NATIONAL INSTITUTE OF POLAR RESEARCH

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SHEET 28 CENTRAL YAMATO MOUNTAINS
MASSIF B AND MASSIF C

Explanatory Text of Geological Map
of
The Central Yamato Mountains,
Massif B and Massif C,
Antarctica

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Explanatory Text of Geological Map of the Central Yamato Mountains, Massif B and Massif C, Antarctica

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1. The Yamato Mountains

The Yamato Mountains are inland mountains about 300 km south-southwest of Syowa Station in East Antarctica, and are located between 71°15′S and 72°05′S in latitude and 34°45′E and 36°55′E in longitude. The mountains are arcuate, extending for about 60 km north-south, 2000–2500 m in altitude, rising 100–800 m from the ice sheet surface, and comprise seven massifs (named A, B, C, D, E, F and G) and several small nunataks separated by outlet glaciers (Fig. 1). In 1960, the Yamato Mountains were visited by the oversnow traverse party of the 4th Japanese Antarctic Research Expedition (JARE-4), and the geological and geomorphological investigation of the mountains were carried out first by KIZAKI and YOSHIDA of the traverse party respectively. The preliminary geological map of the area was made by KIZAKI for the first time, and he described briefly the geology, petrology and geological structure of the mountains (TATSUMI and KIZAKI, 1969; KIZAKI, 1964; TATSUMI *et al.*, 1964). In 1969, M. YOSHIDA and ANDO revisited the mountains and checked geologically the JARE IV Nunataks and the other areas (YOSHIDA and ANDO, 1971). SHIRAISHI surveyed massifs D, E, F and G of the northern Yamato Mountains in more detail and compiled a geological map of massif D (Mt. Fukushima) (SHIRAISHI, 1977). YANAI and MATSUMOTO, in 1974 and 1975 respectively, traced unsurveyed areas. In the 1979–80 season YANAI, NISHIDA and KOJIMA of JARE-20 resurveyed mainly massif C and a few other areas. In the summer of 1980 and 81, four geologists, SHIRAISHI, KIZAKI, OHTA and ASAMI of

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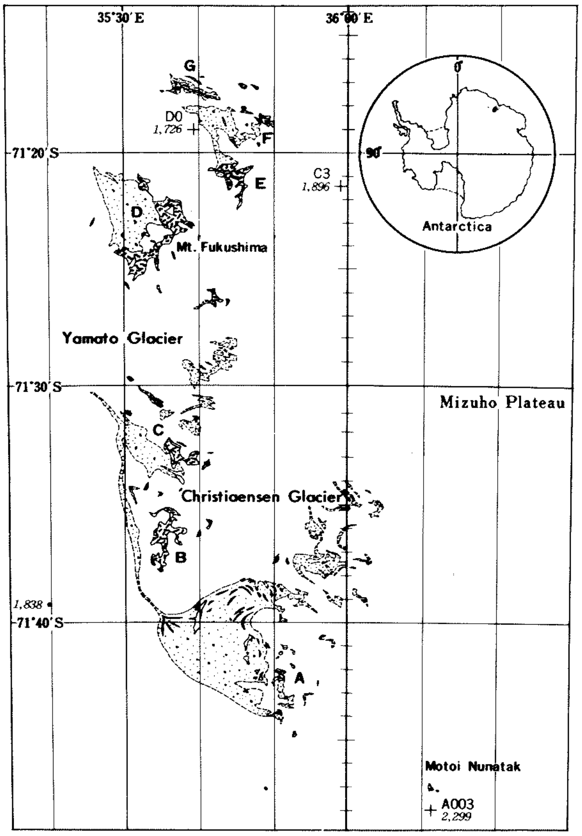

Fig. 1. Location map of the central Yamato Mountains, East Antarctica.

JARE-21 surveyed mainly massif A and checked several other massifs.

This paper is a preliminary report of geology of massifs B and C.

2. Regional Geology

Geologically the Yamato Mountains are believed to be involved in one of the Precambrian crystalline basements of East Antarctica and consist mainly of banded gneiss, granitic gneiss and plutonic rocks. Large amounts of granitic and basic dike rocks intrude the basement complex of a broad area.

Moraines and detritus were formed around the massifs and nunataks consisting of various kinds of rocks which were derived not only from the neighboring rocky areas but also from the basement under the continental ice sheet.

In most cases, moraine occurs as a thin layer directly covering the bare ice and rocky areas.

