Von I 300 W bis I 1500 E stieg der Felsuntergrund um 120 m, die Eisoberfläche nur um 40 m; im Ostteil des Gesamtprofils fiel der Untergrund um 220 m, während die Eisoberfläche um 40 m stieg. Man kann also nicht sagen, daß die Eisoberfläche das Untergrundprofil einfach abgeschwächt widerspiegelt, was bei einem Profil quer zur Bewegungsrichtung auch nicht zu erwarten war. Es war aber klar ersichtlich, daß die Höhenunterschiede des Untergrunds erheblich größer sind als die der Eisoberfläche und daß, selbst bei um 10 % kleineren Eisdicken, der größte Teil des Gletscher-Untergrunds unter dem Meeresspiegel lag. Das Vorhandensein von einigen Spalten im Teilprofil II E hing vermutlich auch mit dem stärkeren Abfall des Untergrundes unter Zelt II zusammen.

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Zusätzliche Bemerkung

Von unserer Arbeitsgruppe wurde Anfang August 1933 in 25 km Abstand von Russischer Hafen (Nowaja Semlja), in 400 m Höhe auf dem „Inlandeis" nahe bei einer Innen-Moräne, jedoch ringsum von Eis umgeben, eine Gruppe von mehr als 10 großen Treibholzstämmen entdeckt. Die Stücke waren bis zu 5 m lang, etwa 1 m im Durchmesser und mehrere Tonnen schwer. Fachleute in Leningrad untersuchten einige Proben und fanden, daß es sich um Nadelholz sibirischer Bäume handelt, von gleicher Art,, wie sie heute von den großen sibirischen Strömen ins Eismeer verfrachtet werden und dann an der Küste von Nowaja Semlja antreiben. Die Fundstücke lagen entlang einer Höhenlinie angeordnet, wie es bei Treibholz üblich ist.

Es sind in Nowaja Semlja zahlreiche alte Strandterrassen bekannt in 40, 60 und bis 70 m Höhe über dem heutigen Meeresspiegel. Der Berichterstatter war über das Aussehen der Stämme erstaunt. Natürlich fehlte die Rinde, und sie waren durch Wind- und Schneefegen abgeschliffen, aber das Holz zeigte nicht einmal den Beginn von Versteinerung und war noch genau so gut brennbar wie frisches Treibholz.

Setzt man 1 m Hebung pro Jahrhundert an, wie an einigen Stellen in Skandinavien gemessen wurde, so müßte das Holz mehr als 40 000 Jahre alt sein. Der Berichterstatter ist kein Fachmann auf diesem Gebiet, und die Fachleute finden möglicherweise gar nichts Erstaunliches daran. Immerhin, eine große Hebung hat stattgefunden; denn Transport durch Wind oder Menschen ist ausgeschlossen. **K. Wölcken**

Differential Behaviour of the ice Cap Margin in the Julianehåb district, West Greenland

By Anker W e i d i c k , Copenhagen *

A review of earlier investigations in the district (K. J. V. Steenstrup, A. Jessen and R. Bøgvad) showed that the highest marine level in the district must be situated at about 40—60 metres. Lack of organic material in contact with the marine deposits makes the datings of the levels very difficult. However, in two more northern districts in West Greenland, Christianshåb near Disko Bay and Godthåb, a holocene sequence of marine levels has been established by means of the marine fauna (D. Laursen, Disko Bay) or by pollen (J. Iversen, Godthåb Fjord). The following results have been obtained for these two areas:

1) Both localities are situated only a few kms from the present ice margin.
2) Both localities have deposits dating back to boreal time.
3) 50 % of the upheaval of the land took place in or before boreal time.
4) From Disko Bay to the south the uppermost marine level decreases in Disko Bay it is around 200 metres, in Godthåb fjord around 100 (a little higher than 100 m.) and measurements made by K. J. V. Steenstrup, A. Jessen, R. Bøgvad and the author indicate, that in Julianehåb district this level is situated at about 50 m.

It is therefore supposed, that the uppermost marine level in Julianehåb as in the districts farther north, is older than boreal time and that 50 % of the upheaval of land (i. e. the upheaval to the 25—30 metre level) took place in or before boreal time. On the basis of these considerations, I have tried

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to establish an absolute chronology for the ice margin deposits in the district.

In the summers 1957, 1958 and 1960 I mapped several moraines, kame terraces and alluvial plains, which indicated several halts in the recession of the ice in holocene time.

A relative chronology is established by the contacts seen in these deposits between the ice margin features and the marine levels.

Chronology of the stages in Julianehåb district:

Three stages in the sense of Brückner and Penck are established, and where these stages represent, local, glaciations, an estimate of the former glaciation limit permits an extrapolation of the former summer climate.

The following stages are represented:

A. Niaqornakasik stage (oldest): Occurs as deposits of the great ice cover or of local glaciations. At the time of deposition of this stage the marine level was situated 30 to 40 metres above the present one and from local glaciation deposits it appears that the glaciation limit was ca. 500 metres lower than at present.

