cliff of Nunatak F is characterized by banded structure. Biotite gneiss and biotite amphibolite form mafic lenticular inclusions within the granitic gneiss, similar to those in the southern area. Several veins of hornblende-biotite gneiss, 10 to 30 cm in width, correlated with basic dike I in the southern area are observed in the east cliff of Nunatak F. However, no dikes correlative with basic dike II are observed in this area. Acidic dikes as granite, pegmatite and aplite also appear at the east cliff of Nunatak F. Strike of the foliation in gneissic rocks varies from NS to EW even in Nunatak F.

3. Petrography

The crystalline basement rocks exposed in this area are classified into the following rock types on the basis of their modes of occurrences and petrographical features.

1. Granitic gneiss
2. Hornblende-biotite gneiss
3. Clinopyroxene-biotite gneiss
4. Basic dikes
   (1) Hornblende-biotite gneiss
   (2) Clinopyroxene-biotite rock
   (3) Biotite schist
5. Acidic dikes
   (1) Granite
   (2) Pegmatite
   (3) Aplite

3.1. Granitic gneiss

Granitic gneiss is the most dominant rock type in the Minami-Yamato Nunataks. It is medium- to coarse-grained, and pale pink in color. Potash feldspar porphyroblasts less than 3 cm in size occur in the southern area. This rock is generally heterogeneous and foliated due to the parallel arrangement of mafic minerals. Irregularly

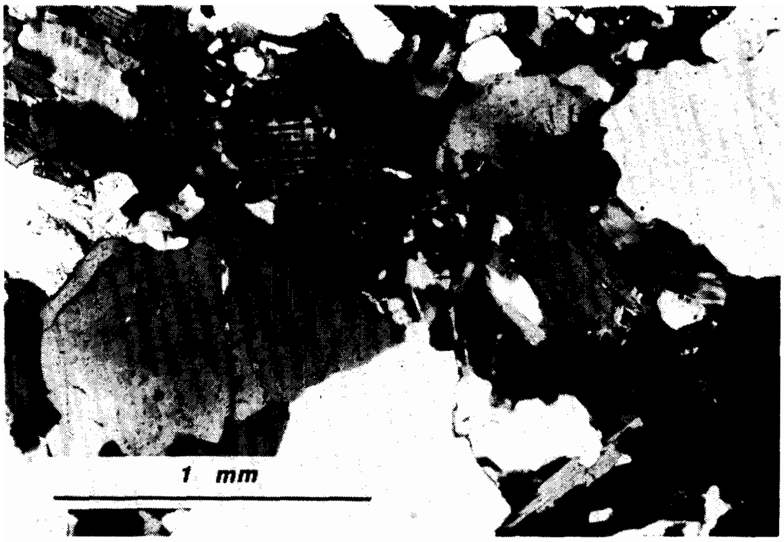

Fig. 12. Photomicrograph of granitic gneiss. Crossed polarized light. Locality: Nunatak D.

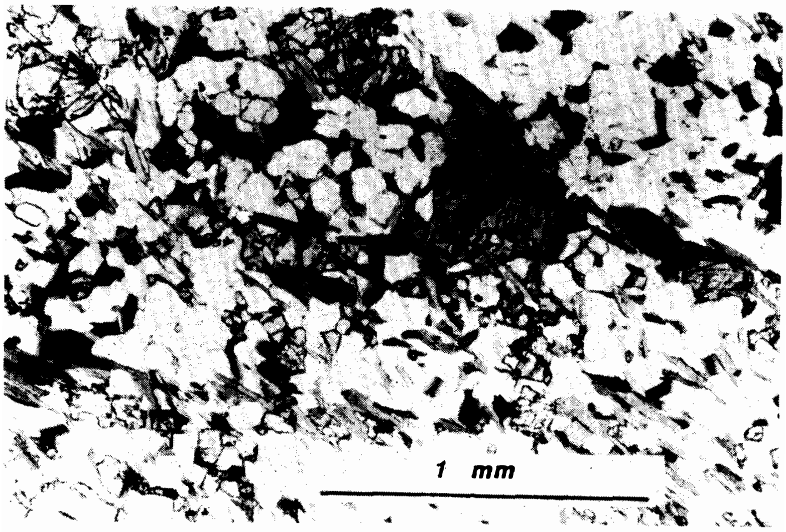

Fig. 13. Photomicrograph of clinopyroxene-biotite gneiss. Plane polarized light. Locality: Nunatak D.

