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SHEET 30 SOUTHERN YAMATO MOUNTAINS
(MASSIF A AND JARE-IV NUNATAKS)

Explanatory Text of Geological Map of the Southern Yamato Mountains (Massif A and JARE-IV Nunataks), Antarctica

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Explanatory Text of Geological Map of the Southern Yamato Mountains (Massif A* and JARE-IV Nunataks*), Antarctica

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1. The Yamato Mountains

The Yamato Mountains are inland mountains in Queen Maud Land which are situated at 71°15′–72°05′S in latitude and 34°45′–36°55′E in longitude. The mountains extend for about 60 km north-south, and are made up of seven massifs named Massifs A to G from the south to the north and several nunataks. They rise 100–800 m from the ice sheet surface of 1500–2200 m above sea level, including the highest peak (2494 m) of Mt. Fukushima in Massif D.

After the first finding of the mountains from the air in 1937 by the Norwegian party and the subsequent confirmation of their existence from the air in 1960 by the Belgian party, the oversnow traverse party of the fourth Japanese Antarctic Research Expedition (JARE-4) visited there and KIZAKI conducted geological investigation of the mountains in 1960 (KIZAKI, 1965; TATSUMI and KIZAKI, 1969; OHTA and KIZAKI, 1966). In 1969, YOSHIDA and ANDO of JARE-10 surveyed geologically the JARE-IV Nanataks in the southeastern part and some other areas of the mountains (YOSHIDA and ANDO, 1971). A more detailed geological survey of Massifs D, E, F and G was made in 1973 by SHIRAISHI of JARE-14 (SHIRAISHI, 1977; SHIRAISHI *et al.*, 1978). YANAI of JARE-15 and MATSUMOTO of JARE-16 traced unsurveyed areas in 1974 and 1975, respectively. YANAI, NISHIDA and KOJIMA of JARE-20 resurveyed mainly Massif C and JARE-IV Nunataks in the 1979–80 season (YANAI *et al.*, 1982). SHIRAISHI, ASAMI and OHTA of JARE-21 surveyed Massifs A and B in detail and reexamined Massifs D, E, F and G in the same season and SHIRAISHI made an additional field work of Massif A in the next season (SHIRAISHI *et al.*, 1982, 1983a, b; ASAMI and SHIRAISHI, 1983, 1985).

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* Tentative place name.

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2. Geology of the Southern Yamato Mountains

2.1. General geology

Massif A, being around 71°43'S and 35°51'E occupies the southernmost part of the Yamato Mountains. This massif consists of the main massif with the highest point (2450 m in altitude) and several nunataks which have characteristically gentle slopes, compared with the other massifs B to G with steep cliffs (Plate 1a). A chain of nunataks (tentatively named JARE-IV Nunataks) trending NNE-SSW extends for 10 km in the north of Massif A. Outcrops are scarce, because most of the ice-free area is widely covered with the morainic debris (Plate 1a, b).

Basement rocks of the Yamato Mountains are composed of various kinds of metamorphic rocks and plutonic rocks of the late Proterozoic and early Paleozoic ages. The metamorphic rocks in the mountains can be divided into two groups; one is the granulite-facies rocks which occur in the northern and southern parts of the mountains, and the other is the amphibolite-facies ones which occupy the central part of the mountains (ASAMI and SHIRAISHI, 1983). Most of the granulite-facies rocks are intimately associated with syenitic rocks, which are a major type of the plutonic rocks in the mountains (SHIRAISHI *et al.*, 1982, 1983a, b; ASAMI and SHIRAISHI, 1983). The association of the granulite-facies rocks and syenitic rocks corresponds to the "charnockite group" classified by KIZAKI (1965). Massif A is made mainly of the rocks of this association. On the other hand, the JARE-IV Nunataks are largely underlain by the amphibolite-facies rocks which resemble those in the eastern flank of Massif B (YANAI *et al.*, 1982).

Whole rock isochron ages of 718.4±33.7 Ma with initial $^{87}Sr/^{86}Sr$ ratio of 0.70899±0.00026 and 696±165 Ma with initial $^{87}Sr/^{86}Sr$ ratio of 0.70725±0.00078 were obtained from the several granulite-facies metamorphic rocks in Massif A (SHIBATA *et al.*, 1986). In addition, two of the above rocks gave 483±15 and 469±14 Ma K-Ar biotite ages and one of the two gave a Rb-Sr mineral isochron age of 493.3±4.5 Ma (SHIBATA *et al.*, 1985). The older 700 Ma ages have been interpreted to represent the time of the granulite-facies metamorphism, and the younger 450–500 Ma ages the time of granite intrusion or cooling after the regional metamorphism (SHIBATA *et al.*, 1985, 1986).

The constituent rocks of Massif A and the JARE-IV Nunataks can be classified into the following rock types on the basis of the mode of occurrence, lithologic facies and mineral assemblages. Abbreviations in parentheses correspond to the legend of the geological map.

A. Metamorphic rocks
  1) Two-pyroxene-biotite gneiss (Gp)
  2) Orthopyroxene-biotite gneiss (Gp)
  3) Garnet-biotite gneiss (Ggb)
  4) Calc-silicate gneiss (Cs)
  5) Metabasite
    a) Two-pyroxene granulite
    b) Two-pyroxene amphibolite
  6) Migmatitic biotite gneiss (Gm)

B. Plutonic rocks

1) Massive quartz syenitic rock
2) Two-pyroxene quartz syenite
  a) K-feldspar-porphyritic quartz syenite (Sp)
  b) Fine-grained massive quartz syenite (Sf)
3) Clinopyroxene quartz monzo-syenite (Qm)
4) Biotite granite (Gr)

C. Dike rocks
1) Metamorphosed basic dike rocks
2) Pegmatite, granite and aplite (P)

Major and some minor chemical compositions of the constituent rocks are given in Table 1.

2.2. Geology and Petrography

2.2.1. Metamorphic rocks

Metamorphic rocks occur as isolated masses often intruded by the syenitic rocks and as xenolithic blocks included in the syenitic rocks in Massif A (Plate 1c). Large masses of the metamorphic rocks are found at the JARE-IV Nunataks and Nunatak 2318 m in Massif A. Smaller masses are on the eastern side of the central part of the main massif, near the eastern peak of the Mosuso Hill, at Mikazuki Rock, at Mt. Nokogiri, at Taka-iwa Rock and at Nunataks 2205 m and 2225 m.

Among the metamorphic rocks rock types 1) to 5) listed above have the granulite-facies mineral assemblages, but type 6) probably belongs to the amphibolite facies, as described below. The T-P conditions of the granulite-facies metamorphism in the area are estimated to be around 750°C and below 6 kb (ASAMI and SHIRAISHI, 1985).

The foliation which is shown by compositional banding generally strikes N-S with steep dips to the east and west. The banded gneisses often show small-scale tight folds whose axes generally plunge 50–60°SE in Massif A, and gently plunge in the JARE-IV Nunataks.