B. The Tunugdliarfik stage: Occurs mainly as marginal deposits of the great ice cover. The marine level at the time of the Tunugdliarfik stage is estimated to have been 10—15 metres above the present level. It is estimated that the glaciation limit was 200—300 metres lower then now.

C. The Narssarssuaq stage (youngest): Occurs mostly as marginal deposits of the great ice cover. The marine level at the time of formation of these deposits was the same as the present one.

Following these stages comes a 4th one:

D. "The little ice age": It is the maximum extension of the glaciers in historical time.

From the earlier considerations of the ages of the marine levels the following conclusions may be drawn:

The *Niaqornakasik* and the *Tunugdliarfik* stages must be older than, or contemporaneous with younger Dryas.

The *Narssarssuaq stage:* The situation of the marine limit near the present one must place the stage on this side of the climatic optimum. In addition, the position of Norse ruins from the period A. D. 1000—1300 clearly demonstrate its age as being older than the mediaeval age. Because of Ahlmann's deduction, that the alteration in climate between subatlantic and subboreal time could have disturbed the economy of the glacier so much that an advance would be expected, it must be assumed that this stage dates from the beginning of Roman time.

The little ice age: In Europe, this 4th stage in Greenland clearly stopped about 1900. Nothing is known about the beginning of the stage either in Greenland or in Europe, but archeological surveys in Greenland (P. Nørlund) indicate, that it began after 1300 A. D., and that the glaciers advanced after 1600—1700 A. D. to their maximum extension in historical time.

The extension of the ice cover under different stages:

On the basis of the ice margin deposits it is possible to estimate the extent of the ice cover in the northernmost part of the Julianehåb district during the different stages in holocene time. The ice cover here, as in most of West Greenland probably retreated rapidly from most of the coastal stretch in the earliest parts of holocene time (or possibly in the last part of Wisconsin glacial time). As early as the Niaqornakasik stage, the ice border was situated near to the present one. However, the interior part of the Tunugdliarfik and Igaliko fjords must have been covered by the ice cap during this stage.

The Tunugdliarfik stage: The stage is very well known from the interior parts of the Tunugdliarfik fjord. Here, it is possible to get a more exact impression of the distribution of the ice. The Inland ice proper had a margin, not more than a few kms south of the present one. This is indicated by moraines situated at *Qaleragdlit* ima and at *Eqaluit ilua.* Intense nivation and lack of ice margin deposits indicate that the whole sector from *Eqalorutsit kangigdlit sermia* until *Niviarsiat* had a maximum very near the same extension as the present ice margin.

At the localities around Narssarssuaq and Qoroq the ice margin calved in the Tunugdliarfik fjord just as the ice lobes farther south, from the Jessens Dal and Østfjordsdal protruded on to Igaliko fjord.

The Nårssarssuaq stage: It is not known what happened during the climatic optimum, between the Tunugdliarfik and Narssarssuaq stages. It must be supposed that the ice cover had a distribution similar to the present one or possibly a little smaller than during the climatic optimum. The deposits of the Narssarssuaq stage are very fresh and the moraines on the terraces in the Qorqup kua valley in Qoroq fjord indicate that it must have been a short, powerfull advance. Nevertheless in the Narssarssuaq area it again reached the Tunugdliarfik fjord. In general, in this area, the distribution of this advance was between that of the Tunugdliarfik stage and the present ice margin.

In the north, the situation was different. Here, the ice margin in the area north of Sermilik fjord was only few kms farther south than the present ice margin. Deposits in the Kangerdluarssuk fjord, from this stage, indicate, that the distribution of the ice in this sector was very much similar to that in the following advance during the little ice age 1600—1900 A. D.

The little ice age: It is known, that the ice margin in the whole period 1700—1900 had an extension greater than now. Two systems of moraines, one very old (though of historical age but lichen covered) and one from an advance 1890—1900 (dated both from the literature and from the thin lichen cover) indicates maximum extension of the ice in the period between 1700 and 1800, and again 1890—1900.

After the year 1900 A. D., the glaciers retreated slowly in the period 1900—1920, and rapidly between 1920 and 1940. After 1940, the retreat occurred with a decelerating rate, and at some places there were actuall small advances.

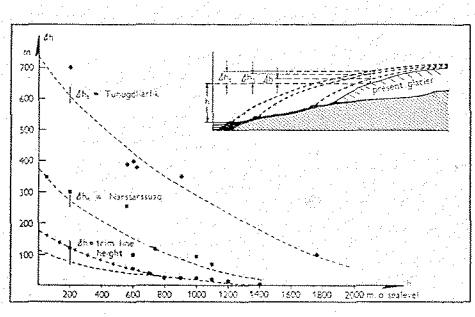
The sectorial behaviour of the ice margin for this period is well known from the reported younger and older moraines of historical age. Though, it must be said that the differences in extension of the glaciers between these two "hochstands" are very small.

North of Brede Fjord from Qornoq fjord to Sermitsialik (Sermilik) the maximum advance occurred during 1890—1900; the older moraines have been destroyed.

