Preliminary Report on the Morphology of the Inland Ice Sheet of Mizuho Plateau, East Antarctica

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I. INTRODUCTION

Mizuho Plateau mentioned here is a part of the inland area to the south of Showa Base in the Antarctic, which was formally called Eastern Queen Maud Land (photo. 1). Here JARE (Japanese Antarctic Research Expedition) has been

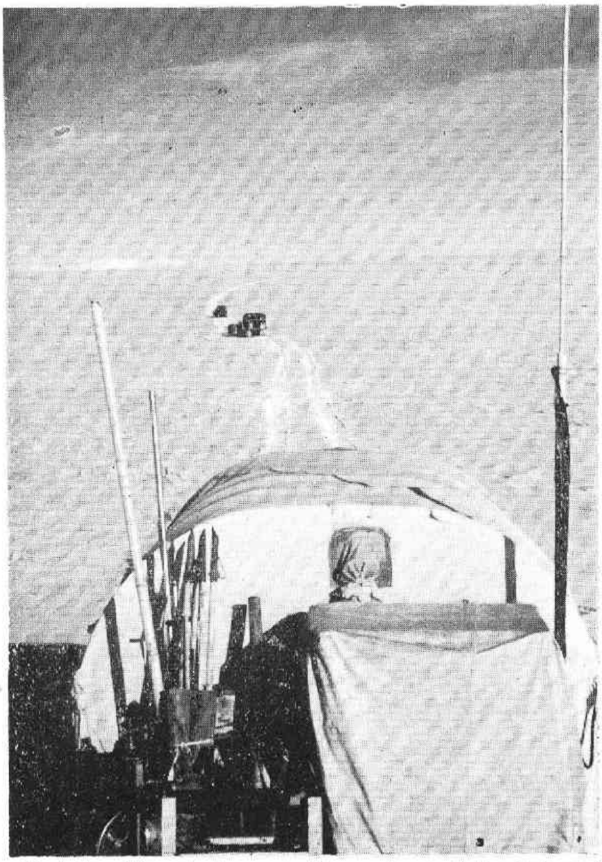

Photo. 1. Broad rolling feature on the surface of the inland ice sheet.

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carrying on an expedition since 1957. The Japanese Expedition not only made the survey of the area around Showa Base, but also it sent a survey trip to Mizuho Plateau every year. From the results, geographical information has been collected concerning an area which was absolutely unknown.

In October to December 1961, the Wintering Party of Fifth JARE dispatched an expedition party which traversed the Yamato (Queen Fabiola) Mountains and went up to 75° South latitude. On the survey trip, the traverse party made several observations, for example measurements of the thickness of the ice sheets by means of seismic soundings and gravity measurements, and meteorological observations. On the return trip, geomorphic surveys were chiefly carried out at the Yamato Mountains. From the latter part of March till the end of April, the Party built a depot for the spring survey trip in the head area of Shirase Glacier (Oku-Shirase-daira)[1]. The data collected from both the spring and autumn survey trips are under compilation by the members of each section, so in this paper the writer gives a preliminary report on the morphology of the inland ice sheet based on his data from those trips. Report on the topography of Yamato Mts. has already been published along with the report from the Fourth Expedition[2].

II. THE INLAND ICE SHEET

The inland ice sheet of Mizuho Plateau has two distinctive surface features, the inland plateau and the marginal slope, with boundaries near the Yamato Mountains. The marginal slope on the edge of the inland ice sheet is rather steep in gradient, making a broad undulated surface feature. On the other hand, such a feature is not observed in the inland plateau south of Yamato Mountains, where the surface feature is extremely smooth. Therefore it is believed that the latter is a part of the main plateau of the East Antarctica. Fig. 2 shows the profile of the inland ice sheet surveyed along the spring trip route. Two barometric altimeters were used during the trip to measure the altitude of the inland ice sheet. Among the height values in Fig. 2, errors owing to temperature changes were corrected but barometric corrections were not made. Since all sledges of the trip party were

Fig. 1. Preliminary general map of Mizuho Plateau, East Antarctica.
(The accuracy of the map varies greatly in different parts of the map. Best known is the coast area and a 40 km wide belt along the trip route.)
1. Massifs and nunataks 2. Glacier and ice stream 3. Trough on the ice sheet surface 4. Crevasse zone 5. Transverse step in the inland plateau 6. Direction of sasturgi distinguished a snow drift 7. Direction of sasturgi formed mainly by wind erosion 8. Spring trip route and camp number 9. Form lines at approximately 200 m intervals