1) Two-pyroxene-biotite gneiss

This rock, together with the two-pyroxene granulite to be mentioned below, was described as enderbitic gneiss by KIZAKI (1965), which means a variety of charnockitic gneiss of diorite to tonalite compositions. The two-pyroxene-biotite gneiss is the most abundant metamorphic rock in Massif A and occurs typically at Nunatak 2318 m and the main massif. The gneiss shows a distinct banded structure defined by an alternation of mafic and felsic layers up to 10 mm thick (Plate 2a, c). There are also many agmatitc blocks, ribbons and lenses of the two-pyroxene-biotite gneiss, tens of centimeters long, in the K-feldspar-porphyritic quartz syenite and the clinopyroxene quartz monzo-syenite at Dango Rock*, Mikazuki Rock, Mosuso Hill and Taka-iwa Rock. These blocks occur in roughly aligned zones in the quartz syenite and quartz monzo-syenite. The two-pyroxene-biotite gneiss always contains quartz, plagioclase, biotite, clinopyroxene and orthopyroxene, and often a small amount of K-feldspar. Brownish green hornblende rarely occurs. Accessory minerals are ilmenite, apatite and zircon.

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* Tentative place name.

Table 1. Chemical compositions of rocks

	1	2	3	4	5	6	7	8
SiO_2	57.00	65.02	66.42	59.31	52.11	72.64	53.81	55.06
TiO_2	0.54	0.69	0.61	1.14	1.18	0.12	1.01	1.13
Al_2O_3	17.92	15.74	15.55	17.11	14.98	13.71	13.35	13.42
Fe_2O_3	1.39	1.22	0.81	1.73	1.91	0.24	1.29	2.05
FeO	4.38	2.70	3.41	4.40	5.17	0.43	5.00	5.40
MnO	0.09	0.04	0.09	0.12	0.12	0.01	0.13	0.11
MgO	3.41	2.22	2.07	2.20	5.50	0.24	7.37	6.67
CaO	6.41	3.41	2.15	4.12	6.52	1.67	6.04	6.12
Na_2O	5.78	5.22	4.22	4.26	3.67	3.87	2.94	2.66
K_2O	1.80	3.11	4.40	2.86	5.71	5.55	6.20	6.29
H_2O (+)	0.56	0.33	0.77	1.15	1.25	0.62	0.54	0.89
H_2O (−)	0.75	0.41	0.15	0.28	0.32	0.19	0.33	0.14
P_2O_5	0.24	0.38	0.11	0.56	0.91	0.05	1.03	1.16
CO_2	0.28	0.16	—	—	—	—	—	—
Total	100.55	100.65	100.76	99.24	99.35	99.34	99.04	101.10
Q	—	12.78	15.49	10.79	—	25.84	—	—
C	—	—	0.20	0.86	—	—	—	—
or	10.64	18.38	26.00	16.90	33.74	32.80	36.64	37.17
ab	48.91	44.17	35.71	36.05	—	32.75	20.31	22.51
an	17.63	10.33	9.95	16.78	7.54	3.65	4.92	6.10
ne	—	—	—	—	7.10	—	2.48	—
di wo	5.26	1.71	—	—	7.90	1.80	7.65	6.97
di en	2.93	1.06	—	—	5.02	0.60	5.17	4.63
di fs	2.13	0.55	—	—	2.24	0.41	1.89	1.83
hy en	1.82	4.47	5.16	5.48	—	—	—	2.59
hy fs	1.32	2.33	4.75	4.99	—	—	—	1.02
ol fo	2.63	—	—	—	6.05	—	9.24	6.58
ol fa	2.10	—	—	—	3.06	—	3.71	2.86
mt	2.02	1.77	1.17	2.51	2.77	0.35	1.87	2.97
il	1.02	1.31	1.16	2.17	2.24	0.23	1.92	2.15
ap	0.56	0.88	0.25	1.30	2.11	0.12	2.39	2.69
Rb (ppm)	—	—	147	—	183	119	269	251
Sr	—	—	313	—	1420	340	908	856
Th	—	—	15.6	—	15.3	29.8	5.5	12.1
U	—	—	4.3	—	3.4	1.5	3.4	3.8
Zr	—	—	210	—	339	56	160	293
Source	A	A	C	C	C	C	B	B

No. 1. YA285 Enderbitic gneiss (Gp)
2. YA303 Enderbitic gneiss (Gp)
3. Y80A530 Banded orthopyroxene-biotite gneiss (Gp)
4. Y80A58 Two-pyroxene biotite gneiss (Gp)
5. Y80A551 Clinopyroxene-biotite-K-feldspar dike rock (Md)
6. Y80A545 Microcline granite (Gr)
7. Y80A537 Two-pyroxene-biotite syenite (Sf)
8. Y80A34A Two-pyroxene-biotite mela-syenite (Sf)
9. Y80A556 K-feldspar porphyritic two-pyroxene quartz-syenite (Sp)
10. Y80A41 Clinopyroxene-biotite mela-alkali-feldspar syenite (Qm)
11. Y80A59A Clinopyroxene-biotite mela-alkali-feldspar syenite (Qm)

from the southern Yamato Mountains.

9	10	11	12	13	14	15	16	17	18
61.82	49.46	50.05	51.66	52.52	54.78	57.64	59.44	59.82	61.30
0.75	1.35	1.52	1.60	1.63	1.60	1.10	1.42	0.78	1.16
15.32	12.33	13.01	15.31	15.13	16.18	16.32	15.12	14.91	15.28
1.15	2.23	1.94	1.68	0.99	1.02	1.32	0.83	0.43	1.10
3.41	6.31	5.80	5.75	6.52	5.42	4.90	4.48	4.23	3.61
0.08	0.15	0.13	0.11	0.10	0.09	0.09	0.08	0.08	0.08
2.75	8.23	7.75	5.27	5.48	3.71	3.86	2.90	3.63	2.15
3.18	7.85	7.51	6.03	6.02	4.45	4.19	3.87	3.94	3.27
3.67	1.93	2.43	3.22	3.57	3.64	3.23	3.77	3.51	3.82
6.50	6.81	6.22	6.12	5.22	6.59	4.99	5.82	6.40	6.05
0.51	0.86	0.86	1.01	0.88	0.85	0.60	0.56	0.67	0.71
0.27	0.13	0.24	0.18	0.35	0.23	0.49	0.29	0.27	0.27
0.40	1.45	1.68	1.36	1.20	0.96	0.88	0.78	0.53	0.59
—	—	—	—	—	—	—	—	—	—
99.81	99.09	99.14	99.30	99.61	99.52	99.61	99.36	99.20	99.39
5.41	—	—	—	—	—	4.65	3.89	1.87	6.81
—	—	—	—	—	—	0.09	—	—	—
38.41	40.25	36.76	36.17	30.85	38.95	29.49	34.39	37.82	35.75
31.05	3.64	10.97	19.03	23.43	26.63	27.33	31.90	29.70	32.32
6.13	4.87	6.22	9.25	9.84	8.35	15.04	7.14	6.02	6.68
—	6.87	5.20	4.45	3.67	2.26	—	—	—	—
2.94	10.27	8.38	4.92	3.67	3.11	—	2.01	4.20	2.38
1.73	6.89	5.71	3.06	5.09	1.74	—	1.61	2.38	1.31
1.06	2.62	2.01	1.57	2.97	1.25	—	1.19	1.65	0.97
5.12	—	—	—	—	—	9.61	5.62	6.67	4.04
3.16	—	—	—	—	—	6.26	4.16	4.62	2.98
—	9.54	9.52	7.06	7.49	5.26	—	—	—	—
—	4.00	3.69	3.99	5.23	4.16	—	—	—	—
1.67	3.23	2.81	2.44	1.44	1.48	1.91	1.20	0.62	1.59
1.42	2.56	2.89	3.04	3.10	3.04	2.09	2.70	1.48	2.20
0.93	3.36	3.38	3.15	2.78	2.22	2.04	1.81	1.48	2.20
323	177	142	149	127	148	190	125	293	132
742	1620	2380	2080	1540	1910	1530	1760	815	1550
27.0	2.5	3.1	1.6	3.2	4.9	19.6	7.1	18.1	6.5
5.8	0.6	0.7	0.5	1.2	1.7	5.6	2.1	6.9	2.8
435	328	326	448	465	647	544	460	300	484
B	B	B	B	B	B	B	B	B	B

