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ANTARCTIC GEOLOGICAL MAP SERIES
SHEET 5 LANGHOVDE

Explanatory Text of Geological Map of Langhovde, Antarctica

Terumi ISHIKAWA, Tatsuo TATSUMI, Koshiro KIZAKI, Keizo YANAI,
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Yoshio YOSHIDA and Yukio MATSUMOTO

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National Institute of Polar Research
9-10, Kaga 1-chome, Itabashi-ku
Tokyo 173, Japan

Explanatory Text of Geological Map of Langhovde, Antarctica

Terumi ISHIKAWA[1], Tatsuo TATSUMI[2], Koshiro KIZAKI[3], Keizo YANAI[4], Masaru YOSHIDA[5], Hisao ANDO[6], Toru KIKUCHI[7], Yoshio YOSHIDA[8] and Yukio MATSUMOTO[9]

1. Introduction and General Information

A geological reconnaissance of the Langhovde area, Lützow-Holm Bay, East Antarctica, was carried out in 1959 (TATSUMI and KIKUCHI), 1960 (KIZAKI), 1968 (YANAI), 1968 (YOSHIDA) and during the period from January to November, 1972 (ISHIKAWA). The area, some 52 km^2, is bounded by latitudes 69°10′ and 69°19′S and longitudes 39°34′ and 39°52′E.

The maps available at the time of the survey were the 1 : 1,000,000 reconnaissance toposheet, 1 : 250,000 series Lützow-Holm Bay and the 1 : 25,000 series Langhovde compiled by the Geographical Survey Institute, Japan, in 1956, 1963 and 1968. Geological information was plotted in the field directly on to the 1 : 25,000 series Langhovde. Also available for field work was the aerial photograph, which was produced at the scale of approximately 1 : 25,500 by the Japanese Antarctic Research Expedition (JARE) in January, 1962.

2. Previous Geological Work

Little geological work was carried in the area before the present report. Preliminary surveys and investigations of the geology along the Lützow-Holm Bay coast including Langhovde were carried out in 1957-58 and reported by T. TATSUMI and T. KIKUCHI, members of the first wintering party of the JARE (TATSUMI and KIKUCHI, 1959a, 1959b). Then this area was surveyed by some geologists, such as KIZAKI in 1960, YANAI in 1968, YOSHIDA in 1969 and ISHIKAWA in 1972. On this area were also carried out biological, glaciological, geochemical and geomorphological surveys in co-operation with geological surveys.

[1] Department of Earth Sciences, Faculty of Science, Nagoya University, Chikusa-ku, Nagoya 464.
[2] Geological Institute, Faculty of Science, University of Tokyo, Bunkyo-ku, Tokyo 113.
[3] Institute of Earth Science, University of Ryukyus, Naha, Okinawa-ken 903.
[4] National Institute of Polar Research, Itabashi-ku, Tokyo 173.
[5] Department of Geosciences, Faculty of Science, Osaka City University, Sumiyoshi-ku, Osaka 558.
[6] Laboratory of Hydrogeology, Hiragishi 5-jo 4-chome, Sapporo-shi, Hokkaido 062.
[7] Daisy Lake Enterprise Ltd., Vancouver, Canada.
[8] Department of Geography, Faculty of Literature, Hiroshima University, Higashi-senda-machi, Hiroshima 730.
[9] General Education, Nagasaki University, Bunkyocho, Nagasaki 859.

3. Physiography

The Langhovde area along the east coast of Lützow-Holm Bay, is an ice-free area located on the Prince Harald Coast in East Antarctica and is 14 km north-south and 8 km east-west in extent. The basement rocks are covered by the Langhovde Glacier and the ice sheet on the east, and is bounded on the west by the shoreline with many indentations.

