NATIONAL INSTITUTE OF POLAR RESEARCH

ANTARCTIC GEOLOGICAL MAP SERIES
SHEET 16 AKEBONO ROCK

Explanatory Text of Geological Map of Akebono Rock, Antarctica

Yoshikuni HIROI, Kazuyuki SHIRAISHI
and Kiyotaka SASAKI

NATIONAL INSTITUTE OF POLAR RESEARCH
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National Institute of Polar Research
9–10, Kaga 1-chome, Itabashi-ku
Tokyo 173, Japan

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Yoshikuni HIROI[1], Kazuyuki SHIRAISHI[2] and Kiyotaka SASAKI[3]

1. Introduction

The Akebono Rock is a small ice-free area located at 42°54′–43°00′E in longitude and 68°05′–06′S in latitude on the Prince Olav Coast. The bedrock is exposed for about 4 km along the coastal line and about 1 km in width. The geological survey of the area was carried out by Y. HIROI and K. SASAKI of the 22nd Japanese Antarctic Research Expedition (JARE-22) and K. SHIRAISHI of JARE-21 in January 1981. The geomorphological survey was done by K. MORIWAKI of JARE-22 and a geodetic survey was conducted by the Geographical Survey Institute at the same time. The Akebono Rock appears in the topographic map of "Akebono Rock" on a scale of 1:25000 which was published in February 1983. An orthophoto map of about 1:10000 in scale was prepared for the field survey. It is the striking feature of the ice-free area that in the topographically flat parts rocks are highly fractured in pieces (Plate 3), so that the strike and dip of the rocks are difficult to be determined. This may be the result of intensive weathering after glacial erosion.

2. Geology

2.1. General

The Akebono Rock is underlain mainly by well-layered gneisses, migmatitic rocks, granites, and pegmatites. The most remarkable feature of the bedrock exposure is the occurrence of both well-recrystallized and slightly-recrystallized dike rocks of basic-intermediate compositions (Plate 1b, Plate 2, Plate 7b, and Plate 9). It follows that there were two stages of dike intrusion in this bedrock exposure; before or during the regional metamorphism, and after the regional metamorphism but before the emplacement of pink gneissose granite. The occurrence of garnet-bearing white granite-pegmatite and the existence of a "shear zone" are also notable features of the ice-free area.

Two stages of folding have been recognized in the Akebono Rock; the earlier tight folds trending NW-SE and the later open to close folds with the axial trends of nearly E-W. Such a superimposed folding feature of the basement rocks in the ice-free area is in common to those of other bedrock exposures throughout the Prince Olav Coast (SHIRAISHI *et al.*, 1983).

Cummingtonite occurs in both the well-layered gneiss of appropriate bulk chemical

1) Department of Earth Sciences, Faculty of Science, Chiba University, 1–33, Yayoi-cho, Chiba 260.
2) National Institute of Polar Research, 9–10, Kaga 1-chome, Itabashi-ku, Tokyo 173.
3) Institute of Mineralogy, Petrology and Economic Geology, Faculty of Science, Tohoku University, Aramaki Aoba, Sendai 980.

composition and the well-recrystallized dike rock, but no orthopyroxene has been found. Therefore, it is safely concluded that the bedrock exposure is within the amphibolite-facies area in the progressive metamorphic sequence from the amphibolite to granulite facies along the Prince Olav and Sôya Coasts (HIROI *et al.*, 1983; SHIRAISHI *et al.*, 1984). It is worthy of note that garnet up to 3 cm in diameter occurs commonly in various rock types; pelitic, quartzo-feldspathic, basic-intermediate, and calcareous in bulk chemical composition.

Table 1. Chemical analyses of rocks from the Akebono Rock.

Sp. No.	1	2	3	4	5	6	7	8	9
SiO_2	72.60	64.03	70.79	68.36	50.84	52.78	52.22	73.17	55.07
TiO_2	0.32	0.97	0.30	0.40	2.95	0.91	0.98	0.08	1.47
Al_2O_3	13.03	15.54	14.12	15.30	13.88	15.35	18.30	14.71	16.05
Fe_2O_3	1.93	1.35	2.22	1.04	3.26	4.44	2.96	0.20	2.10
FeO	2.31	6.67	2.64	2.83	10.88	8.13	8.30	0.58	7.61
MnO	0.06	0.12	0.12	0.05	0.21	0.19	0.17	0.01	0.14
MgO	1.60	2.73	0.96	1.90	4.85	5.90	4.69	0.34	5.24
CaO	1.89	1.06	3.83	4.56	7.76	6.50	5.86	1.03	8.04
Na_2O	4.83	2.06	4.12	3.93	1.72	4.03	4.27	3.57	3.35
K_2O	1.22	4.08	0.55	1.69	2.26	0.52	0.09	5.74	0.10
H_2O (+)	0.85	1.48	0.35	0.75	1.45	1.05	1.48	0.58	1.12
H_2O (−)	0.07	0.13	0.16	0.06	0.07	0.20	0.14	0.10	0.09
P_2O_5	0.06	0.14	0.10	0.12	0.40	0.19	0.23	0.02	0.10
Total	100.77	100.27	100.26	100.99	100.53	100.19	99.69	100.13	100.48
Q	32.56	26.05	34.12	25.64	6.31	2.45	2.91	27.42	8.18
C	0.47	6.05	0.02	—	—	—	1.07	0.80	—
or	7.21	24.11	3.25	9.99	13.36	3.07	0.53	33.92	0.59
ab	40.87	17.43	34.86	33.25	14.55	34.10	36.13	30.21	28.35
an	8.98	4.34	18.35	19.12	23.48	22.26	27.57	4.98	28.46
di wo	—	—	—	1.14	5.18	3.65	—	—	4.50
di en	—	—	—	0.61	2.48	2.07	—	—	2.45
di fs	—	—	—	0.49	2.63	1.43	—	—	1.89
hy en	3.99	6.80	2.39	4.12	9.60	12.62	11.68	0.85	10.60
hy fs	2.23	9.75	2.74	3.28	10.18	8.69	11.49	0.79	8.18
mt	2.80	1.96	3.22	1.51	4.73	6.44	4.29	0.29	3.05
il	0.61	1.84	0.57	0.76	5.60	1.73	1.86	0.15	2.79
ap	0.14	0.32	0.23	0.28	0.93	0.44	0.53	0.05	0.23
Analyst	A	A	A	A	A	A	B	A	A

