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THE DEGLACIATION OF LABRADOR-UNGAVA — AN OUTLINE *

by

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Since the days of the Canadian Government geologist, A. P. Low, towards the close of the last century, the great peninsula of Labrador-Ungava has been recognised as a major centre of ice accumulation and dispersal, and as one of the final centres of wastage. Until recently, however, little progress had been made towards a detailed understanding of the role of the area in the glaciation of North America. Work had been largely confined to the coastal areas, from which arose the controversy of the extent of the continental glaciation in the Torngat Mountains (Coleman, 1920 ; Odell, 1933 ; Tanner, 1944 ; Dahl, 1947 and 1955 ; Ives, 1957 and 1958). The first major work was undertaken by the late Professor V. Tanner and his colleagues immediately before the Second World War, and Tanner's publication remains the standard text for Labrador-Ungava today.

The advent of air photography in the late 1940's provided the basic tool for dealing with a large area, which hitherto had been lacking : inaccessibility, overwhelming size, and scarcity of research workers was at least partially off-set. Large scale air photograph interpretation of glacial features, conducted independently by F. K. Hare (1955 and 1960) and by J. T. Wilson (1958), led to the realisation that the detailed pattern of esker and drumlin distribution was not the simple radial figure envisaged by Low (1896) and Flint (1945) but much more complicated, with a major zone of lineation fanning out from Ungava Bay. The interpretation of this pattern (see figure I) is perhaps one of the greatest challenges to the glacial geomorphologist working in Labrador-Ungava. It is on the basis of the air photograph interpretation and the intermittent and earlier field work that the present series of studies is based.

From work in the central sector of the peninsula in 1955 (Ives, 1956 and 1959) it was tentatively concluded that an area 25 to 35 miles north-northwest of Schefferville saw the disintegration and stagnation of some of the final pieces of the continental ice sheet. This work initiated a long-term study of the glaciation and, particularly, the deglaciation of the peninsula. Work so far has been concentrated on the northeast quadrant and the author has been able to conduct a series of summer surveys between the northeast coast (Torngat), where the first indications of thinning of the continental ice sheet were anticipated, southwards and inland towards the final centre of stagnation and wastage on the plateau.

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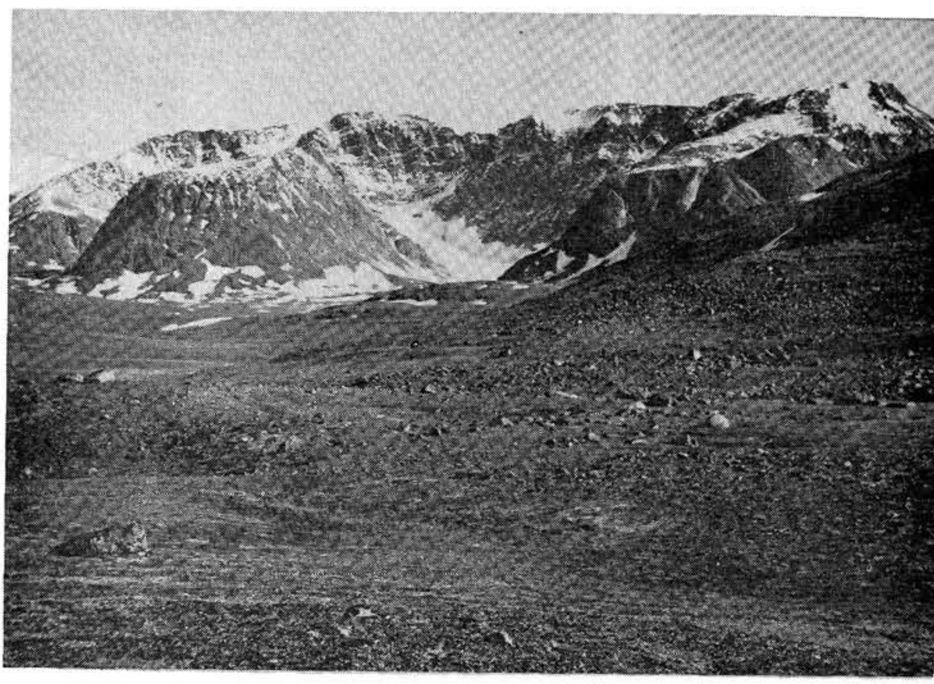
* Paper presented to the XIXth International Geographical Congress, Stockholm, August, 1960, Section 4, Geomorphology.

This work has been carried out over a five-year period : [1] during the last three years it has formed the basis of the major research undertaking of the McGill Sub-Arctic Research Laboratory, and several of the research staff have helped to extend the area of investigation and have added considerably to the study. The map (figure II) shows which areas have been studied in the field and which are being studied during the current field season.

Glacier wastage from the maximum of the last glaciation

Because of difficulties inherent in the study of a centre of dispersal, no stratigraphic evidence of more than the last glaciation has yet been discovered.

PHOTO I



(Sept. 1st., 1956.)

The north face of Mount Tetragona (4,500 ft.).) is a good example of the almost alpine nature of the coastal Torngat zone. The deep cirque contains Bryants Glacier. Moraine with kettles, associated with the outlet glaciers of the inland ice in foreground.

Consequently, it has been customary to refer all glacial features to this final glaciation. It has been widely assumed that the Wisconsin maximum resulted in the general submergence of the entire peninsula and there have been very few

[1] The field work has been supported by : the Arctic Institute of North America ; the Geographical Branch, Department of Mines & Technical Surveys, Ottawa ; the McGill-Carnegie-Arctic Research Programme ; and the McGill Sub-Arctic Research Laboratory. The British Newfoundland Exploration Company have assisted generously with the provision of transport by light aircraft.

critics of this facile generalisation (Dahl, 1947 & 1955). In agreement with Dahl's theoretical considerations, the maximum extent of the final glaciation has been clearly recognised in the Torngat Mountains (Ives, 1958*b*) and this upper limit of continental inundation has been used as the point of departure for the present study. Erratics on the higher Torngat summits (Ives, 1957 & 1958*b*) and on the Kaumajet Mountains (Wheeler, 1958) indicate complete inundation by continental ice in contradistinction to Dahl's conclusions (Dahl, 1947), although it is postulated that this inundation was achieved at the maximum of a glaciation (Torngat) prior to the last (Koroksoak) — local names are given because it seems unwise at this stage to correlate with the standard American chronology further south. In the Torngat Mountains the upper limit of continental glaciation at the maximum of the final, or Koroksoak, glaciation, varies between 1,500 and 2,900 feet above present sea level and is marked by a distinct line of lateral moraines, kame terraces and felsenmeer trimline, rising inland from the Atlantic coast. At this phase it is envisaged that an ice sheet of continental proportions lay over the Labrador-Ungava plateau and Ungava Bay, and was probably confluent with Baffin Island ice. Large outlet glaciers passed through the Torngat Mountains into the Atlantic Ocean. A considerable area of the mountains projected above the ice sheet, although numerous cirque glaciers, a few local ice caps and valley glaciers existed which merged with the omnipotent inland ice. Felsenmeer is found only in areas which were ice-free at this time, or else covered only by thin and stagnant ice. Its distribution is taken as an indicator of the extent of the ice-free areas in coastal Labrador (Ives, 1958*a*). From this and other considerations it is proposed that the upper limit of glaciation rose, not only from east to west, but also from north to south. In latitude 57°N. only two or three of the higher summits of the Kiglapait Mountains (circa 3,000 ft.) on the outer coast projected above the continental ice sheet, south of which the land was completely inundated (figure III).