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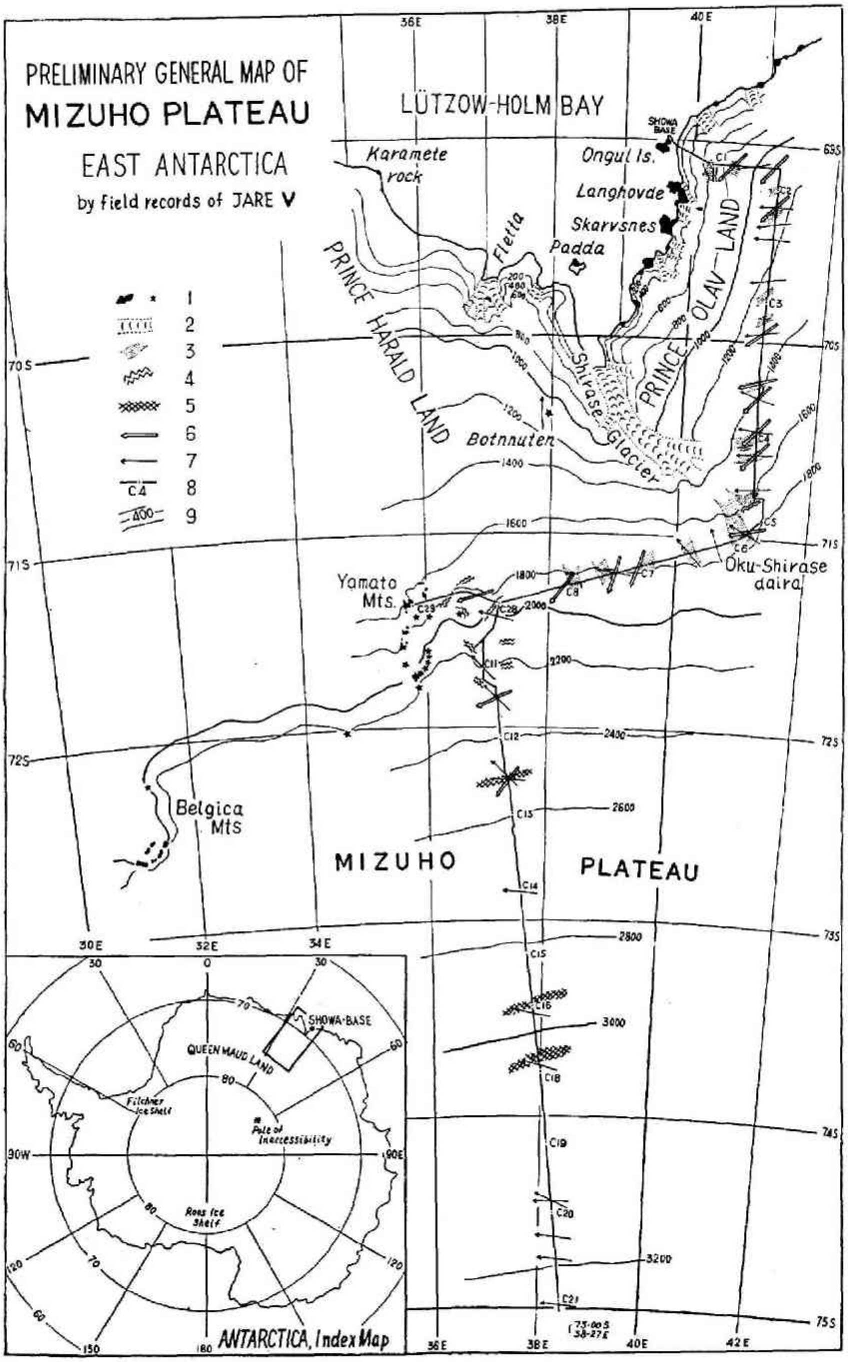
1) Thus named officially.

2) Yoshida, Y. and Fujiwara, K. (1963): Geomorphology of the Yamato Mts., Antarctic Record, No. 18, pp. 1–26.


PRELIMINARY GENERAL MAP OF
MIZUHO PLATEAU
EAST ANTARCTICA
by field records of JARE V
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C4
9
400
36E
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40E
LÜTZOW-HOLM BAY
SHOWA BASE
Karamete rock
Ongul Is.
Langhovde
Skarvsnes
Padda
Fletta
PRINCE HARALD LAND
PRINCE OLAV LAND
Shirase Glacier
Botnnuten
Oku-Shirase daira
Yamato Mts.
Belgica Mts
MIZUHO PLATEAU
69S
70S
71S
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ANTARCTICA, Index Map
QUEEN MAUD LAND
SHOWA-BASE
Filchner Ice Shelf
Pole of Inaccessibility
Ross Ice Shelf
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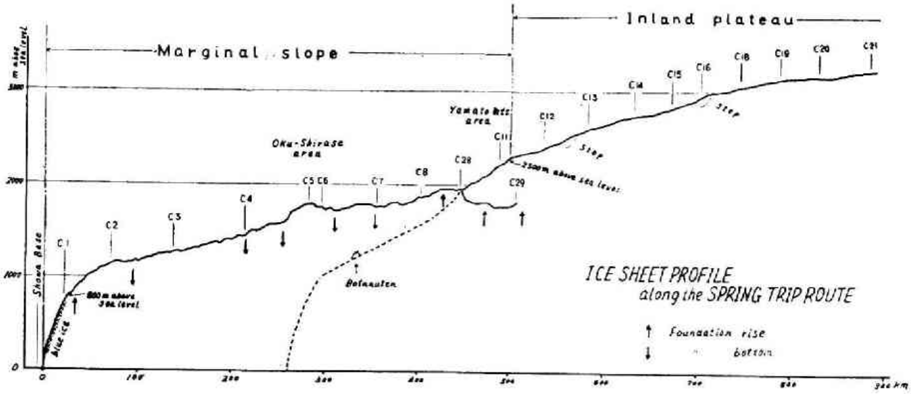

Fig. 2. Ice sheet profile along Spring trip route.

operated to move simultaneously, it is difficult to correct the errors due to the atmospheric pressure variation[3].

Inland ice sheet of the marginal slope

The morphology of the ice sheet on the marginal slope is greatly controlled by the rock exposures on the coast. Also it is influenced in some degree by the rock relief under ice cover. Because of the conspicuous mountain blocks of the Langhovde and Skarvsnes, the east coast (Prince Olav Coast) of the Lützow-Holm Bay is quite unlike the west coast (Prince Harald Coast), where there are only dotted small rock exposures.