3. Massifs B and C

Massif B and massif C are located in the central area of the Yamato Mountains, the both massifs are separated from massif D (Mt. Fukushima) by the Yamato Glacier in the north and from massif A by the Ôgi Glacier in the south. Massif B extends for about 5 km north-south and has steep cliff (Akakabe Bluff) (Plate 1). Massif C extends for 13 km northwest-southeast, and consists of several mountains and nunataks which are separated by outlet glaciers (Plate 2). The tributary separates the main ice sheet flow into the central area from the northwest. Main mountains constituting the massif are Mount Tyô (2072 m), Maku Rock (2112 m), Tuitate Rock (2066 m), Syôzi Rock (1932 m), Mimi Rock (1955 m) and the heighest peak (2273 m) of the area. Those mountains and nunataks have steep cliffs on their southwest side, particularly remarkable in Mount Tyô, Maku Rock, and Tuitate Rock. On the other hand, their east sides have comparatively gentle slopes and are partially covered with snow and moraine (Plate 3a).

Geology of massifs B and C was surveyed by KIZAKI, YANAI and MATSUMOTO in 1960, 1974, and 1975 respectively, but many points remained unclarified. Recently, a geological party of JARE-20 investigated massif C in more detail, and the geology of the area has become fairly clear.

4. Geology of Massif B and Massif C

4.1. General geology

Massif B and massif C belong to the geological system constructing the Precambrian crystalline basement of East Antarctica which is composed mainly of metamorphic sequences and plutonic rocks. The both massifs consist mainly of gneiss and syenite. Varieties of granitic, syenitic and basic dikes intrude the metamorphic sequences and syenite masses. The basement rocks of this area are metamorphic sequences consisting of banded gneiss, granitic gneiss, augen gneiss and interbeded amphibolites. Syenites are divided into three types by their mode of occurrences in the field. The main mass of syenite concordantly intrudes the structure of metamorphic sequences, but small dikes of syenite intrude gneisses discordantly. Abundant dike rocks varying from granitic to dioritic-gabbroic compositions intrude complexly the gneisses and syenites. A thin layer of moraine consisting of varieties of rocks covers widely the area of bare ice and mountains.

The K-Ar age determination on whole rock of augen gneiss and syenite in

Table 1. Radiometric ages of rocks from the central Yamato Mountains.

No.	Sample No.	Rock	Material	% K	scc $Ar^{40Rad}/g \times 10^{-5}$	% Ar^{40Rad}	Age (Ma)
1	74121709	Augen gneiss	Whole rock	3.73	5.87	93.1	363±18
				3.76	5.86	92.7	
2	K79112910	Syenite	Whole rock	5.72	9.94	93.8	400±20
				5.76	10.0	93.9	
3	A79120102	Syenite	Whole rock	6.08	9.37	97.8	359±18
				6.08	9.42	98.0	
4	N79120112	Syenite	Whole rock	6.21	9.75	97.7	363±18
				6.20	9.64	97.8	

The constants for the age calculation are: $\lambda_\beta=4.962\times10^{-10}a^{-1}$, $\lambda_\epsilon=0.581\times10^{-10}a^{-1}$, $K^{40}=1.167\times10^{-4}$ atom per atom of natural potassium.
Analyst: Teledyne Isotopes Co., U.S.A.

massif C gave the results in Table 1, which might indicate the latest event in the present region.

4.2. *Geology and petrography of the central Yamato Mountains*

The rocks exposed in the central Yamato Mountains are classified into the following types on the basis of their mode of occurrences and petrographic features. The bulk chemical compositions of the several rock types in this area are presented in Table 2.

1) Amphibolites (Am)
2) Gneiss (granitic gneiss, augen gneiss, banded gneiss) (Gn)
3) Syenites (porphyritic syenite; pSy, coarse-grained syenite; cSy, medium-grained syenite; mSy)
4) Granite, aplite and pegmatite (Gr)
5) Basic meta-dike (Bd)
6) Unconsolidated deposits (moraine, detritus) (Mo)

4.2.1. Amphibolites (Am)

Concordant amphibolites varying from thin layers to hundred meters in width occur as bands and lenses in the gneisses throughout this area (Plates 3b, 4a). Discordant amphibolites also occur as small bodies in the gneisses and syenites (Plates 3c, 6a). These amphibolites are grouped in two types by their composition. One group is pyroxene amphibolite which occurs not so much as bands and small lenses, and is dark green to greenish black in color. The foliation is not clear in the field. The constituent minerals are mainly green clinopyroxene and biotite, with subordinate amounts of hornblende and plagioclase. The other group is amphibolite which is abundant in the basement throughout this area. The rock is generally dark gray to black in color due to the large amounts of hornblende and biotite. Gneissosity of the rock is recog-

Table 2. Chemical compositions of rocks from the central Yamato Mountains.