No. 1. 81AK03 Garnet-biotite gneiss
2. 81AK47 〃
3. 81AK01 Garnet-biotite-hornblende gneiss
4. 81AK66 Biotite-hornblende gneiss
5. 81AK71 Garnet-biotite amphibolite (amphibolite I)
6. 81AK06 Cummingtonite-bearing amphibolite (amphibolite II)
7. 81011808 〃
8. 81AK28 Garnet-bearing granite
9. 81AK63 Meta-andesitic dike

Analyst A: Japan Chemical Analysis Center
B: TEZUKA and ONUKI

The basement rocks of the Akebono Rock are classified into the following types based on the mode of occurrence and petrographic characteristics.

1. Biotite gneiss
2. Garnet-biotite gneiss
3. Biotite-hornblende gneiss
4. Calc-silicate rock
5. Amphibolite I (well-layered gneiss)
6. Amphibolite II (well-recrystallized dike rock)
7. Garnet-bearing white granite and pegmatite
8. Basalt-andesite (slightly metamorphosed dike rock)
9. Pink gneissose granite and pegmatite

Representative bulk chemical compositions of the rocks are presented in Table 1.

2.2. *Geology and petrography*

2.2.1. Biotite gneiss

1) Biotite gneiss: This is a fine- to coarse-grained rock with lepidoblastic to granoblastic textures. It also varies from melanocratic to leucocratic according to the modal amount of biotite. This rock usually occurs as well-layered gneiss, but it sometimes shows a migmatitic mode of occurrence (Plate 4a). The constituent minerals are biotite, plagioclase, K-feldspar, and quartz, with minor amounts of apatite, zircon and opaque mineral(s).

2) Cummingtonite-hornblende-bearing biotite gneiss: This rock occurs locally alternating with the biotite gneiss described above. It is characteristically pale brownish green in hand specimen due to the colored feldspar and quartz just like the case of pyroxene gneiss in the granulite-facies area. Greenish brown cummingtonite is identified with the naked eye on the fresh surface. Black biotite occurs as porphyroblasts sporadically distributed in the rock. The constituent minerals are cummingtonite, hornblende, biotite, plagioclase, quartz, apatite, zircon, and opaque mineral(s). Under the microscope, colorless cummingtonite and green hornblende are intergrown with each other (Plate 7a).

2.2.2. Garnet-biotite gneiss

1) Garnet-biotite gneiss: This rock shows granoblastic to porphyroblastic textures. Garnet sometimes occurs as porphyroblasts, up to 2 cm in diameter, with a snowbal texture. In the central to western parts of the bedrock exposure, garnet-biotite gneiss is closely associated with the garnet-bearing white granite and pegmatite, showing "injection gneiss"-like mode of occurrence. The constituent minerals are garnet, biotite, plagioclase, quartz, apatite, zircon, and opaque minerals with or without K-feldspar.

2) Sillimanite-garnet-biotite gneiss: This rock occurs only rarely in the bedrock exposure. Sillimanite is usually present in a small amount within the matrix and as inclusions within plagioclase and garnet in non- to weakly-mylonitized rocks, whereas it is completely replaced by muscovite in a highly-mylonitized rock with silky luster (Plate 8a). The constituent minerals are similar to those of the garnet-biotite gneiss described above except for the occurrence of sillimanite or its altered product, muscovite.

2.2.3. Biotite-hornblende gneiss

1) Biotite-hornblende gneiss: Biotite-hornblende gneiss and amphibolite I are the most common rock types in this bedrock exposure, and alternate with and change gradually to each other. Biotite-hornblende gneiss is a fine- to coarse-grained and massive to well-foliated rock. It sometimes contains magnetite porphyroblasts, up to 5 mm in diameter, which are surrounded by plagioclase. The constituent minerals are biotite, hornblende, plagioclase, quartz, apatite, zircon, and opaque mineral(s) with or without sphene.

2) Garnet-biotite-hornblende gneiss: This rock differs from the garnet-free biotite-hornblende gneiss described above only in the presence of garnet. Garnet occurs sporadically as highly poikilitic porphyroblasts up to 3 cm in diameter.

2.2.4. Calc-silicate rock

This rock occurs as rounded to lensoid blocks included in other well-layered gneisses (Plate 5a). The block varies in size from several cm to several m. It is usually composed of garnet (grandite), clinopyroxene, hornblende, An-rich plagioclase, quartz, and sphene with or without opaque mineral(s). Secondary epidote is also present in many cases, replacing plagioclase and garnet.

2.2.5. Amphibolite I

Amphibolite I is predominant in the bedrock exposure, as mentioned above. It sometimes occurs as blocks included in pink gneissose granite (Plate 3). In such a case, both hornblende and plagioclase show alteration to various degrees. Amphibolite I is subdivided into two as follows.

1) Clinopyroxene-bearing amphibolite I: This is a fine- to coarse-grained and well-foliated to massive melanocratic rock. It occasionally contains plagioclase porphyroblasts up to several mm in diameter. The coarse-grained massive one seems as if it is hornblende gabbro. The constituent minerals are clinopyroxene, hornblende, plagioclase, and a trace amount of apatite with or without quartz, sphene, opaque mineral(s), and biotite. It seems that garnet does not occur and biotite, if present, occurs only in a trace amount in the clinopyroxene-bearing amphibolite.

