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# Deglaciation of the Whitegull Lake Area, Labrador-Ungava

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Article abstract

Les diverses étapes de la glaciation et de la déglaciation de la région du lac Whitegull sont l'objet de cet article. Au cours de la période de déglaciation, de longs eskers d'une hauteur de plus de 50 pieds, avec des pentes atteignant 35°, furent construits par les eaux de fusion sous-glaciaires ; par la suite plusieurs lacs de

barrage glaciaire se formèrent, dont on peut déterminer l'extension grâce à des vestiges bien conservés d'anciennes formes littorales d'érosion ou d'accumulation. Ces formes soulevées se sont apparemment construites très lentement, probablement au cours d'un long temps d'arrêt dans le recul du glacier. L'auteur peut ainsi faire l'hypothèse que la déglaciation de la péninsule du Québec-Labrador, loin d'être un simple recul d'une grande calotte glaciaire, s'effectua au contraire suivant un rythme saccadé.

# DEGLACIATION OF THE WHITEGULL LAKE AREA LABRADOR - UNGAVA *

*by*

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Although the magnificent raised shorelines of the George River basin were first recognized as early as 1911 [1] it was not until 1959 that the pro-glacial lake phase of the deglaciation was recognised.[2] Following that study the shorelines have been examined by Matthew in the Pic Pyramide area,[3] Barnett in the Indian House Lake area [4 and 5] and by the author in the Whitegull Lake area [6] (figure I). In each case the raised shorelines were surveyed from bench marks of either the Topographic Survey of Canada or the Quebec Streams Commission.[7] The results have enabled general pro-glacial lake stages to be determined, but it was not until Barnett and the author completed their traverses that the extent of the main phase was defined and discussed.[8]

Accepting this survey data and its implications the present paper describes the sequence of events during glaciation and deglaciation in the Whitegull Lake area.

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* The writer's field work during the summer of 1963 was supported by the McGill Sub-Arctic Research Laboratory. Grateful acknowledgement is made to members of staff of the Geography Department of McGill University, and to Dr. J. D. Ives — Director of the Geographical Branch, Department of Mines and Technical Surveys, Ottawa — for help in planning the field season and discussing results.

Appreciation is expressed for the most able field-assistance of Mr. J. Middleton-Elliott.

Thanks are due to Professor J. Brian Bird of McGill University and to Mr. E. Derbyshire of Monash University for reading and commenting upon earlier drafts of this paper.

[1] PRITCHARD, H. H., 1911, *Through trackless Labrador* (with a chapter on fishing by Gathorne-Hardy), Sturgis and Walton, New York, 244 pp.

[2] IVES, J. D., 1960, *Former ice-dammed lakes and the deglaciation of the middle reaches of the George River, Labrador-Ungava*, in *Geographical Bulletin*, No. 14, pp. 44-70.

[3] MATTHEW, E. M., 1961, *The glacial geomorphology and deglacierization of the George River Basin and adjacent areas in Northern Quebec*, M.Sc. thesis presented to McGill University, Montréal. *Unpub*; MATTHEW, E. M., 1961, *The deglaciation of the George River Basin, Labrador-Ungava*, in *Geographical Paper No. 29*, Geographical Branch, Ottawa.

[4] BARNETT, D. M., 1963, *Former pro-glacial lake shorelines as indicators of the pattern of deglaciation of the Labrador Peninsula*, in McGill Sub-Arctic Research *Annual Report 1961-2*.

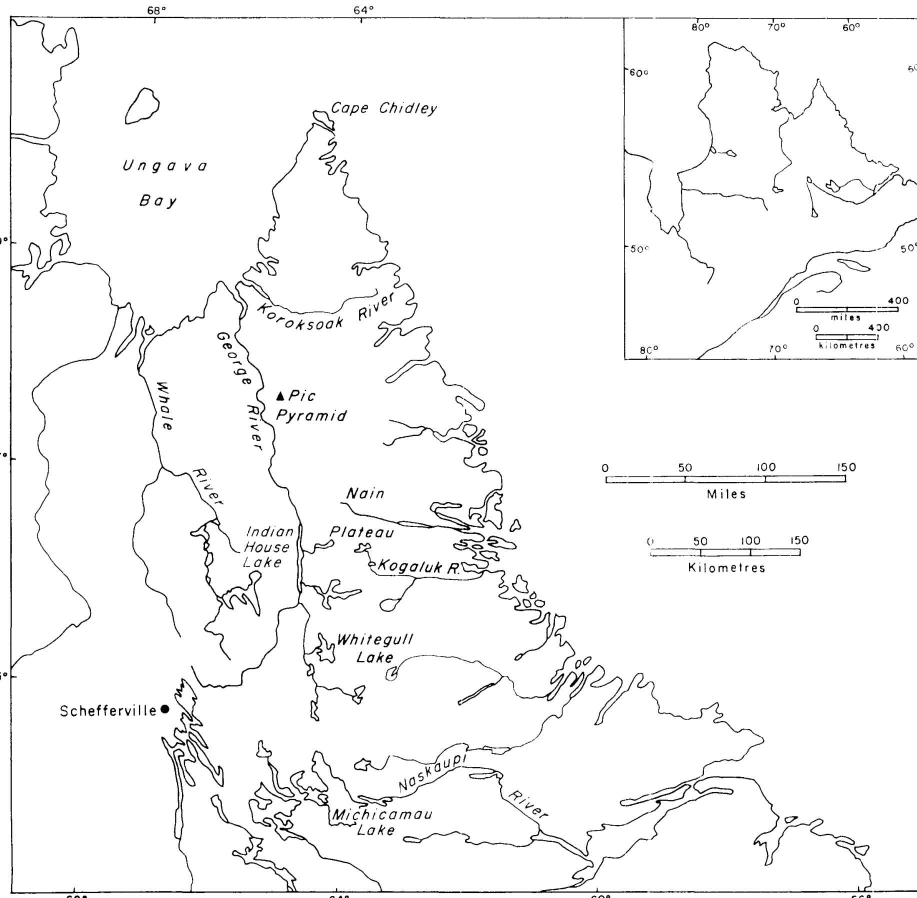
[5] BARNETT, D. M., 1964, *Some aspects of the deglaciation of the Indian House Lake area with particular reference to former pro-glacial lakes*, M.Sc. thesis presented to McGill University, Montréal. *Unpub.*

