THE ABANDONED GLACIAL LAKE SHORELINES OF SOUTHWEST LABRADOR

by

DAVID ALAN HARRISON

A thesis submitted to the Faculty of Graduate Studies and Research in partial fulfilment of the requirements for the degree of Master of Science.

Department of Geography,
McGill University,
Montreal.

February, 1964.

TABLE OF CONTENTS

ACKNOWLEDGMENTS

The writer is indebted to the McGill Sub-Arctic Research Laboratory for financial support and the loan of surveying and field equipment. Most valuable help was given by the Iron Ore Company of Canada and Wabush Mines and the writer expresses thanks to Mr. W. Campbell and Mr. B. Savage of these two companies.

The writer would like to acknowledge the invaluable assistance of Jim Peterson, Brian Westlake and Tom Hoopes in the field and Professor R. N. Drummond, Professor J. T. Parry, Professor J. B. Bird and Mr. D. M. Barnett for their helpful suggestions in the preparation of this thesis.

The writer wishes to thank Mrs. L. E. Murray and Mrs. D. M. Barnett for typing the thesis.

LIST OF MAPS

LIST OF OVERLAYS

LIST OF FIGURES

LIST OF SECTIONS

LIST OF PHOTOGRAPHS

PHOTOGRAPH Page

CHAPTER 1

INTRODUCTION

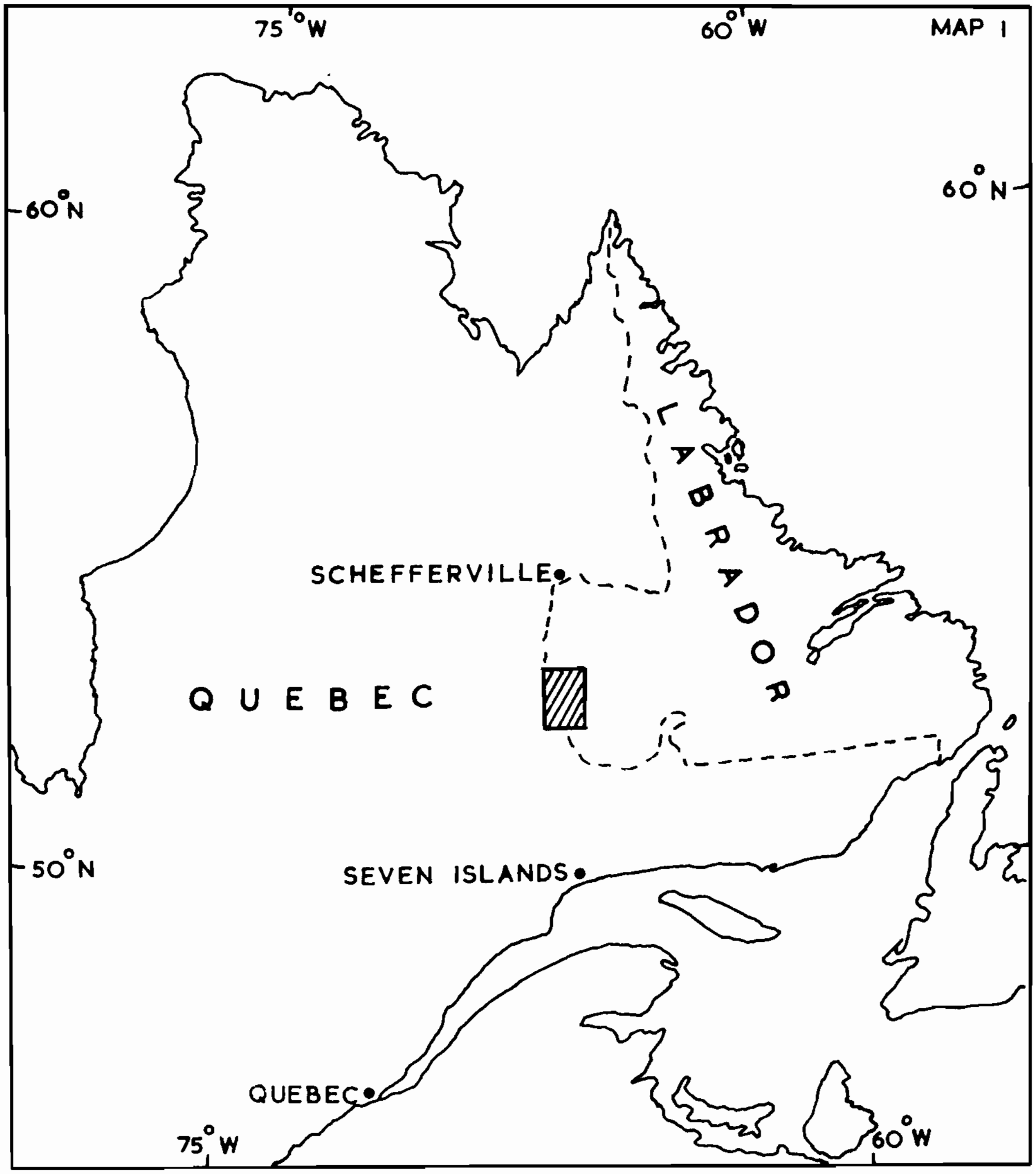
PURPOSE OF STUDY

The purpose of this thesis is to describe in detail the form, lithology, elevation, tilt and distribution of abandoned glacial lake shoreline features and associated fluvioglacial and glacial deposits of Southwest Labrador (map 1). These characteristics are the result of distinct geomorphic and geophysical processes operating in late glacial and post glacial times and therefore a study of these characteristics reveals certain facts about the glacierization of Labrador-Ungava* and the deglacierization of Southwest Labrador.

The tilt of the glacial lake shoreline features is a result of glacial isostatic recovery and therefore the tilt of the shorelines reflects the differential thickness of the Laurentide Ice Sheet over Southwest Labrador during a certain stage in the Wisconsin period. If tilts of shorelines in other areas are used in conjunction with the tilts from Southwest Labrador it is possible to locate a point which represents a centre of ice dispersal of the Laurentide Ice Sheet during a certain stage in the Wisconsin period.

---

* The term "Labrador-Ungava" is used throughout this thesis for the peninsula bounded by the Atlantic Ocean, Hudson Bay and Straits and the Gulf of St. Lawrence. The term has been adopted by the McGill Sub-Arctic Research Laboratory and its derivation and usage have been explained in detail by Ives (1959).



LOCATION OF SOUTHWEST LABRADOR

The distribution and character of the various glacial lake shoreline features and associated fluvioglacial and glacial deposits indicate the position and character of the ice barriers during the various stages of retreat of the ice from Southwest Labrador.

This area of Southwest Labrador surrounding Wabush Lake and Shabogamo Lake (map 2, in pocket) was chosen because the pattern of relief and drainage and the direction of ice retreat favoured the formation of glacial lakes. Southwest Labrador lies south of the position of the final ice divide of Ives (1960c) and the ice divide shown on the Glacial Map of Canada (Wilson et alia, 1958) and therefore a study of the tilt of the glacial lake shorelines should reveal further evidence for the correct positioning of these ice divides. This area, although well known geologically has only been studied briefly from the glacial geomorphological point of view by Henderson (1959). Previous geomorphological work has been mainly concentrated in the region of the final ice divide and on the Labrador coast so that this study helps to broaden the field of geomorphological information of the Labrador-Ungava peninsula.

LOCATION OF SOUTHWEST LABRADOR

The area designated Southwest Labrador lies about the headwaters of the Ashuanipi-Hamilton River system in southwest Labrador, between latitudes 52°35' north and 53°34' north and longitudes 66°00' west and 67°20' west. Southwest Labrador covers an area of 2,814 square miles and lies 190 miles north of the town of Seven Islands on the north shore of the St. Lawrence River and 120 miles south of

Schefferville (map 1). Labrador City (LC, map 2) is situated in the southwest quadrant of the field area, at the southern end of Wabush Lake.

PREVIOUS WORK

A. P. Low of the Geological Survey of Canada during his explorations of Labrador-Ungava in 1892 - 1895 (Low, 1895) reached the northeast corner of Southwest Labrador and from a small hill just north of the Bernadette River surveyed the Molson Lake, Wightman Lake and Ashuanipi River area (map 2). From the presence of lake terraces around the Menihek Lakes and the low relief of the drift ridges to the south of his view point Low postulated that former lakes would have covered the whole country (with the exception of a few ridges) to and perhaps beyond the southern watershed and it must consequently have been at least partly enclosed by an ice barrier. This is the earliest information regarding glacial lakes in Southwest Labrador and the full importance of Low's statement will be discussed later.

The next scientific investigations were made by Gill, Bannerman and Tolman (Gill, 1937) in 1933 in the area bounded by latitudes 52°45' north and 53°10' north and longitudes 66°35' west and 67°05' west. This expedition, organized to investigate reported gold bearing quartz veins in the area, located several prominent abandoned shoreline features on the hill which is now called Wabush Mountain and described the main glacial geomorphological features of the area.

In 1936 the Labrador Mining and Exploration Company was formed and intensive mapping of the geology of the Proterozoic rocks of southern Labrador was started.

This mapping was mainly of bedrock geology but minor notes were made on the surficial deposits. Pegrum (1936) studied the Shabogamo and Contact Lake area and noted the presence of abandoned lake shorelines around Julienne Lake as well as those on Wabush Mountain. The major part of this geological mapping was north of the area under study until 1949 when exploration was extended to the south and west by the Labrador Mining and Exploration Company, the Iron Ore Company of Canada, Wabush Mines, Canadian Javelin Company and the Quebec Geological Survey. Unpublished reports of these mining companies and the published reports of the Quebec Geological Survey give general information as to the distribution and character of abandoned lake shorelines, glacial and fluvioglacial deposits (Neal, 1950 and 1951; Almond, 1953; Crouse, 1954; Jackson, 1954; Eckstrand, 1956; Mumtazuddin, 1958; Murphy, 1959 and 1960 and Canadian Javelin Ltd., 1959).

Henderson (1959) of the Geological Survey of Canada made an extensive study of the glacial geology of Central Quebec-Labrador during the summers of 1953 and 1954, spending part of the summer of 1953 in Southwest Labrador. He made a preliminary study of the tilt of the abandoned glacial lake shorelines around Wabush and Julienne Lake and described the main glacial geomorphological features of the area.

Recently detailed studies have been made of the abandoned lake shorelines of the Indian House Lake and the upper Whale River areas, New Quebec by Ives (1960a), Matthew (1961) and Barnett (1963). The present study of the abandoned lake shorelines of Southwest Labrador was carried out in a manner similar to the above three studies and uses the direction and amount of shoreline tilts calculated by Barnett.

METHOD OF STUDY

The whole of Southwest Labrador was studied using maps and air photographs. Southwest Labrador is covered by 1:50,000 scale maps with contour intervals of 50 feet and vertical air photographs of scale 1:35,000 approximately. The central portion of the area, consisting of a belt 15 miles wide running northeastward from Lac Carheil to Sawbill Lake (map 2), forms the mining properties of the Iron Ore Company of Canada and Wabush Mines. This central portion is covered by maps of scale 1:4,800 and vertical air photographs of scale 1:12,000. Smaller scale maps and trimetrogon photographs are also available for the whole of Southwest Labrador.

The distribution and general form of the shoreline features, glacial and fluvioglacial deposits were found by studying the air photographs and maps. Detailed ground measurements and inspection were made in the central area from Long Lake and Wahnahnish Lake in the south to Sawbill Lake in the north. An east-west traverse was made from Ross Bay to Wabush Lake. The more inaccessible areas were inspected from the air and from air photographs. Transport within the field area was mainly by boat and thus the large size and the numerous extensions of the Wabush-Shabogamo Lake system greatly facilitated field investigations in the distant part of the area. The only disadvantage of the area is the presence of tall dense forest which hindered inspection, surveying and photography of the landforms.

MEASUREMENT OF THE ELEVATION OF THE ABANDONED LAKE SHORELINE FEATURES

A Wild N10 quickset level and a twelve foot staff graduated in hundredths of a foot were used in measuring the elevation of the shoreline features. The rise and fall method of booking was used and all traverses were closed. The maximum closing error was ± 0.15 feet. The most prominent shorelines were levelled and only the less distinct features were measured using an aneroid or a hand held abney level.

A Paulin surveying aneroid was used only for the measurement of abandoned shoreline features situated near to the present shore of the Wabush-Shabogamo Lake system. The aneroid traverses were always closed within fifteen minutes except for one traverse across the deltaic deposits northwest of Sawbill Lake where the traverse was closed after several hours. No corrections for atmospheric pressure changes were made for the short traverses but corrections for both temperature and pressure change were made for the long Sawbill Lake traverse. The atmospheric pressure change during this long traverse was calculated from a second aneroid left at the beginning of the traverse. The approximate error in measuring elevations by using the aneroid was ± 2 feet.

The abney level was used in the measurement of the elevation of the lower shoreline features on open ground where trees and bushes did not obscure vision. The approximate error in measuring elevations by using the abney level was ± 1.5 feet.

All measurements wherever possible were made from National Topographic Survey, Iron Ore Company of Canada and Wabush Mines bench marks. The Iron Ore Company of Canada datum lies 22.53 feet below the National Topographic Survey datum and 21.04 feet below the Wabush Mines datum therefore corrections had to be applied to all measurements made from mining company bench marks in order to give elevations above the National Topographic Survey datum which is mean sea level (a.s.l.).

The mining company bench marks are situated mainly at the southern end of Wabush Lake and the National Topographic Survey bench marks are very widely spaced throughout Southwest Labrador so that for most of the surveying north of Labrador City the surface of the Wabush-Shabogamo Lake system was used as a base level of known elevation. No visible rapids or currents were seen in the narrow channels separating Wabush Lake from Julienne Lake and Julienne Lake from Shabogamo Lake so it is assumed that the lake system is level within the accuracy of the surveying methods used.

The height of Wabush Lake was calculated to the nearest hundredth of a foot near Labrador City using an Iron Ore Company of Canada bench mark as a point of known height. The height of the lake was checked before each level traverse in order to eliminate any error caused by the fluctuation of the lake level.

The total error in calculating the height of the shorelines, that is the instrument error, the traverse closing error and the error in measuring the height of the lake varied from ± 0.16 to ± 2.17 feet.

CHAPTER 2

GEOLOGY AND PHYSIOGRAPHY

The geology and physiography are of importance in the study of abandoned glacial lake shorelines because they influence the pattern of drainage and the position of the watershed which affect the distribution of glacial lakes.

The bedrock and surficial geology also control to some extent the character and distribution of the abandoned glacial lake shoreline features because rocks with different lithology and structure will have different degrees of susceptibility to wave action.

NATURAL DIVISIONS

Southwest Labrador lies at the junction of three major geological and physiographic divisions (map 2, overlay 1 and 2, in pocket). It is essentially the bedrock geology which controls the form of the physiographic divisions but glaciation has modified them to some extent. The three geological divisions are the Archaean, the Proterozoic and the Grenville.

The Archaean division lies north of the Grenville Front which runs north-eastwards from Jackson Lake (J, map 2) past the northern shore of Lac Montenon, Bruce Lake, Pegrum Lake, Steers Lake and across Molson Lake just north of the

Bernadette River and west of the Proterozoic rocks of the Labrador Trough which lie east of a line from Sawbill Lake to Mount Albert.

The rocks of the Archaean division are mainly white granitoid gneisses containing variable amounts of orthoclase, biotite, garnet, hornblende and muscovite. The gneisses are well jointed and the main joint and fracture lines run in a northwest and a northeast direction with minor joints and fractures running west-northwest, east-northeast and north-northeast. These joints and fractures have been eroded by glacial and probably preglacial processes to give a mammilated topography and the joints and fractures are occupied by lakes as a result of drainage derangement by glaciation (map 3, in pocket). The hills between the flooded valleys have bare rounded summits with a fairly uniform elevation of 2,400 to 2,600 feet a.s.l. giving a very level skyline and the appearance of an old erosion surface. This type of country belongs to the Upland Area B, Centre of Kaniapiskau Massif zone of Hare's physiographic divisions of Labrador-Ungava (Hare, 1959) and the Kaniapiskau-Ashuanipi node of Douglas and Drummond (1955).

The Proterozoic rocks of the Labrador Trough lie north of the Grenville Front and east of the Archaean granitoid gneisses. The rocks consist of relatively soft sediments with a general north-northwest to south-southeast axis of folding but at this southern end of the Trough these rocks are covered by glacial debris and this area may be included in the Lake Plateau physiographic division of Hare's classification (Hare, 1959).

These sedimentary rocks of the Labrador Trough extend southwest of the Grenville Front and form the western portion of the Grenville Province (overlay 1). These sediments were metamorphosed, folded, faulted and intruded during the Grenville orogenic period and now form the higher western Grenville Mountains which stretch from Mount Wright in the extreme southwest to the Wapussakatoo Mountains west of Wabush Lake.

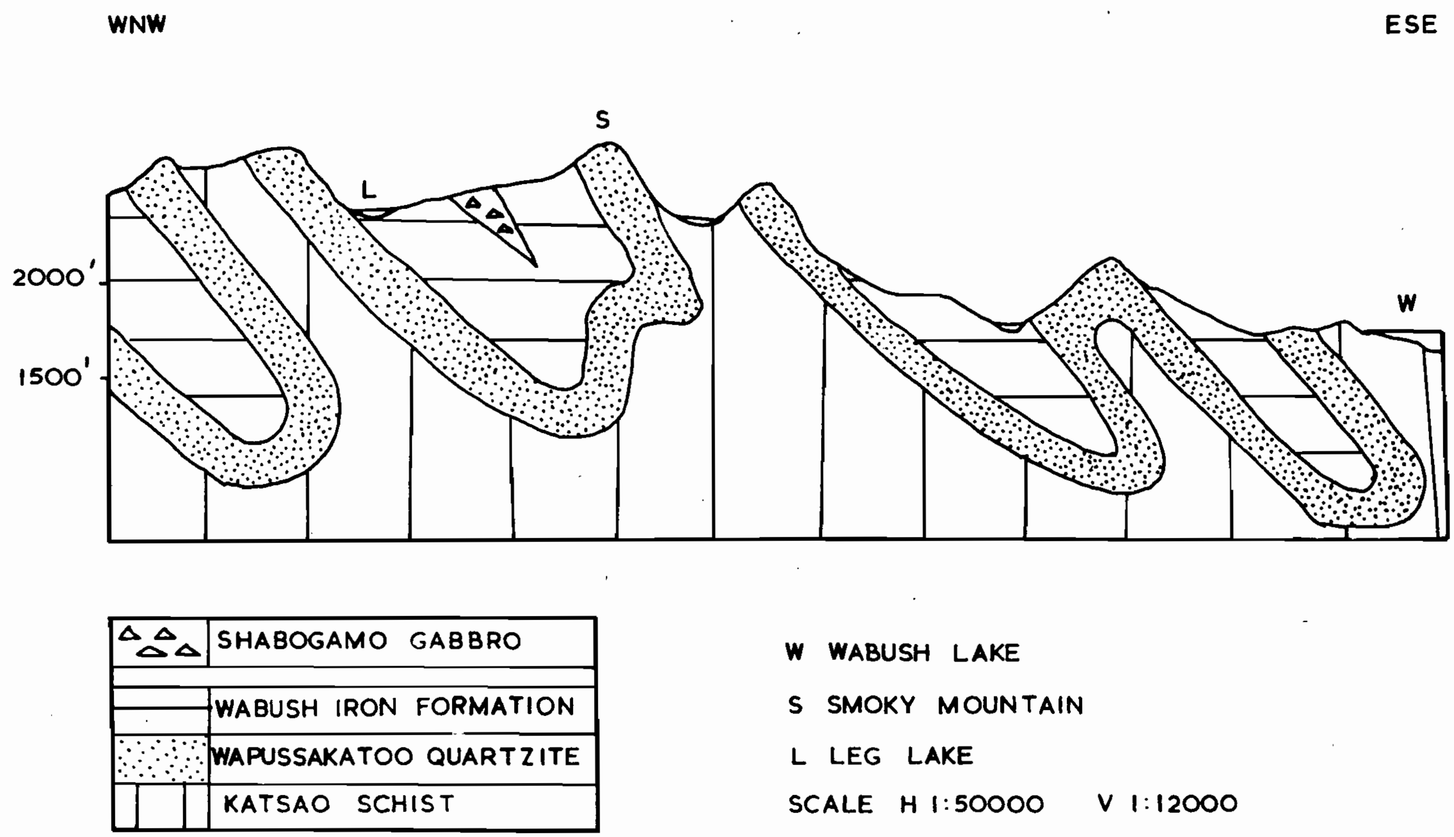
The following description of the Wapussakatoo Mountains is typical of the whole of the western section of the Grenville Mountains.

The Wapussakatoo Mountains rise to an elevation of 2,980 feet a.s.l., that is 1,200 feet above the Lake Plateau to the east and 400 to 600 feet above the Kaniapiskau Massif to the west and northwest. These mountains are composed of tightly folded pitching anticlines and synclines. The general strike of the folds is north and northeast, parallel to the Grenville Front. Folding is intense and the limbs of the folds are squeezed tightly together and are generally 1/2 to 1 mile apart. The limbs dip at 35° to 60° and the wider synclines and narrower anticlines show a 20° to 60° plunge varying from N.-S. to NNE.-SSW. Steep thrusts and small cross faults occur. A detailed account of the geology of the area is given by Gastil and Knowles (1960).

The more resistant massive granular Wapussakatoo quartzite forms the higher parts of the folded ridges (section 1). Minor ridges are formed of less resistant iron formations, for example Iron Mountain (map 4, I) which has an elevation of

SECTION I

SECTION ACROSS THE WAPUSSAKATOO MOUNTAINS SHOWING THE RELATIONSHIP BETWEEN GEOLOGY AND TOPOGPAPHY



2,450 feet a.s.l. and the Smallwood Mine Ridge (2,400 feet a.s.l.). Minor knolls are formed of intruded basic igneous rocks.

Southeast of the Wapussakatoo Mountains the ground is covered by glacial debris but the topography is controlled by the bedrock geology. The resistant quartzites of the Wapussakatoo Mountains merge into metadolomites to the southeast and the country is formed of mesa and cuesta topography. This is especially true of the area east of Long Lake where metadolomites and gabbro sills form hills which rise to 2,200 to 2,400 feet a.s.l. These metadolomite and gabbro mesas and ridges form the lower eastern lobe of the Grenville Mountains (overlay 2).

The low land to the east of the Kaniapiskau Massif and the Grenville Mountains constitutes the Lake Plateau division. It is characterized by its low relief formed mainly by glacial debris, large expanses of open water and flat muskeg. The bedrock is mainly metasedimentary granitoid gneisses and intrusive gabbro which only appear at the surface in minor crag and tail features.

DRAINAGE

The direction of drainage is of great importance in the formation of glacial lakes because where regional drainage was towards the edge of the waning ice sheet glacial meltwater was impounded in front of the ice edge.

In this area which lies mainly in Labrador the direction of drainage is north along the Ashuanipi River to the Menihek Lakes and then via the Hamilton River to the North Atlantic Ocean. Short rivers drain westward into the Ashuanipi River, for example the Bernadette River and the Miron River. The Shabogamo River system drains almost all the land west of the Ashuanipi River. The remainder of the area is drained by rivers flowing towards the south, into the Moisie River and the Rivière aux Pekans and towards the northwest, into the Kaniapiskau River.

The watershed between the Atlantic drainage and the St. Lawrence and Ungava Bay drainage forms the boundary between Labrador and Quebec (map 2).

The major part of the area has a drainage system directed towards the north which was also the general direction of ice retreat. Thus favourable conditions for glacial lake formation occurred north of the watershed in the upper reaches of the Ashuanipi-Hamilton River system, particularly on the low lying Lake Plateau and the Labrador Trough where the low relief would have formed few barriers to the spread of glacial lakes.

The high western and southwestern parts of the watershed formed by the Kaniapiskau Massif and the western Grenville Mountains would have restricted the western extent of glacial lakes. The lower eastern extension of the Grenville Mountains forms the irregular southern part of the watershed in Southwest Labrador. Here deep valleys penetrate between mesas and ridges and would have allowed the southern extension of glacial lakes.

The low cols of the eastern Grenville Mountains and the low relief of the

Lake Plateau would have permitted only shallow glacial lakes to be impounded and it is probable that the ice barriers and the main glacial lake outlets were located in these two areas.

CHAPTER 3

ABANDONED GLACIAL LAKE SHORELINE FEATURES

This chapter gives a detailed regional description of the abandoned glacial lake shoreline features of Southwest Labrador, their location, elevation, form, lithology and their association with fluvio-glacial features. A brief study is made of these fluvio-glacial features because they yield evidence of the character of the melting ice as well as the position of the ice margin whereas the shoreline distribution helps to fix the position of the ice margin on a more regional scale.

The abandoned glacial lake shorelines are marked by wave formed benches. These benches are bounded by steep slopes called the backslope and the foreslope. The backslope is often cliff like whilst the foreslope is less steep. The terms backslope and foreslope have been used in previous studies of abandoned glacial lake shorelines by Ives (1960a) and Matthew (1961). The bench is formed by both erosive and depositional wave action. The inner part of the bench is wave cut but is covered by a residual layer of large widely spaced boulders which wave action was unable to carry away. The outer part of the bench is smooth and built of the finer material eroded from the backslope.

In order to see if there is any ordered arrangement of these shoreline features within Southwest Labrador it is necessary to choose one facet of the shoreline which will suitably represent the shoreline and can be compared from area to area throughout the whole of Southwest Labrador.

The break in slope between the foreslope and the outer edge of the bench is usually free of a thick vegetation cover, rarely disturbed by periglacial activities and has a sharp angle. This break in slope is well represented throughout Southwest Labrador and its elevation can be measured to the nearest foot.

The break in slope between the backslope and the back of the bench is not well developed in all areas and is often hidden by blocks which have fallen from the backslope and by the moss and lichen covered residual boulder layer. The exact elevation of this break in slope is therefore difficult to measure.

The break in slope between the foreslope and the outer edge of the bench is therefore most suitable to represent the shoreline for the purpose of correlating these shoreline remnants by height. The break in slope between the backslope and the back of the bench although it represents more accurately the actual position of a former lake surface would not be suitable for comparative purposes because of the errors involved in measuring the elevation of this break in slope. The elevations of the shoreline features given below refer to the elevation of the break in slope between the foreslope and the outer edge of the bench unless stated otherwise.

The order of description of the abandoned glacial lake shoreline features is mainly based on the chronology of the field investigations but the more prominent shorelines were visited first and the more obscure and doubtful shoreline features afterwards.