On the sea floor near the coast, FUJIWARA (1971) found a glacial trough formed by glacial erosion. The bottom of this broad glacial trough is about 400 m deep near the western coast of the Langhovde. A number of glacial troughs are found in the Langhovde area. Many of them were formed along "weak" lines of joints and faults, suggesting selective erosion by former glacier flow. Deep depressions of glacial troughs are often occupied by glacial lakes. A conspicuous glacial trough, called Naka-no-tani Valley, is located in the middle of the Langhovde and divides the area into two parts. A temporary marginal lake has been formed near the upper end of the Naka-no-tani Valley, dammed by morainic deposits at the edge of the Langhovde glacier. Fluvio-glacial deposits including much silt and clay are accumulating to build small deltas, suggesting active glacial abrasion. The direction of the Naka-no-tani Valley and Oyayubi Island corresponds to the strike of foliation of the gneisses in this area.

The slopes of the mountains in the Langhovde area have been carved into steeps-walls by glacial abrasion and plucking. They are steeper on the western side and gentler on the eastern side. It is noticed that the slopes facing upstream of ice flow are smoothly rounded by ice abrasion, whereas those on the downstream or lee side are strongly plucked. On the other hand, Mt. Heitô, a massif characterized by its extensive flat top, some square kilometers in extent, displays a quarried surface with small scale stoss-and-lee features. Moraine occurs on many of the exposures extending from the sea level to the height of several hundred meters. Raised beaches have been found in many places along the coast below 20 meters in height. A flat surface of about 10 m height found on Oyayubi Island seems to be a wavecut beach.

4. Geology of the Langhovde Area

4.1. General geology

The Lützow-Holm Bay region is considered to be one of the Antarctic platform shields. The geological map of the Lützow-Holm Bay region (TATSUMI and KIZAKI, 1969), drawn originally at a scale of 1 : 500,000, summarizes geological result of investigations by the JARE till 1969. According to the map, the rocks of the region, mainly metamorphic and plutonic, are classified on the basis of petrography and mode of occurrence as follows: (1) pyroxene gneiss, (2) pyroxene syenite, (3) marble and quartzite, (4) metabasites, (5) biotite gneiss, (6) garnet gneiss, (7) hornblende gneiss, (8) migmatite gneiss, (9) granitic gneiss, (10) biotite or microcline granite, (11) pegmatites, (12) fossil bearing beach sand and gravel, and (13) terrestrial deposits including moraines, fluvio-glacial deposits, talus and aeolian sand. Most of the metamorphic rocks are belong to the granulite facies (BANNO *et al.*, 1964a, 1964b).

Along the eastern coast of the bay, the foliation and banding generally strike N-S and dip E 30° to 60°, but local fluctuations and gently folds are found in some places. A detailed geological survey in the south of Lützow-Holm Bay was carried out by YOSHIDA and ANDO (1971). According to them, the geological structure of the Skallen area is characterized by recumbent folds. The foliation generally strikes E-W to ENE-WSW and dips S 30° to 40°. The geological structure of Botnneset is shown by foliation striking NW-SE and dipping S.

In the past, metamorphic rocks in the region have been correlated with the basement complex of East Antarctica purely on petrographical grounds, and they have been considered Precambrian in age. However, the recent dating of biotite, euxenite, K-feldspar and phlogopite by Rb-Sr, U-Pb and K-Ar methods suggest that regional metamorphism in this region occurred in late Cambrian (NICOLAYSEN *et al.*, 1961; SAITO *et al.*, 1961; MAEGOYA *et al.*, 1968; YANAI and UEDA, 1974). Radiometric age determinations made on biotite, euxenite and phlogopite show good agreement and record the ages as about 500 m.y. However, K-feldspar shows generally an older age than other minerals and gives the value between 700 and 1,100 m.y. Age determinations on the basement rocks of the Langhovde area have been carried out and are listed in Table 1.

Table 1. Radiometric ages of rock from the Langhovde.