PHOTO II

(Aug. 2nd., 1956).

Inland from the Atlantic coast the Torngat forms are more massive, although cut through by huge troughs which served as corridors for the outlet glaciers of the inland ice. The summit form assemblage suggests absence of glacial influence and, superficially, they appear unglaciated, while morainic forms mantle the trough floors. View to the south from 4,000 feet.

Following the maximum stand of the inland ice, thinning of the outlet glaciers occurred ; at first gradually for some 300 to 400 feet while the glaciers remained active, and then very rapidly with increasing stagnation of the ice. During this second phase great flights of lateral and sub-lateral drainage channels were cut and the high cols on the watershed emerged so that the trunks of the

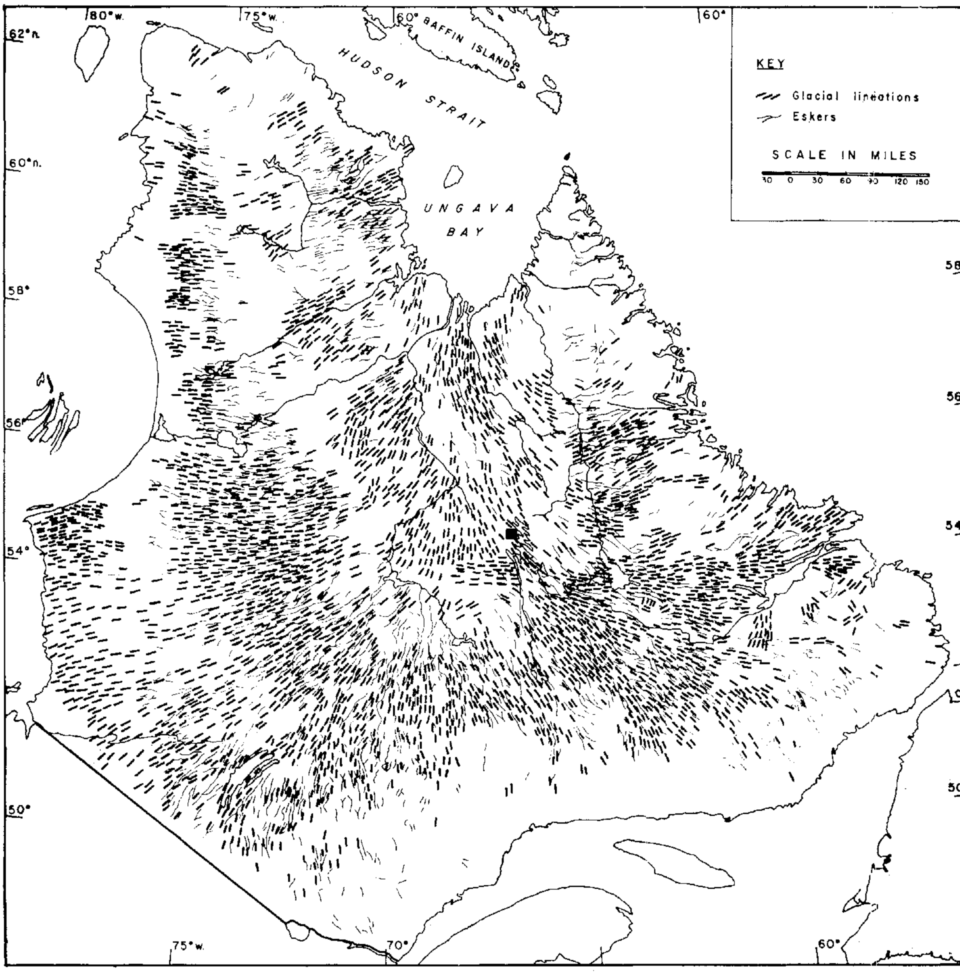


FIG. 1. LABRADOR-UNGAVA : GLACIAL LINEATIONS AND ESKERS
(DRAWN FROM THE GLACIAL MAP OF CANADA — SLIGHTLY MODIFIED)

outlet glaciers were severed. This might be taken as the beginning of the third phase in which stagnation and wastage of the detached pieces in the Atlantic valleys proceeded apace while, with further thinning and exposure of land west of the watershed, proglacial lakes accumulated between the inland ice, situated over Ungava Bay and the Labrador-Ungava plateau, and the high land to the east. Several series of these lakes have been traced almost to the heads of the

Ungava Bay fiords, their drainage taking place eastwards across cols into the Atlantic streams. The shorelines have not only been traced in the tributary valleys, but also in the main valleys.

Concurrently with the thinning and withdrawal of the inland ice from the Torngat Mountains, the local glaciation was reduced to insignificance, although Løken has recognised still-stands in this withdrawal, and possible resurgence of local ice on a limited scale (Løken, 1960). The near-final phase is illustrated graphically (figure IV). The mountains are depicted as ice-free, except for

PHOTO III

(*Aug. 2nd., 1956.*)

Despite deep dissection the summits coalesce to form a rolling skyline. Gentle slopes (foreground) are mantled with mountaintop detritus and evidence of glaciation is extremely rare above 2,800 feet. View towards the southwest from 4,000 feet.

small areas of local ice, while the plateau and Ungava Bay carried a major continental ice sheet.

Although no direct correlation can yet be made between various localities along the Labrador coast, it is postulated that thinning of ice and withdrawal of outlet glaciers resulted in the emergence of all the high coastal areas northwards from the Mealy Mountains so that, when the Torngat Mountains were ice-free, a large tract of the coastal area had also emerged, perhaps as far back as the watershed in some areas. At this point the focus of the study shifts from the coastal mountains south-southwestwards onto the Nain plateau and into the basins of the George and Whale rivers.

The formation of the major proglacial lakes

Glacial drainage channels and col gullies (Mannerfelt, 1945), lake shorelines and spill-ways, indicate that, as the higher land near the coast emerged