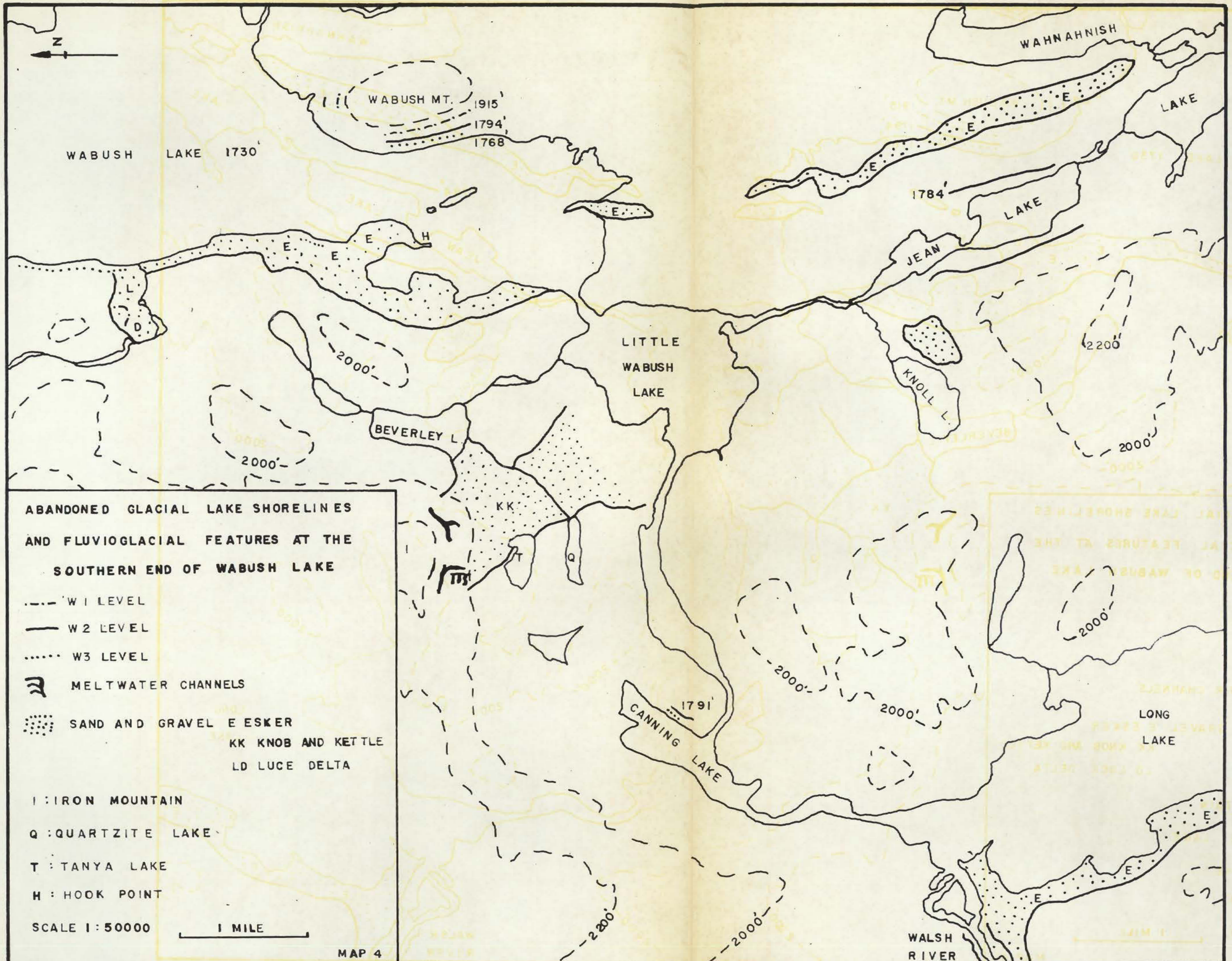
LABRADOR CITY AREA, SOUTH END OF WABUSH LAKE (map 4)

Prominent abandoned glacial lake shorelines are found on the western side of Wabush Mountain. These were photographed by Gill in 1933 and he gave an elevation of 100 feet above lake level (1,730 feet a.s.l.) for the highest shoreline. Only two abandoned shorelines were recognized by previous writers and the highest shoreline was given elevations which varied from 75 feet to 150 feet (Almond, 1953 and Neal, 1950) above the lake. Henderson (1959) mentions only two shorelines. The only reference to more than two shorelines was found in a Canadian Javelin report (1959) which stated:

> The western side of the mountain is marked by several wave cut terraces, corresponding to former lake levels during the time of glacial melting. These are less prominent on the eastern side.

There are in fact three distinct levels of shoreline features at 185, 64 and 38 feet above Wabush Lake, that is 1915, 1794 and 1768 feet a.s.l.

The very prominent shoreline at 1915 feet a.s.l. is marked by a wave cut bench. Wave cut or wave built benches corresponding to this level were not found in any other locality. This shoreline is best developed on the west facing slope of the



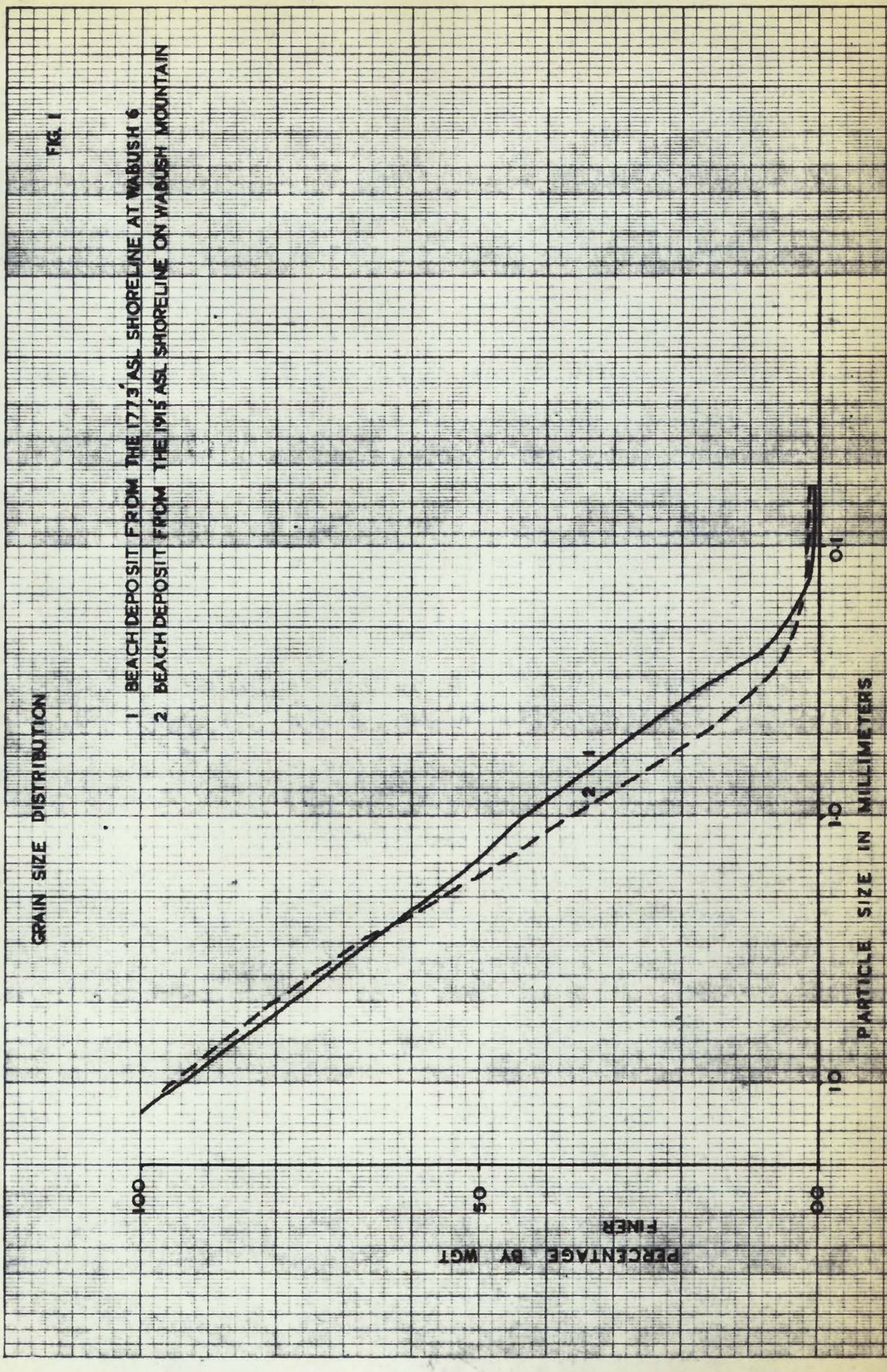
N
WABUSH LAKE 1730'
WABUSH MT.
1915'
1794'
1768
WAHNAHNISH LAKE
1784'
JEAN LAKE
LITTLE WABUSH LAKE
KNOLL L.
2200'
2000'
BEVERLEY L.
KK
T
Q
H
L
D
E
1791'
CANNING LAKE
LONG LAKE
WALSH RIVER
ABANDONED GLACIAL LAKE SHORELINES AND FLUVIOGLACIAL FEATURES AT THE SOUTHERN END OF WABUSH LAKE
W1 LEVEL
W2 LEVEL
W3 LEVEL
MELTWATER CHANNELS
SAND AND GRAVEL E ESKER
KK KNOB AND KETTLE
LD LUCE DELTA
I : IRON MOUNTAIN
Q : QUARTZITE LAKE
T : TANYA LAKE
H : HOOK POINT
SCALE 1 : 50000
1 MILE
MAP 4

mountain as are all the lower shorelines. There is approximately 3,000 feet of wave cut bench at this highest level and also a slight notch in the northern tip of the mountain marks the same shoreline. No indication of this and any lower shoreline was found on the less steep eastern slope of the mountain.

This highest shoreline is cut entirely in surficial deposits and no outcrops of solid rock were seen at any locality on the mountain. The vertical amplitude of the bench varied from 6 to 8 feet. The backslope forms a cliff up to 40 feet high with a slope of 45° to 60°. This cliff has been partially destroyed by mass movement and buried by small sandy outwash fans which have formed below gullies in the cliff. The inner part of the bench is covered by quartzite, schist, gneiss and ironstone boulders 4 to 8 feet in diameter. There are no fines between the boulders and the boulders are covered by a thick layer of lichens and mosses. The outer edge of the bench is built of coarse sand and subangular gravel. A bulldozer trail cut through the southern part of this shoreline revealed 9 inches of well graded gravel (Fig. 1, graph 2) covered by a podzol soil and overlying sandy till with intercalated granitoid gneiss boulders.

This highest shoreline represents a wave cut platform in unconsolidated glacial debris from which the fines have been washed out leaving a very coarse boulder layer on the inner part of the bench. The fines have been deposited on the outer part of the bench and also form a thin beach layer.

The shoreline at 1,794 feet a.s.l. is not as apparent as the highest shoreline


GRAIN SIZE DISTRIBUTION
FIG. 1
1 BEACH DEPOSIT FROM THE 1773' ASL SHORELINE AT WABUSH 6
2 BEACH DEPOSIT FROM THE 1915' ASL SHORELINE ON WABUSH MOUNTAIN
PARTICLE SIZE IN MILLIMETERS
PERCENTAGE BY WGT FINER
100
50
0.0
10
1.0
0.1
1
2

(photo 1) but is much wider, varying from 70 to 185 feet. This intermediate shoreline is as extensive as the highest shoreline on the western side of the mountain and forms a narrow bench at the northern tip of the mountain. The central part of this intermediate shoreline has a variable character, some parts have low boulder strewn backslopes, other parts have steep high cliffs and few boulders on the bench whilst the northern and southern extremities have a similar appearance to the highest shoreline.

The shoreline at 1,768 feet a.s.l. is only visible at close quarters and is not very prominent. It varies in form from a small notch in the foreslope of the intermediate shoreline to a 27 foot wide wave cut bench covered by a layer of coarse sand and gravel. In places on the western side of the mountain all traces of this lowest shoreline disappear and no break in slope marks its occurrence at the northern tip of the mountain.

On both sides of the southern half of Jean Lake there are narrow benches 50 to 125 feet wide occurring at an elevation of 1,783 to 1,786 feet a.s.l. They form marked breaks in slope at the foot of an otherwise straight hillside. The outer edge of the benches are severely dissected indicating that the benches are formed of soft unconsolidated surficial deposits. The benches on the west side of Jean Lake are not very well developed. This may be due to direction and character of wave movement and longshore drift at the time of formation of the benches.

A similar form of shoreline occurs on the west side of Wabush Lake north of the Luce Delta but has an elevation of 1,766 to 1,769 feet a.s.l. This shoreline also

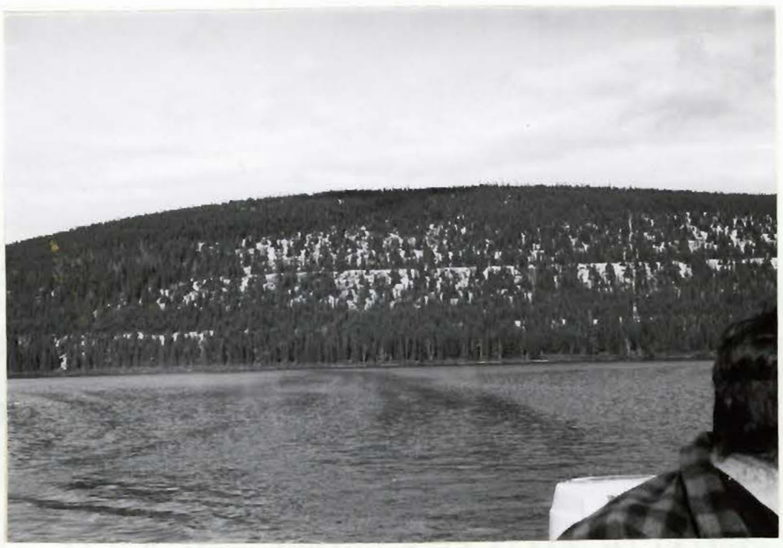


Photo. 1.
The western slope of Wabush Mountain. The two shorelines visible are at 1915 feet and 1794 feet a.s.l.

forms at the base of a steep uniform slope and is severely dissected by narrow dry gullies. The bedded shoreline material consists of well washed angular and subangular sand with a pebble or gravel surface layer. The characteristics of this shoreline material are very similar to those of the esker deposits farther south. This shoreline is 4,000 feet long and varies in width from 60 to 200 feet.

A very short wave cut bench occurs in the Wabush esker system at an elevation of 1,768 feet a.s.l. However, sections cut through this bench gave no evidence of disturbed esker deposits or the presence of horizontal beach deposits.

On the peninsula between Canning Lake and Harrie Lake vegetation patterns clearly visible on the air photographs indicate the presence of two shorelines. The vegetation patterns are emphasized by the presence of darker, taller and denser trees following the edge of the shorelines. These vegetation patterns are well developed on the east side of the peninsula but are less well developed on the steeper west side of the peninsula. Here, however, shoreline features were found. The upper shoreline is marked by a 10 to 20 foot wide bench covered by a residual boulder layer. This shoreline lies at 1,791 feet a.s.l. The lower shoreline is marked by a minor break in slope at 1,765 feet a.s.l. No surface indications of these shorelines were seen on the east side of the peninsula under the vegetation patterns.

Neal (1951) mentions the presence of abandoned lake shorelines along Canning Lake but no other shoreline features apart from those mentioned above were found in the Canning Lake area.

Neal (1951) also observed an esker near the mouth of the Walsh River which drains the Lac Virot basin. He states:

> The esker rose 50 feet to 75 feet above the surrounding ground, the top was flat and about 50 feet wide which would suggest that it was cut down by wave action in a lake once covering this region.

This portion of the esker has subsequently been destroyed during the construction of an airstrip and therefore could not be examined.

The Walsh River valley is followed by an esker whose sands and gravels have been redeposited as river terraces in the lower part of the valley. The paired terraces near the mouth of the Walsh River are 24 to 28 feet high and the height of Long Lake is given as 1,763 feet a.s.l. (Wabush Mines map data). This would give an elevation of 1,787 to 1,791 feet a.s.l. which is just a little less than the elevation of the intermediate shoreline on Wabush Mountain. These terraces are formed of sediments deposited by the Walsh River when it drained into a higher lake stage. The terraces would have been cut as the river lowered its bed in response to the lowering of its outlet, that is the lowering of the lake level.

Along the northeast shore of the small wedge shaped lake west of Tanya Lake there is a boulder strewn platform 1 to 5 feet above the present lake level (1,791 feet a.s.l.). The residual boulder layer consists of large widely spaced boulders covered by a thick layer of mosses and lichens. The platform is 40 to 80 feet wide and backed by a low cliff 10 to 25 feet high. This shoreline has a similar elevation to the intermediate shoreline on Wabush Mountain.

Fluvioglacial features between Iron Mountain (I, map 4), Beverley Lake, Quartzite Lake (Q, map 4) and Little Wabush Lake give evidence as to the character of the ice sheet and the position of the ice edge at one stage in the deglacierization of Southwest Labrador. Some of these features have a similar elevation to the highest shoreline on Wabush Mountain.

Two sets of fluvioglacial channels occur on the south slope of Iron Mountain. The western set consists of four marginal channels in a parallel sequence connected by a submarginal and a subglacial channel. The highest channel has an elevation of 2,102 feet a.s.l. and the lowest channel in parallel sequence has an elevation of 1,984 feet a.s.l.

The highest channel is cut into the slope of Iron Mountain and the upper section of the channel is parallel to the hillside for 750 feet. The intake is a wide shallow depression of the gentle slope of the hillside. The upper section has a steep rock slope to the north, a flat scrub covered floor 20 feet wide and a gentle outer southern slope 15 feet high. Farther to the east the channel is cut into a steeper slope where the northern side of the channel is 40 to 50 feet high and the southern outer slope of the channel is 20 to 30 feet high. The lower part of the channel swings slowly downslope and then cuts down the hillside at right angles to the slope thus forming a subglacial channel (photo 2). At an elevation of 2,042 feet a.s.l. there is a short marginal channel which almost immediately forms a subglacial channel and this is joined by two other short marginal channels at 2,000 and 1,984 feet a.s.l.

Photo.2.
The highest meltwater channel in parallel sequence (2102 feet a.s.l.). View westwards up the channel. The subglacial channel cuts through steeply dipping iron formation in the lower left hand corner of the photograph.

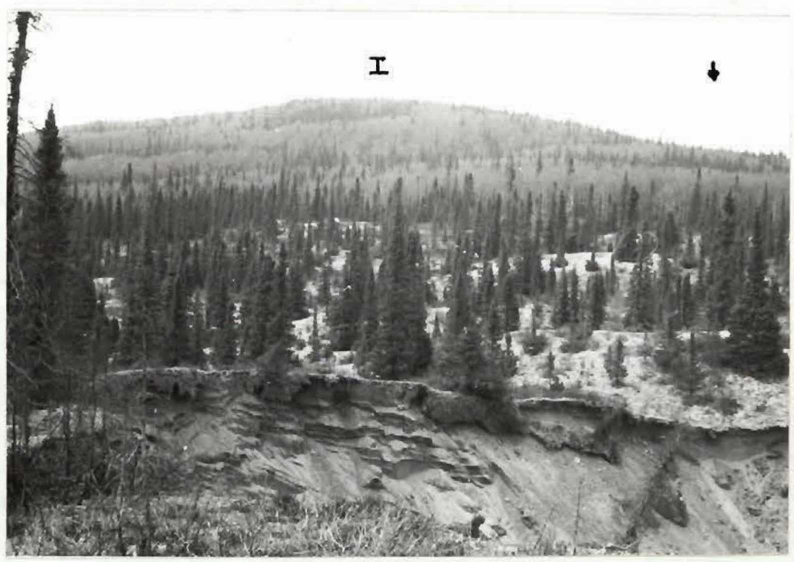


Photo.3.
Knob and kettle country, view north towards Iron Mountain (I). Arrow indicates the position of the aligned meltwater channels.

The physiography and its relationship to bedrock and surficial geology indicates that these features were formed by fluvioglacial processes and not by normal fluvial processes. The channels run across the general slope of the hillside, they are not occupied by streams and they start and end abruptly. All the channels are cut in Wabush Iron Formation. The subglacial channels cut across the steeply dipping and contorted ironstones at right angles to the strike and the short marginal channels follow lines of structure in the ironstones.

The second set of channels is aligned in sequence on the southeast side of Iron Mountain at an elevation of 2,092 and 2,054 feet a.s.l. They are formed entirely in contorted and steeply dipping ironstones. The two channels run northeastward, their northern wall is entire and steep but their southeast wall is breached and the two ridges which form the southeast sides of the two channels rise 100 feet above the channel floors. The western intake is a deep notch in the hillside and the northeastern outlet is a narrow shallow valley. The floor of the channel is irregular, from the intake it is level for 200 feet before it drops steeply to a small pool twenty feet below. Northeast of the pool there is a small valley running into the breach in the southern wall. The northeast part of the aligned channel system is flat (elevation 2,043 feet a.s.l.) but both ends of this section are slightly notched by small valleys leading into the breach and the outlet valley.

Fluvioglacial deposits are found immediately below the two sets of fluvioglacial channels (map 4) and extend southeastwards to Tanya Lake, Quartzite Lake and Little Wabush Lake and eastwards to Beverley Lake and the Labrador City Townsite.

These deposits are thickest northwest of a line from the eastern end of Quartzite Lake to the southern end of Beverley Lake and have a knob and kettle topography. Southeast of this line the fluvioglacial deposits are thin and sporadic and overlie sandy till.

Immediately below the two subglacial channels two lobate deposits of sand and gravel occur with gently rounded summits (elevation 1,962 feet a.s.l.) and steep frontal slopes. Irregular sandy deposits with boulder strewn surfaces lie to the south of the aligned channels. The topography east of Tanya Lake is very complex, consisting of elongated esker-like ridges 25 to 40 feet high, small knobs and hummocks separated by marsh and water filled kettle holes with no definite pattern of drainage (photo 3). The heights of the knobs within this area range from 1,901 to 1,915 feet a.s.l. and these heights are approximately the same as that of the highest shoreline on Wabush Mountain.

South of the knob and kettle country the fluvioglacial deposits do not make a significant contribution to the relief of the area. Low ridges and mounds 10 to 30 feet high are formed both of sandy till and of bedded sands and gravels.

A detailed study of the lithology and internal structure of the ridges and knobs indicates a fluvial origin. The deposits consist of gravel and sand with small quantities of pebbles and silt. The sand consists almost entirely of quartz, feldspars and iron formations. The gravel and pebbles consist of resistant quartz, granites and granitoid gneisses. The surface deposits are usually loose coarse sands and gravels with intercalated pebbles 2 to 6 inches in diameter. The surface deposits lie unconformably over finer compacted sands. These sands are well sorted, showing current bedding, lenses of gravels, wash outs, small ripple bedding and alternating beds of coarse and fine grained sand (photo 4 and Fig. 2, graph 1). These features indicate deposition in moving water with a variable rate and direction of flow. High angled faults, tilted beds and folded beds occur at depth and near the surface (photo 5).

The second major fluvioglacial deposit complex lies east of the Labrador City Townsite. This complex extends from the Luce Delta in the north southwards along the west shore of Wabush Lake to Hook Point (H, map 4) and continues south of Wabush Lake forming part of the ridge between Jean Lake and Wahnahnish Lake. For a greater part of its length it has the surface appearance of an esker ridge or a series of anastomosing ridges. South of Wabush Lake the fluvioglacial deposit consists mainly of one sinuous esker ridge with thin sand deposits with kettle holes at both sides. Between Jean Lake and Wahnahnish Lake this esker ridge hugs the eastern side of a rock ridge and is separated from the rock ridge in places by a series of kettle holes. The esker ridge consists of current bedded sands and gravels with minor ripple bedding, faults and small surface distortions. The surface layers here also consist of loose coarse sands and gravels (photo 6). This esker contains large proportions of iron

Photo.4.
Section through knob and kettle country northwest of Labrador City, showing loose coarse surface deposits overlying fine grained current and ripple bedded sands.

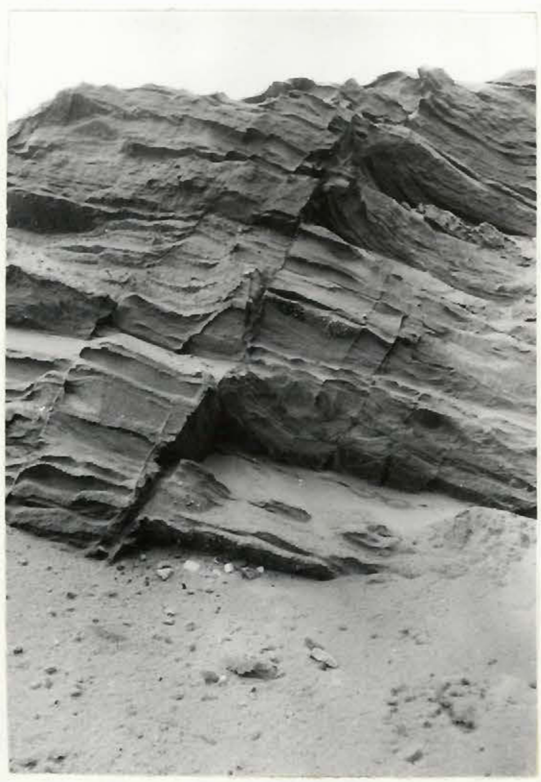


Photo.5.
Close up of photo.4. showing faulting, tilting and folding of the bedded deposits.