2) Garnet-bearing amphibolite I: This rock is more common than the clinopyroxene-bearing amphibolite I. In general, it is fine- to medium-grained and well-foliated. Garnet usually occurs as euhedral to subhedral porphyroblasts up to 3 cm in diameter, which sometimes show a snowball texture. On the other hand, it is not uncommon that garnet occurs as anhedral aggregates constituting thin layers rich in garnet. Garnet-bearing amphibolite I is composed of garnet, hornblende, biotite, plagioclase, sphene, apatite, and zircon with or without quartz.

2.2.6. Amphibolite II

This rock occurs as meandering dikes within the well-layered gneisses in the eastern part of the bedrock exposure (Plate 2), and was completely recrystallized together with the country gneisses during the regional metamorphism. Amphibolite II is a fine- to medium-grained rock with a granoblastic texture. It characteristically contains cummingtonite, reflecting the P-T conditions of the regional metamorphism and probably its relatively aluminous bulk chemical composition. The constituent minerals are cummingtonite, hornblende, biotite, plagioclase, quartz, apatite, zircon, and opaque minerals. Garnet is an additional phase in some cases. Under the microscope, colorless cummingtonite and green hornblende are intergrown with each other.

2.2.7. Garnet-bearing white granite and pegmatite

These rocks occur mainly in the central to western parts of the Akebono Rock as concordant to discordant masses, pools, and veins. They characteristically contain garnet in addition to biotite and muscovite. Occasionally they also contain corundum, spinel, and sillimanite, which are entirely included in muscovite or garnet. Thus, these rocks have characteristics of the S-type granite, and may be of anatectic origin during the regional metamorphism. It is significant that they commonly show deformed (mylonitized) textures which are usually absent in the pink gneissose granite and pegmatite (Plate 8c).

2.2.8. Basalt-andesite

These rocks occur mainly in the eastern part of the bedrock exposure, cutting the high-grade metamorphic rocks including amphibolite II (Plate 2). They are dark gray, dark brown, or dark green and very fine- to fine-grained massive rocks. The $^{87}Sr/^{86}Sr$ ratios of the rocks are characteristically low (Table 2). These rocks have been thermally metamorphosed to various degrees according to the distance from the pink gneissose granite. However, they usually preserve igneous textures and contain two igneous pyroxenes in many cases (Plate 9). Green to brownish green hornblende usually surrounds the igneous pyroxenes. No evidence of mylonitization has been found in these rocks as well as pink gneissose granite and pegmatite.

Table 2. Rb-Sr analytical data for slightly metamorphosed basalt-andesite dike rocks.

Sample No.	Rb (ppm)	Sr (ppm)	$^{87}Rb/^{86}Sr$	$^{87}Sr/^{86}Sr$
81011805	1.71	455.9	0.011	0.70339 ± 0.00014
81011810	4.13	282.3	0.042	0.70469 ± 0.00008
81AK63	1.47	407.9	0.010	0.70349 ± 0.00013

Analyst: Teledyne Isotopes

2.2.9. Pink gneissose granite and pegmatite

These rocks are extensively intruded in two parts, central and western, in the bedrock exposure. Pink gneissose granite sometimes contains abundant blocks of the country rocks such as amphibolite I and biotite-hornblende gneiss (Plate 3), while pink pegmatite rarely contains garnet.

2.3. Geologic structures

The most conspicuous macroscopic structure of the Akebono Rock is a tight and nearly upright synform which trends NW-SE in the eastern part (Plate 1a). The axial trace of the synform is convex toward east resulting from the E-W trending later folding.

Foliation of the gneisses which is shown by the alternation of felsic and mafic layers is generally distinct. Foliation generally trends NNW-SSE and steeply dips east and west.

On a mesoscopic scale, two kinds of the folding axes are observed; the earlier NW-SE and the later WNW to ESE-WSW to ENE trends. The earlier folding axis roughly parallels the axial trace of the major synform of the eastern part, and the styles of the earlier folds are variable (Plate 6). The later folds are generally open to close, and their fold axes plunge 40° to 80°E.

A shear zone which trends E-W traverses the central to western parts of the Akebono Rock. Mylonitic gneisses and granites occur along the zone.

A right-lateral fault trending NE-SW is found in the eastern part. The strike slip is about 5 m. The exact contact of the fault plane is missing due to erosion.

