GLACIER STUDIES IN THE UMANAK DISTRICT WEST GREENLAND, 1950

BY

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WITH 6 FIGURES IN THE TEXT

CONTENTS

1. Introduction.

The West Greenland coast between latitudes 69° and 73° North exhibits the most remarkable system of iceberg-forming glaciers in the northern hemisphere. These glaciers are fed directly from the vast reservoir of the inland ice, which, everywhere except in the two peninsulas Svartenhuk and Nûgssuaq, approaches to within an average of 20 km of the coast.

Rink (4) was the first to study this system of glaciers, and he found that the five most productive fjords were the Jakobshavns Isfjord, Torssukátak, Qarajaqs Isfjord, Kangerdluk, and Upernaviks Isfjord. Later investigators, such as Helland, Hammer (1), Nordenskjold, Steenstrup (2), Ryder (3), Søren-Hansen, Drygalski (5), Engell, J. P. Koch, Wegener, Georgi, Loewe (8), and Sorge (6), confirmed his findings and together showed that these fjords are unsurpassed by all others for the number and size of the icebergs discharged yearly into Baffins Bugt.

The glaciers discharging into the Jakobshavn, Torssukátak, Qarajaq, and Upernavik fjords were visited, their speeds measured and their snouts surveyed long before those of the Kangerdluk. For a long time the Kangerdluk remained the least known, because of its comparative inaccessibility and danger due to the enormous quantities of ice which often completely block it.

The Kangerdluk, in latitude 71°35′ N., is a fjord about 38 km long and 6 km wide which discharges into the Karrats Isfjord in the northern part of Umanak district (Fig. 1). Two main glaciers feed it, the Rink and Umiámáko. Rink (4) himself only saw the glacier subsequently named after him from afar. In April 1880 Steenstrup (2), using dogs and sledges, reached a point near the snout of Umiámáko Isbræ, and in April 1893 Drygalski (5) penetrated the Kangerdluk to within 12 km of the Rinks Isbræ, again using dogs and sledges. Drygalski made a sketch-map of the fjord and estimated the size of the Umiámáko ice-front, his figures agreeing with those of Steenstrup. Apparently not for another 46 years did a European travel into the Kangerdluk, until in 1929, whilst seeking an easy route up on the inland ice, Alfred