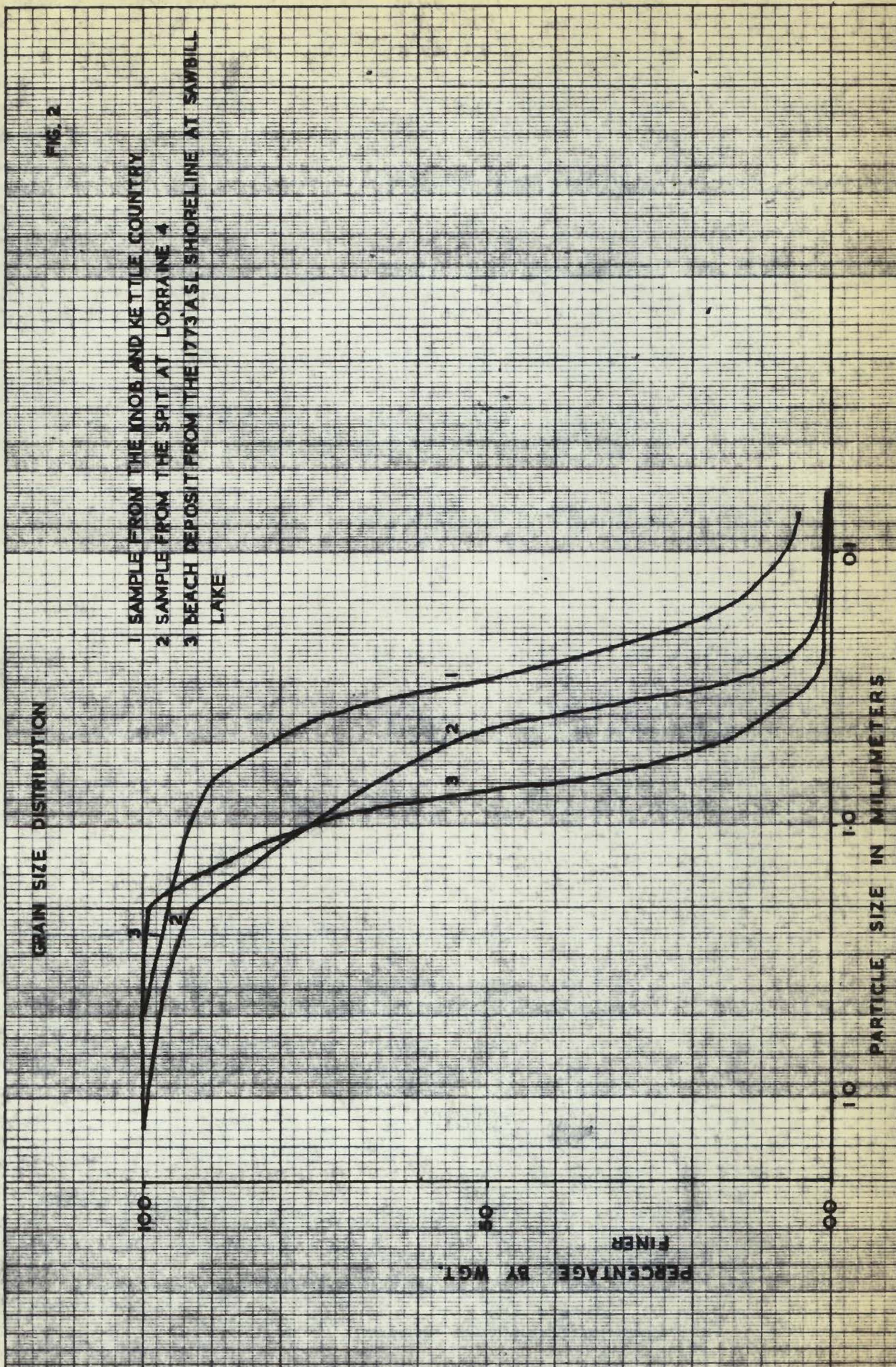

GRAIN SIZE DISTRIBUTION
1 SAMPLE FROM THE KNOB AND KETTLE COUNTRY
2 SAMPLE FROM THE SPIT AT LORRAINE 4
3 BEACH DEPOSIT FROM THE 1773' A.S.L. SHORELINE AT SAWBILL LAKE
PERCENTAGE BY WGT. FINER
100
50
00
10
1.0
0.1
PARTICLE SIZE IN MILLIMETERS
1
2
3

FIG. 2

Photo.6.

Section through esker deposits between Jean Lake and Wahnahnish Lake, Southwest Labrador, showing a loose coarse, bedded surface layer of gravel overlying fine grained current bedded sand with iron partings.

formations, particularly specularite which usually forms the thin partings between beds of sand. The presence of iron formations in the esker ridge indicates that the water which deposited the esker sediments came from the north because the main iron formations outcrop to the north of the esker ridge in the Wapussakatoo Mountains.

On the southeast side of Knoll Lake an isolated irregular knoll of fluvio-glacial material rises to an elevation of 1,879 feet a.s.l. The knoll is separated from the neighbouring hillslope by several kettle holes.

On the west side of Wabush Lake the esker has a more complex form but a very similar lithology, grain size distribution and internal structure. A 25 to 40 feet high, sinuous esker ridge runs northwards from Hook Point parallel to the lake shore. Just south of the Luce Delta the esker has been largely destroyed by wave action and has roughly the same form as the shoreline at 1,766 to 1,769 feet a.s.l. north of the Luce Delta.

West of the esker ridge there are several irregular ridges of fluvioglacial deposits 20 to 50 feet high. These are separated from the main esker ridge by kettle holes filled with marsh or small lakes. There appears to be no correlation between the height of the highest shoreline and the vertical extent of the fluvioglacial deposits. The fluvioglacial deposits extend up to an elevation of 2,022 feet a.s.l. but are mainly below 1,880 feet whereas the highest shoreline lies at an elevation of 1,915 feet a.s.l. in this area.

The Luce Delta is of a fluvial origin as indicated by its lithology, grain size and internal structure. It differs slightly from the esker ridge deposits in that there is a larger proportion of gravel and boulders within the surface layers. The delta lies north of the present stream which drains Luce Lake and is rather elongate and has a short base. The delta is cut through by a dry gully (photo 7) which roughly divides the northern third of the delta from the southern two thirds. The delta is notched at three levels. These levels are most prominent north of the gully (photo 7). The elevations of these notches are 1,914 feet a.s.l., 1,880 feet a.s.l. and 1,835 feet a.s.l. A distinct shoreline at 1,766 to 1,769 feet a.s.l. is situated at the base of the delta. Only the highest notch corresponds to a shoreline level. It is most probable that the deposits here are of fluvioglacial origin and that the notches were cut at a subsequent date.

Fluvioglacial sands and gravels similar to those of the knobs and kettle country and the Wabush esker complex are found west of Beverley Lake and due north of Beverley Lake at an elevation of 1,942 feet a.s.l.

The above fluvioglacial features give evidence as to the character and position of the ice sheet during the deglacierization of this small area.

The fluvioglacial channels on the southern slope of Iron Mountain are of the ice marginal type. There is an average slope of 1:75 along the uppermost channels which compares favourably with the slopes of 1:50 to 1:100 calculated by Mannerfelt

Photo.7.
View of the northern part of the Luce Delta looking north. The deep gully forms the foreground and the two upper notches at 1914 and 1880 feet a.s.l. form the middle section of the photograph.

(1949) for ice marginal channels in Sweden. These marginal channels indicate a considerable standstill of the ice margin particularly at the highest level where the channels are cut deep into bedrock. The highest channel in parallel sequence at 2,102 feet a.s.l. was probably connected to the aligned channel by a channel formed in the margin of the ice sheet, of which no evidence remains. The southern wall of the aligned channels between the two ridges would have also been formed of ice.

The ice margin at this highest level sloped to the east. Glacial meltwaters flowed partly on the ice and partly on the bedrock, the meltwater at the outlet of the channel flowing on to or into the ice. The sands and gravels on the hillslope west of Beverley Lake indicate the retardation of the meltwater and the deposition of sediments in this area.

The ice margin gradually thinned and this is indicated by the small marginal channels in parallel sequence. The length of standstill of the ice at each of these levels was considerably less than the standstill at the highest level.

The presence of subglacial channels indicates an open texture of the ice margin area, with crevasses diverting water from the ice surface and ice marginal channels into steep subglacial channels. These fluvioglacial channels indicate a melting of the ice and an increase of the open texture of the ice with the formation of crevasses.

The fluvioglacial deposits also indicate an open texture of the ice margin area. The delta-like lobes of sands and gravels below the subglacial channels indicate once more the retardation of the flow of the meltwater as it becomes sub or intra glacial. The internal structure of the deposits indicates a very variable direction of water movement within the different crevasses and channels which are continually forming in the marginal areas of the melting ice sheet.

The sands and gravels were deposited in crevasses, tunnels and hollows within the open textured marginal ice, the material being brought by glacial melt-water streams flowing over the ice and being diverted into subglacial and englacial channels. Subsequent wasting of the ice caused the sands and gravels to be disturbed, faulting, folding and tilting occurred as ice masses between and below the deposits melted leaving them unsupported. The coarse loose surface deposits are most probably formed of ablation moraine melted out from these stagnant ice masses. The melting of these final ice masses gave rise to the kettle holes and the indefinite drainage pattern.

The regular height of the outer ring of knobs and hummocks at 1,901 to 1,915 feet a.s.l. may be due to a limit of deposition within the marginal ice formed by an englacial water table. However, the subsequent disruption of the sands and gravels would undoubtedly have disturbed the level nature of their summits. It is suggested that the knobs and hummocks were roughly planed off by wave action at a glacial lake stage at 1,915 feet a.s.l. No distinct shoreline features were seen in the vicinity but samples from near the summits of the knobs show a less well sorted grain size distribution than the fluvioglacial deposits. The surface layers may have been disturbed by periglacial activity or mass movement but samples of beach deposits from more distinct shorelines show a fairly well graded grain size distribution (Figure 1, graph 1 and 2).

The Wabush esker complex indicates similar ice conditions. Fluvioglacial sands and gravels indicate open textured ice. The direction of meltwater flow was to the south up the regional slope. Kettle holes near the sides of the esker ridges indicate the melting of ice masses in situ. The sands and gravels above the esker ridges were probably deposited at the margin of the melting and downwasting ice.

The Luce Delta is a fluvioglacial deposit, the material being brought by meltwater streams from the Wapussakatoo Mountains. The abrupt beginning of the Wabush esker suggests that the main volume of material came down the Luce River valley. The dry gully cutting through the delta was probably formed by an earlier stream draining the Luce valley as the present stream occupies an irregular steep-sided valley cut in rock and indicates a more recent origin.

The esker complex with its well sorted clean sands and gravels has been used for concrete aggregates and large portions of the original esker surface have been destroyed by quarrying so that the general lack of shoreline features in this area may not be entirely a result of natural causes. Maps and air photographs of this area made before mining operations commenced do not, however, reveal any prominent shorelines.

SHORELINE FEATURES BETWEEN THE LUCE DELTA AND LORRAINE 4

North of the Luce Delta the western shore of Wabush Lake is bounded by a straight steep hillslope formed of steeply dipping Wapussakatoo Quartzite and Wabush Iron Formation. Along this shore there are only small patches of abandoned shoreline features associated with small bays and deep valleys.

At the Wabush 6 ore body a small bay lies to the south of a ridge of Iron Formation which runs at an angle to the general north-south trend of the lake shore. In this small bay two distinct shorelines are situated at 1,773 feet a.s.l. and 1,804 feet a.s.l. The lowest shoreline is 115 feet wide and has a steep foreslope which extends down to the present shoreline. The backslope of the lowest shoreline forms the foreslope of the higher shoreline which is more extensive and between 50 and 150 feet wide. The two shorelines are formed of sands and gravels. The lower shoreline is built of well graded sand (Fig. 1, graph 1) with a few intercalated boulders and the inner part of the bench is covered with small boulders 1 to 3 feet in diameter. The upper shoreline is of a similar nature, large boulders 2 to 4 feet in diameter being found at the base of the backslope. A trench 42 inches deep in the steep foreslope of the upper shoreline revealed very coarse deposits consisting mainly of cobbles 6 to 12 inches in diameter with a small amount of coarse interstitial sand and gravel.

North and south of these bay deposits for a distance of 2,000 feet small lobate patches of level ground at heights similar to the shoreline deposits in the embayment indicate former lake levels.

On the east side of Wabush Lake opposite Wabush 6 similar lobate forms occur. These are the only indication of former lake levels on the whole of the east shore of Wabush Lake from Wabush Mountain to the entrance of Julienne Lake.

Southeast of Lorraine Lake (L, map 2) at the northern end of the Wabush 6 ore body there is a small deposit of bedded sand whose upper surface lies at an elevation of 1,765 feet a.s.l. This deposit is at the lower end of a deep U-shaped valley which runs from Lorraine Lake to Wabush Lake. A low gap at 2,010 feet a.s.l. breaches the quartzite ridge which lies between Lorraine Lake and Wabush Lake. The U-shaped valley runs eastwards for 200 feet from this gap, then east north east for 400 feet and east for 300 feet and finally 1,200 feet to the southeast. The west-east and northwest-southeast sections are the deepest. The lower part of the channel is shallow and eventually opens out into the hillside at an elevation of 1,822 feet a.s.l. A misfit stream occupies the valley and from the lower end of the valley runs northeastward and cuts through the bedded sands at 1,765 feet a.s.l. Sub-lake contours do not indicate the presence of large deposits of sand at the mouth of the misfit stream. There are no indications of former lake levels around Lorraine Lake except for the presence of a wide sandy beach at the northern end of Lorraine Lake which rises 6 feet above present lake level. The sand deposits at the lip of the U-shaped valley indicated on Iron Ore Company of Canada maps were not found.

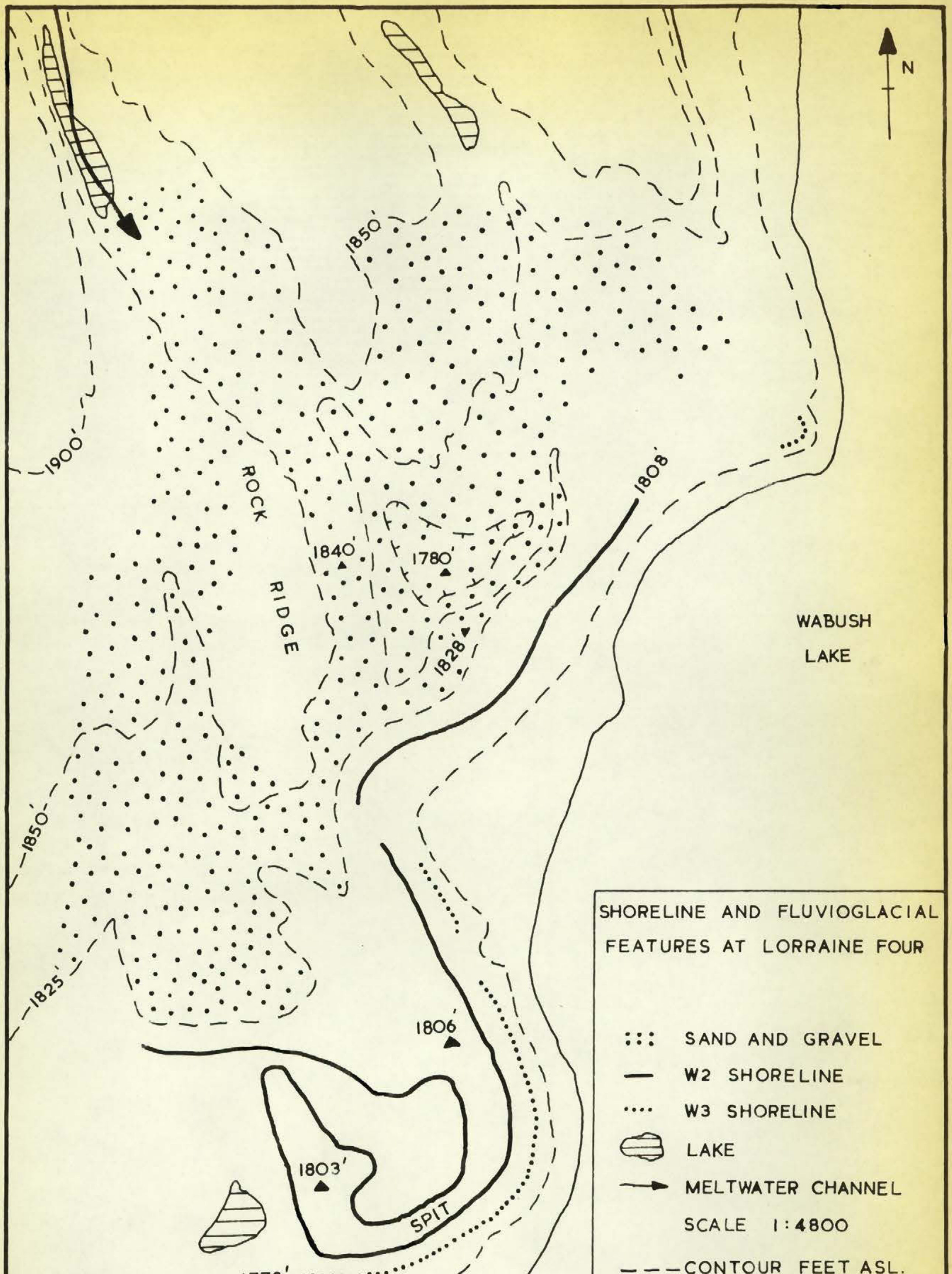
A fault line exists 400 to 600 feet to the southwest of the valley but neither dip, strike or faulting of the bedrock nor the regional slope have any influence on the orientation of the valley.

This U-shaped valley may be a subglacial channel or an old lake outlet for Lorraine Lake. The lack of control by bedrock geology and local relief suggests control by an ice mass lying in the Wabush Lake valley. The lack of large quantities of fluvioglacial sand and gravel was probably the result of the glacial meltwater flowing into the ice at 1,822 feet a.s.l. or the fact that the ice was relatively clean.

The evidence for a higher lake level for Lorraine Lake is small but a barrier only 25 feet high and 600 feet long at the northern end of the lake would bring the water level up to the height of the lip of the U-shaped valley. Fluvioglacial deposits on the lowland of the Helen River valley north of Lorraine Lake indicates the presence of ice in that area in late glacial times. This ice probably blocked the normal drainage lines causing the water to spill over the low gap to the southeast of the lake and form the deep U-shaped valley. The abrupt ending of the outlet valley can only be explained by the outlet waters flowing into a lake at 1,822 feet a.s.l. or flowing into or on to an ice mass which still remained in the Wabush Lake valley. The water leaving the dammed lake would be relatively clean due to the settling of its sediment content and this would account for the general lack of fluvioglacial deposits at the lower end of the U-shaped valley.

LORRAINE 4 (map 5)

A complex system of fluvioglacial deposits and shoreline features lies in a small embayment bounded to the west and north by two high quartzite ridges. The two


N
1900'
1850'
1850'
1825'
ROCK
RIDGE
1840'
1780'
1828'
1808'
WABUSH
LAKE
1806'
1803'
SPIT
1779'
1775'
SHORELINE AND FLUVIOGLACIAL
FEATURES AT LORRAINE FOUR
SAND AND GRAVEL
W2 SHORELINE
W3 SHORELINE
LAKE
MELTWATER CHANNEL
SCALE 1:4800
CONTOUR FEET ASL.
400 FEET
MAP 5

ridges rise to an elevation of 2,275 feet a.s.l. and are separated by a deep narrow lake studded valley. This valley is a fault line valley cut into steeply dipping Iron Formation and links the Helen River valley with Lorraine 4.

South of this narrow valley the fluvioglacial deposits spread out and extend as far as the present shoreline of Wabush Lake. These deposits generally lie below the 1,850 foot contour. The deposits are divided into two sections by a north-south orientated bare rock ridge of Iron Formation. East of this ridge the fluvioglacial deposits have a flat surface with an elevation of 1,840 feet a.s.l. This is particularly noticeable immediately east of the rock ridge and south of the narrow valley. The centre of this eastern section of the deposits consists of a 65 foot deep kettle hole which is partially filled with minor ridges and knolls. The outer rim of this kettle hole forms a narrow sinuous ridge (elevation 1,828 feet a.s.l.) (photo 8). South and east of the rock ridge the fluvioglacial deposits again have an elevation of 1,836 to 1,850 feet a.s.l. with a few small kettle holes, 5 to 10 feet deep.

The outer edge of the fluvioglacial deposits, that is the edge bounding Wabush Lake, has been modified by wave action. South of the rock ridge there is a large recurved spit (photo 9) at an elevation of 1,803 feet a.s.l. with one large bulbous lateral ridge. The spit is 38 to 50 feet wide, conspicuously bare of trees and encloses a now wooded hollow 14 feet deep which once formed the lagoon behind the spit (photo 10). The recurved tip swings northwards and almost rejoins the shore. The base of the spit forms an extensive flat area which is restricted in extent towards the north by the rock ridge.

Photo. 8.
Narrow sinuous ridge (1828 feet a.s.l.) forming the outer rim of the large kettle hole in the northeast quadrant of Lorraine 4.

Photo. 9.
View of the recurved spit at Lorraine 4, looking east towards Wabush Lake.

Photo. 10.
View of the recurved spit (1803 feet a.s.l.), Lorraine 4, looking east towards Wabush Lake. The spit curves round to the left enclosing the tree covered former lagoon.

The outer edge of the spit is cut into by a lower shoreline at an elevation of 1,779 feet a.s.l. The width of this shoreline varies from 120 feet wide near the middle of the spit to 50 feet wide near the base of the spit. The shoreline is again marked by the lack of or less dense vegetation (photo 11). The backslope of this shoreline is steep, about 15 to 20 feet high, and has no boulder deposit at its base. The outer edge of the bench is often disturbed by mass movement processes which reveal the sandy nature of the shoreline (photo 12). In places there has been slumping of the shoreline material forming enclosed hollows with the appearance of kettle holes.

A two foot section across the recurved spit (photo 13) revealed steeply dipping (33°) beds of alternate fine and coarse sands. The steeply dipping beds are truncated at the surface and covered by a sporadic layer of quartzite and granitoid gneiss pebbles 1 to 3 inches in diameter. A grain size analysis of a small sample collected from this section revealed a well sorted deposit (Fig 2, graph 2).

Northeast of the rock ridge the sinuous ridge forming the outer edge of the kettle hole is cut into by a wide shoreline. This shoreline is 77 to 125 feet wide, has an elevation of 1,808 feet a.s.l. The backslope is low and leads up to the sinuous ridge. The foreslope is very steep (60°) and stretches down to the present lake shoreline. There is no indication of another shoreline below 1,808 feet a.s.l. except for a small patch of level ground on the headland east of the sinuous ridge.

The level surface of the fluvioglacial deposits immediately east of the bare rock ridge has a form similar to the shorelines. It has a steep backslope of Iron

Photo. 11.
1779 feet a.s.l. shoreline at Lorraine 4, showing the type and height of vegetation growing on the various facets of the shoreline.

Photo. 12.
Destruction of the outer edge of the 1779 feet a.s.l. shoreline by periglacial activity. Mass movement features expose the sandy nature of the shoreline.

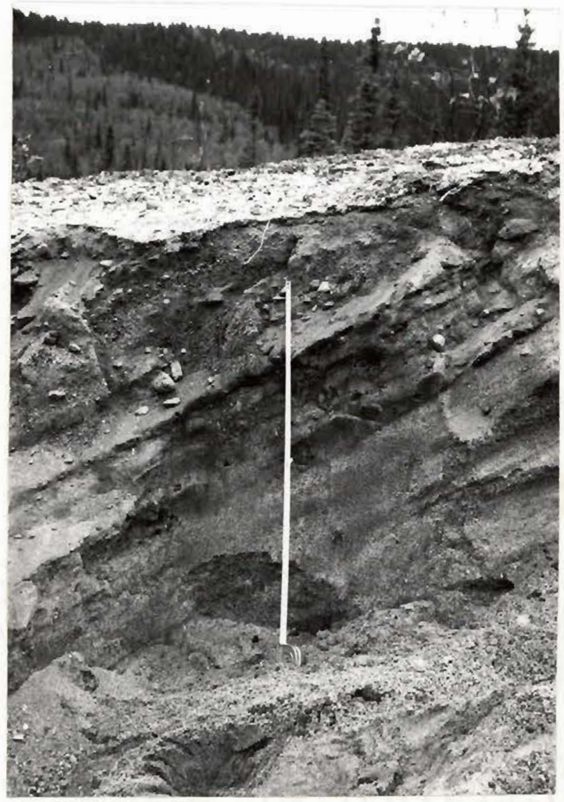


Photo. 13.

Section through the recurved spit at Lorraine 4, showing steeply dipping truncated beds of sand with a sporadic surface layer of quartzite and granitoid gneiss pebbles. The ruler is 2 feet long.

Formation, a flat beach-like area and a steep slope down into the 65 foot deep kettle hole.

From the elevations of the different features three main levels can be distinguished. The lowest level forming the 1,779 foot a.s.l. shoreline around the outer edge of the spit. The second level is formed by the spit and the 1,808 foot a.s.l. shoreline northeast of the rock ridge. The highest level is formed by the original surface of the fluvioglacial deposits.

The outward form of the recurved spit and the sinuous ridge appear to indicate similar landforms - that is recurved spits which developed north and south of the bare rock ridge. A closer examination yields evidence to suggest that this is not the case. The two ridges are at different elevations and the depth of the hollow behind the sinuous ridge and the detailed character of this hollow are not that of a lagoon formed behind a spit but that of a kettle hole formed by the melting out of an ice mass from within a fluvioglacial deposit. The highest level at 1,836 to 1,850 feet a.s.l. forms the surface of a fluvioglacial deposit pitted with kettle holes.

The sands and gravels forming the fluvioglacial deposits came down the narrow fault line valley from the Helen River valley which contained a substantial inactive ice mass. This is indicated by features to be discussed in the next section. Ice still lay within the main body of Wabush Lake but the small bay between the two quartzite ridges was practically free of ice except for isolated blocks which formed the kettle holes northeast of the bare rock ridge. This embayment allowed a small lake or an extension of an ice marginal stream to form, in which the fluvioglacial deposits were laid down. The level of the surface of the deposits is a function of the height of the water in the small lake or in the marginal stream. A normal lake delta could have formed a similar flat topped deposit but it is difficult to explain the presence of the large deep kettle hole.

The southeastern extent of the fluvioglacial deposits is not known but it is assumed that it extended farther to the southeast than at the present. After the deposition of the sands and gravels the ice melted and the deep valley to the northwest became dry. The outer edge of the deposits were then subjected to erosion and deposition at two levels by shoreline processes active around the edge of glacial lakes. Only in ideal localities have remnants of the lower shoreline survived because of the unconsolidated nature of the sands and gravels forming the shorelines and their susceptibility to wave erosion.