12. Y80A100 Clinopyroxene-biotite syenite (Qm)
13. Y80A540 Clinopyroxene-biotite monzonite (Qm)
14. Y80A544 Clinopyroxene-biotite quartz-monzonite (Qm)
15. Y80A122 Clinopyroxene-biotite quartz-monzonite (Qm)
16. Y80A557 Clinopyroxene-biotite quartz-syenite (Qm)
17. Y80A520 Clinopyroxene-biotite quartz-syentite (Qm)
18. Y80A501B Biotite-hornblende quartz-syenite (Qm)

Source A: KIZAKI (1965)
B: SHIRAISHI *et al.* (1983a)
C: This study (analyst: Japan Chemical Analysis Centre (major elements) and H. KANAYA (minor elements))

2) Orthopyroxene-biotite gneiss

This gneiss commonly occurs as concordant thin layers in the banded two-pyroxene-biotite gneiss. The orthopyroxene-biotite gneiss is commonly composed of quartz, plagioclase, K-feldspar, biotite, orthopyroxene and accessory ilmenite, apatite and zircon, sometimes lacking K-feldspar (Plate 5a, b). The gneiss is also found as xenolithic lenses in the clinopyroxene quartz monzo-syenite at Mikazuki Rock (Plate 4a, b). In this case, the gneiss is free from quartz, and have spindle-shaped aggregates of anorthite with or without green spinel, which include matrix consisting of oligoclase, biotite and orthopyroxene.

3) Garnet-biotite gneiss

The garnet-biotite gneiss is found only at two localities. One is an outcrop between the Mosuso Hill and Dango Rock, where the gneiss occurs as a large xenolithic block in the fine-grained massive two-pyroxene quartz syenite. The other is a small outcrop on the western slope of the Mosuso Hill, where the gneiss alternates with the two-pyroxene amphibolite mentioned below. Constituent minerals of the gneiss are quartz, plagioclase, K-feldspar, biotite, garnet and accessory graphite, ilmenite, apatite and zircon.

In the garnet-biotite gneiss, retrograde metamorphic effects such as the embayment of garnet by secondary biotite are observed. Detailed descriptions about the effects were given by ASAMI and SHIRAISHI (1985).

4) Calc-silicate gneiss

The calc-silicate gneiss, a few meters in width, is concordantly associated with the banded two-pyroxene-biotite gneiss on the eastern side of the main massif, and is also found as xenolithic blocks in the monzo-syenite at Mikazuki Rock and Dango Rock (Plate 2b). Small amount of calcite marble is poorly developed in the calc-cilicate gneiss from the main massif. This gneiss includes some rock types having the following mineral assemblages:

(1) Wollastonite + clinopyroxene + scapolite + plagioclase + sphene
(2) Wollastonite + clinopyroxene + scapolite + calcite + sphene
(3) Clinopyroxene + scapolite + quartz + sphene ($\pm$hornblende)
(4) Calcite + clinopyroxene + sphene

The gneiss of assemblage (1) often contains retrograde garnet and quartz which are characteristically developed along the boundaries between wollastonite and plagioclase (An_{92-94}) (ASAMI and SHIRAISHI, 1985) (Plate 5c).

5) Metabasite

The two-pyroxene granulite and the two-pyroxene amphibolite occur as concordant layers, up to 2 m thick, in the two-pyroxene-biotite gneiss, and as agmatitic blocks in the K-feldspar-porphyritic quartz syenite and the clinopyroxene quartz monzo-syenite at Dango Rock, Mikazuki Rock, Mosuso Hill and Taka-iwa Rock (Plate 2a). The two-pyroxene amphibolite is also found as xenolithic blocks in the oldest aplite mentioned later. The two-pyroxene granulite is composed mainly of plagioclase, clinopyroxene, orthopyroxene and biotite, with or without small amounts of quartz and zircon (Plate 6a, b). The two-pyroxene amphibolite commonly consists of plagioclase, brown hornblende, clinopyroxene, orthopyroxene, biotite and accessory ilmenite and apatite. This rock sometimes contains quartz, accessory pyrite and zircon as additional constituents.

6) Migmatitic biotite gneiss

The migmatitic biotite gneiss occurs in the JARE-IV Nunataks and at Nunataks 2225 m and 2205 m in the northernmost part of Massif A. This rock was described as the biotite gneissose granite by YOSHIDA and ANDO (1971) and as the migmatitic biotite gneiss by SHIRAISHI *et al.* (1982). It shows nebulitic, diktyonitic and banded structures. Lit-par-lit injection of pink granite is also found at these localities. At a nunatak in the Ôgi Moraine Field, the two-pyroxene biotite gneiss grades into the migmatitic biotite gneiss. The constituent minerals of the migmatitic biotite gneiss are mainly quartz, plagioclase, K-feldspar (microcline) and biotite, with accessory apatite and ore mineral. Clinopyroxene and green hornblende sometimes join the above constituents. Garnet is found in association with the above main minerals at a locality in Nunatak 2225 m (Plate 6c). Orthopyroxene associated with clinopyroxene is found in one specimen from the Nunatak 2387 m in the JARE-IV Nunataks (Plate 7a, b). Biotite amphibolite sometimes occurs as concordant layers in the migmatitic biotite gneiss. The amphibolite is composed of plagioclase, biotite and green hornblende, with or without quartz or clinopyroxene. Accessory apatite and ore mineral are common.

2.2.2. Plutonic rocks

Plutonic rocks in the southern Yamato Mountains are mainly syenitic rocks which are classified into three lithologic types. Petrochemical characters of the syenitic rocks except for the massive quartz syenitic rocks were given in SHIRAISHI *et al.* (1983a).

1) Massive quartz syenitic rock

Although this rock does not occur in a mappable size, it is found at Nunatak 2318 m and sporadically occurs at Dango Rock, east peak of the Mosuso Hill, and in the western outcrops of the main massif. Its geological relationships to the other rock types are not known because of the lack of the exposures except for an outcrop, 500 m east of the Mosuso Hill (Plate 3a, b). Since lenses of this rock are included just as xenoliths in the K-feldspar-porphyritic quartz syenite at this locality, we refer it to the oldest plutonic rock in the present area.

This rock is characterized by coarse-grained K-feldspar aggregates which are spotted in this clinopyroxene-biotite matrix. Idiomorphic clinopyroxene and biotite laths are scattered inside the K-feldspar grains and aggregates. Orthopyroxene is found in one specimen. Small amounts of quartz, plagioclase and sphene are also found.

