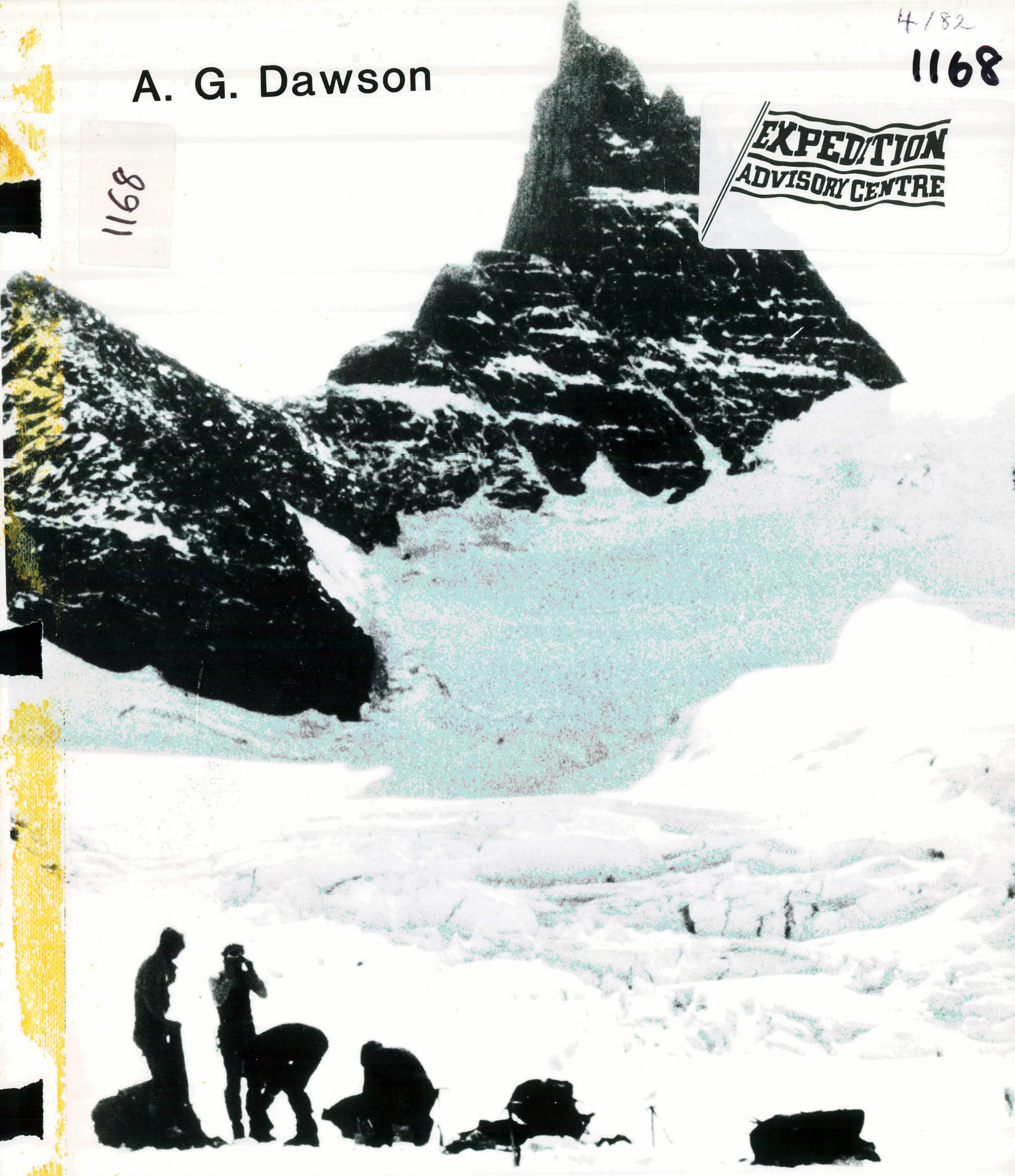
A. G. Dawson



Coventry (Lanchester) Polytechnic

SOUTH GREENLAND EXPEDITION 1982

SOUTH GREENLAND

COVENTRY (LANCHESTER) POLYTECHNIC

RESEARCH EXPEDITION

JULY-AUGUST 1982

A.G. DAWSON

(with contributions from G. Shaw

J. Sahota, J. Lindsay, I. Roy

and S. Billing)

CONTENTS

		Page
Chapter 1	Introduction	1
Chapter 2	The Hullet Lake area	4
	Drainage : October 1981	5
	Lake-level changes : August 1982	8
	Former glacier oscillations	10
	Stage I	11
	Stage IIa	12
	Stage IIb	14
	recent	15
	Former ice-dammed lakes	16
	Lake drainage processes	23
	The lower shorelines	25
	Lichenometry	26
	Conclusion	28
Chapter 3	Iceberg Geomorphology	31
Chapter 4	Lake Sediments and Periglacial Landforms	34
Chapter 5	Botanical Report (S. Billing)	36
Chapter 6	Wild Life (J.Lindsay)	38
	Hullet	38
	Tasermiut (I. Roy)	42
Chapter 7	The Tasermiut Area	46
Chapter 8	Tasermiut to Kangikitsoq (G. Shaw)	49
Chapter 9	Dansakh West Face (J. Sahota)	61
	Acknowledgements	
	Income and Expenditure	

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Chapter 1

Introduction

Planning

Expedition planning and organisation commenced in October 1981. Preliminary investigations indicated that the cheapest and most efficient method of arranging food supplies was for their purchase in Copenhagen, Denmark and their transport by boat from Aalborg to Narssarssuaq. Hence, DVL Rejser (Kultorvet 7, 1175 København K) were contracted to purchase our food supplies and to transport them to Narssarssuaq. DVL Rejser is the travel department that organises hiking vacations in Greenland. Consequently, they own many tourist cabins in remote areas of SW Greenland and are responsible for the organisation of many travel activities in this region.

The expedition had two main objectives. Firstly it was hoped to undertake geomorphological and glaciological studies of the Lake Hullet area ca. 30 km north of Narssarssuaq (Fig. 1). Secondly it was hoped to establish a mountaineering party farther south at the head of Tasermiut Fjord from which exploration and ascents could be undertaken (Fig. 1). With the agreement of DVL, Copenhagen, it was decided that the Tasermiut base camp would be located near a DVL base camp already established in this area. DVL kindly permitted access to their radio-telephone at Tasermiut. Hence the safety of the mountaineering party was established. On the arrival of the mountaineers at Narssarssuaq, DVL contracted to transport them to their base at Tasermiut and to return them in late August to Narssarssuaq. Hence the Tasermiut group arrangements were facilitated by the supply of all food supplies to Tasermiut by DVL and by the establishment of all internal travel within Greenland by the same organisation.

The establishment of a field base camp at Lake Hullet proved more complicated. At present the Greenland Geological Survey are undertaking glaciological and glaciohydrological studies in the Lake Hullet and Nordbosø areas (Fig. 2). At an early stage, Mr. P. Clement, leader of the Greenland Geological Survey research project in this area, kindly offered to transport our food supplies from Narssarssuaq to Lake Hullet during May 1982. Hence DVL ensured that the Hullet food supplies were delivered to Narssarssuaq by that date. These were subsequently transported by helicopter to the Hullet base camp located c. 300 m south of Nordgletscher (Fig. 2). Travel arrangements from London to Narssarssuaq were thereafter completed with Mr. N. Cairns, Regent Holidays, Shanklin, Isle of Wight. Thus flights were booked to Narssarssuaq via Copenhagen. The departure was scheduled for July 28th, 1982 and the return date arranged for 3rd September.

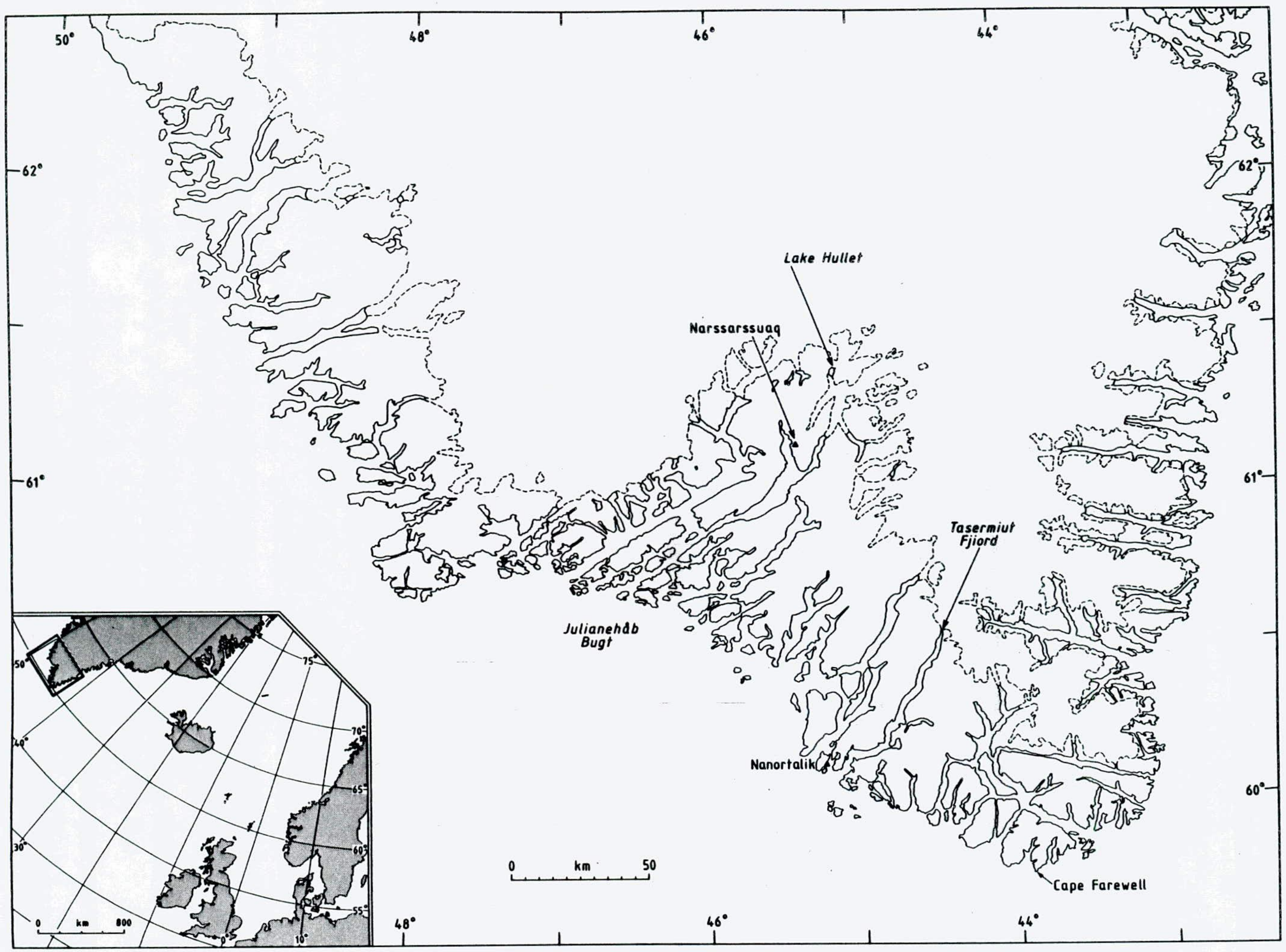
Owing to the bulk of scientific equipment required at Lake Hullet, a helicopter was booked to transport both the Hullet group and equipment from Narssarssuaq to Nordgletscher. This was arranged by Mr. N. Cairns with Mr. P. Rasmussen of "Greenlandair" at Narssarssuaq. Early expedition discussions considered seriously the proposal of an overland walk from Narssarssuaq to Hullet. In this way the field equipment would have been carried to the field area. The decision not to do this, in retrospect, was completely justified (despite the cost of the helicopter) and ensured the success of this part of the expedition.

The return from Nordgletscher base camp to Narssarssuaq was not so pleasant. The Greenland Geological Survey kindly offered to return our equipment to Narssarssuaq by helicopter. In contrast, the field members undertook a "tour de force" hike of c. 50 km from their Nordgletscher base to Narssarssuaq. The Hullet and Tasermiut groups finally camped together on 29th August. The Hullet field equipment arrived by helicopter at Narssarssuaq on 2nd September and departure for the U.K. took place on 3rd September. The expedition proved most successful. The scientific results surpassed all expectations. The Tasermiut mountaineering party completed many of their proposed explorations and ascents. Fortunately no serious injuries were incurred.

For future expeditions to these areas we strongly recommend the following:-

1. Ensure that excess baggage on aircraft is kept to an absolute minimum. Problems of this nature at the beginning of the expedition almost cost the expedition a great deal of money. These were fortunately avoided.

2. Ensure that the expedition is granted the appropriate permits from the Ministry for Greenland in Copenhagen.



Location map of Tasermiut and the Hullet Lake area, S. Greenland.

3. Consider carefully the possibilities of external food purchasing and its transport. Purchase of food in the U.K. and its shipping from the U.K. to Greenland is a time-consuming and expensive procedure.

4. If helicopters are to be chartered in Greenland, ensure that the helicopter is of the minimum size. Carefully check the payloads of available helicopters before booking.

5. If possible, undertake research in areas above ca. 500 m. In S Greenland, many low-lying ground areas are dominated by extensive areas of dwarf birch trees. These are exceedingly difficult to penetrate, particularly with a heavy pack.

6. Do not use tents that are susceptible to wind damage. S Greenland is particularly prone to the occurrence of extremely severe föhn winds that can attain velocities of 80 m.p.h. The wrong choice of tents can result in the destruction of a base camp within several hours.

7. Expeditions who propose to camp adjacent to fjords are strongly recommended to take telescopic fishing rods!

Chapter 2

The Hullet lake area

The Hullet lake area is located at the margin of the South Greenland ice-sheet in Johan Dahl Land c. 30 km north east of the settlement of Narssarssuaq (Fig. 1). Within this area most major valleys are occupied by large outlet glaciers that extend from the ice-sheet margin. The largest of these is the Kiagtût sermiat that flows from the ice-sheet to within six kilometres of Narssarssuaq. In its northern part, the valley of the Kiagût sermiat glacier is connected to a north-south trending tributary valley. This valley is occupied by a glacier, Sydgletscher, that flows northwards from its source in the Kiagût sermiat trunk glacier. Sydgletscher is therefore unusual since, unlike most glaciers, it flows upvalley. The lake Hullet occurs north of Sydgletscher and is impounded by the glacier terminus which forms the southern margin of the lake (Figs. 1 and 2). Two outlet glaciers, Nordgletscher and Østgletscher, are located north and east of Hullet. Meltwater drained from these glaciers during spring and summer is discharged into the lake and causes it to rise. The lake also receives water from local streams, by precipitation and from the calving into the lake of icebergs at the snout of Sydgletcher.

Observations of changes in the level of Hullet have indicated that since 1960, the lake has been subject to periodic drainage (Weidick 1963, Brathay 1969, Clement 1982).

During each period of lake drainage, the lake is emptied beneath Sydgletscher and Kiagtût sermiat glacier along a c. 23 km subglacial tunnel. The last drainage of Hullet occurred during October 1981 and resulted in flooding of the lower Narssarssuaq valley and the discharge of large volumes of freshwater into the adjacent fjord. In the Hullet area, numerous glacial moraines and lake shorelines indicate that the size of Sydgletscher and the location of the ice-dammed lake Hullet have varied considerably since the Holocene climate optimum. In the following pages, evidence is presented for the sequence of former glacier oscillations and the development of ice-dammed lakes in this area.

Techniques and Field Methods

Prior to fieldwork, published maps of the Hullet area (Brathay 1969, 1980) were enlarged to 1:5000 scale. Owing to the changing level of Hullet, the

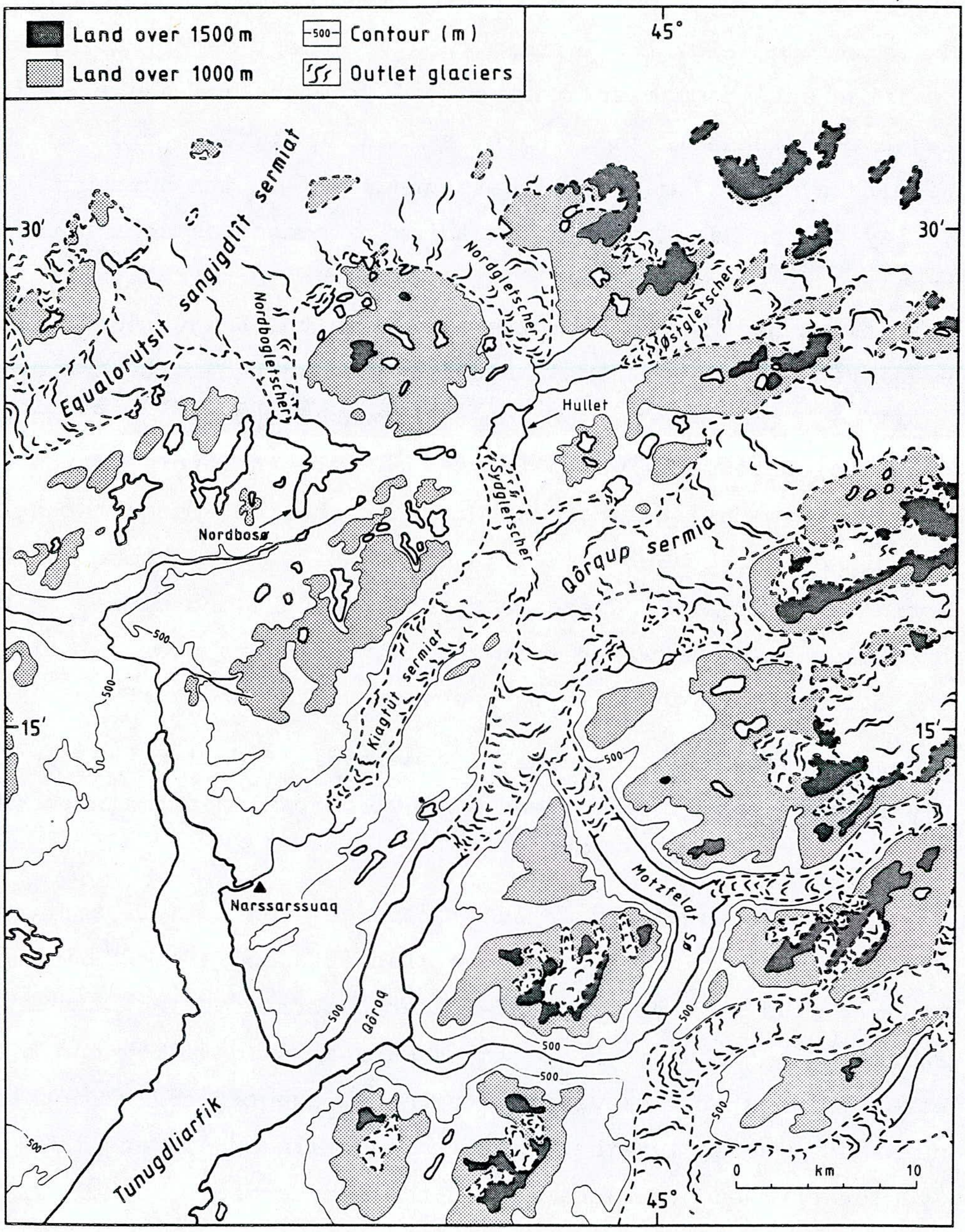


Fig. 1 The Hullet lake area, South Greenland.

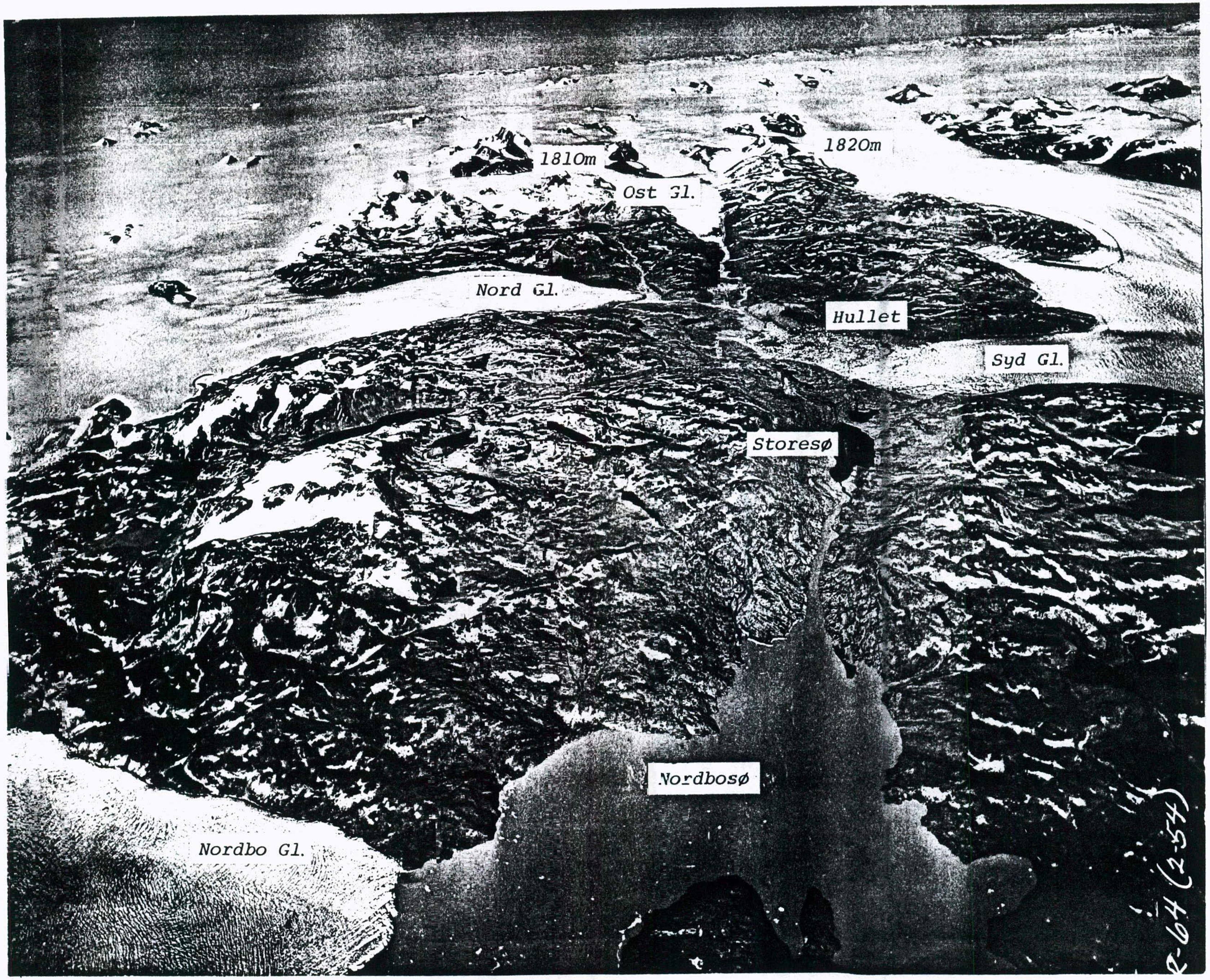


Fig. 2 Oblique aerial photograph of Johan Dahl land and the Hullet lake area, South Greenland. Copyright Geodaetisk Institut, Copenhagen.

mapped perimeter of the lake was drawn as the 474 m level measured by Brathay on 29th July,1969. All ice-marginal landforms were initially mapped from aerial photographs supplied by the Brathay Exploration Trust, the Department of Geography, University of Aberdeen and the Geodaetisk Institute, Copenhagen. Thereafter, the mapping of landforms was checked and amended in the field.

