

# Frontal Variations at Upernaviks Isstrøm in the Last 100 Years

by

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## Abstract

In this paper an account is given of the available information concerning the positions of the front of the Upernaviks Isstrøm from 1849 to 1953. The variations in the area of this outflow are compared with those of the well-known Jakobshavns Isbræ outflow in Disko Bugt. Both outflows have, in the last 100 years, lost between 150 and 200 sq.kms, which characterise exceptional changes in the Inland-ice margin.

## Introduction and acknowledgments

Upernaviks Isstrøm (Upernavik ice stream) is an outflow from the Inland-ice situated at lat.  $72^{\circ} 50' - 73^{\circ} 00'$  on the north-west coast of Greenland, about 50 kms east of the village of Upernavik. The outflow is situated between the Southwest-Greenland area, where a coastal land strip separates the Inland-ice from the sea, and the Melville Bay area, where the Inland-ice is, but for individual islands, limited by the sea.

The area around Upernavik was already described by K. L. GIESECKE in 1807 (edn. 1910) and H. RINK 1848, but the first detailed account of the ice and cartographic basis for an estimate of the former ice-margin is that given by RINK (1857) after his visit in 1849. Besides RINK's account the outflow is later described thoroughly by C. RYDER (RYDER 1889) and W. CARLSON (CARLSON 1939). Concerning the significant geographical and glaciological facts about the outflow reference need only be made to these papers.

Already CARLSON (1939) has given information about the changes in the position of the glacier front between the visits of C. RYDER in 1886-87 and his own in 1931, but he did not try to determine the position previous to RYDER's visits. As there now exists besides the information of RINK from 1849 information concerning the glacier from aerial photographs taken during and after the last world war, it is the hope of the author that this paper will bring up to date and supplement CARLSON's work.

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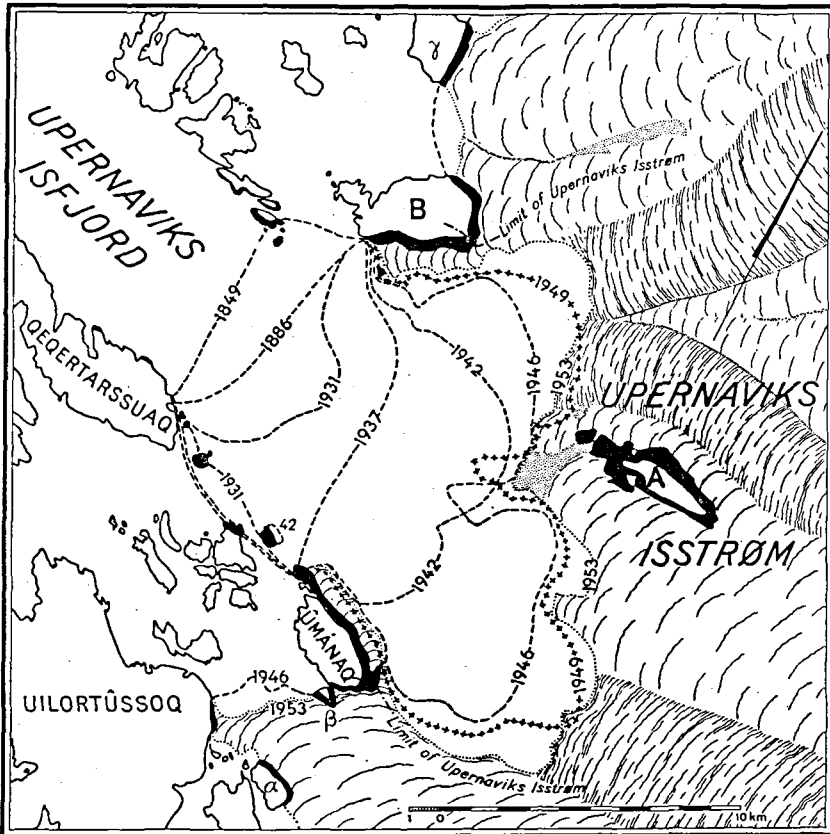


Fig. 1. Sketch-map of Upernavik Isstrøm showing the variation in position of the glacier front. Black area = melting zone.