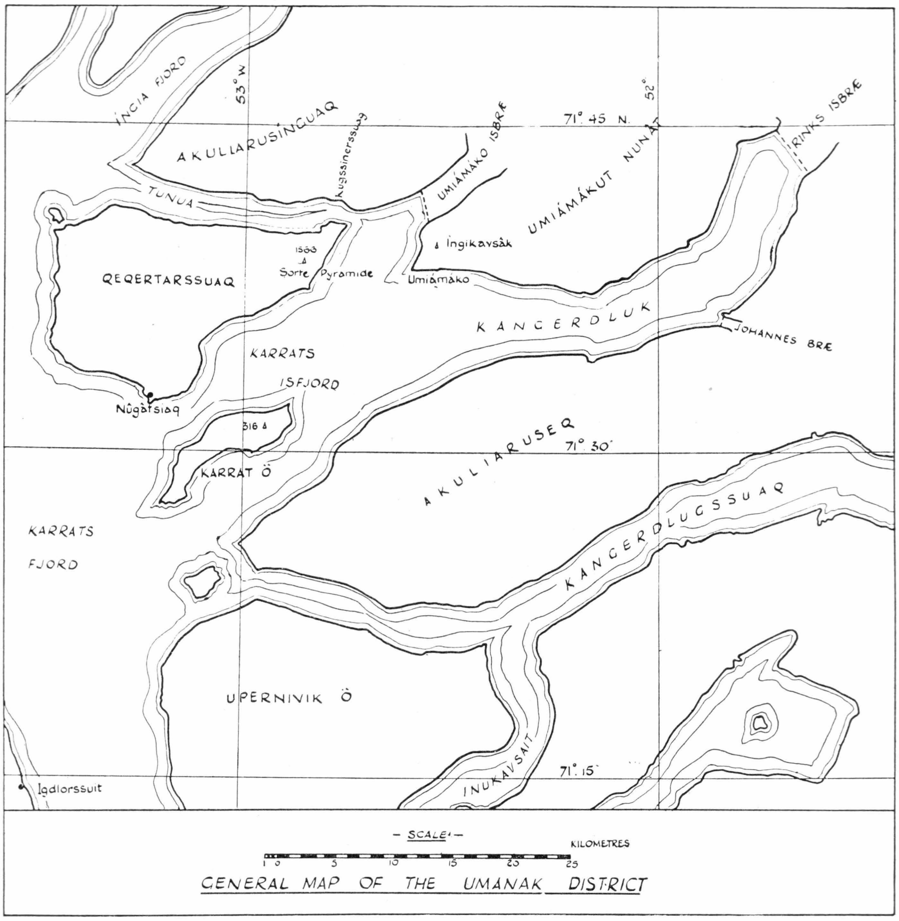

Fig. 1.

Wegener and Johannes Georgi went as far as the snout of the Johannes Bræ, where it discharges into the southern side of the Kangerdluk about 15 km from the snout of the Rinks Isbræ (Fig. 2).

Then in 1932 Ernst Sorge (6, 7), as a member of the German expedition led by Dr. Fank, penetrated the Kangerdluk several times. He measured the rate of advance of the Umiámáko ice-front, fixed its position, and took soundings in the fjord right up to the front. Out of eleven attempts to approach the Rink front by boat (any direct approach by land being quite impracticable) only four were successful, owing to the difficult and hazardous ice conditions often prevailing. Again he sounded the fjord up as far as the immense front, and later landed from a collapsible boat on the shore of the fjord close to the snout. From here Sorge measured not only the height and width of the

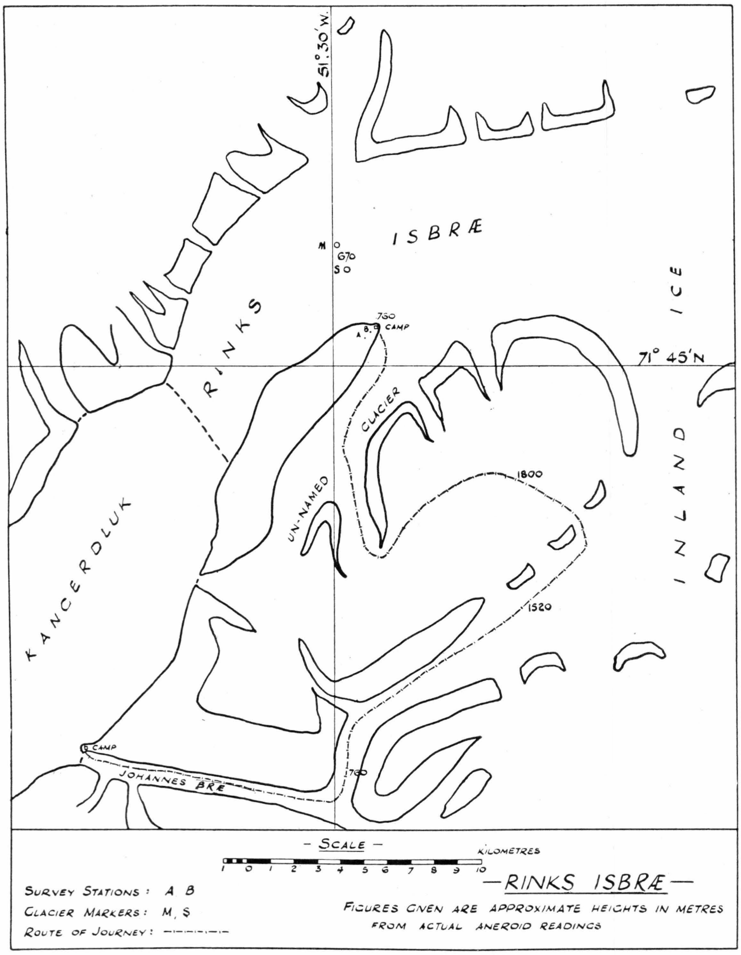

Fig. 2.

front, but he also measured the rate of advance of the front. Furthermore, he witnessed and photographed some of the catastrophic calvings that had hitherto only been surmised from the enormous amounts of ice liberated into the fjord. Sorge actually reached the margin of the glacier at one point near the snout, but he found that progress on it was impossible owing to the highly contorted and broken surface. Nevertheless, he was the first man to set foot on the Rinks Isbræ.

