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Explanatory Text of Geological Map of Skarvsnes, Antarctica

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1. Introduction and General Information

The Skarvsnes region lies on the east coast of Lützow-Holm Bay, East Antarctica. The Skarvsnes region includes the Breidvågnipa and Byvågåsane area, and is located 69°19′S–69°32′S latitude and 39°27′E–39°53′E longitude. The region was mapped for the first time by HANSEN (1946) based on the oblique aerial photographs taken by CHRISTENSEN (in his 1936–1937 expedition) who is the first observer of the present region. The ground survey of the region was conducted by a Japanese geologist in 1957 and since then some members of the Japanese Antarctic Research Expeditions visited the region with various scientific objects.

The geology of the region was surveyed by T. TATSUMI and T. KIKUCHI in 1957–1958 and K. KIZAKI in 1962–1964, and was outlined by TATSUMI and KIKUCHI (1959a, 1959b) and the brief petrography was presented by them (TATSUMI *et al.*, 1964). From 1967 to 1976, some scientists surveyed this region: geomorphological and/or limnological surveys by T. TORII, R. HIGANO, Y. YOSHIDA, and K. OMOTO in 1967–1969, and J. HIRABAYASHI, K. OMOTO, K. MORIWAKI and H. SANO in 1973–1975, and M. HAYASHI and T. ABIKO in 1974–1976, and geological survey by S. KOJIMA and K. SHIRAISHI in 1972–1974, T. ISHIKAWA in 1971–1973, and K. YANAI in 1973–1975, and Y. MATSUMOTO in 1974–1976. The superimposed folding of Lützow-Holm Bay and geologic outline of this region and surrounding areas have been reported by T. ISHIKAWA (1974, 1976).

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The maps available at the time of the geological survey were the 1 : 1,000,000 reconnaissance toposheet, the 1:250,000 series Lützow-Holm Bay and the 1:25,000 series Skarvsnes compiled by the Geographical Survey Institute, Japan, in 1956, 1963, 1972 and 1974. 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 in January, 1962.

The Skarvsnes is situated about 40 km south of Syowa Station, East Ongul Island, and is the largest ice-free area on the east coast of Lützow-Holm Bay. A gneissose rock is well exposed there and its vicinity. This area is bounded by continental ice on the east; the highest part is 361.8 m above the sea level. The Byvågåsane area is located in the northeast of the Skarvsnes area; the highest part is 243.5 m ; gneissose rocks are also well exposed. The Breidvågnipa area is located in the north of the Byvågåsane area, and in the south of the Langhovde area; the highest part is 312 m, gneissose rocks are also well exposed. This area had not been surveyed until ISHIKAWA carried out a field investigation in 1972 (ISHIKAWA, 1976), followed by the geological survey by MATSUMOTO in 1975, although MAEGOYA, a member of the 7th Japanese Antarctic Research Expedition, collected rock samples from there for the purpose of radiometric dating. The geological map of the Skarvsnes region was compiled by Y. MATSUMOTO, supplemented by geologic data mainly after K. KIZAKI, S. KOJIMA, T. ISHIKAWA, K. YANAI and discussions on geologic structures with K. YANAI and M. YOSHIDA.

2. Geology of the Skarvsnes Region

2.1. General geology

Geology of the Skarvsnes region is characterized by porphyroblastic gneiss, garnet-biotite gneiss, marble, hornblende gneiss, pyroxene gneiss, and by subordinate amounts of garnet-bearing granitic gneiss, garnet gneiss, and metabasites. Age determination on the basement rocks of the Skarvsnes region was carried

Table 1. Some radiometric ages of rocks from the east of Lützow-Holm Bay, Antarctica.

Sample No.	Locality	Rock	Minerals	Method	Age (m.y.)	Ref.
JARE 5711070	69°26′S, 39°34′E	Granitic pegmatite in dioritic gneiss*	Biotite	Rb-Sr	510+30	1
AS	69°29′S, 39°34′E	Garnet biotite gneiss*	Whole rock	K-Ar	363	2
A-04	69°27′S, 39°37′E	Gneissose rock*	K-feldspar	Rb-Sr	745	3
A-24	69°22′S, 39°46′E	Gneissose rock**	K-feldspar	Rb-Sr	1,116	3

* Collected from the Skarvsnes.

** Collected from the Breidvågnipa.

(1) NICOLAYSEN *et al.*, 1961.