2) Two pyroxene quartz syenite

The rocks of this type occur widely in the main massif and surrounding nunataks, *i.e.* Mosuso Hill, Nunatak 2813 m etc. The rocks have been named two-pyroxene syenite and quartz syenitic charnockite (SHIRAISHI *et al.*, 1982, 1983a). Though there are some lithologic varieties in this rock type, they could be divided into K-feldspar-porphyritic quartz syenite and fine-grained massive quartz syenite in general. All varieties are characterized by the presence of blue-gray to brown-gray feldspars. The fine-grained massive quartz syenite seems to be younger than the K-feldspar-porphyritic quartz syenite from the observation at an outcrop, 500 m east of the Mosuso Hill, where the latter is clearly cut by the fine- to medium-grained massive quartz syenite (Plate 3b).

The K-feldspar-porphyritic quartz syenite typically occurs around the top of the southern part of the main massif. This rock obliquely cuts the banded two-pyroxene biotite gneiss and includes xenoliths of the gneiss and the two-pyroxene granulite near the contact. K-feldspar porphyritic crystals of up to 1 cm in size show distinct oscillatory zoning (Plate 7c). The quartz syenite is composed of perthitic K-feldspar, biotite, clinopyroxene, orthopyroxene and small amounts of quartz and plagioclase. Some varieties contain brownish green hornblende. Apatite, zircon and ore mineral are contained as accessories. This rock has a weak foliation and it shows not only the N-S trend with both easterly and westerly dips, but also the E-W trend with northerly dips.

Dense and dark-colored fine-grained massive quartz syenite typically occurs at Mt. Nokogiri, Mt. Kame-no-se and in the northen part of the main massif. In contrast with the K-feldspar-porphyritic quartz syenite, no inclusion of the gneisses has been found in this rock. Constituent minerals of this rock are the same as those of the K-feldspar-porphyritic quartz syenite (Plate 8a, b).

3) Clinopyroxene quartz monzo-syenite

This rock is found at Mt. Kame-no-se, Nunatak 2318 m, Taka-iwa Rock, Mikazuki Rock and on the southernmost cliff of the main massif. This rock was designated as quartz monzonite in SHIRAISHI *et al.* (1982). The rock is a light gray to brown-colored, homogeneous, medium- to coarse-grained rock. Modal mineral composition of the rock changes from that of quartz syenite to quartz monzonite. This rock contains clinopyroxene (4–22 modal %), biotite (9–31 modal %), K-feldspar (23–48 modal %), plagioclase (12–34 modal %) and quartz (1–15 modal %), with or without dark green hornblende (up to 2.5 modal %) (Plate 8c). Orthopyroxene has not been found. Sphene (up to 0.2 modal %) and apatite (up to 1 modal %) is a very common accessory, and zircon and opaque mineral also accompany. Foliated structure is commonly weak in the rock, but flow-like structure shown by the concentration of mafic minerals is sometimes found. In the case where elongated blocks of the gneisses and two-pyroxene quartz syenite are included, the trend of elongation is also harmonious with these structures. These foliations show the general N-S to NW-SE strike and moderate to high angle dips to the east.

The quartz monzo-syenite intrudes the fine-grained massive quartz syenite at Mt. Kame-no-se, where a large number of biotite clots are formed randomly in the latter. This rock is in a diffused contact with the K-feldspar-porphyritic quartz syenite on the southernmost cliff of the main massif, and nebulitic and agmatitic structures are developed around the border, and various intermediate lithologic facies between these two rocks were formed here.

At Mikazuki Rock and Taka-iwa Rock, melanocratic bands, a few meters wide, are found in the quartz monzo-syenite. The bands contain many agmatitic and lense-shaped blocks of the banded two-pyroxene biotite gneiss and the two-pyroxene granulite (Plate 4a, b). In many places inclusions of the fine-grained massive quartz syenite with round edges are observed in the quartz monzo-syenite (Plate 3c). These phenomena represent various stages of hybridization of the pre-existing rocks by the quartz monzo-syenite.

4) Biotite granite

Dike-like intrusions of granitic to granodioritic compositions make migmatite in the fine-grained massive quartz syenite on the northernmost cliff of the main massif and also cut the clinopyroxene quartz monzo-syenite at Nunatak 2318 m (Plate 4c).

The granite shows agmatitic and schollen structures with a predominant neosome. Small (generally a few tens of meters in scale) granite and granodiorite stocks in the JARE-IV Nunataks and Motoi Nunataks are considered to be equivalent to this group. The paleosomes are composed of amphibolite and biotite gneiss, which is similar to the migmatitic biotite gneiss. The constituent minerals of the granite and granodiorite are biotite, K-feldspar, plagioclase and quartz. Clinopyroxene and hornblende are also included in places.

2.2.3. Dike rocks

Narrow (up to a few meters in width) dike rocks of various compositions are described in this section.

1) Metamorphosed basic dike rocks

Metamorphosed basic dikes discordantly cut the banded two-pyroxene biotite gneiss, the two-pyroxene quartz syenite and the clinopyroxene quartz monzo-syenite. Some dikes show a distinct schistose structure parallel to the wall of intrusion vent. Mineral constituents are in metamorphic origin, and are commonly composed of clinopyroxene, biotite, K-feldspar and plagioclase with or without quartz. A dike in the K-feldspar-porphyritic quartz syenite consists of orthopyroxene, clinopyroxene, green hornblende, plagioclase and accessory ore.

2) Granite, pegmatite and aplite

Several different stages of emplacement of these dike rocks are recognized by their modes of occurrence.

The oldest aplite closely associated with the banded two-pyroxene biotite gneiss, is cut by the K-feldspar porphyritic quartz syenite at the east peak of the Mosuso Hill. This aplite characteristically contains dark gray-colored quartz, K-feldspar (hair perthite) and plagioclase, and has small amounts of orthopyroxene, biotite, zircon and ore mineral.

A gray-colored, fine- to medium-grained biotite granite intrudes the clinopyroxene quartz monzo-syenite. The occurrence of this rock is restricted in the quartz monzo-syenite, suggesting the intimate relationship between them in origin. Pink-colored granite and granitic pegmatite cut all rocks except for the youngest aplitic veins. Pink hornblende granite dikes at Mt. Nokogiri altered the adjacent fine-grained massive quartz syenite into a medium-grained hornblende-rich syenitic rock. A granitic pegmatite at a nunatak in the Ôgi Moraine Field converted the banded two-pyroxene biotite gneiss into the migmatitic biotite gneiss at the contact.

There are the youngest aplite veins which cut all of the rock types mentioned above.

2.3. Genetic relations of the rocks

On the basis of the field and petrographical observations described above, it is possible to consider the following genetic relations of the plutonic and metamorphic rocks occurring in the southern Yamato Mountains.

The oldest rocks are the metamorphic rocks such as the banded two-pyroxene biotite, orthopyroxene-biotite and garnet-biotite gneisses with older aplite and the associated calc-silicate gneiss, two-pyroxene granulite and two-pyroxene amphibolite. The plutonic rock such as the massive quartz syenitic rock are possibly included in this group, because they often occur as agmatitic paleosomes or as xenolithic masses in the two-pyroxene quartz syenite and the clinopyroxene quartz monzo-syenite.

Dominant plutonism in the present region is represented by intrusions of the two-pyroxene quartz syenite and the clinopyroxene quartz monzo-syenite, among which the former intrusive was followed by the latter one with sharp contacts. The two-pyroxene quartz syenite could be subdivided into those of two generations, *i.e.*, the K-feldspar-porphyritic quartz syenite belongs to the older generation, and the fine-grained massive quartz syenite to the younger one. The clinopyroxene quartz monzo-syenite was followed by the gray granite dike which seems to be the latest activate of the clinopyroxene quartz monzo-syenite.