During fieldwork (August 3-23, 1982) the altitudes of all ice-dammed lake shorelines were determined by instrumental levelling using a Kern NAK2 level and a metric staff. All traverses were closed and where closing errors exceeded 0.05 m, the traverses were repeated. The datum level used in the research was selected as a cairn established by the 1969 Brathay Expedition, on the main abandoned ice-dammed lake shoreline adjacent to Langesø (Fig. 4). Brathay (1980) re-surveyed the altitude of the cairn base by aneroid barometer and confirmed a value of 684 m.a.s.l. Numerous temporary bench marks were established throughout the field area and all of these were closed with respect to each other and to the original datum. In order to calculate daily changes in the water level of Hullet a temporary bench mark was established adjacent to the lake. Thus, the lake surface altitudes were related to local datum.

Drainage of Hullet - October 1981

In order to calculate the volume of the lake Hullet prior to its October drainage, the following information was used. The only accurate map of Hullet was published by Brathay (1980), who showed that on 29th July, 1969, the lake had an area of 5.7 km^2 and an altitude of 474 m. We assume the same lake area for the first 1982 survey of Hullet (4th August, 1982) when the lake had an altitude of 474.4 m. The maximum level of the lake immediately prior to the October, 1981 drainage is indicated by the upper limit of stranded icebergs located c. 40-45 m above the August 1982 lake levels. The crests of the highest group of stranded bergs occur at 520-521 m and are continued elsewhere around the lake by an abandoned shoreline below which are thick accummulations of lake sediments. Since the highest level of stranded bergs measured by Brathay during 1969 was 516 m, it would appear that the lake has regularly attained similar altitudes prior to its drainage during the last c. 20 years. These maximum altitudes also correspond with altimeter readings (515 m and 518 m) of maximum lake levels measured by Grønlands Geologiske Undersogelse (Clement 1982, p. 60) on 22nd August, 1980 and 24th September, 1981.

Minimum lake level altitudes have been documented for 30th June, 1960 (Weidick 1963) and 3rd October, 1980 (Clement 1982). For example, during July, 1960, Weidick observed that the lake was almost entirely drained of water and that its level was c. 430 m. Hence, in order to calculate a minimum volume of the lake prior to drainage, it was assumed that:

(a) the 475 m lake has an area of 5.7 km^2

(b) the maximum lake level was 521 m

(c) the lake bed is flat at 440 m

(d) the average lake perimeter slope is 20^o

(e) 5% of the lake volume is displaced by icebergs.

The results indicate a lake volume of c. 397 x $10^6 m^3$. This value is suggested as a minimum lake volume prior to drainage since:

(1) the lake floor locally occurs below 440 m and

(2) the iceberg displacement volume may be too high.

Observation on the changing levels of Hullet during June, 1960 (Weidick 1963) indicate that during this period, complete lake drainage occurred. Drainage of ice-dammed lakes may often occur as a catastrophic discharge of water during a short period of time. The catastrophic drainage, or jökulhlaup, of an ice-dammed lake is imperfectly understood. However, the principal conditions are:

(i) that a subglacial tunnel is present beneath the ice so that the lake waters may escape. Under certain conditions, ice-dammed lakes may drain across the glacier surface or along its sides. However, in the case of Sydgletscher, lake drainage has always taken place beneath the ice (Weidick 1963).

(ii) that the ice-dammed lake is of sufficient depth to float the barrier of ice that dams the lake. In this way the lake may undermine the glacier margin and eventually connect with a subglacial tunnel.

(iii) that during lake drainage, thermal erosion of ice by meltwater in the subglacial tunnel results in the enlargement of the tunnel and hence enables the rapid discharge of the escaping meltwater.

(iv) that lake drainage eventually leads to the collapse of the ice barrier and may cause blockage of the lake outlet. Diminished water flow within the tunnel (either as a result of blockage or after complete lake drainage) results in tunnel closure by ice pressures.

Although rates of lake level rise are known for several periods (Fig. 3), the rate at which Hullet is drained has only partly been documented. That the lake drained completely between 22nd August and 3rd October, 1980 is indicated by the reported fall in lake level from 515 m to 421 m during this period. However in 1981, between 24th September and 8th October, partial lake drainage took place from 518 m to 481 m (Clement 1982). The occurrence between 518 m and 521 m of the highest stranded icebergs indicates also that the lake did not exceed these altitudes before falling to 481 m. During this period of lake drainage approximately 235 x 10^6 m^3 of water was released from the lake and escaped subglacially beneath Sydgletscher. Hence the average rate of lake drainage during this period was c. 200 m^3 s^{-1} and is equivalent to an average lowering of the lake level by 11 cm/hour. Evidence that the lake lowering from 518-521 m to 481 m was associated with a slow pattern of drainage rather than by a catastrophic outburst, is also indicated by a staircase of c. 14 shorelines at the northern end of Hullet that extend from 521 m to the present lake level (475.4 m on 4th August, 1982). All of the shorelines could only have been produced during the last (1981) lake drainage event. Their formation during a period of slowly (or pulsed) falling lake level is therefore indicated. Thus 14 separate shorelines were produced in fourteen days, during which period the lake was subject to a progressive and slow lowering. Indeed, the reconstructed lake volumes show that by 8th October, 1981, over 60% of the initial lake volume had been drained. By inference, the subglacial tunnel outlet was not opened sufficiently to permit a major jökulklaup.

The above interpretation contrasts with many published accounts of other ice-dammed lakes whose observed patterns of drainage are catastrophic (see Clague and Mathews 1973, Blachut and Ballantyne 1976). Indeed Clague and Mathews suggested that a good relationship exists between the volume of water drained from an ice-dammed lake and the peak flood discharge of the water on its emergence at the glacier snout. The relationship proposed by them is based on measurements from ten ice-dammed lakes and is expressed as:

$$Q\ max = 75\ V\ max^{0.67}$$

where Q max = the peak flood discharge (m^3 s^{-1})

V max = the total volume of water drained from the ice-dammed lake (in m^3 x 10^6)

Application of this relationship to the 1981 Hullet drainage suggests a peak water discharge at the snout of Kiagtut sermiat glacier of c. 4130 $m^3\ s^{-1}$. Although no information is available for the rate of lake drainage after the lake had fallen to 481 m, when 40% of the original lake volume remained undrained, it would appear that the Clague and Mathews (1973) drainage model does not correspond with the inferred pattern of lake drainage.

Changes in the lake level of Hullet: August 4th-22nd, 1982

The 1982 Hullet Survey indicated that the lake altitude on the first day of measurement was 475.4 m. (4th August, 12.35 hours). Hence by assuming the basin shape and area parameters as outlined above, daily increases in lake level measured during August 1982 were calculated as equivalent volumes of water added to the lake. Table 1 shows the measured increases in the level of the lake Hullet for each 24-hour period from 4th-22nd August. Also shown are the estimated volumes of water entering the lake for each 24-hour period. These values have been adjusted for the changing shape and volume of the lake for each lake level rise. In this way the mean daily discharge of water into the lake was calculated. These values represent the sum of:

(a) the combined discharge of the Nordgletscher and Østgletscher meltwater rivers

(b) the combined discharge of other minor rivers entering the lake

(c) daily precipitation

(d) any rise in lake level caused by water displacement associated with iceberg calving from Sydgletscher.

It is assumed that during this period of measurement, there was no subglacial leakage of lake water beneath Sydgletscher. Indeed, any leakage that may have taken place during this period would increase the calculated daily discharge values.

Moreover, since it is considered that 5% of the lake volume is occupied by icebergs, the calculated discharge values may be too high (probably by 5-10%). The data exhibits several trends. Firstly there is a progressive decline in discharge throughout August. Since most discharge is derived from Nordgletscher and Østgletscher meltwater, the decline is considered to be related to diminishing ablation over the ice-sheet. Superimposed on this long term trend, is a high daily variability in discharge values (for example 14-15 August and 20-21 August). This is partly due to the periodic occurrence of föhn winds that drastically increase ablation rates and to periodic tapping and damming

TABLE 1

Date (1982)	Cumulative Lake Level Rise (m)	Volume Increase ($\times 10^6 m^3$)	Average Q ($m^3 s^{-1}$)
August 4	1.20	6.799	77.9
August 5	2.00	4.543	52.2
August 6	3.03	5.888	69.3
August 7	3.70	3.839	44.4
August 8	4.37	3.860	44.7
August 9	4.92	3.166	36.6
August 10	5.64	4.169	45.0
August 11	6.22	3.359	41.9
August 12	7.06	4.895	48.9
August 13	7.50	2.563	34.6
August 14	8.24	4.331	43.9
August 15	8.58	1.994	26.5
August 16	-	-	20.0*
August 17	9.20	3.644	20.0*
August 18	-	-	37.2*
August 19	10.24	6.143	37.2*
August 20	10.44	1.173	13.2
August 21	10.96	3.084	37.1
August 22	11.48	3.091	34.5

* these values are calculated as averages

Surveyed lake-level rises of Hullet, August 4-22, 1983. The daily volumes of water added to the lake ($\times 10^6 m^3$) and the daily average discharge into the lake ($m^3 s^{-1}$) are also given.

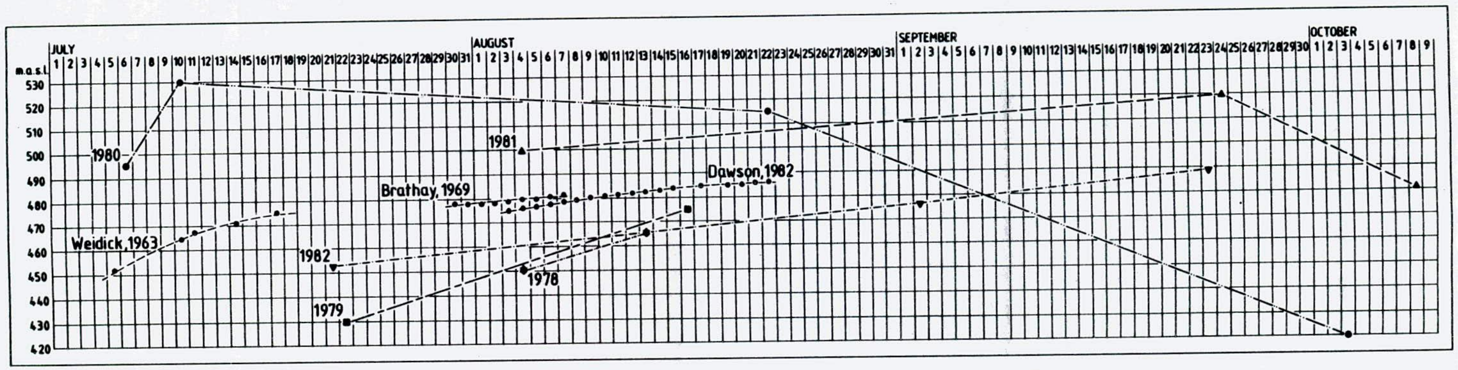


Fig. 3 Measured changes in the level of the glacier-dammed Hullet lake since 1960 based on Weidick (1963), Brathay (1969), Clement (1982) and this author.

small subglacial lakes beneath Nordgletscher.

The latter explanation, for example, is considered responsible for the marked variations in average discharge between August 15th and 21st. On 15th and 19th August, large sections of the ice cliffs which form the snout of Nordgletscher were observed to collapse onto the proglacial zone. The ice blocks which collapsed along the western section of Nordgletscher resulted in the damming of the adjacent meltwater river and its diversion underneath the glacier. On both occasions, the ice falls were followed by major declines in the stage level of the Nordgletscher river and a simultaneous decrease in the rate of rise of the Hullet lake. Thus the process of river diversion and the decline in the stage level of Nordgletscher indicate clearly that the pattern of river diversion was accompanied by meltwater storage beneath Nordgletscher. On the 18th and 21st August, sufficient melting of the ice boulders had taken place to permit the restoration of the original drainage. Since the latter events were accompanied by major flooding of the Nordgletscher river along its original course, it is inferred that the source of the excess meltwater was produced by the tapping of the subglacial lakes which were filled during the preceding phases of river diversion. The maximum daily rate of lake level rise in Hullet was 1.2 m/day (4th August), while the total lake level rise during the period of obervation was 11.5 m. These values are stressed since they clearly indicate the dynamic changes that take place in ice-dammed lake environments.

Former glacier oscillations in the Hullet area

The existence of a climatic deterioration after the mid-Holocene climatic optimum has been recognised in West Greenland (Kelly, 1980) and was characterised by an increase in glacierisation. Within the Hullet area, numerous fossil lateral and terminal moraines testify to former glacier-oscillations that took place after the climatic optimum. At present knowledge of these events is poor since the ages of most moraines have not been determined. The most comprehensive account of glacier oscillations in this area is by Weidick (1963) and is briefly summarised below (see also Fig. 4).

Weidick (1963) proposed that the main expansion of glacier ice accompanied the formation of the Narssarssuaq moraines which he sub-divided as having been formed during Stages I, IIa and IIb. At Narssarssuaq the presence of

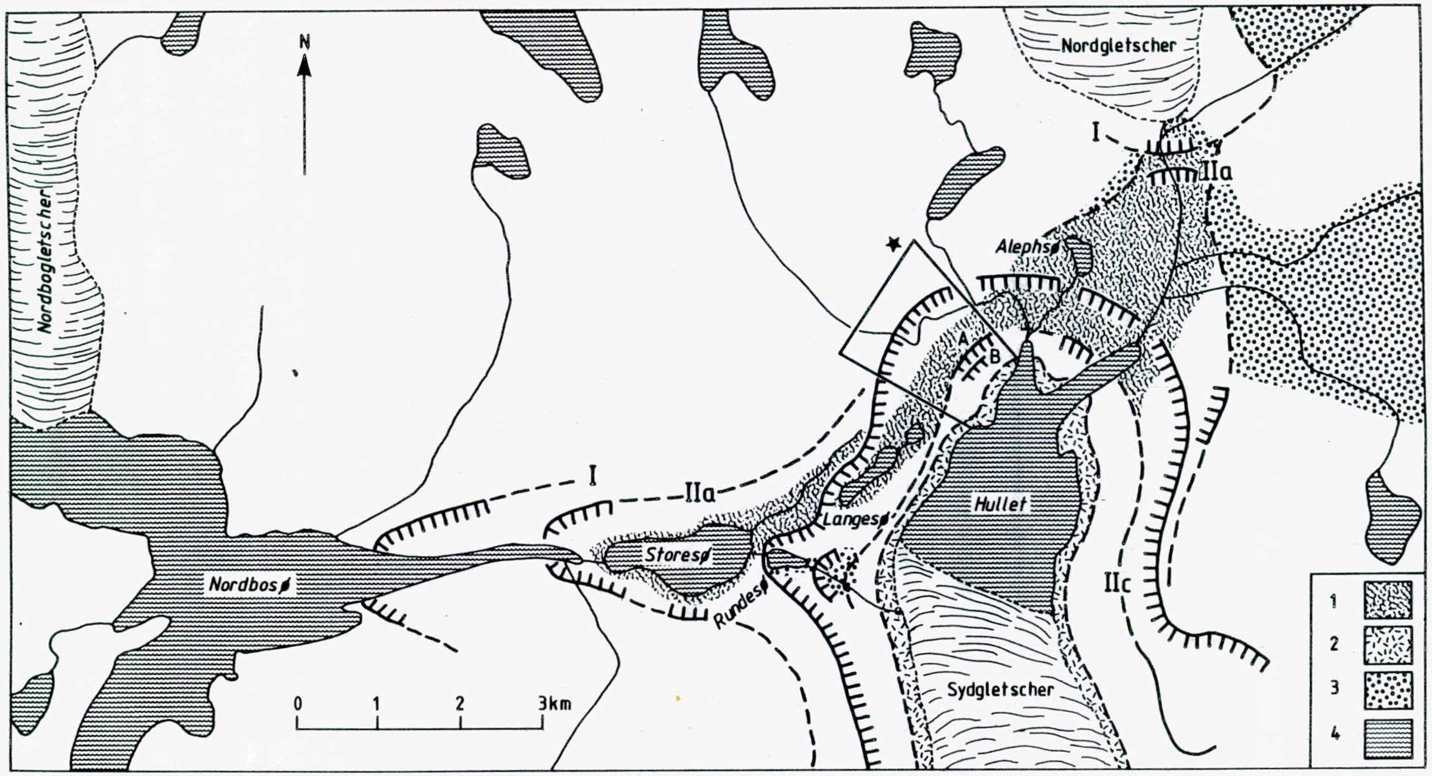


Figure 4 Glacier limits in the Hullet area as presented by Weidick (1963, Fig. 11) 1. Lake and river deposits 2. Sydgletscher trim line zone. 3. Terraces (undifferentiated). 4. Lakes. The area shown by an asterisk represents the area from which measurements were undertaken on the lichen Rhizocarpon geographicum. A and B represent sections of the stage IIc West Hullet moraines (see text, Fig. 12 and Table 3).

Norse buildings on outwash plains belonging to the stage II moraines (Weidick 1963, p.51) indicate that the moraines are almost certainly older than those produced elsewhere during the Little Ice Age. Moreover, Kelly (1980) has argued on palynological grounds that the Narssarssuaq moraines were produced between 1000 and 2500 years B.P. Weidick, however, (1963, p.31) proposed that the Stage I ice advance was older than the Holocene climatic optimum and that this was followed by an intermediate period during which the ice had a more limited extent than at present. Thereafter a major Neoglacial ice advance occurred during Stage II.

Following Stage II, there was a recession of the ice which was succeeded by a readvance of ice in historical times, Weidick suggested that evidence for the latter advance occurs at Sydgletscher where historical observations of ice dimensions and the presence of a trim line zone above the glacier margin indicate that the glacier retained its maximum extension until c. 1900. Thereafter significant ice retreat took place.

It should be stated that Weidick (1963) stressed that most of the SW Greenland glaciers responded differently to climatic change during the Neoglacial. Hence it is extremely difficult to correlate moraines between different glaciers. This is clearly illustrated by recent glacier oscillations in the Hullet area. For example, Nordgletscher has advanced 600 m since 1947 (Clement 1982) and similarly, c. 12 km farther west, Nordbøgletscher has advanced 665 m since 1942 (Clement 1982). In contrast Sydgletscher has remained essentially stationary since 1960 (cf. Weidick 1963, Brathay 1969, 1980) and may even have retreated.

In the following pages new evidence is presented on former glacier oscillations in the Hullet area. The information is presented within the context of stages I, IIa and IIb proposed by Weidick. The discussion also attempts to examine critically the field evidence on which Weidick's relative chronology is based.

Stage 1

Weidick (1963) suggested a distribution of stage I ice as shown on Fig. 4. He described a series of terminal and lateral moraine fragments at the eastern end of Nordbosø lake and proposed that they were produced by an outlet glacier that flowed westwards from Sydgletscher. The presence of the outlet glacier at Storesø and eastern Nordbosø during stage I requires a more advanced position of Sydgletscher. However, Stage I moraines produced by

Sydgletscher have not been identified, Weidick having suggested that they were eroded during the stage II advance of Sydgletscher ice. The position of Nordgletscher during stage I is uncertain. Weidick (1963, p.29) described an exposure south of the 1963 Nordgletscher snout that he considered as indicative of a Stage I ice advance (Table 2).

Weidick assigned units A and B to a glacial advance during stage II and unit D as part of a moraine produced during stage I. Consequently, unit E was proposed as having been deposited in an ice-dammed lake impounded between Sydgletscher and Nordgletscher prior to the stage I ice advance. This section has now been destroyed by the recent advance of Nordgletscher. However, numerous sections of glacial deposits are presently exposed opposite the snout of Nordgletscher. At numerous places, isolated lenses (up to 0.7 m thick) of laminated silts and clays are both overlain and underlain by glacial till. In the Hullet area, such laminated deposits may accumulate in:

(a) ice-dammed lakes
(b) in subglacial water bodies
(c) in topographic depressions where fallen blocks of ice have collapsed from the glacier snout onto the adjacent ground surface (e.g. at the snout of Nordgletscher).

As a result, the presence of laminated sediments need not indicate the former presence of a <u>large</u> ice-dammed lake. Moreover, the presence of glacial till deposits should not be considered synonymous with an end moraine.

South of the present snout of Nordgletscher, the presence of well-developed terminal and lateral moraines indicates that Nordgletscher reached a more advanced position during stage I or II (Fig. 4). The clearest feature is an arcuate end moraine located on the interfluve between the Nordgletscher and Østgletscher rivers. The end moraine is continued west of Nordgletscher river by a large lateral moraine fragment that is continuous as far as the snout of Nordgletscher. The former movement of ice towards the position of the end moraine is also supported by the orientation of fresh glacial straie (160^{o}) recorded on ice-moulded bedrock exposures in Nordgletscher river. The end moraine is succeeded upslope by shorelines of an ice-dammed lake produced during stage IIb. Thus formation of the end moraine during stage I or II requires that the snout of Nordgletscher terminated in an ice-dammed lake and that the moraine could only have been produced by the collapse of the glacier snout onto the floor of a drained ice-dammed lake.

<u>Stage IIa</u>

There is no morphological evidence to indicate whether the outlet glaciers

TABLE 2

	Top		Unit
0-0.5 m	Sandy till with large rounded boulders		A
0.5-1.5 m	Sandy till, sometimes passing into cross-bedded alluvial deposits with few rounded boulders	glacial beds	B
1.5-1.8 m	Red layer of large rounded bounders with a sandy matrix, cemented together by hematite	glacio-fluvial beds	C
1.8-2.1 m	Sandy-gravelly cross-bedded layers with sub-angular boulders		
2.1-2.7 m	Sandy till, exclusively with subangular boulders	glacial beds	D
2.7-6.5 m	Cross-bedded sand with rounded boulders, passing gradually downwards into almost varved silt and clay	glacio-fluvial beds	E
	Base		

Lithostratigraphic units form the front of Nordgletscher described by Weldick (1963, p.29).