No.	Locality	Lithology	Mineral	Method	Age (m.y.)	Ref.
JARE 57112001	69°13′S 39°38′E	Granitic pegmatite in granitic gneiss	Biotite	Rb-Sr	525±40	1
A-09		Gneissic rock	Biotite	Rb-Sr	526	2
A-1 68013113	69°13′S 39°45′E	Biotite pyroxene Amphibolite	Biotite	K-Ar	463	3

1. NICOLAYSEN *et al.*, 1961, 2. MAEGOYA *et al.*, 1968, 3. YANAI *et al.*, 1974.

4.2. Petrography of the Langhovde area

The rocks exposed in this area are classified into the following units on the basis of their modes of occurrence and their petrographic features:

(1) Metabasites.
(2) Pyroxene gneiss.
(3) Hornblende gneiss.
(4) Garnet-biotite gneiss.
(5) Porphyroblastic gneiss.
(6) Garnet gneiss.
(7) Garnet-bearing granitic gneiss.

(8) Pegmatites.
(9) Microcline granite.
(10) Terrestrial deposits (moraines, fluvio-glacial deposits and talus).
(11) Aeolian sand.
(12) Beach sand and gravel.

4.2.1. Metabasites (Bm)

Within hornblende gneiss, pyroxene gneiss, garnet gneiss and garnet-biotite gneiss there are many layers, lenses and irregular-shaped bodies of basic metamorphic rocks. They are medium- to coarse-grained and usually black in colour. In the northern part of Mt. Tyôtô and in the Yukidori and Naka-no-tani Valleys, they continue in the direction of their strike for a considerable distance. In the vicinity of the axis of fold structure, similar minor folds are observed in the metabasites. Especially the metabasites in garnet gneiss show continuity as a thin bed, often with boudinage (Plate 1-a).

Most of the basic metamorphic rocks are composed of hypersthene, diopside, hornblende, biotite and plagioclase. Plagioclase is a clear crystal accompanied by no secondary mineral, and shows distinct twin lamella, but sometimes is a non-twin crystal. Hornblende is greenish brown to pale yellow in pleochroism. Strongly pleochroic hypersthene is rimmed with biotite on rare occasions. These minerals occur as anhedral grains. Biotite occurs in a small quantity compared with the others, and shows the following occurrences:
(1) Biotite is independent of other minerals.
(2) A part of hornblende transforms into biotite.
(3) A part of pyroxene transforms into biotite.
Biotite shows pleochroism of reddish brown to golden yellow in three cases. Chemical composition of this metabasite is shown in Table 2.

4.2.2. Pyroxene gneiss (Gp)

Pyroxene gneiss occurs extensively throughout the Langhovde area, especially in Mt. Tyôtô, Naka-no-tani Valley and Yukidori Valley. The rock is medium-grained and usually dark brown and gray in colour due to the colouring of feldspar and quartz crystals. It generally shows a faint gneissose structure. The rock is rather homogeneous in texture and structure over a wide area, and is characterized by the presence of pyroxene and the absence of garnet. The rock contains a small quantity of coloured minerals and a large quantity of plagioclase. Hornblende is gathered clot-like in some parts, but generally massive in other parts (Plate 1-b).

Constituent minerals of the rock are quartz, plagioclase, hornblende, pyroxenes and biotite. Quartz and plagioclase are most common. Perthite and/or antiperthite are present in addition to plagioclase. Plagioclase in the pyroxene gneiss from Mt. Hutago is labradorite (An 52.6), twinned on the albite and pericline laws, and is of low-temperature form. Hornblende is blue tinge green hastingsite (SUWA, 1966). Pyroxenes are nearly always present, usually associated with brown to green hornblende. They are hypersthene and clinopyroxene.

Table 2. Chemical composition of rocks and minerals from Langhovde.