The surface profile of the inland ice sheet passed by the party break distinctly at about 800 m above sea level. The mean gradient of the terminal slope under 800 m above sea level is 1/31 and is much steeper than in the area above 800 m, where the mean gradient is 1/125. The surface of the terminal slope shows broad undulations rising into steplike terraces towards inland. And in the convex surface many tortoise-shell shaped crevasses develop. Blue ice is exposed on the slopes from the coast to an alitude of 650 m above sea level. In summer 10 cm to 20 m diameter plate shape like hollows are formed all around, suggesting that there is active ablation of ice by melting. The melting is more noticeable closer to the coast. Especially, in the steep slopes, the melting water flows

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[3] Though small in scale, the atmospheric pressure variation at the camping ground during stagnation is similar to that of Showa Base (see Fig. 3). Consequently, through the meteorological date of Showa Base, it was possible to some extent to calculate the atmospheric variations. But since some suppositions are necessary, it is not given in this report.

making channels as deep as 20 cm to 50 cm on the surface of the blue ice. Even in the blue ice zone, snow drifts are spottedly distributed wherever the surface is slightly dented. After a blizzard or soon after the winter, they are of course distributed widely, but are generally very thin having no continuity with the blue ice.

Transverse crevasses are highly developed on the conspicuous convex features seen on the surface of the inland ice sheet at an altitude of 800 m above sea level. Apparently this crevasse zone stretches out long in the SSE direction. It is believed that the convex features of the ice sheet are influenced by the subglacial ridges, the existence of which being known in this area from seismic soundings made by the 3rd Expedition party[4]. It is interesting to know that this direction is identical with the structural trend of Langhovde Mountains.

The surface of the inland ice sheet above 800 m makes a broad rolling feature with relative heights of 30 m to 80 m (photo. 1). The mean gradient of the ice sheet in this area is small, especially between Camp 2 and Camp 3. Because the 5th Expedition party took the course parallel to the coast line, the real cross section of the inland ice sheet is not shown in Fig. 2.

Even the 3rd Expedition party which advanced across steepest slopes met only easy slopes. According to the 3rd Expedition party, the subglacial foundation in this area is a great broad valley 1000 m below the sea level. For this reason, it seems that the ice sheet in the valley is very thick representing a low gradient surface, dammed up by the subglacial rise to its west.

The small undulations of the ice sheet surface between Camp 2 and Camp 4 must be the reflection of the foundation form under the ice cover, but the relations between the two are not clear. However, between Camp 4 and Camp 7 at Oku-Shirase-daira, there are four subglacial valleys extending from the Shirase Glacier, and leading four troughs into the ice sheet surface. Some of these troughs are only 50 m to 100 m lower than the surrounding area, but on the side slopes of each trough, transverse crevasses are seen here and there, impassable for the sledges. This is where the 4th party encountered at crevasse zone (70°30' S, 41°00'E), and is where the 5th party made a detour at crevasse zone (70°50'S, 4°10'E). According to the seismic soundings made by the 4th party, the subglacial valley below a trough is from 1000m to 1400m deep[5].

The morphology of inland ica sheet in the vicinity of Yamato Mountains

The Yamato Mountains consists of seven massifs and several nunataks ex-

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[4] Official report of JARE III (1960): Ministry of Education.

[5] Ishida, T. (1962): Seismic Observation of the Yamato Mts. Traversing Trip. Antarctic Record, No. 14, pp. 36–43.