#### Early sources of information

1849: From H. RINK's description in "Grønland" 1857 (Vol. 2, pp. 192, 194) it is evident that he visited the locality called Qeqertarsuaq (in RINK spelled Kikertarsoak) and that the map drawn by him is based on his own observations and not on second-hand information. The text given by RINK does not tell anything about the position of the glacier front at the time of his visit to Upernavik Isstrøm, but from the map in the same work it is evident that the glacier was bounded on the south by Qeqertarsuaq and on the north by a little island, and from there it turned further towards northeast. This information is all that is given about the position of the glacier front, and it is therefore with some uncertainty that the frontier for the glacier for 1849 is drawn as in fig. 1.

1886/87: C. RYDER visited and mapped the glacier front on two occasions, in August 1886 and in April 1887. In addition to information given in "Meddelelser om Grønland" Vol. 8, four photographs are to be found in

the files of the Mineralogical Museum, Copenhagen, together with a map of the area made by the geologist N. V. USSING, RYDER's companion in 1886. It does not appear in the text of RYDER's report whether RYDER was able to observe some annual variation in the position of the glacier front between the two visits, as this subject is not mentioned. The photographs from the expedition show the southern part of the glacier front from Qeqertarsuaq to Umanaq in August 1886 and also in April 1887, and from these pictures it is not possible to comment on the alteration of the position of the glacier margin between the two visits. It must be presumed that the glacier front generally had approximately the same positions in 1886 and 1887. RYDER pointed out in the text in "Meddelelser om Grønland" Vol. 8 that the glacier front at Qeqertarsuaq is bounded by the eastern side of the island and that the vegetation began only few Alen (1 Alen =  $0_{,686}$  Yard =  $0_{,627}$  m) from the ice margin. In addition it was reported by the Greenlanders residing in the district that a former icefree stretch with a river had existed east of Qeqertarsuaq, and the ice had moved over some islands where, a generation before, eider ducks had nested.

The text and the photographs in RYDER's report show that the ice margin in 1886/87, as in 1849, was on the skerries and the islands in Upernaviks Isfjord (ice fjord), and from the trim-line this position is estimated as very near the outermost in historical time.

In the fig. 1 the ice margin for 1886/87 is marked a little distance behind that of 1849. The reason for this determination is that RINK on his map of 1849 has given the position of the ice margin a little more westerly on Qeqertarsuaq than RYDER, and that RINK shows the northernmost part of the glacier front connected with an oblong island which probably represents that group of small islands north of Qeqertarsuaq and Upernaviks Isstrøm. On RYDER's map the limitation of the glacier front is shown to pass near these islands, but not to connect them. It is therefore presumed that there was a retreat in the period 1849-1886.

This retreat is not in accordance with the Greenlander's story of an advance in the generation before 1886. However it should be said about such assertions that experience from other places on the westcoast of Greenland shows that these are not quite trustworthy (J. A. D. JENSEN 1890, p. 43) since they often include vagueness regarding place names or an impression of advance which has a human tendency to be exaggerated. Also RYDER gives no information about the manner of inquiry and it is the author's experience that suggestive inquiries are very often answered affirmatively from politeness without regard to the contents of the question.

1893: E. V. DRYGALSKI visited the area around the Upernavik Isstrøm in May 1893, but, beyond a communication by trading assistant P. JENSEN, Tasiusaq, about an advance of the glaciers near that outpost, he mentions nothing directly concerning fluctuations of the front of the Upernaviks Isstrøm since 1887. It appears from his text (1897, Vol. 1, pp. 158-160) that DRYGALSKI at any rate visited the northern part of the front at the Upernaviks Isstrøm. The fact that DRYGALSKI does not deny RYDER's

mapping of the glacier front suggests that there was hardly any alteration in the position of the front in the years between 1887 and 1893.

1931: W. S. CARLSON visited the glacier in 1931 as member of the University of Michigan Expedition and, like RYDER, he measured the rate of movement of the glacier surface and determined the alteration of the positions of the front since 1887. The position of the front for 1931 is drawn in fig. 1 from CARLSON's thorough account. Carlson's investigations took place in the month of April, when a maximum damming-up of the fjord ice must affect the maximum extension of the glacier.

1937: The Geodetic Institute's map-sheets 72V1 and 72V2 show the glacier front this year ca. 2 kms behind the 1931 position. The map is not quite correct in the coast contours but it marks the glacier front going approximately in a straight line from Umanaq in the south to the Seminunataq B in the north.