[6] PETERSON, J. A., 1964, *The Whitegull Lake Area, Labrador-Ungava : Studies of the late-glacial geomorphology*, M.Sc. thesis presented to McGill University, Montréal. *Unpub.*

[7] Details of relevant bench marks may be obtained from *The Dominion Geodesist*, Geodetic Survey of Canada, Dept. of Mines and Technical Surveys, Booth Street, Ottawa ; and the « Directeur général des eaux », Ministère des Richesses naturelles, Québec City.

[8] BARNETT, D. M., and PETERSON, J. A., 1964, *The significance of Glacial Lake Naskaupi 2 in the deglaciation of Labrador-Ungava*, in *Canadian Geographer*, Vol. VIII, No. 4.

FIGURE I




Location

*Glaciation*

The Glacial Map of Canada,[9] based largely on air photo interpretation, suggests that the last major ice movement across the Eastern Plateau Belt[10] was from the central areas of the Peninsula toward the Labrador coast.

Field work confirms this for the Whitegull Lake area more clearly than for many other parts of the Peninsula. The Whitegull lowlands are flanked to the east by the syenite Vendet Hills which rise abruptly some 700 feet above the lake itself. This situation has given rise to a fine suite of forms indicating the direction of ice movement. They include *roches moutonnées*, mamillated surfaces, grooves, crescentic marks, modified cols, and erratics of younger rocks from the Labrador Trough some fifty or more miles to the west.

[9] WILSON, J. T., *et al.*, 1958, *Glacial Map of Canada*, in *Geol. Assoc. Can. Toronto.*

[10] HARE, F. K., 1959, *A photo reconnaissance survey of Labrador-Ungava*, Geog. Branch, Mines and Technical Surveys, Ottawa, *Mem. 6*, 64 pp.

A phase of complete inundation is indicated by overridden hilltops bare of soil and marked by glacial grooves ; by theoretical considerations proposed from field work in other areas ; and by the evidence of widespread isostatic recovery in the Peninsula as a whole.

A later stage of considerably reduced ice thickness is indicated by the disposition of large pressure release saxums [11] of syenite. Their presence suggests a much greater thickness of ice than is necessary for the breakout and later limited transport of these blocks across the summits of the Vendet Hills. Some of the blocks were found as little as a few hundred yards from the western boundary of the syenite.

### *Deglaciation*

While there is evidence of retreat stages in the coastal valleys [12] the deglacierization of much of the Peninsula was by stagnation on a regional scale, large areas having become affected by the snow line rising above the general level of the plateau. Downwasting caused the ice front to move progressively toward the central ice dispersal area where it was thickest.

Retreat from the coast to the George River Basin exposed the Atlantic-Ungava Bay watershed before the major equilibrium in the downwasting caused the major pro-glacial lake phase.

Before this stage was reached the ice lying over the dissected plateau had become stagnant enough to allow the deposition of sub-glacial eskers. These are impressive for their comparative continuity and relative straightness. Their lateral slopes reach 35° and fifty feet is a common height along the more prominent sections. In general these eskers can be traced for many miles and are of the simple embankment type. Their routes, although ignoring minor topographic features, seem to be governed by the passes and cols.

Small eskers also occur ; they are generally more pitted and less persistent and are unrelated to the main ridges. They belong to a later stage of ice wastage. The ice on the dissected plateau, cut off from the still active ice west of the Vendet Hills, disintegrated *in situ*. However, dead ice features are not plentiful, probably due to the small amounts of englacial material present at this stage. This is not surprising as the effect of glaciation over many Shield areas remote from outcrops of younger rock has been to impoverish them of surficial materials. In places drainage channels provide the best evidence of the immobile condition of the ice. Although poorly developed in resistant bedrock, a number of very well formed channels have been cut in the drift in the few localities where it is locally abundant. Because the responsible meltwater was derived from ice cut-off from the main ice mass, channel slopes are of little use as indicators of the regional ice slope (c.f. drainage channels on the Nain Plateau).[13]

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[11] CHARLESWORTH, J. K., 1956, *The Quaternary Era*, Arnold, London, 2 vols. p. 226.