Acknowledgments

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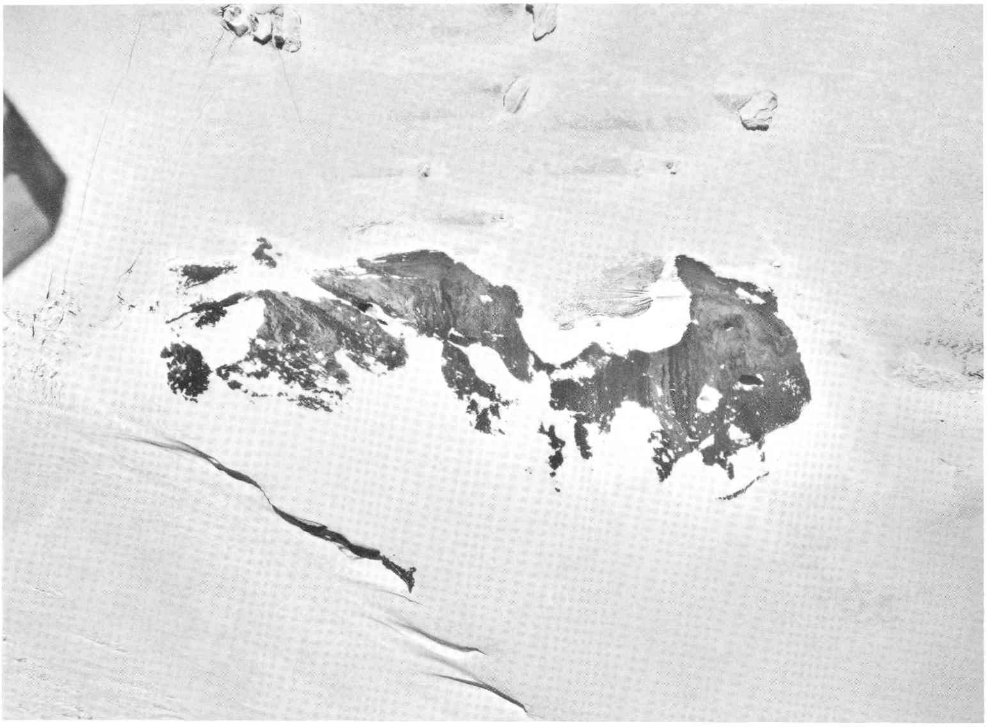
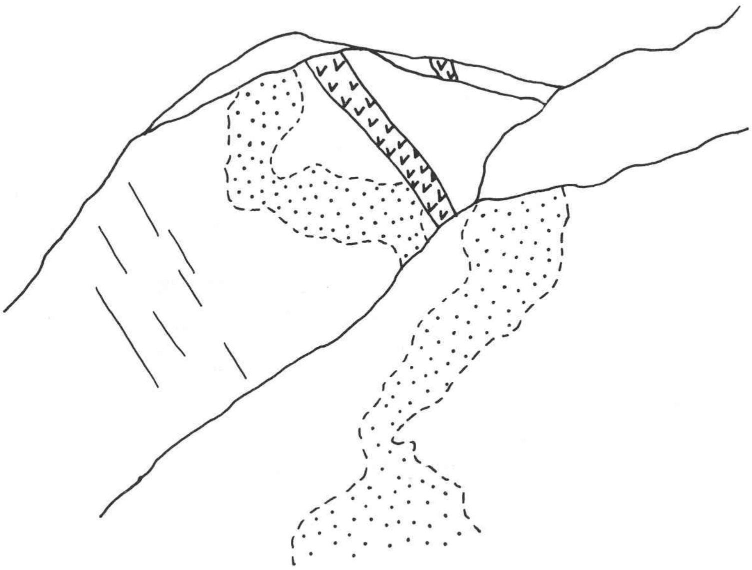


a. Aerial photograph of the Akebono Rock. JARE Antarctic air photograph (22AV-81, C4-18).

b. Slightly metamorphosed basalt-andesite dikes in the eastern part of the Akebono Rock.

Plate 2

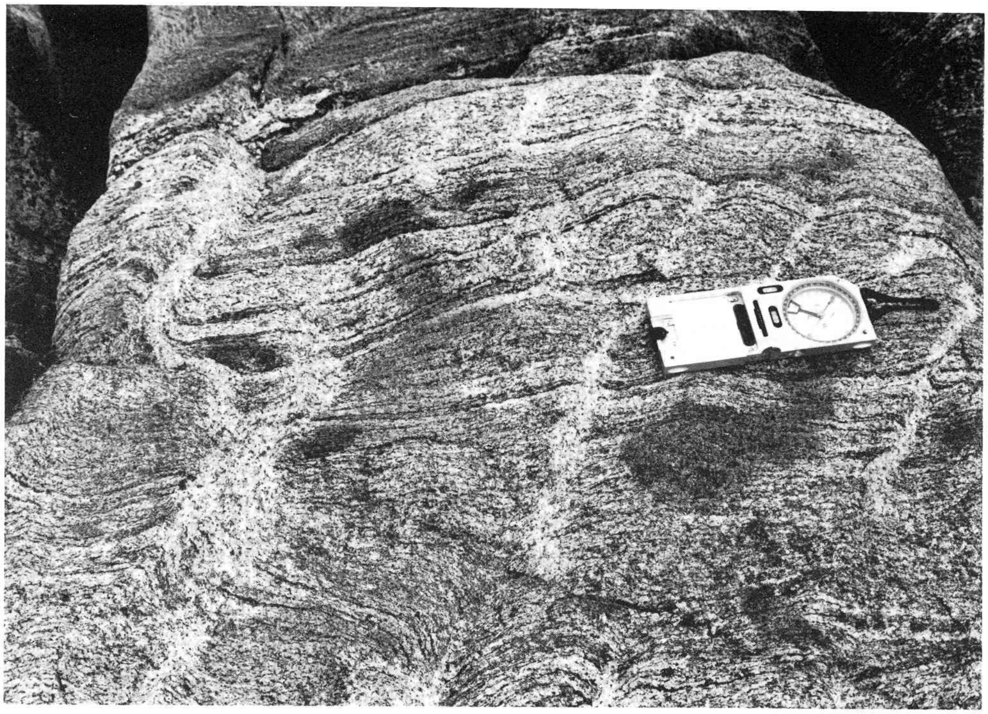


Two distinct dikes in the eastern part of the Akebono Rock. The earlier well-recrystallized one (dotted) meanders, while the later slightly-metamorphosed one (V-marked) runs straight and cuts both well-layered gneisses and the earlier well-recrystallized dike.