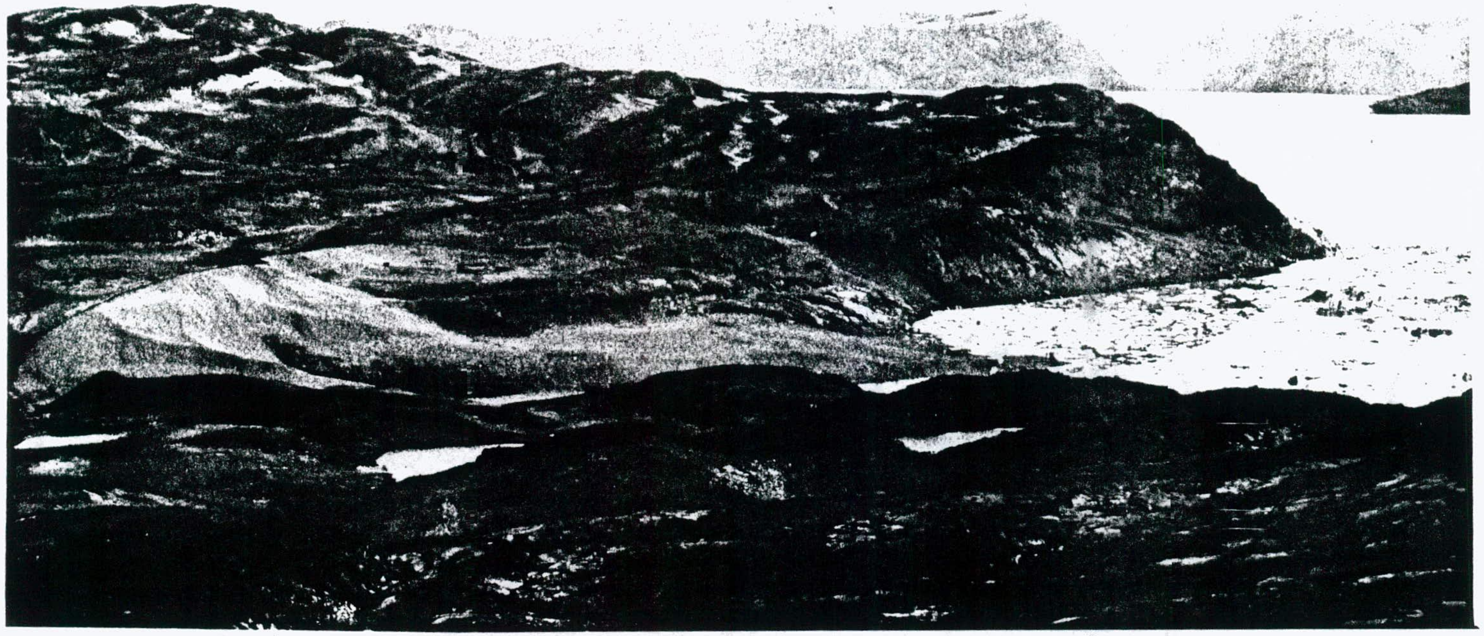


Fig. 5 Photograph of the Hullet area showing the lake, Sydgletscher and in the distance the Kiagtut sermiat glacier. The stage IIb end and lateral moraine complex of Sydgletscher is also a clear feature and is visible as far as the slopes above the lake. The trim line zone is also a clear feature and is shown as a horizontal line on the slopes above the lake.

receded between stages I and II (Weidick, 1963). However, if the intervening period is represented by the Holocene climatic optimum, this would appear likely. The ensuing stage II ice advance was suggested by Weidick as representing a clear landscape unit. The earliest ice advance of this stage (IIa) is indicated by an end moraine and adjacent lateral moraine at the western end of Storesø (Fig. 4). In this area the end moraine is c. 30 m high and is succeeded westward by outwash terrace fragments that decline in altitude towards Nordbosø. Weidick (1963, p. 32) suggested that during stage IIa, Sydgletscher extended northwards to almost the present position of the Nordgletscher snout. He argued that Sydgletscher impounded an ice-dammed lake during this period and proposed that "kame terrace fragments" south of Østgletscher represented the margin of a 700 m lake that ultimately drained via Storesø into Nordbosø. It is suggested here that this interpretation requires modification. The "kame terrace fragments" described by Weidick on both sides of the Hullet valley occur at a uniform altitude of 684-685 m. The morphology and distribution of the features and their regionally uniform altitude indicate clearly that they are <u>shoreline</u> fragments of an abandoned ice-dammed lake. However, on the west side of the Hullet valley, the shoreline is eroded in glacial deposits produced during stage IIb (see page 17). Hence the 684 m lake was produced during or after stage IIb. There are no fossil shorelines above 684 m to indicate the existence of a similar ice-dammed lake during stage IIa. It is therefore likely that during stage IIa, Sydgletscher and Nordgletscher were contiguous ice masses.

Stage IIb

Weidick (1963, p. 32) considered that stage IIb represents the main Neoglacial stage in the Hullet area. During this period, a well-developed end moraine c. 40 m high was produced at the snout of Sydgletscher (Fig. 5). The end moraine extends almost continuously across the Hullet valley and is located at Alephsø c. 4.5 km north of the present snout of Sydgletscher (Fig. 4). The end moraine is continued on both sides of the Hullet valley by well-defined lateral moraines that can be traced intermittently over c. 22 km to the Narssarssuaq area. On the east side of the Hullet valley, lateral moraine fragments produced during this period extend as far as Kiagtût sermiat glacier. On the west side of the Hullet valley at Rundesø (Fig. 4) the lateral moraine passes into a terminal moraine, the western margin of which is located between Rundesø and Storesø lakes. That moraine deposition at Rundesø was complex is indicated in several areas by triple end moraine ridges. The

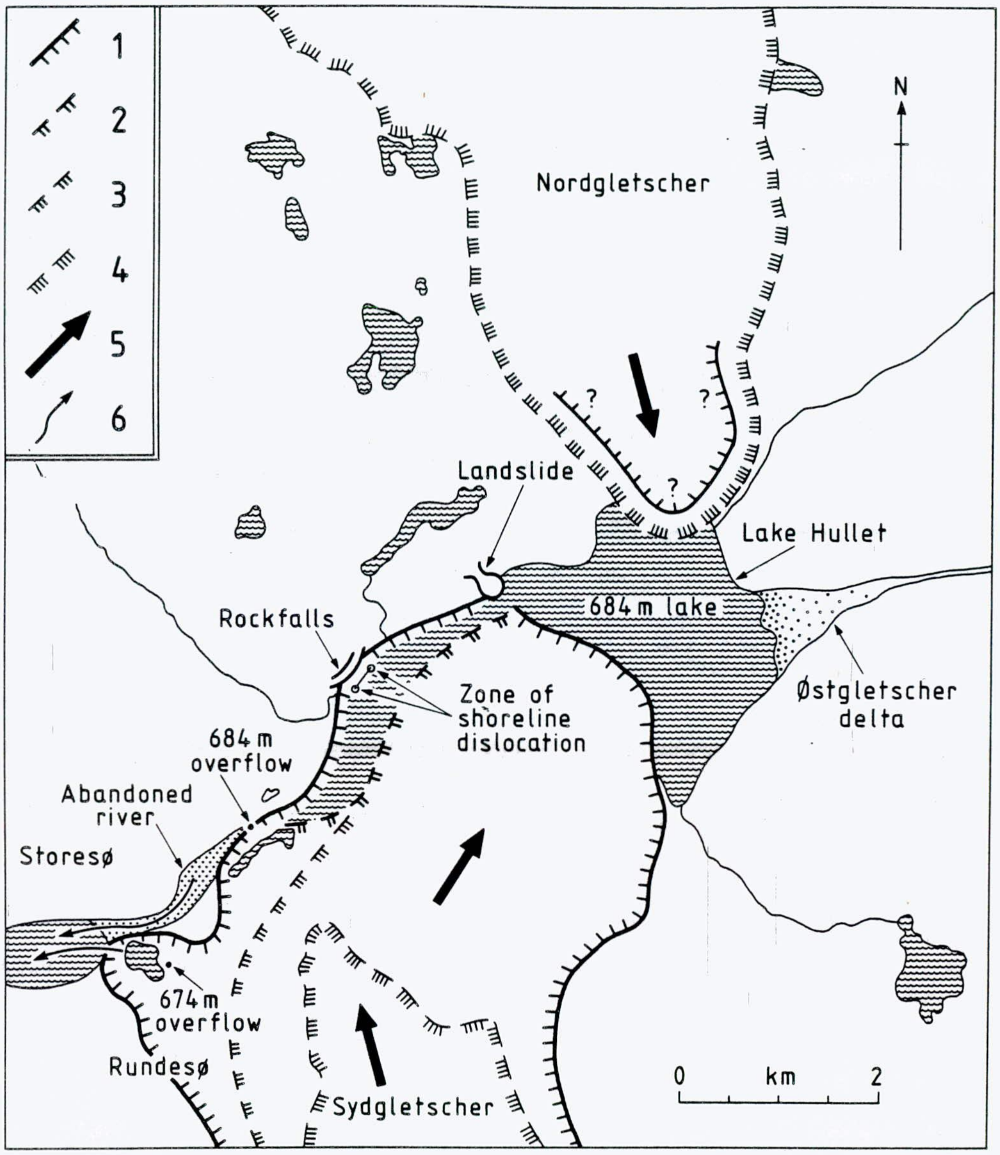


Fig. 6 Reconstruction of the Hullet area during the 684 m and 674 m lake phases. The locations of the 684 m and 674 m overflow channels are also shown. Owing to the recent advance of Nordgletscher, its position during the 684 m lake phase is not known. The locations of the landslide, the zone of shoreline dislocation and the major area of rockfall are also shown. 1. stage IIb ice-limit 2. Location of stage IIb ice margin during maximum expansion of 684 m lake 3. Location of stage IIb ice margin during 674 m lake phase 4. Positions of Sydgletscher and Nordgletscher, 1982 5. Ice-flow directions 6. Overflow channel routes.

continuity and size of the lateral and terminal moraines over a wide area leave ittle doubt that they were deposited during a glacial advance associated with the expansion of the Kiagtût sermiat glacier, Sydgletscher and the Rundesø glacier lobe. Together the stage II moraines may be defined as the Narssarssuaq moraines (Weidick, 1963).

During stage IIb a large ice-dammed lake was impounded between Sydgletscher, Østgletscher and Nordgletscher (Fig.6). The lake margin during this period is defined by a well-developed shoreline at c. 684 m which is virtually continuous on both sides of the Hullet valley. The shoreline is locally up to 50 m wide and at several locations is backed by a rim of lake ice-pushed boulders. Discussion on the evolution of this lake (hereinafter referred as the 684 m lake) is presented later. Southeast of the present Nordgletscher snout, the 684 m shoreline merges with a large fossil delta (Fig. 6), the inner edge of which occurs at the same altitude as the shoreline. The delta displays foreset and topset bedding and its altitude clearly indicates that the feature was deposited in the 684 m lake. The source of the sediment of which the delta is composed is therefore derived from meltwaters that issued from Ostgletscher during the existence of the 684 m lake. Hence during stage IIb, the position of Østgletscher varied little from its present position.

Glacier oscillations after stage IIb

The former existence of an ice-dammed lake that was subject to numerous changes in lake level and which was contemporaneous with the formation of the Sydgletscher end moraine south of Alephsø is demonstrated by sets of abandoned lake shorelines eroded in the distal slopes of the end moraine. The contemporary presence of Sydgletscher ice during the existence of the lake is suggested by the absence of shorelines at similar altitudes inside the moraine. However, at lower altitudes, lake shorelines are eroded on both sides of the end moraine and extend considerable distances southward. The most conspicuous of these shorelines is at 577 m and extends as far southward as a second end moraine located between Hullet and the stage IIb Sydgletscher end moraine (Fig. 4). The end moraine and associated lateral moraine are best developed west of Hullet where they consist of a vegetated ridge c.5 m high and ca. 800 m long. South of the moraine, the 577 m shoreline is absent. Therefore it is suggested that this lake was produced following a glacial retreat of Sydgletscher from its stage IIb to IIc positions. Two brief glacial stillstands (IIb, and IIb_2) interrupted the general retreat of ice between stages IIb and IIc. Interpretation of these stillstands is based on evidence of former lake level changes. These are discussed on pages 25-6.

South of the stage IIc moraine, the only other end moraine is reported as located on the floor of Hullet (Weidick 1963, pp. 36-37). Weidick suggested that this feature was produced around 1900 when Sydgletscher attained a more advanced position than at present. Weidick (1963, pp. 35-38) correlated the end moraine with a well-defined trim line zone that occurs parallel to and on the slopes above the present margin of Sydgletscher. Weidick therefore interpreted the trim line zone as indicative of the margin of Sydgletscher at c. 1900. The trim line zone occurs between 556 m and 571 m (Weidick (p. 39) quotes 600 m) around Hullet and is continuously developed at this level. However, the 556-571 m altitude zone also coincides with maximum levels of former ice-dammed lakes impounded by Sydgletscher during and prior to 1900. It is therefore argued (see p. 25) that although the trim line zone is a true ice-marginal landform elsewhere in this area,: the feature also represents the upper zone of lake deposits around Hullet: It is also proposed that the position of the c. 1900 glacial trim line zone around Hullet cannot be determined but presumably is located at and below the level of the lake deposits. Hence it is clear that the investigation of various levels attained by former ice-dammed lakes in the Hullet area is critical to the reconstruction of former glacier oscillations in this area.

Former ice-dammed lakes

During the expansion of Sydgletscher during stage IIb a large ice-dammed lake was impounded by the glacier (Fig. 6). The altitude of the lake is represented by a well-developed shoreline at 684 m. The lake possessed an area of c. 10 km^2 and had an estimated volume of c.947 x 10^6 m^3 of water (approximately 2.4 times the present volume of Hullet). The lake shoreline is locally up to 50 m wide and is virtually continuous around the margin of the former lake. the shoreline is generally eroded in unconsolidated Quaternary sediment but locally (e.g. between Nordgletscher and Alephsø) the feature is eroded in granite bedrock. On the eastern side of Nordgletscher, the shoreline extends as far as the present ice-margin. Farther east, the shoreline merges with the Østgletscher delta that resulted from the progradation of fluvioglacial sediments into the 684 m lake. Notably, the shoreline terminates at the stage IIb end moraine northeast of Hullet. In the centre of the Hullet valley, the end moraine is everywhere located below 684 m. Hence the absence of the 684 m shoreline inside the stage IIb ice limit on the east side of the Hullet.

valley indicates the contemporary presence of active Sydgletscher ice during stage IIb over the eastern and central parts of the Hullet valley (Fig. 6).

On the western side of the Hullet valley, the 684 m shoreline is present both inside and outside of the stage IIb ice-limit (Fig. 6). For example, southwest of Alephsø the 684 m lake shoreline is a continuous feature and is eroded in the proximal and distal slopes of the end moraine. Thereafter, the feature is continued southward for 3 km and is eroded on the inside of the stage IIb lateral moraine. The shoreline extends as far south as Langesø where it merges with an abandoned lake overflow channel (Fig. 6).

The shoreline is best preserved between Langesø and Alephsø lakes (Fig. 4) where it is backed by lake ice-push boulder ramparts (Fig. 7). The shoreline surfaces are generally flat and are usually bare of vegetation. Notably the shoreline fragments are free of local topographic depressions and undulations. At two locations, however, exceptions to this pattern occur. Between Langesø and Alephsø, (Fig. 4), the continuity of the shoreline is interrupted by three large kettle hole depressions. The features are c. 40 m deep and are 85 m, 100 m and 145 m wide respectively. The kettle holes possess open eastern flanks and are continued downslope by widespread boulder accumulations. The bases of the kettle holes occur at c. 640 m and, significantly, their inner slopes, despite being partially colonised by vegetation, are not notched by any shorelines (i.e. between 640 m and 684 m).

The overflow channel near Langesø of the 684 m lake (Fig. 6) breaches a series of lateral moraine fragments produced during stage IIb. The channel surface occurs at 684.6 m and passes into an abandoned braided river that functioned as the overflow route for the 684 m lake. The abandoned river is ca. 2 km long and up to 500 m wide and consists of a series of anastomosing channels separated by channel bars consisting of large boulders. The channel bars are locally pitted by circular and oval depressions generally 1-2 m wide and 1 m deep. The most likely origin of these features is that they resulted from the deposition and melting of river ice blocks during periods of flood. This interpretation is supported by observations of recent river ice deposition in the proglacial river at the snout of Nordgletscher during periods of high river stage. During these periods, calved ice blocks are eroded by fluvial processes into c. 1 m^3 ice boulders and deposited on river bars. Thereafter the boulders were observed to melt <u>in situ</u> producing topographic depressions

Fig. 7 Fragment of 684 m shoreline near Langesø. The inner edge of the shoreline is defined by a boulder rampart formed by lake ice-push processes. Note that several of the boulders exhibit pronounced "lichen lines" that separate the rock surfaces where lichen growth only commenced after lake drainage from those where growth commenced before the shoreline was produced.

Fig. 13 Staircases of abandoned lake shorelines north of Hullet. Each shoreline is c. 1 m in width.

within the channel bar deposits.

At the southern end of the abandoned river, fossil fluvial deposits merge into a raised shoreline that surrounds the edge of Storesø. The raised shoreline here occurs at 679 m and is located 6 m above the present level of Storesø. The raised shoreline occurs at a uniform altitude around Storesø and is therefore demonstrably not a kame terrace (cf. Weidick, 1963). At the western margin of Storesø the shoreline is succeeded westward by fossil fluvial deposits that decline in altitude towards Nordbosø. Thus during the existence of the 684 m lake, Nordbosø was continuously supplied with overflow waters from this lake. At the western end of Rundesø, raised shoreline fragments at similar altitudes are eroded in and deposited upon the proximal slopes of the stage IIb Rundesø end moraine. Hence, during the existence of the raised (679 m) Storesø lake, sufficient ice stagnation and retreat of the Rundesø glacier lobe had takenplace to enable the Storesø lake to extend inside the Rundesø end moraine.

However, although stage IIb ice had retreated from the Rundesø and moraine, ice remained active east of Rundesø and at the western edge of Sydgletscher. This is demonstrated by the presence of an overflow channel at 674.2 m located immediately east of Rundesø. Hence, the existence of the 684 m overflow route demonstrates that the 674 m Rundesø overflow channel was not used until the entire Rundesø glacier lobe had melted. The significance of this inference is fundamental since it demonstrates that during the existence of the 684 m Hullet lake, ice had melted from the western margin of Sydgletscher from Alephsø to Langesø but not as far as Rundesø. Thus the 684 m overflow channel was utilised. However, the absence of the 684 m shoreline inside the stage IIb moraines on the east side of the Hullet valley shows that while the western flank of Sydgletscher was in stagnation, the eastern edge of the glacier was active.

Reconstruction of the dimensions of the 684 m lake indicate that the lake had an estimated volume of c. 950 x 10^6 m^3. The abandonment of the shoreline was presumably caused by lake drainage that could only have taken place either under or over Sydgletscher and Kiagtût sermiat glacier. Since present-day drainage of Hullet takes place by drainage through a subglacial tunnel beneath both glaciers, it is suggested that the drainage of the 684 m lake took place in this manner.

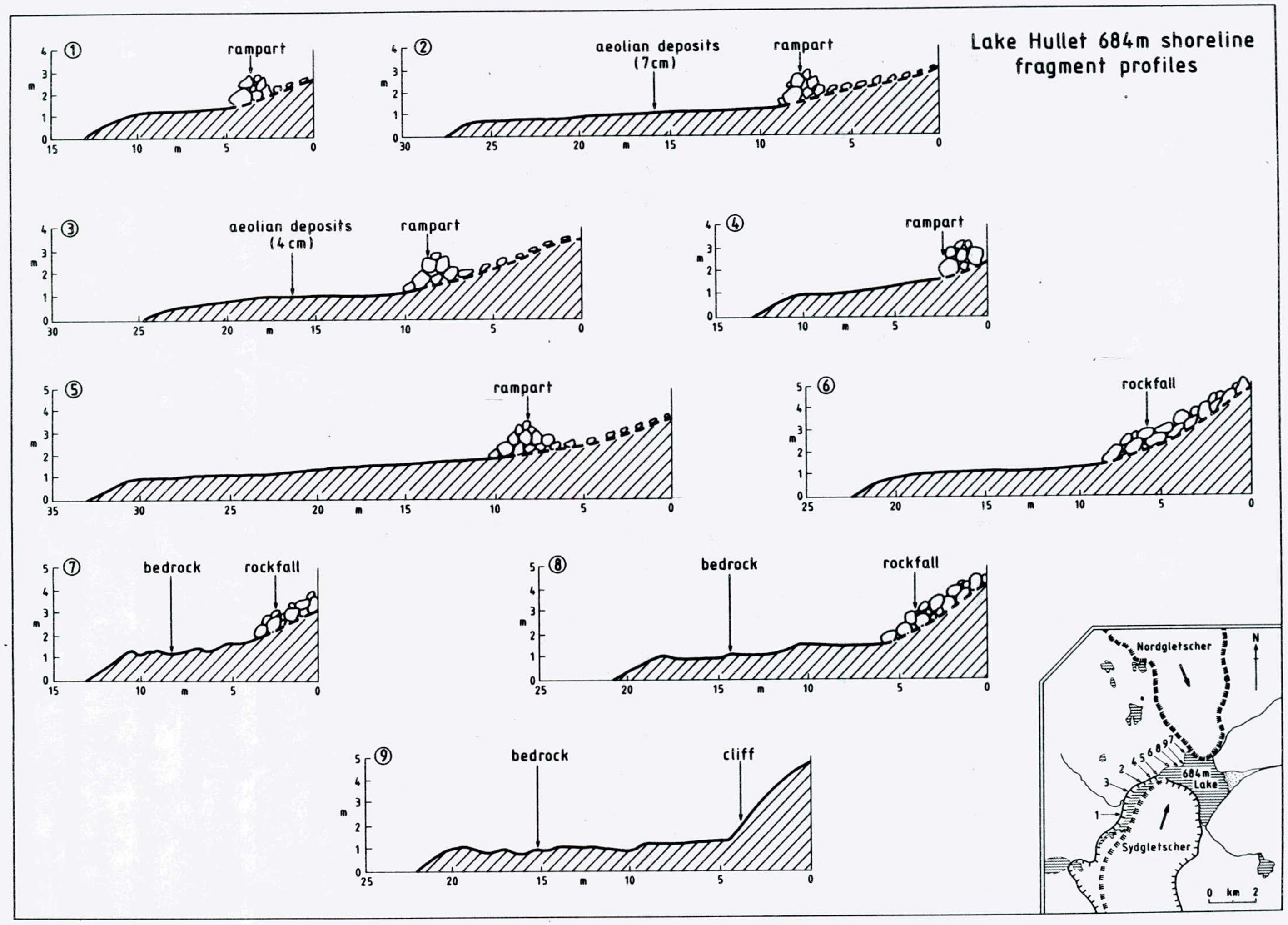


Fig. 8 Surveyed cross-profiles of 684 m shoreline fragments. The locations of the measurement sites are shown on the inset.

From the aforementioned, it could be argued that the 684 m shoreline is a composite feature caused by the repeated emptying of the lake and its refilling on several occasions to the 684 m level. This process is unlikely to have taken place for the following reasons. The refilling of the lake to the same level requires exceptional conditions. It requires that Sydgletscher had neither advanced or retreated during the refilling phases and that its thickness remained constant. That widespread stagnation of Sydgletscher was taking place during stage IIb is indicated by the erosion of the 684 m shoreline on the inside of the stage IIb lateral moraine between Alephsø and Langesø. Furthermore, the locations of the 674 m and 684 m overflow channels indicate the widespread glacier retreat that had taken place between the 674 m and 684 m lake phases and which had probably commenced during the existence of the 684 m lake.

The shoreline of the 684 m lake varies between 5 m and 50 m in width and is generally bare of vegetation. The feature is usually eroded in unconsolidated sediments but locally is eroded in granite bedrock (Fig. 8). The shoreline platform fragments in granite are attributed to frost-shattering on littoral cliffs and the removal of debris by lake ice during spring break-up and are similar to features described from other former ice-dammed lakes (eg. Sissons 1978). The constructional role of lake ice is also demonstrated by the presence of boulder ramparts that locally define the inner edge of the shoreline (Figs. 7 and 8). The ramparts most probably owe their origin to lake ice-push and ice expansion processes that may also be responsible for the extensively planated nature of the shoreline surface (Fig. 8) (cf. Worsley 1975).