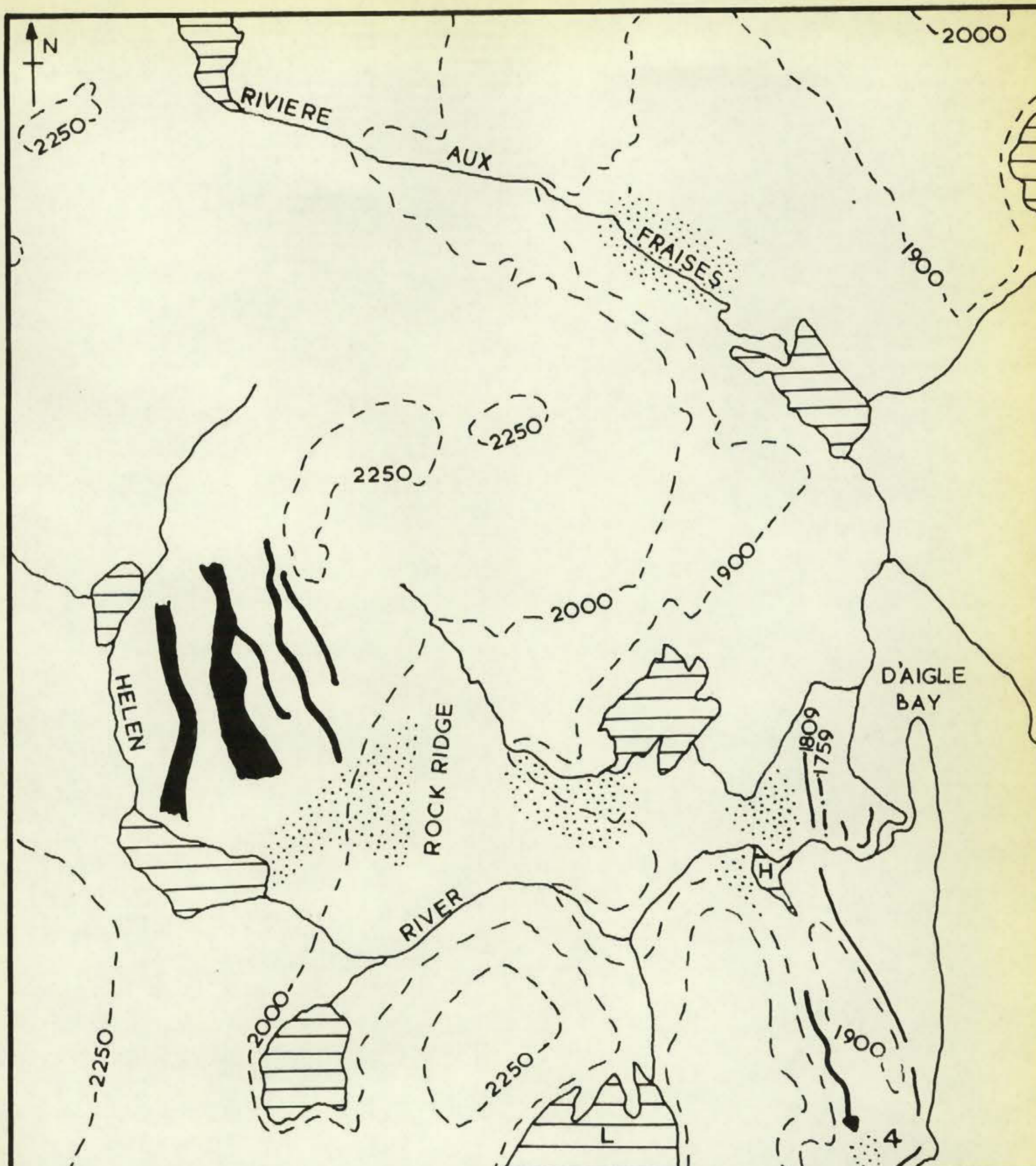
Along the eastern side of the northern quartzite ridge a rocky shoreline was located at an elevation of 1,808 feet a.s.l. The shoreline is wave cut and backed by a very steep cliff of quartzite. The shoreline 20 to 50 feet wide is covered by a large angular and subangular boulders of quartzite.

HELEN RIVER VALLEY (map 6)

The Helen River valley lies north of the Wapussakatoo Mountains and is occupied by one of the largest rivers draining into Wabush Lake. It has a broad upper valley section occupied by three lakes and a wide lower valley below Helen Lake. The middle valley section is narrow and steep and follows close to the northern edge of the Wapussakatoo Mountains. The whole valley is occupied by sands and gravels and below Helen Lake extensive shoreline features are found both north and south of the river.

Five meltwater channels in parallel sequence are cut into the eastern side of the upper valley. They vary in size and depth indicating varying periods of formation or variations of meltwater flow. The highest channel is shallow, meandering and extends from 2,200 to 2,125 feet a.s.l. The next channel is longer and deeper extending from 2,160 to 2,090 feet a.s.l. The third channel is meandering and shallow extending from 2,100 to 2,050 feet a.s.l. Its upper end is truncated by the fourth channel which is both deep and wide. It extends from 2,080 to 2,050 feet a.s.l. It possesses meander scars and meander scrolls. The fifth and lowest channel is also deep, flat floored but has only a slightly winding course. It extends from 2,060 to 2,040 feet a.s.l. This lower end of this channel opens out into a small delta fan.

All five channels commence in the low col leading from the Rivière aux Fraises valley to the Helen River valley. The upper three channels are relatively small



SHORELINE AND FLUVIOGLACIAL FEATURES IN THE HELEN RIVER VALLEY

SHORELINE W2 — MELTWATER CHANNEL — SAND AND GRAVEL

SHORELINE W3

HELEN LAKE : H LORRAINE LAKE : L LORRAINE 4 : 4

SCALE 1:50000 1 MILE

MAP 6

and indicate short formation periods and short standstills of the ice margin. The fourth channel indicates a longer ice standstill with the formation of a meandering meltwater stream.

The bedrock in this area is schist but the character of the meltwater channels indicates the formation of at least the two lower channels in surficial deposits.

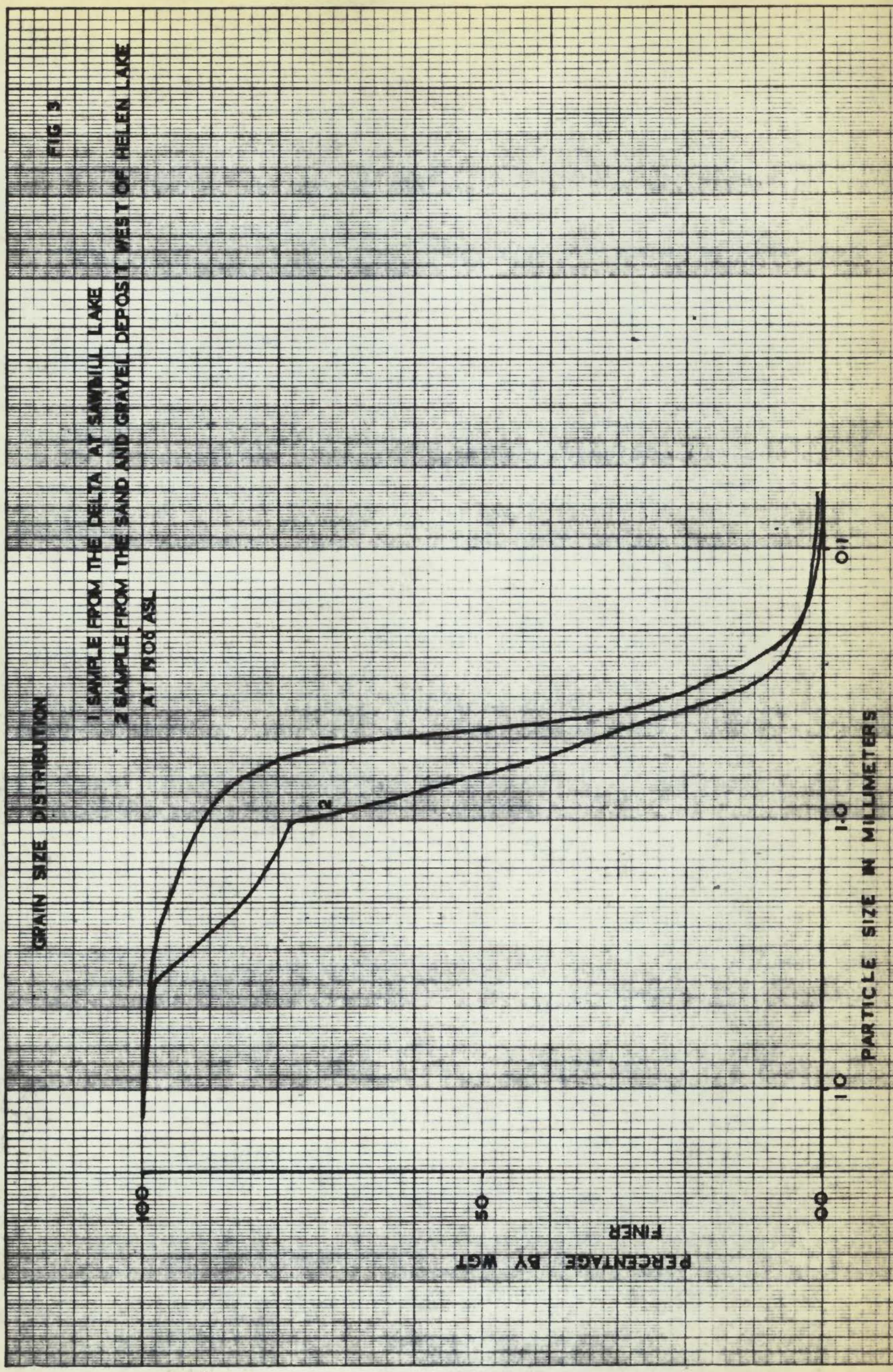
A large area of sands and gravels lies below the meltwater channel outlets, particularly below the fourth and largest channel. It is cut into by numerous small dry channels radiating from the lake which lies to the west of this sand and gravel area. These channels are north of the present stream draining the lake and indicate an earlier direction of drainage possibly in late glacial times when there was abundant meltwater and former drainage lines were deranged.

A rock ridge running north-south separates this sand and gravel deposit from another deposit which has a general elevation of 1,930 to 1,950 feet a.s.l. This lower deposit is formed of low elongated ridges and small knolls separated by closed marsh and lake filled hollows.

On the southern side of the Helen River valley above Helen Lake (1,798 feet a.s.l.) a road cut which has been deeply eroded reveals bedded sands and gravels up to an elevation of 1,906 feet a.s.l. (photo 14). The sands and gravels are only 15 to 20 feet thick and overlie smoothed schist bedrock. The surface deposits are formed of loose well sorted, current bedded sands and gravels (Fig. 3, graph 2) and

Photo. 14.

Section through the eroded road cut west of Helen Lake, showing loose, coarse, bedded surface deposits overlying current bedded medium and fine grained sand. The ruler is 1 foot long.


GRAIN SIZE DISTRIBUTION
FIG 3
1 SAMPLE FROM THE DELTA AT SAWMILL LAKE
2 SAMPLE FROM THE SAND AND GRAVEL DEPOSIT WEST OF HELEN LAKE
AT 1900' ASL
1
2
100
50
0
10
1.0
0.1
PARTICLE SIZE IN MILLIMETERS
PERCENTAGE BY WGT
FINER

are underlain by alternate layers of current bedded fine micaceous sand and medium grained sand (photo 14). No distinct shoreline features were visible at this elevation but the slope of the valley side was gentle between 1,890 and 1,940 feet a.s.l.

Just below this road cut a distinct shoreline feature occurs at an elevation of 1,879 feet a.s.l. (photo 15). It is 500 feet long, 50 to 60 feet wide and has a steep backslope and foreslope. This shoreline feature is in the narrow deep middle section of the Helen River valley and the opposite side of the valley has no similar shoreline feature but is marked by a steep cliff cutting across steeply dipping schists.

Sands and gravels form a relatively flat area north of Helen Lake and also form the lower slopes west of Helen Lake and gives rise to the very dissected nature of the slope.

Shoreline features are located mainly east of Helen Lake and occur at two distinct levels. The construction of an airstrip has destroyed most of the lowest shoreline and part of the upper shoreline but maps and air photographs taken before construction commenced make it possible to reconstruct a map showing the distribution of the shoreline features.

The wave cut shoreline which occurs at an elevation of 1,808 feet north of Lorraine 4 gives way to a wave built sandy shoreline south of D'Aigle Bay. This shoreline is well developed further south from Helen River and becomes less well developed towards the river and has been much disturbed during the construction of the airstrip.

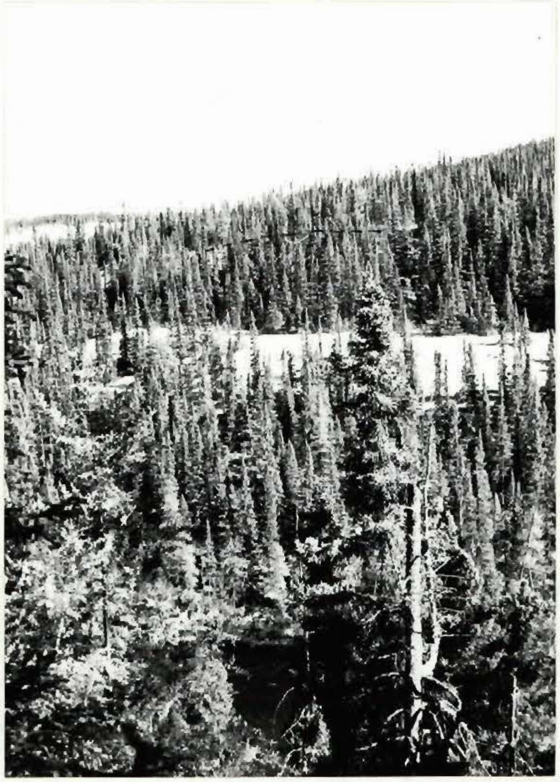


Photo. 15.
Cladonia covered shoreline (1879 feet a.s.l.) in the narrow middle section of the Helen River valley west of Helen Lake.
- - - - = position of the eroded road cut.

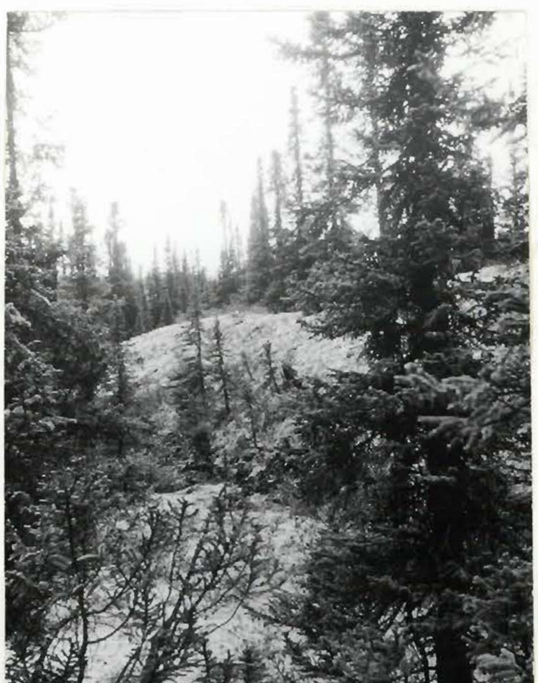


Photo. 16.
Steep bare foreslope of the 1759 feet a.s.l. terrace which lies in the lower section of the Helen River valley east of Helen Lake.

The southern part of this shoreline has a well marked foreslope 25 feet high with an angle of repose of 50°. The shoreline is 150 to 160 feet wide and has an elevation of 1,805 feet a.s.l. The backslope is not well developed in this southern section but becomes well developed further north whilst the foreslope becomes less well developed. Two thousand feet south of the river this shoreline has an elevation of 1,813 feet a.s.l. Trenches cut into this shoreline reveal sands and gravels with a similar grain size, lithology and bedding as the sands and gravels west of Helen Lake and of the Wabush esker. North of the river this shoreline continues for two thousand feet and has an elevation of 1,809 feet a.s.l.

The second distinct shoreline level is marked by features north of the river. Here a long thin isolated ridge with an elevation of 1,775 feet a.s.l. lies some distance from the main slope of the land and has the form of an offshore bar. The main slope behind the offshore bar has small shoreline remnants at an elevation of 1,775 feet a.s.l. South of this ridge there is a small conical hill rising to a height of 1,774 feet a.s.l.

South of the river the main area in which the lower shoreline would most likely have formed has been used as an airstrip and all traces of this shoreline have been destroyed. The detailed contour maps reveal the presence of this lower shoreline to the east of the well developed section of the upper shoreline.

North of the river a small flat terrace, elevation 1,752 feet a.s.l., fans out below the waterfalls which form the Helen River below Helen Lake. The inner end of the terrace has an elevation of 1,759 feet a.s.l. The foreslope of this terrace is 8 feet high and is marked by the absence of large trees (photo 16).

The lower Helen River valley has small river terraces or lake side terraces at an elevation of 1,738 and 1,733 feet a.s.l. that is, 8 feet and 3 feet above the present lake level.

Small hummocky mounds of sand and gravels were seen in the Rivière aux Fraises valley.

The landforms at Lorraine 4 and the deep channel southeast of Lorraine Lake as mentioned above require the presence of ice within the Helen River valley for their formation.

The hummocky deposits within both the Helen River valley and the Rivière aux Fraises valley give evidence of the presence of stagnant masses of ice in late glacial times. The five meltwater channels were the main transportation lines for material to be deposited with the valley. The three lower channels indicate down-wasting in situ as they are ice marginal channels. The two distinct shoreline levels and the terrace at 1,752 feet a.s.l. were formed at the margin of three distinct lake stages, the material forming these shorelines being eroded from the stagnant ice deposits higher up the valley.

The low river terraces have been formed by the meandering river below the waterfalls at the outlet of Helen Lake.

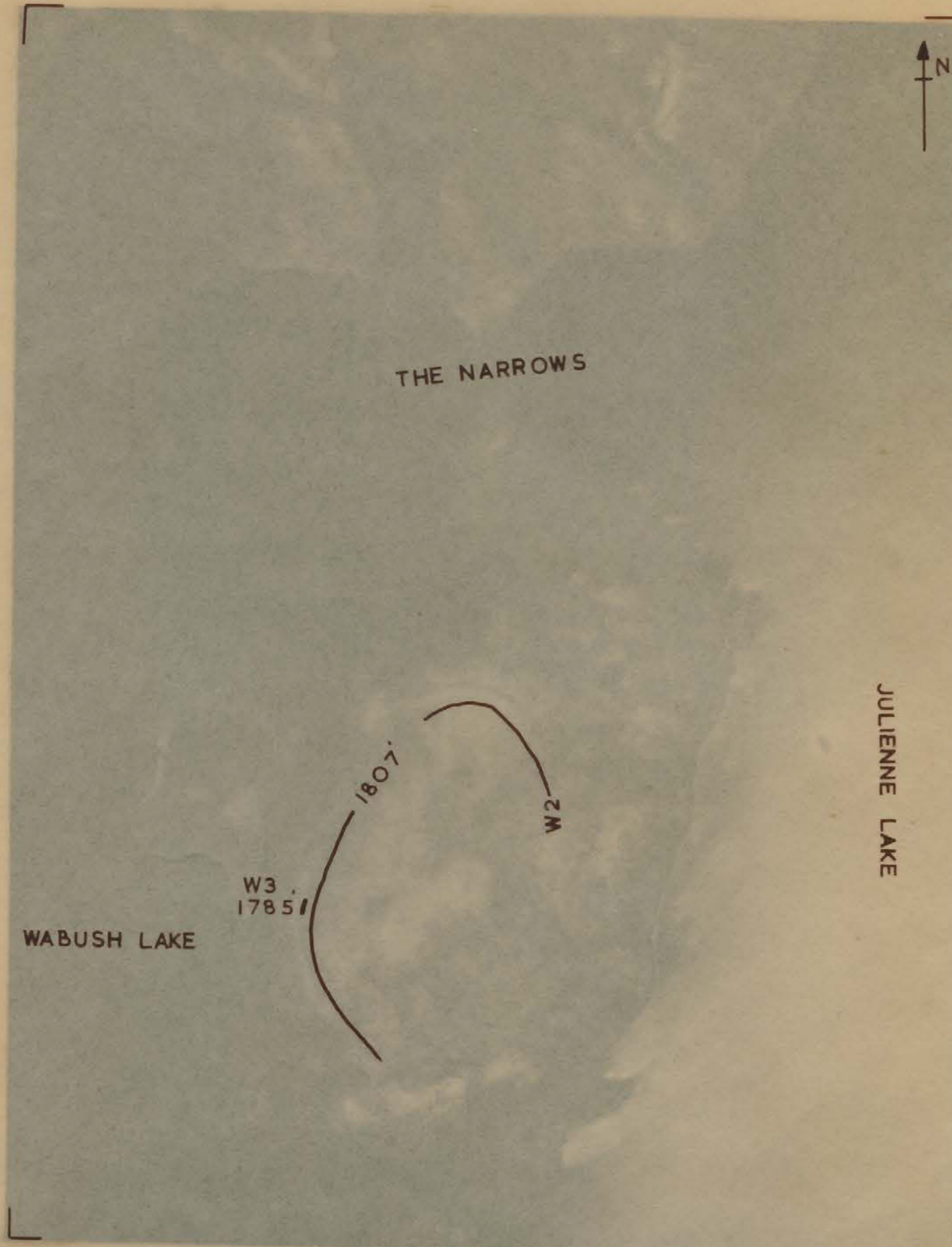
JULIENNE PENINSULA (photo 17)

The Julienne Peninsula separates the northern end of Wabush Lake from Julienne Lake and the two lakes are joined by a short narrow channel called The Narrows which lies due north of the peninsula.

The peninsula rises to an elevation of 1,950 feet a.s.l. and has a semi-ovoid shape elongated in a north-south direction. The peninsula has a complex bedrock geology and consists mainly of highly folded iron formations. The surficial deposits consist of coarse till and the peninsula is covered with subangular erratics of granitoid gneisses and angular boulders of Wabush Iron Formation.

One very distinct shoreline occurs around the southwest side and at the northern tip of the peninsula. The outer edge of the wave formed bench has an elevation of 1,807 feet a.s.l. and the base of the backslope has an elevation of 1,817 feet a.s.l.

The southwest section of the shoreline is clearly visible on the air photographs (photo 17) as a broad line with very little tree cover whereas the backslope and foreslope are thickly covered with trees. On the ground this section of the shoreline is 90 to 110 feet wide and has a steep backslope cut in specularite. The outer edge of



JULIENNE PENINSULA

— SHORELINE   SCALE 1:20000   PHOTO 17

the bench is built of coarse sand and gravel of local surficial deposits and the base of the backslope is covered by a residual layer of boulders which have a diameter of 3 to 6 feet. The outer edge of the bench becomes less distinct towards the north.

The northern section is most marked on the northwest side of the peninsula and decreases in width towards the east. The shoreline is 70 to 80 feet wide and its backslope forms a cliff 4 to 15 feet high cut in specularite (photo 18). At the foot of the cliff there are large angular specularite blocks which have fallen from the cliffs. The surface of the shore is covered with subangular pebbles 2 to 4 inches in diameter (photo 19). These pebbles are mainly formed of specularite but there is an occasional subrounded pebble of granitoid gneiss. The specularite pebbles were formed by wave action on material eroded from the cliffs behind the shore. Their shape indicates relatively little erosion and transportation compared with the subrounded granitoid gneiss pebbles which are glacial erratics.

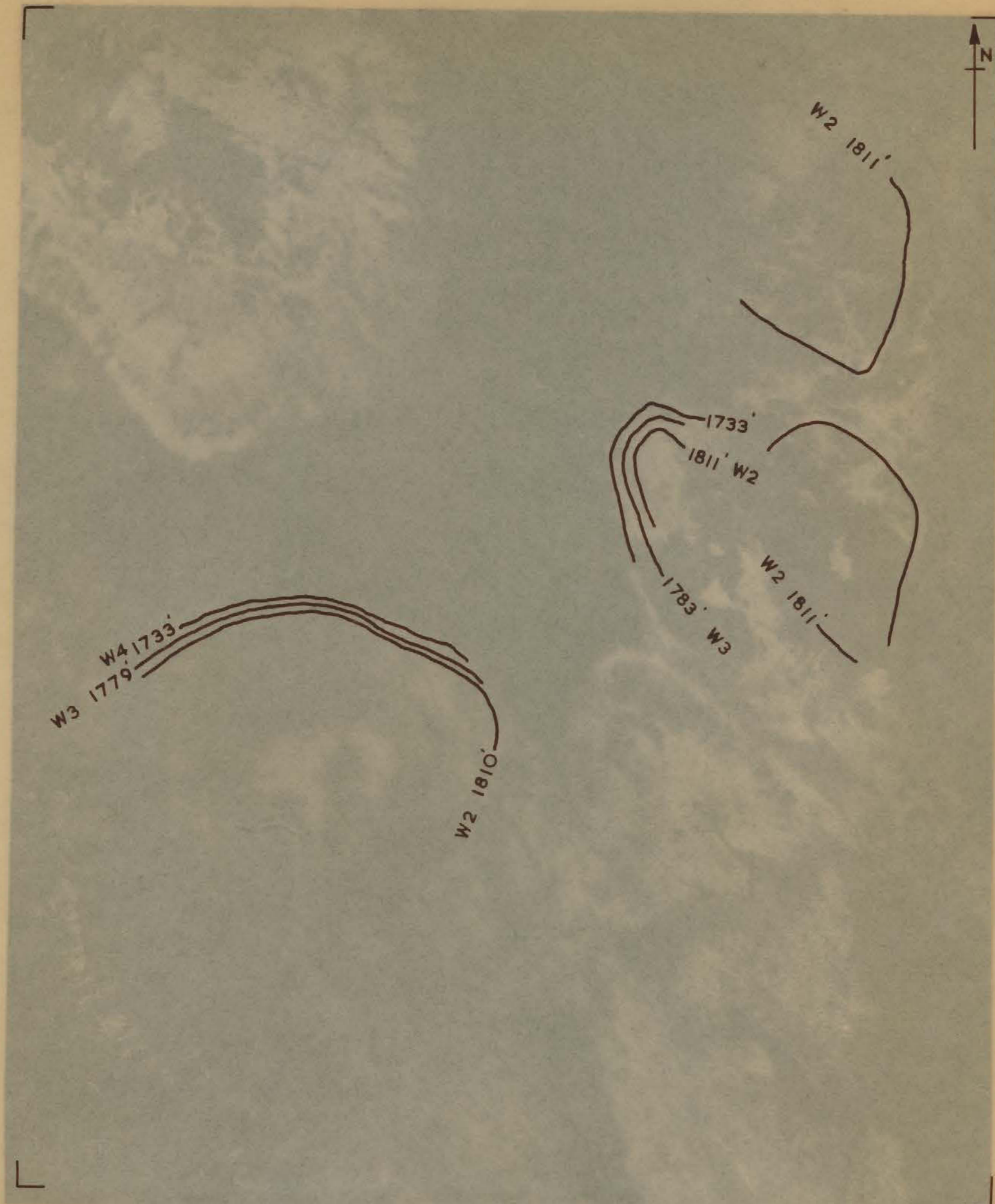
A small notch at the base of the foreslope of the southwestern section of the shoreline at an elevation of 1,785 feet a.s.l. is the only evidence of a lower shoreline.