In 1950 members of the British expedition fixed the position of the Umiámáko ice-front again, and later, by means of an indirect land route (Fig. 2), reached the upper part of the Rinks Isbræ, where they measured its speed. Thus they were actually the first people to visit the upper part of the glacier and to travel on it.

2. Expedition Journeys.

The main basecamp of the expedition for the glacier exploration was at Nûgâtsiaq on the island Qeqertarssuaq (Fig. 1). This was reached from Umanak on the 23rd July. From here an open boat, 5 metres long, powered by an outboard motor, was used for travelling in the Karrats Isfjord and Kangerdluk.

A temporary camp was established on the 26th July at the mouth of the valley called Kugssinerssuaq on the mainland, and a reconnaissance made of this valley as a possible route for reaching the upper part of the Umiámáko Isbræ. The route was abandoned, however, as the ground was, in the main, too difficult for the speedy relaying of supplies and equipment necessary for a glacier camp. Subsequently a camp was made for two days on the point named Umiámáko. From here on the 29th July, a journey was made on foot, carrying surveying instruments, along the shore towards the snout of the Umiámáko Isbræ, and a survey was made of the ice-front.

On the 30th July, after withdrawing from Kugssinerssuaq and Umiámáko, a camp was established on the northern side of the snout of the Johannes Bræ (Fig. 2). Manhauling two Swedish pulka sledges and using crampons and ski as necessary to suit the ice or snow surface, the party of four men journeyed to point 760 (Fig. 2)—which should be point 494 on the 1 : 250,000 Danish Geodetic Institute map of 1937 —on the Rinks Isbræ. The route lay up the Johannes Bræ all the way to its head and then across the ice-plateau formed by a spur of the inland ice. The party left the Kangerdluk on the 4th August and made their camp by the Rinks Isbræ on the 9th, after a total journey of about 47 km. The ice-plateau, which was crossed at a maximum elevation of about 1800 metres, and the site of the camp on the spur of land between the Rinks Isbræ itself and its un-named tributary, are well seen in Fig. 5. The last 10 km of the journey was made on foot without the sledges, as it was found impracticable to take the sledges down to the Rinks Isbræ from the edge of the ice-plateau on account of the steepness of the slopes.

Six days were spent by the Rinks Isbræ, and during this time observations were made for the speed of the glacier and studies were made of ice-crystal structure in crevasses. The return journey to the Kangerdluk, using the same route, which was reached on the 19th August, took three days.

For fuller details of the sledges and other equipment used and for notes on the results of the crystallographic studies, reference should be made to the paper by Drever and Wyllie (11).

3. Survey of the Umiámáko Isbræ Snout.

This was made on the 30th July from a short baseline, 230 metres above sea level, situated to the east of the point Ingikavsâk and about 2500 metres from the snout.

Before arriving at Umiámáko Isbræ it had been intended to set up the baseline immediately opposite the snout, but a reconnaissance showed this to be completely impracticable owing to the rapidly increasing steepness of the ground above the fjord as the snout of the glacier was approached. Unfortunately, considerable difficulty was found in selecting two base stations to satisfy the requirements of intervisibility, visibility of distant trigonometrical points, and adequate length of baseline, on account of the rocky, undulating ground and the steep side-slope into the fjord. A compromise was finally arrived at, but as a result little more than half the width of the snout was visible. Nevertheless, it happened to be the more important part, as previous observers had used the northern side for recession comparisons.

The length of the baseline was determined by the subtense method, using an improvised subtense bar. From the two base stations sights were taken to two known trigonometrical points selected from the map, namely Point 316 on Karrat Ö, and Point 1566, or Sorte Pyramide, on the eastern end of Qeqertarssuaq. Then angular observations were made to salient points, at water level, on the icefront from each base station. All observations were made with a special lightweight $3^1/_4$ inch Watts micrometer theodolite.

The positions of the surveyed points on the front have been calculated in terms of rectangular co-ordinates relative to the baseline, and the geographical position and azimuth of the baseline have been calculated from information concerning the trigonometrical points supplied by the Danish Geodetic Institute.

Whilst actually searching for suitable positions for the base stations two small stone cairns were discovered. These could only have been those built by Sorge after his speed measurements here on 24th—26th September, 1932. They were not used as it was decided that more suitable points had been found, and these new points were marked by larger cairns.