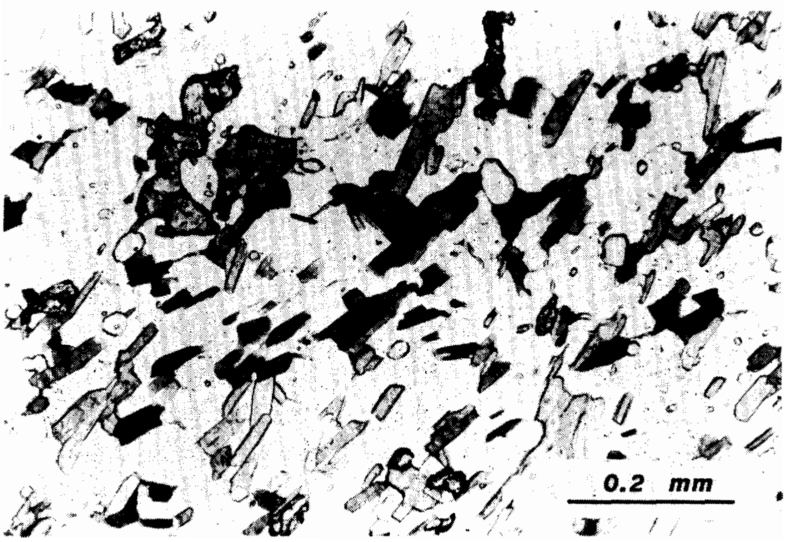

Fig. 14. Photomicrograph of biotite schist. Plane polarized light. Locality: Nunatak C.

shaped mafic parts rich in biotite are found sporadically in this rock. The granitic gneiss and the hornblende-biotite gneiss described in the following section are intergradational. The granitic gneiss consists of potash feldspar, plagioclase, quartz, biotite with or without hornblende, associated with small amounts of white mica, calcite, apatite, zircon and opaque mineral (Fig. 12).

3.2. *Hornblende-biotite gneiss*

This rock alternating with granitic gneiss is distributed in all the nunataks. A maximum thickness is 200 m in this area. The rock has the same mineral assemblages as the granitic gneiss but is richer in mafic minerals. Grain size and modal composition are variable. Foliation is more conspicuous than that of the granitic gneiss. Small lenticular melanocratic bodies of biotite gneiss without amphiboles and biotite amphibolite with a large amount of hornblende are also found in the hornblende-biotite gneiss. They are generally fine-grained and foliated more distinctly. Biotite amphibolite is dark-colored, and biotite gneiss is more or less light-colored. They are elongated parallel to the foliation of the surrounding gneissic rocks.

3.3. *Clinopyroxene-biotite gneiss*

Two layers of clinopyroxene-biotite gneiss appear in the north of Nunatak D. The rock is slightly massive and fine-grained, and the foliation is parrallel to the structure of the surrounding granitic gneiss. It consists of biotite, clinopyroxene and plagioclase with subordinate amounts of quartz and potash feldspar. Biotite is more abundant than clinopyroxene and shows a parallel arrangement. Clinopyroxene is subhedral to anhedral and generally 0.4–0.8 mm in size. Hornblende is anhedral and pleochroic with pale brown (X), and brownish green ($Y \doteqdot Z$), and sometimes it encloses clinopyroxene. Accessory minerals are sphene, apatite and opaque mineral (Fig. 13).

3.4. *Basic dike*

As described in the preceding section, basic dike rocks are metamorphosed and can be classified into three rock types; *i.e.*, hornblende-biotite gneiss, clinopyroxene-biotite rock and biotite schist. Their original rocks are assumed to have been potash-rich basic to intermediate volcanic rocks. However, their detailed characteristics remain unknown.

3.4.1. Hornblende-biotite gneiss

This rock occurs in Nunataks A, C and F. It contains the same amounts of biotite and hornblende. Although its mode of occurrence is different from that of the hornblende-biotite gneiss described in Subsection 3.2, they are petrographically similar to each other.

3.4.2. Clinopyroxene-biotite rock

This rock is found in Nunatak D. Mafic minerals are mainly biotite and clinopyroxene. Biotite is most abundunt and larger than other minerals (maximum size 3 mm). Clinopyroxene is subhedral to euhedral and is partially converted into actinolite. Prisms of apatite are dispersed throughout. Small amounts of epidote, sphene and opaque mineral are also observed. Potash feldspar is the major component, and often shows stringlet type perthite. This rock clearly differs from the clinopyroxene-biotite gneiss (Subsection 3.3) due to the predominance of potash feldspar and absence of hornblende.

3.4.3. Biotite schist

The rocks distributed in Nunataks A and C are lepidoblastic and most fine-grained among all rock types. The constituent minerals are quartz, potash feldspar, plagioclase, biotite and hornblende with subordinate amounts of sphene, apatite, calcite and opaque mineral. Quartz, plagioclase and potash feldspar are anhedral, nearly polygonal and equigranular. Biotite, 0.02–0.06 mm in size, shows strongly preferred orientation and is pleochroic with X=light brown, Z=greenish brown. Hornblende is much less than biotite, and shows preferred orientation. Many grains of sphene and apatite are characteristically observed in contrast to other rocks (Fig. 14).

3.5. Acidic dike

3.5.1. Granite

It is fine- to medium-grained and massive. Granitic dikes, generally several to 30 cm wide and less than 1 m, are distributed in all nunataks. Some of them include gneissic xenoliths. In hand spacimens they are pink and gray. They consist of quartz, plagioclase, potash feldspar, biotite and white mica with accessory apatite, zircon and opaque mineral.