GOETHITE BAY (photo 20)

Goethite Bay is located at the north end of Julienne Lake. Three distinct shoreline levels are found around four ovoid hills formed of Wabush Iron Formation which lie between Goethite Bay and Scott Bay (map 8). These shorelines were first

Photo. 18.
Low cliff of specularite forming the backslope of the 1807 feet a.s.l. shoreline at the northern tip of Julienne Peninsula.

Photo. 19.
Subangular specularite pebbles covering the 1807 feet a.s.l. shoreline at the northern tip of Julienne Peninsula.



GOETHITE BAY

— SHORELINE SCALE 1:20000 PHOTO 20

mentioned by Pegrum (1936) and more fully described and measured by Henderson (1959).

The lowest shoreline lies just above the present lake level at an elevation of 1,733 to 1,736 feet a.s.l. The shoreline is 25 to 40 feet wide and in some places it is backed by a steep cliff rising up to the second shoreline. This lowest shoreline is equivalent to Henderson's 12 foot terrace (Henderson, 1959, page 40) but measurements revealed that the outer edge of the wave formed bench is only 3 to 6 feet above lake level and the base of the backslope is only 10 feet above lake level. Prominent shoreline features at this level were not found in any other locality around the Wabush-Shabogamo Lake system.

The second shoreline is poorly developed especially in the northern parts of this area. The southern section of this shoreline has an elevation of 1,779 feet a.s.l. and a bench 10 to 25 feet wide (photo 21).

Three quarters of a mile farther north on a bare rocky hill (photo 22) this same shoreline has an elevation of 1,783 feet a.s.l. The bench is covered with up to 2 feet of granitic sand containing subangular pebbles. The grain size distribution of this sand shows a moderate degree of sorting (Fig. 4, graph 1).

The highest shoreline is best developed of all three and occurs around all four hills on north, south, east and west facing slopes whereas the two lower shorelines are restricted to the north and west facing slopes.

Photo.21.
Southernmost hill in Goethite Bay. Shorelines at 1779 and 1810 feet a.s.l. are marked by pale Cladonia lichen.

Photo.22.
The bare rocky hill in Goethite Bay on which three shorelines are well developed.

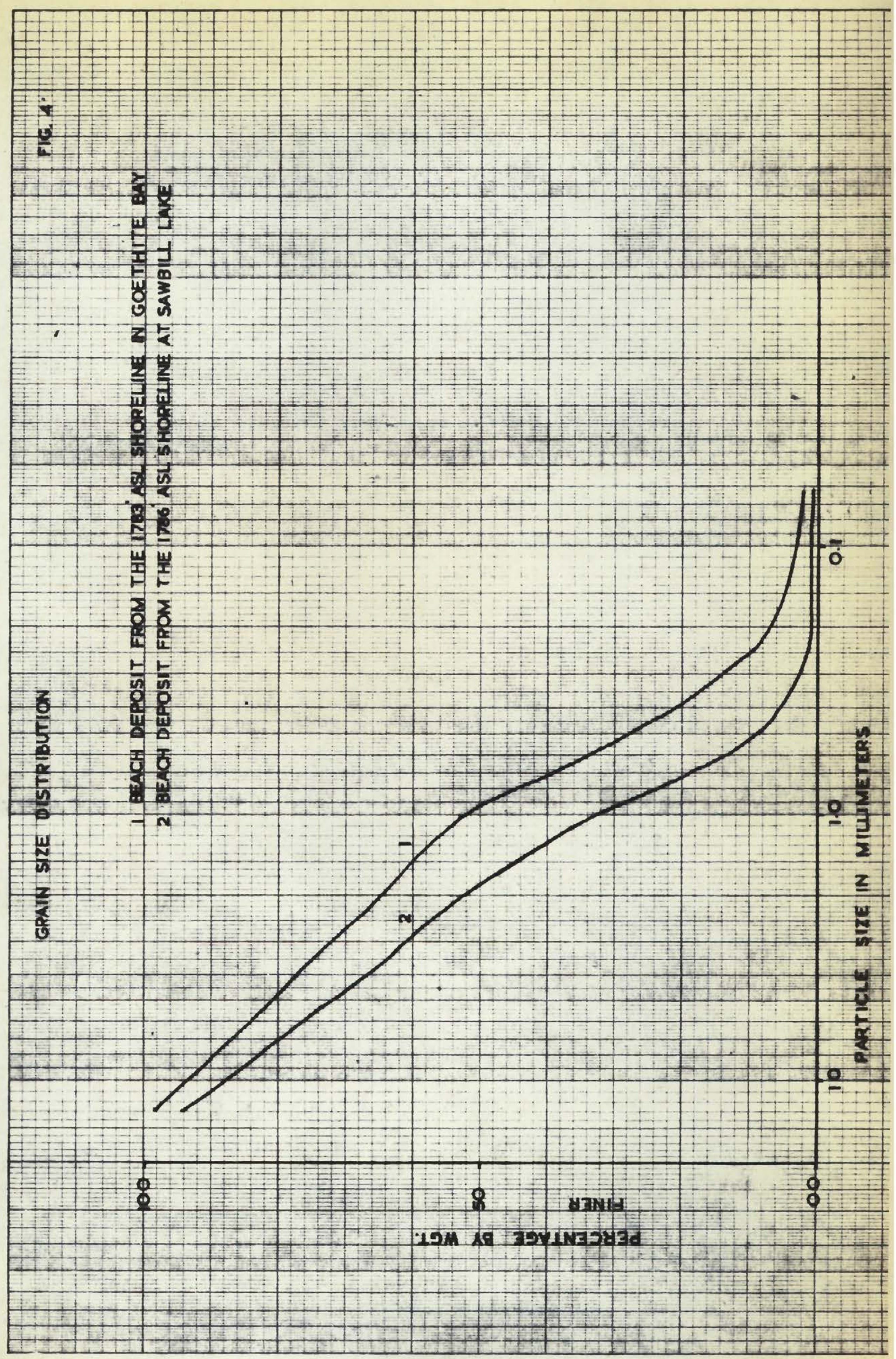


FIG. 4
GRAIN SIZE DISTRIBUTION
1 BEACH DEPOSIT FROM THE 1763' ASL SHORELINE IN GOETHITE BAY
2 BEACH DEPOSIT FROM THE 1786' ASL SHORELINE AT SAWBILL LAKE
1
2
10
1.0
0.1
PARTICLE SIZE IN MILLIMETERS
100
50
00
PERCENTAGE BY WGT. FINER

On the southern most hill the highest shoreline is restricted to the northern slope overlooking Goethite Bay. It has an elevation of 1,810 feet a.s.l. The inner part of the bench is free of large boulders indicating a fine grained surficial deposit into which all the shorelines on this slope are cut.

On the bare rocky hill this shoreline is cut into solid rock and is very well preserved (photo 23). The outer and inner edges of the wave cut bench have elevations of 1,811 feet a.s.l. and 1,814 feet a.s.l., respectively. The bench is backed in places by a rock cliff 12 to 15 feet high. The cliff is formed of goethite and the bench is covered by a layer of small subangular goethite pebbles (photo 23).

The bench varies in width from 20 to 150 feet. The north facing portions of the shoreline are generally wider but constrictions occur at the base of the rock cliffs.

The two northern most hills have shorelines on all slopes but here again they are more pronounced on north facing slopes. These shorelines have an elevation of 1,811 feet a.s.l. The northern sections are 50 to 85 feet wide and the eastern sections are from 50 feet to a few feet wide. The western slope of this hill lying to the east of the bare rock hill has no shoreline features because the bare rock hill would have protected this slope from strong wave action.

A small sand and gravel deposit occurs at the northern end of Goethite Bay and has an elevation of 1,810 feet a.s.l.

Photo.23.
Shoreline cut in solid rock (1814 feet a.s.l.), Goethite Bay.

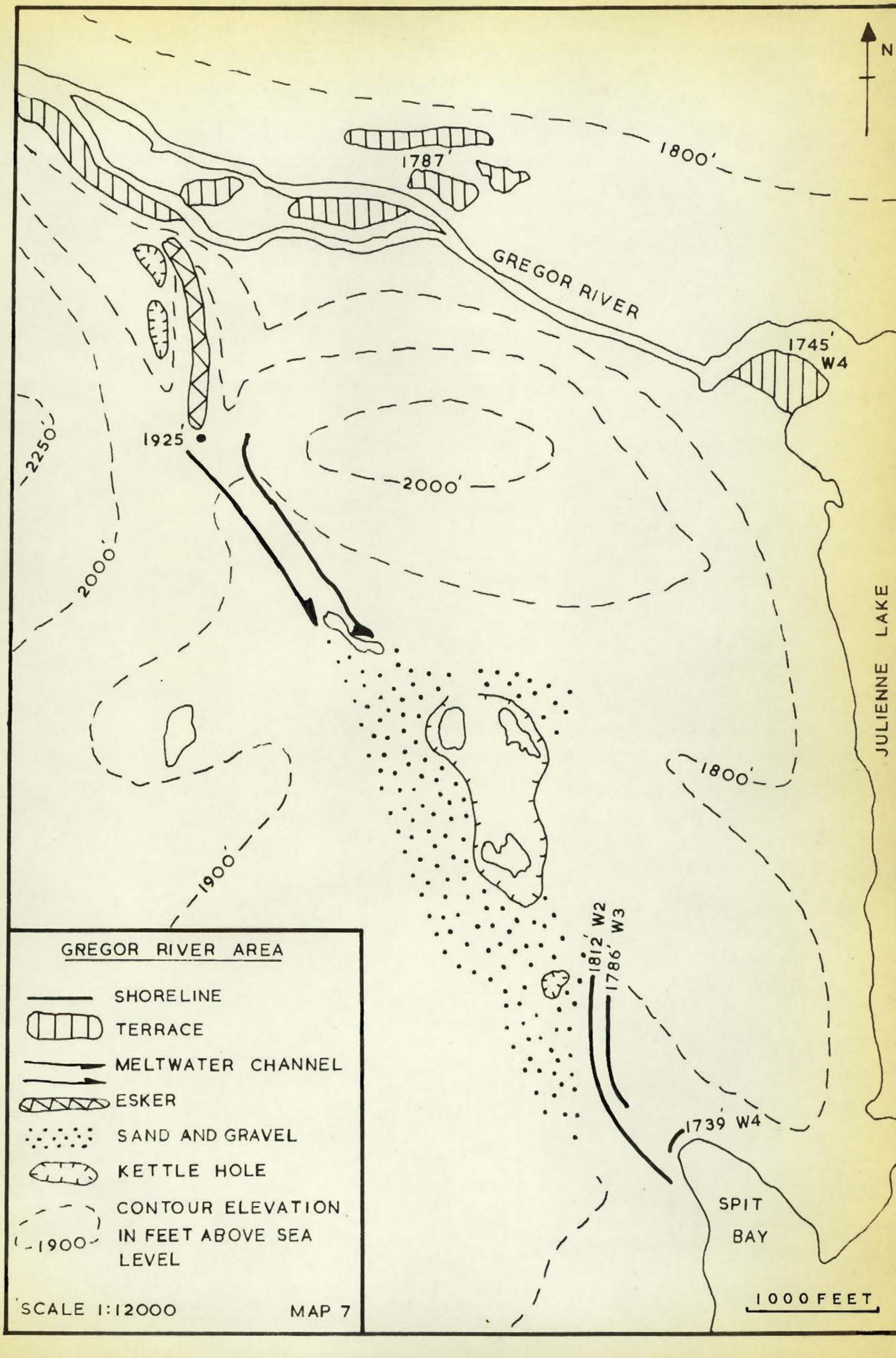
GREGOR RIVER AREA (map 7, photo 24)

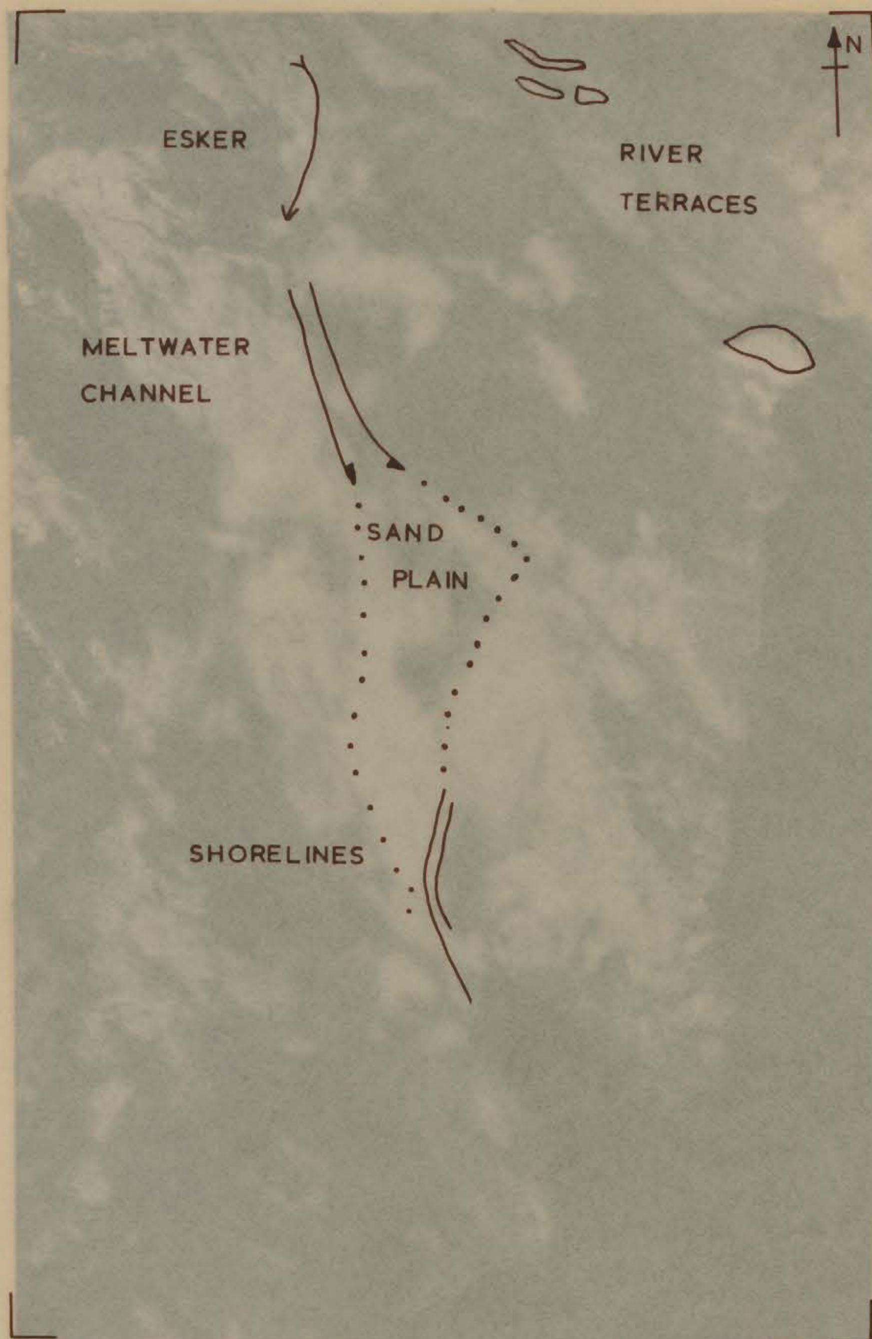
This area lies northwest of Julienne Lake and is drained by the Gregor River, a major drainage line in Southwest Labrador. In this area large fluvioglacial deposits are found in association with two shorelines and two river terraces.

South of the river there is a quartzite ridge with an elevation of 2,350 feet a.s.l. at its northwestern end and 2,050 feet a.s.l. at the narrower southeast end. The ridge is cut through by a col at 1,925 feet a.s.l. A short esker ridge rises out of the Gregor River valley and runs towards the col where it ends abruptly (photo 25). The esker has steep slopes of 35° to 50°, the outer slope towards the Gregor River is from 60 to 100 feet high and the inner slope is 50 to 60 feet high. The esker is separated from the hillside by two main kettle holes which contain irregular fluvioglacial debris. The esker is formed of sands and gravels and the tops and sides of the esker are littered with rounded boulders of granitoid gneiss (photo 26).

South of the col there is a deep gorge cut into the quartzite ridge. From the col the gorge plunges over a steep quartzite slope to a flat marshy floor at 1,845 feet a.s.l. The lower end of the gorge is flooded and constricted by a high rock buttress (photo 27). The lower end of the gorge opens out on to a broad flat sand plain (elevation 1,840 to 1,830 feet a.s.l.). This sand plain appears to bury the surrounding rock ridges and several dry and lake filled kettle holes occur within this sand plain.

The outer edge of this sand plain at Spit Bay has been cut into by wave action and two shorelines are visible.


N
1800'
1787'
GREGOR RIVER
1745'
W4
1925'
2250'
2000'
2000'
JULIENNE LAKE
1800'
1900'
1812' W2
1786' W3
1739 W4
SPIT
BAY
GREGOR RIVER AREA
SHORELINE
TERRACE
MELTWATER CHANNEL
ESKER
SAND AND GRAVEL
KETTLE HOLE
CONTOUR ELEVATION
IN FEET ABOVE SEA
LEVEL
1900
SCALE 1:12000
MAP 7
1000 FEET



GREGOR RIVER AREA

SCALE 1:20000

PHOTO 24

Photo. 25.
View south over Gregor River valley, showing the esker ridge rising up to the col which cuts through the quartzite ridge.

Photo.26.
Esker ridge leading up to the col in the quartzite ridge.

Photo.27.
Deep meltwater channel cutting through the quartzite ridge. View northwestwards towards the col in the quartzite ridge.

The upper shoreline extends inland from the head of Spit Bay for a distance of 1,800 feet. At the head of the bay this shoreline forms a sand bar with a width of 20 to 60 feet and an elevation of 1,809 feet a.s.l. This is equivalent to the bar top mentioned by Henderson (1959, page 40) for which he gives an elevation of 1,826 feet a.s.l. The sand bar increases in elevation inland and gives way to a distinct shoreline 40 to 50 feet wide backed by a short steep vegetated slope which rises to the height of the sand plain. This upper shoreline has an elevation of 1,812 feet a.s.l.

Into the foreslope of the upper shoreline a narrow ledge at the most 8 feet wide is cut at an elevation of 1,786 feet a.s.l. It is marked by the presence of small spruce trees growing on it (photo 28). It is not as extensive as the higher shoreline but in several places small flat topped lobes on the side of the sand plain which appear to be caused by slumping of the steep slope have a similar elevation to the ledge like shoreline. These lobes appear therefore to be remnants of this lower shoreline.

In the Gregor River valley small terraces formed of sands and gravels lie beside the present river channels and old river channels. These terraces have an elevation of 1,787 feet a.s.l. Further up the valley irregular mounds and ridges of sand and gravel occur.

At the mouth of the river there is a small terrace of faintly bedded sands and gravels which rises to an elevation of 1,745 feet a.s.l. that is 15 feet above lake level (photo 29). North of the river two small shorelines occur at 1,735 and 1,745 feet a.s.l.

Photo.28.
Shorelines cut into the outer edge of the sand plain at the head of Spit Bay at an elevation of 1812 and 1786 feet a.s.l.

Photo.29.
River terrace at the mouth of Gregor River at an elevation of 1745 feet a.s.l.

and a small bay-head beach at the head of Spit Bay has an elevation of 1,739 feet a.s.l. These features are all indications of Henderson's 12 foot shoreline.

The presence of large quantities of fluvioglacial material and a deep meltwater channel indicate that the Gregor River valley was a major drainage line during deglacierization. The esker and meltwater channel indicate movement of water through and under the ice in englacial and subglacial channels. The water deposited material as it crossed the low valleys and eroded channels as it crossed the high ridges. The kettle holes within the sand plain indicate deposition near the edge of the ice where isolated blocks of ice remained.

The meltwater channel through the quartzite ridge was probably cut along a fault line which would have been an original line of weakness for the meltwater to follow. The only geological map available for this area is of a very small scale and shows a fault line southwest of the meltwater channel but a detailed examination of the air photographs revealed no evidence of a fault in this position. It is assumed therefore that the fault line follows the meltwater channel.

The small terrace remnants in the Gregor River valley are probably formed of resorted fluvioglacial deposits. The terrace remnants have an elevation of approximately 1,787 feet a.s.l. which is slightly higher than the height of the lower shoreline in Spit Bay. These terraces were probably deposited by a braided river entering the former glacial lake which stood at an elevation of 1,786 feet a.s.l. The lowering of the glacial lake caused downcutting of the Gregor River and erosion of part of the terraces.

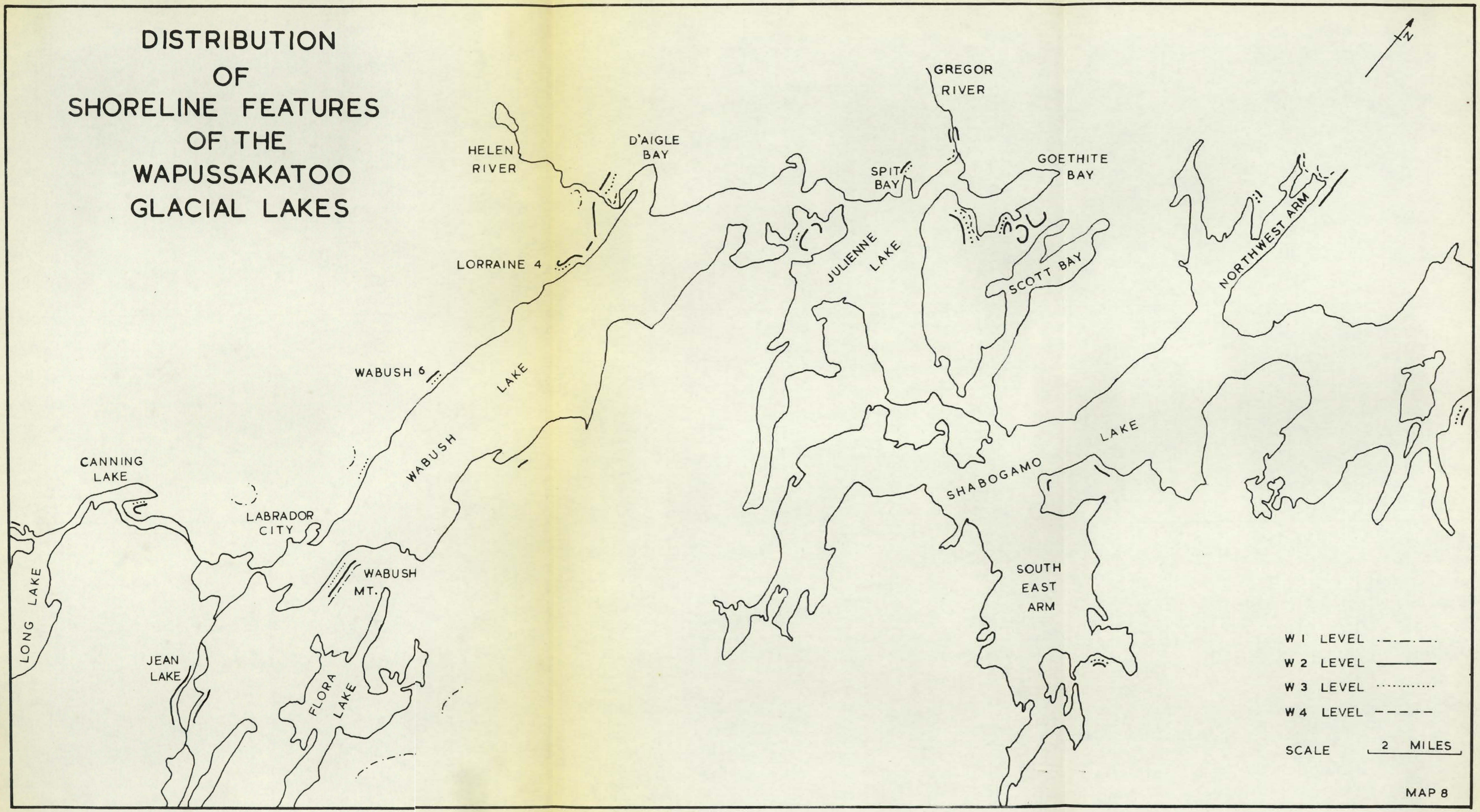
The lower terrace at 1,745 feet a.s.l. represents another river deposit at the mouth of the Gregor River when the former lake stood about 10 to 11 feet above its present level.

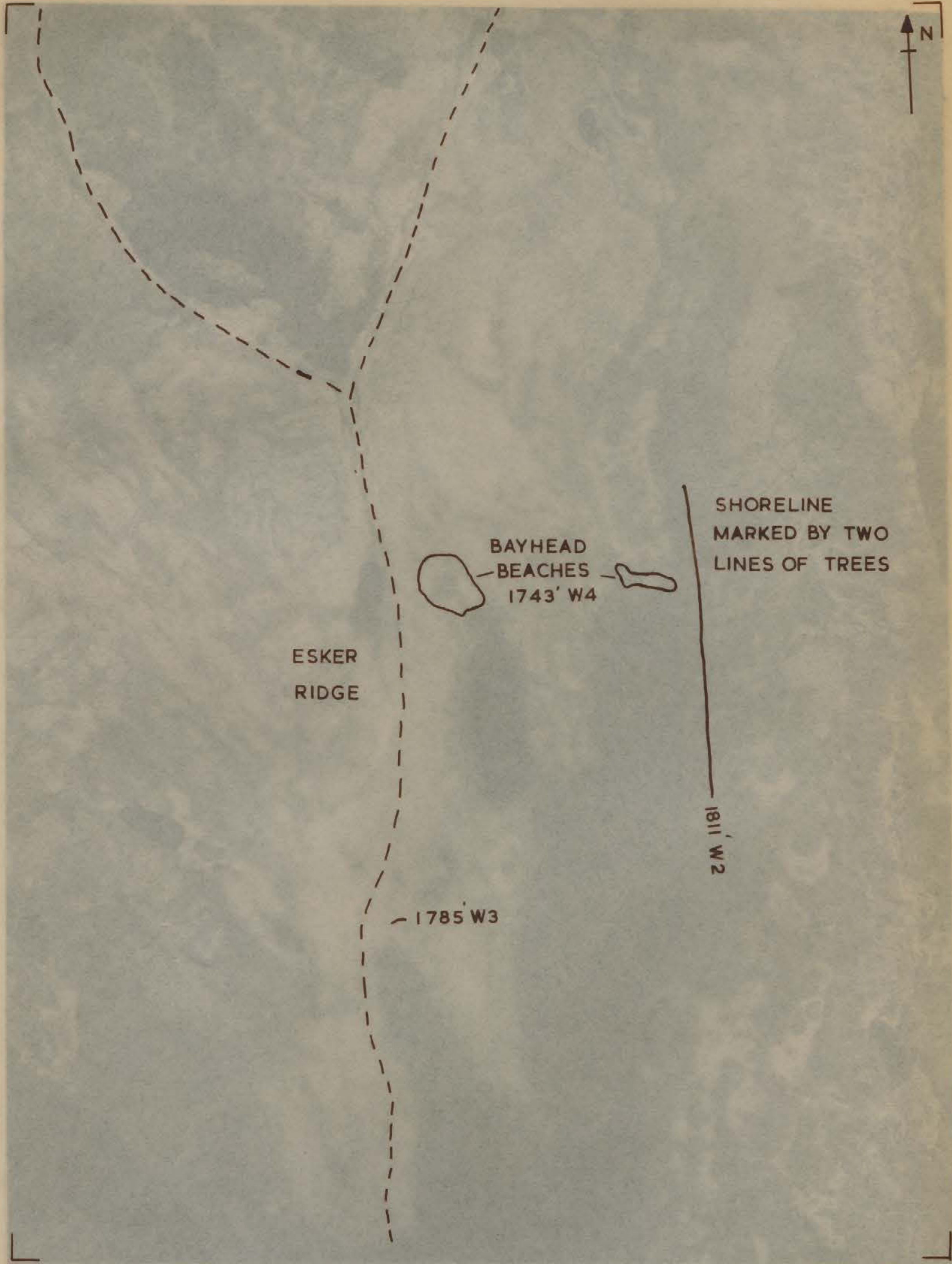
This association of shorelines and fluvioglacial deposits is very similar to that in the Helen River valley and Lorraine 4 area.