4. Recession of the Umiámáko Isbræ Snout.

While it appears that Sorge did not make an accurate positional survey of the Umiámáko snout in 1932, it is hoped that that described above and plotted in Fig. 3 will prove useful for comparison with future surveys carried out in a similar manner.

However, it is possible even now to make an estimate of the rate of recession of the snout from photographs taken at various times. In 1932 Sorge deduced that the north side of the snout had receded 3 km since Drygalski's visit in 1893. That is equivalent to an average rate of 77 metres per year.

An approximate scale for distances on the north bank of the snout in Fig. 6 has been deduced with the assistance of the Danish Geodetic Institute. This gives 1 cm as equivalent to 0.70 km. Applying this to the changes in position of the front, it is found that from 1932 to 1949 the north side receded 2.1 cm on the photograph, or actually 1.47 km. This gives an average rate for the 17 years of 86 metres per year. For the year 1949 to 1950 the change is 0.25 cm, or actually 175 metres.

The agreement of the average rates for the long periods of 39 and 17 years is good, although the apparent acceleration may or may not be significant. The accuracy of the recession noted by Sorge is not known, and the deductions from the plates are only approximate. That the rate for the ultimate one year period should be double the average for the previous 17 years must be held with scepticism. An acceleration as marked as this is hardly to be expected, and the result has no doubt been vitiated by calvings from the front. An average over several years is essential to avoid this source of error.

In conclusion, it may be confidently stated that the front of the Umiámáko Isbræ has been retreating for more than half a century at an apparent average rate of about 80 metres per year.

It is interesting to compare this result with some obtained for other notable glaciers in West Greenland. Between 1888 and 1925 the Jakobshavns Isbræ retreated over 10 km, i. e. at an average rate of at least 270 metres per year, and between 1886 and 1931 the Upernaviks Isström retreated about 1.5 km, i. e. at an average rate of about 33 metres per year.

5. Speed Measurements on the Rink Isbræ.

The speed was measured at two points on a transverse section about 9 km above the snout during the middle of August, 1950. The section was roughly perpendicular to the centre-line of the glacier, and the two points are shown approximately in Fig. 2.

Out of the six days occupation of the camp, observations were made on four. The fourth and sixth days were both lost owing to bad weather, when very strong föhn winds blew down from the icecap.

Lightness of materials for the point markers on the glacier was essential in view of the necessity to reduce weight to a minimum on the difficult sledging journey from the Kangerdluk. Each of the two markers