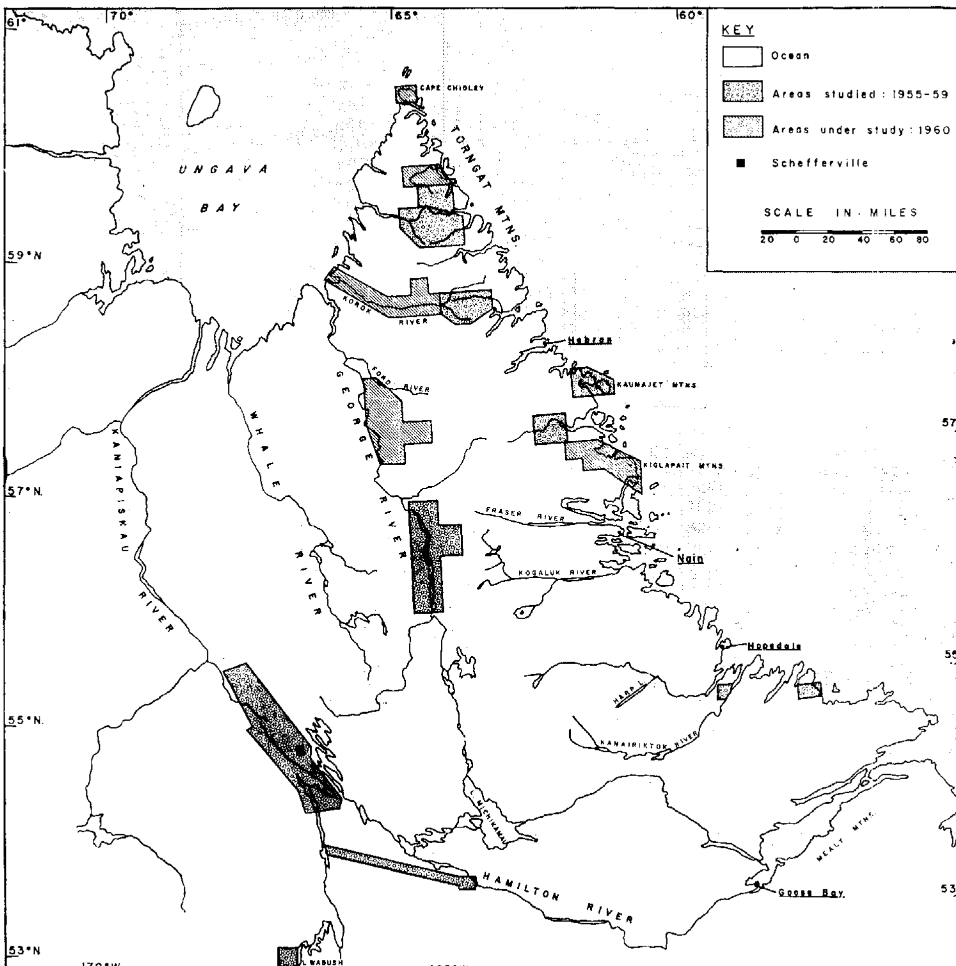
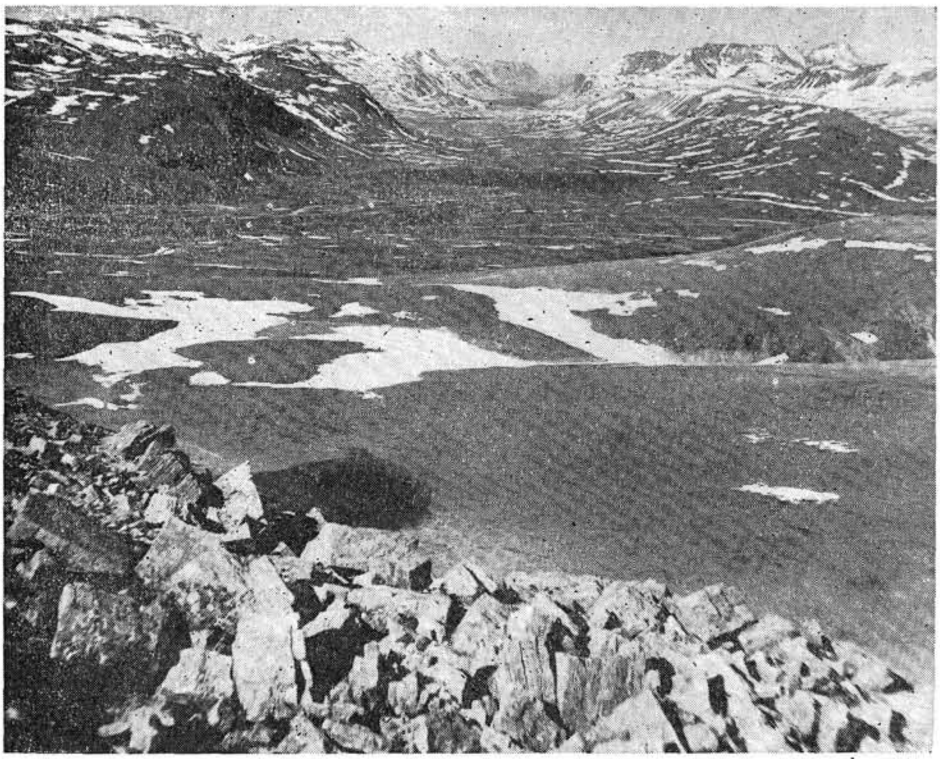


FIG. 2 : PLACE NAMES AND AREAS OF FIELD STUDY

from the ice, the snow line had already risen above the land surface. Lakes accumulated on the landward side of local watersheds and spilled eastwards into the Atlantic Ocean. On the plateau the ice thinned and stagnated while in the great valleys gravity drainage from the inland ice maintained the outlet glaciers in an active state, probably long after the Torngat valleys had become ice-free.

End moraines in the major valleys south of the Torngat Mountains mark temporary halts in the recession of the outlet glaciers while areas of dead-ice topography indicate separation and stagnation. On the other hand, the extensive sets of end moraines in the Nain-Okak sector may represent a major still-stand, mid-way in time between the maximum of the last glaciation and the total emergence of the Torngat Mountains. This aspect of the deglaciation is receiving

PHOTO IV



(*Aug. 2nd., 1956.*)

Looking northeast from 4,000 feet across Kangalaksiorvik Lakes to Ryans Bay. The Four Peaks form the skyline to the right. High level, gentle surfaces (fore- and middle ground) are mantled with mature detritus.

detailed attention during the current field season by Mr. John T. Andrews, of the Laboratory staff, who is working in the Nain vicinity.

The proglacial lakes which formed on the plateau were initially small and short-lived and of ever-changing size and level as the damming ice thinned and new outlets were exposed. As more of the land west of the watershed emerged, however, the lakes increased in size until a vast volume of water was trapped between the residual inland ice and the rising land to the east. Detailed level and staff survey in the George River basin in 1958 led to the recognition of three