[12] ANDREWS, J. T., 1961, *The glacial geomorphology of the northern Nain-Okak section of Labrador*, M.Sc. thesis presented to McGill University, Montréal. *Unpub.*

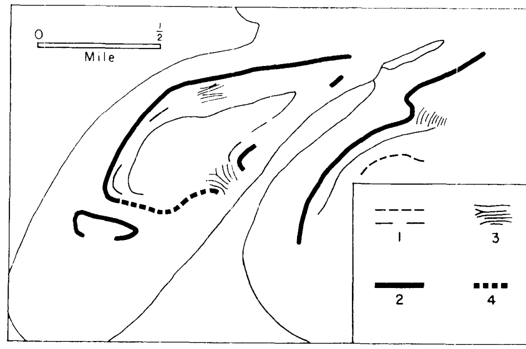
[13] IVES, J. D., 1960, *op. cit.*, p. 52.

Further deglaciation brought about the formation of pro-glacial lakes in the valleys between the western ice mass and the watershed to the east. Progressive wastage allowed lateral connections between valleys so that eventually one larger lake spilled across the lowest divide. Unfortunately lack of detailed topographic data renders an exact account of the sequence impossible but shorelines such as the higher ones shown in figure II are evidence enough of this stage. These shorelines stand at 1,647 and 1,607 feet above sea level and have no counterpart in the Indian House Lake area to the north. This indicates a distinct deglacial history for the Whitegull area up to the formation of pro-glacial lake N2, shorelines of which have been proved to exist in both areas. The N2 shoreline was established at 1,544 feet.

During the minor pro-glacial lake phase the ice front lay along the mouths of the passes of the western border of the Vendet Hills. The ice tongues in the passes built only minor moraines in the pass mouths. One of these moraines suggests a concave ice front. The general situation is shown in figure III*a*.

It is seen that the Mistinibi ice lobe divides the Whitegull area from proglacial lake Naskaupi 1 to the north. The field evidence for this ice lying across the Mistinibi Lowlands and countaining the waters of N1

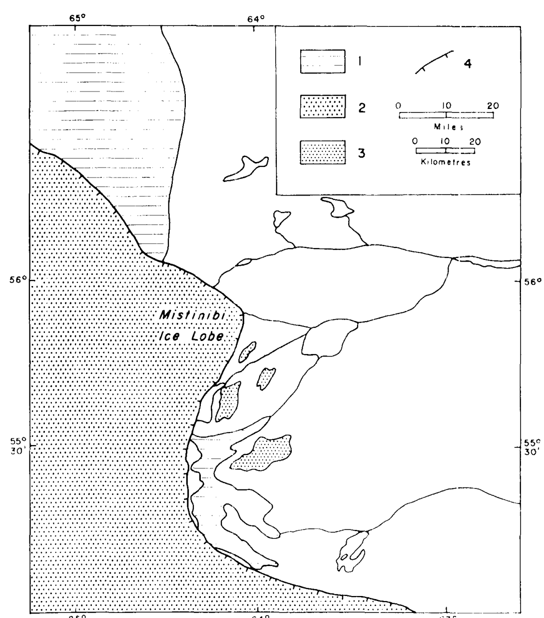
FIGURE II




Shoreline remnants in the east Lac Machault area (*see also northern inset figure IV*).

1. pre-N2 remnants ;
2. N2 remnants ;
3. pre-N2 shingle beach ridges ;
4. N2 sand beaches.

FIGURE III*a*



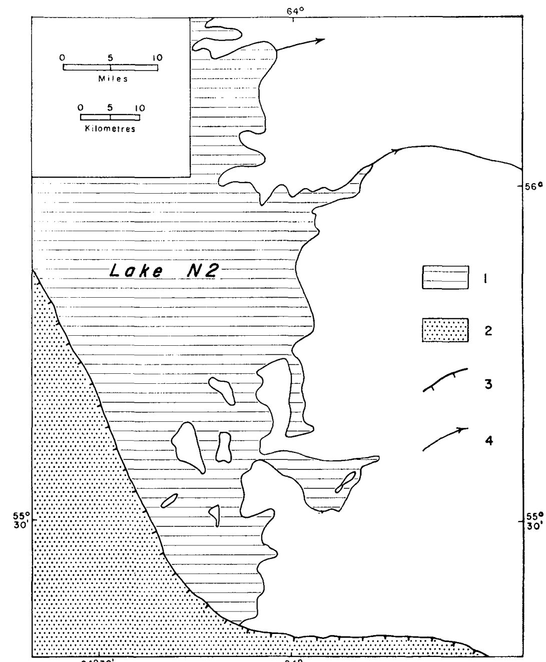

General situation in the Upper George River basin during the minor pro-glacial lake phase in the Whitegull Lake area.

1. pro-glacial lakes ;
2. ice mass ;
3. stagnant ice mass locations ;
4. active ice front or ice barrier.

has not been examined. However the occurrence of such extensive pro-glacial lake shorelines as the N1 remnants of the Indian House Lake areas is strong circumstantial evidence because where shorelines are lacking ice can be postulated with some confidence.[14]

The existence of the ice lobe is further supported by the drumlinoid pattern across the Mistinibi lowlands. Accepting the long narrow shape of drumlinoids as being due to formation under active ice,[15 and 16] they must have been formed by a late stage ice movement as they are divergent from the strong regional trend.[17]

FIGURE III*b*




The southern extent of N2 in the Whitegull Lake area.

1. pro-glacial lake ;
2. ice mass ;
3. ice front.