No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SiO_2	69.29	67.51	59.17	59.19	46.17	51.27	54.14	50.20	55.28	58.03	58.24	53.96	71.63	72.36	50.18
TiO_2	0.64	1.04	1.48	1.43	1.97	3.00	2.71	2.76	1.14	0.97	1.24	1.28	0.24	0.36	1.30
Al_2O_3	13.53	16.21	17.56	13.57	16.98	14.28	14.44	14.69	13.00	14.36	15.66	12.95	13.76	14.26	7.19
Fe_2O_3	2.06	0.92	1.09	3.62	2.18	3.68	3.43	3.16	2.07	1.94	1.27	1.52	1.39	0.80	6.91
FeO	1.77	1.77	4.00	3.95	9.28	7.64	6.92	8.02	5.01	4.12	4.67	4.42	0.89	1.87	6.81
MnO	0.02	0.01	0.05	0.15	0.20	0.22	0.19	0.23	0.10	0.10	0.09	0.12	tr	0.04	0.18
MgO	0.83	0.50	1.48	2.51	5.34	3.95	3.35	3.89	6.18	5.88	3.57	6.18	0.05	0.08	9.21
CaO	2.09	1.94	3.10	4.44	8.81	6.72	6.24	6.34	5.77	5.11	4.20	6.72	1.36	1.23	7.48
Na_2O	4.25	3.28	3.81	3.06	2.89	2.22	2.48	2.83	2.94	2.52	2.58	1.60	3.75	3.16	1.89
K_2O	4.39	6.19	6.19	6.20	2.51	2.74	3.18	6.02	5.97	6.08	7.57	7.76	5.51	5.79	6.50
P_2O_5	0.31	0.33	0.49	0.92	1.67	1.84	1.54	1.63	0.89	0.75	0.59	1.25	0.09	0.06	1.36
$H_2O(+)$	0.11	0.28	0.67	0.32	1.42	0.89	0.52	0.88	0.48	0.38	0.67	0.98	0.04	0.40	0.85
$H_2O(-)$	0.17	0.64	0.28	0.25	0.27	0.67	0.60	0.20	0.67	0.68	0.51	0.27	0.38	0.28	0.24
CO_2	0.34	nd	nd	tr	nd	nd	nd	nd	0.20	nd	nd	nd	0.37	nd	0.03
Total	99.80	100.62	99.37	99.61	99.69	99.12	99.74	100.85	99.70	100.92	100.86	99.01	99.46	100.69	100.13

No. 1. YC310 Granitic gneiss (nebulitic gneiss).
2. Y80B501 Granitic gneiss.
3. K79113004 Biotite gneiss.
4. YC307 Pyroxene amphibolite layer.
5. A79113002 Amphibolite.
6. Y80B502 Amphibolite.
7. Y80B503 Amphibolite.
8. Y80B506 Amphibolite.
No. 9. YC238 Porphyritic pyroxene syenite.
10. 74121803 Syenite.
11. A79112908 Syenite.
12. K79120208 Syenite.
13. YC313 Microcline granite.
14. K79112908 Biotite granite dike.
15. YC318 Pyroxene amphibolite dike.

Nos. 1, 4, 9, 13 and 15: KIZAKI (1964).
Nos. 2, 3, 5, 6, 7, 8, 10, 11, 12 and 14: analyst; R. SUGISAKI.

nized well and it is in parallel with the surrounding rocks. The constituents are hornblende, biotite and plagioclase, occasionally with clinopyroxene, K-feldspar and quartz.

4.2.2. Gneiss (granitic gneiss, augen gneiss and banded gneiss) (Gn)

Gneiss occupies a major part of massif B and a half of the southwestern part of massif C. It continues to Mt. Fukushima (massif D, SHIRAISHI, 1978) in the northwest. The gneiss shows various features such as granitic, augen, banded and partially migmatite structures.

Occurrence of granitic gneiss, augen gneiss and banded gneiss continues laterally and alternates sequentially in this area. The augen gneiss is distributed typically in the south of Mount Tyô, where augen structure of rounded and large K-feldspar is recognized very conspicuously (Plate 4c). The banded gneiss is distributed mainly in massif B and its field occurrence is shown in Plate 4b. The granitic gneiss occurs widely in the present area and varies from granitic to dioritic in composition. The gneiss also varies in texture, showing weak-granitized to nebulitic and migmatitic appearances (Plate 4a). The constituent minerals are biotite, plagioclase, quartz and K-feldspar with minor hornblende.

Thickness of the gneisses is estimated approximately as 3 to 4 km.