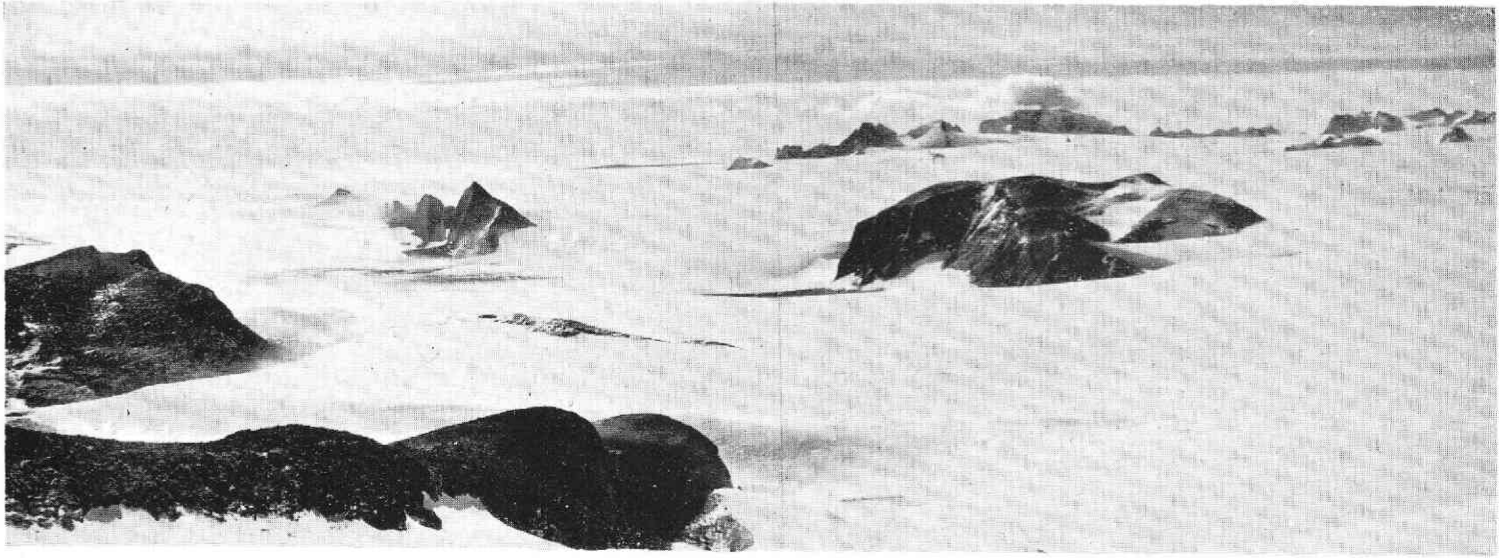

Photo. 2. Looking north from the summit of C-group, Yamato Mts. Farthest massifs are E,- G- and D-group (The summit is named Fukushima-dake) from the right hand. The ice sheet flows between these massifs from the right to the left, making outlet glacier.

tending over 50 kilometers N to S. The heights of the massifs are from 2000 m to 2400 m above sea level. The ice sheet in the vicinity of the mountain area flows from SE to NW through the mountains, making outlet glaciers 200–300 m in relative height. Therefore, the ice sheet on the SE side is from 1800 m 1900 m above sea level, while on the NW side the heights are only from 1500 m to 1600 m (photo. 2)[6].

The ice sheets on the east side of the mountains are mostly covered with accumulated snow, but on the west side a wide blue ice zone composed of true glacier ice is noticeable. Drift snow could not be seen especially on the lee side of main massifs sheltered from the predominant wind (photo. 3). Ice ablation by melting is active in summer in the blue ice zone on the coast, but that phenomenon is not observed in this area. Here, the ice is consumed chiefly by sublimation and wind corrasion. Far from the mountains the blue ice zone disappears, and once again a snow covered area appears.

Photo. 3. Blue ice zone on the lee side of the main massifs.

To the east near Yamato Mountains, the existence of an S-N trend of subglacial rise is known means of several nunataks and the conspicuous mounds of ice sheet surface. The inland ice sheet around 37°30′E long. displays a broad ridge-like feature stretching from S to N. It is manifested clearly in the surface profile

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[6] Yoshida, Y. (1961): Preliminary Report on Geomorphological Survey of the Yamato Mts. East Antarctica. Antarctic Record, No. 13, pp. 3–6.

of the ice sheet between Camps 8 and 29 in Fig. 2. The 5th sledge party on the way from Camp 28 to Camp 27 discovered several rounded ice mounds on their left side. There the crevasses are highly developed, and so it is assumed that the foundations of the ice mounds are comparatively shallow. Consequently, it is assumed that the subglacial rise exists stretching S-N centering at 37°30'E meridian. The influence of the rise on this ice sheet becomes fainter fowards the north until it is vague in the area passed by the 4th party (30 km north of the course taken by the 5th party). Even in the area, however, from seismic soundings it was found that a subglacial rise 500 m in relative height is hidden underneath the ice cover[7].

As mentioned above, three mountains with S-N trend and two subglacial rises are known to exist in the area around Yamato Mountains. These make a group and interferes with the flows of the ice sheets from the inland plateau, transforming the ice sheet. There is every reason to believe that this is the cause of the break in the surface profile around 2300 m above sea level shown in Fig. 2. It is also believed that this break (where ice sheet forms steep slopes) passes through several nunataks in the southwest of Yamato Mountains and extends onto the Belgica Mountains[8] (Photo. 4).

Photo. 4. Looking south from the summit of Fukushima-dake. A gentle ice cliff stretches from the A-group (farthest) to the right hand.

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[7] Ishida, T.: ibid 4).

[8] According to the maps of the Belgian Antarctic Expedition 1957–'58.

In the Queen Maud Land in general, about 200–300 km inland, there are many 2000 m–3000 m mountains arranged in a row. For example, Kottas Mts., Muhlig-Hofmann Mts., Wohlthat Mts., Sr Rondane Mts. and the like. Probably the Belgica Mts. and Yamato Mts. are situated at the eastern end of the mountain chain. There is no evidence what relations this mountain chain has with geological structure, but they disturb the outward flows of the ice sheet, and all of them have identical features where they make the boundary between the inland plateau and the marginal slopes in each meridian sector. The outer edge of the inland plateau shows an elevation of 2800 m above sea level to the south of Wohlthat Mts. which consists of several massifs ranging over 3000 m. Also the conspicuous outer edge of the inland plateau at Western Queen Maud Land makes a great escarpment that drops from 2400 m to 2200 m.[9]

Ice sheet in the inland plateau

The ice sheet surface in the inland plateau is very smooth and unbroken with a few exceptions. The exceptions which disturb the distinctive features are transverse steps with a relative height of 100 m along the contour lines of 2000 m and 2950 m. On the steep slopes the snow cover is blown away by the wind exposing a firn with small tortoise-shell shape cracks (photo. 5).