Present evidence suggests that the Mistinibi ice lobe was breached rather than circumscribed by the N1 waters. Ives,[18] for the northern edge of the lobe, postulated a relatively slow recession followed by rapid withdrawal, on the basis of the upper limit of wave action. South of the lobe area, however, widely spread shingle beach ridge complexes point to a steadily falling level over an area comparable to that later occupied by N2 in the Whitegull area. The apparent anomaly indicates the breaching of the lobe so that the spillway was at that stage partially occupied by ice — possibly the same ice that prevented till washing north of the lobe. The lowering and southward spread of the waters of N1 to form the major pro-glacial lake stage in the upper George River basin has been proved by survey (*see above*) of N2 remnants. The general situation at this stage is shown in figure III*b*.

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[14] BARNETT, D. M., 1963, *Former pro-glacial lake shorelines as indicators of the pattern of deglaciation of the Labrador Peninsula,* in *McGill Sub-Arctic Research Annual Report 1961-2,* pp. 24.

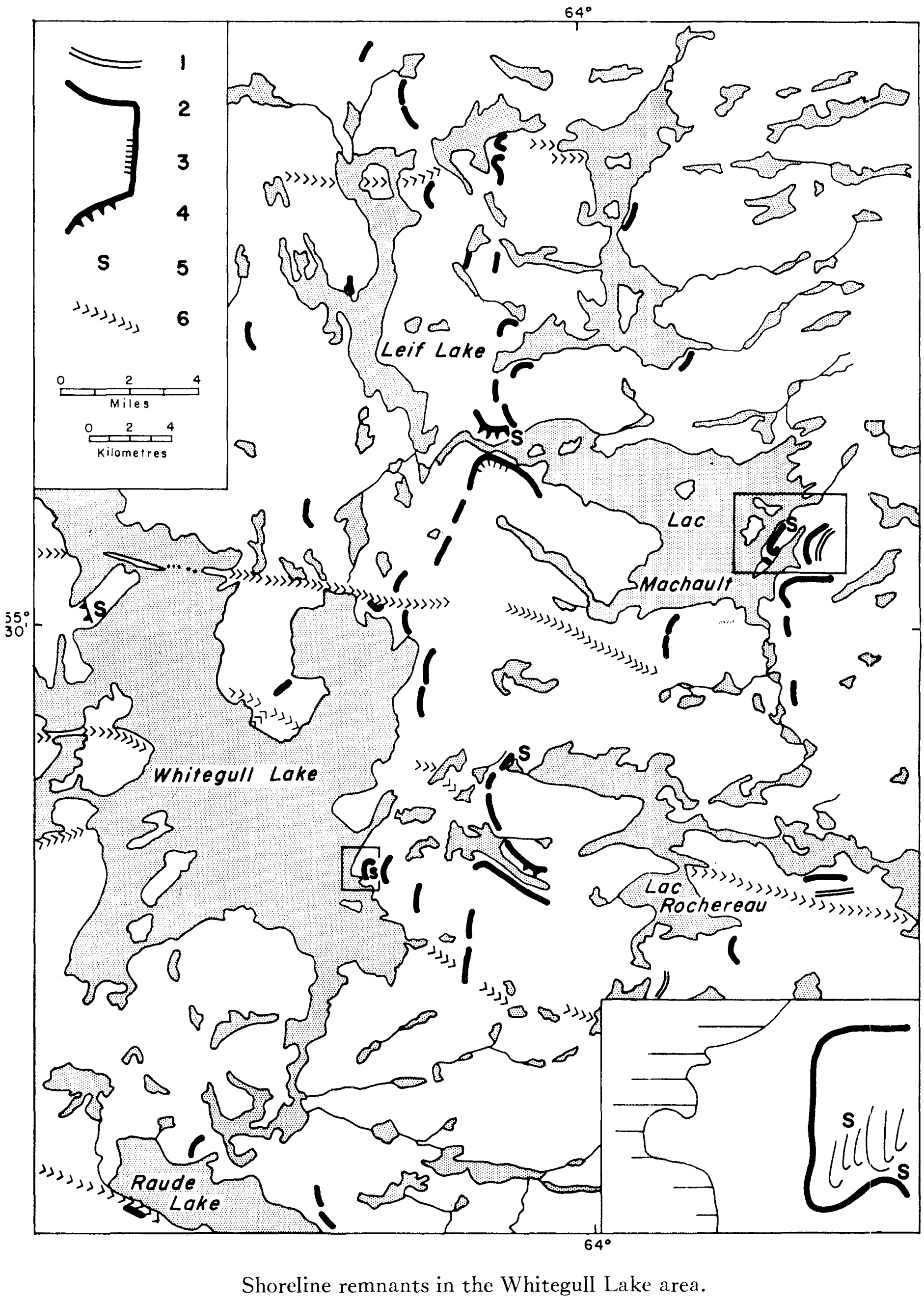
[15] CHORLEY, R. J., 1959, *The shape of drumlins,* in *J. of Glac.,* 3, 25, pp. 339-345.

[16] BIAYS, P., 1960, *Quelques travaux et documents concernant le Bouclier Canadien,* in *Norois,* No. 25, 7th vol., pp. 13-31.