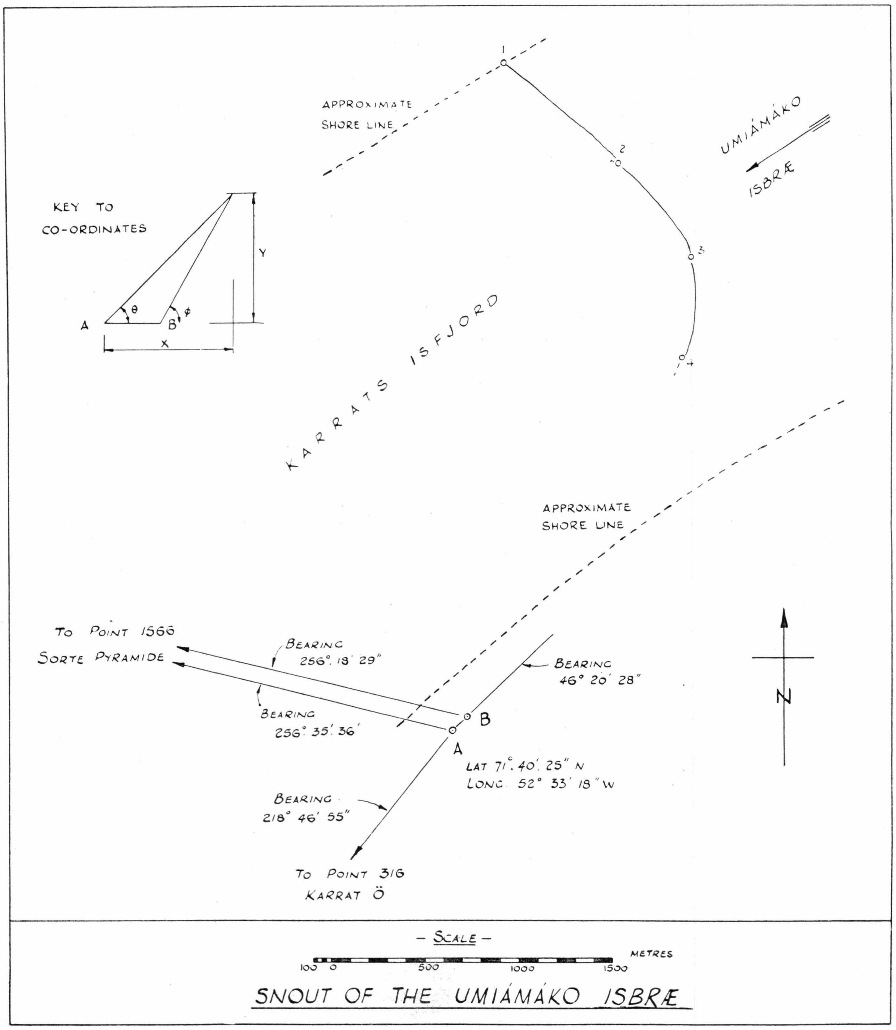

Fig. 3.

consisted of light bamboo canes bound together into the skeleton of a triangular pyramid standing about 2.5 metres high. Red cloth was used to fill in the faces of the pyramid and so render them visible by telescope from the baseline stations, and a flag was tied to the apex.

The width of the Rinks Isbræ across the chosen section is about 7 km (from 1937 map) and the calculated distances of the two markers from the baseline are 2.53 and 3.55 km. As the baseline was very close to the lateral moraine of the glacier, these figures show that, for all practical purposes, the main marker at 3.55 km was on the centre-line of the glacier, and the subsidiary marker at 2.53 km approximately one third across. Actually, owing to the intensely contorted surface of the glacier and the limited time available, the markers had to be placed in position by estimation. The altitude of both markers above sea level was found to be 670 m, as measured by aneroid barometer. Allowing for the average height of the ice-front to be 95 m (Sorge (7) estimated it to vary between 90 and 100 m), this gives the average gradient of the

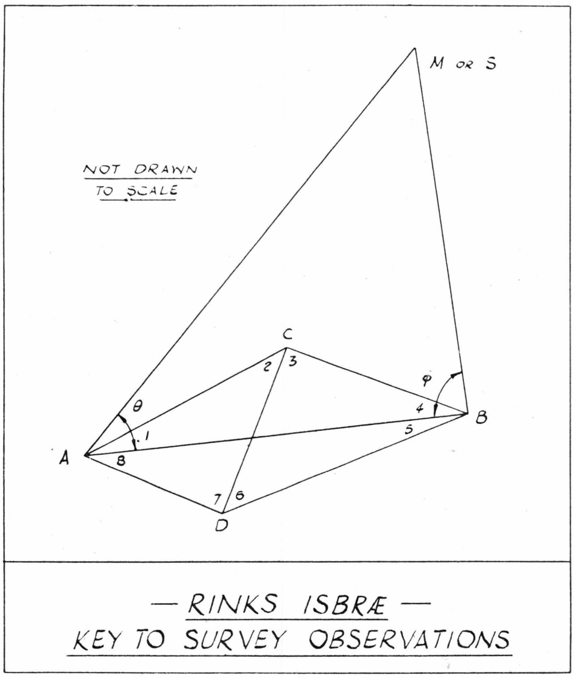

Fig. 4.

surface of the glacier from the selected points to the snout as 1 in 15.6, or about 3°40′.

Very little choice was possible in the position of the baseline or in its orientation relative to the glacier owing to the nature of the terrain. It was finally placed on the gently sloping stretch of the rocky spur between the Rinks Isbræ and its big un-named tributary, well seen in Fig. 5. A subsidiary baseline was first measured by the subtense method, as for the Umiámáko survey, and this was then extended by a quadrilateral expansion to the main baseline, which was a little over 400 m long. No established trigonometrical points of the Danish Geodetic survey were visible, but magnetic bearings of the baseline and to prominent points were taken.

Angular observations from each end of the main baseline to both markers were made as often as conditions permitted. The movement and direction of motion for each marker were calculated by means of rectangular co-ordinates relative to the main baseline. Fig. 4 illustrates the elements of the survey diagrammatically, and the more essential results have been included in Appendix D.