(2) KANEOKA *et al.*, 1968.

(3) MAEGOYA *et al.*, 1968.

out by NICOLAYSEN *et al.* (1961), KANEOKA *et al.* (1968) and MAEGOYA *et al.* (1968), with the results as listed in Table 1. Rb-Sr age determinations on biotite and potassium feldspar of gneissose rock yielded two different age groups of about 500 m. y. and 1,100 m. y. (Table 1).

2.2. Petrography of the Skarvsnes region

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 (Bm).
(2) Pyroxene gneiss (Gp).
(3) Hornblende gneiss (Gh).
(4) Marble (Mb).
(5) Garnet-biotite gneiss (Ggb).
(6) Porphyroblastic gneiss (Gpo).
(7) Garnet gneiss (Gg).
(8) Migmatitic gneiss (Gm).
(9) Garnet-bearing granitic gneiss (Ggg).
(10) Gneissose microcline granite (Grm).
(11) Pegmatite (Pg).
(12) Terrestrial deposits (moraines, fluvio-glacial deposits and talus) (At).
(13) Beach sand and gravel (Ags).

2.2.1. 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 color. In the northern part of Mt. Suribati, in the northern part of Mt. Hiroe, and in the southern and central parts of the Byvågåsane area, they continue in the strike direction 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. Metabasites occur at Osen as many ovoid-shaped bodies within garnet-biotite gneiss.

Most of the basic metamorphic rocks are composed of hypersthene, diopside, hornblende, biotite and plagioclase. Plagioclase occurs as clear crystals accompanied by no secondary mineral, and shows distinct twin lamella, but sometimes crystals are non-twinning. 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 is smaller in quantity than the others, and shows the following occurrences:

(1) Independent of other minerals.
(2) Transformed from part of hornblende.
(3) Transformed from part of pyroxene.

Biotite shows pleochroism of reddish brown to golden yellow in three cases.

2.2.2. Pyroxene gneiss (Gp)

Pyroxene gneiss is the most widespread especially in the medial part of this region. Typically, it is a uniformly fine- to medium-grained granulitic-textured rock with the dark coloration in a hand specimen. It contains hypersthene, quartz, potassium feldspar, plagioclase, hornblende and biotite, and rarely garnet. A weak foliation is developed in the rock. The foliation is made of the parallel orientation of mafic minerals and the elongated dark inclusions.

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 is labradorite, twinned on the albite and pericline laws, and is of low-temperature form. Hornblende is bluish green hastingsite. Pyroxenes are nearly always present, usually associated with brown to green hornblende. They are hypersthene and clinopyroxene. Biotite is found in some specimens, and brown to yellow in pleochroism. Accessory minerals are zircon and apatite.

2.2.3. Hornblende gneiss (Gh)

This rock is distributed in the northern part of Mt. Suribati and the southern part of the Byvågåsane. It is characterized by the presence of hornblende and the absence of garnet and pyroxene. The rock is medium- to coarse-grained. Colored minerals are small in quantity but plagioclase and quartz are found in large quantities. The gray color 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.

2.2.4. Marble (Mb)

This rock is distributed in the northern part of the Breidvågnipa. In this area three or four layers, one meter to several tens of meters thick, occur. The layers are generally associated with the skarn and allied rocks. Intrusive appearance of marble into other plutonic and metamorphic rocks was observed in many places. Migmatitic appearance with xenolithic blocks of surrounding rocks, the blocks being margined with a reaction rim, is not unusual. The marble is classified into pure marble and marble with scattered colored minerals, both being variable in mineral assemblages.

The marble is very leucocratic, very white, coarse- to very coarse-grained, and equigranular, being composed mostly of equant calcite. Very small amounts of small-grained phlogopite, spinel, and/or graphite occur as rare cases.

2.2.5. Garnet-biotite gneiss (Ggb)

This rock is widely distributed in the Skarvsnes and is characterized by the large quantity of garnet and biotite and the absence of hornblende. The rock is reddish brown in color because of the abundance of garnet. Potassium feldspar often occurs as phenocrystic crystals, 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 leucocratic layers consisting of biotite and melanocratic layers consisting of quartz and feldspar accounts for the distinct foliation. The rock possesses a well-defined large-scale banding due to concentration of biotite and garnet. Becouse the layers vary in resistance to erosion.

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 a halo around it. Garnet occurs abundantly and includes zircon. Accessories are sphene, zircon, and apatite which is rare. Secondary mineral is sericite.