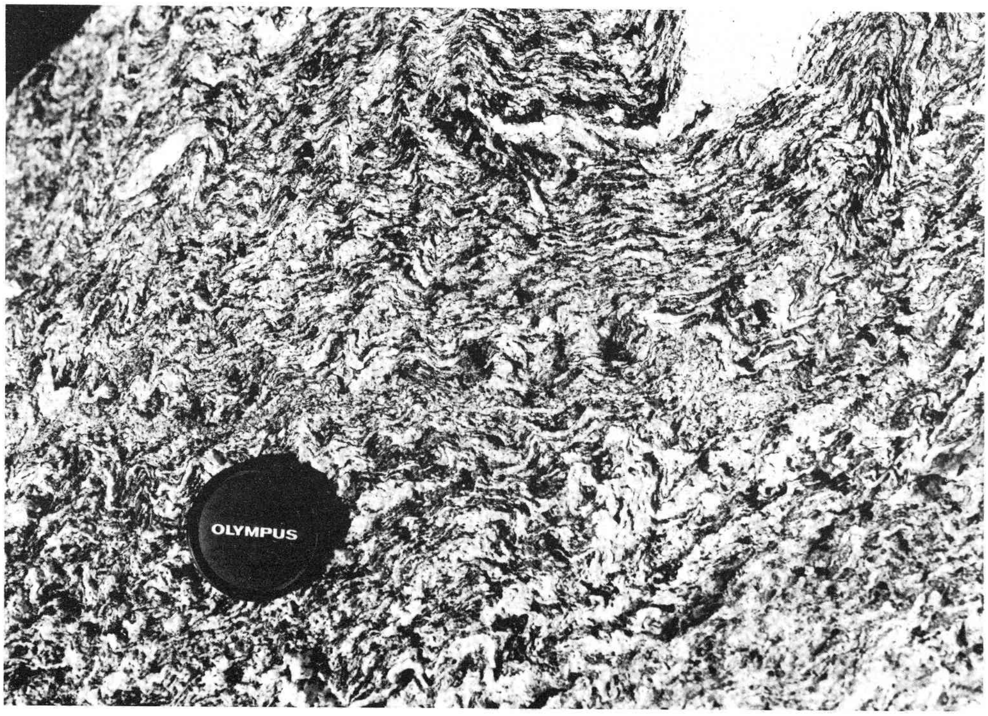
Plate 3

Highly fractured basement rocks in the topographically flat part of the Akebono Rock. Pink gneissose granite (white) contains blocks of amphibolite I (black).

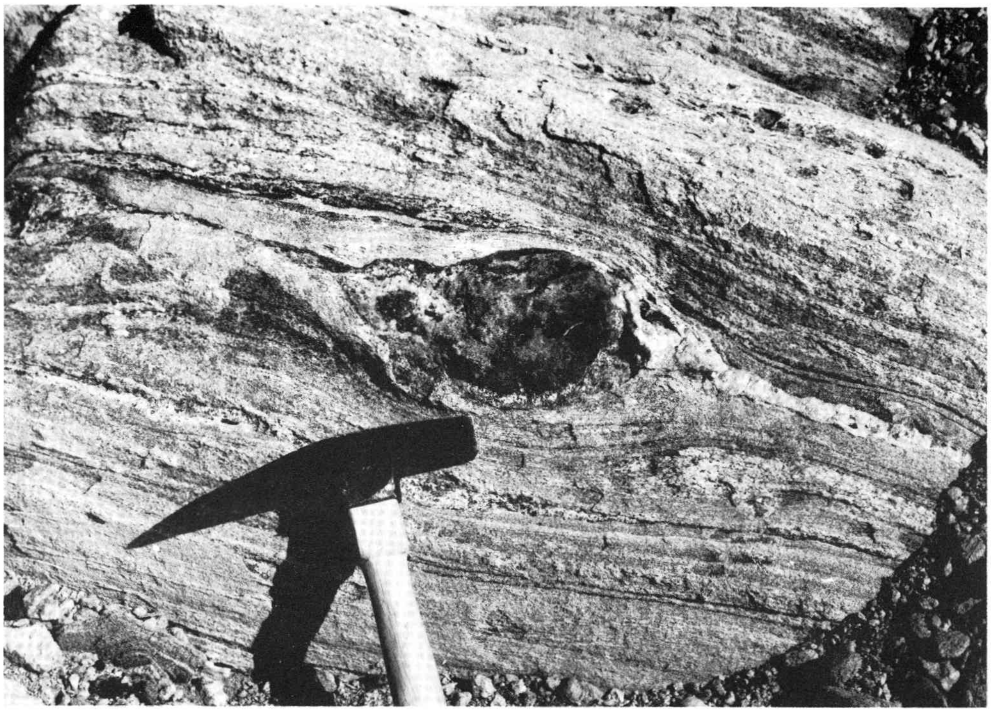
Plate 4



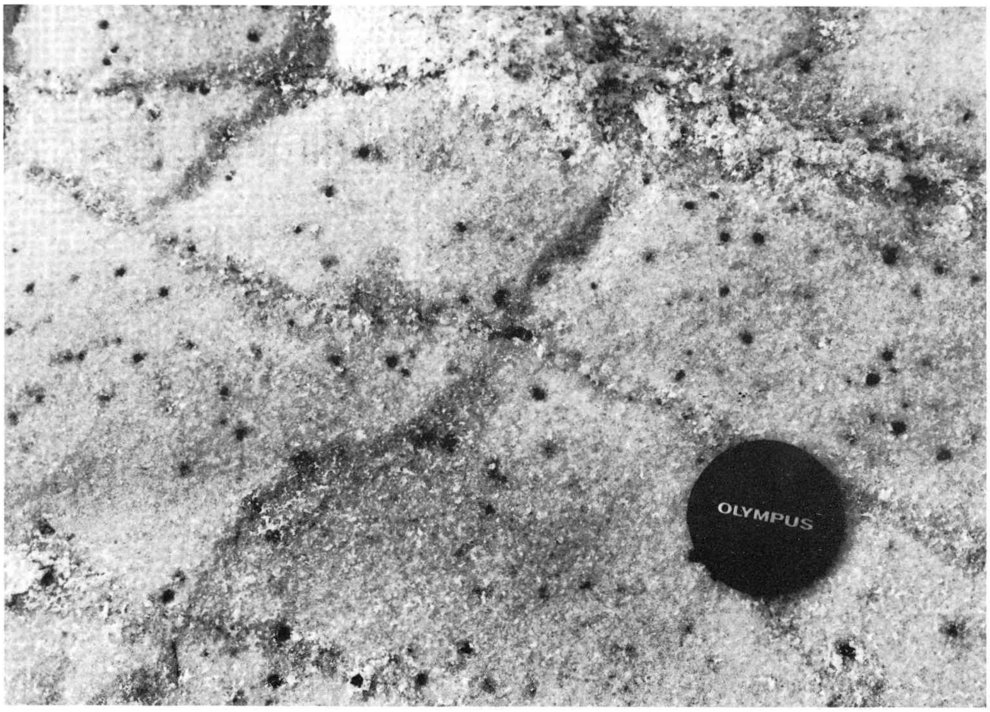
a. Migmatitic mode of occurrence of biotite gneiss.



b. Mylonitic garnet-biotite gneiss.