No.	1	2	3	4	5	6	7	8	9	10	11	12
SiO_2	64.32	38.74	37.66	50.59	39.15	56.77	49.49	40.85	36.33	54.28	72.68	46.54
TiO_2	0.83	0.07	4.86	0.16	1.88	27.40	0.25	2.49	5.22	28.82	0.42	0.87
Al_2O_3	15.56	22.09	17.09	0.50	13.57	0.01	1.62	12.69	14.46	0.01	13.46	7.91
Fe_2O_3	1.15	2.97	0.77	1.71	4.58	0.24	1.19	3.57	1.40	0.39	0.77	2.99
FeO	6.57	23.23	9.71	27.10	15.08	0.07	28.01	14.12	17.30	0.16	1.62	11.23
MnO	0.11	0.47	0.00	0.82	0.30	0.01	0.57	0.15	0.07	0.01	0.02	0.18
MgO	5.22	11.20	17.59	18.23	9.42	0.01	17.88	9.91	12.28	0.01	0.60	17.34
CaO	2.24	1.10	0.00	0.40	10.93	8.85	0.00	11.40	0.00	10.78	1.73	8.51
Na_2O	1.82	0.23	0.22	0.07	2.03	6.70	0.00	1.44	0.19	5.37	2.54	1.75
K_2O	1.64	0.11	9.30	0.00	1.29	0.29	tr	1.76	8.96	0.16	5.08	1.05
H_2O+	0.45	0.05	2.53	0.09	1.66	0.40	1.01	2.01	3.29	0.56	0.57	1.95
H_2O-	0.11	0.02	0.04	0.09	0.13	0.09	0.17	0.22	0.47	0.13	0.12	0.03
P_2O_5	0.18	—	—	0.006	—	0.02	n.d.	—	—	0.02	0.09	0.01
Cr_2O_3	0.045	0.07	0.16	—	—	—	—	—	n.d.	—	—	—
Total	100.245	100.35	99.93	99.766	100.02	100.83	100.19	100.59	99.97	100.67	99.70	100.26

No. 1. JARE57110506: Garnet gneiss from Langhovde. The rock is composed of garnet, biotite, potassium feldspar, plagioclase and quartz (BANNO *et al.*, 1964b).

2. JARE57110506: Garnet from garnet gneiss (BANNO *et al.*, 1964b).
3. JARE57110506: Biotite from garnet gneiss (BANNO *et al.*, 1964b).
4. JARE57020905: Hypersthene from basic granulite from Langhovde. The rock consists of hypersthene, salite, hornblende and plagioclase (BANNO *et al.*, 1964b).
5. JARE57020905: Hornblende from basic granulite (BANNO *et al.*, 1964b).
6. JARE57020905: Plagioclase from basic granulite occurring as blakish band in granitic gneiss from Dokkene of Langhovde. A gneissose fine- to medium-grained rock, composed of andesine, green-yellow tinge brown hastingsite, hypersthene, and reddish brown biotite, and accessory of opaque minerals, pyralspite garnet, clinopyroxene, apatite and zircon (SUWA, 1966).
7. JARE57112402: Hypersthene from pyroxene gneiss from Langhovde. The rock is composed of hypersthene, hornblende, salite, potassium feldspar and andesine, with subordinate apatite, ilmenite, pyrrhotite and pyrite (BANNO *et al.*, 1964b).
8. JARE57112402: Hornblende from pyroxene gneiss (BANNO *et al.*, 1964b).
9. JARE57112402: Biotite from pyroxene gneiss (BANNO *et al.*, 1964b).
10. JARE57021001C: Plagioclase from pyroxene gneiss from Mt. Hutago of Langhovde. A fine to medium-grained blue-greyish rock, composed of labradorite, blue tinge green hastingsite, green yellow biotite, hypersthene, and pyralspite garnet (SUWA, 1966).
11. 68020201: Biotite granite. Analyst, K. YANAI.
12. 68051904: Biotite pyroxene amphibolite. Analyst, K. YANAI.

Biotite is found in some specimens, and brown to yellow in pleochroism. Garnet occurs rarely, it is rich in Mg and Fe, and scarce in Ca ($Mg : Fe^{2+} : Mn : Ca =$ 45.6 : 43.1 : 1.0 : 10.3). Accessory minerals are zircon and apatite. Chemical composition of minerals from this pyroxene gneiss is shown in Table 2.