4.2.3. Syenites

Syenites are divided into the following three types on the basis of color index and textures.

a) Porphyritic syenite (pSy)

b) Coarse-grained massive syenite (coarse syenite) (cSy)

c) Medium-grained massive syenite (medium syenite) (mSy)

a) Porphyritic syenite (pSy)

Porphyritic syenite is the major type of the syenites in the region of the Yamato Mountains, and corresponds to the porphyritic pyroxene syenite designated by KIZAKI (1964). Mount Tyô, Mount Sentyô and Mount Eyskens (heighest peak in massif C) are composed of the porphyritic syenite. The syenite is medium- to coarse-grained characterized by porphyritic texture of potash feldspar (Plate 5a), and is marked with the flow structure or foliation due to the oriented large crystals of euhedral potash feldspar.

At the south end of Mount Tyô, the porphyritic syenite is in concordant contact with gneisses and amphibolites sequences (Fig. 2, Plate 5b). Syenite near the contact is fine- to medium-grained and shows non-porphyritic texture, is dark gray in color, and the foliation is more remarkable than the main mass due to the strong parallel orientation of biotite and K-feldspar. The foliation of the syenite trends northwest-southeast and dips monoclinally toward northeast, because the syenite lies on gneisses and amphibolites.

Some dikes of porphyritic syenite intrude gneisses at Norosidai Nunatak

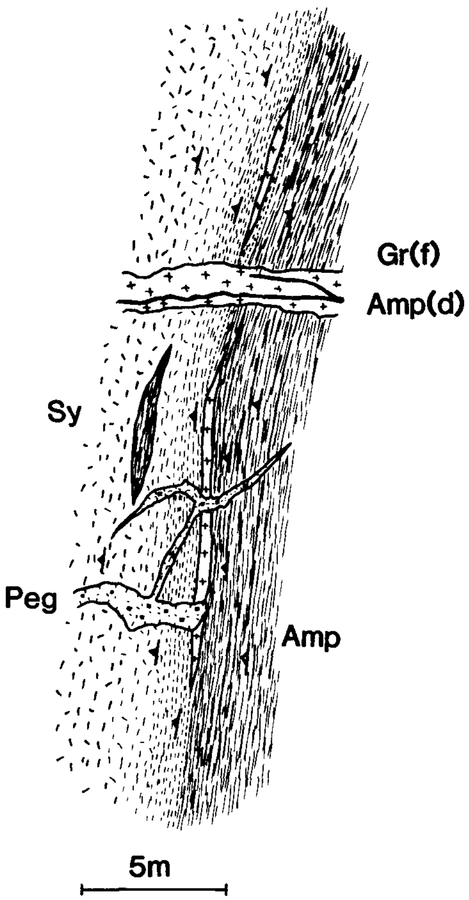

Fig. 2. Contact of porphyritic syenite and amphibolite.
Sy: porphyritic syenite, Amp: amphibolite, Gr(f): fine-grained granite dike, Amp(d): amphibolite dike, Peg: pegmatite.

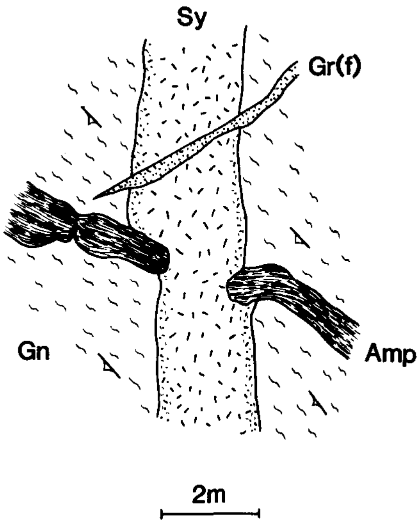

Fig. 3. Porphyritic syenite intruding gneiss and amphibolite.
Sy: porphyritic syenite, Gn: gneiss, Amp: amphibolite layer, Gr(f): fine-grained granite dike.

and the rock is similar to the porphyritic type syenite intruding gneiss in the southern cliff of Tyô-no-kubo (Fig. 3). As shown by the field sketch in Fig. 3, the syenite dike about 2 m wide clearly cuts and discordantly intrudes the gneiss and amphibolite sequences, while the syenite is intruded by the acidic dike which is fine- to medium-grained aplite, light gray and several tens of centimeters in width. The syenite is fine-grained at the contact and no contact effect is recognizable.

Constituent minerals are clinopyroxene, biotite and K-feldspar with minor amounts of orthopyroxene, hornblende, plagioclase and quartz. Hornblende is recognized to occur by partially replaced pyroxene. Accessory minerals are apatite, zircon and opaque minerals.

b) Coarse syenite (cSy)

This rock is very coarse-grained massive syenite. The coarse syenite is light-colored due to dominant K-feldspar which is 2–3 cm in size, and is characterized by the gray core of orthoclase in large microcline crystals as shown in Plate 5c. Foliation of the rock is not clear due to very coarse-grained K-feldspar, but sometimes it is foliated very weakly by the orientation of mafic minerals.