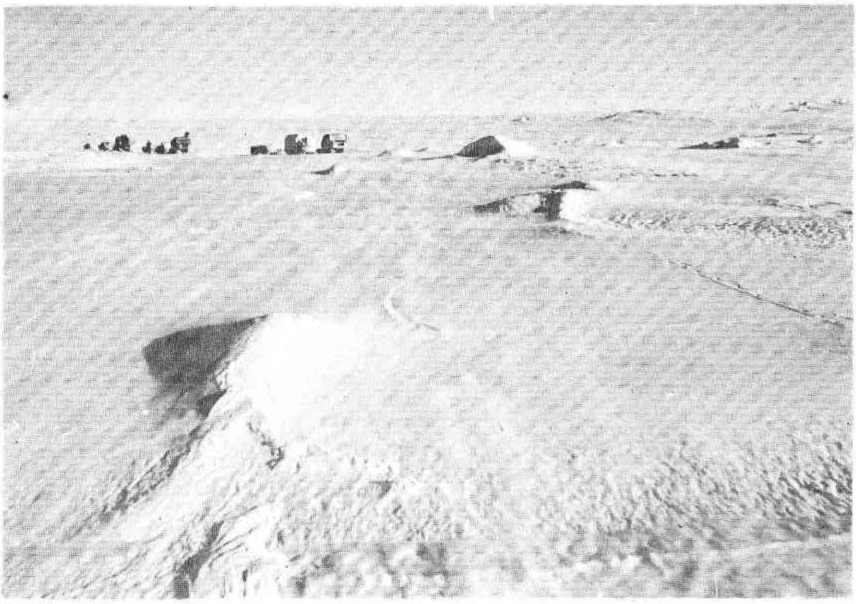

Photo. 5. Bare firn on the transverse step. Tortoise-shell shape cracks show on the surface.

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[9] Swithinbank, C. (1959): The Morphology of the Inland Ice Sheet and Nunatak Areas of Western Dornning Moud Land. Norwegian-British-Swedish Antarctic Expedition, 1949–'52. Scientific Results, Vol. 3, pp. 101–117.

The mean gradient of the inland plateau is 1/600 up to 3000 m above sea level, and is 1/800 above 3000 m, and there are no undulations. The surface of the ice sheet is even and smooth as far as one can see. The destination of the 5th party (75°S, 38°27'E) was at a plateau 3230 m above sea level and 660 km south of Showa Base, and it is believed that the smooth surface features continued further inland.

According to the data furnished by the USSR expedition, the highest part of the ice sheet in the East Antarctica is in the neighborhood of 81°–82°S and 70°–80°E and surpasses 4000 m above sea level[10]. From the highest part it seems that a giant ice sheet divide juts out to NW and NE. Presumably, the NW continuation extends to the inland plateau south of Wohlthat Mts. If this is so then it can be assumed that the divide to the south of the Mizuho Plateau is in the neighborhood of 80°S. Its hieght could be deduced as ranging from 3600 m to 3800 m in reference to the altitude of "Pole of Inaccessibility", 3720 m above sea level.

The results of the 5th party are being analysed now, but from preliminary information we have reasons to believe that the ice sheet south of the subglacial rises around Yamato Mts. are fairly thick[11]. Also in West Queen Maud Land it is known that the ice sheets are extremely thick where the inland plateau ice is dammed up behind the subglacial mountains. Hence, it will be more appropriate if the inland plateau is described as an ice filled basin, and not as an ice covered rock plateau. There are instances in some parts of the East Antartica such as on the way from Komosomolskaya, Sovetskaya to the "Pole of Inaccessibility". There, despite of the fact that the surface feature showed no variations, a large scale subglacial rock plateau was discovered concealed underneath. This indicates that in the inland plateau, there is almost no subglacial topography reflected on the surface feature, but is revealed only by seismic soundings.

III. THE MINOR FEATURES ON THE SURFACE OF ICE SHEET

Excepting where blue ice is exposed on the coastal slopes, and where Yamato Mountains shelter from the wind, most of the ice sheets are covered with snow layer. The surfaces of the snow layer are modified by wind into various shapes of sasturgis[12][13]. The writer observed the modification of the snow surface by the wind in

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[10] Gusef, A.M. (1961): Vchetakh. Antarktidi. Moskva.

[11] Official Report of JARE V (1962): Ministry of Education.

[12] Wright, C.S. and Priestley, R.E. (1922): Glaciology. British Antarctic Expedition 1910–13.

[13] Tatsumi, T. and Kikuchi, T. (1959): Report of Geomorphological and Geological Studies of the Wintering Team of JARE I (Part 2), Antarctic Record, No. 8, pp. 1–21.

the Mizuho Plateau, and encountered so many different shapes hard to classify into separate groups. Several forms of the main sasturgi are shown in the photographs.

The most important factor to form sasturgi is the wind, but the effects of the wind must not overlooked too. It is somewhat similar to the relation of running water in fluvial erosion. The strength and direction of the wind and the amount of snowfall vary by the season, and, in accordance with the changes, the form of sasturgi shows remarkable differences. The sasturgi are less modified the further one and are also greatly influenced by the shape of the ice sheet, and consequently there are conspicuous regional differences.

The easterly wind, the blow off from the Antarctic anti-cyclone, predominantly blows in the Mizuho Plateau, but sometimes strong blizzard accompanying the passage of the cyclone far off the antarctic coast rages and breaks the monotony[14]. Fig. 3 illustrates the changes of atmospheric pressure and wind observed on the Spring trip, in contrast with the changes at Showa Base. As is illustrated, the easterly wind with velocity 5 m–15 m prevails in Mizuho Plateau, and calm days are rare. In general the wind velocity decreases inland, 400–500 km from the coast, it blows 5–10 m SE every day.