1942: Oblique aerial photographs (route B44L, Geodetic Institute) taken on 14th July 1942 show the northern part of the glacier front (between A and B on the fig. 1) going in a direction from B's southwestern point towards Nunataq A. About 4 kms west of this Nunataq the front turns towards south-west to the middle part of Umanaq's northeastern coast. Glacier ice on two of the small skerries between Umanaq and Qeqertarsuaq must be interpreted as remnants of the glacier's winter extent.

1946: From this year there is a trimetrogon series (6PM173, M14, Geodetic Institute) from the 4th August. The route passes vertically over the Seminunataq B and the skerries between Umanaq and Qeqertarsuaq. At B the glacier front is delimited by the outermost southwest promontory in the area, and continues from here approximately parallel with B's southern coast for a distance of ca. 2 kms from the solid rocks. From B the front turns abruptly in a southern direction towards Nunataq A, as it passes at a distance of 2 kms west of it. Immediately south of the western part of the nunataq the glacier front forms a great projection towards the west. South of this there is a great embayment of the ice margin, which then swings westwards and ends at the north coast of Umanaq.

1949: In this year the series of aerial photos 535BØ/1570 were taken on 23rd July and 530FN were taken on 25th July. Both series are oblique photographs, showing the glacier front as seen from the west. The delimitation of the northern part of the glacier front is best seen on the series 530FN, where the ice, as on the photographs from 1946, is shown as a border along the southern coast of Seminunataq B with approximately the same extension as in 1946. From B the front turns in a great arc towards east, ending at Nunataq A. A great projection west of A probably indicates, as in 1946, a remnant of the winter extension.

The position of the glacier front south of Nunataq A can be determined partly from the FN-series, which show the ice margin at Umanaq very clearly, and partly from the series 535BØ, which show the ice margin as seen from a great distance from the west, hence the southeastern arc (south of Nunataq A) of the glacier front is seen very indistinctly. The innermost part of the glacier front here is fixed therefore only approximately on the map fig. 1.

1953: The contour map fig. 1 is constructed from two series of vertical photos from this year; the series A99/192:61 from 24th July and series VJ-62, DET "A" 83/84 from 6th July. When the two series overlap each other no alteration of the glacier front is to be seen, so it is to be supposed that the position of the glacier front on the 6th and 24th July was approximately the same. Between 1953 and 1949 it seems that the recession of the glacier front is stagnate; this supposition arises from the fact that the 1949- and 1953-position are both given for July, thus no annual variations are concerned.

### Conclusions

In fig. 2 the retreat of Upernaviks Isstrøm is shown in sq.kms. The ordinate gives the amount by which the area was greater than the position in 1953, the abscissae the years of observation. For comparison the retreat of the Jakobshavns Isbræ (Jakobshavn glacier) in Disko Bugt is shown in the same fig. and dealt with in the same manner on the basis of information from I. P. KOCH and A. WEGENER (1930), E. SORGE (in A. WEGENER, Vol. IV, 1939, pp. 356-362) and H. LARSEN and JØRGEN MELDGAARD (1957). Both Upernaviks Isstrøm and Jakobshavns Isbræ shows a great retreat (and loss of area) over the last 100 years and for both it must be stated that the extension around 1850 is that indicated by the trim line as the maximum in historical time (for Jakobshavns Isbræ, see MELDGAARD 1957, p. 28).

For Jakobshavns Isbræ an advance around 1888 and a decrease of the rate of retreat between 1913 and 1930, and again after 1940, deserves notice. For Upernaviks Isstrøm there is the same overall slow decrease between 1887 and 1931, but the advance around 1888 cannot be noticed from the few observations recorded. The maximum retreat took place in the period 1931-46. Since 1946 the retreat was again slower. Considering the advance around 1888 at Jakobshavns Isbræ, the determination of the glacier front's position this year has later been questioned by M. C. ENGELL (ENGELL 1904, p. 33, also referred to by I. P. KOCH 1931, p. 387), so until now an advance at this time has not been confirmed in Northern Greenland, possibly on account of the lack of observations around that year. In Southwest-Greenland (Julianehaab, Frederikshaab and Godthaab districts) a widespread advance in the period 1890-1900 has been established (WEIDICK 1958) so it is very likely that this general advance also occurred farther north.