The shoreline of the 684 m lake was surveyed at 50 m intervals along its length (Fig. 9). The altitudes clearly show, with two exceptions, the uniformity of altitude of the feature over a wide area. The exceptions to this trend occur c. 1 km north of Langesø where two blocks of the shoreline are dislocated by c. 1 m and 3 m above the general level of the feature. The two blocks of uplifted shoreline are respectively 200 m and 250 m in length (Figs. 9 & 10). The dislocated shoreline fragments are both clear features c. 15-25 m wide and backed by lake ice-push boulder ramparts. Moreover, the uplifted blocks of shoreline exhibit only minor variations in altitude along their lengths (less than 0.3 m) (Fig. 10) and thus indicate that the process of dislocation involved the block uplift of two entire

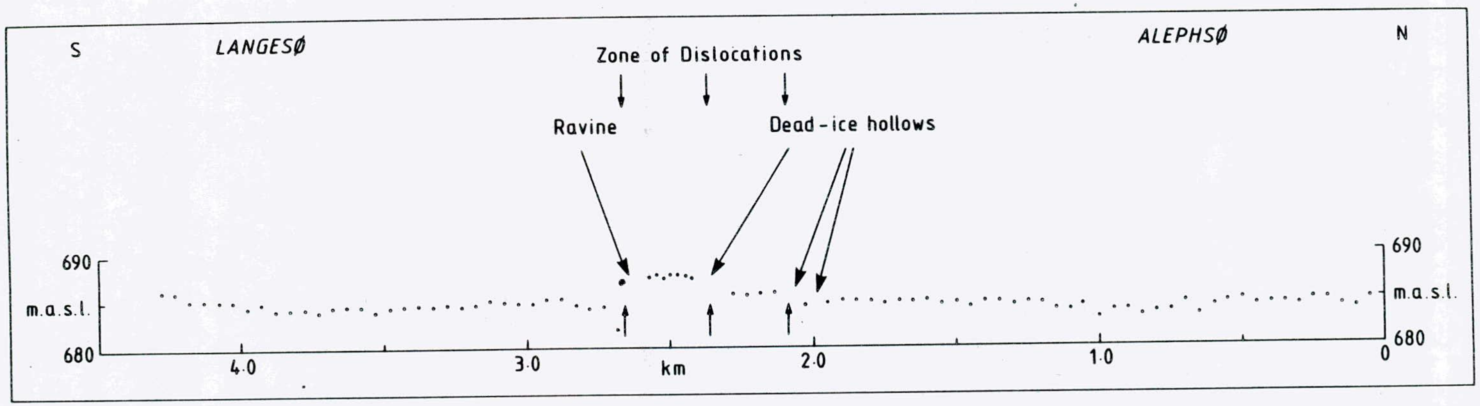


Fig. 9 Height-distance diagram of 684 m shoreline between Langesø and Alephsø showing the principal sections of dislocated shoreline. The locations of the kettle holes (dead ice hollows) and the incised alluvial channel (ravine) are also shown.

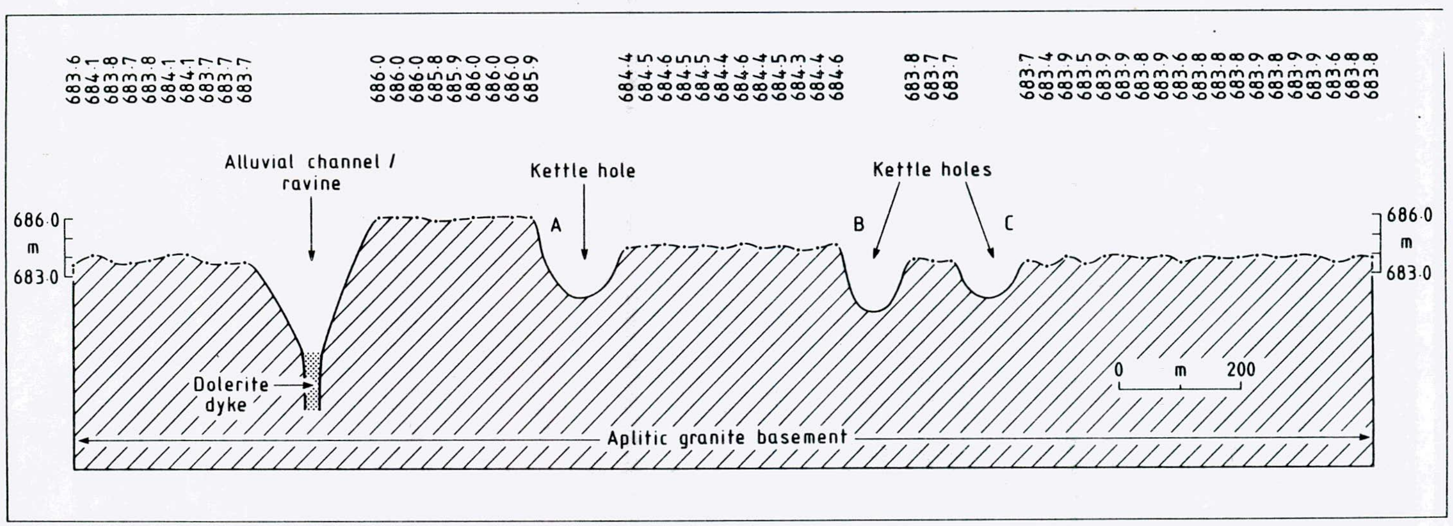


Fig. 10 Detailed height-distance diagram of area of shoreline dislocation showing individual surveyed altitudes. The widths of the kettle holes and the alluvial channel are drawn to scale. The depths of the latter features are represented diagrammatically and are not to scale.

sections of shoreline 200 m and 250 m in length. The dislocated shoreline fragments are separated from each other and from the remainder of the 684 m shoreline by two kettle holes (Fig. 10, A and B) and by an incised river channel eroded in Quaternary sediments and underlain by a dolerite dyke. Hence the locations of the dislocations occur in the areas occupied by the kettle holes. However, the precise mapping of the dislocation zones is not possible owing to occurences of unconsolidated surface sediments in both kettle holes.

From the above, it may be suggested that the zones of dislocation are associated with the presence of the kettle holes. However a third kettle hole (Fig. 10, C), c. 100 m wide, is also present farther north and interrupts the continuity of the shoreline in this area (Figs. 9 & 10). In contrast to the displacements described above, the 684 m shoreline occurs at exactly the same altitude on both sides of this kettle hole and therefore indicates that the shoreline dislocations are unlikely to be related to kettle hole formation.

Evidence is available of the timing of the shoreline dislocation. At several locations in the Hullet area, a poorly developed lake shoreline c. 1 m wide occurs c. 10 m below the 684 m shoreline. This shoreline is everywhere eroded in gravel and boulder accumulations that form the frontal slopes of the 684 m terrace. Owing to the narrow width of the feature and its development among large boulders, the measured inner edge altitudes of the shoreline fragments enable the reconstruction of the shoreline altitude to $\pm$ 0.5 m. The measured range of shoreline fragment altitudes is 673-675 m and includes fragments located in the dislocated area of the 684 m shoreline. The regional horizontality of the 674 m shoreline fragments therefore suggests that the dislocation of the 684 m shoreline took place prior to the formation of the 674 m shoreline.

Several explanations can be invoked to account for the differential block uplift of sections of the 684 m shoreline and most encounter major difficulties. For example, the view that shoreline dislocation took place through the collision of icebergs and shoreline sediments is not supported by the undisturbed nature of the uplifted shoreline blocks and their considerable dimensions. Furthermore, deformation of the shoreline fragments as a result of waterlogging of shoreline sediments is likely to induce local slumping rather than differential block uplift. Instead, it is suggested here that the differential

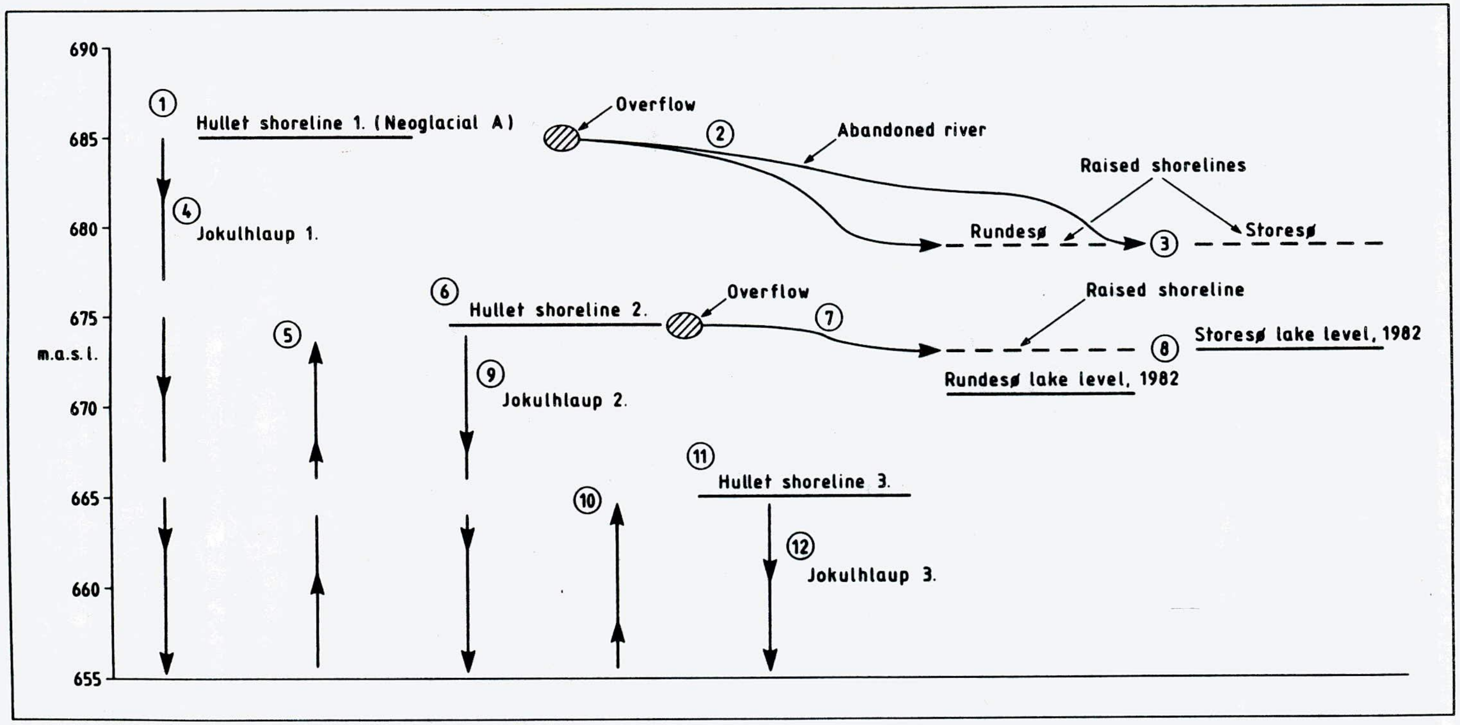


Fig. 11 Reconstructed sequence of drainage events associated with the 684 m, 674 m and later lakes.

block uplift of the shoreline fragments resulted from neotectonic activity of the earth's crust caused by the catastrophic drainage of the 684 m lake. This remarkable explanation is supported by two arguments. Firstly, block uplift associated with the drainage of the 684 m lake is in accordance with the inferred timing of the dislocations since these could only have taken place after the formation of the 684 m shoreline yet before the production of the 674 m shoreline. Secondly there are numerous published accounts of crustal faulting and earthquake activity induced by a) reservoir loading and unloading (Carder 1945, 1970, Gough and Gough 1962) b) postglacial glacio-isostatic uplift (eg. Lundqvist & Lagerbäck 1976, Lagerlund 1977. Mörner 1981) and by c) the catastrophic drainage of ice-dammed lakes (Sissons & Cornish 1982). The latter authors describe faulted shoreline blocks and landslide deposits that resulted from the catastrophic drainage of a former ice-dammed lake in Glen Roy, Scotland. Moreover, they demonstrated that crustal faulting took place during a period of glacier retreat. Carder (1970) and Sissons and Cornish (1982) have also noted that earthquake activity is particularly common where a lake or reservoir is deeper than 100 m owing to the high strains imposed on the underlying crust (the depth of Hullet during the 684 m lake period was c. 120 m).

It is therefore suggested that drainage of the 684 m lake triggered crustal activity that resulted in neotectonic faulting and the block uplift of separate shoreline fragments. That block uplift of this magnitude was triggered by drainage of the lake from 684 m to 674 m is unlikely. For example, a lowering of the lake level by c. 10 m implies the drainage through subglacial tunnels of c. 100 x 10^6 m^3 of water. It is suggested instead that the differential uplift of the shoreline blocks was associated with the complete drainage of the 684 m lake and the catastrophic drainage of c. 950 x 10^6 m^3 of water as a jökulhlaup. Therefore the 674 m shoreline represents the level attained by the lake after it had refilled (Fig. 11). An additional factor that may have contributed to the differential uplift of the shoreline fragments is the widespread retreat of Sydgletscher that followed the formation of the 684 m shoreline. During this period the crust was also recovering from glacier unloading (cf. Sissons & Cornish 1982, p. 285) and is likely to have been subject to considerable strain. In the area of shoreline dislocations, the basement granite rock is generally mantled by glacial sediments and rockfall debris and thus the search for small-scale fault scarps has to date proved unsuccessful. This should be a major objective for future research in this area. Additional evidence that earthquake activity may have occurred in this area is suggested by the presence of a large landslide, formed of aplitic granite boulders c. 1 km north of the shoreline dislocations on the slopes above Alephsø. The landslide is 150 m wide and extends c. 400 m upslope to a well-defined scarp. The foot of the landslip mantles the 684 m shoreline and thus demonstrates the occurrence of landslip activity after the formation of the 684 m shoreline. Similarly, extensive rockfall accumulations of aplitic granite debris mantle the bedrock cliffs located adjacent to the dislocated shoreline fragments and locally rest upon the stage IIb lateral moraine of Sydgletscher in this area. Since there is no evidence of modern large scale rockfall and landslide activity in this area it is possible that these major mass movement events were also associated with earth movements following the jökulhlaup of the 684 m lake.

The coincidence in altitude of the 674 m overflow channel east of Rundesø and its associated shoreline indicates that a significant ice retreat of Sydgletscher followed the drainage of the 684 m lake. In order for the 674 m overflow channel to operate, deglaciation of the Rundesø glacier lobe must have taken place. Thus deglaciation of the western flank of Sydgletscher as far south as Rundesø is indicated. The overflow waters that entered Rundesø lake are locally represented by small terrace fragments eroded in the higher terraces (679 m), around Rundesø and Storesø. The water that entered Rundeso during this period raised the level of the lake by 3.4 m and overflowed into Storesø lake and thereafter into Nordbosø lake (Fig. 11).

The 684 m and 674 m lakes are the only two fossil ice-dammed lakes in the Hullet area that possessed overflow channels. However, whereas the 684 m lake level is represented by a well-developed shoreline and the large Østgletscher lacustrine delta, the 674 m lake level is represented by only a poorly-defined shoreline. It is therefore suggested that the 684 m lake maintained its maximum level for a considerable period. In contrast, the 674 m lake was a short-lived feature. The most likely explanation for the brief existence of the latter lake is that once it attained maximum level, the subglacial tunnel beneath the adjacent glacier, eroded during the 684 m lake jökulhlaup, was more easily reopened to provide an escape route for the waters of the 674 m lake.

At altitudes below 674 m, shoreline fragments at different levels indicate the former existence of additional ice-dammed lakes in the Hullet area (Figs. 12 & 13). Many of these lakes can be related to different positions of the Sydgletscher ice barrier. The changing distribution of the lakes show clearly a progressive retreat of Sydgletscher that was associated with the formation of lakes at successively lower levels and by inference lower volumes.

Following the drainage of the 674 m lake a series of seven lower lakes were produced between Sydgletscher and Nordgletscher (Fig. 12). Each of the former lake levels is indicated by shorelines eroded on the distal slopes of the Alephsø end moraine and occur respectively at 665, 659, 652, 634.5, 626, 622 and 617 m. The distribution and altitude of these shorelines indicate that a) the formation of the Alephsø moraine had taken place prior to the production of the 665 m shoreline, b) the Hullet river area that presently breaches the Alephsø moraine remained covered by ice during the formation of all of the above shorelines, c) that drainage of lake waters could only have taken place through the gap in the end moraine. Unlike the 684 m and 674 m lakes where jökulhlaup activity has been proposed, there is no evidence to indicate whether the seven shorelines were produced in association with one lake that decreased in volume or whether the shorelines indicate the maximum levels of separate lakes. The former proposal, however, requires a series of drainage events that are separated by periods of stable lake level. A consequence of this interpretation is the repeated opening and closing of the drainage outlet beneath Sydgletscher. In the areas where the shorelines are present, all measured features are regionally horizontal.

Lake drainage processes

Many authors have suggested that a prerequisite for the drainage of ice-dammed lakes is the flotation of the glacier terminus in the lake (Thorarinsson 1939, Glen 1954, Weidick 1963, Clague & Mathews, 1973, Blachut & Ballantyne 1976). In this way, subglacial drainage is initiated once the water depth at the ice dam reaches nine tenths of the glacier snout thickness and the ice barrier begins to float. Under such conditions the water at the ice barrier is capable of enlarging ice cavities through the inducement of horizontal stresses (Glen 1954) and is also capable of enlarging ice tunnels by thermal erosion (Liestol 1956). However, a problem associated with the barrier flotation hypothesis is that the subglacial water outlet may close once the lake depth is less than nine tenths of the ice barrier thickness (Glen 1954). In contrast, the progressive enlargement of the subglacial tunnel by thermal erosion of escaping meltwaters may permit lake discharge to continue or possibly increase (Liestol 1956). Together, these processes have had a profound effect on the drainage of the ice-dammed lakes of the Hullet area. That the patterns of lake drainage have been highly variable

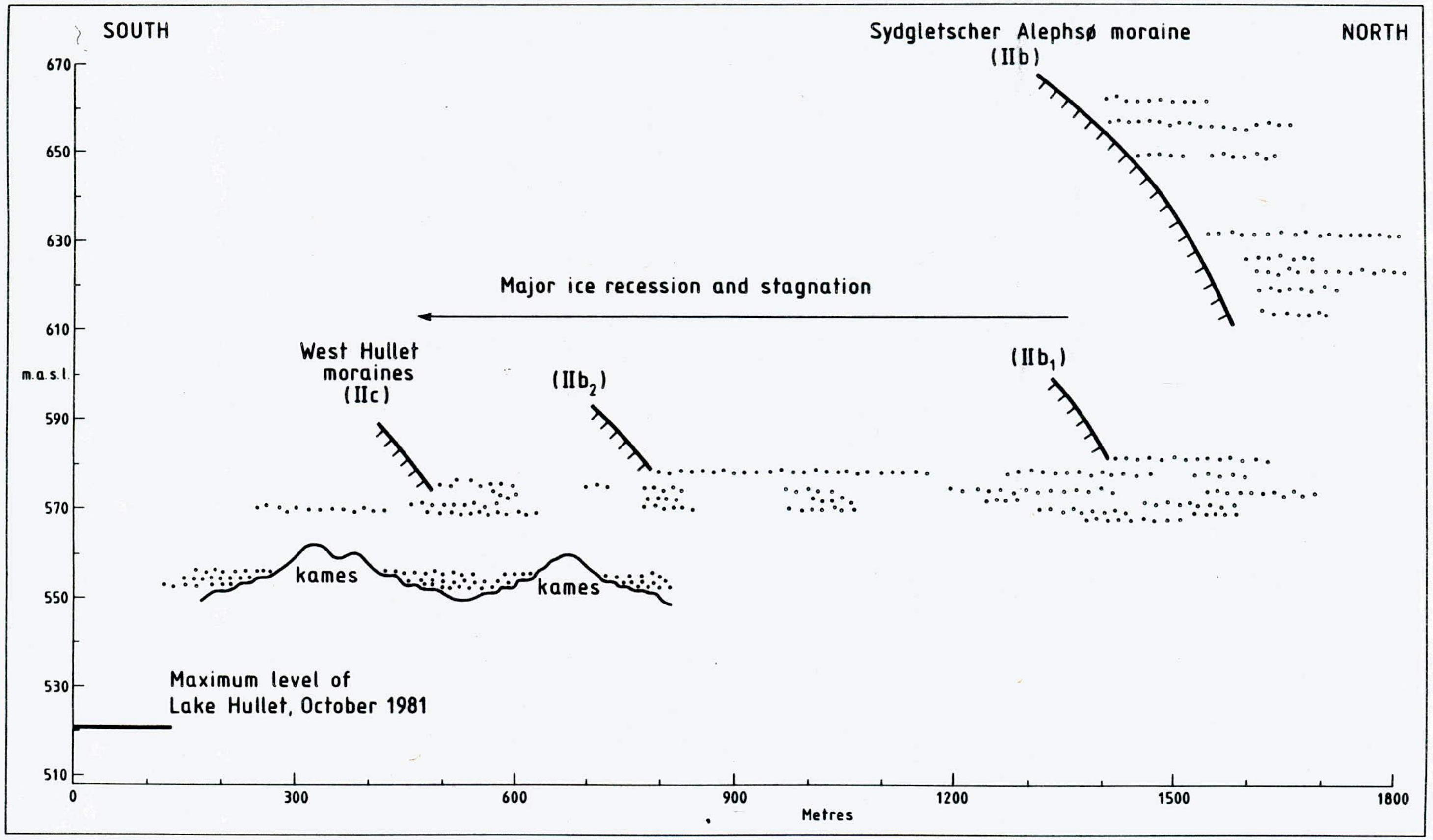


Fig. 12 Height-distance diagram of shoreline fragments between 670 m and 550 m showing the recession of Sydgletscher and the falling lake levels. The location of the stage IIc West Hullet moraines are shown on Fig. 4 (A and B).

is described below.

The 684 m lake was the first ice-dammed lake impounded by Sydgletscher. That the 684 m lake level was maintained for a considerable period of time is demonstrated by the well-developed shoreline and the large volume of deltaic sediments deposited in the lake by meltwaters that issued from Østgletscher. This interpretation is also supported by the fact that the formation of the 684 m lake was accompanied by a major advance of Sydgletscher to the position of the stage IIb end moraine. As a result it is likely that a considerable period of time would have elapsed before a 23 km subglacial tunnel could be produced between the snout of Sydgletscher and Narssarssuaq in order to permit lake drainage. That drainage of the 684 m lake through the subglacial tunnel was rapid is suggested by the dislocated shoreline fragments of this lake.

In contrast, it is suggested that the 674 m lake existed only for a short period of time. This lake, although possessing an overflow channel, resulted in the formation of a poorly developed shoreline c. 1 m wide. It is suggested that the narrowness of the shoreline resulted from the relatively quick re-opening of the subglacial tunnel that was produced during the preceding jökulhlaup.

The subglacial drainage of Hullet that took place between 24th September and 8th October 1981 differs markedly from those described above. (see page 11). During this period lake drainage took place relatively slowly. The reasons for this are unclear although the confining ice pressures around the subglacial tunnel(s) are likely to have played an important role. The most important inferences, however, are:-

a) <u>that former periods of Hullet drainage have been associated with both rapid (jökulhlaup) and slow discharges and</u>

b) <u>that the Hullet ice-dammed lakes have existed for both long and short periods of time before being subject to drainage.</u>

<u>The lower shorelines and the recession of Sydgletscher</u>

All shorelines below 600 m are located inside and south of the stage IIb Alephsø end moraine and were produced in association with the retreat and stagnation of Sydgletscher. Consequently the highest of these shorelines are confined to areas immediately south of the Alephsø end moraine whereas the lower shorelines extend farther south. Most of the shorelines have abrupt southern limits. It is suggested that the southern limit of each shoreline coincides with former recessional positions of Sydgletscher. However only one shoreline is related to distinct lateral and terminal moraines. The sequence of shoreline formation is described below.