2.2.6. Porphyroblastic gneiss (Gpo)

Porphyroblastic gneiss occurs mainly in the vicinity of Maruyama Peak. The rock is characterized by relatively large crystals of potassium feldspar, approximately 4 cm in diameter. It is fine-grained and has a distinct gneissose structure displayed by concentration of biotite flakes. Major constituent minerals are quartz, potassium feldspar, plagioclase, biotite and garnet. The rock is generally bedded with garnet-biotite gneiss. These two rocks are very similar in appearance, and probably closely related in their genetical process.

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

2.2.7. Garnet gneiss (Gg)

Garnet gneiss occurs at Knappen and in the eastern part of the Skarvsnes, and in the central part of the Byvågåsane. Garnet gneiss alternates with garnet-biotite gneiss. The rock is generally leucocratic and massive, includes spot-like garnet, and shows weak foliation. It is useful as a key bed because of its continuity. A gneissose structure is not distinct.

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. The grains are often antiperthitic with inclusions of the film and patch type potassium feldspar. Garnet of pale red color 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.

2.2.8. Migmatitic gneiss (Gm)

This rock is distributed in the northwestern part of the Breidvågnipa. Migmatitic gneiss is generally medium-grained and composed mainly of biotite, plagioclase, perthite, quartz and garnet, with or without a little antiperthite. A gneissose structure is usually distinct and is developed parallel to the contact plane, but in some locality the rocks are quite massive.

Migmatitic gneiss is composed of potassium feldspar, plagioclase, quartz, biotite and garnet. Hornblende is rare. Potassium feldspar is microcline, showing a distinct microcline texture. Most of microcline is perthitic. Plagioclase forms myrmekite where it contacts potassium feldspar. Biotite occurs in a small amount, chloritized, and is brown to pale yellow green in pleochroism. Garnet is rare. Accessory minerals are zircon and apatite.

2.2.9. Garnet-bearing granitic gneiss (Ggg)

This rock is distributed in the southern part of Skarvsnes and Breidvågnipa. Garnet-bearing granitic gneiss is generally medium-grained, roughly equigranular, and consists essentially of pink or white feldspar, quartz and biotite, with garnet in minor amounts. The rock is bedded, and shows weak foliation which is due to linear arrangement of minute crystals of biotite. A gneissose structure is usually distinct but in some locality the rocks are quite massive. The rock occurs as a thin layer and is employed as a key bed in the vicinity of the Torinosu Cove and Mt. Tenpyô.

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.

2.2.10. Gneissose microcline granite (Grm)

This gneissose microcline granite is distributed in the northeastern part of Breidvågnipa. The rock always has pink-colored 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.

Gneissose microcline granite is composed of potassium feldspar, plagioclase, quartz, biotite and garnet. Most of potassium feldspar show perthitic texture, and suffered 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 the secondary minerals.

2.2.11. Pegmatite (Pg)

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

2.2.12. Terrestrial deposits (At)

Terrestrial deposits are distributed throughout the ice-free area and along the margin 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. Glacial deposits is distributed in the eastern part of Mt. Tenpyô, in the southern part of Knappen of the Skarvsnes, in the eastern part of Tankobu Peak of the Byvågåsane, and in the eastern part of the Breidvågnipa. 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 of pebbles which turn round in their matrix of ice. The sand and silt particles in till generally consist of rock powder. Most of the boulders and pebbles in till are of the same rock type as the bedrock on which the till was deposited, but some are of different 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.

2.2.13. Beach sand and gravel (Ags)

Near the present shoreline and in the lowlands around Torinosu Cove, Kizahasi Beach, Lake Suribati and Lake Hunazoko, 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 to the low areas, their highest locality being 20 m above sea level in the vicinity of Lake Suribati. 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, 1974). Main localities of the fossils are Lake Suribati and Torinosu Cove.

3. Geologic Structure

Many types of folds, fractures, and a thrust were found in the Skarvsnes region. General geologic structures and their succession and tectonic interpretation were given by ISHIKAWA (1976).

A thrust is observed in the northeast part of Torinosu Cove, and this thrust plane strikes N50°E, and dips 60° to the east. This thrust trace passes through the east of Torinosu Cove, the offing of Kizahasi Beach and the north of Lake Hunazoko, and show a convex form to the east. This thrust is designated as "Hunazoko Thrust". This thrust might have occurred in relation with the F_1 Osöya antiform.