The biotite granite is the youngest intrusion among the plutonic rocks except for some later dikes of granites and pegmatite and veins of aplite, because it traverses the clinopyroxene quartz monzo-syenite.

The metamorphosed basic dikes cut the two-pyroxene biotite gneiss, the two-pyroxene quartz syenite and the clinopyroxene quartz monzo-syenite, but their genetic relationships are problematical. The metamorphic condition of the basic dikes is similar to that of the country metamorphic rocks although the former obliquely cut the latter. For the interpretation that the dikes are free from the deformation which might occur at the time of the granulite-facies metamorphism, SHIRAISHI *et al.* (1982) considered that the basic dikes were emplaced at the waning stage of the granulite-faces metamorphism after the main deformation but still retaining high temperature.

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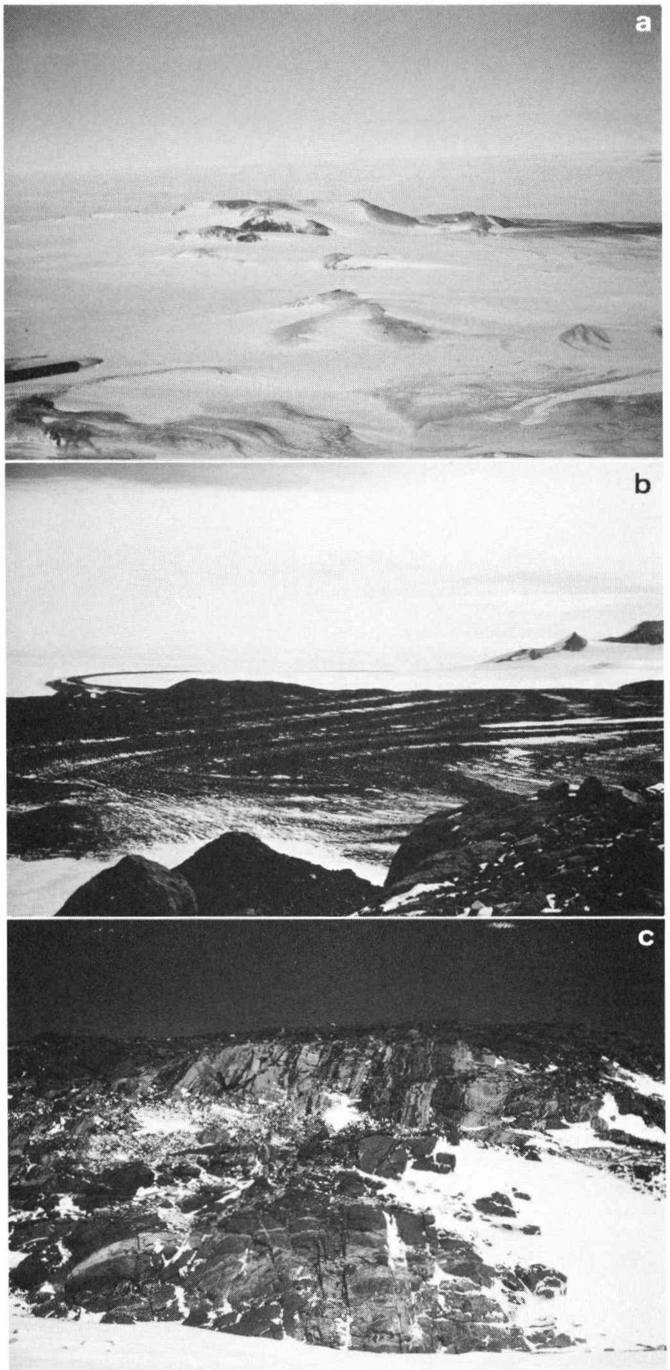
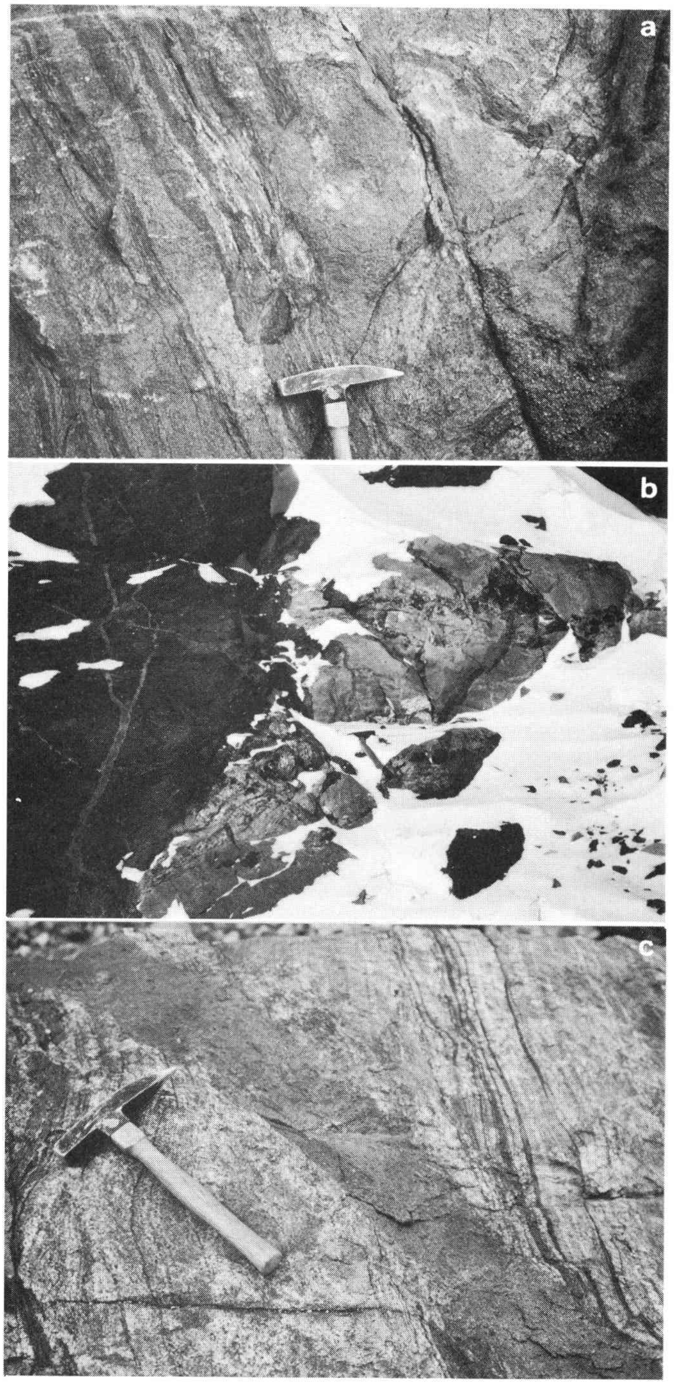
Plate 1



a: Main part of the southern Yamato Mountains (Massif A). View from north.
b: Ôgi Moraine Field. The right ridge is a part of Massif B. View from the top of Massif A.
c: Banded pyroxene-biotite gneiss surrounded by fine-grained massive quartz syenite. The lower part of the cliff is intruded by clinopyroxene quartz monzo-syenite. (Nunatak 2318 m)