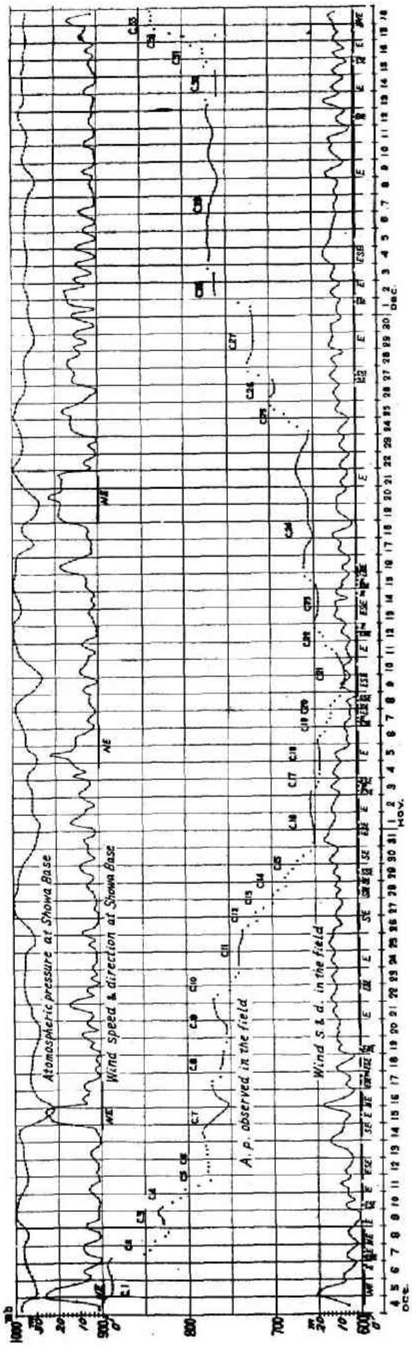

Fig. 3. The changes of atmospheric pressure and wind during the Spring trip. Upper, at Showa Base. Lower, in the field.

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[14] Murakoshi, N. (1959): Some Synoptic Problems at Syowa Base. Antarctic Record, No. 6, pp. 22–33.

Hence, even in fair weather there is continuous modification owing to the easterly wind in the snow surface, and the sasturgi formation is constantly going on.

On the smooth surface of the inland plateau, sasturgis, as shown in photo. 6, are normally seen. These sasturgis consist of the parts that are indented and rugged by wind corrasion, and the parts in the leeward where blown snow accumulates long and thin. They are the most conspicuous, being present at all times of the year and in all types of snow. The snow composing these sasturgis become compact by wind pressure, but is much softer than the old snow beneath. The characteristics of both are considerably discontinuous. They are not so large. Normally they rise 20 cm–50 cm above the old hard surface. For that reason, it is believed that the wind velocity in the inland plateau is not strong all the year

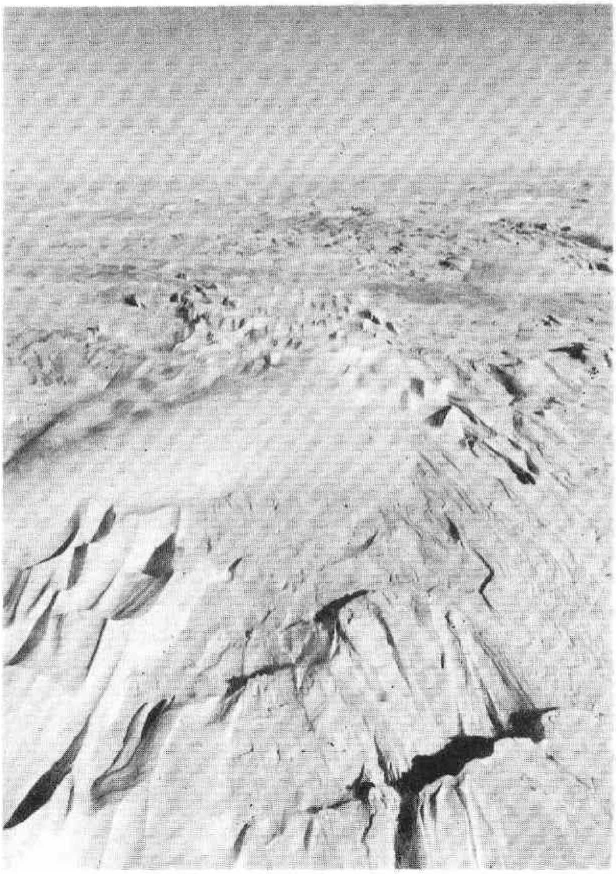

Photo. 6. Typical form of sasturgi on the smooth surface of the inland plateau. Its height is normally 20-50cm above the general surface level.

around. Ripple marks are found on the old and hard snow surface of this area, similar to that of a sandy shore (photo. 7). Sometimes, the snow drifts are long in shape, and in other times they are like snow barchans with crescent plans making a convex figure windwards (photo. 8). They are between 20 cm–30 cm in height and are normally found on a smooth even snow fields. The slopes of snow barchans are gentle on the windward but steep on the leeward, and so the profiles are extremely asymmetrical. There are clear evidences of snow barchans moving leeward as is shown in banded structures exposed on the windward slope.