In the sector between Manitsup tunua and Eqalorutsit kitdlit sermia the ice margin had a maximum extension about 1750. To the east, the difference between the extension of the 1750 and 1900 ice becomea greater. From the Eqalorutsit kangigdlit sermia glacier to Niviarsiat the situation is different; here, the glacier margin is stationary or advancing over thurf and old vegetation.

From Niviarsiat qaqat to Jespersen glacier the 1890—1900 advance is the greatest one in historical time. Farther south, the area is not so well known, and it is possible both at the margins of the Julianehåb ice cap and at local glaciations to find either 1700—1800 or the 1890—1900 as the maximum advances.

The volume alterations of the ice cover in Julianehåb district: We have discussed the extension of the ice margin, however, it is generally more useful to estimate the volume of the ice cover during the different stages. The great development of ice contact features in the northern part of the Julianehab district provides an opportunity for an evaluation of the former thickness of the ice cap in the district. Assuming two stages and the maximum historical extension of the ice, the alteration in height (△sh) is a function of the present altitude of he glacier surface (h), a diagram can be prepared. This diagram shows the following:



All three curves thin out between 1100 and 1700 metres above sea level. This indicates that the height of the Inland ice and the Julianehåb ice cap must have been rather constant through most of the holocene period. It is in accordance with the theoretical considerations of the plasticity of an ice cap, as given by J. Orowan and J. Nye.

It must be noticed, that the trim line thins out ca. 1200 metres above sea level. One factor could be that the Inland Ice and the Julianehåb ice cap, expressed as a function of the altitude, than have an ablation less than the local glaciers (after H. Ahlmann).

Another and more possible cause for the fast thinning out of the lowermost curve could be a new wave of ice indicating a future advance. Push moraines in higher altitudes of the Qoroq and Kiagtut sermia glaciers could be so interpreted. Considering this mechanism, we should have a melting and retreating system in the lowermost parts of the lobes from the ice cap, but an expanding system of ice in the areas near the firn limit.

Glacial Geology of Northern Greenland*

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Abstract. From 1956 through 1960 studies on the glacial geology of northern Greenland have been made in cooperation with the U. S. Air Force Cambridge Research Laboratories. As a result of these studies four distinct phases of the latest glaciation have been recognized. The last glaciation extended over most of the land and removed traces of previous ones. Retreat of the ice mass began some time previous to 6000 years ago. This was followed by a rise in sea level which deposited clay-silt succeeded by kame gravels around stagnant ice lobes in the large valleys. Marine terraces, up to 129 meters above present sea level, developed as readjustment occurred in the land free of ice. About 3700 years ago an advance of glaciers down major fjords took place followed by retreat to approximately the present position of the ice. Till in Peary Land, north of Frederick E. Hyde Fjord, contains only locally derived materials indicating that the central Greenland ice cap did not cover the area.

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Zusammenfassung: Glazialgeologie von Nordgrönland. Von 1956 bis 1960 wurden in Zusammenarbeit mit den U.S. Air Force Cambridge Research Laboratories Studien über die Glazialgeologie von Nordgrönland gemacht. Als ein Ergebnis dieser Untersuchungen wurden vier getrennte Phasen der letzten Vereisung erkannt. Die letzte Vereisung dehnte sich über den größten Teil des Landes aus und beseitigte Spuren von vorhergegangenen. Der Rückzug des Eises begann vor gut 6000 Jahren. Dieses wurde aus dem Anstieg des Meeresspiegels festgestellt, wobei Ton und Schluff gefolgt von Kame Schottern rund um die stagnierenden Gletscherzungen in den großen Tälern abgelagert wurden. Marine Terassen — bis zu 129 m über dem jetzigen Meeresspiegel — zeigen, wie der Rückzug in dem eisfreien Land eintrat. Vor etwa 3700 Jahren fand ein Vorrücken der Gletscher durch die Hauptfjorde statt, gefolgt von einem Rückzug auf etwa den gegenwärtigen Eisstand. Grundmoränen in Peary-Land, nördlich des Frederick E. Hyde-Fjordes, enthalten nur örtliches Material, was beweist, daß das zentrale grönländische Inlandeis dieses Gebiet nicht bedeckte.

Since 1956 the U.S. Air Force Cambridge Research Laboratories has conducted studies of landforms and enginering properties of soils in northern Greenland. Members of the U. S. Geological Survey participated in the geological aspect of this research, and investigated the glacial geology of Peary Land, Kronprins Christian Land, and adjacent areas.

Northern Greenland consists of three major physiographic divisions:

1) an area of low alpine mountains in Peary Land, north of Frederick E. Hyde Fjord,
2) similar mountains along the northeast coast south of Independence Fjord, and
3) a dissected plateau formed of non-folded late Precambrian and early Paleozioc rocks inland from the mountainous coastal areas.

The glacial geology of northern Greenland has been given scant attention. Lauge Koch outlined the basic concepts of former glaciation, which were based on observations made while on the Danish Bicentenary Jubilee Expedition in 1921 (Koch, 1927, 1928a, b). Troelson (1949, 1952), while on the Dansk Pearyland-Ekspedition 1947-50, filled in details around Brønlund Fjord.

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