Plate 2

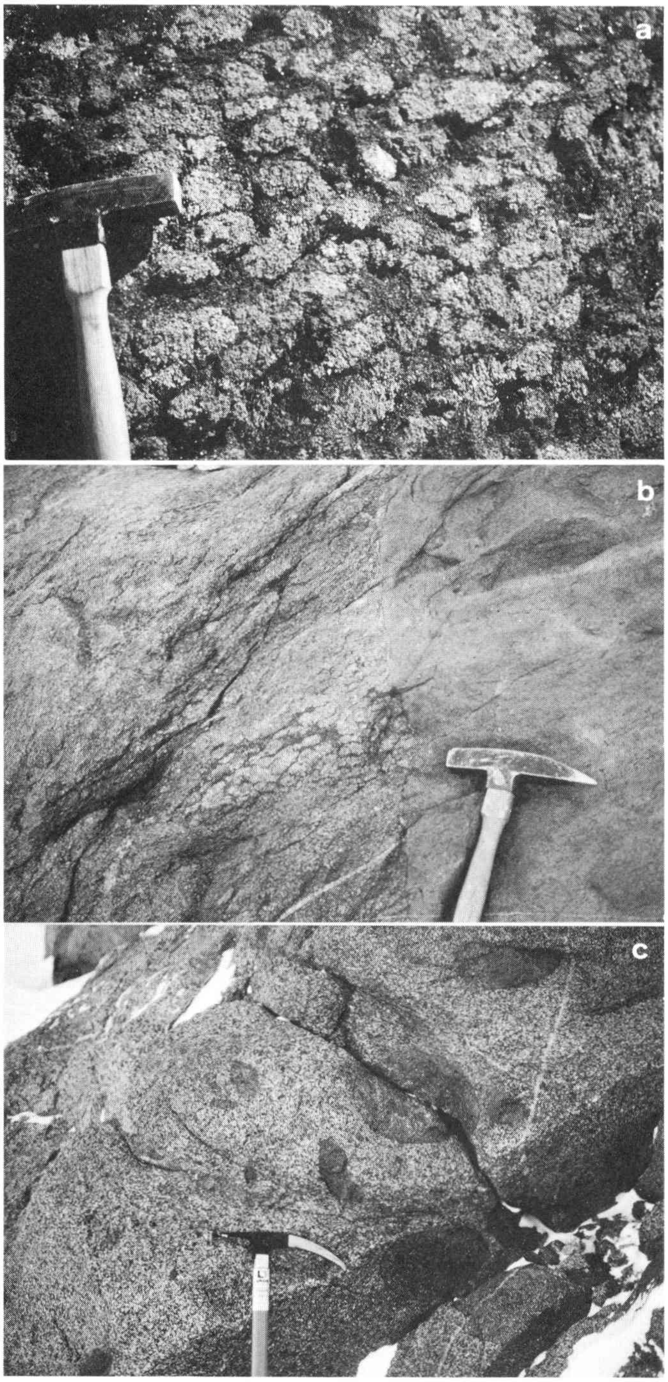


a: Banded pyroxene-biotite gneiss and two-pyroxene granulite concordantly intruded by fine-grained massive quartz syenite. (Mosuso Hill)

b: A lensoid body of calc-silicate gneiss in the clinopyroxene quartz monzosyenite. (Dango Rock)

c: Banded pyroxene-biotite gneiss obliquely cut by the fine-grained massive quartz syenitic rock. (Mosuso Hill)

Plate 3

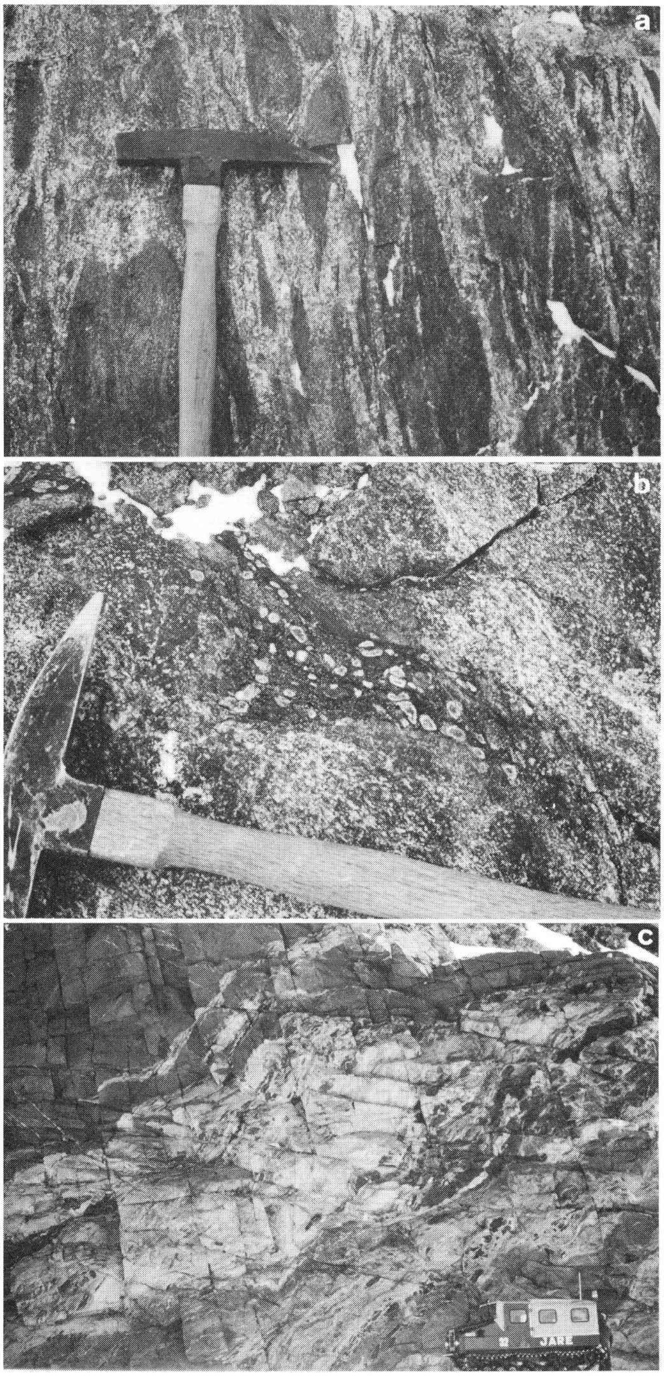


a: Massive quartz syenitic rock. (Peak 2439 m, the southern peak of the main part of Massif A)

b: A block of massive quartz syenitic rock is included in the K-feldspar porphyritic quartz syenite. Note the fine-grained massive quartz syenite intrudes them with a sharp contact. (Mosuso Hill)

c: Clinopyroxene quartz monzo-syenite including rounded two-pyroxene quartz syenite blocks. (Southeastern corner of the main part of Massif A)