On the inland plateau, conspicuous development of sasturgi can be seen on the steep slopes of the transverse steps (photo. 9). In the places, the very hard snow surface are deeply scooped by the katabatic wind and hence, creates large sasturgis. The height of these are normally between 0.5 m–1 m but some exceed 1 m. Because of the violent wind, snow drifts are not to be seen. These sasturgis are so large and hard that it proved to be malignant to the passing sledge

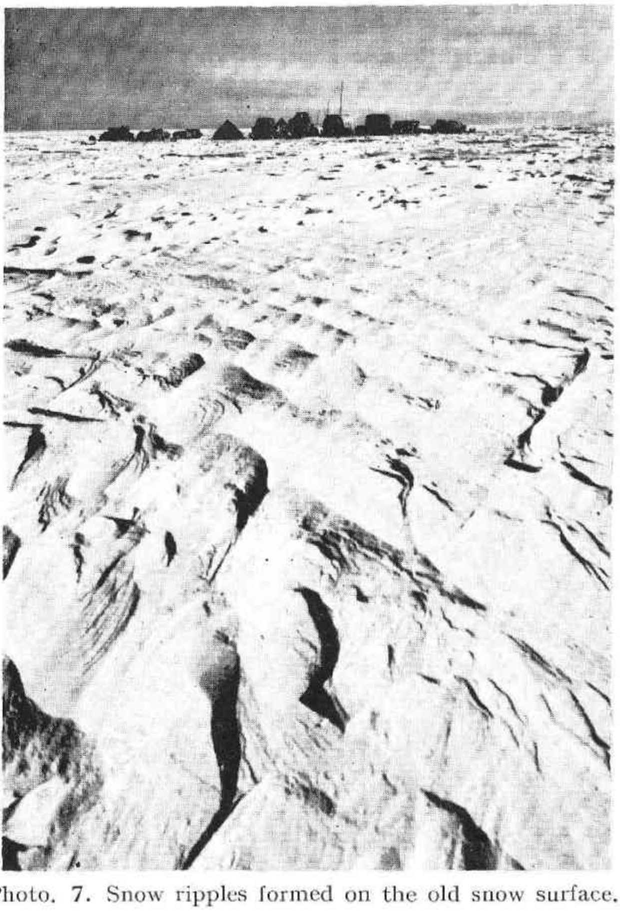

Photo. 7. Snow ripples formed on the old snow surface.

Photo. 8. Snow barchans. They are normally found in the smooth even snow surface.

Photo. 9. Conspicuous development of sasturgi owing to the katabatic wind on the transverse step.

party. It is known that the sasturgis the British Trans-Antartic Expedition encountered were all on the transverse slopes facing north. It is presumed that it is of the same nature as that which the Japanese sledge party encountered[15]. Photo. 10 shows the shape of the sasturgi when further exposed to wind corrasion. Its base of the windward side is deeply carved showing how strong the wind corrasion is near the snow surface. It resembles a toad in many ways from the windward and also the back surface represents a pustule like that of a toad's back. Therefore the Japanese party named it the "snow toad".

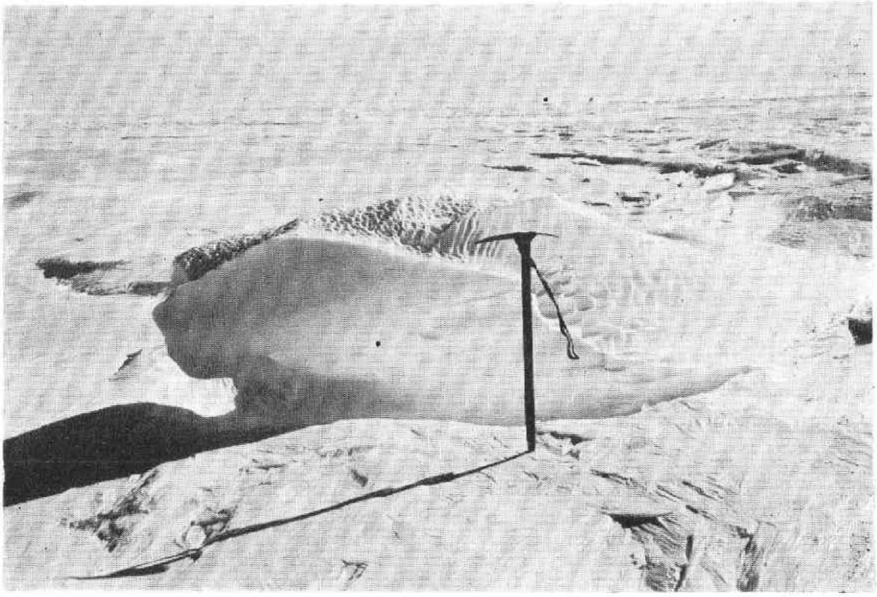

Photo. 10. Snow toad named by the Japanese party.

The katabatic wind is more predominant on the marginal slopes. During the Spring trip in this area 10 m–15 m wind blew everyday, and blown snow swept about 2 m–3 m above the snow surface, transforming sasturgi. As noted in Fig. 1, the direction of sasturgi development in this area is extremely different in regionally influenced by ice sheet topography. Having Oku-Shirase-daira as boundary, the sasturgi in Prince Olav Land develops in the east by north but in the area from the Oku-Shirase-daira to Yamato Mountains ESE or SE direction sasturgi prevails[16]. The sasturgi at the troughs of the Oku-Shirase-daira develops well parallel to the direction of troughs. The direction of the sasturgi near Yamato Mountains is ESE

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15) Fuchs, V. and Hillary, E. (1958): The Crossing of Antarctica. London.