There are two possible sources of error in using scattered observations to determine the position of a calving glacier and to plot these on graphs suggesting climatic changes. These are:

1) Seasonal variations in the position of the glacier front: Already HAMMER and DRYGALSKI (HAMMER 1893, p. 20, DRYGALSKI 1897, p. 131) pointed out the significance in Umanaq and Jakobshavn districts of the damming up of the great outflows of the Inland-ice by fjord ice in winter time, causing a great advance of the glacier fronts. Such conditions are present both at Upernaviks Isstrøm and Jakobshavns Isbræ. At Upernaviks Isstrøm RYDER reports no alterations in the position of the glacier

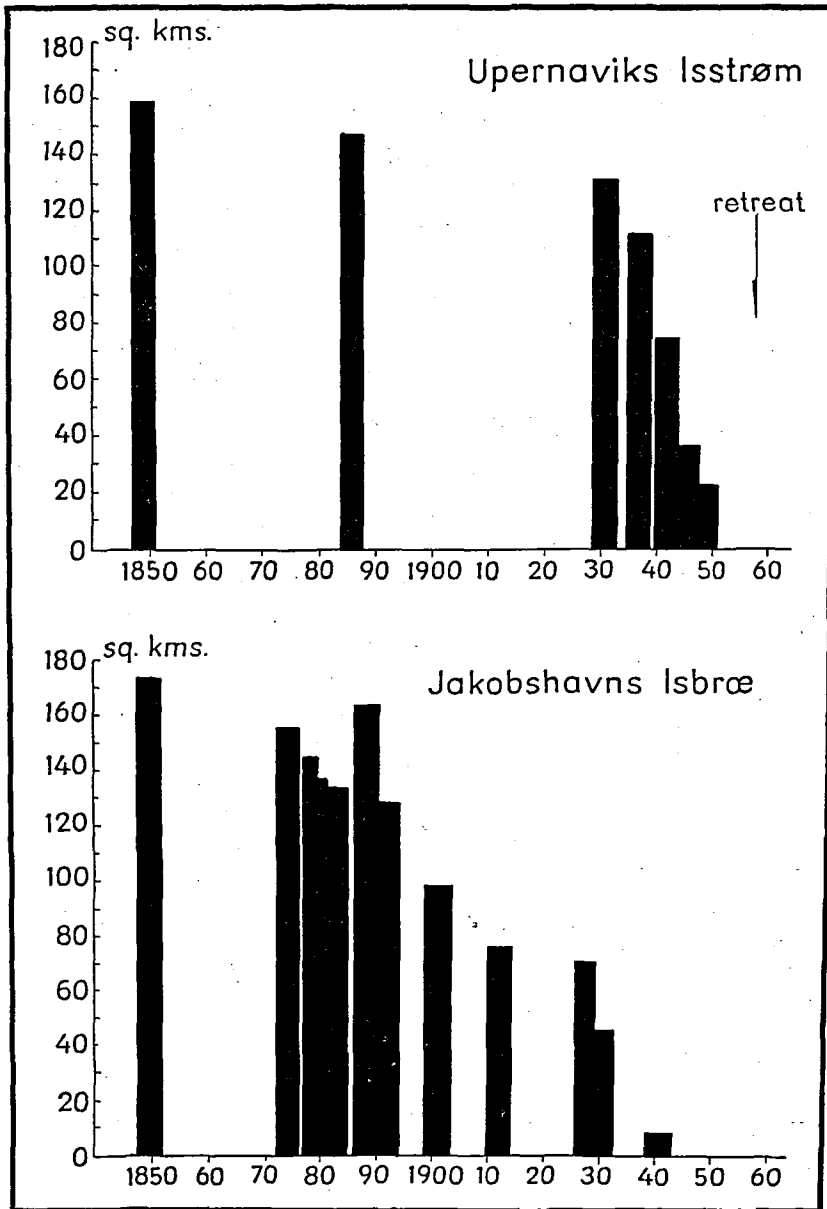


Fig. 2. Variations in the areas of the Upernaviks Isstrøm and the Jakobshavns Isbræ 1849(50)-1953.

front in 1886-87, whereas in July 1942 the glacier ice on the skerries between Umanaq and Qeqertarsuaq possibly indicates a seasonal variation of the glacier front that year of 4 kms. R. HAMMER (HAMMER 1893, p. 20) states that the annual variation of the glacier front at Jakobshavns Isbræ from Sept. 1879 to March 1880 is ca.  $\frac{1}{2}$  km.