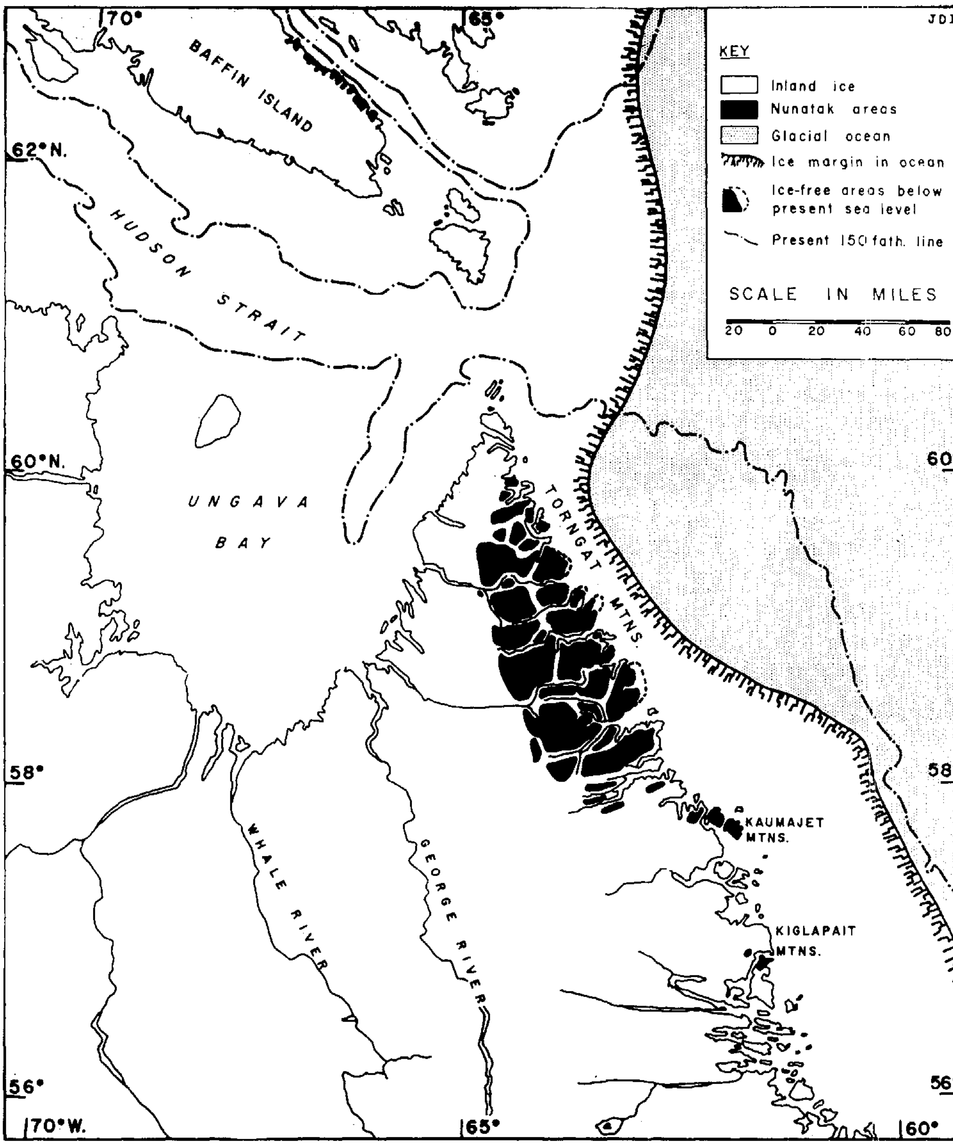
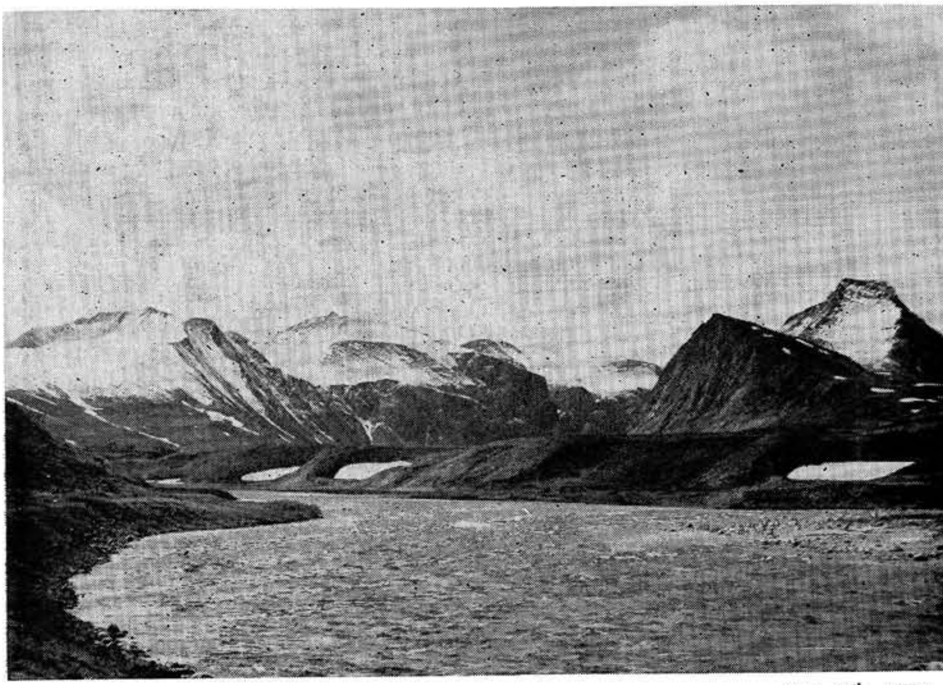


FIG. 3 : NORTHEAST LABRADOR-UNGAVA AT MAXIMUM OF LAST GLACIATION

major lakes, which have been named Glacial Lakes Naskaupi I, II and III (Ives, 1960*a*). The shorelines stand at 1,700, 1,500 and 1,350 feet respectively above present sea level, although these figures are approximations on account of the pronounced tilt of the shorelines. A plot of the extent of the shorelines has facilitated the positioning of the contemporaneous ice barriers and the surveyed tilt has enabled the postulation of the spill-way locations on the Atlantic-Ungava Bay divide. Extrapolation of the field work by air photograph study and

PHOTO V



(Aug. 25th., 1956.)

The central section of the Torngat is typified by massive summits between 4,000 and 5,500 feet high and separated by spectacular troughs. The trough floors are largely buried beneath terraced outwash (sandar) deposits laid down during the melt of the outlet glaciers. Komaktorvik Brook in the foreground and Precipice Mountain on right.

parallax computations has provided an estimate of the extent of the former lakes. Naskaupi II, the largest, was practically 200 miles from north to south and 50 miles in breadth (figure V). The large Glacial Lake McLean, still further west, flowed into it. Its shorelines have been tilted up towards the south at a rate of 1.57 feet per mile as calculated from a levelled base of 60 miles. This is only the apparent tilt and it is estimated that the direction of absolute tilt will be somewhat west of south. Work in the area north of Indian House Lake during the present summer by Mr. E. Michael Matthew, of the Laboratory staff, should