The rock grades into medium-grained syenite on the south side of Maku Rock, but the distinction between coarse and porphyritic syenites is not clear because there is no direct contact of them.

Constituent minerals are hornblende, biotite and K-feldspar with minor plagioclase and quartz. Clinopyroxene is a relic of hornblende. Accessory minerals are sphene (relatively abundant), apatite, zircon and opaque minerals.

c) Medium syenite (mSy)

This rock occurs mainly in Syôji Rock–Tuitate Rock (Plate 3c) and in a small amount in Maku Rock. The rock is melanocratic, gray to dark gray in color and shows a weak foliation due to the orientation of mafic minerals and basic inclusions, but the facies is relatively massive compared with the porphyritic and coarse syenites. Many dikes of granitic and basic (metamorphosed) compositions are remarkable in the rock (Plate 6a).

Constituent minerals are hornblende, biotite and K-feldspar with minor plagioclase and quartz. Sphene, apatite, zircon and opaque minerals are accessories.

4.2.4. Granite, aplite and pegmatite (Gr)

Large amounts of acidic dikes including granites, aplite and pegmatite are found throughout the present area as discordant dikes to the host rocks which are gneisses, amphibolite and syenites. An example of occurrence of the dikes is shown in Plate 6a photographed at Tuitate Rock. In rare cases, the rocks cut basic metamorphosed dikes which will be mentioned later. The rocks are less than one meter to several tens of meters in width and do not show distinct foliation, and the contact effect is recognized slightly where the host rocks are partially granitized. In most cases, the contact with the host rocks is very sharp.

Granites are reddish, gray and light gray, usually fine- to medium-grained and massive. They are composed of K-feldspar, plagioclase, quartz and biotite, with or without hornblende. Aplite and pegmatite are light gray or pinkish, composed mainly of plagioclase, quartz and K-feldspar, with or without biotite.

4.2.5. Basic meta-dikes (Bd)

Basic metamorphosed dikes occur widely as granitic dikes with a width of several meters to approximately ten meters in this area. The dikes are discordant to the foliation of syenites and the gneissosity of gneisses, but contact effects are not recognized. As shown in Plate 6a, the rocks cut the acidic dikes of granitic, aplitic and pegmatitic compositions, but in some cases the basic meta-dikes are clearly cut by the acidic dikes. Relationship between the basic and the acidic dikes is very complex. The basic meta-dikes show strong foliation which is parallel to the contact but is independent of the structure of the host rocks.

In most cases, the rocks are found to contain a large amount of biotite due to later metamorphism, but it is geologically clear from the shape of the dikes that the rocks had intruded as an igneous facies (magma) before metamorphism.

Most of the dikes consist of biotite, plagioclase and clinopyroxene with or without hornblende.

4.2.6. Moraine and detritus (Mo)

Unconsolidated deposits are mainly moraine and detritus. Thin moraine covering the bare ice and rocky areas, is distributed in the west and the northeast of the present area. Especially the moraine on the bare ice in the west of massifs B and C continues for about 40 km along the Yamato Mountains (Plates 1 and 2), and disappears in the northwest of Mimi Rock. The detritus is accumulated around the cliffs (Plate 3b) and usually continues to the moraine. They consist of fine silty materials to big boulders (over a few meters in diameter) or fragments of rocks of various types and sizes.

5. Geological Structure

The geological structure of this area is rather simple. The foliation of gneiss and amphibolite sequences trends generally in the NW-SE direction and dips 40° to 60° NE in massif C including Norosidai Nunatak. On the other hand, in massif B the foliation trends in the N-S or NNE-SSW direction and dips E. At the north end of massif B, the foliation is modified to the NNW-SSE or NW-SE direction and the structure is continuous to that of massif C.

The foliation of syenites trends generally NNW-SSE or NW-SE and dips NE or N irrespective of their facies, and the structure is concordant to the metamorphic sequences (gneisses and amphibolites). An anticlinal fold is recognized in the porphyritic syenite, gneiss and amphibolite in the south of Mount Tyô. Their structures are harmonious with each other.

A thrust fault is found in the metamorphic sequence in the south of Mount Tyô. The fault strikes generally E-W and dips gently to the north. As shown in Plate 6c, the fault is parallel to the foliation of the metamorphic sequences in the lower part of the plate, but in the upper part of the plate, the fault is discordant to the syenite (at the right on the plate) and to the gneiss (left).