NORTHWEST ARM OF SHABOGAMO LAKE (map 8, photo 30)

Both large scale and small scale air photographs show two distinct lines of tall spruce trees crossing the hillside east of the head of the Northwest Arm at right angles to the steepest slope. Between the two lines the spruce trees are shorter and more widely spaced. In places the two lines of trees merge with lines of trees running down the slope but they are still distinguishable by their greater height. Viewed stereoscopically the air photographs reveal that the tree lines mark the inner and outer edge of a narrow shoreline. These photographs were taken in 1949 and 1955. On the ground these tree lines are not so distinct. This is because of the growth of the vegetation since the photographs were taken and because of the low obscured viewing position.

The shoreline is 15 to 40 feet wide and at its northern end has a steep backslope and a less marked foreslope. Both the foreslope and the backslope have a taller denser


DISTRIBUTION
OF
SHORELINE FEATURES
OF THE
WAPUSSAKATOO
GLACIAL LAKES
N
GREGOR
RIVER
HELEN
RIVER
D'AIGLE
BAY
SPIT
BAY
GOETHITE
BAY
JULIENNE
LAKE
SCOTT BAY
NORTHWEST ARM
LORRAINE 4
WABUSH 6
WABUSH
LAKE
CANNING
LAKE
LABRADOR
CITY
SHABOGAMO
LAKE
WABUSH
MT.
LONG LAKE
JEAN
LAKE
FLORA
LAKE
SOUTH
EAST
ARM
W 1 LEVEL
W 2 LEVEL
W 3 LEVEL
W 4 LEVEL
SCALE 2 MILES
MAP 8



NORTHWEST ARM OF SHABOGAMO LAKE

— SHORELINE SCALE 1:35000 PHOTO 30

tree cover than the level shoreline. A trench cut into the shoreline near the backslope revealed a surface layer of rounded and subrounded granitoid gneiss boulders overlying a twelve inch layer of gravel. The gravel is underlain by granitoid gneiss sand. The southern section has a more marked foreslope and a less well developed backslope as indicated by the lack of a distinct upper treeline in this section. The whole shoreline is formed partly by cutting into the surficial hill slope deposits and partly by deposition of the eroded materials on the foreshore. The shoreline has an elevation of 1,811 feet a.s.l.

At the head of the Northwest Arm there is a narrow beach deposit (elevation 1,743 feet a.s.l.) separating the lake from a large string bog. Also in the inlet west of this beach deposit there is a flat topped bay head beach with an elevation of 1,743 feet a.s.l.

On the west side of the Northwest Arm, there is a complex system of esker deposits with anastomosing ridges, kettle holes, outwash deposits and boulder filled gullies. The summits of the ridges are well rounded and show no indication of wave action. At one point only in this esker system was a shoreline-like feature observed. At the head of the first inlet in the Northwest Arm a notch 20 feet wide was seen on the side of an esker ridge at an elevation of 1,785 feet a.s.l. The top of the esker ridge at this point had an elevation of 1,811 feet a.s.l.

SCATTERED SHORELINE FEATURES AROUND SHABOGAMO LAKE (map 8)

Lines of trees similar to those in the Northwest Arm of Shabogamo were found in the Northeast Arm. However, they were not associated with any distinct shoreline features. The ground here is covered with small bogs and the slope of the hillside is very gentle so that any shoreline formed in the area would be indistinct and later obscured by a deep vegetation cover. Minor breaks in slope were seen at approximately 1,810 feet a.s.l. and 1,785 feet a.s.l.

The large tabular peninsula east of the entrance of Shabogamo Lake has steep sides into which are cut two shoreline sections both at an elevation of 1,802 feet a.s.l. The shorelines are 40 to 60 feet wide and covered by moss and lichen covered boulders of granite gneiss 2 to 4 feet in diameter with no fines between the boulders. The back-slope and foreslope of both sections were not well developed.

Two short shorelines of a similar nature to those seen in the Northwest Arm of Shabogamo are found on the drift covered hill overlooking the Southeast Arm. The lower shoreline is best developed and is 10 to 25 feet wide. It has an elevation of 1,770 feet a.s.l. and the shore is covered with subangular and subrounded boulders of ironstone, schist and granitoid gneiss (photo 31) similar in size and shape to boulders on the present day shoreline (photo 32). The higher shoreline forms a small boulder covered notch at an elevation of 1,798 feet a.s.l.

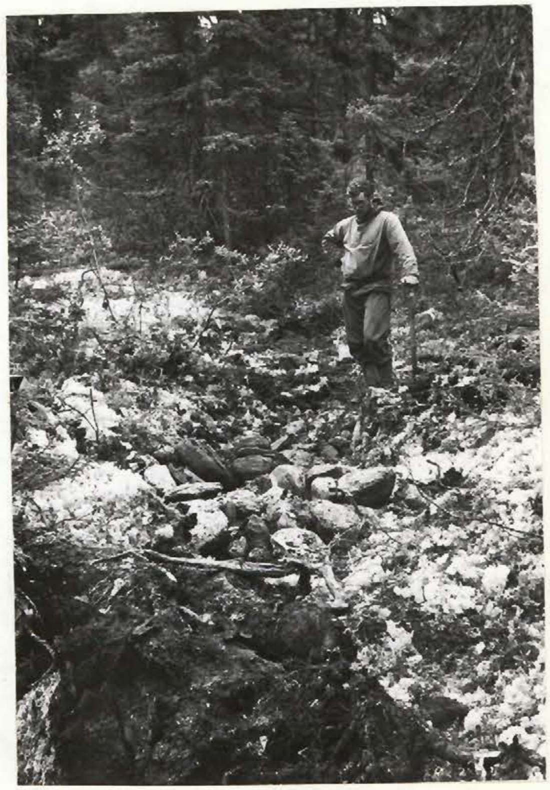


Photo.31.
Shoreline at an elevation of 1770 feet a.s.l. with an irregular covering of boulders, Southeast Arm of Shabogamo Lake.

Photo.32.
Modern shoreline in the Northwest Arm of Shabogamo Lake.

EAST OF FLORA LAKE (map 8)

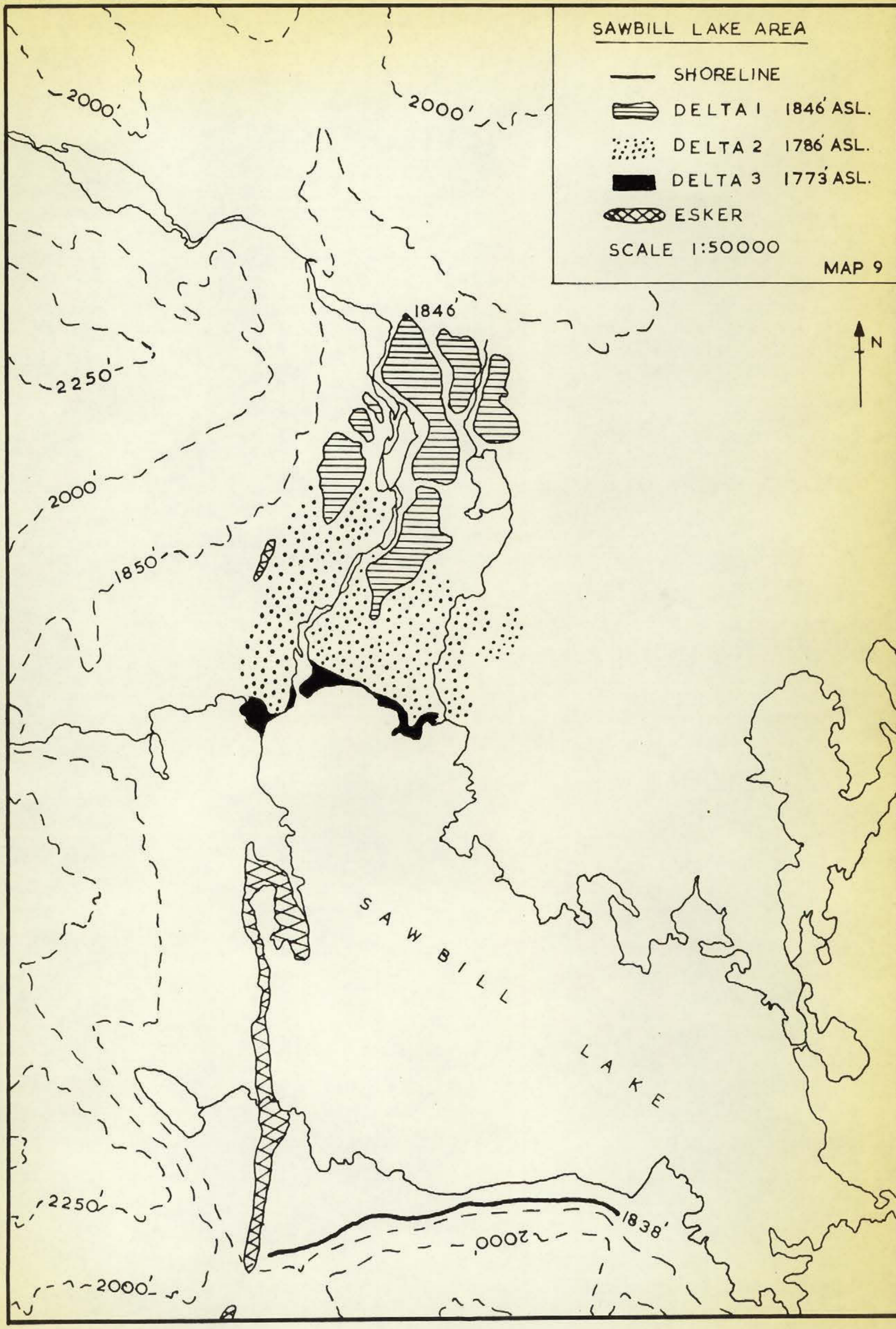
Faint vegetation markings on air photographs of the area east of Flora Lake are similar to those in the Northwest Arm of Shabogamo and in the Sawbill Lake area. These markings may indicate the presence of shoreline features at an elevation of 1,900 to 1,925 feet a.s.l. but this was not verified as no ground check was made.

SAWBILL LAKE AREA (map 9)

Sawbill Lake drains into the Northeast Arm of Shabogamo Lake by way of Steers Lake and two narrow stretches of rapids. Steers Lake lies above the 1,750 foot contour and it is estimated that Sawbill Lake lay at an elevation of 1,770 feet a.s.l. during the period of time spent in this area.

A large river drains into the northwest corner of Sawbill Lake and in this river's lower valley large deltaic deposits are found. Indications of abandoned lake shorelines were found on the steep drift covered slopes on the southeast shore of the lake.

At the southeast corner of the lake where an irregular promontory juts out into the lake an 800 foot long shoreline occurs at an elevation of 1,838 feet a.s.l. The bench is 30 to 50 feet wide, and the rear part of which is covered with lichen and moss covered boulders 1 to 4 feet in diameter.



SAWBILL LAKE AREA
SHORELINE
DELTA 1 1846' ASL.
DELTA 2 1786' ASL.
DELTA 3 1773' ASL.
ESKER
SCALE 1:50000
MAP 9
N
2000'
2000'
1846'
2250'
2000'
1850'
1850'
SAWBILL LAKE
2250'
1838'
2000
2000'

Further to the west this shoreline becomes less well developed but here again the position of the shoreline is marked by lines of tall spruce trees crossing the other vegetation patterns. These tree lines are more noticeable along the western section of the shoreline for here the surrounding vegetation is open lichen woodland. In this western section a detailed examination of the photographs revealed a line of closely spaced tall spruce trees forming the front and back of the band of trees. In between these two lines the trees are wider spaced and shorter. This is similar to the tree line pattern in the Northwest Arm of Shabogamo Lake.

On the ground no marked shoreline forms were seen in this western section but the shoreline became increasingly more distinct towards the east.

A narrow esker with associated lateral sand and gravel deposits and kettle holes lies along the western side of the lake and rises up to the col leading to Pegrum Lake. The col is free of esker deposits but the esker ridge reforms just south of the col. No shoreline features are cut into the sides of the esker and the summit is well rounded. A small esker ridge lies just to the west of the deltaic deposits.

The deltaic deposits have a typical delta outline with a base 1 1/2 miles long and a length of 2 1/4 miles from apex to base. The deltaic deposits are distinguished on the air photographs by their light tone due to the covering of Cladonia lichen and the very sparse tree cover.

Three distinct levels are seen in the deltaic deposits especially on the east side of the river.

The upper surface of the delta is severely dissected especially to the west of the river but it has an elevation of 1,846 feet a.s.l. at its southern extremities. The southern part of the delta forms a narrow ridge whose sides are free of vegetation and subject to periglacial activity indicated by the presence of small stone polygons and stone stripes. The material forming this narrow ridge is a coarse moderately well sorted sand (Fig. 3, graph 1) with few intercalated pebbles.

A wide flat shoreline at an elevation of 1,786 feet a.s.l. cuts back into the southern face of the delta. The shoreline is very smooth with no surface boulder cover and is crossed only by wide shallow depressions. Sections through this shoreline in the river bank reveal a moderately well sorted coarse sand with some intercalated rounded and subrounded granitoid gneiss pebbles 1 to 4 inches in diameter (Fig. 4, graph 2).

The lowest level is marked by a shoreline which cuts into the outer edge of the 1,786 foot a.s.l. shoreline. This lowest shoreline is only 3 feet above the lake level and is formed of very well sorted sand (Fig. 2, graph 3). Small ridges on this lower shoreline may represent old storm beaches or ice push features. These ridges are close to the modern beach where the vegetation is thin and scattered.

The valley northwest of the delta leads into a wide open valley containing a large southeasterly flowing esker and irregular fluvioglacial deposits. The extent of these deposits and the size of the deltaic deposits indicate that this river valley was a main drainage line during deglacierization. The esker running up to the col leading to Pegrum Lake must have been formed subglacially and under hydrostatic pressure for it to have risen from 1,770 to 1,875 feet a.s.l. The small esker ridge to the west of the delta is probably a continuation of this ridge, the rest of the ridge having been destroyed during the formation of the delta.

The upper delta surface indicates the presence of a former lake at 1,846 feet a.s.l. which maintained this level for a considerable period of time in order to allow the deposition of such large quantities of sand. The shorelines cut into the delta and the shoreline southeast of the lake indicate lake levels higher than the present lake level.

THE WAPUSSAKATOO GLACIAL LAKES

The above described abandoned lake shoreline features indicate the presence of glacial lakes at four distinct levels. It will be demonstrated in the next chapter that only one large lake formed at each level. These four glacial lakes have been named the Wapussakatoo Glacial Lakes, the name being derived from the local Indian name for the high range of hills and mountains which overlook the area formerly covered by the glacial lakes. The four lake stages are herein named Wapussakatoo 1, 2, 3 and 4. Wapussakatoo 1 (abbreviated to W1) is the highest and Wapussakatoo 4 (abbreviated to W4) is the lowest. Map 8 shows the distribution of the shoreline features marking the extent of these four glacial lakes.

CHAPTER 4

ELEVATION AND TILT OF THE ABANDONED LAKE SHORELINES

In this chapter the elevations of the previously described shorelines are correlated and this correlation yields evidence of the distribution and character of the glacial lakes. The tilts of the glacial lake shorelines are calculated and these together with geophysical evidence from other areas in Labrador-Ungava indicate the position of a centre of ice dispersal of the Laurentide Ice Sheet in late Wisconsin times. The position of this ice dispersal centre is compared with the positions of other ice centres indicated by glacial geomorphological features.

The fact that the abandoned glacial lake shorelines of Southwest Labrador are not horizontal was first mentioned by Henderson (1959, pages 39-40) who studied some of the shorelines around Julienne Lake and Wabush Lake and calculated their tilt. This study will be quoted in full as it is the most recent work on the shorelines of this area and it provides in part the foundation for the present study.

> Wabush and Julienne Lakes are located 25 miles west of the outlet of Ashuanipi Lake. They are connected by a narrows, stand at the same altitude, and drain north into Shabogamo Lake. Strong terraces have been formed along the steeper west and north-west facing parts of the shores. The highest terrace

above Julienne Lake (Goethite Bay)* is 87 feet above the present water surface and where best developed is over 50 feet wide and backed by a 25 foot shore cliff largely cut in rock. This terrace may have originated contemporaneously with a bar top 2 miles to the west on the opposite shore (Spit Bay)* that stands 96 feet above Julienne Lake. The top of this bar probably represents the annual high-water level of the earlier phase of the lake. If this is so, and since the base of a rock shore cliff can be cut well below average water level, the average height of the former lake surface was about 90 feet above the present level of Julienne Lake. A weaker but nevertheless well developed terrace was cut in drift at 53 feet (W3)* and a third terrace at 12 feet above the lake (W4)*. Fifteen miles S23°W on the south end of Wabush Lake there are two terraces on the steep western slope of a prominent hill (Wabush Mountain)*. The strongest terrace, 140 feet wide, is 82 feet above Wabush Lake, the second is 41 1/2 feet above the lake. These terraces were formed by the same water-planes that cut the two highest terraces on Julienne Lake, and may be traced at intermediary points where less prominent terraces are present. A tilt of about 10 inches to the mile on the terrace surfaces in the direction N23°E is indicated by the terrace elevations. As the ice retreated somewhat to the west of north the actual tilt may be nearer twice that figure. The 12-foot terrace measured on Julienne Lake was not seen on Wabush Lake; it probably dips below the water-line towards its southern end. The topmost terrace with its rock shore cliff and broad wave-built outer platform must have taken a long time to form, perhaps more than a century; the lower terraces represent much shorter standstills of the water.

Henderson assumes that the two prominent higher shorelines in Goethite Bay were formed by the same water-planes that cut the two lowest shorelines on Wabush Mountain. It is necessary to correlate the isolated shoreline features because there are no continuous shoreline features upon which tilt can be adequately measured.

If the positions of breaks of slope between the outer edge of the bench and foreslope which represent abandoned lake shorelines and former lake levels are plotted on a graph, on which the vertical axis represents elevation and the horizontal axis

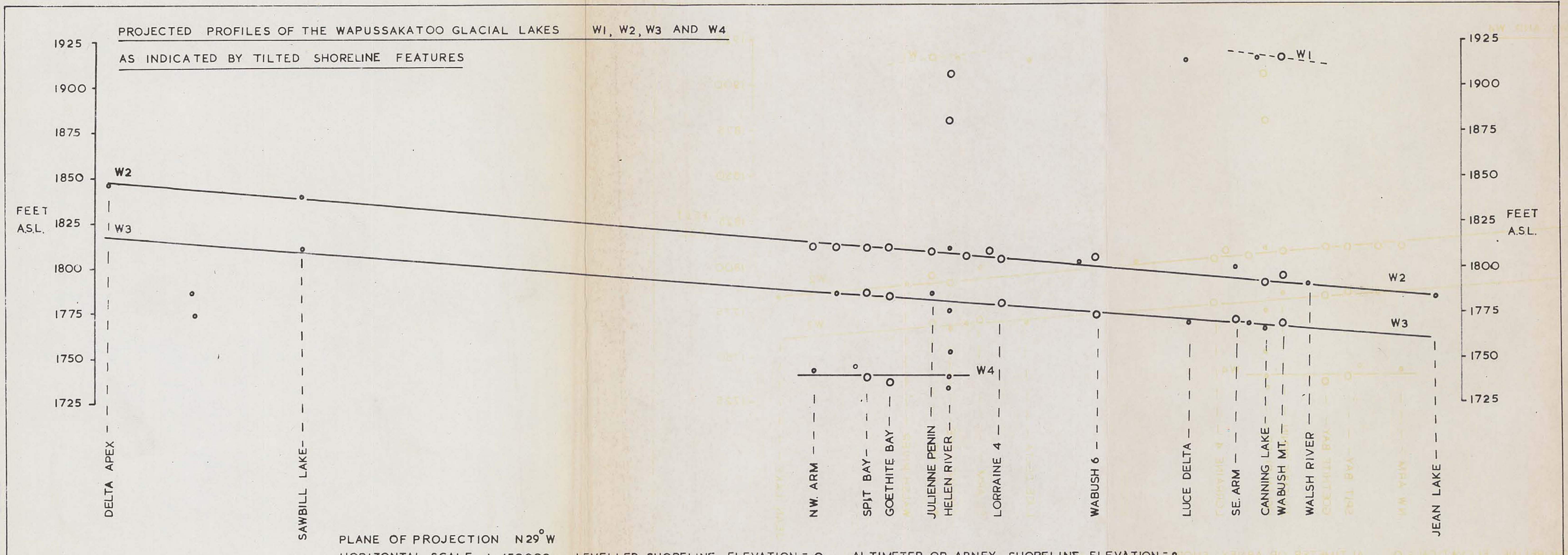
---

* Words in brackets inserted by author.

represents horizontal distance, it will be seen that the shoreline features lie along four distinct planes. These planes represent the four Wapussakatoo Glacial Lakes W1, W2, W3 and W4 (Fig. 5). If the shoreline features were formed around the shores of a series of small ice marginal lakes a more irregular distribution of these features would have resulted.

Besides this graphical evidence, ground evidence indicates that the two intermediate levels of shoreline features were formed not along the edges of a series of small ice marginal lakes but around only two large glacial lakes. The W2 level is well developed throughout Southwest Labrador. Its shoreline features are the widest of all four levels and wave cut shorelines in solid rock are found in several localities. This W2 level is nearly always associated with lower not too well developed shoreline features at the W3 level. If the shoreline features at the W2 level had been formed by a series of small ice marginal lakes one would expect to find a greater variation in width of the shoreline features and some ground indications of the outlets of these small marginal lakes in the form of ice marginal channels. No such channels were found. The close association of the W3 level with the W2 level also indicates the presence of a single large lake at this level.

Ground evidence to indicate that the shoreline features at level W1 and W4 were formed by only two water-planes and not by a series of small ice marginal lakes is very limited. Only one section of wave cut shoreline occurs at the W1 level and this suggests that the glacial lake at this stage was very limited in extent. The extent


PROJECTED PROFILES OF THE WAPUSSAKATOO GLACIAL LAKES W1, W2, W3 AND W4
AS INDICATED BY TILTED SHORELINE FEATURES
FEET A.S.L.
1925
1900
1875
1850
1825
1800
1775
1750
1725
W1
W2
W3
W4
DELTA APEX
SAWBILL LAKE
NW. ARM
SPIT BAY
GOETHITE BAY
JULIENNE PENIN
HELEN RIVER
LORRAINE 4
WABUSH 6
LUCE DELTA
SE. ARM
CANNING LAKE
WABUSH MT.
WALSH RIVER
JEAN LAKE
PLANE OF PROJECTION N29°W
HORIZONTAL SCALE 1 : 150,000
LEVELLED SHORELINE ELEVATION = O
ALTIMETER OR ABNEY SHORELINE ELEVATION = o
FIG 5

of the shoreline features at the W4 stage is limited and seems to indicate only a small lake yet this can hardly be the case as it lies below the W2 and W3 levels which are much more extensive and the topography of the area is not sufficient to restrict the extent of this lowest level by any considerable amount.

On the basis of the above evidence it is considered justifiable to state that a single water-plane formed the shoreline features at each of the four lake levels and that it is possible to calculate the tilt of these former glacial lake levels by comparing the elevations of the shoreline features which occur at each lake level.

Henderson's elevations for the shoreline features at Goethite Bay and on Wabush Mountain are higher than those of the present writer's but the difference in elevation of the shorelines between the two areas is very small. These differences are probably due to the difficulties in delimiting the shoreline features and the height of the lake surface at the time of the observations.

Henderson's tilt value was only an apparent tilt value based on a straight line graph (Henderson, 1959, fig. 4) joining the two distant groups of shoreline features, that is, those in Julienne Lake and those at the southern end of Wabush Lake. He assumed that all intermediate shoreline features lay on this straight line but in fact all intermediate points lie west of this line. Only if all shoreline elevations occurring on one water plane are compared can the true shoreline tilt be calculated. Henderson suggests that the tilt shown by his graph is probably only half the true value, this was found to be correct. Henderson does not, however, measure the tilt on both shoreline levels and give a direction for the true tilt or maximum tilt.

CALCULATION OF THE TILT OF THE SHORELINES OF GLACIAL LAKES WAPUSSAKATOO 2 AND 3

Only at the W2 and W3 glacial lake levels are shoreline features sufficiently widespread and well developed to allow the calculation of shoreline tilt.

The tilt was calculated from eight points on the W3 level and from 12 points on the W2 level. The elevation of these points on the shorelines were measured to the nearest whole foot using level and staff and all refer to the break in slope between the outer edge of the bench and foreslope.

The former glacial lakes had plane horizontal surfaces and it is assumed that within the field area the tilted surfaces depicted by the abandoned lake shoreline features are plane surfaces but not horizontal surfaces.