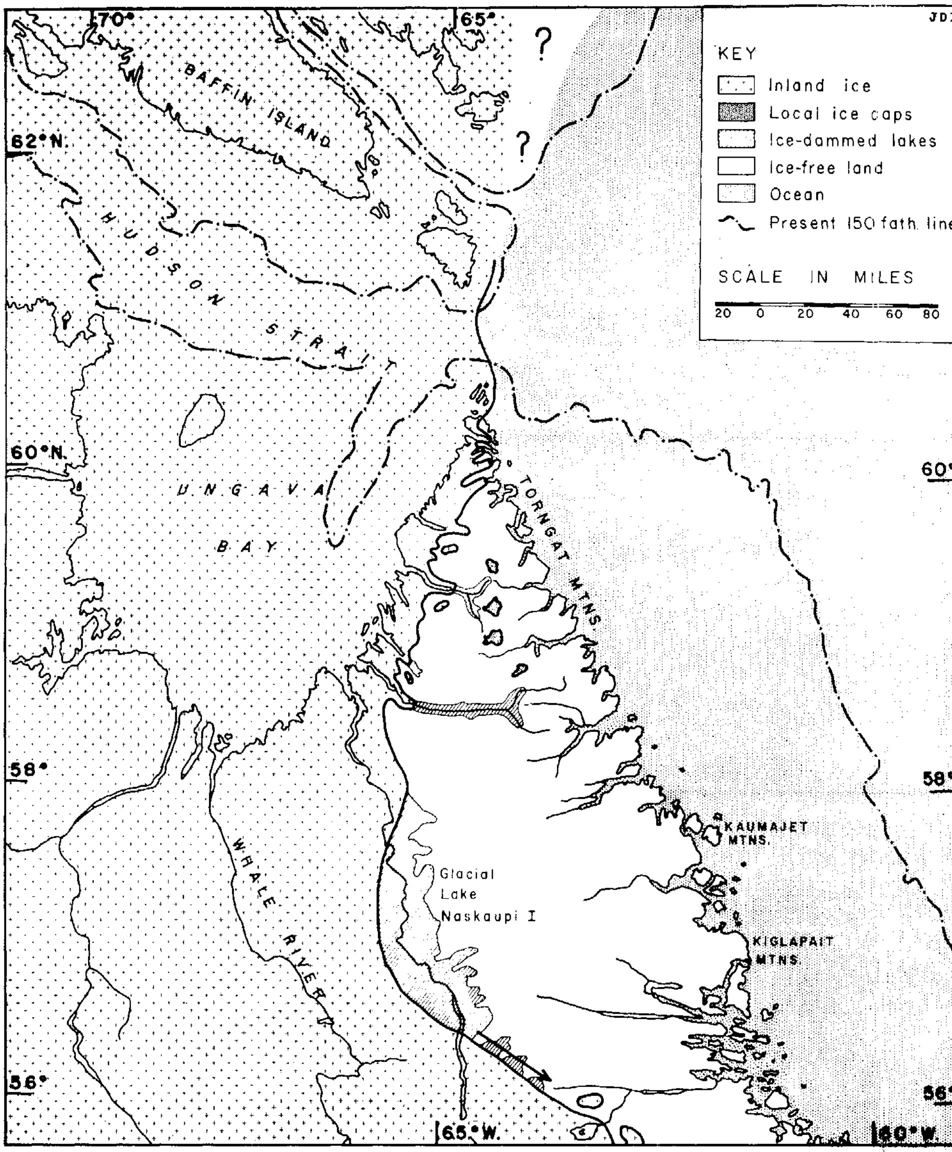


FIG. 4 : NORTHEAST LABRADOR-UNGAVA: NEAR-FINAL PHASE OF DEGLACIATION OF TORNGAT MTNS. (NASKAUPI I PHASE ?)

establish the direction and amount of absolute tilt and provide a precisely levelled base of more than 100 miles.

The former existence of this vast system of lakes is of overwhelming significance in any study of the deglaciation of Labrador-Ungava, and its recognition has an important bearing upon the interpretation of the drumlin and esker patterns. The sites of glacial lakes McLean and Naskaupi II straddle the site of the « late-glacial ice-divide » as depicted on the Glacial Map of Canada (Wilson, 1958). This alone indicates that the so-called divide is either mis-placed, or

PHOTO VI

(*Aug. 7th., 1956.*)

The « upper trimline » rises from east to west and, on their western side, the Torngat summits have been glaciated during the Koroksoak Glaciation to heights of 2,800 feet. These erratics stand at 2,800 feet southeast of the head of Abloviak Fiord.

never did exist. Secondly, the damming by ice of lakes several thousands of square miles in extent and up to 1,000 feet deep, would have required a massive ice barrier to shut off their natural drainage outlet — Ungava Bay. Allied with the conclusions drawn for the Torngat Mountains, this results in the postulation of the existence of a major cupola of the inland ice over the present site of Ungava Bay until relatively late in glacial time. This concept is somewhat alien to current hypothetical thought. The work of Mr. Matthew, and that of Mr.

Brian Haywood, also of the Laboratory staff, who is spending the summer studying the deglaciation of the Koroksoak Valley between the Torngat and Ungava Bay, should be an invaluable test of the concept of deglaciation which is provided here.

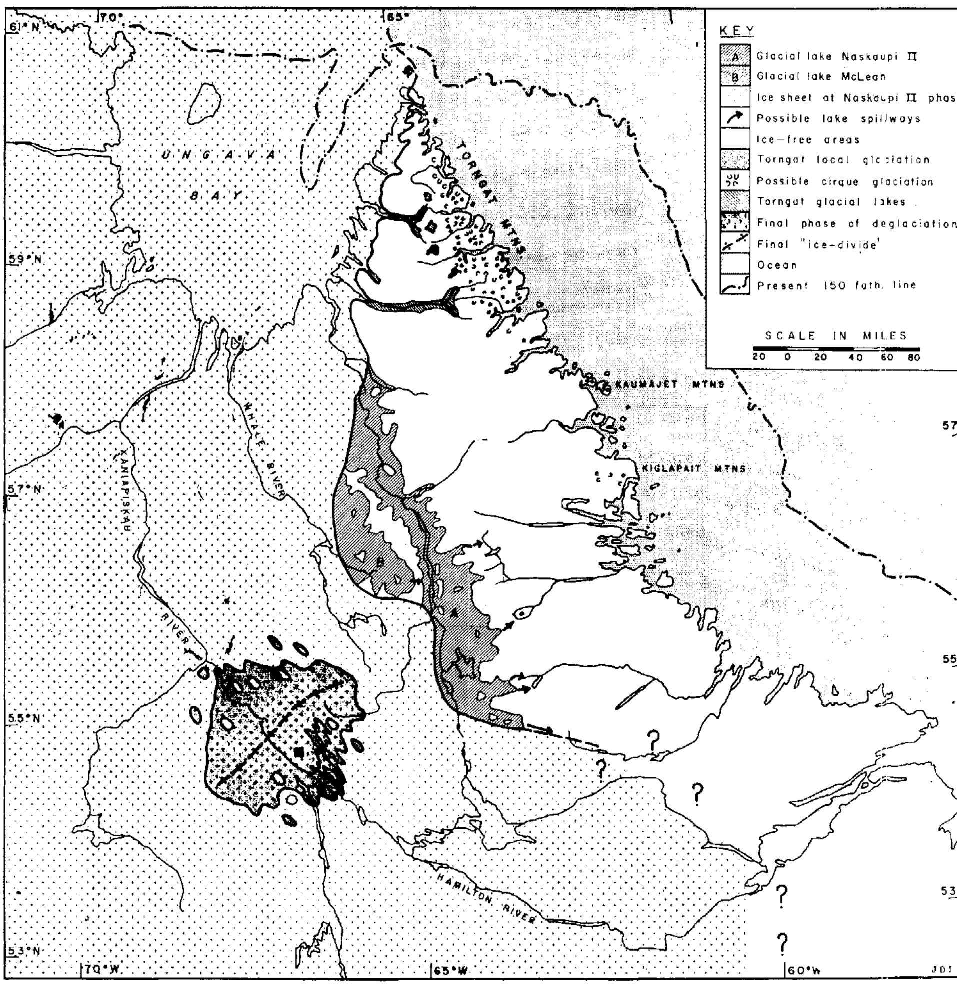


FIG. 5 : NASKAUPI II PHASE OF DEGLACIATION AND FINAL (Kivivic Lake) PHASE IN SCHEFFERVILLE AREA

The maps (figures IV and V) show sketches of the extent of the « great lakes » based upon the existing field work and air photograph interpretation. Also included are the conjectured positions of the ice barriers and the estimated extent of the contemporaneous ice-free land. For the final phases of deglaciation, also outlined on figure V, work has been concentrated within a 70-mile range of Schefferville in the geographic centre of the peninsula.

The final phases of deglaciation on the plateau

Study of the final phases of deglaciation was based upon the systematic plotting from air photographs of all glacial drainage channels in the area and their detailed examination in the field. The map (figure VI) shows the distribution and direction of slope of the channels in the central section of the « Labrador Trough ». It is apparent that the north-northwest structural and topographic trend of the « Trough » has had a marked influence on the trend of the channels.