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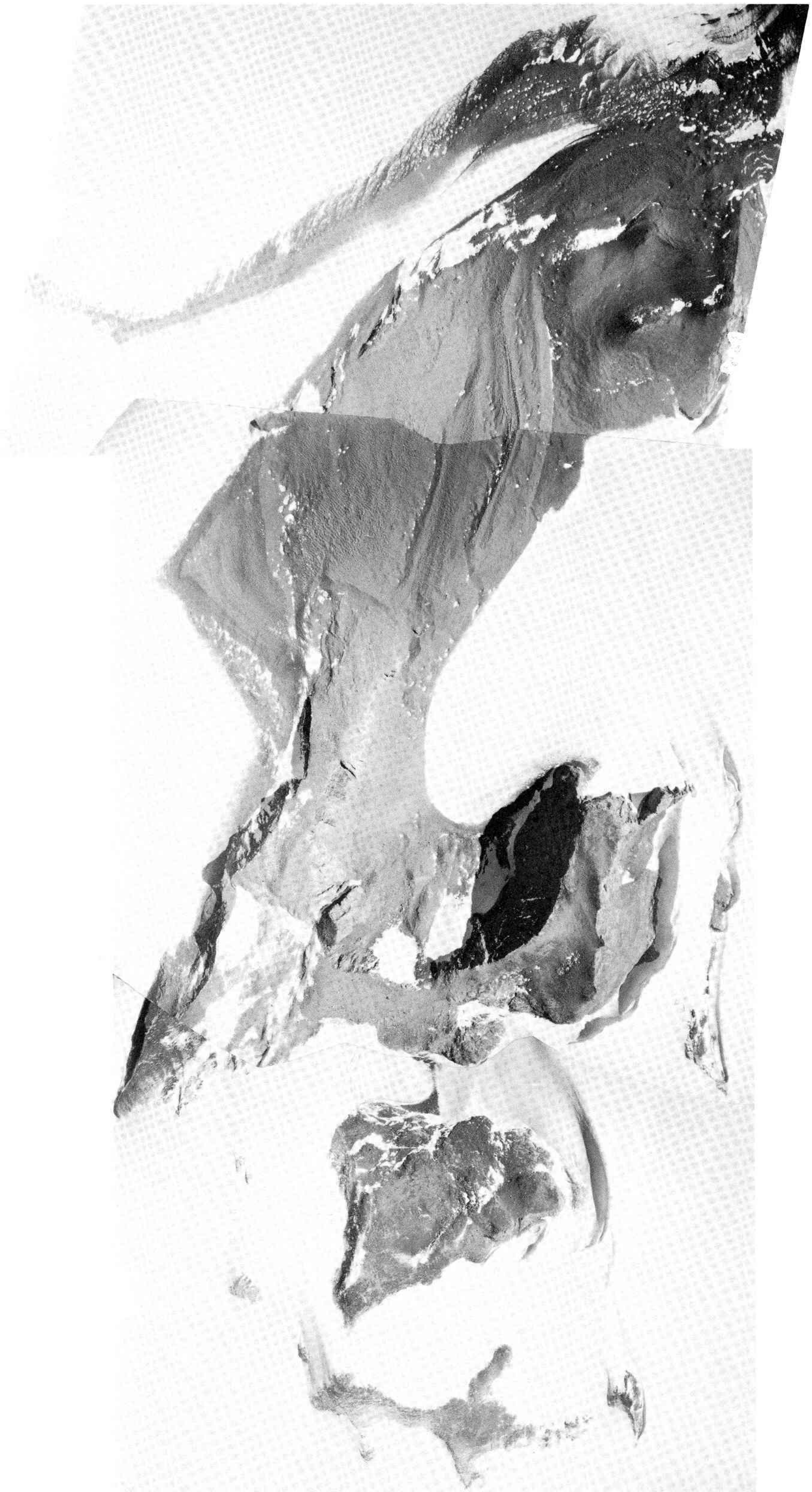
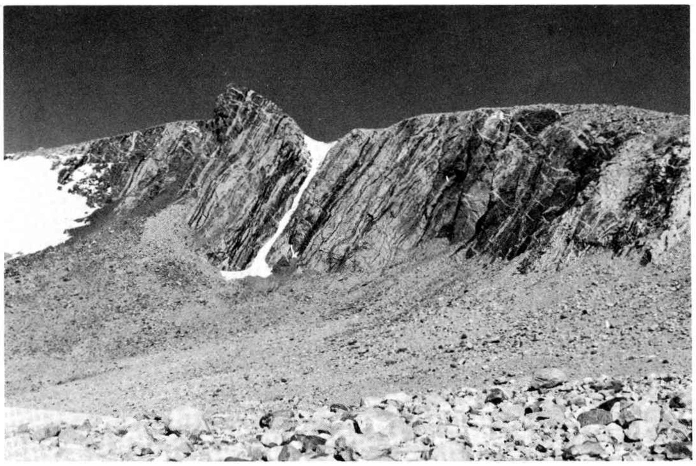
Aerial photograph of massif B, Yamato Mountains.
JARE Antarctic air photo 22AV-81, C2-4.