4.2.3. Hornblende gneiss (Gh)

This rock is distributed at Mt. Heitô and Mt. Minami-heitô. It is characterized by the presence of hornblende and the absence of garnet and pyroxene. The rock is medium- to coarse-grained. Coloured minerals are small in quantity but plagioclase and quartz are found in large quantities. The gray colour of the rock is due to the large quantity of plagioclase. Basic xenoliths, lenticular or irregular in form, are often found in the rock.

Constituent minerals are hornblende, biotite, potassium feldspar, plagioclase and quartz. Garnet is generally absent but rarely present. Potassium feldspar is mostly perthitic. Plagioclase exsoluted from potassium feldspar shows albite law twinning. Plagioclase is abundant in the rock, and often occurs as antiperthite due to exsolution. Plagioclase in immediate contact with potassium feldspar replaces the latter and forms myrmekite. Hornblende shows green to pale green pleochroism. Biotite occurs in a small quantity and shows brown to pale yellow pleochroism. Accessory minerals are zircon and apatite.

4.2.4. Garnet-biotite gneiss (Ggb)

This rock is widely distributed in the Langhovde area and is characterized by the large quantity of garnet and biotite and the absence of hornblende. The rock is reddish brown in colour because of the abundance of garnet. Potassium feldspar often occurs as phenocrystic crystal, giving a porphyroblastic appearance to the rock in places. Foliation of this rock is due to the parallel arrangement of garnet and biotite. Alternation of a leucocratic layer consisting of biotite and a melanocratic layer consisting of quartz and feldspar accounts for the distinct foliation. As the layers vary in resistance to erosion, the effect of differential erosion can be seen on layered bedrocks in the northern part of the Langhovde area.

Constituent minerals of the garnet-biotite gneiss are biotite, garnet, quartz, potassium feldspar and plagioclase. They are medium-grained, partly fine-grained. Plagioclase shows albite law twinning, and is antiperthitic. Potassium feldspar is mostly perthitic, and myrmekite is not uncommon. Feldspar is sericitized for the most part. Biotite shows reddish brown to pale yellow pleochroism. It includes zircon, and forms haloes around it. Garnet occurs abundantly and includes zircon. Accessories are sphene, zircon, and apatite which is rare. Secondary mineral is sericite.

4.2.5. Garnet gneiss (Gg)

The rocks of this group occur in the southern part of the Langhovde area, and form thick beds in the Yukidori Valley. Garnet gneiss alternates with garnet-biotite gneiss. The rock is generally leucocratic and massive, include spot-like garnet, and shows weak foliation. It is useful as a key bed because of its continuity. The rock in the southern part of the Langhovde contains lenticular bodies and boudinage of metabasite.

The rock is composed of quartz, potassium feldspar, plagioclase, garnet and biotite. The quartz content ranges from 30 to 40 percent. Potassium feldspar is generally more abundant than plagioclase, and is perthitic. Plagioclase is generally oligoclase and, less commonly, andesine. Grains are often antiperthitic with inclusions of the film and patch type potassium feldspar. Garnet of pale red colour is scattered. Biotite occurs more rarely in the rock and shows brown to pale yellow pleochroism. Accessories are zircon and apatite, both being minor constituents. Chemical composition of the garnet gneiss is shown in Table 2.

4.2.6. Porphyroblastic gneiss (Gpo)

This rock occurs mainly in Hamnenabben, and is characterized by porphyritic potassium feldspar. The rock is generally bedded with garnet-biotite gneiss. Potassium feldspar is elongated, averaging about 3 cm in size. The matrix is composed of minute crystals of garnet, biotite and quartz. Biotite shows linear arrangement but garnet is scattered in the groundmass (Plate 1-c).

The rock consists of potassium feldspar, quartz, plagioclase, biotite and garnet. Potassiun feldspar shows microcline texture and is perthite. Myrmekite is commonly observed where plagioclase contacts potassium feldspar. Biotite occurs as minute crystals scattered, and is brown to colourless in pleochroism. Garnet is about 1 mm in size. Accessories are zircon, apatite and sphene. Secondary minerals are sericite and chlorite.