16) Yoshida, Y. Murakoshi, N. and Yota, A. (1962): On the Climatological Observations in Survey Trips of the Wintering Party JARE IV. Antarctic Record, No. 15, pp. 12–24.

or SE but it is said that around Botnnuten to the north the sasturgi develops in the right angle from the coastline, namely in the south direction[17].

Besides the above mentioned E or SE sasturgi, there are diagonal NE or NNE sasturgi on the marginal slopes. When the falling snow during a blizzard is accompanied with a powerful NE wind, it is known that the sasturgi formation is affected by it. Consequently, the scale of such sasturgi is large, especially of its drift part. Many snow drifts were over 1 m in height, 15 m to 20 m in length and 4 m to 5 m in width. During the Spring trip, the parties at Camp 1 and Camp 7 were shut in the camps by the blizzards, and immediately afterwards witnessed in the snow field the development of a NE sasturgi. Based on the records of Showa Base, two severe blizzards attacked the coastal area on November 5 and November 19–21 also. During each period the party was at Camps 18 and 19, and witnessed only a slight falling snow but no variation in wind velocity nor of wind direction (Fig. 3). No more developments of NE sasturgi were to be seen in that area. For these reasons it is thought that the two blizzards in November did not come as far as Camp 18. Judging from the meterological observations and the morphology of sasturgis, it is ascertained that the range of the blizzard reached only as far in land as Camp 13 (about 400 km from the coast).

After blizzard, the NE sasturgi were modified by the easterly wind from the Antarctic anti-cyclone or the katabatic wind as shown in photo. 11. The wind-

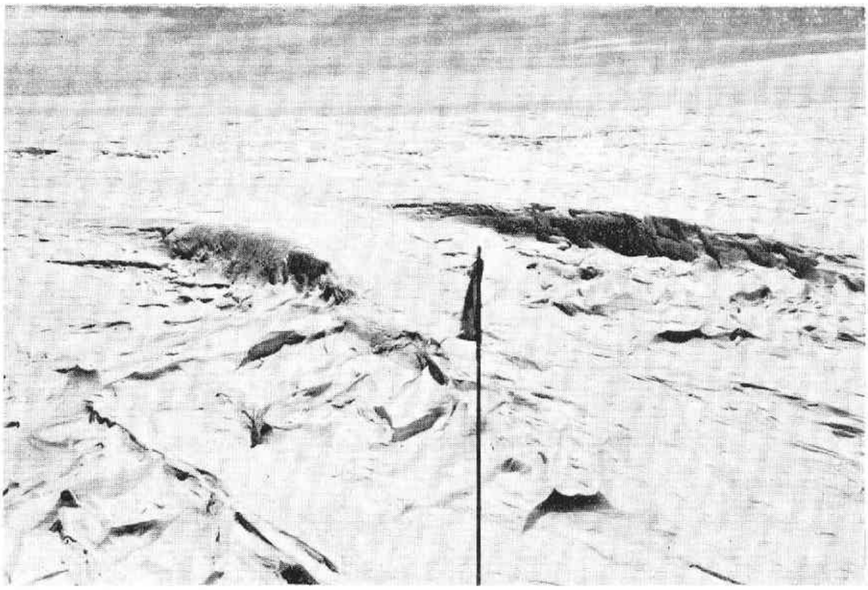

Photo. 11. Sasturgi showing two components of the wind directions.

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[17] Ibid. 13).

ward side of the NE sasturgi was corraded and a small steep scarp was formed facing to the new wind direction, and small sharp ridges were formed in the direction of the new wind. On the other hand, on the leeward snow drift extended long in the direction of the new wind. Many sasturgi having the two components of the wind direction, were seen between Oku-Shirase-daira and Yamato Mountains.

IV. CONCLUSION

1. From the morphology of the inland ice sheet, Mizuho Plateau can be divided into two parts: the inland plateau and the marginal slope. The boundary is south of Yamato Mountains, in the area about 2300 m above sea level. To the east of Yamato Mountains the existence of two ranges of subglacial mountains running parallel to Yamato Mountains is known. It is believed that Yamato Mountains and the subglacial mountains block the outward flow of the ice sheet from the inland plateau. The dam-up of such an ice sheet makes a distinctive feature commonly seen 200 km to 300 km inland from the coast of Queen Maud Land.

2. The marginal slopes of the ice sheet are generally steep. It also shows the surface feature influenced by the subglacial rock morphology. The ice sheet surface of the inland plateau is perfectly smooth and no conjecture could be made on the subglacial rock morphology from the surface observation. The terminal point of the party was 3230 m above sea level. The ice sheet further south forms easy slopes, and is believed to rise up to the divide assumed to be in the neighborhood of 80°S in latitude.

3. Conspicuous regional characteristics were recognized in the morphology and arrangement of sasturgis. It illustrates the strength and the directions of the prevailing wind in each area. Generally the wind in the inland plateau is constant and weak. The blow-off of the Antarctic anti-cyclone is east by south in direction. Other than the easterly wind, strong NE wind blows on the coast due to the cyclone and is closely related with the large scale sasturgi formation. It is presumed that the influence of the NE wind appears from about 400 km south of Showa Base to the inland. The katabatic wind blows violently on the steep slopes of the ice sheet making the regional characteristics of the sasturgi development more complicated. The development of sasturgi on the Oku-Shirase-daira and to the east of Yamato Mountains is effected greatly by such katabatic wind.

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