3.5.2. Pegmatite

Pegmatites are also distributed in all nunataks. They are several tens of centimeters to two meters in width and characterized by coarse grains of potash feldspar, attaining to 8 cm in maximum size. They consist of potash feldspar, plagioclase, quartz, biotite and hornblende. Hornblende rarely exceeds 5 cm in size. Although the intrusive relations to granites are complex, it may be inferred that they were emplaced at the same time.

3.5.3. Aplite

Aplite veins distributed throughout the nunataks have various directions. They are several to several tens of centimeters in width, and with a distinct pink color they can be observed from a distance.

4. Discussion

4.1. Plutonism and metamorphism

It is considered that the metamorphic rocks distributed in this area, such as the granitic gneiss and the hornblende-biotite gneiss associated with lenses of biotite gneiss and biotite amphibolite, were all subjected to amphibolite facies metamorphism, judging from their mineral assemblages. The hornblende-biottie gneiss grouped in basic dike I intruded into these metamorphic rocks, and were subsequently penetrated by granite and pegmatite, followed by aplite. At the latest stage, basic dikes grouped in basic dike II such as clinopyroxene-biotite rock and biotite schist were emplaced. These intrusive relations are schematically presented in Fig. 15. Basic dikes I and II were also metamorphosed. Therefore, after the main metamorphism, these rocks went through one or two stages of metamorphism.

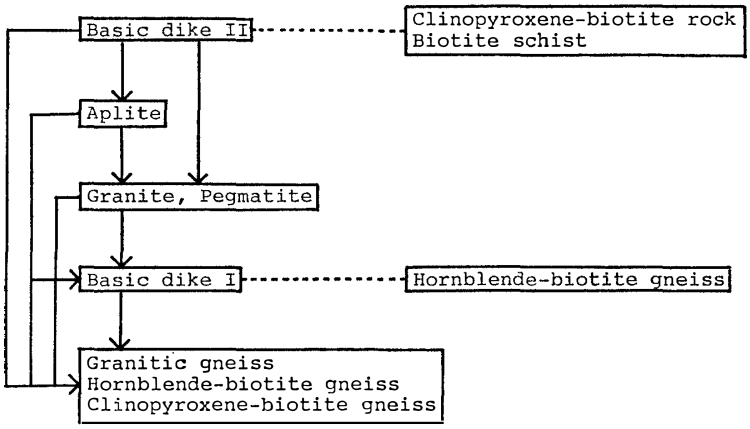

Fig. 15. Mutual relations of the rock types. Arrows indicate the intrusive relations observed in the field.

4.2. Correlation with the Yamato Mountains and other areas

The basement rocks of the Yamato Mountains are classified into two groups, *i.e.*, granitic group and charnockitic group (KIZAKI, 1965). The geology of the Yamato Mountains has been presented in several reports since TATSUMI *et al.* (1964). There are some reports on Massif D (SHIRAISHI *et al.*, 1978) and Massifs B and C (YANAI *et al.*, 1982) published as geological map series. Moreover, the geology of the northern part of the Yamato Mountains (SHIRAISHI, 1977) and of Massif A (SHIRAISHI *et al.*, 1982) has been reported. The geology of the Belgica Mountains situated west of the Minami-Yamato Nunataks has been clarified by KOJIMA *et al.* (1981, 1982). Considering these recent investigations and the present work, the basement rocks in this area are similar to the granitic group of the Yamato Mountains. Massifs B and C are composed mainly of granitic gneiss with various dikes. Some of the basic dikes are intruded by acidic dikes, whereas the others conversely intrude into acidic dikes. Main mafic minerals of the basic dikes are biotite and clinopyroxene (YANAI *et al.*, 1982). These descriptions show that the rocks of the Minami-Yamato Nunataks are correlated with those of Massifs B and C of the Yamato Mountains.

Meanwhile, Massif A consists mainly of the charnockitic group rocks. The author has also investigated Massif A. According to his observation, granitic gneiss is the main constituent of the moraine extending around Massif A and resembles that in the Minami-Yamato Nunataks, Because these rocks were carried from the upstream area of the ice sheet, it is expected that there should be a rise of the basement rocks in the upstream area, which consists of the same kind of rocks as those exposed in the Minami-Yamato Nunataks.

OHMAE *et al.* (1984) present that it is possible to infer the rock types of the basement covered with the ice sheet by means of an ice radar. The study indicates that the granitic gneisses of the Minami-Yamato Nunataks and the charnockitic rocks of Massif A can be distinguished by the difference in their dielectric constants. Although we cannot realize exactly the geology of the basement under the ice sheet at present, various geophysical methods are expected to throw light on this aspect in the near future. The results obtained by an ice radar suggest that the ice sheet south of Massif A is underlain by granitic gneiss, although its extent has not been clarified. This is consistent with the observation derived from the moraine.

Acknowledgments

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