PHOTO VII

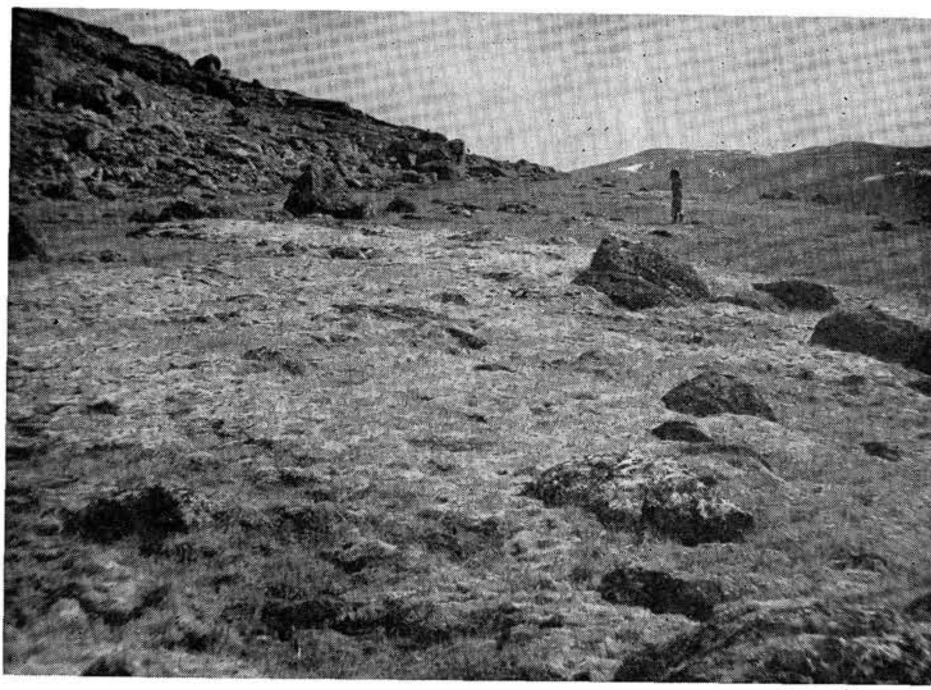
(*Aug. 2nd., 1957.*)

Evidence of high-level (Torngat) glaciation is found only rarely. The hammer is leaning against an erratic of massive quartz-granite on the summit north of Nakvak Lake in the southern Torngat. The bedrock is paragneiss and the altitude is a little over 4,000 feet above sea level. View northwards across the upper Koroksoak Valley.

Nevertheless, it is very significant that a line, trending east-northeast, can be drawn through the south end of Kivivic Lake to separate the channels sloping down towards the north from those sloping down towards the south. The sites of the final pieces of wasting ice are to be found in the bottoms of the deeper valleys along this line.

A detailed study of the morphology of the channels, together with a precise survey of their vertical interval, degree of slope and depth, has led to the conclusion that the majority were formed by melt-water flowing beneath the ice (Ives, 1959 and 1960*b*). Steepness of slope — an average of 1: 20 to 1: 35 — depth varying from one foot to more than 100 feet, and the extensive development of tributary channels, are some of the more important characteristics. Similarly, though the average vertical interval was 19.8 feet, this conceals a range of from 0.5 to 76.0 feet, and strongly implies that they are not annual features, a conclusion compatible with the statement that they were formed largely sub-glacially.[2] An estimated ice-surface slope of 1: 140 has been obtained from a study of the localities

PHOTO VIII



(*Aug. 3rd., 1957.*)

The southern Torngat through-troughs carry extensive lateral moraine-kame terrace systems which slope down towards the east at 90 to 100 ft/mile. The kame terrace in the foreground stands at 2,300 feet on the north side of Nakvak Lake and lies 400 feet below the « upper trimline ». It is attributed to the second phase of deglaciation following the « upper trimline » phase of the Koroksoak maximum.

of spill-ways from small ice-dammed lakes, in conjunction with an estimate of the maximum possible slope obtained from the gradients of some of the sub-lateral and lateral channels.

Local relief exceeds 1,000 feet and melt-water features are found close to the highest summits (circa 3,000 ft.). It is concluded, therefore, that the snow

[2] By this it is not implied that strictly marginal (lateral) features do not exist in the area under study, but merely that sub-glacial erosion predominated. These general conclusions seem in agreement with the work of Derbyshire (1960), of the Laboratory staff, who has studied a small area in the immediate vicinity of Schefferville, although the present author would classify as sub-glacial a greater proportion of the channels than Derbyshire.

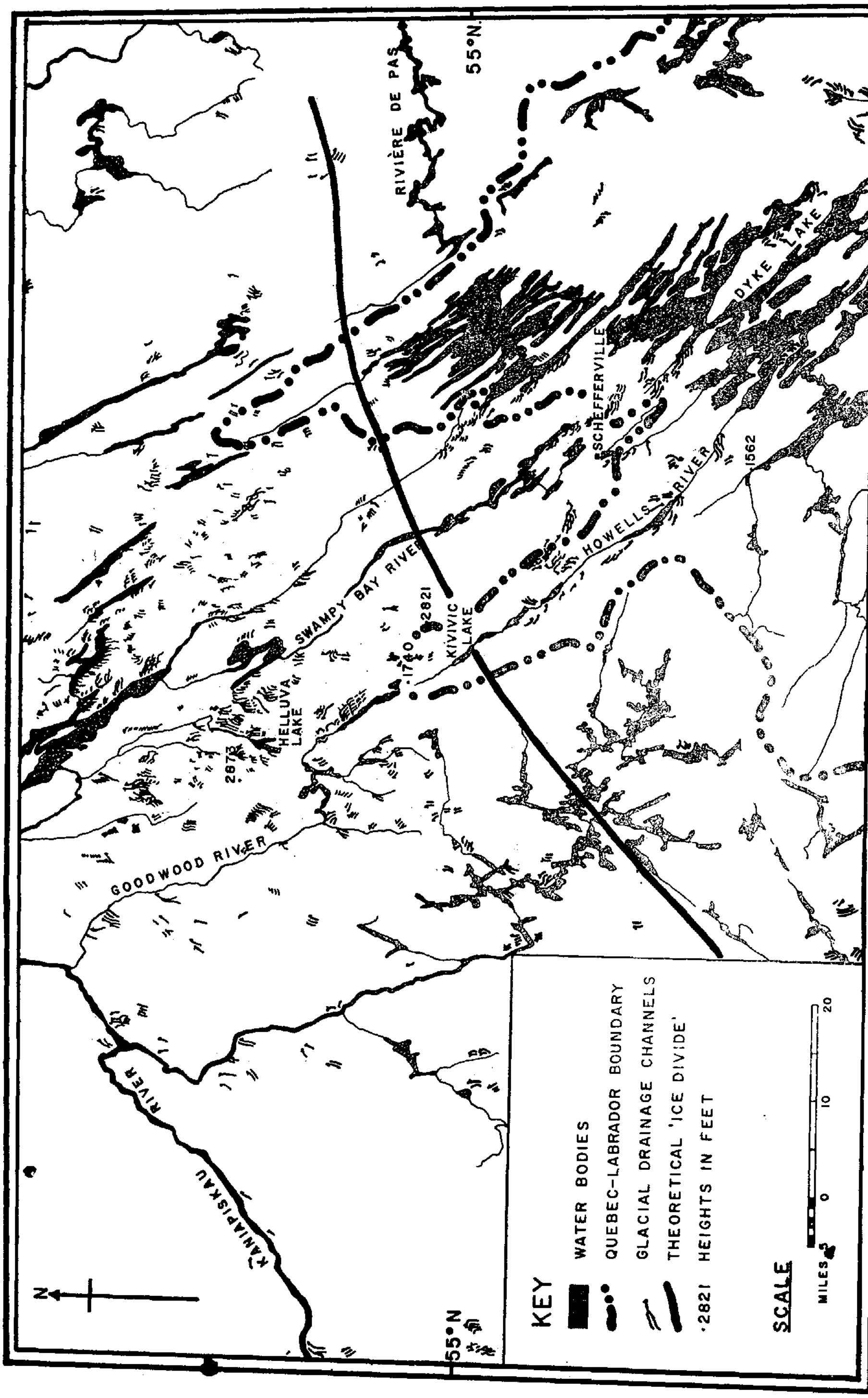
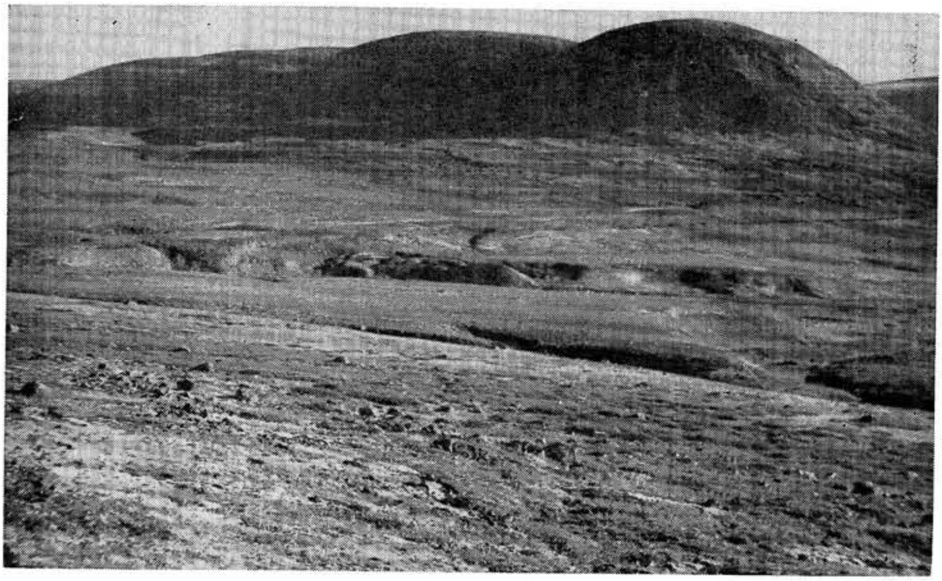