2) Producing glaciers under high arctic conditions very often give rise to tabular ice bergs and, to a lesser degree, to what is understood by calvice, i.e. smaller ice bergs produced by down-fall (nakarneq) of the front or hydrostatical uplift of the same (igarneq). (Nakarneq and igarneq are the Eskimo nomenclature for these phenomena and were introduced into Glaciology by STEENSTRUP (1883, pp. 93-94) and later used by DRYGALSKI (1897, p. 391) and by O. KAYSER (1928, p. 418)). Concerning the formation of such tabular ice bergs in Western Greenland LAUGE KOCH (KOCH 1928, p. 200) gives some examples of glacier variations in Melville Bay north of Upernaviks Isstrøm, where the alteration of the glacier front (Inland-ice margin) is caused by the breaking-away of more than one years ice production as a whole unit. In this case it is quite impossible to see any climatic fluctuation as the immediate cause for variations of the glacier front.

Conditions of Upernaviks Isstrøm and Jakobshavns Isbræ do not seem to be such that tabular ice bergs of these dimensions can be formed, and so variations in the ice front due to ice breaking away are unlikely to be sufficiently large to create a misleading impression of climatic fluctuations. Annual variations, due to other causes, e.g. damming up of fjord ice, could, however, be sufficiently large to obscure the overall patterns of retreat.

Thus it must be stated that although for both the outflows given in fig. 2, there is a recession of the front of the glaciers in accordance with the present climatic fluctuation ascertained in other ways (L. LYSGAARD 1949, ADOLF JENSEN 1939), it is not certain whether minor glacier variations are caused by these climatic fluctuations or by local factors which mask such fluctuations.

#### Fluctuations of the Inland-ice margin around the Upernaviks Isbræ

Fig. 1 shows that the Inland-ice in the Upernaviks Isstrøm was bounded by the sea along a length of ca. 10 kms in 1849 and of ca. 30 kms in 1953. The total loss in area through the last 100 years is here ca. 160 sq.kms.

In addition to Upernaviks Isstrøm the adjacent marginal areas of the Inland-ice immediately north and south of the Isstrøm totalling 19 kms in length, are shown in fig. 1. These are the stretch from  $\gamma$  to B north of the Isstrøm and that from Umanaq to  $\alpha$  south of it. The melting zone, by which is understood here the area between the trim-line and the recent ice margin, i.e. the ice cleared landstretch in historical time, is seen in fig. 1 to occur around the ice margin (in the fig. 1 it is shown with black colour) with a width from 200 to 500 m. When the recession in the single sectors of this stretch occurred is not known in detail, since they are not dealt with in the accounts of 1849 and 1887. What is best known from these

sources is the southern sector south of Upernaviks Isstrøm, and it must be stated that the Inland-ice margin here was situated very near the trim line as late as ca. 1887, and (from the aerial photos), that the greatest part of the recession began in the nineteen-thirties. The variations of the Inland-ice margin are thus synchronous with those of the front of the Upernaviks Isstrøm, but the size of the variations were far smaller at the Inland-ice margin. The total area from these two stretches to have been cleared of ice in historical time is only 7 sq.kms, of this area only ca. 3 sq.kms is land, the rest of the clearance having taken place in small ice fjords.

The variation of the Upernaviks Isstrøm is to be interpreted as a very powerful expression of the same climatic fluctuation as was responsible for a slight retreat along the "normal" ice margin elsewhere in historical time. The linear retreat at the Inland-ice margin in the neighbourhood of the Upernaviks Isstrøm was, as given above, only ca. 350 m on land, while the same retreat in three other districts in Southwest-Greenland, namely Julianehaab, Frederikshaab and Godthaab must be estimated as 500-1000 m under the same terrain conditions as in the Upernavik district, i.e. weakly undulating roches moutonnées landscape under ca. 500 m above sea level.

It seems, that there is in West-Greenland a decrease of the width of the melting zone from south to north though early information about the melting zones is very scarce. Information about the variations of the glaciers, including glaciers with local firns as well as outflows or tongues from the Inland-ice, shows a retreat of the glaciers in Southern Greenland beginning in about 1850 in some cases, and in about 1890 in others (exceptionally as early as about 1750) and in Thule often as late as about 1920 (L. Koch 1928). The lesser width of the melting zones around the Inland-ice margin in the area around Upernaviks Isstrøm than around those in Southwest-Greenland (under the same morphological conditions) agrees with the theory that the start of the present retreat of the glaciers was later the farther north they are situated. The ice margin around Upernaviks Isstrøm should in behaviour be intermediate between that in Southwest-Greenland and that at Thule.

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