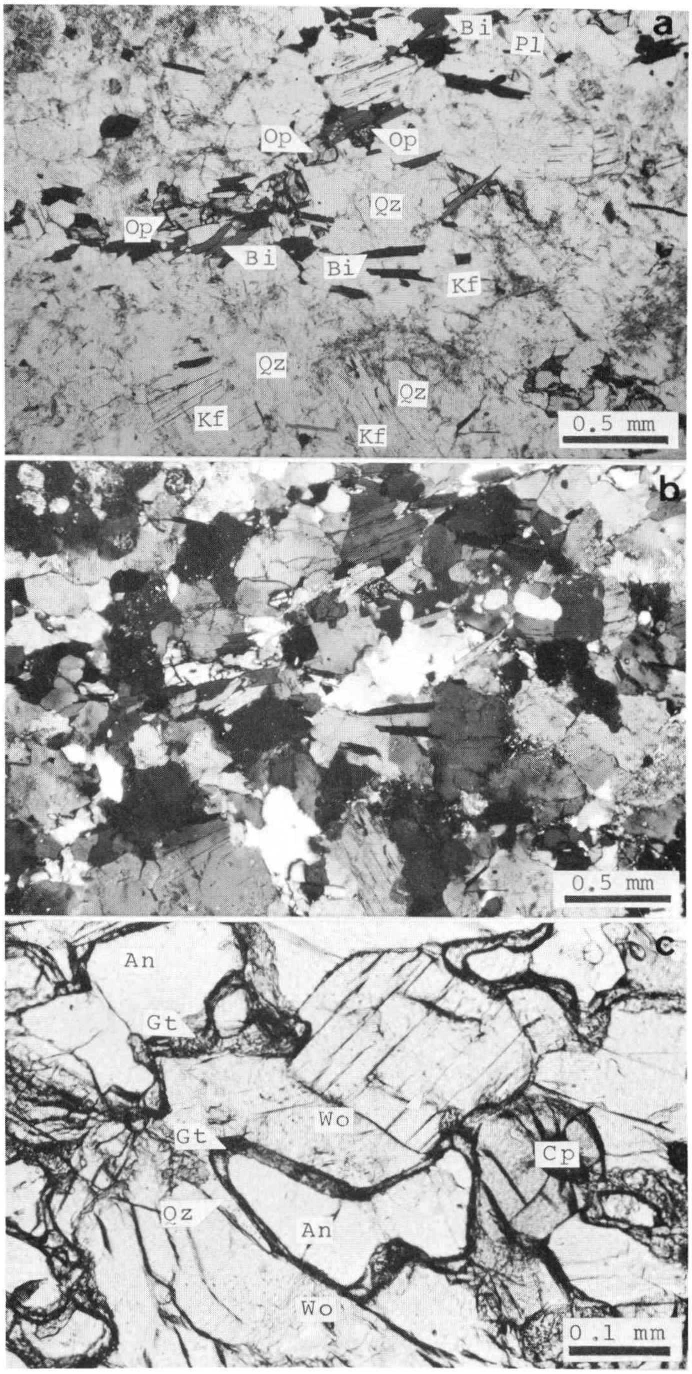
Plate 4



a: Clinopyroxene quartz monzo-syenite including ribbons of two-pyroxene granulite. (Mikazuki Rock)

b: Clinopyroxene quartz monzo-syenite including a lens of spinel-bearing orthopyroxene-biotite gneiss. (Mikazuki Rock)

c: Biotite granite intrudes the clinopyroxene quartz monzo-syenite. Note migmatitic structure of the margin. (Nunatak 2318 m)

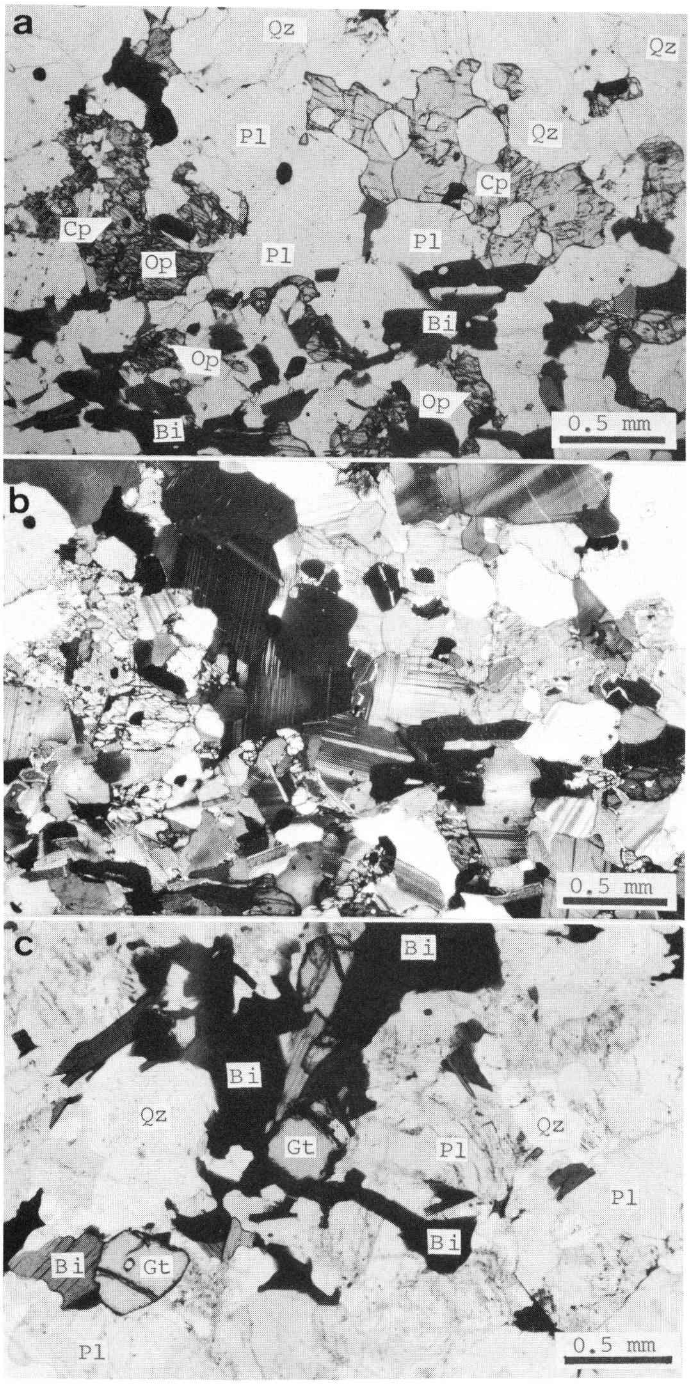


a: Photomicrograph of orthopyroxene-biotite gneiss (sp. no. Y80A529). Mineral abbreviations are common in all microphotographs. Bi: biotite, Kf: K-feldspar, Pl: plagioclase, Qz: quartz. Plane-polarized light.

b: ditto. Crossed polars.

c: Photomicrograph of calc-silicate gneiss (sp. no. Y80A18). An: anorthite, Gt: garnet, Wo: wollastonite. Plane-polarized light. Note intergranular garnet and quartz between anorthite and wollastonite.