The direction and amount of maximum tilt was calculated by using every suitable combination of three points on each lake level. This method has been used by Løken (1961) in Northernmost Labrador and much earlier by G. K. Gilbert in the Great Lakes area (Gilbert, 1898).

Points forming very small and acute triangles were not used in order to eliminate the error caused by the construction of the triangles. The distribution of the abandoned lake shoreline features around the long north-south extending Wabush and Julienne Lakes limited the number of large well conditioned triangles, especially at the W2 level. In the case of the lower W3 stage the shoreline feature in the Southeast Arm of Shabogamo Lake made it possible to draw a larger proportion of well conditioned triangles at this stage than at the W2 stage.

Fifty four triangles were constructed for the W2 stage giving a mean direction of maximum tilt of 331° (geographical bearing) and an amount of tilt of 1.84 feet per mile.

Only seventeen triangles were constructed for the W3 stage but these were well conditioned triangles and gave a mean direction of maximum tilt of 333° and an amount of tilt of 1.43 feet per mile.

The mean deviation for the values of direction and amount of maximum tilt at the W2 stage are 17° and 0.49 feet per mile and at the W3 stage 3° and 0.29 feet per mile.

A series of 4 projected profiles was constructed from 42 shoreline elevations measured by level and staff, abney level and surveying altimeter (Fig. 5, in pocket). The plane of projection extends from Jean Lake in the south to Sawbill Lake in the north, running in a direction N29°W that is parallel to the mean direction of maximum tilt of the W2 stage.

Two distinct profiles form the tilted planes of the W2 and W3 stage in the Wabush-Shabogamo Lake area. If the projected profile of the W2 stage is extended northwards to the Sawbill Lake area it cuts through two points marking the abandoned lake shoreline which lies at an elevation of 1,838 feet a.s.l. on the southeast shore of Sawbill Lake and the apex of the delta deposits which lie to the northwest of the lake. This relationship between the two northern points and the projected profile in the Wabush-Shabogamo Lake area indicates that the Wapussakatoo Glacial Lake W2 extended as far north as Sawbill Lake.

Similarly if the W3 profile is extended into the Sawbill Lake area it passes just below a point marking a small wave cut bench which lies at an elevation of 1,810 feet a.s.l. on the southeast shore of Sawbill Lake. None of the shorelines cut into the deltaic deposits northwest of Sawbill Lake can be correlated with the W3 projected profile. This minor correlation indicates that the glacial lake forming shoreline features at the W3 stage also extended as far north as Sawbill Lake.

There is only one definite shoreline feature at the W1 stage and that is the wave cut beach at an elevation of 1,915 feet a.s.l. on the western side of Wabush Mountain. The notch at 1,914 feet a.s.l. in the Luce Delta and the summits of the knobs and kettle country west of Labrador City at 1,901 to 1,915 feet a.s.l. probably indicate the extent of glacial lake W1 but do not accurately portray the elevation of the water surface at this stage. The sand and gravel deposits in the middle Helen River valley, at an elevation of 1,806 feet a.s.l. may indicate a wider extent of the

W1 glacial lake but as there is no associated shoreline feature, the elevation of these deposits cannot be used in the calculation of tilt.

It would be expected that the factors controlling tilt would not have changed rapidly during the period of formation of the Wapussakatoo Glacial Lakes and that the tilt of the W1 stage would have been in the same direction as the tilt of the W2 and W3 stage. If the higher points on fig. 5 are joined a tilt to the southeast is seen but this is not valid because these points do not accurately depict the W1 water surface.

There is also only one definite wave cut shoreline at the W4 stage. This is Henderson's 12 foot shoreline in Goethite Bay which has an elevation of 1,733 to 1,736 feet a.s.l. at the outer edge of the bench and an elevation of 1,740 feet a.s.l. at the base of the backslope. The other features occurring approximately at this same elevation are the bayhead beaches at the head of Spit Bay and two bays in the North-west Arm of Shabogamo Lake which have elevations of 1,739 and 1,743 feet a.s.l., respectively. Terraces occur along the lower Helen River valley at 1,733 and 1,738 feet a.s.l. and at the mouth of the Gregor River at an elevation of 1,745 feet a.s.l.

The bayhead beaches were formed slightly above the general level of the former lake surface because they lie at the heads of long narrow bays in which storm waves would have carried beach material above the general lake level. The river terraces will grade down to the former lake surface and therefore their elevations will be slightly higher than the actual elevation of the former lake surface. The shoreline features in Goethite Bay are very narrow and the base of the backslope as discussed above marks the position of the former lake surface.

From this scanty and varied evidence it is considered probable that the W4 glacial lake had an elevation of 1,739 to 1,741 feet a.s.l. and that its shoreline features were not subjected to tilting. Henderson assumes a tilt on this shoreline, stating that it probably dips below the waterline towards the southern end of Julienne Lake. His evidence for this is the lack of shoreline features at the W4 level around Wabush Lake. However, Henderson on his graph (Henderson, 1959, fig. 4) does not show the W4 shoreline dipping below the water surface. In fact he gives the W4 shoreline the same apparent tilt as to the two higher shorelines (W2 and W3) that is 10 inches per mile. This assumed tilt of the W4 shoreline is not considered justified in the light of present evidence.

If the W4 shoreline is horizontal and does not dip below the water surface then all shoreline features at this level have been destroyed or did not form in the first place in the Wabush Lake area south of the Helen River valley. The western side of Wabush Lake and parts of the east side are very steep and in places formed of bare rock and therefore unsuitable for the formation and preservation of shoreline features at levels just above the present lake surface. The esker system at the southern end of Wabush Lake shows a lack of any substantial shoreline features at all levels because of its unconsolidated nature which makes the esker suitable for both shoreline formation and for subsequent destruction of the shoreline by subaerial processes.

THE SIGNIFICANCE OF THE TILT OF THE ABANDONED LAKE SHORELINES

The position of abandoned lake shorelines above the present lake level can be explained by the draining of the lakes which formed these shorelines, as a result of the removal of the barriers damming the lakes. The tilt of former glacial lake shorelines must be due to crustal movement after their formation because the original shorelines being formed by wave action of glacial lakes would have been horizontal.

Movement of the earth's crust in areas which have been formerly glacierized is largely the result of isostatic readjustment consequent upon the removal of the ice load. A large ice mass 300 miles in diameter and 3,300 feet thick (Daly, 1938) placed on the earth's crust affects it in two ways, by elastic compression and by plastic deformation. The elastic compression and elastic recovery takes place immediately on increasing or decreasing the load whilst plastic deformation and reformation takes much longer than the time taken to change the load. The time lag between the removal of the ice load and the plastic reformation permits the glacial lake shorelines formed at this time to register some but not all of the isostatic readjustment. It is generally accepted that the amount of crustal adjustment is equal to approximately one third of the thickness of the ice sheet that covered the area (Flint, 1957).

The abandoned glacial lake shorelines in Southwest Labrador are tilted, they lie in an area which has been recently glacierized and in an area of Pre Cambrian rocks which are tectonically very stable. The tilt of the Wapussakatoo Lakes W2 and

W3 shoreline features indicates the presence of unequal glacial isostatic recovery within the area.

As soon as the Laurentide Ice Cap began to thin, the crust began to rise but actual shrinkage of the ice margin had to take place permitting the Wapussakatoo Glacial Lakes to occupy part of Southwest Labrador formerly covered by ice, before shoreline formation could start. Hence some recovery of the crust must have occurred before even the earliest shoreline (W1) had formed and the tilt of the shorelines indicates only that isostatic recovery occurring after the formation of the glacial lakes.

Lines of equal isostatic recovery, that is isobases, occur at right angles to the mean direction of maximum tilt for both the W2 and W3 shorelines. The isobases have a geographic bearing of 241° on the W2 surface and 243° on the W3 surface. The amount of isostatic recovery increases to N29°W at a rate of 1.84 feet per mile in the case of the W2 surface and to N27°W at a rate of 1.43 feet per mile in the case of the W3 surface. The smaller amount of isostatic recovery indicated by shoreline features at the W3 stage is because of the later formation of these shoreline features and the decreasing rate of isostatic recovery. The lack of any tilt at the W4 level indicates either that isostatic recovery was completed or that it was uniform throughout the area or else too small a value to be detected by surveying methods used.

The total amount of isostatic recovery occurring within Southwest Labrador since the glacial lake shorelines were formed cannot be calculated because the measurement of tilt was not made from a fixed datum but from the level of the Wabush-Shabogamo Lake system which is also subject to isostatic recovery. The only value that can be given to the isostatic recovery of Southwest Labrador is that it is in excess of 63 feet. This amount is the difference in elevation between the two ends of the W2 shoreline profile.

The isostatic recovery increases in amount in the direction N29°W to N27°W and therefore it was in that direction that the Laurentide Ice Sheet was thickest in late Wisconsin times.

Løken (1961) who studied the deglaciation and postglacial emergence of Northernmost Labrador states that the marine strandlines have their maximum slope towards the centre of the last continental ice sheet and that the strandlines are deformed in a direction perpendicular to the isobases. The directions of maximum tilt of the two strandlines in this area are S24°W and S29°W and the amounts of tilt are 5.3 feet per mile and 3.2 feet per mile respectively.

Barnett (1963) who studied the abandoned glacial lake shorelines in the Indian House Lake area calculated the direction of maximum tilt of the Naskaupi 2 shoreline as S44.6°W and the amount of tilt of this shoreline as 2.31 feet per mile.

If rays representing direction of maximum tilt are projected from the centre of these three areas they intersect in a small area lying about a point 54°25' N and 68°15'W.

This small area marks the centre of glacial isostatic recovery of Labrador-Ungava since the formation of the strandlines and the glacial lake shorelines and also marks a centre of ice dispersal of the much reduced Laurentide Ice Sheet in late Wisconsin times. The glacial lake shorelines were formed when the Laurentide Ice Sheet had a radius of 125 miles to 150 miles but because of the time-lag between the removal of the ice load and land recovery the glacial lake shoreline tilt reflects the pattern of ice distribution of a slightly larger ice sheet.

The marine strandlines and glacial lake shorelines were formed at different times and therefore they must reflect the pattern of ice distribution at these different times.

The differences in the amount of tilt between the three areas indicates that the strandlines in Northernmost Labrador were formed first, then the Naskaupi 2 shoreline and finally the shorelines of Southwest Labrador.

More positive evidence of the age of these marine and lacustrine shorelines is given by radiocarbon dates for marine fossils collected by Løken (1961) in Northernmost Labrador and for peat samples collected by Grayson (1956) in Central Labrador-Ungava.

Løken gives the mean age of the two strandlines on which tilts were measured as 9,000 years B.P. ± 200 years.

Grayson (1956) using radiocarbon dates for peat samples collected from a bog in the Ashuanipi valley near Ross Bay, Southwest Labrador estimated that the area was deglacierized before 8,500 years B.P. However, a re-examination of Grayson's data suggests that the area was deglacierized at a later date, at about 7,250 years B.P. In this bog 215 inches of peat and silt were deposited; the age of the peat at 66 inches and 138 inches below the surface of the bog is 3,400 years B.P. ± 600 years and 5,250 years B.P. ± 800 years respectively. Grayson assumes that the rate of deposition of sediments was constant throughout the bog (1 inch in 38 years) and calculates the age of the bog by extrapolation downwards from the known age at 138 inches. The rate of deposition was not constant but decreased towards the surface. The rates of deposition between 138 inches and 66 inches and between 66 inches and the surface were 1 inch in 26 years and 1 inch in 52 years respectively. Difficulties in estimating the age of the lowest sample are caused by the different rates of deposition of peat and silt which occur in the lower layers and the increase in compaction with depth. However, it is most probable that the rate of 1 inch in 26 years gives a better approximation of the rate of deposition of the sediments below 138 inches than the rate of deposition of 1 inch in 52 years or the rate used by Grayson. The extrapolated age of the sediments at 215 inches is therefore 7250 years B.P.

From this evidence it is estimated that the shorelines of Southwest Labrador were formed just before 7,250 years B.P.

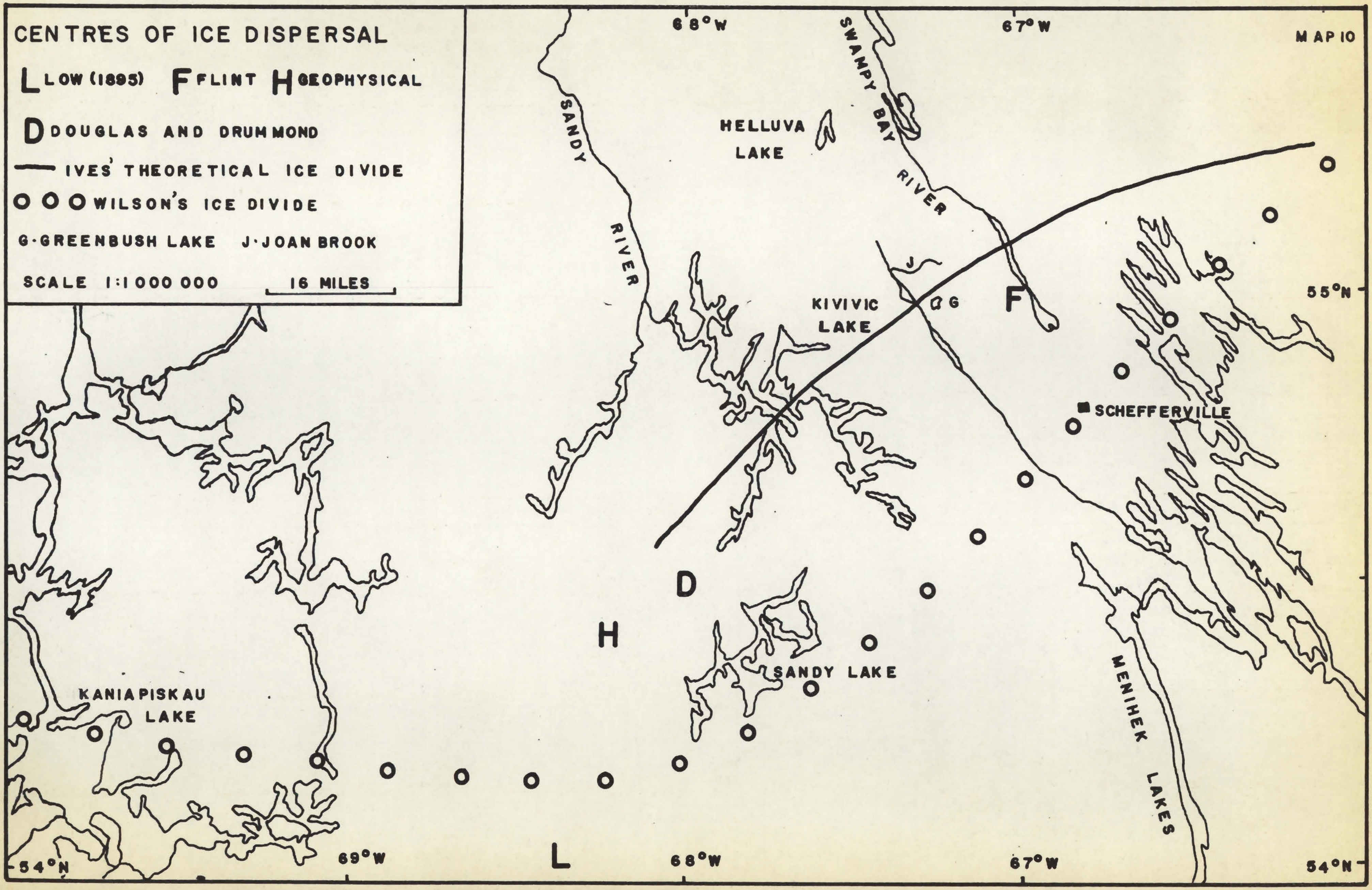
The age of the Naskaupi 2 shoreline is not known to any high degree of accuracy but from the values of shoreline tilt and the dates of the marine and lacustrine shorelines of Northernmost Labrador and Southwest Labrador it is estimated that the Naskaupi 2 shoreline is intermediary in age and was probably formed about 8,500 years B.P.

In spite of the different ages of the marine and lacustrine shorelines the direction of maximum tilt of the shorelines in all three areas is towards the centre of the Labrador-Ungava Peninsula. This suggests that the centre of ice dispersal was relatively stable in late Wisconsin times between approximately 9,000 years B.P. and 7,250 years B.P.

THE RELATIONSHIP BETWEEN THE CENTRE OF ICE DISPERSAL AS INDICATED BY MEASUREMENTS OF ISOSTATIC RECOVERY AND CENTRES OF ICE DISPERSAL AS INDICATED BY GEOMORPHOLOGICAL EVIDENCE (Map 10).

The centre of ice dispersal of the Labradorian remnant of the Laurentide Ice Sheet (54° 25' N and 68° 15' W) between approximately 9,000 B.P. and 7,250 B.P. as indicated by measurements of isostatic recovery in Southwest Labrador, Northernmost Labrador and the Indian House Lake area had a similar location to centres of ice dispersal as indicated by geomorphological evidence.

The geomorphological evidence is very varied and abundant. It indicates a much more complex pattern of ice dispersal than the measurements of isostatic recovery,


CENTRES OF ICE DISPERSAL
L LOW (1895) F FLINT H GEOPHYSICAL
D DOUGLAS AND DRUMMOND
IVES' THEORETICAL ICE DIVIDE
O O O WILSON'S ICE DIVIDE
G·GREENBUSH LAKE J·JOAN BROOK
SCALE 1:1 000 000
16 MILES
MAP 10
68°W
67°W
69°W
55°N
54°N
SANDY RIVER
SWAMPY BAY RIVER
HELLUVA LAKE
KIVIVIC LAKE
J
G
F
D
H
L
SCHEFFERVILLE
SANDY LAKE
KANIAPISKAU LAKE
MENIHEK LAKES

nevertheless some similarities can be seen.

The geomorphological evidence includes the distribution of glacial striations, drumlinoid ridges, eskers and meltwater channels and till fabric orientation. These features formed under different conditions and their age of formation is not definitely known. Presumably they are all features of recent glacierization as those formed by earlier movements would have been obliterated except for a few protected remnants. The patterns of distribution of the geomorphological features are time transgressive but one could say that the eskers and the meltwater channels indicate very late movements and areal extent of the ice sheet and that the drumlins and striations indicate slightly older conditions.

The geomorphological evidence is therefore relatively young and may be compared with the geophysical evidence both in time and space.

The geomorphological evidence has been used not only to indicate the centres of ice dispersal but also the area of final deglacierization. These two may not necessarily have had the same location but evidence suggests that this was the case.

The centre of dispersal of the Labradorian Ice Sheet according to Low (1895) was situated "about midway between the east and west coasts of the (Labrador-Ungava) peninsula and between 53° and 58° N." This conclusion was based on several hundred striae observations and other geomorphological evidence. However as a result of his observations along the east coast of Hudson Bay, Low (1900) found evidence to indicate a migrating centre of ice dispersal. He states:

> three marked sets of striae are found and from these it is seen that the earliest ice flow started from a central gathering ground between the 50th and 51st parallels of north latitude, near the centre of the peninsula. The second set of striae show that the centre of glaciation had moved in a northwest direction to beyond the 54th parallel while the latest set shows a continuation of the northwest movement leaving the centre of dispersion between the 55th and 56th parallels and about 100 miles inland from the east coast of Hudson Bay.

This evidence used by Low to indicate a shifting centre is very scanty (Flint 1951). Low's evidence apparently came solely from the east coast of Hudson Bay yet only five years earlier using twice as many striation measurements and supplementary information he had proposed a central névé. The presence of a shifting centre of ice dispersal in Labrador Ungava has been based mainly on this evidence of Low and theoretical climatic considerations by Flint (1943) and Manley (1955). Geomorphological evidence and botanical evidence strongly suggest a single centre of ice dispersal and deglacierization, although Derbyshire (1962) has proposed a very late shift of 10 miles based on geomorphological evidence.

Flint (1951) uses the pattern of esker distribution displayed in part on the Glacial Map of North America (Flint 1945) as an indicator of the centre of ice dispersal. He states:

> The general arrangement of the eskers is radial with respect to a centre on the height of land in the neighbourhood of 55°N latitude and 67°W longitude. .... It is improbable that long eskers could have formed or could

have been protected against serious modifications by flowing ice before final deglaciation of the region. Hence the eskers on the Quebec-Labrador highland probably record the existence of a very late center of outflow in the region.

This centre is approximately 60 miles northeast of the geophysical centre.

Douglas and Drummond (1953) plotted the distribution of drumlins, glacial furrows and eskers for the whole of Labrador-Ungava and these were incorporated into the Glacial Map of Canada (Wilson et al, 1958). These investigations showed that the centre of ice dispersal or as it was renamed the ice divide was more complex than the previous investigations had shown. However the esker and drumlin distribution showed that there was a marked discontinuity of ice movement about a line running from the northern end of Kaniapiskau Lake to Schefferville. This line lies only twelve miles south of the proposed geophysical centre and four miles north of Low's 1895 centre. It is most probable that the ice divide on the Glacial Map of Canada is more correct than the centre of outflow suggested by Flint.

Later work in the Labrador Trough has shown that the Labradorian remnant of the Laurentide Ice Sheet finally wasted away northwest of Schefferville in the Kivivic Lake (55° N and 67° 20' W) and Swampy Bay River (55° 7' N and 67° 3' W) area. Ives (1959b) mapped the distribution of most of the meltwater channels in Labrador-Ungava and found that most of them generally flowed outwards in all directions from the Kivivic Lake - Swampy Bay River area. This is especially so in the trough area but even outside the trough where relief and surficial geology was not conducive to channel formation no contradictory evidence was found. Ives (1960b) after detailed work around Helluva Lake twenty miles north of Kivivic Lake again concluded that the meltwater channels and also striae indicated that a final ice divide, at the time of the formation of the meltwater channels ran in a direction northeast-southwest through Kivivic Lake. He also suggests on the basis of striae and crag and tail ridge evidence that "the position of one of the final centres of ice dispersal, at a somewhat earlier date, may have approximately coincided" with the final ice divide. If the line representing the theoretical ice divide on Ives' figure 6 (Ives 1960c) is extended fourteen miles to the southwest it passes through the area of intersection of the three sets of rays representing direction of maximum tilt.

Kirby (1961) found that till deposits in the Joan Brook area three miles north of Kivivic Lake had no preferred orientation and suggests very tentatively that this may indicate that the ice here was stagnant and near the area of final disappearance of the ice sheet.

Grayson (1955) using palynological methods and radiocarbon dating concluded that the area around Greenbush Lake which is only three miles southeast of Kivivic Lake was the last area in Labrador-Ungava to be deglacierized.

From the above descriptions there appears to be two groupings of proposed centres of ice dispersal or ice divides yet the two most extreme cases are only eighty-four miles apart. This distance is relatively small when compared with the four hundred and sixty mile shift proposed by Low (1900). This shift proposed by Low presumably occurred throughout the whole of the Wisconsin period and not just in the late Wisconsin period. The first group lies about Sandy Lake (54° 20' N and 67° 50' W) and includes the centres of ice dispersal proposed by Low, Wilson and the author.

The second group lies within the Labrador Trough near Kivivic Lake and includes the centres of ice dispersal proposed by Flint and Ives and the areas of final deglacierization proposed by Ives, Kirby, Grayson and Derbyshire.

Grayson dated the final deglacierization of the Greenbush Lake area at 5600–5750 years B.P. and the age of the centre indicated by measurements of isostatic recovery has been estimated as having been 9000–7250 years old. The final ice divide indicated by meltwater channels formed when the ice was thinner than the surrounding relief must have been older than the final deglacierization, possibly 6500 years B.P. Striae and drift tails indicate that this final divide was stable for a number of years but the exact number is not known.

It is therefore not possible to say that the proposed centre of ice dispersal indicated by measurements of isostatic recovery was older than the centre of ice dispersal over Kivivic Lake, although the evidence of a slight northward shift of the final ice divide indicated by Derbyshire (1962) would suggest this might have been the case. In the extreme case it may be said there was a movement of 50 miles from the first group of centres to the second group of centres in a period of less than 3400 years.

The present scattered distribution of proposed centres of ice dispersal may be due to the inaccuracies in the methods used in delimiting ice centres and also the difficulties in defining an ice centre or ice divide as regards its shape and areal extent. It must be said however that the evidence of the meltwater channels within the Labrador Trough gives an accurate picture of the ice distribution in the ultimate stages of deglacierization but the distribution of the ice sheet and its thickness when its surface was above the surrounding land cannot be evaluated with as much certainty.

Field investigations have been restricted mainly to the Labrador Trough and further work in the area to the west may reveal evidence of an elongated centre of ice dispersal as indicated by Ives (1960c, Map 6) and Wilson et al. (1958).

From this above discussion it can be seen that the study of the tilt of abandoned glacial lake shorelines adds relevant information as regards the location of the centre of ice dispersal of a late Wisconsin remnant of the Laurentide Sheet in Labrador-Ungava. However much more quantitative evidence is required to substantiate these initial findings.*

---

* The direction of maximum tilt of a marine shoreline on Tikkigaksiogak Island, Tasiuyak Bay, on the Labrador coast (57° 15' N and 61° 50' W) is S55°W (personal communication J. T. Andrews 1963). A line representing this maximum tilt if projected southwestwards passes through the position of the geophysical centre of ice dispersal (H, map 10). This tilt was calculated from only two triangles but it nevertheless substantiates the above results.

CHAPTER 5

THE WAPUSSAKATOO GLACIAL LAKES

In this chapter the extent and duration of each lake is discussed because these facts make it possible to draw some conclusions as to the character and distribution of the retreating ice sheet which dammed these glacial lakes.

The nature of the retreating ice sheet and the location of the outlets of the glacial lakes will be discussed separately in the following chapter because the evidence used is different.

GLACIAL LAKE W1

The W1 lake stage had a limited extent. The only distinct shoreline features at this stage are the wave cut benches on the western slope and northern tip of Wabush Mountain at an elevation of 1915 feet a.s.l. The vegetation markings southeast of Flora Lake, the flat summits of the knobs and kettle country, the highest notch in the Luce Delta and the bedded sand and gravel deposit at 1906 feet a.s.l. in the middle Helen River valley are the only other indications of a more extensive W1 lake stage. This latter evidence is far from conclusive for although these features are approximately the same elevation as the wave cut benches on Wabush Mountain, their lithology and forms are different.

If all this evidence is accepted then the W1 lake would have occupied a position marginal to the Wapussakatoo Mountains and extended from D'Aigle Bay southwards to Flora Lake and Quartzite Lake. The whole of Wabush Mountain would have formed an island in this long narrow north-south orientated lake and, therefore, one would expect to find shoreline remnants on all sides of the mountain. Similarly one would have also expected to find shoreline remnants on the high drift-covered headlands along the eastern side of Wabush Lake. No such shoreline remnants were found and it is suggested that the Wabush Lake valley was still occupied by ice at the time of formation of the W1 shoreline on Wabush Mountain.