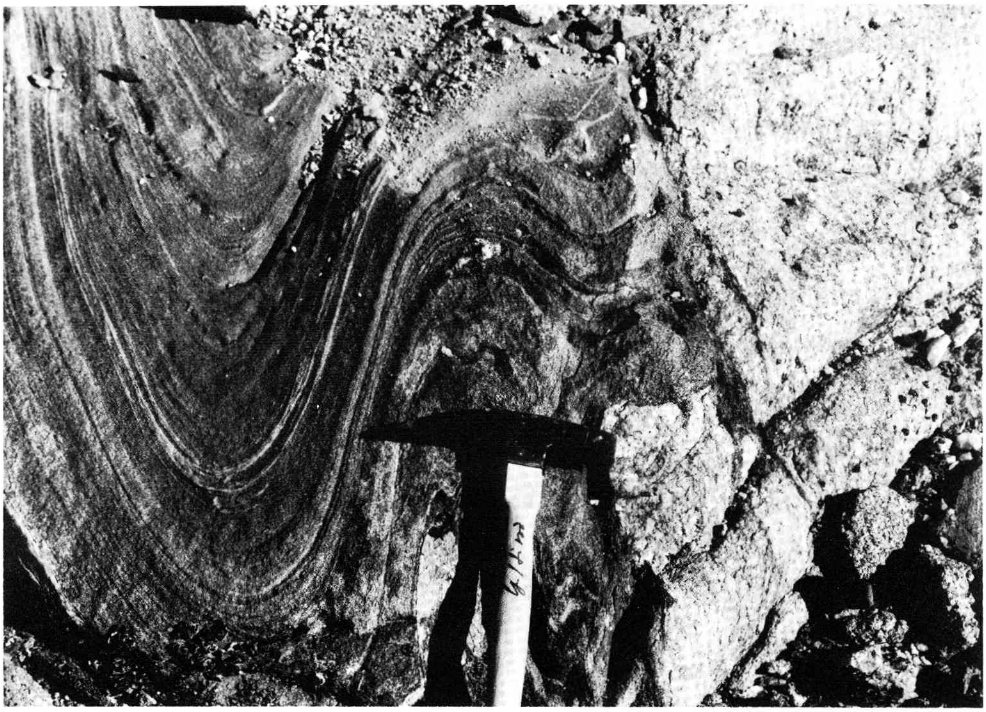


a. Mode of occurrence of a small block of a calc-silicate rock in the well-layered gneisses.

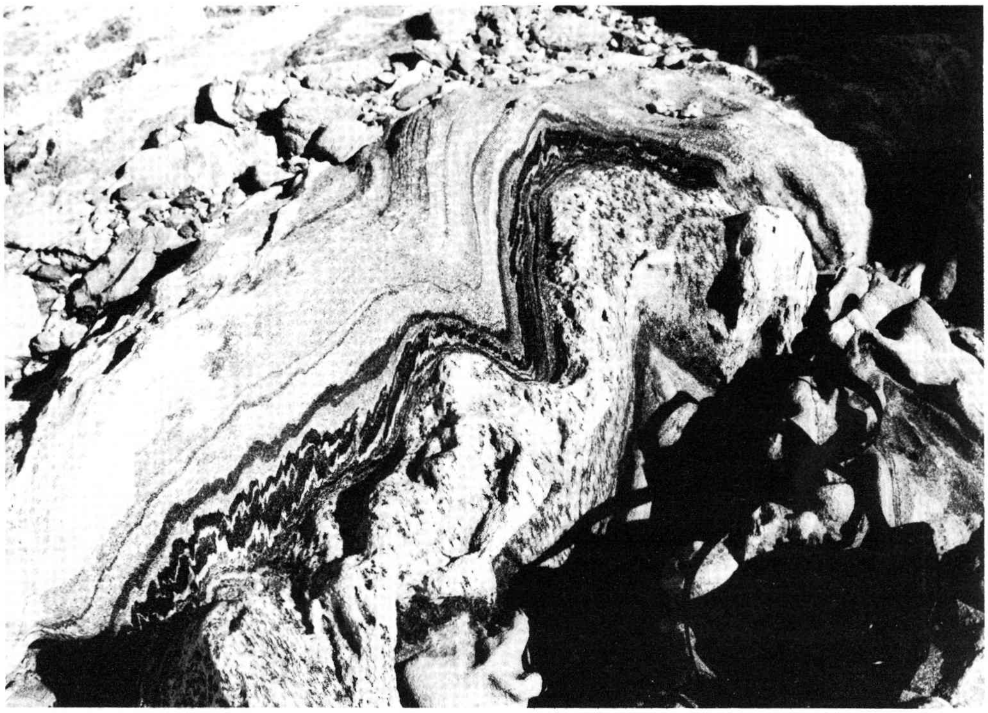


b. Garnet-bearing white granite.