Plate 6

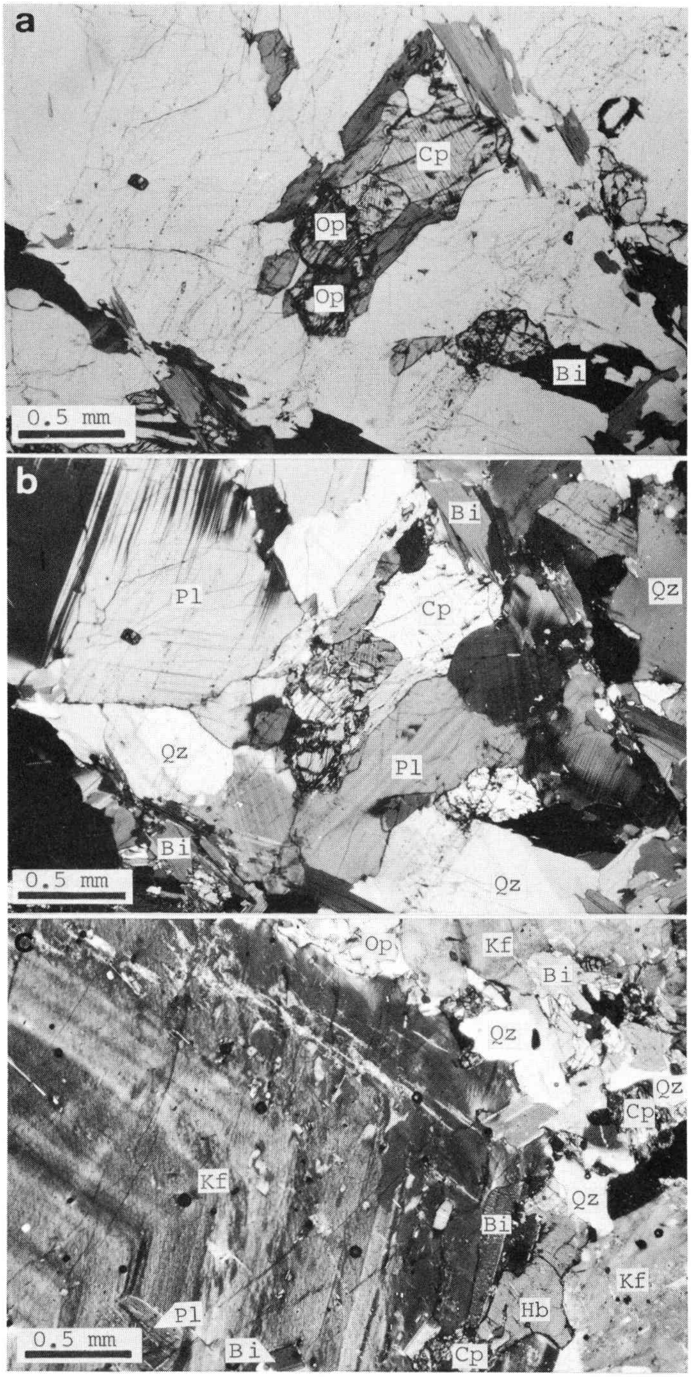


a: *Photomicrograph of two-pyroxene granulite (sp. no. Y80A120C). Plane-polarized light.*

b: *ditto. Crossed polars.*

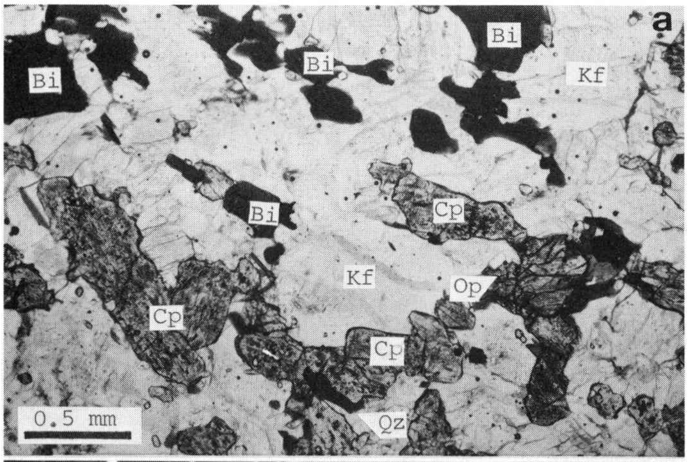
c: *Photomicrograph of garnet-bearing migmatitic biotite gneiss (sp. no. Y80A47). Plane-polarized light.*

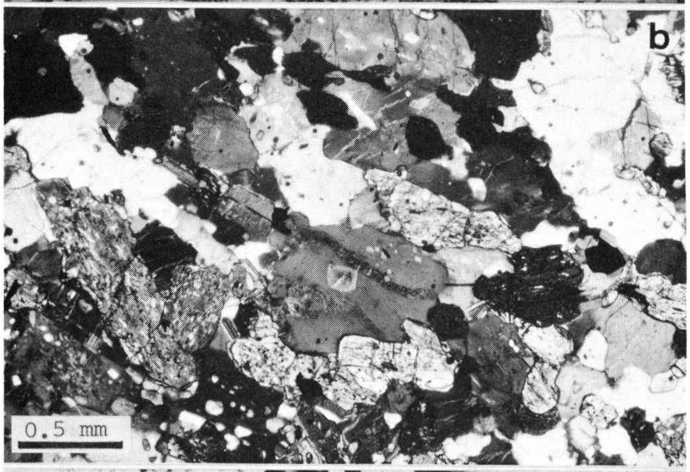
Plate 7

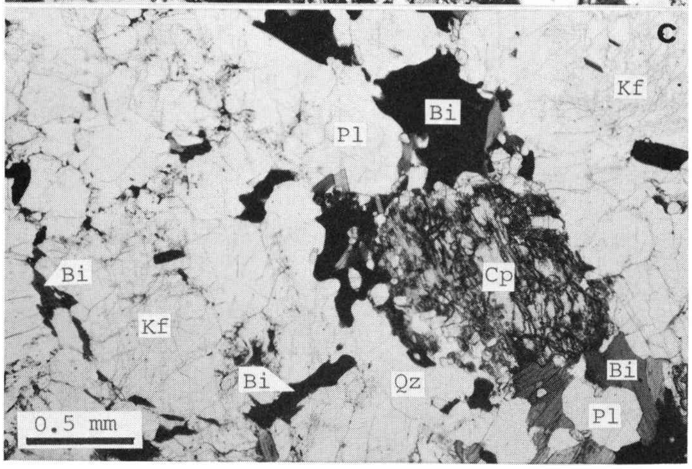


a: Photomicrograph of two-pyroxene-bearing migmatitic biotite gneiss (sp. no. N80012105). Plane-polarized light.
b: ditto. Crossed polars.
c: Photomicrograph of K-feldspar porphyritic quartz syenite (sp. no. Y80A556). Hb: hornblende. Crossed polars.

Plate 8







a: *Photomicrograph of fine-grained massive quartz syenite (sp. no. Y80A34). Plane-polarized light.*

b: *ditto. Crossed polars.*

c: *Photomicrograph of clinopyroxene quartz monzo-syenite (sp. no. Y80A122). Plane-polarized light.*

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GEOLOGICAL MAP OF THE SOUTHERN YAMATO MOUNTAINS (MASSIF A AND JARE-IV NUNATAKS)

やまと山脈南部（A群・JARE-Ⅳヌナターク群）地質図

地形は国土地理院刊行25,000分の1地形図による。

ANTARCTIC GEOLOGICAL MAP SERIES, SHEET 30 (1988)

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Masao ASAMI in 1980
Yoshihide OHTA in 1980
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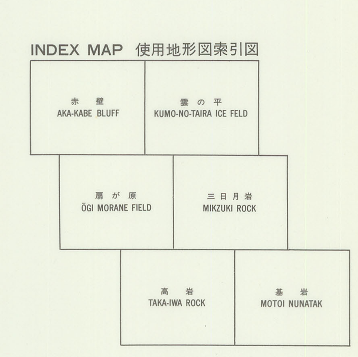

1988
THE SOUTHERN
YAMATO MOUNTAINS
(MASSIF A AND JARE-IV NUNATAKS)
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(A群，JARE-Ⅳヌナターク群)
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