The principal geologic structure of this region is intense polyclinal folding F_1 trending north with an almost horizontal enveloping surface. Some other open and gentle folds were found superposing on the polyclinal folds. All the folds in the present region are classed as N-S trending polyclinal fold of isoclinal, mushroom, and asymmetric forms with wavelength over few kilometers (F_1), E-W trending open to close fold with wavelength over some kilometers (F_2), and again N-S trending gentle fold with wavelength over ten or more kilometers (F_3). Diagonal set of fractures took place after these foldings. F_1 folds are the Osöya antiform, Sirasusoyama synform, Maruyama antiform, and Hiroe synform, F_2 folds are the Kizahasi antiform and other antiforms with the folding axis of E-W trend, and F_3 fold is the Osen synform.

3.1. F_1 folds

The Osöya antiform is found from the closed distribution of the garnet biotite gneiss widely occurring near Osöya. The crest of this antiform lies at the NE of the Hunazoko thrust, running parallel to it, in south of Osöya and north to NW in north of Osöya. This antiform is an isoclinal type with an axial plane moderately dipping east to northeast, the axis plunging south to southwest.

Sirasusoyama synform is found east of Knappen, through Mt. Sirasuso, to the east of Trillingöyane. This synform is an asymmetric close fold with a near vertical axial plane. The profile of this fold appears to change from close to gentle toward south, *i.e.* upper horizon, indicating a disharmonic nature of this fold. This antiformal axis gently and northerly plunging to the north of the Kizahasi antiform, and southerly plunging to the south of the Kizahasi antiform.

Maruyama antiform is estimated from the distribution of metamorphic rocks near Maruyama Peak. Axial trace of the Maruyama antiform passes through the Maruyama Peak, and show a semicircle convex to the west. Porphyroblastic gneiss is distributed parallel with the axial trace. This antiform is a tight or mushroom fold with near vertical axial plane trending north.

The Hiroe synform is distinctly shown on the geological map in Breidvågnipa, where zonally arranged pyroxene gneiss and garnet-biotite gneiss whose a horseshoe shaped distribution convex to the north. Axial trace of the Hiroe synform passes through the central part of this horseshoe shape. This synform is asymmetric close fold with vertical axial plane, its axis gently plunging south.

Isoclinal minorfolds with a N-S trend developed near Knappen are considered to belong to the F_1 folds.

3.2. F_2 folds

The folding axes of the F_1 folds above mentioned are curved in various styles. This is caused by easterly trending F_2 folds.

Gneisses occurring around Maruyama Peak show a semicircle distribution convex to the west, and those of the Kizahasi Beach and Osöya convex to the east. A continuing line of the axes of these semicircles is the axial trace of the Kizahasi antiform, its axis plunging west in the eastern part and plunging east in the western part. The axial trace of the Kizahasi antiform passes through the Kizahasi Beach, Osöya, Osen, and the north of Maruyama Peak, thus curved convex to the north.

In Breidvågnipa and the northern and southern part of Byvågåsane, E–W trending antiforms or synforms of F_2 stage are found in the geological map. These folds have steep axial planes. The wavelength of F_2 major folds is some kilometers but that of the minor folds is several hundreds of meters.

3.3. F_3 folds

Some of the axes of F_2 folds appear to be gently bent north or south. The change in the plunge and trend of the F_2 folds indicate superposition of F_3 folds.

Osen synform runs north-south near Osen, central part of Skarvsnes. The change in the trend and plunge of the Kizahasi antiform distinctly displays the effect of this Osen fold. The axial plane of this fold appears vertical and planer trending north, although the plunge of the axis is uncertain.

3.4. Diagonal set of fractures

Diagonal sets of fractures trending N65°W and N60°E are well developed throughout the region. The fractures are easily traced as linearment on aerial photographs. These fractures are considered to be conjugate sets of shear fractures caused by E–W compressional stress field (ISHIKAWA, 1976).

ISHIKAWA (1976) summarized the tectonic succession wide area around Syowa Station including Skarvsnes region somewhat analogous with the result of present text as showing the decrease in plasticity of the gneissose rocks from older to younger, the decrease in plasticity being conformable to the decrease in metamorphic grade as from the granulite facies to the amphibolite facies. He insisted the third stage fold trending north (not strict but generaly reparable to the F_3 fold the present text) to be accompanied with the amphibolite facies and to be a representative of the Ross orogenesis in the East Antarctic platform and fractures to show the upheaval of the East Antarctic region.