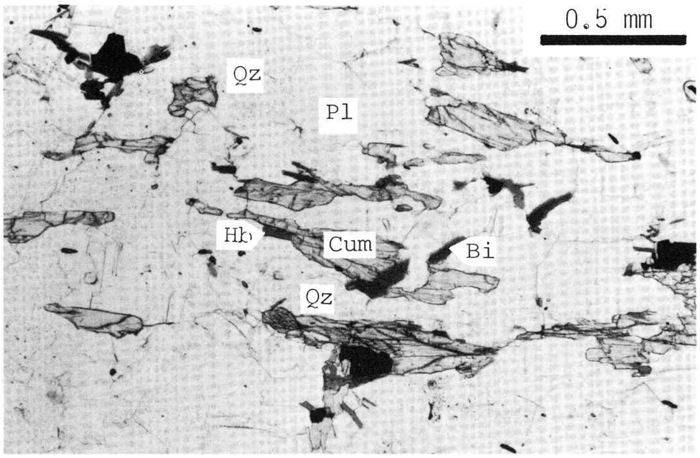
Plate 6



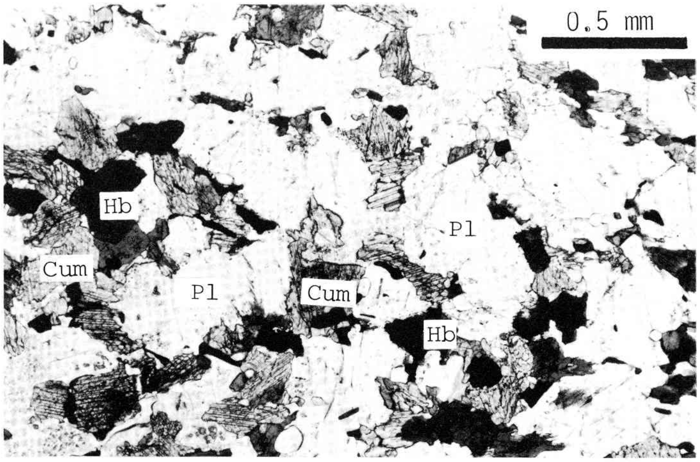
a. Harmonically folded well-layered gneisses and discordant garnet-bearing white granite.



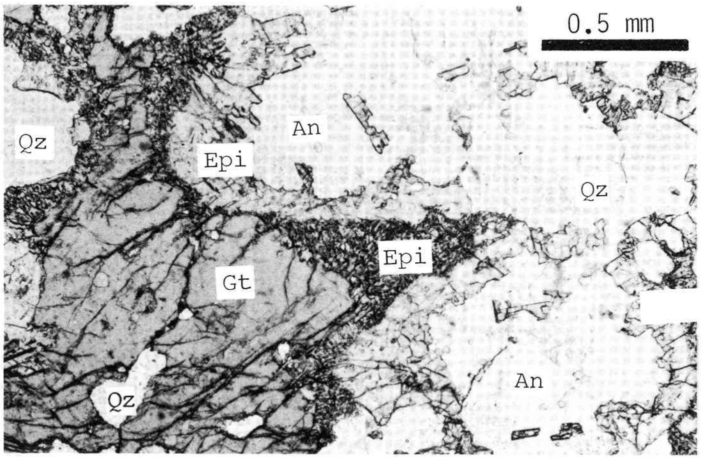
b. Disharmonic foldings in well-layered gneisses.



a. *Commingtonite (Cum) and hornblende (Hb) in cummingtonite-hornblende-bearing biotite gneiss (Sp. 81012108).*
Pl: Plagioclase, Qz: quartz, Bi: biotite.

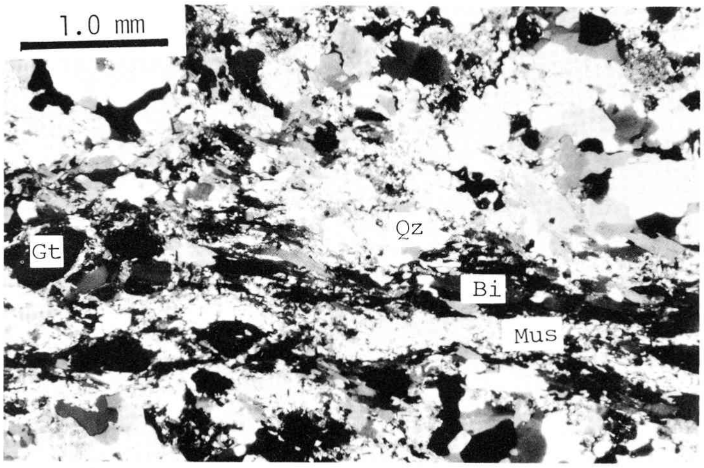


b. *Cummingtonite and hornblende in amphibolite II (well-crystallized dike rock) (Sp. 81011808).*



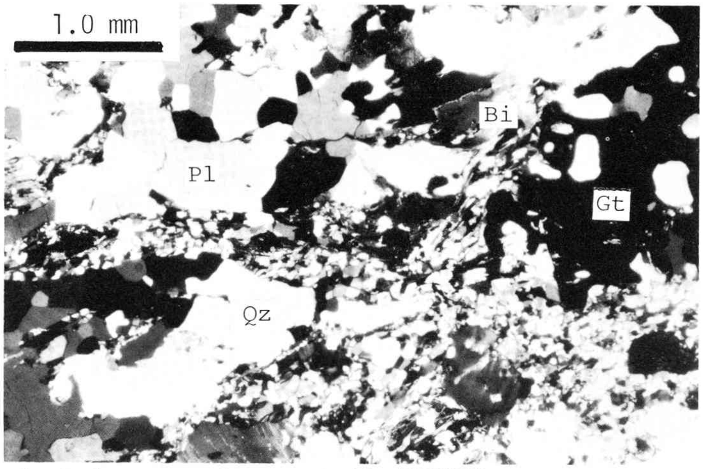
c. *Garnet (Gt), anorthite (An) and quartz in calc-silicate rock (Sp. 81011802). Secondary epidote (Epi) is also present.*