The average speed of the main marker was found to be 7.1 metres per day, and that of the subsidiary marker 2.4 metres per day.

6. Previous Speed Measurements and Discussion of Results.

The only previous measurement of the speed of the Rinks Isbræ was that of Sorge in 1932. He observed a large number of séracs very close to the snout, and deduced that the average speed over the central 3 km of the front was about 20 metres per day, with a maximum of 27 metres per day (7). The width of the entire front is about 4.5 km. Measurements were made over two periods using two different baselines, and agreement of results was obtained.

The difference between Sorge's values and those found here can almost certainly be explained by two causes. First, if it can be reasonably assumed that the glacier is approximately constant in thickness along its length (Sorge found it to be 700 to 800 metres at the front), then the speed will be inversely proportional to its width. Hence, it will be considerably greater at the snout than 9 km above it. More likely, however, the thickness will increase towards its source in the icecap, in which case the acceleration effect towards the snout will be heightened. Second, Ahlmann (10) has shown that for a glacier which terminates in the water, the speed will increase towards the snout.

Interesting comparison can be made with other high glacier speeds measured in West Greenland. They include 19.8 metres per day measured by Drygalski on the Qarajaq Store Gletscher (south-east of Umanak) in 1883; 37.8 metres per day by Ryder on the Upernaviks Isström in 1887; and 22.8 metres per day by von Engell on the Jakobshavns Isbræ in 1902. Sorge criticised these measurements on the grounds that they were made in too short a time and without due regard to the relative directions of baseline and glacier motion. In the latter case the difficulties attending accuracy become great owing to the relatively large effect of the unmeasured angles at the point itself. Unfortunately the obstacles provided by the mountainous regions of Greenland make these difficulties only too common. In support of Sorge's criticisms it may be mentioned that Carlson in 1931 remeasured the speed of the Upernaviks Isström and obtained a maximum of 20.6 metres per day, with an average for the centre of about 18.2 metres per day (9). These values are only about half those of Ryder. Thus Sorge's speed for the snout of the Rinks Isbræ still stands as the highest measured in West Greenland.

The difficulties mentioned above were encountered in these measurements, but the results for the two markers are, to a large extent, mutually supporting. The speed of the subsidiary marker is, perhaps, lower than might have been expected, considering its distance across the glacier, but the separate ice-stream by the left hand bank, as derived from the tributary glacier previously mentioned, is almost certainly much slower than the main stream of the Rinks Isbræ, and this would have its effect. Sorge found the stream on the north, or right-hand, bank at the snout to be much slower and to calve much less frequently than the main stream.

No intermediate period speeds have been included, as, although angles were observed, it was considered that the total period was too short to give reliable comparisons. Several workers have found that glaciers do not flow at a constant speed even over short intervals of time, as, for example, Washburn and Goldthwait on the South Crillon Glacier in Alaska, Finsterwalder on the Nanga Parbat Glacier in the Himalaya, and Battle (12) on the Frejagletscher in North East Greenland.

7. Conclusions.

For future work on such a notable glacier as the Rinks Isbræ, it would be most instructive to combine with speed measurements at several widely-spaced points up and down the glacier centre-line determinations of width and depth, the latter by modern echo-sounding methods, so that a study could be made of actual bulk flow, rather than surface speed alone.

It is hoped that this small contribution to the comparatively meagre results already obtained from this important group of glaciers in West Greenland will materially assist future studies. Sorge's measurements showed that the Rinks Isbræ has probably the highest speed of any in the world.

Appendices.

A. Acknowledgements.

Grateful thanks are due to Prof. N. E. Nørlund, Director of the Danish Geodetic Institute, Copenhagen, for kind permission to reproduce the two aerial photographs, Figs. 5 and 6, and for the two maps, Figs. 1 and 2, which have been based on the 1937 1 : 250,000 map of the Danish Geodetic Institute, sheets 71.Vl and 2. To him thanks are also due for the provision of data concerning the trigonometrical points used in the

Fig. 5. Aerial view of upper Rinks Isbræ, looking north, 1949 (Geodætisk Institut. Eneret).

Umiámáko survey, and for help in deducing the scale of distance used in conjunction with Fig. 6.

The Royal Geographical Society of London is to be thanked for the loan of all surveying instruments used by the expedition.