FIG. 6. GLACIAL DRAINAGE CHANNELS IN CENTRAL LABRADOR-UNGAVA

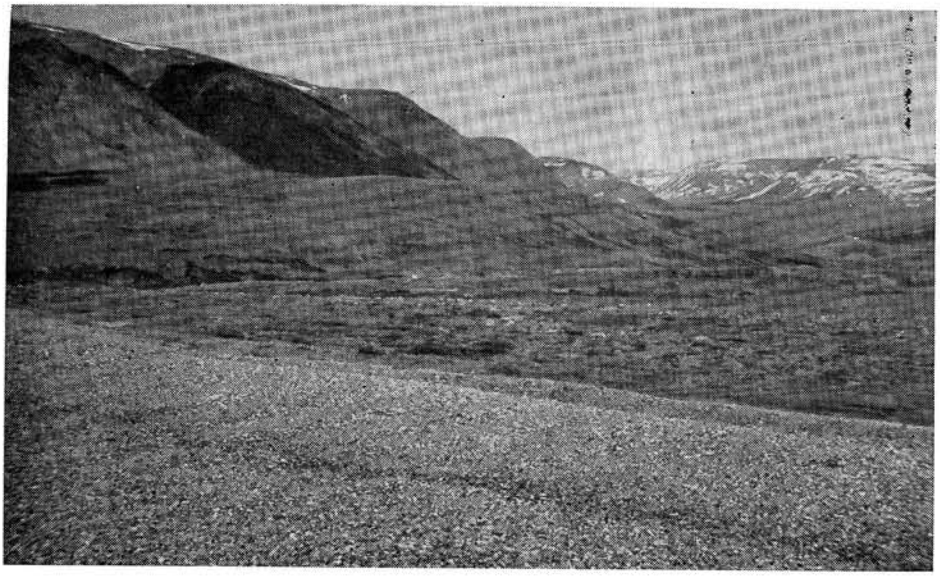
PHOTO IX



(*Aug. 10th., 1957.*)

View to southwest across « Shoreline Brook », the main south-bank tributary of the west-flowing Koroksoak. The extensive system of kame terraces and marginal deposits slopes down into the valley and marks successive phases of the rapid wastage of the outlet glacier remnants west of the watershed.

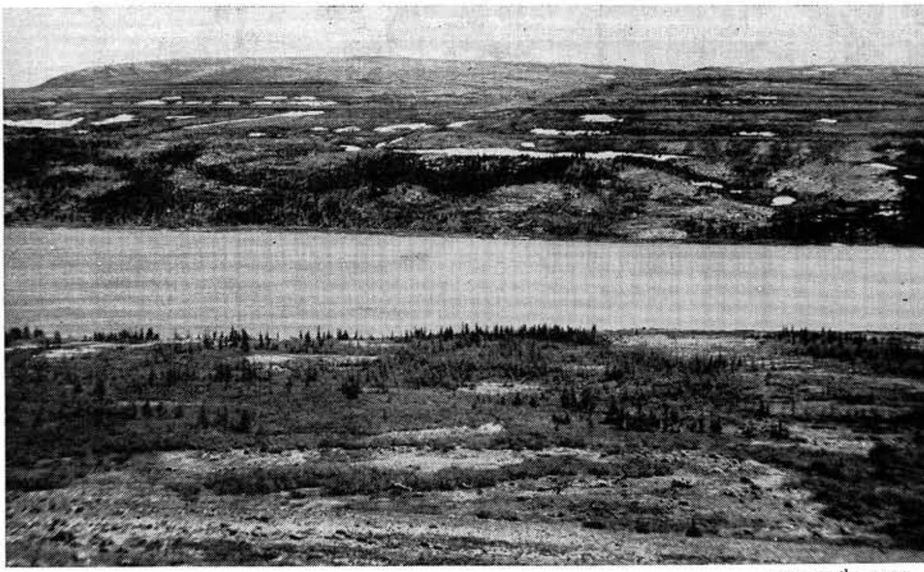
PHOTO X



(*Aug. 6th., 1956.*)

Once the ice in the western Torngat valleys had thinned below the level of the cols, lakes were trapped between the inland ice and the watershed to the east. A lake shoreline of shingle (foreground) was located at approximately 600 feet above sea level in the Abloviak Valley.

PHOTO XI



(July 10th., 1958).

Sections of the Naskaupi glacial lake shorelines looking east across Indian House Lake from « High Bluff ». The massive boulder barriers at the foreslope of the beaches give the impression of double shorelines where, in fact, there is only one.