The highest of the above shorelines is at 583.3 m and is eroded along the inner margins of the Alephsø moraine. The feature extends c. 100 m south of the moraine and indicates that a minor recession of the Sydgletscher ice-margin accompanied the formation of this lake. Hence, during this period, the Sydgletscher end moraine was already a fossil feature despite the close proximity of the glacial snout.

Approximately 2.5 m below the 583.5 m shorelines an extremely well-developed shoreline c. 3 m wide extends c. 700 m farther south at an altitude of 581 m. Hence during the period between the existence of the 583.5 m and 581 m lakes a considerable recession of Sydgletscher took place. Similarly, the shoreline immediately below the 581 m feature which is at 577 m extends to within 400 m of the modern lake Hullet. However rapid ice retreat and stagnation of Sydgletscher is best demonstrated by shorelines at 574.5 m, 572 m and 570.5 m. These shorelines extend from the Alephsø moraine to the slopes surrounding Hullet. However, in the intervening areas the shoreliines are locally eroded in kames produced during the stagnation of Sydletscher. Hence, the retreat of Sydgletscher from Alephsø to Hullet was associated with progressive ice stagnation and the formation of six separate shoreliines. It is not possible to determine whether the shorelines represent the drainage of six separate lakes or the slow leakage of one lake. However, it is clear that following the initial retreat of Sydgletscher from the stage IIb moraine, the glacier was subject to rapid retreat and downasting.

Numerous lake shorelines occur below the 570.5 m feature, the most conspicuous of these are at 557 m, 556 m, 525 m and 512 m. These shorelines occur adjacent to Hullet. Most of the features are interrupted by numerous crater depressions and abandoned channels produced by the decay and collapse of icebergs. The 570.5 m, 557 m and 556 m shorelines occur within the trim line zone suggested by Weidick (1963) as representative of the margin of Sydgletscher at around 1900. The trim line zone is represented on the ground surface as a transition zone between an upper area of lichen-encrusted slope debris and a lower zone that is draped by relatively recent lake sediments exhibiting only a sparse lichen cover. The trim line zone is located above and parallel to the present margin of Sydgletscher and rises gradually in altitude southwards from c. 560 m to the present firn line (c. 1600 m). Hence on the slopes that surround Hullet the coincidence in the altitudes of the shorelines and the trim line zone, in addition to the widespread occurrence of iceberg depression, renders it impossible to correlate the shorelines with former positions of th Sydgletscher ice margin. The exception is Weidick's (1963) description of an end moraine on the floor of Hullet and the correlation of this moraine with the trim line zone. If this interpretation is correct, it would appear that the shorelines at 570.5 m, 557 m and 556 m were produced around 1900.

Lichenometry

As mentioned previously the age of the stage IIb Narssarssuaq moraine has not been determined although Kelly (1980) has suggested that they were produced between 1000 and 2500 years B.P. (see page 11). In order to clarify this problem, the maximum diameters of 50 Rhizocarpon geographicum lichens over 10 mm thallus diameter were measured from each of 105 separate locations on 7 major landforms in the Hullet area (Figs. 4 & 14)(Table 3). Thus, lichen diameters were measured at 15 locations of similar aspect on each landform. Comparison of the average maximum lichen diameters (Fig. 14, Table 3) permit the establishment of relative ages for the respective landforms and support the relative chronology of glacial and glacial-lacustrine events already proposed. Inspection of the data suggests strongly that the stage IIb moraines and the 684 m shoreline are of the same general age and that the 674 m shoreline is a considerably younger feature. Furthermore, the trim line zone is a relatively recent feature.

The average maximum lichen diameters can be compared with those measured from W Greenland (Beschel 1961, Ten Brink 1973) and from the Colorado Front Range (Benedict 1967). However, direct correlation of lichen diameters with these areas is not possible since lichen growth rates are inversely proportional to the continentality of the area under investigation

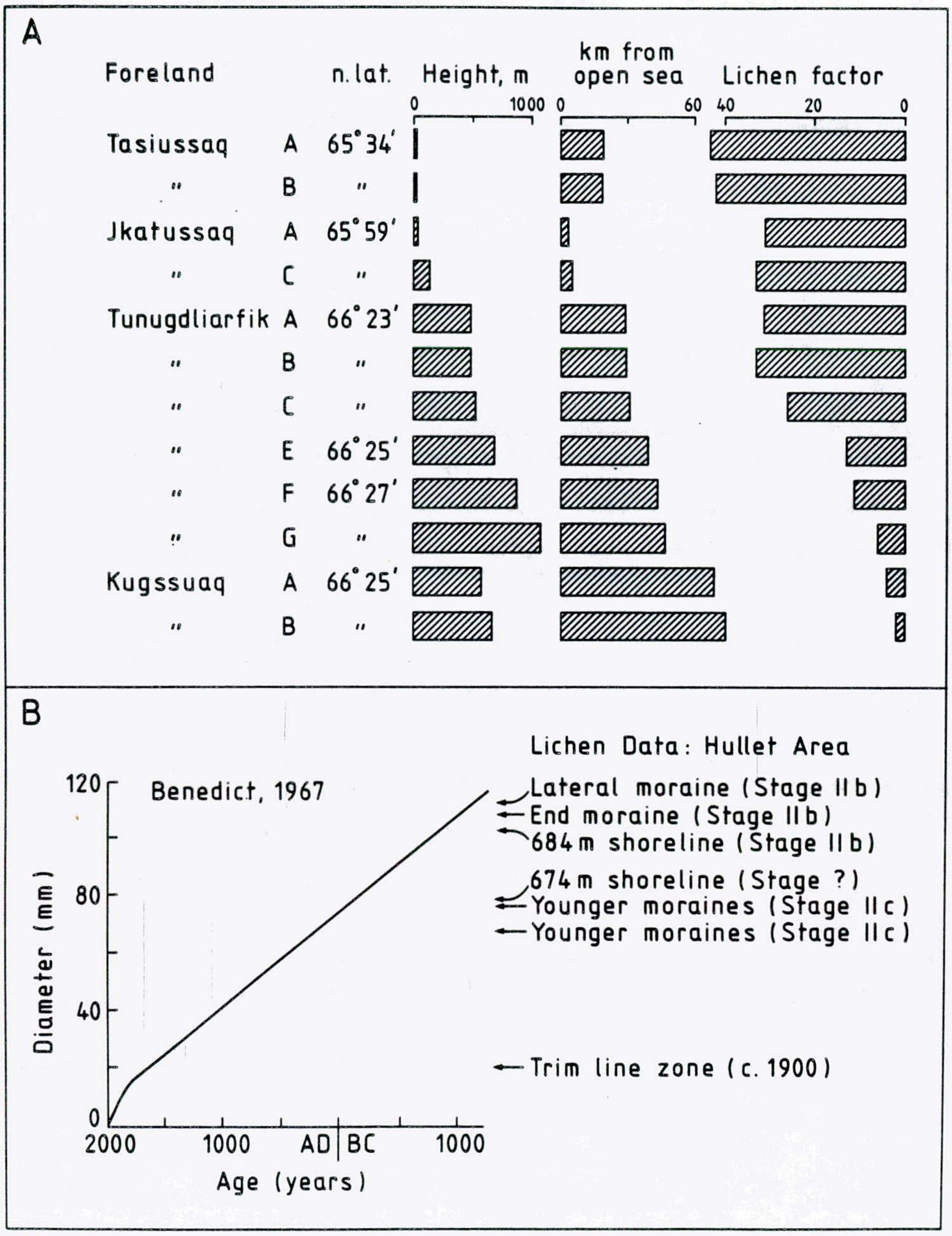


Fig. 14 A. The lichen factor (maximum diameter of century-old thalli of Rhizocarpon in mm) in relation to continentality of glacier forelands in West Greenland (after Beschel, 1961 Fig. 1).

B. Growth curve for Rhizocarpon geographicum from the Colorado Front Range (after Benedict, 1967, Fig. 9) and the maximum lichen thalli diameters of landforms in the Hullet area. It should be noted that no correlation between the Colorado and Hullet data is implied (see text).

TABLE 3

Landform	Maximum thalli diameters (mm)	Inferred minimum ages (years B.P.)
lateral moraine (stage IIb)	111	2375
terminal moraine (stage IIb)	109	2325
684 m shoreline (stage IIb)	102	2150
674 m shoreline (stage ?)	78	1550
younger moraine A (stage IIc)	76	1500
younger moraine B (stage IIc)	67	1275
trim line zone (c. 1900 A.D.)	20	c.100

Maximum diameters (in mm) of Rhizocarpon geographicum measured for the principal landforms in the Hullet area. The location of the lichen measurement area is shown on Fig. 4 and includes the positions of the younger moraines A and B. The calculated minimum ages for the features are also shown (see text) and are based on an initial 100 year "great period" growth rate of 20 mm/100 year and a subsequent growth rate of 4 mm/100 years.

and are also sensitive to local microclimates (Beschel 1961)(Fig. 14). Although no direct correlation of the Hullet lichen data with those of Beschel, Benedict and Ten Brink is warranted, it is instructive to apply the maximum growth rates identified by these authors as a basis from which to derive minimum ages for the principal landforms in the Hullet area.

For example Benedict (1967, p. 830) suggested that Rhizocarpon geographicum in the Colorado Front Range grows at a rate of 14 mm/100 years during an initial 100 - year "great period" before slowing to a rate of growth of 3.3 mm/100 years. Similarly Miller and Andrews (1972, p. 1135) concluded that the initial lichen growth rate on Baffin Island is 15 mm/100 years and then is 2.7 mm/100 years. In West Greenland, Ten Brink (1973, p. 329) suggested that the initial "great period" growth rate is 17 mm/100 years and is followed by a long term growth rate of 2 mm/100 years. Comparison of the Hullet lichen data with those of Beschel (1967, Fig. 1, p. 1048) is particularly instructive. Beschel demonstrated that the maximum diameter of 100 year-old thalli of Rhizocarpon geographicum (mm) in West Greenland is related to the continentality of the area as measured by km from the open sea and by altitude (Fig. 14). The Hullet trim line zone occurs between 556 m and 571 m, is c. 100 km from the open sea and was produced c. 1900. The maximum lichen diameter of the trim line zone is 20 mm, a value considerably greater than that predicted by Beschel (Fig. 14) but similar to that of Ten Brink (1973, Fig 4, P. 326). As a result a trim line zone maximum "great period" growth rate of c. 20 mm/100 year is suggested for the first 100 years of lichen growth in the Hullet area. Thus a subsequent maximum growth rate of 4 mm/100 years (higher than the maximum growth rate of 3.3 mm/100 years measured by Benedict (1967, p. 830)), is applicable to the Hullet area, suggests a minimum age for the stage IIb moraine of c. 2350 years B.P. (maximum lichen diameter of 110 mm)(Table 3). Similarly the 684 m shoreline is a slightly younger feature (c. 2150 years B.P.) than the stage IIb moraines, yet is clearly older than the 674 m shoreline. The data also suggests that the stage IIc moraines were produced prior to the Little Ice Age and by inference it would appear that Sydgletscher was not characterised by marked advance during this period.

CONCLUSION

During the Neoglacial, the position of the Sydgletscher ice-margin resulted in the formation of numerous glacier-dammed lakes in the Hullet area. The earliest ice-dammed lake had an altitude of 684 m and accompanied the formation of the Narssarssuaq moraines during stage IIb (Weidick, 1963). The 684 m lake had an ara of c. 10 km^2 and a volume of c. 950 x $10^6 m^3$ of water. During the existence of the lake, a well-defined shoreline up to 50 m wide was eroded in bedrock and in Quaternary sediments. The 684 m lake level was also associated with the formation of a large lacustrine delta that resulted from the deposition in the lake of fluvioglacial sediments that issued from Østgletscher. The 684 m lake possessed an overflow channel near Langesø. The overflow waters resulted in the formation of a 2 km long river that drained into Storesø. During the period of overflow, the level of Storesø was raised by 5.9 m. The raised Storesø lake also extended inside the stage IIb end moraine at Rundesø, while farther west the water overflowed into Nordbosø. Eventually the 684 m lake drained catastrophically through a subglacial tunnel beneath Sydgletscher and the Kiagtut sermiat and thus caused the extensive deposition of sediment at Narssarssuaq. The rapid drainage of the 684 m lake and the retreat of Sydgletscher are considered responsible for the vertical dislocations of sections of the 684 m shoreline caused by straining of the earth's crust.

The drainage of th 684 m lake was followed by the refilling of the lake Hullet to 674 m. Deglaciation of the Rundesø glacier lobe and of the western margins of Sydgletscher enabled the 674 m lake to overflow into Rundesø and thereafter into Storsø and Nordbosø lakes. The 674 m shoreline is a narrow feature (c. 1 m wide). It is therefore inferred that the 674 m lake existed for only a short period of time before lake drainage occurred as a result of the reopening of the subglacial tunnel.

The drainage of the 674 m lake was followed by the formation of a series of seven lakes each of which is represented by an abandoned shoreline. These lakes occurred at 665, 660, 652, 634.5, 626, 622 and 617 m. All of these shorelines were produced after the formation of the stage IIb end moraine yet during a period when the Sydgletscher ice margin was located immediately behind the end moraine. Drainage of the 617 m lake was succeeded by an initially slow and later rapid retreat and stagnation of Sydgletscher. The initial recession of Sydgletscher to a position c. 100 m south of the end moraine was accompanied by the formation of a shoreline at 583 m. Thereafter shorelines were produced at 581, 577, 574.5, 572 and 570.5 m as Sydgletscher was subject to widespread stagnation and retreat. It is suggested that by c. 1900 the maximum levels of Hullet prior to drainage had fallen to between 570 m and 555 m. During this period, the snout of Sydgletscher was located farther north than present and is believed to have produced an end moraine that is presently located on the floor of the lake.

The last drainage of Hullet took place during October 1981. During a fourteen day period the lake level fell from its maximum level of 518 - 521 m to 481 m. This lowering of lake level was accompanied by the formation of c. 14 well-defined shorelines and was equivalent to the drainage of c. 60% of the original lake volume of 397 x $10^6 m^3$. The formation of the shorelines during a period of falling lake level suggests that catastrophic lake drainage did not occur during October 1981. Together, the evidence of glacier-dammed lakes in the Hullet area suggests that a) former periods of Hullet drainage have been associated with both rapid (Jökulhlaup) and slow discharges and b) the Hullet glacier-dammed lakes have existed for both long and short periods of time before being subject to drainage.

Although it has not proved possible to determine the age of the events described above by ^{14}C dating of organic material, the lichen data provide valuable information on the relative ages of the major phases of lake drainage and glacier expansion. The suggested lichen growth rates in the Hullet are <u>maximum</u> growth rates based on published information from other artic and alpine environments. Thus they provide <u>minimum</u> ages for the moraines and the abandonment of the 684 m and 674 m lake shorelines. As a result it is suggested that the stage IIb expansion of Sydgletscher had occurred by c. 2350 years B.P. and that the 684 m lake was drained approximately 200 years later. The 674 m shoreline and the stage IIc moraines appear to represent younger features although it is surprising that the 674 m shoreline appears to be c. 500 years younger than the 684 m feature. However, there can be little doubt that the stage IIb and IIc moraines were produced considerably earlier than the Little Ice Age and that no evidence is present to indicate a period of glacier expansion in the Hullet area during the latter period.

Chapter 3

The Geomorphological significance of icebergs

Ice-dammed lake environments are ideal for the study of iceberg erosion and sedimentation since lake drainage enables direct observation of the landforms produced by iceberg activity. To the author's knowledge there are no previous studies of iceberg geomorphology from glacier-dammed lake environments. However, owing to the limited time available during fieldwork for the study of iceberg processes, the following discussion is essentially a preliminary statement on a very complex topic.

During a period of rising lake level, a critical lake depth is reached that enables the ice barrier to float. When this occurs, icebergs calving takes place and groups of bergs enter the lake. The displacement of water by the bergs increases the rate at which the lake is rising. Icebergs which are floating in the lake are subsequently driven across the lake according to the prevailing winds. In the Hullet area most iceberg motion occurs in association with high velocity fohn winds. The distance of iceberg movement is largely controlled by the depth of individual bergs. Where moving bergs come into contact with the lake floor, their motion is retarded. During this stage, the bergs erode shallow trenches in the lake sediments and eventually come to rest.

Following the drainage of an ice-dammed lake many icebergs are stranded on the slopes of the former lake. In the Lake Hullet area, the drainage of the October 1981 lake resulted in the stranding of several hundred thousand icebergs. The base of each iceberg is represented by a depression in the lake sediments. Often the depressions exceed 1.5 m in depth and are up to 10 m wide and 40 m long. Iceberg melting often results in the production of a channel that extends downslope to the present lake level. The channels are generally 0.5 m deep, up to 1 m wide and are eroded into all shorelines located between the berg and the lake. Refilling of the lake results in the deposition of lake sediments within the channels. However, if the lake does not refill to its original level the channels are preserved.

Iceberg melting also results in the disintegration of individual bergs into numerous ice blocks. Often the ice blocks collapse onto the ground surface and produce new areas of ice melting. However most iceberg decay takes place by ablation and melting. During these processes, sediments are released from within the ice. The principal sediments that are released are water-saturated silts and clays. These flow over the surfaces of the icebergs and accumulate at the base of the ice. Complete iceberg melting often results in the preservation of the original topographic depressions and the accumulation of often thick (up to 0.8 m) accumulations of silt and clay.

There are three main types of topographic depression produced by iceberg activity: (a) linear and semi-linear trenches produced by iceberg furrowing of lake sediments during periods of high lake level (b) circular and semi-circular crater depressions produced by the collapse of icebergs onto the lake floor during periods of lake drainage (c) superimposed depressions produced by the collapse of groups of closely spaced bergs. The preservation of iceberg depressions in the landscape requires that the features are located above any later maximum lake level.

Linear iceberg trenches are generally 1 m deep, 2 m wide and can extend up to 30 m in length. Frequently the trenches are surrounded by narrow (0.5 m) and low (0.3 m) ridges composed predominantly of small boulder accumulations and gravel deposits. The lower ends of the trenches are generally open and represent the first area of berg gouging. In contrast, the upper ends of the trenches taper to a point that represents the upper limit of iceberg gouging. Generally the floors of the trenches are occupied by iceberg melt (silt and clay) deposits and by thin accumulations of wind-blown loess.

Circular and semi-circular depressions exhibit crater forms and hence are completely closed depressions produced by the impact of collapsing bergs on lake sediments. Similarly, these depressions are surrounded by shallow ridges and are partially infilled by iceberg melt-out deposits and aeolian sediments. Many of the depressions contain shallow lakes. Superimposed depressions resemble composite craters and are distinguished by often extensive areas of crater and ridge topography. In many areas, groups of craters are superimposed upon each other and are produced by the decay of groups of closely-spaced bergs. In the Hullet area, large areas of iceberg trenches, crater and ridge topography disrupt the continuty of individual shorelines.

Chapter 4

Lake Sediments and Periglacial Landforms

Lake Sediments

Many studies of glacier-dammed lakes describe laminated silts and clays (varves) as the typical lake deposits. In formerly glaciated areas therefore, the occurrence of varved sediments is normally recognised as indicative of former ice-dammed lakes. In the Lake Hullet area, observations were made on the lake sediments presently exposed following the lake drainage of October 1981 and on the floors of former lakes. The modern sediments are similar to those in earlier Hullet lakes. They consist predominantly of sand and gravel and include many subangular boulders. The highest concentrations of boulders occur on the abandoned shorelines at the northern end of Lake Hullet where the major meltwater river enters the lake. The paucity of fine-grained sediments is largely attributable to severe fohn winds (periodically in excess of 50 m.p.h) that transport the sediment out of the field area. Sandstorms are common and partly reflect the arid climate that prevails at the margin of the South Greenland ice-sheet. Ironically, the highest local concentrations of silt and clay occurs within iceberg craters. Modern varve sedimentation in Lake Hullet is therefore considered minimal and there is no evidence of former varved clay deposition in any of the former basins of Lake Hullet. Ice-dammed lake sediments therefore may consist of subangular boulders set in a matrix of sand and gravel.

Periglacial landforms

Periglacial landforms are widespread not only in the Lake Hullet area but also in many uplands area of Johann Dahl Land. Although most of the landforms are fossil, evidence is available for modern periglacial activity. Sorted stone polygons, generally 0.6 m - 0.9 m in diameter are particularly well-developed on the few flat areas of terrain (e.g. adjacent to Alephsø lake adjacent to and north of the Alephsø end moraine, on the margins of a small lake c. 400 m east of Alephsø). North of the Alephsø moraine, the stone polygons merge into sorted stone stripes that extend up to 40 m downslope.

The most spectacular periglacial landforms and eminently suitable for future study are the large sorted boulder polygons located along the western margin of Finger lake located c. 7 km south of Nordbosø lake and which forms part of the headwaters of the Qornup Kua river

In this area the boulder polygons occupy an area of c. 2 km^2 between the lake and the surrounding slopes. Each polygon is ca. 3 m in diameter and consists of a rim of boulders that enclose a central area of fine grained sediments. Boulder polygons of similar size also surround several small lakes ca. 5 - 7 km SSE of Storesø lake.

The most widespread periglacial landforms however are blockfields, gelifluction lobes and talus accumulations. Blockfields are particularly common features on the upper slopes of most rock ridges. Fine examples occur on the slopes located west of Nordgletscher and SW of Storesø lake. Gelifluction lobes are common features on most of the slopes located between Nordgletscher and Alephsø lake. Generally lobes are c. 2.5 m wide and terminate at risers c. 1 - 1.5 m high. Particularly well-developed lobes mantle the slopes that flank the river that drains Nordgletscher. Talus accumulations are also extensive. In many areas, however, the talus blocks are extensively covered by lichens and hence indicate that the deposits are fossil. Elsewhere, unvegetated talus slopes are conspicuous features of the landscape. North of Lake Hullet, many of the slopes are composed of recently frost-shattered granite blocks. The occurrence of frost-shattered boulders in resistant rocks such as granite demonstrates that modern frost-action has resulted not only in the formation of talus slopes but also of blockfields and the highly angular debris of which many of the gelifluction lobes, polygons and stripes are composed.

Chapter 5

Botanical Report

Since the purpose of this expedition was not primarily a botanical one, no rigid study proposals of this nature were planned. However, the Brathay reports from previous expeditions (1969, 1972) had been studied to give the expedition members an impression of what was to be expected.

In early July 1982, several members of the expedition visited Dr. Geoffrey Halliday at Lancaster University, for discussions and to visit the Arctic Herbarium in order to enable the identification of the commonest species likely to be found around Lake Hullet and in the south with the climbing party.

At this meeting, reference was made to the possibility of finding hybrids of several species, principally the Betula (Birch) species and chamaenenon (Willow Herb) species. It was also hoped that the expedition would be able to add to the list of species found by previous expeditions to the Lake Hullet area. An interesting addition to the present knowledge of species distribution in this area would be an altitudinal study, concentrating on the higher ground above Lake Hullet. However, when the expedition reached Lake Hullet, most of these proposed studies proved difficult to undertake.