4.2.7. Garnet-bearing granitic gneiss (Ggg)

This rock is distributed in the south of the Naka-no-tani Valley and in the west of Mt. Tyôtô. It is characterized by pink-coloured potassium feldspar and garnet in minor amounts. The rock is bedded, and shows weak foliation which is due to linear arrangement of minute crystals of biotite.

The rock consists of potassium feldspar, quartz, biotite and garnet in minor amounts scattered throughout. Hornblende is absent. Potassium feldspar is microcline, showing a distinct microcline texture. Most of microcline is perthitic. Plagioclase forms myrmekite where it contacts potassium feldspar. Biotite shows brown to pale yellow pleochroism, and mostly chloritized. Accessory minerals are zircon and apatite.

4.2.8. Pegmatite (Pg)

Pegmatite occurs as lenticular bodies, clear-cut veins and dikes in the vicinity of Mt. Tyôtô. Straight dikes of pegmatite are about 30 cm wide and 1.5 km long, and trend N-S across the geological structure. The rock stands out in relief 40 cm high from the country rock all around. Irregular-shaped pegmatite occurs in garnet-biotite gneiss. It is observed that the garnet content increases in the country rock near the pegmatite.

4.2.9. Microcline granite (Grm)

This granitic rock is widely distributed in the vicinity of Hukuro Cove. The rock always has pink-coloured potassium feldspar as the most characteristic constituent. It is fine- to rather coarse-grained and composed mainly of biotite, plagioclase, perthite, quartz and garnet, with or without a little antiperthite. A gneissose structure is usually weak and is developed parallel to the contact plane. The granite includes in some places many irregular-shaped blocks of basic metamorphic rocks of varying size.

Microcline granite is composed of potassium feldspar, plagioclase, quartz, biotite and garnet. Most of potassium feldspar show perthitic texture, and received sericitization. Plagioclase is rare, often forms myrmekite where it contacts potassium feldspar, and is also sericitized in part. Biotite occurs in a small amount, chloritized, and is brown to pale yellow green in pleochroism. Garnet is rare. Accessories are apatite and zircon. Sericite and chlorite are secondary minerals.

4.2.10. Glacial deposits

Glacial deposits are distributed throughout the ice-free area and around the marginal part of the ice sheet. A large quantity of glacial deposits accumulated around the continental glacier and formed moraine. They are poorly sorted mixture of gravel, sand and silt. In the Naka-no-tani Valley the glacial deposits accumulate at the terminal of the continental glacier and form a dammed lake, gathering melting water from the glacier. Most of glacier boulders are angular, but some boulders have facets that join at the smoothed or rounded edges, some of the facets are striated. Facets are produced by grinding action. As pebbles turn round in their matrix of ice, new facets are formed. The sand and silt particles in till generally consist of rock powder. Most of the boulders and pebbles in till are the same kind of rock as the bedrock on which the till was deposited, but some are of other kinds, such as garnet-tourmaline hornfels, tourmaline-biotite hornfels, quartzose sandstone and basalt, transported from far distant places. The hornfels and sandstone, and perhaps basalt also, were probably derived from the Beacon formation which is supposed to underlie the ice sheet in the inland area.

4.2.11. Beach sand and gravel

Near the present shoreline and in the lowland around Ko-minato Inlet, Yatsude Valley, Yukidori Valley and Lake Oyayubi, some fossil-bearing sand and gravel deposits are found. These deposits are composed mainly of fragments of rocks exposed in the region, although there are also some erratic boulders. The sorting of the deposits is notably poor. The distribution of the deposits is restricted

Table 3. ^{14}C ages of fossils from raised beach deposits.