The expedition as a whole is completely indebted to the staff of the Grønlandsdepartementet, both in Copenhagen and in Greenland, for their invaluable help and cooperation in all matters and for making the work described above possible.

B. The Expedition.

The British West Greenland Expedition, 1950, was organised from the University of St. Andrews, Scotland, and received generous financial assistance from that body, the Carnegie Trust for Scotland, and the Royal Society of London. The members in the field consisted of H. I. DREVER, leader and senior geologist; W. S. MACKENZIE, geologist; T. J. RANSLEY and C. G. M. SLESSER, surveyor-mountaineers; N. S. TENNANT, mountaineer and photographer; and P. J. WYLLIE, glaciologist and geologist.

In addition to the glacier studies recounted in this paper, the geological survey (begun in 1938 and 1939) of Ubekendt Ejland was completed, and towards the end of the time spent in Greenland two members ascended four hitherto unclimbed mountains in the north-west of Upernivik Ö.

C. The Umiámáko Survey.

The following trigonometrical points were used:

	Lat.	Long.	y metres	x metres	Height metres
Ingikavsâk ...	71°39′28.7″ N.	52°32′01.3″ W.			
Sorte Pyramide	71°38′52.0″ N.	52°51′48.2″ W.	+ 295661	+ 30360	1566
Karrat Ö.....	71°30′59.7″ N.	52°56′26.4″ W.	+ 281059	+ 33304	316

For the rectangular co-ordinates, the y-axis is congruent with the meridian 52° W. and positive to the north, and the x-axis is tangent to the parallel 69° N. and positive to the west.

Calculated distance *A—S. P.* (Fig. 3), from vertical angles measured: 11,150 metres.

Calculated position of *A*:

Lat.	Long.	x	y
71°40′25″ N.	52°33′18″ W.	+ 298211	+ 19506

Baseline *AB*:

Subtense bar, 2.743 metres; mean subtended angle, 01°26′29″.
Baseline length, 108.8 metres.
Azimuth of *B* from *A*, 46°20′28″.

Co-ordinates of points on the ice-front:

With reference to Fig. 3,

$$X = L + \frac{L \cdot \tan \theta}{\tan \phi - \tan \theta}$$

$$Y = \frac{L \cdot \tan \theta \cdot \tan \phi}{\tan \phi - \tan \theta}$$

Fig. 6. Aerial view of north bank and snout of the Umiámáko Isbræ, 1949 (Geodætisk Institut. Eneret).

θ	ø	X	Y
41°42′42″	52°53′50″	2672 metres	2382 metres
29°47′42″	30°48′21″	2741 —	1570 —
19°26′50″	20°12′41″	2673 —	944 —
14°39′40″	15°21′56″	2269 —	594 —

D. The Rink Survey.

Subtense baseline *CD* (Fig. 4):

Subtense bar, 3.048 metres; mean subtended angle, 02°07′54″; Baseline length, 81.93 metres.

Quadrilateral angles:

	Observed	Adjusted
1	11°06′09″	11°06′13″
2	71°30′26″	71°30′40″
3	87°47′26″	87°46′35″
4	9°37′12″	9°36′32″
5	10°57′36″	10°56′58″
6	71°40′22″	71°39′55″
7	83°23′29″	83°24′06″
8	13′58′16″	13°59′01″

Main baseline *AB*:

Length 406.7 metres.
Azimuth of *B* from *A*, 42° approximately (deduced from magnetic bearing).
Observed angles to markers (Fig. 4):

To main marker (*M*)

Date	Time	θ	ø
11.8.50	19.15	54°53′33″	60°26′28″
15.8.50	10.00	55°03′34″	50°34′49″

To subsidiary marker (S)

Date	Time	θ	ø
11.8.50	19.15	48°52′08″	56°10′43″
15.8.50	10.00	49°01′58″	56°20′40″

Mean direction of glacier movement:

308° approximately, true bearing.

Summary.

After an introduction which outlines the main points of this important glacier region and then reviews the principal previous visits to it, a summary of the journeys made by the British West Greenland Expedition is given. An account is then given of the survey of the snout of the Umiámáko Isbræ, which is followed by deductions concerning the recession of this snout from photographic evidence. The observations for the speed of the Rinks Isbræ are described in detail, and the results are compared with previous measurements. The difficulties of making such measurements are briefly reviewed in connection with work on other glaciers, and suggestions for future lines of work are made.

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