[17] DOUGLAS, M. C., and DRUMMOND, R. N., 1953, Maps of eskers, drumlins and till deposition in Quebec-Labrador. Maps produced for the Canadian Defense Research Board and the Arctic Institute of North America. *Unpub.*

[18] IVES, J. D., 1960, *op. cit.,* p. 56.

FIGURE IV




Shoreline remnants in the Whitegull Lake area.

1. pre-N2 remnants ;
2. N2 remnants ;
3. wave cut cliff ;
4. sandy beach ;
5. shingle ridge complexes ;
6. eskers.

Deglaciation to this time presents a sequence transitional between that of the retreat and wastage on the higher Nain Plateau to the north and the lower lying Lake Plateau to the south. Situated, as it is, across the dissected south-western border of the Eastern Plateau Belt, the eastern part of the present study area is too dissected to show the sensitively adjusted smaller pro-glacial lakes that have been described from the Nain Plateau further north.[19] Nor is the eastern Whitegull region sufficiently low or flat to retain intact a considerably thinned ice cover as did the eastern extremity of the Lake Plateau to the south of the Whitegull area.

Further elucidation of deglaciation north of the Mistinibi ice lobe is the subject of a future paper by D. M. Barnett (Geographical Branch, Ottawa), with whom the present writer has discussed some of the problems examined later in this paper.

*The N2 shorelines in the Whitegull Lake area*

The history of the N2 phase of the deglaciation is best traced by examination of the shoreline remnants. The lacustrine deposits so characteristic of the areas occupied by pro-glacial lakes in southern Canada and the United States are apparently absent from the George River valley. A similar lack of deposit characterizes the areas of the former pro-glacial lakes of the Keewatin area.[20 and 21] This absence of sediment is attributable to the resistant nature of the Archean basement complex which produces coarse-grained sediment of a sandy nature.

Well-marked erosional and depositional shorelines belonging to the basin-wide N2 shoreline remnant group are in places the most conspicuous glacial features in the Whitegull area (figure IV). Essentially they are the same as those described from other parts of the basin. Erosional forms are restricted to the west and southwest sides of hillslopes. The depositional forms occur in southern lee positions. The best developed examples of wave-cut platforms are associated with moderately steep hillsides open to the west thus exposing them to the most effective fetch of N2 (photo I).

Ice conditions on the former Naskaupi lakes are not immediately apparent from field evidence. The influence of lake ice on the development of the Naskaupi shorelines has been discussed by previous workers [22 and 23] and is still an open question. If wind-driven lake-ice floes set free by partial break-up be taken as the main agent responsible for ice push ramparts in this region,[24] then the lack of these features may be attributed to a combination of a short partial-open-water season and unsuitable topography. It seems likely that many of the modern

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[19] Ives, J. D., 1960, *op. cit.*, p. 52.

[20] Lee, H. A., 1959, *Surficial Geology of the southern district of Keewatin and the Keewatin ice divide*, in *Geol. Survey of Canada Bull. 51.*

[21] Bird, J. B., 1953, *The glaciation of Central Keewatin, Northwest Territories, Canada*, in *Am. J. Sci.*, vol. 251, pp. 215-230.

[22] Ives, J. D., 1960, *op. cit.*, p. 61.

[23] Matthew, E. M., 1961, *op. cit.*, p. 112.

[24] Peterson, J. A., *Ice-push ramparts in the George River Basin, Labrador-Ungava*, in *Arctic*, Vol. 18, No. 3, June 1965.

PHOTO I

N2 wave cut platform — east Lac Machault.

ice-push ramparts owe their preservation to their position near gently shelving shores upon which much of the energy of the waves is expended.

Depositional shoreline features of the N2 phase are restricted to the sheltered southern and east-facing slopes of the hillsides forming the eastern boundary of the lake N2 and are usually associated with or adjoin a west facing wave cut terrace. Some of these features are quite remarkable (photo II).

*Post N2 features*

Unlike the lower parts of the basin, there is very little evidence of the lake stages subsequent to the N2 stage. Raised shorelines that may represent N3 can be seen above the George River from air photos but were not checked in the field. Extrapolation from the Indian House Lake area suggests that the N3 shorelines in the Whitegull Lake area are not to be expected outside the immediate trench of the George River itself.

* * *

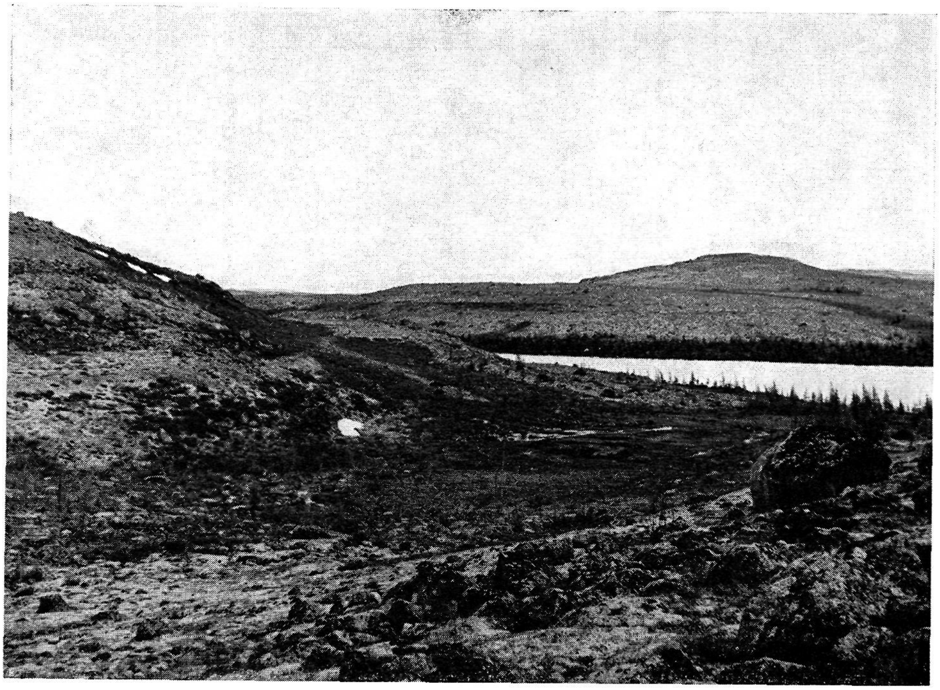
The implication of the field work are relevant not only to the history of the George River basin but to the question of causes and effects of the glaciation of the whole Québec-Labrador Peninsula.