As the previous expeditions to this area have produced comprehensive guides to local flora, we were unable to add any new species to this list. However the expedition was able to add a new species to the Arctic Herbarium collection at Lancaster University. This was a white Willow Herb species.

As with previous expeditions the western facing slopes above Lake Hullet were inaccessible due to the presence of Sydgletscher and the glacial meltwater river from Nordgletscher and Ostgletscher to the north.

The vegetation in the area around Hullet shows marked adaptations to the Arctic climate. Most of the flora is prostrate or only standing a few centimetres above the ground. These adaptations are designed to minimise the effects of the harsh climate. The plants are relatively slow growing, and the leaves are usually small, fleshy or long and slender, or found in a basal rosette, and in many cases very hairy. The Arctic summer is very short and many plants show a response to this by having bright flowers, these being smaller in number than for similar plants found in less extreme climates. Where shelter is provided plants colonised readily and on sunny aspects many plants could be seen.

Table 4

Campanula rotundifolia
Empetrum nigrum
Polygonum viviparum
Potentilla tridentata
Chamaenenium latifolium
Silene acaulis
Salix glauca
Betula glandulosa
Sedum spp
Taraxicum spp
Cerastium spp
Vaccinium spp

Various grasses and sedges.

It was also noted during the trek back to Narssarssuaq the vegetation growth strategies changed and towards the coastal lowlands the plants became larger and more shrubby, the birch standing 1 to 2 metres high on the coastal plains.

It is recommended that future expeditions take some basic equipment for botanical work and plant identification. A very useful book is one by Christopher Grey-Wilson and Marjorie Blamey "The Alpine flowers of Britain and Europe", Collins, St. James Place London. This contains good illustrations of many of the flowers to be found in southern Greenland. A small hand lens and a light-weight flower press are also useful.

S. Billing.

CHAPTER 6

WILD LIFE.

1. Members of the Hullet group kept a watch for animal life as follows: between July 29 and August 22 in the vicinity of Nordgletscher and Hullet, between 23 August and 27 August on the journey south to Narssarssuaq via Johan Dahl Land, and from then until 2 September around Narssarssuaq and Qagssiarssuk.

Environments

As might be expected from its inland position, the Hullet area has a small animal population. The range of environments offers little opportunity. Most of the land surface is stony tundra with little or no vegetation, and thus offers little in the way of shelter or nutrition. Some of the slopes sheltered from the northerly and easterly winds off the ice support willow and birch scrub up to c. one metre high; this is true particularly of the northern margin of Alephsø. There is also a fairly lush grass vegetation in a few sheltered areas such as the wet flats of the marshy Alephsump between Alephsø and Hullet. However the lowest parts of the area (400-500m) fall within the zone periodically covered by Hullet, and are consequently more or less devoid of vegetation.

As far as fresh water is concerned, there was no evidence of life in the turbid water of Hullet itself, but several of the larger lakes at intermediate altitudes (e.g. Alephsø and Langesø) supported some animal life directly and indirectly. Most of the higher lakes at altitudes from c 800 to 1100 m appeared more or less sterile.

Fish

Arctic char (Salvelinus alpinus) were seen in the larger lakes around 6-700m; small specimens were also numerous in the shallow-water pools of Alephsump. Since these must freeze completely in winter, the young fish presumably winter upstream in Alephsø or downstream in Hullet if they are to survive.

Mammals

There were almost no sightings of mammals. One Arctic Hare (Lepus arcticus) was seen near Alephsø on July 30, and a second in Hospitalsdalen north of Narssarssuaq on September 2. Apart from some rather decomposed droppings, there was no evidence of Arctic fox (Alopex lagopus). Although sheep forage to fairly high altitudes (one was encountered over 900 m in

Johan Dahl Land), none were seen alive as far inland as Hullet. Skulls and other bones testified to visits by sheep in the past.

Birds

For a variety of reasons southern Greenland does not have the density of breeding migrants found further to the north, and the expedition terminated before the beginning of the normal build-up of wintering numbers around the south Greenland coasts. Birds associated with water were therefore few in species and sparse in numbers, and this was particularly true of the salt water of Tunugdliarfik. In contrast the number of passerines found in the Hullet area, although by no means large, was certainly greater than expected. Most were evidently juveniles, as one would expect in the later part of the breeding season.

There was little evidence of predation in the Hullet area. As mentioned before, there was no evidence of foxes, although it is not impossible that they were active earlier in the summer when the fledglings were still nest-bound. Birds of three predatory species were seen around Hullet, but sightings were not a daily occurrence, and inland predators presumably work through very large territories.

Snow bunting (Plectrophenax nivalis)

These were the most widely distributed of the passerines, covering an altitudinal range from sea level to at least 1150 m; they were also the most flexible in environment, and the passerines most frequently found on the exposed tundra and the more or less vegetation-free margins of Hullet. Most were juveniles, moving in small groups or in flocks of 10-20, and sometimes in association with one or more of the other species. There was some evidence that adults in the Hullet area tended to forage at higher altitudes than the juveniles; some adults retained recognisable summer plumage into late August.

Lapland bunting (Calcarius lapponicus)

Lapland buntings occupied a rather narrower range of environments and altitudes than Snow buntings. Around Hullet they were generally found in the lower and more sheltered areas around the lakes, although they were found making excursions to eat Empetrum berries and other delicacies on open sites. Some males had more or less full breeding plumage in late July, but this had been lost by late August.

Greenland Wheatear (Oenanthe oenanthe leucorrhoa)

Most of the birds seen were juveniles. Like the other passerines they were curious about intruders and quite approachable, but a number of Wheatears also roosted among stones very close to the camp or under the overhanging banks next to it; at times the foraged around the tents. The juveniles showed more clearly than the other species the contrast between fully developed flight feathers and down on the breast and other less critical areas.

Like the Snow bunting, the evident preference was for open and stony sites, although they were not seen above c, 1000 m. Flocking was not so evident as in the Snow bunting, but the scarcity of Wheatears around Hullet and Nordgletscher on some days suggests group movement over substantial distances. Like the other passerines, numbers of Wheatears around Hullet in late August seemed little different from those in late July, although the autumn migration for all but the Snow bunting takes place in August and September.

Redpoll (Acanthis flammea)

Redpolls were most restricted in environment. Unlike the other species mentioned earlier, Greenland Redpolls are normally scrub-nesters, and the small flocks of the Hullet area were usually found in the restricted areas of low scrub on lee slopes. Individuals even within small flocks were very variable in size and coloration. Most groups contained some birds which were dark, with large darkish bills; although possessing the adult's red brow, these were noticeably smaller than the others. Redpolls were understandably much more numerous in the head-high birch scrub of the Narssarssuaq area.

Ptarmigan (Lagopus mutus).

Because of their exceptional camouflage Ptarmigan are easily overlooked. Females with young were only seen on two days (9 and 21 August) near Nordgletscher. A mixed flock of about 10 was seen in Johan Dahl Land on 24 August.

Raven (Corvus corax)

Like the Carrion crow further south, the Raven in Greenland exploits refuse tips and scavenges on the sea shore. A group of about 15 at Narssarssuaq divided their time between the municipal tip and the shorelines, although some birds (one identified by primary damage) from the group were also seen several kilometres north near the snout of Kiagtût Sermiat.

Around Hullet Ravens were seen singly or in a pair five times during the period.

Gyrfalcon (*Falco rusticolus*)

A tentative sighting near Hullet (2 August) was confirmed by a second during departure on 23 August. The bird(s) belonged to the dark form more common in south Greenland.

Peregrine (*Falco peregrinus*)

A single bird was seen over Qagssiarssuk township on 29 August.

White-tailed Eagle (*Haliaeetus albicilla*)

On 14 August the tracks of a single bird were found in mud at Alephsump, where it had apparently landed to investigate the edibility of a stray plastic bag. A definite sighting was made near Nordgletscher on 21 August.

On 27 August two adults circled for some minutes over a temporary camp south of the snout of Kiagtût Sermiat, and on 2 September a single adult was seen on the hillside immediately north of Narssarssuaq, about 2.5 km away. On 31 August two were seen circling inland of Qagssiarssuk; at least one of these was immature.

Red-throated Diver (*Gavia stellata*)

A pair were seen on Langesø on 30 July. A single bird was seen on Alephsø on 12 and 17 August, and circling over the lake on 20 August.

Great Northern Diver (*Gavia immer*)

A pair was seen on Storesø during the departure from the Hullet area on 23 August.

Turnstone (*Arenaria interpres*)

A small group (three and possibly more) were seen daily near Nordgletscher from 15 to 20 August, presumably on migration southward; all were in winter plumage. They fed on the open tundra and roosted by the river near the camp; on 17 August, while the expedition was having lunch at the camp, a Turnstone walked through the group to feed on a patch of *Empetrum* some metres away.

Great Black-backed Gull (*Larus marinus*)

Gulls were very sparse, and on Tunugdliarfik stayed mainly well offshore. On 30 August a group of 5 adult Great Black-backed gulls were identifiable from Qagssiarssuk.

Jim Lindsay

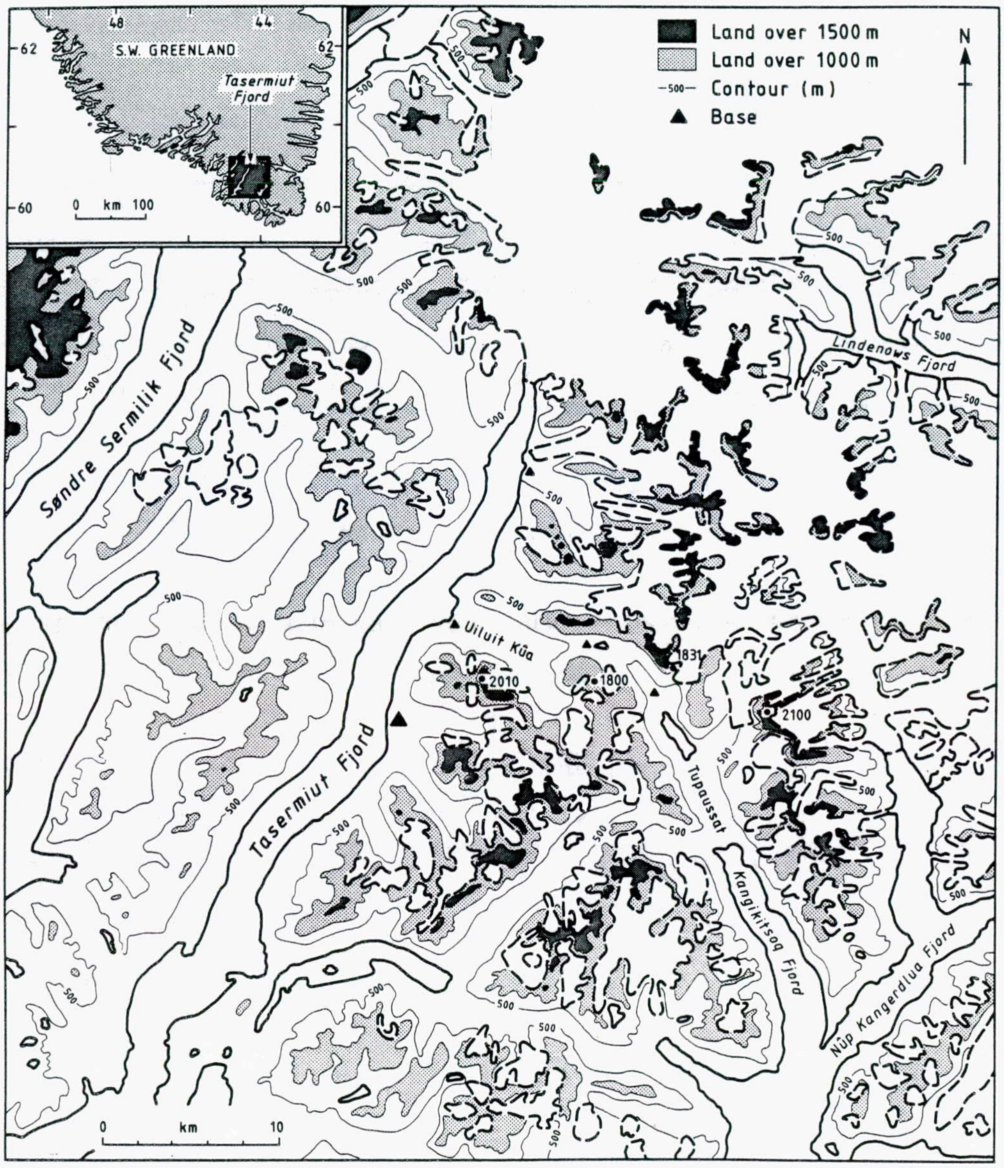


Fig. 15 Location map of Tasermiut fjord area, S. Greenland.

Members of the Tasermiut group also kept watch for animal life throughout their stay in the upper fjord, at various sites, between 28th July and 24th August. The total number of species recorded was somewhat disappointing, the passerine population of the dense scrub belts and boulder fields being most abundant.

Environments

This heavily glaciated landscape with its deeply indented fjord coastline and steep-sided valleys leading up to the ice-cap provided a variety of habitat, the main categories of which may be summarised as follows:

1. Deep Water Fjords
2. Beaches Formed by alluvial material at river mouths. These gritty beaches are tidal but did not show much evidence of crustacean or molluscan life. Small mussels were found amongst the rocks at the edge of the fjord, and a few fragments of small shells were found on the beach below the Sermitsiaq glacier terminal moraine. (The local name of Uliut kua translates as "valley of the place of mussels")
3. Tundra usually covering the low plateau up to half a mile wide and about 10-50 metres above the beaches. Ground cover consisted mainly of lichens, dwarf birch, juniper, and cranberries with the hollows densely filled by dwarf willow, in which most of the Lapland Buntings were seen.
4. Wetlands, in particular a highly vegetated marsh in the Uliut valley with many slow-running channels. This water system was silted up with reddish sand washed down from the parent mountain of the upper-valley.
5. Lower Slopes (between 50-400 m) densely covered by birch and willow scrub up to 5 m high. Most of the Redpolls were found here.
6. Tidal Lagoons, issuing from the snout of Sermitsiaq glacier and connected to the main fjord by a narrow outlet channel which cut through the surrounding terminal moraine.
7. Moraine-dammed lakes and tarns with intervening meadows in valleys east of Uliut kua. No aquatic species were observed in these lakes and streams. The species most frequently found at the margins was Snow Bunting.

8. <u>Screes, gullies, rock walls, high plateau and peaks</u> (200-2000+ m) The main ornithological disappointment was not seeing any Sea Eagles or Snowy Owls which according to D.V.L. sources did inhabit the highlands of the upper fjord.

<u>Fish</u>

The only fish observed in upper Tasermiut were found in the waters of the fjord itself. (Most of the rivers and streams were fast flowing and no 'survey' was conducted in the larger fresh water lakes) <u>Cod</u> seemed fairly numerous in the fjord waters as were the grotesque <u>Dragon fish</u> (Sp.?) On several occasions <u>Sea-Trout</u> (Sp) were found, notably beneath the waterfall into the fjord at the church camp at Uliut kua.

<u>Mammals</u>

<u>Arctic foxes</u> (Alopex lagopus) were seen several times, all of dark coloration. The first sighting was on the beach at the first base-camp (near D.V.L.H.Q), and at the church camp at Uliut kua another became a regular nocturnal intruder. Arctic hares (lepus articus) were also seen, but infrequently, and usually at slightly higher altitudes. It is possible that the mammalian population of the area has been depleted by excessive hunting. Local (Nanortalik based) hunters shoot Fox, Hare, Ptarmigan and Bear in the upper valleys in season. The expeditions encountered no Polar Bears but an unconfirmed report said that one had been shot near Nanortalik during our stay in Tasermiut.

<u>Birds</u>

<u>Red-throated Diver</u> (Gavia stellata): one pair close inshore near promontory at Uliut kua on 5th August.

<u>Common Eider</u> (Somateria mollisscina)

Raft of 11 in fjord off Uliut kua on 8th August, including and eclipse or immature.

<u>Gyrfalcon</u> (Falco rusticolus)

One flew overhead in the valley behind Sermitsiaq moraine on 20th August. Another was glimpsed on the mountain behind the Arctic hotel after our return from Narssarssuaq.

<u>Ptarmigan</u> (Lagopus mutus)

A few around 500 m + including ♀ with c. 6 young at the col east of Uliut kua.

<u>Plover (Sp.)</u>

On 19th August at the margin of the Sermitsiaq lagoon, a small plover with a pronounced bobbing habit was observed. It seemed slightly smaller that a <u>Ringed plover</u> (Charadrius hiaticula) although it had the characteristic orange/brown legs. However the head pattern showed no white above the eye or forehead. A broad dark patch extended through the eye, below which was a narrow white collar and then a half dark collar which did not reach round on the upper breast. The back looked uniformly grey-brown and when it flew, no other distinctive wing or tail patterns were observed. No call note was heard. This bird was the only recorded passage wader and stayed for a day. Of the European species their field-marks could signify only a juvenile Ringed plover as the most likely identification but some doubt remains.

<u>Grey Phalarope</u> (Phalaropus fulicarius)

Small fast and erratically flying waders seen along the rocky foreshore at Nanortalik were tentatively identified as Grey Phalarope.

<u>Gulls</u> (Sps.)

Only a few large winged, light backed gulls flew into the upper fjord opposite Sermitsiaq. They were probably <u>Glaucous Gulls</u> (Larus hyperborous). Lower down the fjord several <u>Greater Black-backed gulls</u> (Larus marinus) were seen and at least one other species of gull was also found on the icebergs of the open channels.

<u>Auks</u> (Sp)

During the night of 25th August on board M.V. Taterak, auks were seen to fly into the beam of the mast head light.

<u>Greenland Wheater</u> (Orenanthe oerianthe leucorrfra)

Fairly ubiquitous on open and boulder covered ground and especially common along shorelines.

<u>Lapland Bunting</u> (Calcarius lappornicus)

A few ♂♂ in summer plumage observed during first week, but thereafter only ♀ or winter plumage ♂. Fairly common along shores of fjord particularly in dwarf willow and birch areas.

Snow Bunting (Plectrophenaz nivalis)

Common especially on slightly higher ground where several in summer plumage appeared to be in breeding territories.

Redpoll (Acanthis flammea)

Abundant in birch and willow scrub of valley floors.

Raven (Corvus corax)

Seen often in the side-valleys of Tasermiut which probably has its optimum population density. Most sightings of single birds unlike those seen in the valley N.E of Narssarssuaq where up to 5 were observed at one time.

Ian Roy

Chapter 7

The Tasermiut Group : A Brief Account

Within thirty hours of leaving Heathrow for Copenhagen, the climbing party were established on the upper reaches of Tasermiut Fjord. Given the long delays experienced by some earlier expeditions to the area, the rapidity of our journey was quite extraordinary. Convenient though it was, this speedy transfer from Copenhagen to upper Tasermiut had the disadvantage of compressing a bewildering array of new sights and sensations into an experience almost too overwhelming to be fully savoured.

On arrival at Narssarssuaq in the early afternoon of 28th July, it was found that ice conditions would not allow the journey to Nanortalik to be continued by boat as originally planned. The group were hustled onto a helicoper and after a short stop at Julianehab were soon flying over loose pack ice wreathed in a light fog and past the dramatic pinnacles of Sermersoq Island before slanting around its walls to land at Nanortalik. A fishing boat awaited into which members and their baggage were poured and by six pm we were chugging past some large ice bergs into the mouth of Tasermiut. For the next five hours we were entertained by the spectacle of increasingly large and precipitous mountains as the fjord narrowed and by Captain Madsen and his rather piratical-looking crew conducting rifle practice off the back of the boat. We arrived at the DVL base beneath the huge, truncated tower of Ulamertorssuaq at about 11 pm.

The activities of the next month were carried out in three distinct phases:-

Ulamertorssuaq vicinity. During the first week Roy and Shaw explored and collected botanical specimens in the environs of Ulamertorssuaq itself. MacDonald and Sahota attempted to make their way up to the ridge separating Tasermiut from upper Quinquedalen, encountering difficult conditions in the heavy scrub of the Kimukat valley. The whole party then travelled up to a glacier at the head of the valley separating Ulamrtorssuaq from Uiluit qaqa. MacDonald, Sahota and Till climbed on the Uiluit qaqa ridge while Dowie and

Smithurst climbed from the glacier.

Uiluit Kua. On the 5th August Roy and Shaw travelled up the fjord by boat to the Uiluit Kua, ascending the valley and crossing via Tupaussat to a point close to the head of Kangikitsoq Fjord (see Chap. 8). Arriving in the Uiluit Kua three days later, Dowie, MacDonald, Sahota, Smithurst and Till climbed on the northern ridge of the valley and the westernmost satellite of the mountain, Ketil. Sahota and Smithurst climbed on 'Dansakh' at the head of the Uiluit Kua (see Chap. 9).

Sermitsiaq. On the 18th August the entire party, in extremely rough conditions, moved by boat to the head of the fjord and established a new camp near to the snout of the Sermitsiaq glacier. In poor weather, Roy and Shaw investigated the immediate surroundings of the glacier and the valley to the south-east. Meanwhile, the remainder of the group travelled up onto the ice-cap before being beaten back by persistent blizzard conditions. On the 24th August Captain Madsen reappeared in the "Ellen Kristina", a considerable span before the appointed time, to ferry the group back to Nanortalik. The captain and his mate watched the frenzied, and in some cases not frenzied enough, preparations for departure with enigmatic detachment. After further delays due to engine trouble and the collection of DVL's rearguard officials, Nanortalik was reached in the early evening. The next morning the scheduled coastal steamer failed to appear, finally arriving that evening. After steaming for some hours, the ship suddenly stopped for the night at Sydproven. Wiley Greenlanders, foreseeing this event, had appropriated most of the available sleeping space before expedition members were fully alive to the situation. The next day, 26th August, we sailed into more trouble on arrival at Julianehåb: the ship had decided not to proceed to Narssarssuaq. Fortunately, the local Greenlandair officials were remarkably sympathetic and helpful and it was with some relief that we arrived back at the airstrip in time to rendezvous with the Hullet group.

General Observations

Weather There is some uncertainty regarding the predominant weather patterns in the Cape Farewell region during the summer months. Expeditions during the late 1960s and early '70s encountered very bad weather with frequent storms. Later expeditions experienced more stable conditions which local opinion suggested was more typical of the area. Our experience was mixed with periods of calm, sunny weather balanced about equally by wet, gusty depressions. However, 1983 was reckoned to be the worst summer throughout Greenland for fifteen years and our arrival in Nanortalik coincided with the first dry day for a month. The picture therefore remains somewhat unclear.

Mountaineering The Cape Farewell-Tasermiut region offers great attractions to the climber with a bewildering concentration of splendid peaks. All of it is beautiful. The temptation is to try to see and do as much as you can with a consequent dissipation of effort. Upper Tasermiut, in particular, is characterised by formidable, big-walled mountains and concentration on a relatively limited area of activity would therefore seem to offer the best chances of success.