Locality	Elevation above sea level (m)	Sample	Age B.P. (years before 1950)	Ref.
Ko-minato Inlet				
Langhovde 03	5-6	*Laternula elliptica*	23,830±910	1
Langhovde 04	1.5	*Adamussium colbecki*	4,290± 90	
Langhovde 07	6	*Adamussium colbecki*	10,250±210	
Langhovde 08	6	*Laternula elliptica*	over 33,400	
Oyayubi Island	2		2,000±220	1
Simo-kama Cove	1.5	*Laternula elliptica*	3,840± 90	2

1. MORIWAKI, 1974, 2. ISHIKAWA, 1974.

to the low areas, their highest locality being 20 m above sea level in the central part of the Langhovde area (TATSUMI *et al.*, 1963). The deposits at about 1.5–2 to 6 m above sea level contain such fossils as *Adamussium colbecki* and *Laternula elliptica* (MORIWAKI, 1974; ISHIKAWA, 1975). Main localities of the fossils are Ko-minato Inlet, Lake Oyayubi and Shimo-kama Cove (Plate 2–a, b). Age determinations by the ^{14}C method were done, as shown in Table 3.

5. Geological Structure of the Langhovde Area

This area is composed mainly of pyroxene gneiss, garnet-biotite gneiss, garnet-bearing granitic gneiss and garnet gneiss, accompanied by small amounts of metabasite, porphyroblastic gneiss, microcline granite and pegmatite. The gneissose structure and the boundaries of dark and light bands are conspicuous on these rocks. The geological structure is clearly indicated by the gneissose structure.

In the northern part of the Langhovde area, the most characteristic features are an anticline, a syncline and isoclinal folds. The anticline is located in the east of Ko-minato Inlet and has an east-west axis plunging to the east. The northern wing is steep, but the southern wing is gentle. The syncline is located at Mt. Tyôtô, its axis trending NW-SE to N-S, and shows isoclinal folds in the south of Mt. Tyôtô.

The most characteristic feature of the southern part of the Langhovde area is a monoclinal structure striking N10°E and dipping to the east. But the gneissose structure turns to N60°E in the east of Naka-no-tani Valley, in the east of Yukidori Valley and Mt. Heitô.

The Hamna icefall, 1 km in width, separates Hamnenabben from the southern Langhovde. As the rock facies of the two sides does not show geological continuity, a fault may exist under the Hamna icefall.

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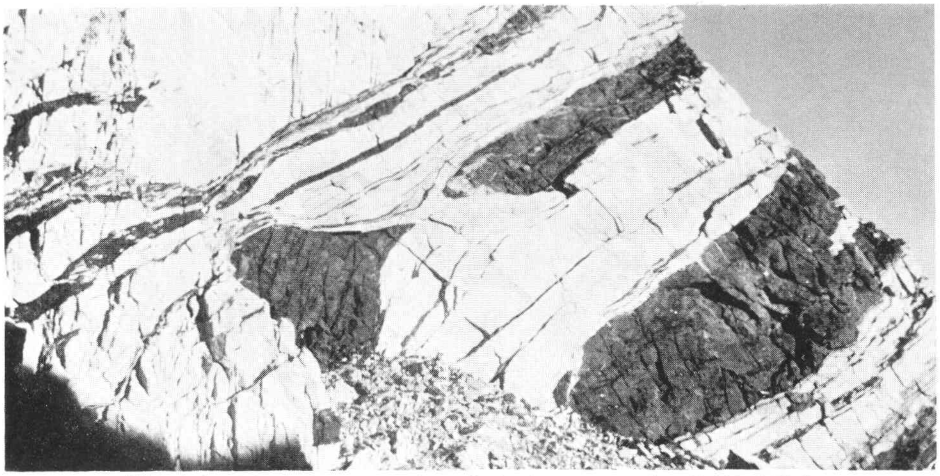
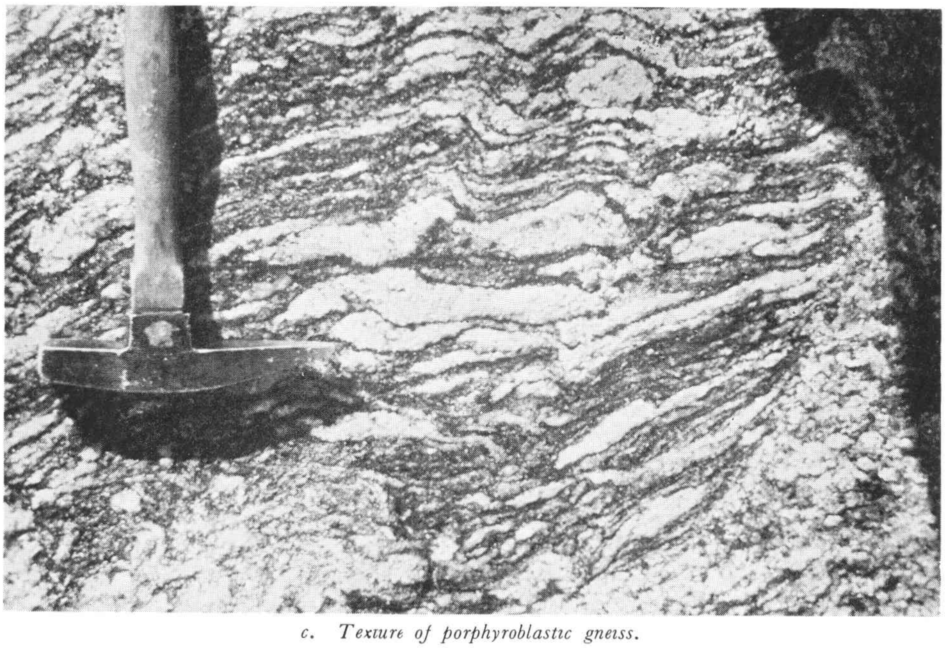