*The nourishment and extent of the northern ice barrier of N2*

Confirmation of the extent of the glacial lake N2 from the levelling data supports Ives [25] original suggestion that consistently well developed and extensive shoreline remnants such as those found in the George River valley could only

[25] IVES, J. D., 1960, *op. cit.*

PHOTO II



N2 sand beach 90′ wide, with wave cut platforms in background.

belong to a large lake. While the best known ice-dammed lakes in maritime areas appear to be unstable [26, 27 and 28] the pro-glacial lakes of arctic areas such as Baffin Island appear stable.[29] In that these latter lakes (Lakes Conn and Bieler) drain across a watershed, they are an analogy to the larger Naskaupi lakes of late-glacial times.

The most logical way of accounting for the lakes is to postulate large masses of ice over the lower basin and Ungava Bay [30] — and possibly also Hudson Strait and Frobisher Bay. Glacial lakes in the Torngat valleys [31 and 32] also indicate the existence of a large mass of ice covering at least part of Ungava Bay in late-

[26] THORARINSSON, S., 1939, *The ice dammed lakes of Iceland with particular reference to their value as indicators of glacier oscillations*, in *Geog. Annaler*, Vol. 21, pp. 216-242.

[27] LIESTOL, O., 1955-56, *Glacier-dammed lakes in Norway*, in *Norsk. Geografisk. Tiddesk*, 15, No. 3-4, pp. 122-49.

[28] HEINSHEIMER, C. J., 1954, *Der Durchbruch des Morenogletschers Largo Argentino, Patagonia 1953*, in *Zeitsch. für Gletscherkunde und Glaziolgeologie*, III.

[29] MATTHEW, E. M., 1961, *op. cit.*, p. 82 and Plate 47.

[30] IVES, J. D., *op. cit.*, p. 66.

[31] IVES, J. D., 1957, *Glaciation of the Torngat Mountains, Northern Labrador*, in *Arctic*, Vol. 10, No. 2, pp. 67-87.

[32] IVES, J. D., 1960, *The deglaciation of Labrador-Ungava — an outline*, in *Cahiers de Géog. de Québec*, Vol. 4, No. 8, pp. 323-343.

glacial time. Objections have been raised by Matthew [33] who suggested that ice lying to the west and north of the middle portions of the George River basin would have been sufficient to form an ice barrier. The suggestion (based on a single C14 date later published by Matthews),[34] that Hudson Strait was open as early as 10,000 years ago supports this view. However the existence of a large ice-body in Ungava Bay should not be dismissed until further work around the south-east shores of Ungava Bay is completed.[35]

### *The Southern Ice Barrier*

Ives [36] tentatively mapped an east-west barrier immediately north of the Atlantic-Ungava Bay drainage divide directly north of Lake Michikamau. The position of the barrier was suggested by the absence of either spillways or well-marked shorelines south of the George River basin. It is interesting to note that Low [37] recorded raised strandlines in the Michikamau area south of the postulated ice divide. Ives [38] mentioned this enigma and tentatively suggested that Low's abandoned shorelines might possibly have been caused by isostatic tilt rather than by glacial damming. As no raised shoreline is identifiable from air photos of the Michikamau region, it is suggested that Low's shorelines are probably ice-push ramparts.[39] Analogy with features in the Whitegull Lake area together with Hubbard's description of ice-push ramparts on the shores of Lake Michikamau [40] supports this idea.

Now that the amount of tilt of the N2 shoreline has been demonstrated [41] and the height of the Michikamau divide is known to be 1,557 feet,[42] Ives' original plotting of the southern ice barrier north of the Michikamau col can be confirmed. In other words the N2 water plane passes over the height of land by some tens of feet. It follows that the lower land on the Lake Plateau lying south of Raude Lake carried glacier ice until after the N2 stage. The date of its break-up is uncertain. Extrapolation of the value and direction of tilt of the younger N3 shoreline from the Indian House area southward across the divide suggests that the latter is too high to have been an outlet of N3. Therefore the ice of the

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[33] MATTHEW, E. M., 1960, *Deglaciation of the George River Basin, Labrador-Ungava*, Geogr. Branch Dept. of Mines and Technical Surveys, *Geog. Paper*, 29, pp. 17-29.