Travel Travel between the airstrip at Narssarssuaq and Nanortalik may be by coatal steamer or helicopter. Variable ice conditions subject the steamer to possible delays and for guaranteed arrival the helicopter service is the better option. The helicopter, however, offers only an imperfect solution since any excess baggage will invite substantial financial penalties. It should be noted that for purposes of correcting the helicopter trim, all hand luggage will also be weighed. As far as the transport of expedition food is concerned two main solutions accordingly offer themselves. Supplies may be air-freighted to Narssarssuaq and then by Greenlandair to Nanortalik-expensive but not so costly as excess baggage. Alternatively, food may be ordered from DVL who will guarantee its delivery on Tasermiut. Again, this is expensive and should this course be adopted it is wise to insist that the food is conveniently packaged for delivery in one consignment and to request confirmation that this will be done. For a very small group, a third option may be open: to buy supplies in Nanortalik. One cannot, of course, rely on the required quantities or type of food being readily available.

Fig. 16 Dansakh from the marsh of Uiluit Kua showing the route to the col (left).

Fig. 17 The Ketil range from the col.

Chapter 8

FROM TASERMIUT TO KANGIKITSOQ : IMPRESSIONS OF A JOURNEY THROUGH SOUTH GREENLAND

by Geoffrey Shaw

Our journey really began with a map that arrived from Copenhagen in the middle of an English winter. The map showed a valley called the Uiliut Kûa stretching south-eastward from Tasermiut and linked by a pass to another valley called Tupaussat. Beyond lay a fjord, Kangikitsoq, leading out to the archipelago surrounding Cape Farewell, the southernmost point of Greenland. The crux of the route was a col* on a mountain chain that would allow passage between the two valleys. Theoretically, then, it would be possible to walk from Tasermiut to the sea at Kangikitsoq. While the rest of the group climbed, Iain Roy and myself decided to make this journey, taking with us food for about ten days.

Our objectives were to be threefold:-

To reach Kangikitsoq, thoroughly exploring the area as we went.
To collect botanical specimens for the arctic herbarium at Lancaster University.
To make a photographic record from which we hoped to mount a public exhibition.

*

After a week near to the Danish base on Tasermiut, we were taken up the fjord by boat to the Uiliut Kûa where the climbers were to join us later. The mouth of the valley was marked by a small curving bay and the shallow, sandy bottom obliged us to wade ashore in the freezing water. We pitched camp on a bumpy heath between the fjord and a patchily vegetated moraine. The valley was about three-quarters of a mile wide and along one side a river cut deeply through the moraine barrier before cascading over a rock ledge into the fjord. For the next few days further exploration was limited by heavy rain, making the attractions of a warm sleeping bag irresistable. We followed our instincts and lay with an almost atavistic sense of security and well-being as the cadence of rain on the tent rose and fell with the wind and the primus purred.

Then, as later, time passed lightly enough in desultory conversation, perhaps the more satisfying because it was unforced and sporadic. Our talk seemed almost to match the rhythm of the weather, becoming more sustained as we hit an interesting theme, dying back and then swelling up again as new subjects developed. We talked of favourite books, the top ten "westerns" and other memorable films, childhood in London and East Lothian and of Scott versus Amundsen. Occasionally more esoteric and, considering our situation, bizarre matters took off; the Arthurian legend, the watercolours of Samuel Palmer, life in the Soviet Union, the Albigensian heresy and Raleigh, North Carolina. It's tempting to record that on such occasions the consciousness

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* Experience showed this feature to be the head of a pass between separate mountains rather than a saddle. However, group members habitually referred to it in this way and since this account seeks to recreate the atmosphere of that particular phase of the expedition, the word 'col' has been retained throughout the text.

sometimes expanded onto a higher metaphysical plane. In truth, even a sustained intellectual debate seemed beyond us. We were generally too tired and preoccupied with more basic issues of food, shelter, warmth and sleep. Mundane enough perhaps, but we were never to exchange an angry word.

The bad weather at least provided an opportunity to reorganise our food stocks in preparation for the journey ahead. A Danish organisation had been contracted to supply us and so we were not toally in control of our diet. During the first week of the expedition, rations had been distributed in a rather haphazard fashion and some incongruous and even intimidating items had appeared; whole frozen chickens, an enormous saucer-eyed halibut and huge gnarled blocks of brown bread so dense and heavy that we could barely cut them. The prospect of preparing such things could anaesthetise hunger very fast and they were hardly very portable. Now we were better equipped with an assortment of tinned and dehydrated food that was to form our staple diet over the following weeks. Yet since we couldn't always understand the instructions on packets or tins, or even learn what they contained, a frisson of uncertainty still surrounded our domestic life. Naturally, we had an incentive for learning fast and, on the whole, we were to eat well.

*

Our tent was pitched amongst the ruins of one of the settlements established on Tasermiut about the year 985 by the Viking, Ketil. Here and there on the hummocky heath above the fjord were a scatter of low stone walls. Some, like the outline of a large rectangular building by which we were camped, could be clearly seen. Others were overgrown by a tangle of birch, willow and juniper. Somewhere amongst them were the ruins of an Augustinian monastery and a nunnery. At the far end of the valley, on ground raised above a marsh, were more remains where large erratic boulders were linked together by a series of walls.

All these buildings had lain empty for over five hundred years shadowed by the dark loom of mountains unchanged since Ketil's arrival in this final, empty place. What life could have been like for the Viking settlers was difficult to imagine. Judging from the evidence of skeletons examined from other sites many of them died young. But even those who survived the brutal succession of Greenland winters invariably fell victim to arthritic deterioration of the joints as cold and damp corroded their bodies.

Some days passed before we discussed the peculiar, eerie atmosphere of Ketil's settlement and the faint tickle of unease that it produced. We had both slept badly since our arrival and Iain not at all; kept awake by what he described as a "wild cacophony of chanting and singing". None of the obvious explanations seemed to fit. Was it the wind, the river or even the effects of unaccustomed temperance? No, it was definitely none of these things. When our friends arrived it was interesting to note Neil's immediate comment that they wouldn't camp at our site "because of the ghosts". Well, we were not about to move and although we fell asleep with antennae tuned, there was no more night music.

*

The Cape Farewell area is an alpine region of spectacular granite towers, many rising from sea-level to over six thousand feet. Surrounded by so many dramatic mountains, it was inevitable that they should become important physical and aesthetic landmarks on our journey. We were aware of this possibility as soon as we arrived in the Uiluit Kûa. The valley contained a variety of interesting features and was relatively open. Yet from the beginning the dominant impression was the overwhelming presence of peaks rising from the crest of the valley walls.

The greatest and most hypnotic of them was named Ketil after the Viking whose fief this was. In Greenlandic it was also called Pingasut (2010 m.). From the fjord the mountain rose in one imperious sweep with the shape, texture and elegant lines of a neolithic flint arrow-head. Sometimes Ketil's face was filagreed with a complex series of chiselled slivers and splinters. But in the thickening light of late afternoon its blank slabs were transmuted into polished facets where great flakes had been knapped off in its making. To either side it radiated serrated ridges terminating in satellite spires, some gabled with snow, others bare grey granite.

Further off, astride the far end of the valley, lay another great mountain. Initially, it crouched unseen in thick mist with only the map to say it was there. Over the days the mist dissipated and it discretely eased off the remaining whorls of cloud that encircled it like the frosted rings around Saturn. Then, finally, it stood clear as a fractured and vaguely triangular mountain marbled by zig-zag ramps in which the ice was fixed. The expedition named this mountain Dansakh (1800 m.).

Just as Dansakh marked the head of the Uiluit Kûa, so the position of the col was signalled by the top of a pillar-mountain that raked the skyline of its cleft. Even from the fjord it was impressive but only from the col itself were the mountain's true dimensions and character more fully revealed: a soaring megalith, yellow-beige in colour and boldly patterned with dark vertical stripes. As we first saw it from the deep shadow of the col the peak was still washed with sunlight and seemed to float in the cold evening air, serene and silent, the upper heights impossibly remote. Because from some angles it suggested the citadel of a mediaeval fortress, we came to know it as The Keep (1831 m.).

The Keep had a remarkable, enigmatic presence. As migratory birds are drawn to the lighthouse beam, almost automatically our furthest camp was to be made under its striped tower. Far above, the yellowy surfaces had appeared to soak up the fierce light and almost to hum with an electrical charge. Then, closer by, the intrusions of grey rock that formed the characteristic stripes ran down the mountain to cut the exposed granite belly of the pass. To one side was a dramatic cirque where the ice-cap edged the rim of high cliff and sprayed the patterned rock with a necklace of waterfalls. An occasional avalanche of ice blocks fell to a small acquamarine tarn at its base. You could not really ask for more.

We were not technically accomplished mountaineers and could never attempt the huge rock faces of the bigger peaks. Perhaps as a result, we veered toward a reverential and romanticised view of the mountains, attributing to them the ethereal qualities that we wished them to have. To big-wall climbers they would represent a physical challenge to be overcome. To us they were more like metaphors for some profound truth that lay just beyond our grasp. Ketil and The Keep looked utterly unclimbable and, overwhelmed by their ambience, we wanted to believe that they were. So it was with a vague sense of regret that we learnt that major French expeditions had hammered and roped their way to the top of both. Later it became clear that even skilled and determined individuals could succeed. We had met two wandering Swiss climbers who, with limited English, described all their ascents as simply "very nice". We ran into Fritz and Franco again at the end of our trip. They had climbed Ketil over two days, had been benighted on the summit and had woken up sheathed in ice. We should have known better than to ask how it was: it was, naturally, "very nice".

*

Although they were large elements in every way, there was much more than mountains in our journey. At the other end of the scale, the flowering plants were a constant delight. Many of them were tiny and inconspicuous. Others, by virtue of size or brilliance of colour, were more obvious. The majority could be found in the mountainous areas of Britain, several only in the more arctic regions. The most dramatic, although not necessarily the most charming, was River Beauty, a willow herb with large red-pink flowers that grew in gravelly valley bottoms. In contrast, the Northern Green Orchid was much more retiring, sheltering on moist vegetated banks, though its fleshy yellow-green spears grew up to a foot high. There were various dandelions and hawkweeds, luminously chrome, clumps of delicate violet harebells and varieties of saxifrage. Alpine gentians opened in warm sunshine, their tiny trumpets of a colour so deep and complete that nothing more blue could be imagined. In open areas fruiting shrubs clung to the ground: crowberry with dense masses of shiny black berries,bilberry with larger purple-black fruit and dusted with a delicate bloom and alpine juniper with variegated berries in different stages of development, green or yellow or subtle hues of fawn and brown verging on black.

At various sites we collected specimens and placed them in a small arctic press. The process was more difficult than it appeared. The plants had to be arranged in an attractive disposition and in a way that would display both sides of their leaves when eventually mounted. The pressing paper had to be periodically changed, especially with the juicier specimens, until they were fully dry and rigid. As the collection grew, the time required for the drying process automatically expanded. Unfortunately, some of the plants became mildewed when, at a later stage of the expedition, our tent was flooded several times. But most survived and we never regretted the time and effort involved. The plants had brought genuine pleasure in themselves and we had learnt a little more about the flora of Greenland.

*

Throughout most of Greenland the cold, dry air restricts vegetation to dwarf species which nestle innocuously close to the ground. But the Cape Farewell region lies in the path of the Atlantic depressions and the moister atmosphere encourages lusher growth and even permits the existence of trees. Birch and willow, with an almost vulgar exhuberance, rear up to twelve feet high and mesh together in a dense lattice. Scrub is therefore a unique feature of these south Greenland valley bottoms.

Scrub covered the walls of the Uiluit Kûa to a height of about five hundred feet and closer acquaintance with it came early. After those first few days of rain, we set out to establish a supply dump closer to the col. The sun shone as we crossed the moraine ridge but we were soon swallowed up into a green maw. For a long time we barely seemed to move, stumbling on hidden roots and rocks and sometimes falling. The tangled branches resisted strongly and then snapped back in elastic recoils. It was like trying to walk through English hedgerows and our language became "colourful". Inconspicuous brown birds flitted in the gloom but at the time a flamethrower would have been more useful than a field guide. With great relief we were eventually thrown clear of the thickets. In time we found ways of avoiding this scrub patch near to the fjord but a further belt below the approach to the col had always to be stormed by frontal assualt. We never saw the approach of scrub without experiencing a sense of dread; you must get above it quickly and stay there.

*

The nature of the terrain can change suddenly and dramatically in south Greenland and, in response, so can your emotional temperature. This first exploration of the upper reaches of the Uiluit Kûa revealed a diversity and richness quite enchanting as one environment gave way to another.

We had emerged from the scrub onto a broad flood plain occupied by an extensive river system carrying glacial meltwater down to the fjord. A wide central channel, speckled with sand bars, spilled out a succession of subsidiary streams that separated and reunited in a complicated braided pattern. Several of the channels looked deep and were embanked by small levees of grey, clayey silt between which were swathes of marsh vegetation with reeds, cotton grass and coarse sedges. Along the margins of marsh and scrub were many pools, mirror-calm in the still air and studded with big red boulders thrown down from the valley walls. A number of the pools were choked with aquatic plants; "horse tails" standing proud of the surface in dense clusters and long spear-shaped plants undulating gently beneath the water. Shoals of small fish darted between the green fronds. Only the high ring of cold summits roughened the impression of some more temperate and gentle place. So despite our heavy loads, the marshy ground and persistent mosquitoes, we had passed on, absorbed by the beauty and charm of this silent valley.

As we drew nearer to Dansakh, wedged into the head of the marsh, the emotional climate changed once again with the scenery. Our route to the col lay up a small subsidiary valley to one side of Dansakh. Meanwhile, the main valley of the Uiluit Kûa curled away around the other flank of the mountain and into a box canyon. Compared to the almost pastoral ease of the marsh, these inner recesses of the valley had a distinctly forbidding atmosphere. Above a terminal rock wall was a large glacier, heavily crevassed and encircled by a further series of smoking spires. A viscous, sulpherated light filled the slim envelope between white ice and low grey cloud. Carried down by its weight, the ice converged on a small fissure through which it oozed to hang like the encrusted tongue of some repulsive reptile hidden in the gloom.

*

Greenland maps, with their wedges and swirls of green, blue, white and brown, are very beautiful. Tracing the path of possible journeys can be a happy business in the months before your arrival. But once in Greenland, matching map to terrain is not always easy and soon you may doubt your own competence. Glaciers can appear where ice has gone unrecorded and vast peaks rear up of whose existence you had little suspicion. Slopes may be far steeper than anticipated; more often than not the slopes are cliffs. Part of the problem may be in the adjustment from British ordnance survey maps. In Greenland the scale of land forms is massively larger but the scale of the map is five times smaller. On British maps crags are clearly marked while here a spot height may be the only indication of some gigantic tusk of rock. In the Cape Farewell ranges, with so many bristling peaks jostling together in a complex maze, these are important considerations. Sometimes, of course, you're confused because you <u>are</u> reading the map badly. But on other occasions the map may be misleading or even downright inaccurate.

Naturally, it follows that the unexpected possibility must always be borne in mind. It is a country where unpredictability is the only predictable certainty. In Greenland, while seeking to minimise the risk of disaster, you must take things as they come. We later stood on a slipway in Nanortalik awaiting the scheduled coastal steamer at dawn. It had gone elsewhere. "This is Greenland" was an explanation considered sufficient for all such anomalies. Yet an unpleasant surprise could also lead to a rewarding experience. Such was the case on our first encounter with the col.

*

As we once again travelled up the valley to begin our journey in earnest, we had been overtaken by the climbers who wanted to see the col for themselves. In due course, reaching our supply dump some way below, we saw them framed in the cleft above. I suppose we should have been forewarned by their casual lack of interest as we arrived; Mac gave rapt attention to a tin of sardines, John studied his disintegrating boot and the others nonchalantly inspected a view we couldn't yet see. Their apparent indifference masked either concern or contempt for our folly, which out of courtesy they preferred to disguise. At the time we were too tired to pick up these alarm signals. So what confronted us as we struggled to the crest to look beyond, was something of a shock.

Encouraged by the map, we had anticipated seeing a shallow basin with a small tarn near which we would be able to camp. Instead, a large emerald lake filled a defile over a mile long. On one side sheer rock rose massively to another Manhattan skyline while opposite, yellow-grey walls angled steeply to the water in a wilderness of boulder and scree. This was not so much a basin, more a huge flooded canyon.

In the dusk there was no alternative to camping on the col but at over a thousand feet and deeply notched between precipices, the site was terribly exposed: a natural wind tunnel if the weather worsened. Equally discouraging was a surface textured with alternating gravel, rock, hard rippled snow and water. Eventually we settled on the only possible site in the lee of a large boulder where we later entertained Rob and Neil to what hospitality we had to offer. We did not envy them their bivouac as it was cold enough in the tent and that night the aurora swayed in the frosted air.

All doubts about our camp on the col soon disappeared. We were completely surrounded by fanged peaks in a way so theatrically implausible, it was as if we lived within the pages of a child's fairy tale. Even the light seemed unreal, its colour and temperature constantly changing in an infinite variety of transitory effects. Occasionally it was muted and quiescent. But mostly it pulsed with an abrasive, scouring brilliance that hurt the eyes as it richochetted back and forth between the reflective walls of the great slabbed mountains.

Then there was morning and evening. Of the three nights and three dawns spent on the col, none was ordinary. Unforgettable images formed and dematerialised in an almost dreamlike sequence: in the dark blueness of dawn a falling moon swung down onto Ketil's finger to kiss the summit snow; the Uiluit K̂ua brimmed with a swirling plasma of cloud that lapped the rim of the col and boiled darkly as the rising sun warmed the frozen layers. Ketil was blurred by a silvered film of mist that swayed and quivered in a silent wind; the serpentined channels of the braided river, far below, were sheened into darkly watered silk as they drew in the last light resting on the night rim of the fjord; searchlights of the aurora probed out from the darkness and built to full power as the cold poured down the sky. Truly this was magic. It was a wonderful place.

*

We had been very lucky on the col. But the depressing feature of object lessons is that they are rarely learnt; in a tiresome sequence, the same or similar mistakes are repeated. In Greenland, apparently, you must learn to regard not only the map with suspicion but also the evidence of your eyes.

From the col, we wanted to climb the ridge on the north side of the pass. The route looked easy enough, a simple rock scramble, and we went up quickly. In fact, the summit was protected on one side by a headwall of sheer rock and on the other by acutely angled, frozen snow. Large and deeply crevassed ice-fields lay below to punish a slip. With axes and crampons reaching the top would have been routine but we had

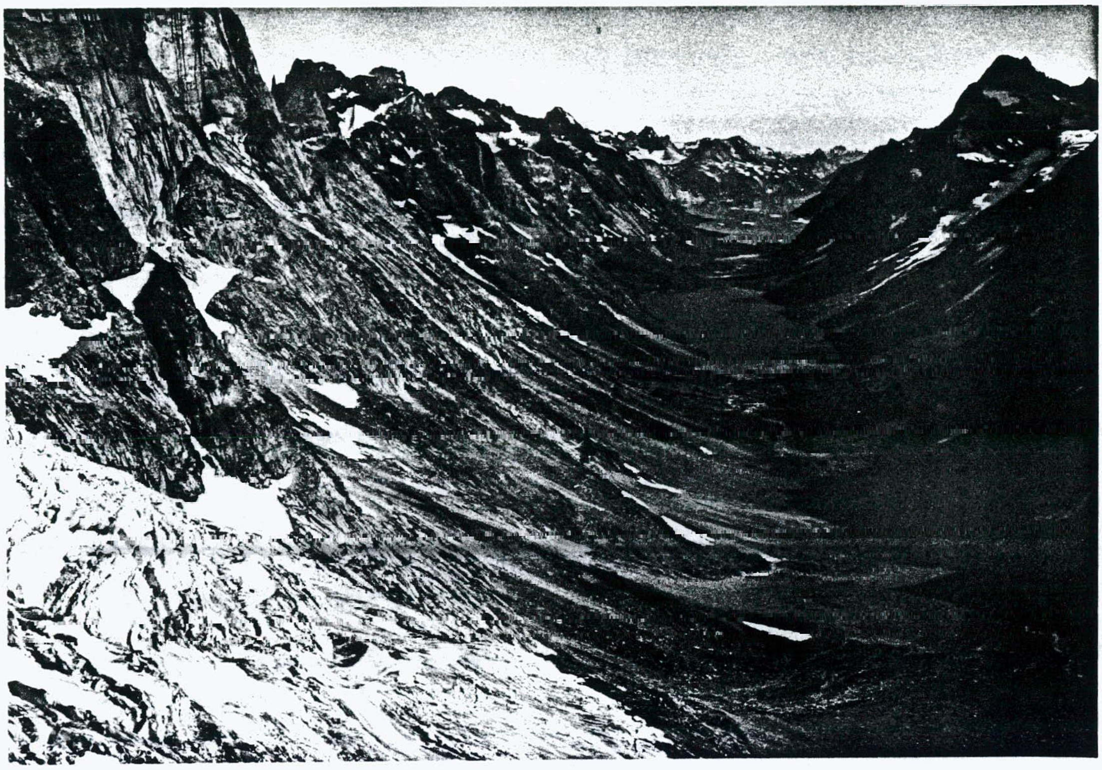

Fig. 18 View down Tupaussat to Kangikitsoq.

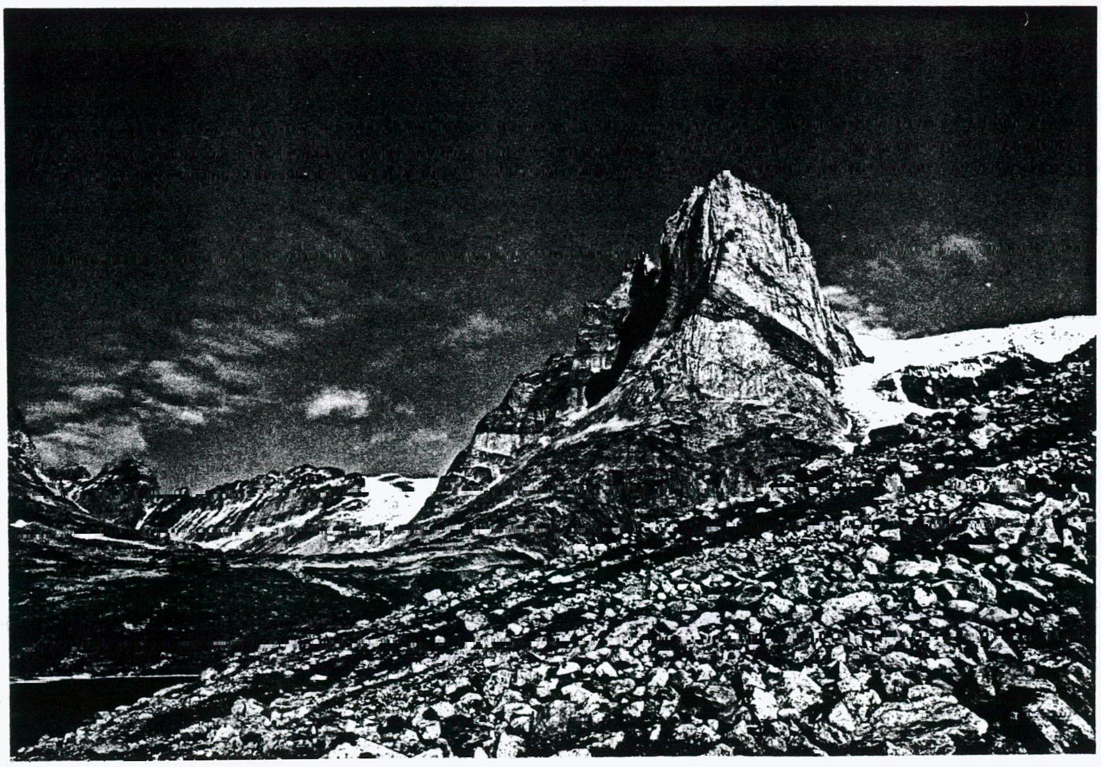

Fig. 19 The Keep and the pass from lower Tapaussat.

left ours on the col : only isolated tongues of snow had been visible from below and even from directly opposite, a thin line of gleaming white was the only sign of the great carapace of ice that lay above. The wisdom of our retreat was confirmed when, later that day, Iain slipped on a snow patch and hurtled down about forty feet before crashing onto some boulders. Although he wasn't badly hurt, it was a timely reminder of how quickly things can go wrong.