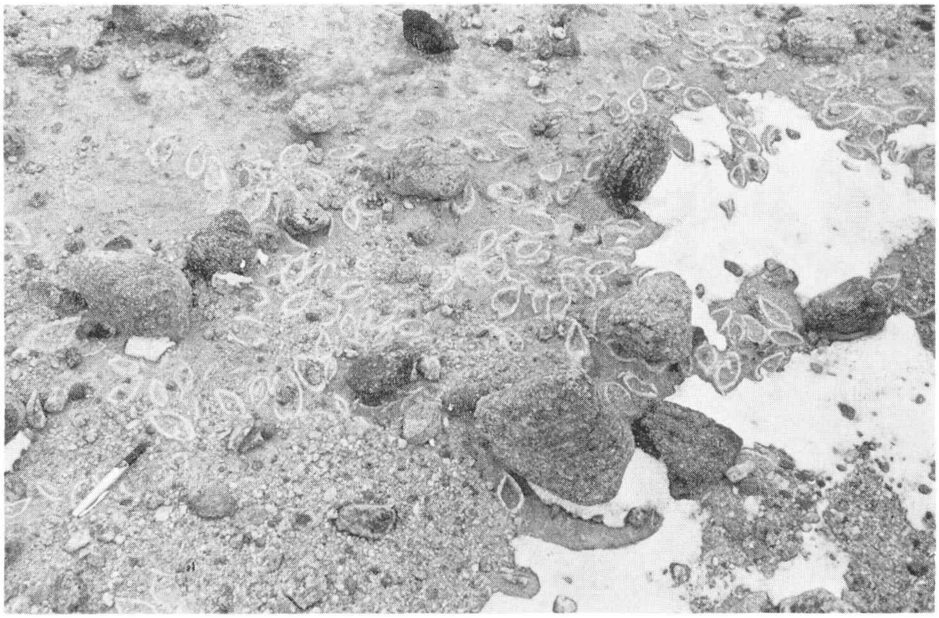
a Thin beds of lenticular seams of metabasite in garnet gneiss, Yukidori Valley.

b. Texture of pyroxene gneiss.



c. Texture of porphyroblastic gneiss.

Plate 2



a. Occurrence of fossils at Simo-kama Cove.

b. Raised beach near Lake Nurume.

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 9	Skallen	March 1976