[34] MATTHEWS, B., 1962, *Glacial and post-glacial geomorphology of the Sugluk-Wolstenholme area, Northern Ungava* in *McGill Sub-Arctic Research Papers*, No. 12, pp. 17-46.

[35] IVES, J. D., 1960, *op. cit.*, outlines the importance of work in this area.

[36] IVES, J. D., 1960, *Former ice-dammed lakes and the deglaciation of the Middle reaches of the George River, Labrador-Ungava*, in *Georg. Bull.*, 14, pp. 44-70, see fig. 7.

[37] LOW, A. P., 1895, *Report on explorations in the Labrador Peninsula, along the Eastmain, Koksoak, Hamilton, Manicouagon and portions of other rivers in 1892-93-94-95*, Geological Survey of Canada, *Ann. Rept.*, 8, part L, 387 pp.

[38] IVES, J. D., 1960, *op. cit.*, p. 69.

[39] PETERSON, J. A., 1965, *op. cit.*

[40] HUBBARD, Mrs. L., 1908, *A woman's way through unknown Labrador*, John Murray, London, 388 pp.

[41] BARNETT, D. M., and PETERSON, J. A., 1965, *op. cit.*

[42] MACLELLAN, W., 1963, Topographic Survey, Dept. of Mines and Technical Surveys, Ottawa. *Pers. comm.*

southern barrier of N2 may or may not have been present at this stage. Comparison between radio-carbon dates south-east of Lake Michikamau [43] and present estimates of the age of the Naskaupi shorelines suggests that it was.

*The Western Ice Barrier*

Although as a general rule the absence of well marked shoreline remnants in the George River basin may be taken as an indication that ice was present at the time of their formation, caution is necessary when dealing with the western shores of N2. Unlike the northern and southern ice barrier margins this western shore was a composite succession of ice-front and land. Without topographic data little detailed information can be offered, but air photo interpretation and some field observation lead to the following assessment. The presence of partial ridge and vale topography west of the George River and the proximity of the ice front have militated against the formation of significant shorelines to the west. As a first approximation the placing of the N2 barrier in the upper basin by Matthew [44] is based on the absence of well-developed shoreline remnants. More detailed interpretation suggests minor modification. This is to be expected, for the western shore of N2 is difficult to trace from the morphological evidence, being complicated in detail by its more direct relation to the main ice mass. Thus it is likely that some « active » retreat of this ice front took place during the N2 and N3 stages. Meltwater drained directly into the lakes in places but in others frontal eskers and ice contact features were formed.

Deglaciation of the area west of N2 is beyond the scope of this study but work on the western barrier may help to date more precisely the pro-glacial lake phases. This work could well include sampling of bogs above and below the shorelines to the east. At present the only dates available are those of Grayson,[45] Morrison [46] and Drummond.[47] Using Grayson's interpretation of the radio-carbon data, Matthew [48] tabled the Naskaupi phase at between nine and ten thousand years ago.

Morrison,[49] however, prefers to assume that the sediment below the peat accumulated much faster than the peat itself. Using this interpretation and assuming that glaciation east of the ice dispersal centre was roughly concentric about the Kaniapiskau-Schefferville area, the Naskaupi Phase can be placed between 9,000 and 7,500 years B. P. Quite apart from its geophysical implica-

[43] MORRISON, A., 1963, *Landform studies in the Middle Hamilton River, Labrador,* in *Arctic,* Vol. 16, No. 4, pp. 272-275.

[44] MATTHEW, E. M., 1961, *The glacial geomorphology and deglacierization of the George River Basin and adjacent areas in Northern Quebec,* M.Sc. thesis presented to McGill University, Montréal. *Unpub.*, fig. 8.

[45] GRAYSON, J. F., 1956, *Post-glacial history of vegetation and climate in the Labrador-Québec region as determined by palynology,* Ph. D. thesis, Univ. of Michigan. *Unpub.*

[46] MORRISON, A., 1963, *op. cit.*

[47] DRUMMOND, R. N., Professor of Geography, McGill University, Montréal. *Pers. comm.*

[48] MATTHEW, E. M., 1961, *op. cit.*

[49] MORRISON, A. (in preparation), *Deglaciation dates in Central Labrador-Ungava : a re-apparaisal.*

tions,[50] dating the shorelines will improve our understanding of shoreline processes on large pro-glacial lakes.

Although the rate of these processes is not yet fully understood it can be confidently stated that the raised shorelines of this major pro-glacial lake phase took some time to develop and that the phase is one involving an important stand-still of the retreating ice front.

*Climatological considerations*

The causes of the climatic amelioration responsible for deglaciation are not fully understood. A number of reasonable explanations have been offered but a clear picture awaits further elucidation of the pattern of deglaciation, the chronology of which involves a number of major problems. These are the times of the opening of Hudson Strait, and the deglaciation of the Hudson Bay area, and the relation of the Ungava Bay ice to the Laurentide ice. The present day climate of Québec-Labrador is controlled by the geographical position of the land and the relative character and configuration of the land mass in relation to marine areas.[51 and 52] Taking the additional influences of the ice caps into account, the same can probably be said for the climate of late glacial times. The actual circulation patterns involved are therefore still debated, and possible patterns have been summarized by Barry [53] and Derbyshire.[54]

As the pattern of deglaciation is not one of simple retreat, perhaps different circulation patterns dominated at various stages. Certainly the pro-glacial lake stage equilibrium was too long to be explained in terms of topography. Precipitation starvation associated with north-westerly flow might eventually cause a major equilibrium and so perhaps may be held in large part responsible for the deglaciation of the Peninsula up to the pro-glacial lake stage. The subsequent, possibly more rapid deglaciation which followed was probably due to a different circulation pattern — very likely northward-moving return flow continental polar air carrying warm rain.