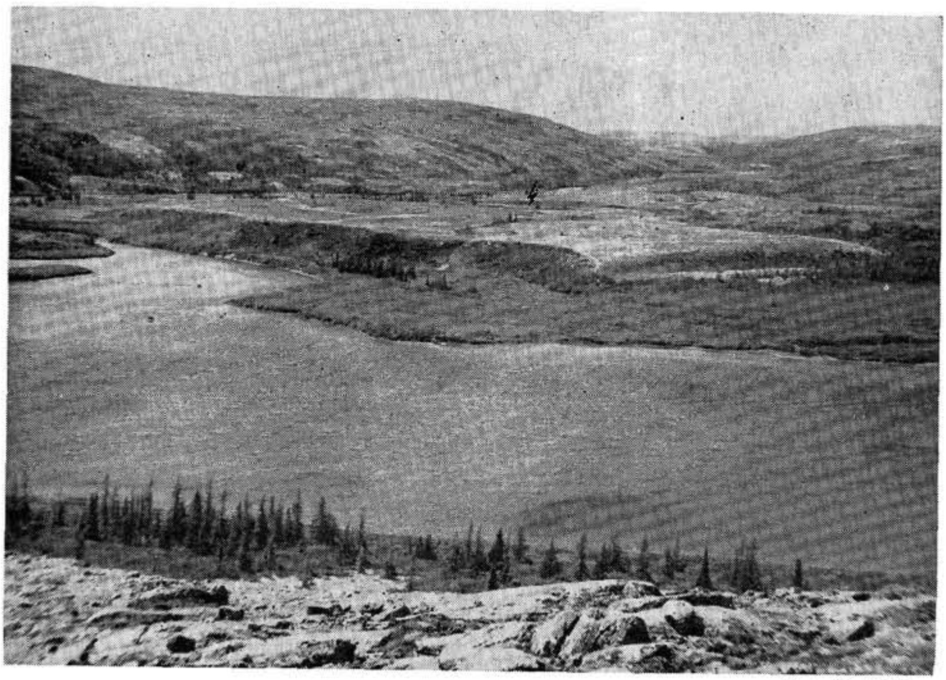
PHOTO XII

(July 14th., 1958.)

View towards the south along Indian House Lake from a large shingle spit of the Glacial Lake Naskaupi II shoreline.

line had risen above the land surface by the time the summits had emerged from the residual ice. From this conclusion, and from the characteristics of the channels themselves, some generalisations on glacio-climatic conditions can be drawn. The present mean annual temperature at Schefferville, based on an 11-year period, is 23.8°F. This is only slightly above a temperature conducive to the active development of permafrost. Indeed, on the higher summits, where the mean temperature is of the order of 20 - 21°F., active permafrost up to 250 feet thick is found today (Ives, 1960*c*). Similarly, if large masses of ice existed at a time when the mean temperature was only slightly below that of today, it is

PHOTO XIII



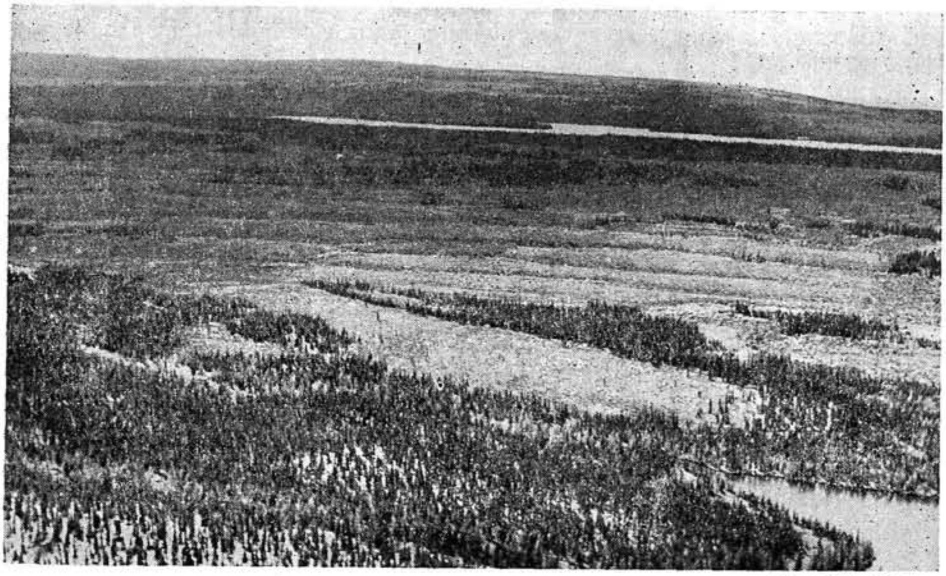
(*Aug. 4th., 1958.*)

Massive deltas, laid down in the Naskaupi glacial lake system, are common at the south end of Indian House Lake.

reasonable to assume that the temperature regime of the ice would have been negative. This is not compatible with the extensive subglacial drainage of melt-water which is usually associated with ice caps and glaciers at the pressure melting point. It is suggested, therefore, that the mean temperature (and particularly the summer temperature) during the final phase of wastage was at least comparable with, and probably higher than, that of today.

It was noted in 1958 (Ives, 1960*b*) that striations and associated features gave evidence of late movement away from the zone separating the two opposed

PHOTO XIV



(*Sept. 16th., 1958.*)

Glacial drainage channels on the east side of Dolly Ridge, 5 miles southeast of Schefferville. View towards the southwest from the air. These channels slope down towards the south-southeast and lie about 30 miles south of the « final ice-divide ».

PHOTO XV

(*Sept. 5th., 1958.*)

Part of a huge system of sub-glacial drainage channels northeast of Helluva Lake. Some of these channels exceed 60 feet in depth. Note the irregular, interconnecting form of the channels. They slope down towards the north and lie 28 miles north of the Kivivic Lake « ice-divide ».

sets of drainage channels. Thus, although it is contended that the ice was climatically dead, some movement under gravity probably occurred, although not sufficient to modify the sub-glacial channels. Detailed till fabric studies at 36 sites across the area in 1959 by Mr. R. P. Kirby, of the Laboratory staff, have shown that the preferred orientation of the long axes of till particles parallels the most recent striations and adds further weight to the concept of slow ice movement at a very late phase. Random orientation in the Kivivic Lake area, along the « divide », also helps substantiate this (Kirby, 1960*a* and 1960*b*).

A general study of ice movement in the central plateau area has yielded much conflicting evidence (Henderson, 1959). It is apparent that the area has been subjected to regional movements from various directions as the main centre of accumulation shifted with time. Despite the fact that Henderson concluded that the most recent movement across the Schefferville area was towards the northeast, it is emphasised that the final movement south of the « divide » was towards the south and south-southeast, while north of this zone, movement was northerly. This places the final « ice-divide » some 50 miles north of that shown on the Glacial Map of Canada.

General considerations and conclusions

Although this study has been primarily confined to the northeast quadrant of Labrador-Ungava, perusal of air photographs allows a general expansion to embrace the whole. The high land fronting Hudson Strait slopes gently southwards and extensive systems of abandoned shorelines on this southern flank prompt comparison with the George River Basin. Similarly, the entire northern flank of the Laurentian Scarp is fringed with glacial lake shorelines suggesting that large bodies of water were trapped by ice to the north. These areas, when studied in detail, should add immeasureably to the theory of deglaciation. The complete omission of all glacio-lacustrine features from the Glacial Map of Canada emphasises the urgency for such a study, particularly when the evidence is contradictory to the current interpretation of that map.

One of the outstanding characteristics of late-glacial conditions in Labrador-Ungava is the many similarities to conditions in Fennoscandia. Much of the work described here has been based upon the outstanding work which has been done in Fennoscandia. Perhaps one of the greatest contributions which Tanner made to the study of the deglaciation of Labrador-Ungava was to emphasise these similarities, a realisation which led him to picture the area as the « homologue » of Fennoscandia. As a tribute to Tanner's invaluable work and indirect encouragement, I would like to conclude by stating that the general picture of deglaciation drawn by him has barely been changed, except in detail, by the efforts of five summers' work on the part of myself and my colleagues.

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