Plate 8

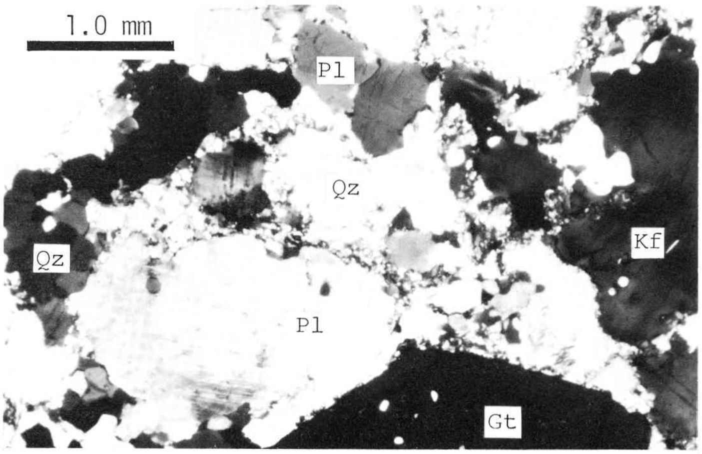


Photomicrographs of mylonitic rocks.

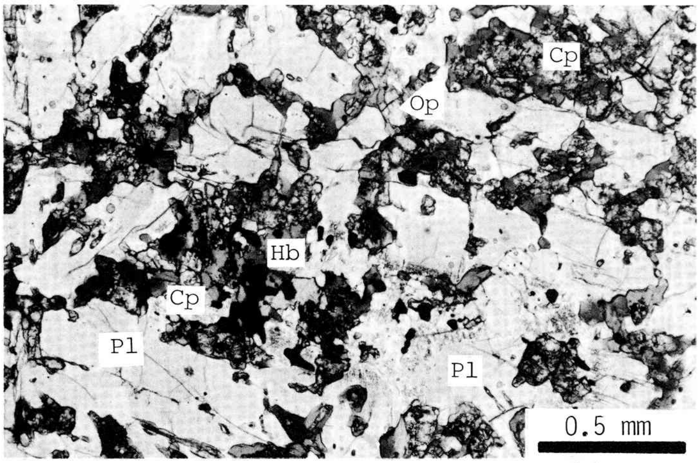
a. Mylonitized garnet-muscovite (Mus)-biotite gneiss (Sp. 81012011). Sillimanite is completely replaced by muscovite.



b. Mylonitic garnet-biotite gneiss (Sp. 81012205).

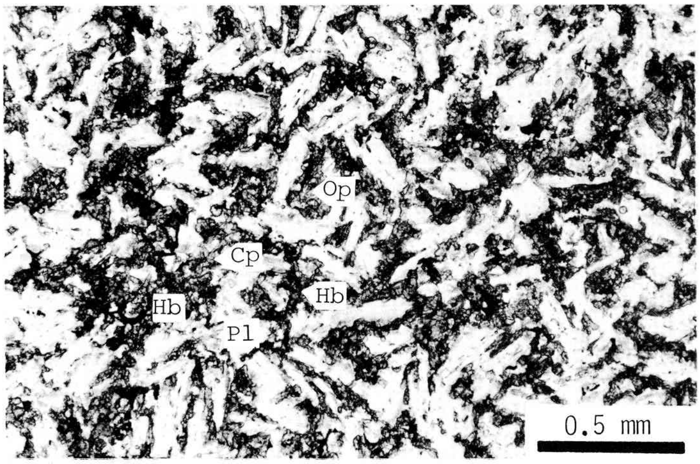


c. Mylonitic garnet-bearing white granite (Sp. 81011909b). Note a deformed twin of plagioclase. Kf: K-feldspar.

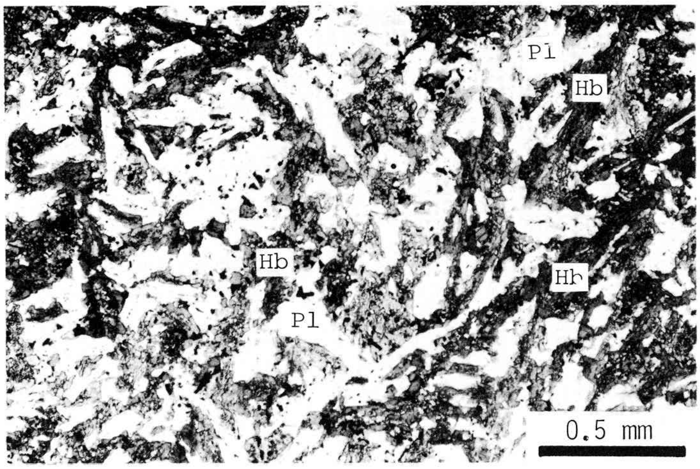


Photomicrographs of basalt-andesite (slightly metamorphosed dike rocks).

a. Relatively coarse-grained one preserving igneous textures and containing igneous pyroxenes (Sp. 81011810).



b. Very fine-grained one preserving igneous textures and containing igneous pyroxenes (Sp. 81011805).



c. Very fine-grained one showing advance state of recrystallization by the thermal metamorphism of pink gneissose granite (Sp. 81121-03).

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 14	Sinnan Rocks	March 1983
Sheet 15	Cape Ryûgû	March 1980
Sheet 16	Akebono Rock	March 1986
Sheet 17	Niban Rock	March 1983
Sheet 18	Kasumi Rock	March 1984
Sheet 19	Tenmondai Rock	March 1985
Sheet 20	Akarui Point and Naga-iwa Rock	March 1984
Sheet 21	Cape Omega	March 1979
Sheet 22	Oku-iwa Rock	March 1981
Sheet 24	Rundvågskollane and Rundvågshetta	March 1986
Sheet 26	Strandnibba	March 1985
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