In considering further to the nature of F_1 folds, the F_1 folds are characterized by their axial planes dipping variously. The crest lines of the folds with axial planes dipping gently are distinctly curved showing semicirclic form, while the axial traces of the folds with steep or vertical axial planes are almost straight in a N–S trend, thus indicating the initial trend to be north, and the style of the initial folding to be polyclinal. These features indicate flow folding under which the rocks behaved plastically.

YOSHIDA *et al.* (1976) and YOSHIDA (1977) pointed out the nappe structure associated with the isoclinal folds in the Skallen region located less than 20 km to the south of the Skarvsnes region. It is probable that a nappe is also the fundamental structure of this region, the axis of which may lies several kilometers to the west of Nökkelöya (island), the root, to the east of Skarvsnes, and the back rimb, over several hundreds of meters above the present erosional surface. The horizontal nature of the probable enveloping surface of the F_1 folds, the easterly dipping thrust accompanied with the anticlinal structure (Osöya antiform) with axial plane dipping east may also be reflections of the nappe structure.

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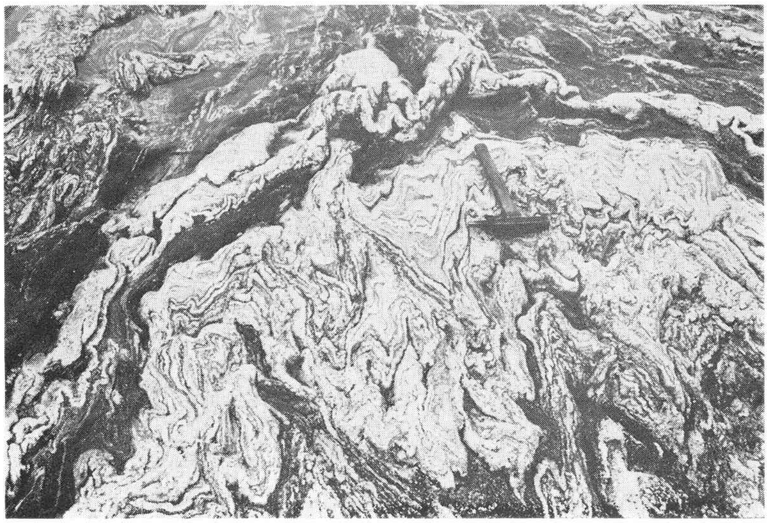
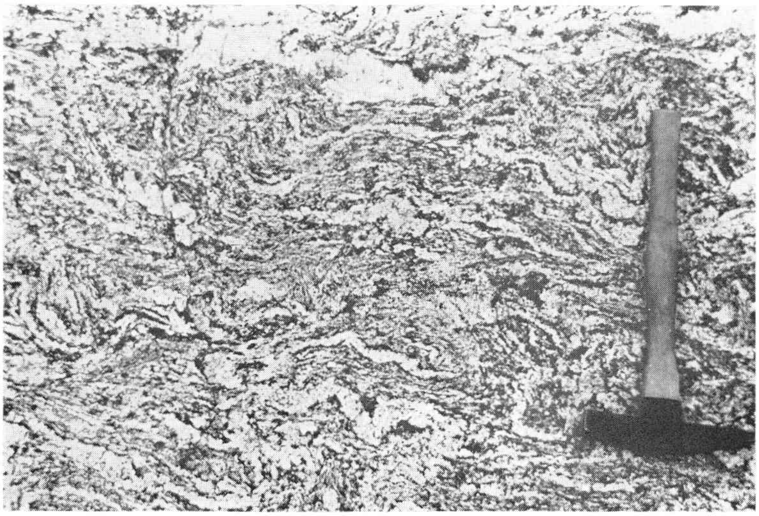
a. Porphyroblastic gneiss in the Skarvsnes region.

b. Garnet-biotite gneiss in Byvägåsane of the Skarvsnes region.



c. Garnet-biotite gneiss showing disharmonic fold in the Skarvsnes region.

Plate 2



a. *Garnet-biotite gneiss showing flow fold in the Breidvågnipa. The gneissose structure is displayed by alignment of garnet and biotite.*

b. *Aerial photograph, north-eastern part of the Skarvsnes JARE Antarctic air photo, 12AV-1, No. 139.*

Antarctic Geological Map Series

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