Having neglected to bring elementary equipment, we probably didn't deserve the majestic panorama that had opened out from beneath the summit ridge. A small but spectacular glacier surged immediately below, breaking up into huge tottering blocks before crashing down to the floor of the pass. The eye could now also travel the entire length of Tupaussat which widened into a deep trough in its lower reaches. While Ketil rose beyond the col at one end, at the other, Kangkitsoq Fjord glittered with large bergs swept in from the open sea-channels of south Greenland. In the hazy blue distance some forty major peaks reared from the islands of the Cape Farewell archipelago, slashing the skyline like a harrow. We sat on a ledge taking a late lunch and basking in the warm sunshine and the still air. Not saying much, one of us would occasionally move to the end of the ledge to take a photograph or just to look at the chaos of jumbled ice below. Only the muffled rumble of glaciers broke the silence as the evening came on. We were reluctant to leave, afraid that time was already carrying this moment away, bleaching the memory.

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Although the col was at barely a thousand feet, in that short rise from the Uiluit Kûa we had passed into another world. Here was a distinctly alpine zone, a high mountain country, where the air had a fresher bite, the sky was more deeply enamelled blue and the sense of isolation was more complete. Scrub and mosquitoes had been our main enemies in the valley bottoms, the mosquitoes the more tiresome if only because they were ever-present and unavoidable. Despite insect repellent, escape to the tent had sometimes offered the only form of relief; at last you understood how sadism may be unleashed in time of war. Happily, in this attenuated mountain world the mosquito could not survive and the scrub had been left below to beat harmlessly against the approaches to the col. More ascetic plants had replaced the lushness of the low valley; delicate fans of dwarf birch etched the surfaces of the boulders, fleshy grey-green sedums dotted the gravel of the col and dense pink cushions of moss campion speckled the rocks.

Although it was an exhilarating environment, travelling on foot through such mountainous terrain is never easy. Greenland is one of the world's great empty quarters and for good reason. There are no paths for there are no people and with constantly broken ground steady progress is impossible. Everything to sustain life must be carried and even when only the most essential items are included, packs are excrutiatingly heavy. Simple truths about the body's mechanisms are emphasised as a disabling fatigue arrives with a rush through lack of sleep or when the blood sugar levels fall too low in the cold. Much later, you may wonder why you didn't climb a particular mountain, explore further along a certain valley or take more pictures, forgetting how tired you were. Exhaustion is an endemic feature of Greenland back-packing.

Seemingly, entertainment can sometimes numb an awareness of physical exertion and our journey from the col continued through scenery so delightful and diverting that we hardly noticed the effort. While the high pass was predominately a world of rock and ice, it had created a succession of cameos and vignettes illustrating the variety of ways in which broken granite could be arranged. First, there was the fierce, jumbled rock of Col Lake and then an area of stony tundra surrounding an idyllic tarn. Turning sharply right, a gentle gradient led down through boulder fields that gave way to bare sand and gravel. A lush meadow appeared, dotted with smooth, striped rocks and cut by small streams lined with white saxifrage, brilliant dandelions and dense beds of bright green sphagnum moss. Finally, in late afternoon, we walked onto platforms of polished granite, littered with huge erratic boulders. Above were the glowing walls of The Keep that had beckoned through the day.

Those early days of rain had seriously affected our schedule and with dwindling supplies, future possibilities had become increasingly limited. In fact, we now stood on a distinct borderline between the alpine environment of the high pass and a scrubbier zone of the lower valley; from the lip of the granite bedrock, a series of boulder falls dropped sharply to a large lake that filled the end of Tupaussat. In the circumstances, the decision was made to use this spot as our base for further excursions. So it was that we made our furthest camp in the thin,stony soil of a rock basin as high, wispy cirrus appeared in the sky.

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On such a journey, mechanical time ceases to be a really significant factor; you eat when hungry, rest when tired, sleep with darkness, wake with dawn and travel when conditions are right. But we did have an identifiable routine. Breakfast, for example, would always be preceded by mugs of tea and dinner was usually sometime after six o'clock in the evening. Pots and pans were always washed immediately. Afterwards, in candle light, journals were written, plants pressed, paperbacks read and plans discussed. We liked to think that our domestic arrangements had developed a smooth efficiency with chores shared on a rough "tit-for-tat" basis. Initially, we had "lost" things as soon as we had put them down, but now each item had its appointed place within the tent with matches, torches and other essentials coming almost intuitively to hand.

In retrospect, this schedule was not without its ritualistic aspects designed, I suppose, to give some sense of order and security in this rather intimidating place. Yet, like most rituals, it couldn't always guarantee protection in every circumstance. We were aware that a föhn storm can suddenly crash down from the ice-cap to demolish everything in its path. We had long dreaded its coming and as Iain's journal suggests, such an event could disrupt our routine very easily:-

> Friday 13th August
>
> A strong wind blew up not long after we had been asleep. From about 1(am) I lie wondering if the tent will hold out against the gusts. G. sleeps on with his hood (of the sleeping bag) up,

unaware of the full fury of the blast. By 6 am, when at least there is light, we have to make a hasty exit and effect running repairs to the guys ... G's phlegmatism, I'm sure, conceals real anxiety. We sit it out. Myself fully clothed with bag packed, G. in his favourite position - lying in his bag staring enigmatically at the tent roof ... Friday the 13th indeed - the first morning we haven't enjoyed our breakfast porridge without fear for our safety. G. eats a Mars bar - is this a good or bad sign? ... We go out to recce for a better site and think we find one out of the main blast which is coming down the valley. This inspection has tired us, especially myself, unexpectedly so we do not make a move immediately. In any case there looks to be a worse patch of weather about to blow toward us. We check the pegs and retire - G. with his No.1 best seller and I crashed out for an hour or two. It is after noon when G. brutally exhorts me to shift. In the event it goes quite smoothly. The tent is bundled up and transferred with our other chattels to the new site.. There is still enough time for us to have a short excursion over the lip and up to the broad glacier to the north of the valley ... Friday the 13th draws to a close with a tin of corned beef ... the wind doesn't seem quite so bad outside, but we are now on our guard and G. has already found a prospective slab for shelter should the worst come to the worst ... It hasn't been all bad but I won't be sorry to wake up (hopefully still in the tent) on Saturday 14th.

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On our last full day in Tupaussat, we had passed along the large lower lake and climbed precariously through a series of precipitous ledges flanking a subsidiary valley (1450 m). A bulky, chocolate-red mountain domed with snow fields lay immediately opposite (2100 m). The Red Mountain was hugely impressive but its surroundings were quite as remarkable. Scoured by every conceivable feature of glaciation, the area between mountain and fjord could not have been invented by the imagination of even the most rabid glaciophile. Large glaciers surged from the ice-cap and small ones hung on mountain walls. Some eased down onto plinths of debris, forming perfect tongues slashed with lateral cuts and feeding emerald lakelets nestling in the rubble. Gigantic moraines choked every part of the main valley, the deposits continuing out into the fjord in a series of protruding domes. It was a scene of awesome devastation. Although we could not now reach Kangikitsoq, regret was tinged with some relief at avoiding so severe a finale.

In many ways, Tupaussat's final passage to the sea typified the character of southern Greenland and the view sharpened our perspective on the land. The jagged mountains, the grinding glaciers and the cratered ground were all resonant with movement and a barely contained energy. Yet it was an entirely hard and geological vitality; not overtly hostile but simply indifferent to life. Almost as if it had shrugged them off, few animals or birds made their homes here. There is nothing comforting, familiar or reassuring in these surroundings and perhaps a peculiar type of vision is needed to find them glorious. For us, some emotional need was evidently satisfied for we had grown comfortable with the place, feeling pleasure and pride in its very

Chapter 9

Dansakh West Face - Medium Hot, Sweet and Sour

The bivvy site was palatial. A slab of rock as accommodating as a four-poster bed (though less than half the size) would easily make the three of us comfy for the night. Dowie quickly made himself at home, Rob cooked the meal while I looked around, rather dazed through my view-finder at the majestic nature of the surrounding South Greenland mountains - peaks in abundance; steep, often Goliath-like, almost aloof, commanding respect. Morale was high, we couldn't be more 'psyched up' for tomorrow's route as we nestled down in the caressing warmth of the sleeping bags. Adrenalin was lying dormant in my veins; I had a feeling it may awake tomorrow - tomorrow was Friday, 13th. Night and silence glided in, the latter only disturbed by occasional rumblings of rock falls, while sleep descended on us, one by one.

I felt wrenched out of the deep recesses of a snuggy sleep; water was splattering my face and trying to trickle down my neck. Morale was being soaked up as we fumbled into our respective bivvy bags, soggy and wet; knowing full well that tomorrow's route would be treacherous.

Around 9.00 a.m. we evacuated the bivvy, abbed one hundred odd feet down the couloir and started the grind back down the valley to Base-Camp. Having our hopes dashed wasn't sweet. Personally, I felt very angry and couldn't care less how much it rained now. I couldn't give two hoots if the wind cracked its cheeks to deliver its potent force, or if oak-cleaving thunderbolts would belt down from the heavens. Base-Camp was the only recluse.

Two days later better weather was in hand, as blue sky laid its paternal hand over Greenland. For hours we had haggled over whether or not to try the snow/ice ramp route again, or to try elsewhere. Rob and I were dead set on it, but long approach-grinds, changeable weather, fresh socks, loads of food, and n number (where 'n' is a vast amount) of brews had got the better of Dowie. Along with the others he took up residence at Base Camp. With mixed feelings Rob and I, after a few shots of whiskey, started the now boring trog up the valley, with sacks bulging, up to the bivvy point again.

After the warming nosh-up, we snuggled down again for the night. A clear sky, sprinkled with stars looking down, but not at us. Warm breafast at 4.00 a.m. preceeded the gear-sorting, as we sifted out who carried how many pegs, ice-screws etc. Then, donning those incongruous but stupidly useful contraptions called crampons, we negotiated the crevasses on the glacier.

In time we found our way to Disappointment No.1 : The bergschrund was uncrossable; its jaws hung open wide. Traversing the length of this huge chasm we found that its minimum width from lip to lip was about 20 feet. I could see the frustration rising in Rob's reddening face as we tried to find an alternative way round. To the left was possible but not likely; it would take a lot of pegs, and much ill-afforded time to bang-n-dangle our way up and across these rockwalls. We walked off to the right and spied a route up the rock. Off came the crampons as Rob led off on the first pitch of rock-climbing. Fortunately, it was easy and we reached the top of a buttress from where we could regain the ramp.

In front of us stood our route. From the valley at Base-Camp this gully/ramp had looked short and easy, with just oneentertaining steep-section in the middle. But now we felt anachronistically insignificant in our surroundings, a situation amplified by no small possibility of rockfalls. The route did, however, look technically easy - and it wasn't Friday 13th. The ice axes were removed from the rucksacks as it was time for our game to start, as all around, the mystique of the surrounding peaks seemed to look down at us and watch.

After a few hundred feet of moving together it was time to start pitching the climb. Rob led off while I took up the stance. Pitch after pitch went superbly - Scottish Gr. 3, perfect ice, not too hard and not brittle, enjoyable front-pointing and good axe and hammer placements. Rob placed no pro and only stopped at full run-outs; no big deal - just pleasure. Initially, I had started counting the pitches, but the splendour of the surroundings, the satisfaction of the movement, and the internal feeling of good music from my heart being pumped around my veins soon made me lose count of the pitches after twelve - besides I've only got ten fingers, and you can't count your toes through your boots!

The placements were always sturdy. Occasionally, it took more than two blows to feel a sturdy hold - but they didn't feel like blows; it was more like a hand-shake with the mountain, a sign of friendship. In the art of the movement the mountain felt like a friend.

Some time later, while still ensconsed on the route, the character of the ramp changed. The crux pitch was rather 'exciting', the ramp narrowed to two gullies split by a patch of rock. The right-hand gully was easy - but was right in the path of rockfall debris. Those rocks sat there perched high, occasionally one would shoot down as if to warn us; their aloof airs were off-putting, their patronizing stature above our heads seemed to look down as if to say "Just try it mate!"

The left-hand gully was better but it was technically harder. My stance was on the rock between the gullies, facing disappointment No. 2; bad rock, loose rock, rock not conducive to a good belay. Two small nuts would have to do and Rob set off. The angle was at least 75° and his front-points scratched onto very thin brittle ice. His ice-tools couldn't buy any good placements, and the gully was narrowing. Now only slightly wider than his shoulders as he scratched his way up. An attempt to place an ice-screw only served to spurt out more adrenalin, and the ice wilfully dinner-plated to his axe/hammer placements. Looking up I became frankly worried, he was poised on a thin film of brittle ice, he looked as if he was climbing up some thin huge heavily cracked window. This would have made a good vivid action photo - but honestly, I was far too scared to leave attention from the rope, lift my camera and shoot. Ice fell down to my bad belay, as the almost glass-like substance glanced off my helmet and shoulders. I could feel my knuckles bleeding under my gloves as the ice punched me on its way down as if in revenge. Commitment - he moved slowly - again scratching, somehow with style, up the breaking window, tips of front-points just nipping on the slow articulate, poised movements. Sometime later Rob emerged from the crux, adrenalin pumped, easier snow/ice led onto a belay.

My turn, removing the belay I heard him shout that his belay wasn't "exactly bomb-proof, so take care!" My initial placements were O.K. I moved up trying to place my front-prongs, then (always when you least expect it) my right-foot crampon came off, hanging loosely on my boot. The look of horror as I looked at my foot was amplified by the reeling exposure below, the drop was no small fry. Hanging off the two axes I got a bit of placement for my left-foot and eventually got back on the stance. Breathing heavily I refitted the crampon, wiped the sweat from my forehead and started again. Swearing profoundly to myself I consciously tried to climb this pitch with as much reference to balance as possible, but the axe/hammer doings were no friendly hand-shakes with the moutain as I reached the next stance. "I'm bloody glad I wasn't leading" my expression told Rob. There was still no sign of the top of the gully.

The technically hardest pitch was over and it was back to the grade 3 stuff. But slowly, pitch after pitch, I could feel myself turning into a haggard old man within hours instead of decades. Rob climbed on sure, sturdy and cool.

Eventually, the angle decreased even more as we reached the top of the ramp. To exit we dumped the ice-gear, and Rob led two pitches of rock-climbing, the last pitch was only about 50 feet, but quite entertaining.

We'd reached the top of the ramp, I don't know - what do <u>you</u> think of when you're really hit by a splendiferous mountain panorama? The view here was superb - I'd never seen anything like it. For about ten minutes we sat munching, staring out into the vast beyond, dazed.

Obviously, we weren't on the summit, the remainder of the route was easy rock-climbing but a long way to the top. Rob was looking at it with longing, but I reminded him that it was noon. Although it took a little persuasion, it was quite clear that if we were to get back to Base-Camp there's no way we'd have time to climb to the summit. It'd involved another bivvy here, and we'd left the bivvy tackle at the previous bivvy point by the glacier: Disappointment No. 3

It was worse for Rob, but I felt O.K. as the ice-climbing had satisfied me. Warmth was increasing as the sun was moving overhead.

Descent began by abseiling down the two rock-pitches followed by a 150 foot ab. So far, so good, I'd had some hair-raising descents in the Alps only four weeks previously, and didn't want any more. Rob leant over the edge - just as he was about to rope down, a huge roar resounded through the air; the largest and most horrendous avalanche I'd ever seen thundered its way down one of the peaks to our left, its huge gusto of snow and ice fell with a pounding which seemed to shake the slopes by us. It was totally biting, a far cry from romantic similes of the winged flight of Icarus.

I looked at Rob; I was now convinced the dice had been loaded from the start.

After the ab, we down climbed pitch by pitch the gully, being short of pegs and screws. The angle was too steep to face outwards as we descended in the same way as we came up. Technically easy, but very, very knackering. By about 3 pm we had traversed sometimes onto the rock on the right-hand side, then back to the ramp when the omnipotent stone-falls were too close. The sun had melted the ice into soft sugar. The crux was obviously abbed down, followed by seemingly infinite down-climbing. My calf-'muscles' felt on occasion as though they would burst open, pouring flesh and blood down the snow into the hungry jaws of the bergschrund below. But the descent, long and tortuous, had to go on. I was getting the mixed feelings we always get sometimes; is this what it comes to, thrashing yourself outright? My occasional stare at the surrounding landscape mixed me up even more. Time was pressing, now 6 pm - no chance of getting back to Base-Camp, it was more a matter of making it to the bivvy point for the night. The snow was now very sugary. As the hours went by darkness would soon envelope us. Now I was feeling the pain of true knackeredness. Before me Rob had belayed, the pain in my legs was sickly, - and with a momentary lapse of concentration I'd missed placing my crampons properly which were chossed and balled up; I slipped - whizzing down the slope, attempt at axe brake, dig in, stay, just please stop! I stopped. So this was the non-intentional part of an ambition; an ambition to go on an expedition to a remote mountain area and do a climb which I would remember. My face was still in the snow as I lay there, the mountains seemed to laugh at my insignificance, as more rockfalls rumbled down to my right. Well this descent had totally gripped me and I'd had enough; no more satisfaction in the movement, I wanted to be back at the bivvy point safe and resting in my sleeping-bag. I stood up, quivering.

Well the game wasn't over. Eventually, we got around the rockfall areas and abbed down the rock-pitches.

Sitting here now with pen on paper, in the pool of light from the Angle-Poise Lamp, I can still remember the inky blackness of night descending, far faster than our descent, as if to blot Rob and I out. By 11 pm blackness seemed to have filled every nook and cranny in South Greenland. A rock-fall missed us by no large amount.

By the time we got back on to the glacier it was near midnight and the darkness had soaked up the glacier, only minutely pierced by head-torch lights as we tried frantically to find a route around the hiding crevasses back to the bivvy point. Both of us felt like abject physical wrecks, drained of everything, pushed on only by fear.

To reach the bivvy point and our four-poster like slab of rock was the be all and end all. Exhausted we got there, upon the bank and shoal of time, it was great to be back in one piece. Again to experience the good little things in life. I looked at Rob, as we sat there, too tired as yet to pull the sleeping bags from their stuff-sacs. We shared a biscuit speechless. Looking at my face Rob read my expression: "no more epics".

Snug in the warmth of the sleeping bag, released from the omnipotent shackles of objective danger, I looked up at the stars. Little knowing that in a week's time we'd have another "entertaining" incident in a storm on the South Greenland ice-sheet.

J. Sahota

REFERENCES

Benedict, J.B. 1967 Recent glacial history of an alpine area in the Colorado Front Range, U.S.A. 1. Establishing a lichen-growth curve. J. Glaciol. 6, 817-832.

Baschel, R.E. 1961 Dating Rock surfaces by lichen growth and its application to Glaciology and Physiography (Lichenometry). In "Geology of the Arctic" (G.O. Raasch ed.), Proceedings of the First International Symposium on Arctic Geology. Vol.2, 1044-1062, Toronto.

Blachut, S.P. & Ballantyne, C.K. 1976 Ice-dammed lakes: a critical review of their nature and behaviour. Department of Geography, McMaster University, Hamilton, Ontario. Disc. Pap. No.6, 89 pp.

Brathay Exploration Group 1969 Expedition to South West Greenland. 92 pp.

Brathay Exploration Group 1980 Narssarssuaq, South Greenland. 1972-1976 Expedition Results. Field Studios Report No. 9, 117 pp.

Carder, D.S. 1945 Seismic investigations in the Boulder Dam area 1940-1944, and the influence of reservoir loading on local earthquake activity. Bull. Seismol. Soc. Amer. 35, 175-192.

Carder, D.S. 1970 Reservoir loading and local earthquakes. In "Engineering Geology Case Histories" (W.M. Adams, ed.) 8, 51-61.

Clague, J.J. & Mathews, W.H. 1973. The magnitude of Jökulhlaups. - J. Glaciol. 12: 501-504.

Clement, P. 1982 Glaciologiske Undersogelser i Johan Dahl Land 1981 - Gronlands geol. Unders.; Gletscher-Hydrologiske Meddr. 82/1, 73 pp.

Glen, J.W. 1954 The stability of ice-dammed lakes and other water filled holes in glaciers. - J. Glaciol. 2: 316-318.

Gough, D.I. & Gough W.I. 1962. Geophysical investigations at Lake Kariba. "Internationales Symposium über rezente Erdkrustenbewegungen," Z1, 441-447, Akademic-Verlag, Berlin.

Kelly, M. 1980 The status of the Neoglacial in western Greenland. - Rapp. Gronlands geol. Unders. 96, 24 pp.

Lagerlund, E. 1977 Till studies and neotectronics in northwest Skane, south Sweden, Boreas 6, 159-166.

Liestol, O. 1956 Glacier dammed lakes in Norway. - Norsk Geogr. Tidssk. 15: 122-149.

Lundqvist, J. & Lagerbäck, R.T. 1976. The Pärve Fault: A late-glacial fault in the Precambrian of Swedish Lapland. Geologiska Föreningens i Stockholm Förhandlingar 98, 45-51.

Mörner, N.-A. 1981 Crustal movements and geodynamics in Fennoscandia. Tectonophysics 71, 241-251.

Sissons, J.B. 1978 The parallel roads of Glen Roy and adjacent glens, Scotland. Boreas 7,229-244.

Sissons, J.B. & Cornish, R. 1982 Differential Glacio-Isostatic uplift of Crustal Blocks at Glen Roy, Scotland. Quaternary Research 18, 268-288.

Ten Brink, N.W. 1973 Lichen growth rates in West Greenland. Arctic and Alpine Research 5, 323-331.

Thorarinsson, S. 1939 The ice-dammed lakes of Iceland with particular reference to their values as indicators of glacier oscillations. - Geogr. Annaler, 21: 216-242.

Weidick, A. 1963 Ice margin features in the Julienehab district, South Greenland. - Bull. Gronlands geol. Unders. 33, 133 pp.

Worsley, P. 1975 Some observations on lake ice-push features, Grasvatn, northern Scandinavia. Norsk geogr. Tidsskr. 29, 11-19.

Income and Expenditure

Credits		Debits	
Gino Watkins Fund	200.00	Regent Travel	3900.00
Royal Geographical Society	500.00	Food (Hullet)	614.56
Mount Everest Foundation	500.00	Food (Tasermiut)	905.56
New York Explorers Club	270.00	Grant interviews	38.00
Royal Society	150.00	R. Barnes (København)	32.00
Coventry Polytechnic	500.00	Helicopter	685.00
Personal: Contributions	2405.00	Tasermiut travel	949.75
Personal: Hullet helicopter	300.00	Tasermiut baggage excess	50.00
Personal: Tasermiut travel	999.95	Cine film	39.80
Food	1560.00	Hullet expenses	44.00
		Maps and air photos	73.00
		Reports	9.80
	£7384.95		£7341.47

Balance £43.48