*Isostatic recovery and the pro-glacial lake stage stillstand*

The pro-glacial lake phase demonstrates that the deglaciation of the Québec-Labrador Peninsula was not a case of the simple retreat of a major ice sheet. If then, as seems to be the case, the retreat took place with major interruptions this might reasonably be expected to be reflected in the rate of crustal recovery. In the Great Lakes area, rate variations in uplift have been inferred

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[50] CRITTENDEN, M. D., 1963, *New data on the isostatic deformation of Lake Bonneville,* in U.S.G.S. *Prof. Paper,* H454.

[51] HARE, F. K., 1950, *The climate of the eastern Canadian Arctic and Sub-Arctic and its influence on accessibility,* Ph. D. thesis, Université de Montréal. *Unpub.*

[52] DERBYSHIRE, E., 1960, *Glaciation and subsequent climatic changes in Central Québec-Labrador — a critical review,* in *Geog. Annaler,* XLII, pp. 49-61, p. 50.

[53] BARRY, R., 1960, *The application of synoptic studies in palæoclimatology — a case study for Labrador-Ungava,* in *Geog. Annaler* XLII.

[54] DERBYSHIRE, E., 1960, *op. cit.,* p. 52.

from studies of abandoned shorelines and hinge lines have been recognized.[55] In Northern Canada however the deduction of uplift patterns from shorelines has so far been tied to problems associated with the marine transgression[56 and 57] and only a general pattern is so far apparent.

But there are complicating factors to be considered when using pro-glacial shorelines to discuss the manner and progress of glacio-isostatic updoming. Although the probably rock-bound outlets, and the high degree of shoreline development of N2 suggest a discontinuous uplift (discontinuous per saltum tilting?[58]) the question arises as to how much this temporal pattern is due to the independently spasmodic nature of crustal recoil as demanded by Daly's « punching hypothesis »[59] and supported by other studies, and, to what extent it is due to the interrupted retreat of the ice sheet.[60] The question is complex when applied to the present case. The formation of the N2 shorelines implies two possibilities : the discontinuous updoming, and a still-stand in the general retreat. This still-stand was such that the ice margin was not only in equilibrium but composed of ice active enough to resist excessive calving and also penetration by lake waters while acting as an ice dam. In other words an equilibrium of major significance is recognised. In view of the evidence of shoreline development and glacial still-stand, the possibility of interrupted uplift (whatever the cause or combination of causes) should be seriously considered. Probably the effect of glacial still-stands on the formation of the Naskaupi 2 shoreline was augmented by the effects of a period of quiescence in the updoming. This quiescence may or may not be a prolonged result of the coincidence of normal quiescence associated with some isostatic adjustments and that stemming from a major interruption of retreat.

A significant factor to be evaluated is the life span of the Naskaupi Lake phase. Present estimates are tentative.[61] The longer the phase turns out to be, the more likely a discontinuity of the temporal pattern of tilting appears.

## RÉSUMÉ

*Les diverses étapes de la glaciation et de la déglaciation de la région du lac Whitegull sont l'objet de cet article. Au cours de la période de déglaciation, de longs eskers d'une hauteur de plus de 50 pieds, avec des pentes atteignant 35°, furent construits par les eaux de fusion sous-glaciaires ; par la suite plusieurs lacs de*

[55] LEVERETT and TAYLOR, 1915, *The Pleistocene of Indiana and Michigan and the History of the Great Lakes*, in *U. S. G. S., Mon.* 53.

[56] BIRD, J. B., 1959, *Recent contributions to the physiography of Northern Canada*, in *Zeitsch. Geomorph.*, Bd. 3, Heft. 2, pp. 151-174, p. 163.

[57] LØKEN, O., 1962, *The late-glacial and post-glacial emergence of northernmost Labrador*, in *Geog. Bull.*, 17, pp. 23-56.

[58] RODGERS, J., 1937, *Tilting of pro-glacial lakes*, in *Am. J. Sci.*, ser. 5, 33-34, No. 109, pp. 1-8.

[59] DALY, 1935, *The changing world of the ice age*, Yale Univ. Press, New Haven, 271 p., p. 125.

[60] FLINT, R. F., 1957, *Glacial and Pleistocene Geology*, John Wiley, 533 pp., p. 254.

[61] IVES, J. D., 1960, *op. cit.*
MATTHEW, E. M., 1961, *op. cit.*, p. 130.

*barrage glaciaire se formèrent, dont on peut déterminer l'extension grâce à des vestiges bien conservés d'anciennes formes littorales d'érosion ou d'accumulation. Ces formes soulevées se sont apparemment construites très lentement, probablement au cours d'un long temps d'arrêt dans le recul du glacier. L'auteur peut ainsi faire l'hypothèse que la déglaciation de la péninsule du Québec-Labrador, loin d'être un simple recul d'une grande calotte glaciaire, s'effectua au contraire suivant un rythme saccadé.*