Plate 2

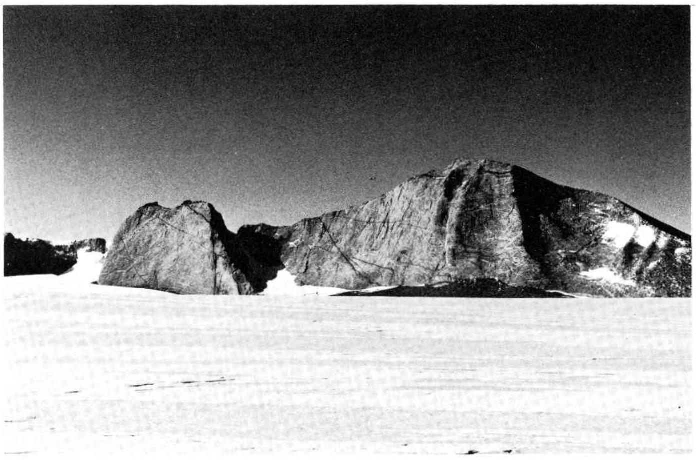


Aerial photograph of massif C, Yamato Mountains.
JARE Antarctic air photo 16AV C13-3 and 4.

a. Massif C, viewed from south. Central part is Mount Tyô which is gentle on the south slope and covered with thin moraine. The steep cliff of Tuitate Rock is shown.

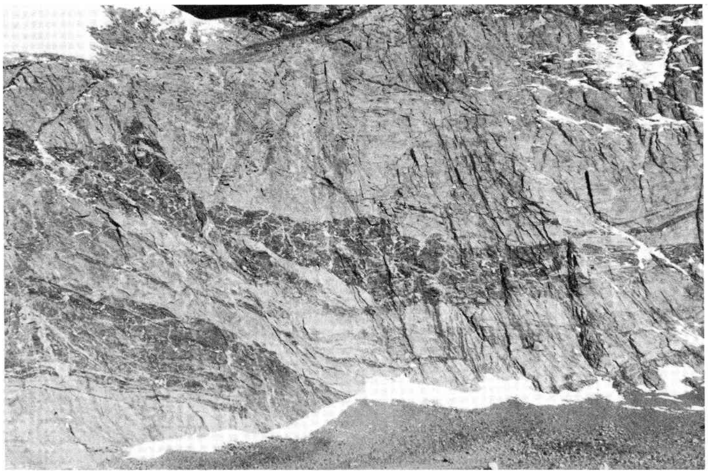


b. Steep cliff in the southern part of Tyô-no-kubo. The cliff consists of gneisses and amphibolites dipping to northeast.



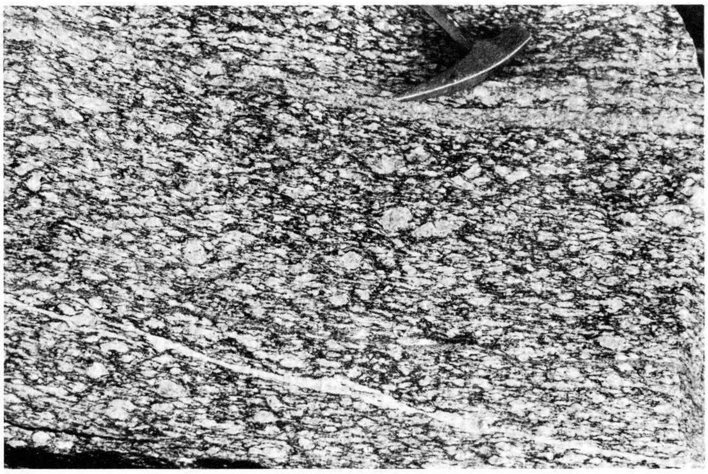
c. Tuitate Rock consisting of medium-grained massive syenite, viewed from west.

Plate 4



a. Concordant amphibolite layer in the Aka-kabe Bluff. There is a head of over 400 meters.

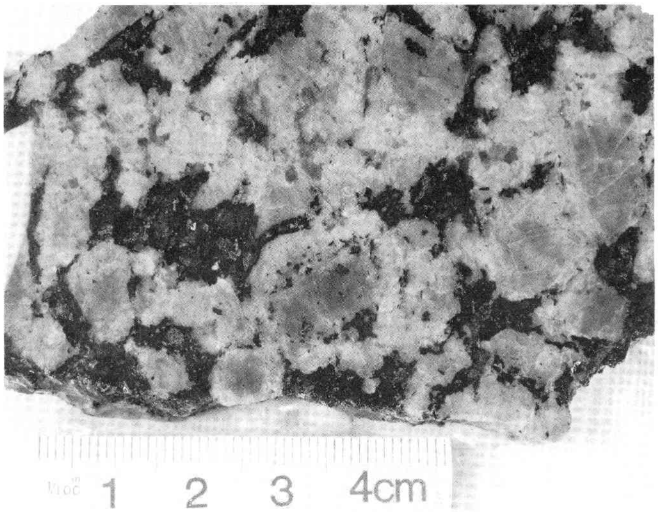
b. Banded gneiss near the highest peak of massif B.



c. Augen gneiss in the south of Mount Tyô.

a. *Porphyritic syenite characterized by porphyritic potash feldspar (white–light gray) in dark gray matrix.*

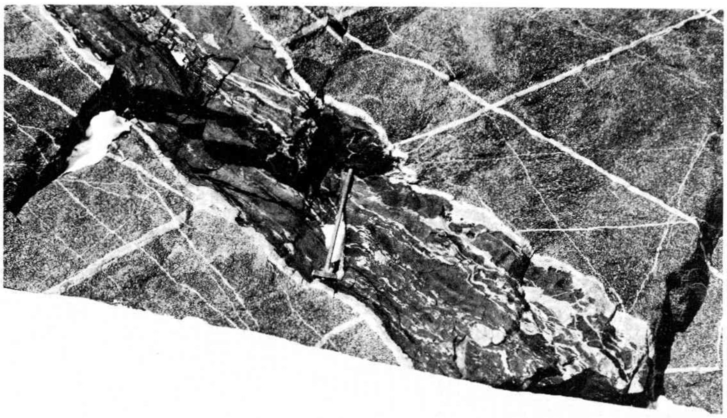
b. *Contact between porphyritic syenite (left) and amphibolite (right). Many dikes of granite intrude in the both rocks.*



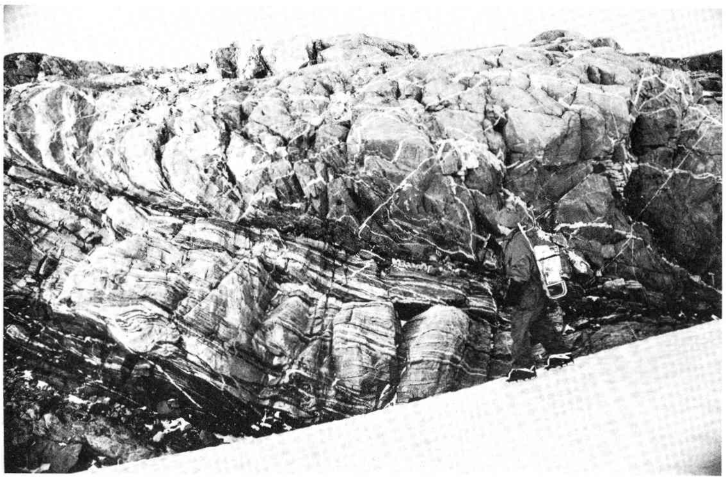
c. *Coarse-grained syenite. Potash feldspar (right) shows the core of gray color.*

Plate 6

a. Medium-grained syenite in the cliff of Tuitate Rock. Many granite and basic dikes intrude the rock.



b. Basic dike (amphibolite) in syenite.



c. Thrust fault in the south of Mt. Tyô.

Antarctic Geological Map Series

Sheet 1	East Ongul Island	March 1974
Sheet 2	West Ongul Island	March 1974
Sheet 3	Teöya	March 1975
Sheet 4	Ongulkalven Island	March 1975
Sheet 5	Langhovde	March 1976
Sheet 6 & 7	Skarvsnes	March 1977
Sheet 8	Kjuka and Telen	March 1979
Sheet 9	Skallen	March 1976
Sheet 10	Padda Island	March 1977
Sheet 11	Cape Hinode	March 1978
Sheet 15	Cape Ryûgû	March 1980
Sheet 21	Cape Omega	March 1979
Sheet 22	Oku-iwa Rock	March 1981
Sheet 27(1)	Mt. Fukushima, Northern Yamato Mountains	March 1978
Sheet 28	Central Yamato Mountains, Massif B and Massif C	March 1982
Sheet 29	Belgica Mountains	March 1981