The positions of the fluvioglacial deposits at approximately the same elevation as the W1 stage are primarily due to the location of the ice margin during this period of deglacierization.

The meltwater channels north of Tanya Lake indicate a downwasting of the ice uncovering the Wapussakatoo Mountains and the high ground to the south. Wabush Mountain would have appeared as a nunatak and it is most probable that a small marginal lake formed between the downwasting ice and the side of Wabush Mountain and cut the shoreline at 1915 feet a.s.l. The width and distinctness of this shoreline indicates that the lake and the ice margin were stable for a relatively long period of time.

The surface deposits covering Wabush Mountain and giving it its smooth drumlinoid shape indicate downwasting and melting of the ice. Several exposures revealed bedded sands and silts which indicate some degree of water deposition.

Thus at the W1 stage there was ice lying on the Lake Plateau but the higher Wapussakatoo Mountains were ice free and the upper limit of the ice lay at about 1915 feet a.s.l. A small marginal lake occurred on the northwest side of Wabush Mountain. The ice was mainly compact but the presence of subglacial meltwater channels and dead ice topography on the west side of Wabush Lake indicate that some of the marginal ice was of an open texture. No evidence was found to indicate the location of the outlet of this lake.

GLACIAL LAKE W2

The shoreline features at the W2 level indicate a much larger and more permanent glacial lake. Indications of this lake stage stretch from the river terraces of the Walsh River valley and the wave built lake terraces of Jean Lake in the south to the lake shorelines and large delta at Sawbill Lake in the north. Further east in the Shabogamo Lake area evidence of the glacial lake W2 is not so well developed. The narrow shorelines in the Northwest and Southeast Arms, the treelines in the Northeast Arm and the boulder beaches in the central part of the Shabogamo Lake area are the only indications of a former higher lake level. This portion of the Lake Plateau is almost entirely covered by glacial debris and has gentle slopes. Shorelines, if ever formed, would not be as noticeable as the marked breaks of slope on steeper hillsides. Subsequent postglacial subaerial weathering would soon mask these shoreline features as would the growth of vegetation. At the present time evidence of postglacial destruction of sandy abandoned shorelines is seen in Goethite Bay and the southern part of Lorraine 4 where mass movement is destroying the very marked break in slope between the foreshore and the foreslope (photo 12). The sandy esker deposits in the Southeast Arm of Shabogamo Lake are at the present time being undercut and destroyed by wave action even when covered by a dense layer of alder shrubs (photo 33).

The majority of the well developed shoreline features at the W2 stage are found on steep west and north facing slopes whilst the remaining shorelines are found cut in fluvioglacial deposits occupying river valleys and small embayments. The sandier shorelines are thus located on the western side of glacial lake W2 on which side all the main river valleys lie, for example, the Walsh River valley, the Helen River valley and the Gregor River valley.

The distribution of the majority of the shoreline features on the north and west slopes may be an indication of the influence of the wind system at the time of the W2 stage. The spit at the W2 level at Lorraine 4 indicates southward longshore movement as a result of northerly wave action. If the dominant winds were from the northwest and north then it would be expected that the shores open to the northwest would have been open to strong wave action and possess well developed shoreline features. Up to a point this is the case, the majority of the well developed shorelines are on north and west-facing slopes, but there are also distinct east facing shorelines cut in

Photo.33.
Erosion of a thickly vegetated esker deposit in the Southeast Arm of Shabogamo Lake.

quartzite bedrock north of Lorraine 4.

There is no relationship between the amount of fetch and the stage of development of the shorelines. The shoreline on the east side of Goethite Bay is cut into bedrock and so also are the shoreline remnants on the Julienne Peninsula although there was only a short fetch of two or three miles to the northwest in W2 times. The shoreline on Wabush Mountain at the southern end of Wabush Lake, however, is only cut in drift and has a limited extent although it was open to a northwesterly fetch of 14 miles.

Within the Goethite Bay area there is a marked variation of character of the north and west facing shorelines which had a similar wave fetch. The southernmost segments (photo 20) cut in drift face due north and are only 20 to 34 feet wide whilst the west and northwest facing shorelines on the bare rocky hill at the W2 level vary from 20 to 150 feet in width and are cut in bedrock. East and northeast of this bare rocky hill lie two ridges which have shoreline features facing north, east and south. These shoreline features vary in width from 20 to 85 feet. No shorelines occur on the west sides of the two ridges, although only the southernmost ridge was protected from wave action by the bare rocky hill which lies to the west. The easterly facing shorelines on these two ridges although not well developed indicate that wave action was not all concentrated on the north and west facing slopes. The fetch onto these easterly facing shorelines would have been about one mile more than the wave fetch affecting the north and west facing shorelines.

From this evidence it is seen that neither direction nor amount of wave fetch has any conclusive effect on the distribution of shorelines. This statement is supported by the lack of shoreline features in areas with ideal conditions of aspect, slope and lithology such as the eastern shore of Scott Bay, the steep irregular east shore of Wabush Lake and the Southwest Arm of Shabogamo Lake.

The lack of shoreline features at the W2 level in some parts of Southwest Labrador appears not to be due entirely to the relief, lithology and aspect but to some other causes. It is suggested that in some areas no lake shoreline features were formed either because the land was not subject to wave action or the wave action that did take place was not prolonged, that is the glacial lake W2 in that area was of short duration. It has been stated before that the ice sheet was downwasting and had uncovered the Wapussakatoo Mountains but still lay on the Lake Plateau. From W1 times the ice on the Lake Plateau downwasted and melted in situ leaving isolated masses of ice on the Lake Plateau about which the glacial lakes formed. The melting of these ice masses would have revealed more land on which wave action could have taken place but there would have been correspondingly less time for shoreline formation as the melting progressed. This melting, however, did not affect the ice barrier holding up the glacial lake and maintaining a constant lake level at the W2 elevation. Thus the shoreline remnants are suggested to be metachronous but the interval between their formation is very small compared with the postglacial period so that it is practical to call them synchronous in connection with the measurement of tilt and isostatic recovery.

Evidence of this downwasting and presence of stagnant ice will be dealt with in connection with the study of the ice barriers holding up the glacial lakes.

From the shoreline evidence and evidence of fluvioglacial deposits it is possible to reconstruct glacial lake W2. This glacial lake spread from Long Lake and Jean Lake in the south northwards over the Lake Plateau east of the Wapussakatoo Mountains covering most of the area now occupied by Shabogamo and Julienne lakes. The glacial lake was interspersed with isolated masses of melting ice.

North of the Northwest Arm of Shabogamo Lake a northern extension of the glacial lake W2 is indicated by the large delta and wave cut shoreline in the Sawbill Lake area. If the profile of the W2 level is projected northwest it intersects the two points marking the foreshore elevation of the shoreline and the apex of the delta (Fig. 5). This is the main evidence indicating the extension of the glacial lake W2. The large size of the delta also indicates a long period of formation and a steady lake level. These are the characteristics of the W2 glacial lake.

No evidence was found to indicate an eastward extension of the lake east of the Northeast Arm of Shabogamo Lake. Low (1895) from his examination of the shorelines around Menihek Lakes postulated that the glacial lakes extended up the Ashuanipi River as far as and possibly beyond the watershed. Low states:

> At the Upper Narrows of the lake (Menihek Lakes)* there are three well marked terraces at 30 feet, 40 feet and 65 feet above the present level with beaches of gravel on them.

---

* Words in these brackets inserted by author.

> These terraces are on drift ridges, with a wide area of country to the south southwest and west that is considerably lower than the height of the lowest terraces and the lake at a level to correspond with the upper terraces would cover the whole country (with the exception of a few ridges) to and perhaps beyond the southern watershed. It must have consequently been at least partly enclosed by an ice barrier.

The present height of Menihek Lakes at the Upper Narrows according to the National Topographic Map sheet 23 S.E. is only 1570 feet a.s.l. and the height of Low's highest shoreline is 1635 feet a.s.l. A lake at this elevation would have extended only as far south as Molson Lake (Map 2) and would have been restricted to the main Ashuanipi valley. The water-shed, however, lies to the south and west of Ashuanipi Lake at an elevation of at least 1740 feet a.s.l.

Low's Menihek Glacial Lakes are much more restricted than he postulated and cannot be linked with the most extensive of the Wapussakatoo Glacial Lakes, the glacial lake W2 but they do indicate a complex system of glacial lakes and deglacierization throughout the area. The whole length of the upper Ashuanipi valley requires a much more detailed survey.

GLACIAL LAKE W3

The shoreline features of the glacial lake W3 are distributed in a similar manner to those at the W2 level except for the absence of shoreline features in the Jean and Long Lake area and the scanty evidence in the Northwest Arm and Northeast Arm of Shabogamo Lake. These shorelines are cut or built out of glacial debris or fluvioglacial material. They are not so distinct or wide as the shorelines at the W2 level and indicate a much shorter period of formation and a shorter standstill of the glacial lake and the ice barrier.

On the southeast shore of Sawbill Lake small remnants of a shoreline at 1810 feet a.s.l. are found and these lie only a few feet above the projected height of the W3 glacial lake. However, there is no corresponding shoreline cut into the delta complex northwest of Sawbill Lake. There is a distinct and well developed shoreline at 1786 feet a.s.l. and it is most probable that wave action of a lake at this elevation cut far into the original delta formed at the W2 stage and destroyed all evidence of the W3 glacial lake.

The glacial lake W3 extended from Canning Lake in the south to Sawbill Lake in the north and the Southeast Arm of Shabogamo Lake in the east. This is essentially the same distribution as for glacial lake W2. The ice sheet must have had a similar distribution as in W2 times, but the ice barrier at the lake outlet must have been lower.

GLACIAL LAKE W4 ?

The extent of glacial lake W4, as indicated by the shoreline features of Julienne Lake and the Northwest Arm of Shabogamo Lake and the terraces in the lower Gregor and Helen River valleys, was very limited. However, this is very improbable as this was the lowest lake stage and the ice barrier if there was one present at all would have withdrawn to its farthest point since the formation of the glacial lakes.

As stated above in the section on the calculation of shoreline tilt the shoreline of glacial lake W4 was either not affected by isostatic recovery or only to a very small degree and that the shoreline features if ever formed were subject to rapid erosion in postglacial times. The poorly developed nature of these shoreline features suggests only a minor standstill of the lake. A short standstill may have been caused by glacial debris blocking the lake outlet, that is the Shabogamo and Ashuanipi Rivers. There are in these river valleys large deposits of outwash sands and gravels, eskers and ripple till which could have formed large barriers across the Shabogamo Lake outlet. The present day Shabogamo River has three sets of large rapids which could have been lowered 10 to 12 feet in postglacial times. It is, therefore, a matter of uncertainty whether in fact the W4 lake which is only poorly delimited was an ice-dammed lake. The extent of this lake would have been very similar to the extent of the present Wabush-Shabogamo Lake system.

GLACIAL LAKES IN THE SAWBILL LAKE AREA

The two distinct shorelines cut into the large delta northwest of Sawbill Lake at elevations of 1786 and 1773 feet a.s.l. and designated delta 2 and delta 3 on map 9 do not correlate with any of the four Wapussakatoo Glacial Lake stages. These shorelines were probably cut by lakes impounded behind the large reticulate esker which lies east of Sawbill Lake. This esker has an elevation of 1830 to 1850 feet a.s.l. The present river draining Sawbill Lake passes through a very narrow gap in this esker. The river above the esker has numerous sets of rapids. The impounded lake at 1786 feet a.s.l., that is 16 feet above the present lake level lay behind this esker ridge and was stable for a considerable period of time in order to cut the wide shoreline in the raised delta northwest of the lake. Subsequent destruction of the esker at the impounded lake outlet caused the lowering of the lake level almost to the present day level. The lowest shoreline which is only three feet above the present lake probably indicates a short standstill caused by minor obstructions in the bed of the outlet river.

ICE RETREAT

The distribution and character of the glacial lakes W1, W2, W3 and W4 indicate a general disintegration of the ice sheet in situ rather than a retreat along a single ice edge. The lakes increased in extent to the northeast indicating the final uncovering of the Wapussakatoo Mountains and the disintegration and melting in situ of the ice sheet on the Lake Plateau. The whole of Southwest Labrador was possibly free of ice by the time glacial lake W4 was formed.

The presence of distinct glacial lakes and their variable duration indicates that the waning of the ice sheet was not regular but that there were still stands of long duration, particularly at the time of formation of glacial lakes W2 and W3.

CHAPTER 6

LAKE OUTLETS AND ICE BARRIERS

The glacial lakes W2 and W3 indicate two periods in which the ice barriers and lake outlets remained stable. The main ice barrier lay to the north and east of the glacial lakes, that is in the broad Ashuanipi valley.

The glacial lakes were impounded behind the ice and extended southwards presumably until restricted by the Atlantic-St. Lawrence watershed. There are, however, no shoreline features to indicate that the glacial lakes extended right up to the watershed.

Earlier workers who noticed the abandoned shoreline features in the Wabush and Julienne Lake areas (Gill, 1937 and Neal, 1951) postulated a southerly lake outlet over the watershed, fifteen miles due south of Wabush Mountain into the Moisie and Ste. Marguerite rivers. The water from these glacial lakes was thought to have assisted in the cutting of the deep Moisie River valley. The Moisie River at the present day has the character of a misfit river (Gleeson, 1956).

However, the lowest cols in the watershed due south of Long Lake and Wahnahnish Lake have an elevation of 1925 to 1950 feet a.s.l. which is even higher than the elevation of the glacial lake W1 if it were assumed that this lake was more extensive than stated above. These cols are 155 feet higher than the projected level of the glacial lake W2.

There are no visible well marked waterworn abandoned lake outlets in the sinuous watershed. Therefore, it was necessary to project the plane of the W2 lake surface southwards until it reached the watershed and to note the points where the height of the watershed was equal to or less than the height of the W2 lake level. Five major points were located, (1) at the col (1740 feet a.s.l.) between the southern extension of De Mille Lake and the northwest arm of Menistouc Lake (1c, map 2), (2) a narrow col between Lac Emerillon and the northeast arm of Menistouc Lake (2c, map 2), (3) a two mile wide swampy col between Ashuanipi Lake and Lac Petite Hermine (3c, map 2), (4) a narrow col between Lac Bau and the southern end of Lac Petite Hermine (4c, map 2), (5) several small cols between Ashuanipi Lake and Lake Opocopa (5c, map 2).

A similar projection of the water plane of W3 reveals only two possible outlets and cols lower than the waterplane. The main one again was the col between De Mille Lake and the northwest arm of Menistouc Lake and the other was the series of small cols between Ashuanipi Lake and Opocopa Lake.

From the shoreline evidence it has been deduced that glacial lakes W2, W3 and W4 extended eastward beyond the low De Mille-Menistouc col but not as far as the Ashuanipi valley. This col would have allowed water to escape across the watershed and no glacial lake with an elevation of more than 1740 a.s.l. could have formed. The height of the W2 lake at this col would have been 1779 feet a.s.l. and that of the W3 lake 1757 feet a.s.l., therefore, there must have been a barrier within the col at least 39 feet high at the W2 lake stage and 17 feet high at the W3 lake stage. No remnants of a rock or glacial debris barrier are visible at present but there is evidence to suggest that the barrier was formed of ice. The cols between the Ashuanipi Lake basin and the basins of Menistouc and Opocopa lakes were probably never used as glacial lake outlets because the main mass of the ice barrier probably lay within this area of lowland.

EVIDENCE INDICATING THE PRESENCE OF ICE MASSES IN THE VICINITY OF THE WATERSHED

Evidence for the presence of stagnant or almost stagnant ice masses on the Lake Plateau and in the vicinity of the watershed takes the form of esker deposits and subglacial meltwater channels. The exact nature of formation of the esker deposits is not known and it is most likely that more than one method of formation is possible. The characteristics of the esker deposits in Southwest Labrador are similar to those of esker deposits of other areas for which methods of formation have been postulated.

ESKERS

The esker deposits in Southwest Labrador consist of single sinuous esker ridges, reticulate esker ridges, triangular shaped braided deposits, outwash deposits and kettle holes. These esker deposits are orientated in a NNW-SSE direction and mainly occupy the broad valleys of the Lake Plateau although small esker ridges occupy the valleys of the Archaean Massif and the Grenville Mountains (overlay 3). No large esker ridge was seen to run across the regional grain of the landscape. There appears to have been a relationship between the sub ice sheet topography and the orientation of the glacial streams which deposited the esker material. This relationship indicates a subglacial mode of formation for the esker ridges.

The esker ridges are often very complex with parallel ridges, transverse ridges, kettle holes and esker troughs partially filled with large well rounded boulders. These features indicate an origin beneath ice which was stagnant or slowly moving ice. If these features were deposited in supra or englacial stream channels the melting of the ice below these elevated channels would have destroyed the complex form of the esker ridges. Similarly if the ice were moving then these intricate forms would have been destroyed.

As some of the esker ridges rise up the regional slope from the Wabush-Shabogamo Lake system to the watershed then some of the glacial streams must have been under hydrostatic pressure.

From the characteristics of the esker deposits it is postulated that they were formed subglacially under thin stagnant or near stagnant ice.

An alternative theory of esker ridge formation put forward by De Geer (1912), the frontal delta theory, may explain the formation of the esker ridges in the areas north of the watershed which were covered by glacial lakes. The essential condition for the origin of the esker ridge according to De Geer's theory was the presence of a glacial lake or sea lying in front of the glacier edge. The overloaded subglacial stream deposited its debris at its mouth. At the recession of the ice, the "esker-deltas" arranged themselves in successive series as a more or less unbroken ridge whose windings conformed with those of the subglacial river. Hanson (1943) also states that there is an association between eskers and proglacial lakes.

> An esker deposited in a lake formed by material from supra, and subglacial streams would ignore slight irregularities of terrain; any change of the lake would result in an outwash type of deposit, hence a break in the esker system; sudden variations of the load of the stream would produce a delta. Thus the main characteristics of an esker system would be satisfied.

Henderson (1959 page 35) partially uses this second theory for the explanation of esker ridges and outwash deposits south of Menihek Lakes. He states:

> The large esker on the east side of Ashuanipi River above Menihek Lakes, and others between Ashuanipi Lake and River and the main watershed to the west are interspersed with long narrow sandplains. These eskers differ from most of the others in the Dyke Lake area in that the formative meltwater streams drained up instead of down the regional slope. This forced their waters to discharge into ponded water in front of the retreating ice-margin. The deltaic sandplains thus laid are connected by long reaches of normal sharp crested esker ridge. The sandplains were formed where the ice-margin retreated slowly and steadily. The sharp-crested ridges represent stretches where belts of ice stagnated and downwasted thus hampering the formation of flat-topped deltaic deposits.

The second theory of esker formation would be adequate to explain the eskers occurring north of the divide but not those on the divide or to the south of it where conditions for glacial lake formation are not very suitable because the direction of drainage is opposite to the direction of ice retreat.

Esker systems occur in the valleys leading up to the watershed, for example the valleys south of Long Lake, Wahnahinsh Lake, Moose Head Lake, Southeast Arm of Shabogamo, Lac Grande Hermine and Ashuanipi Lake. South of the intershed the eskers are best developed on the land between Ashuanipi Lake and Opocopa Lake.

From this study of the eskers of Southwest Labrador and the theories of esker formation it is concluded that thin stagnant ice lay in the watershed area and on the eastern Lake Plateau during late Wisconsin times. The ice in the eastern Lake Plateau area would have formed the main barrier impounding the Wapussakatoo Glacial Lakes W2 and W3. The ice mass in the De Mille-Menistouc col would have formed a smaller sized ice barrier but this would have been the major outlet for the W2 and W3 glacial lakes. The lake water would have drained over or through this ice barrier but would have maintained a constant water level in order to form the distinct shoreline features around the lake edges. Ice remnants would have occurred in the shallow valleys of the Lake Plateau and would account for the sporadic distribution of shoreline features.

FLUVIOGLACIAL MELTWATER CHANNELS

Other features which indicate the presence of masses of stagnant ice on the low cols in the watershed are the fluvioglacial meltwater channels which exist on the southern flanks of the watershed overlooking Menistouc and Opocopa lakes.

At the southern end of the twelve mile long esker ridge which runs from the Southwest Arm of Shabogamo past Michel Lake and Moose Head Lake to the foot of the watershed, there lies a triangular deposit of sand and gravel (Map 2, TD). This triangular deposit has a base length of 3/4 mile and length of 1 1/4 miles from the base to the apex which points northwards. The surface of the deposit is pitted with numerous kettle holes and the intervening ridges form a fine reticulate pattern like the upstanding veins of a leaf. The deposit holds up a small rectangular lake which presently drains northwards through a large steep U-shaped valley.

Southeast of this deposit and the watershed there is a complex system of winding valleys which have the characteristic features of subglacial meltwater channels. This system of valleys is situated just south of the watershed but they start abruptly and have broad deep intakes. The valleys are mainly cut in unconsolidated surficial deposits and have deep U-shaped cross sections in some cases. The valleys have a random interlacing pattern. Some of the valleys have misfit intermittent streams but most of the valleys are dry. There are sections of this old drainage system which do not follow the present regional slope but cut across the modern drainage patterns.

The location of these subglacial meltwater channels indicates the former presence of melting open textured ice over the watershed. The water in the melting ice would have percolated through the ice in cracks and crevasses and formed subglacial streams which would have cut channels in the southern slope of the watershed. Glacial debris would have been redeposited in some areas only to be destroyed again by the wandering subglacial streams. Water which percolated through the ice north of the watershed would have been impounded within the ice and probably would have escaped over some cols onto the southern slopes of the watershed. No distinct water cut cols were visible on the air photographs.

The large triangular deposit north of the watershed indicates the former presence of a stagnant ice mass in the watershed area. The esker ridge indicates a single simple meltwater channel under the ice but the pitted triangular deposit indicates the presence of a very open textured ice mass with a reticulate pattern of crevasses. The spacing between the crevasses would have varied from 75 to 400 feet.

The water which flowed down the simple meltwater channel on reaching the open textured ice would have spread out into all the crevasses and in so doing would have reduced its speed and deposited some of its load. At the final stages of deglacierization the whole crevasse system would have been filled with fluvioglacial material. Whether or not the lake lying south of the triangular deposit occurred at the time of the formation of this deposit is uncertain. It may have been filled by a large ice mass which subsequently melted. There is no indication that the water which deposited the triangular deposit of sand and gravel crossed the watershed but this must have occurred because of the difficulty of explaining a reversal of flow of the water which deposited the esker.

It is most probable that the subglacial meltwater channels and the triangular deposit are roughly contemporaneous features. The ice would have covered the irregular topography of the watershed. The meltwater from the wasting ice would have formed the esker deposits and reticulate deposits in ideal situations north of the watershed in enclosed valleys. The meltwater which flowed over the watershed would have cut the subglacial channels and deposited some of the fluvioglacial material.

These esker deposits and subglacial meltwater channels indicate that thin stagnant wasting ice masses once occurred on the Lake Plateau and in the watershed region and these ice masses provided a sufficient barrier to help impound the glacial lakes.

The main problem is to explain the stable lake conditions at the W2 and W3 lake stages as indicated by the well developed shorelines if the main outlet, that is the col between De Mille Lake and Menistouc Lake was not over solid rock, but over or through an ice barrier thirty-nine feet high. An ice barrier would be more easily destroyed by melting with contact with water as well as by abrasion by waterborne sediments, than a rock outlet. Yet this col must have been the main outlet of the glacial lakes because there are no lower cols to the west and the distribution of the shorelines indicates that the glacial lakes extended as far east as the eastern Shabogamo Lake area.

CHAPTER 7

SUMMARY

CENTRES OF ICE DISPERSAL

The measurement of the elevation of the shorelines of the Wapussakatoo Glacial Lakes and the subsequent calculation of the isostatic recovery of this area in conjunction with similar data from other areas indicated that a centre of isostatic recovery since the formation of the shorelines lay about a point 54° 25' N and 68° 15' W.

This position marks the centre of ice dispersal of the Labradorian remnant of the Laurentide Ice Sheet in late Wisconsin times between 9000 B.P. and 7250 B.P.

The ice sheet had a radius of approximately 125-150 miles when the glacial lakes in Southwest Labrador and the Indian House Lake area were formed but the isostatic recovery indicated by the tilt of the shorelines reflects the thickness of a slightly larger ice sheet because of the time lag between the release of the ice load and the isostatic recovery.

The centre of ice dispersal as indicated by measurements of isostatic recovery was relatively stable and had a similar location to centres of ice dispersal as indicated by striations, eskers, drumlins and meltwater channels. Some geomorphological evidence however exists which possibly indicates a minor shift in the final ice divide.

Finally it must be stated that this centre refers only to the Labradorian remnant of the Laurentide Ice Sheet in late Wisconsin times. Isobase maps of eastern Canada constructed from measurements of the elevations of former marine limits (Cooke, 1930 and Farrand and Gajda, 1962) indicate that a centre of ice dispersal lay over the southeastern part of Hudson Bay in earlier Wisconsin times. This earlier ice centre is also indicated by erratic evidence (Lee, 1959) and geoid measurements by Fischer (1959).

THE DEGLACIERIZATION OF SOUTHWEST LABRADOR

The distribution and character of the various glacial lake shoreline features and associated landforms indicate the general pattern of deglacierization of Southwest Labrador.

The upland areas of the Wapussakatoo Mountains were freed of ice first. This is indicated by the meltwater channels in parallel sequence on the southern slopes of Iron Mountain. Isolated patches of ice would have lingered in the sheltered valleys and supplied the southeasterly flowing streams with the large quantities of glacial debris which now form the sandy shoreline features and deltas of the former glacial lakes.

The ice sheet did not retreat along a single ice edge but downwasted and disintegrated into isolated masses. Away from the margin of the ice sheet however the ice was still active and solid. The fact that the ice disintegrated in situ is indicated by the absence of glacial lake shoreline features in areas which would have had ideal conditions for their formation. The lack of shorelines cannot be solely due to post-glacial destruction. The presence of ice within these areas would not have allowed shorelines to form and the abundance of fluvioglacial material within the northwest-southeast valleys on the Lake Plateau indicates that this was the case.

Map 11 shows the approximate location of the solid ice at the various lake stages but to the west of the solid ice isolated masses of stagnant ice occurred but their exact position is difficult to locate.

The ice sheet "retreated" in a northeasterly direction and accounts for the extension of the glacial lakes in this direction.

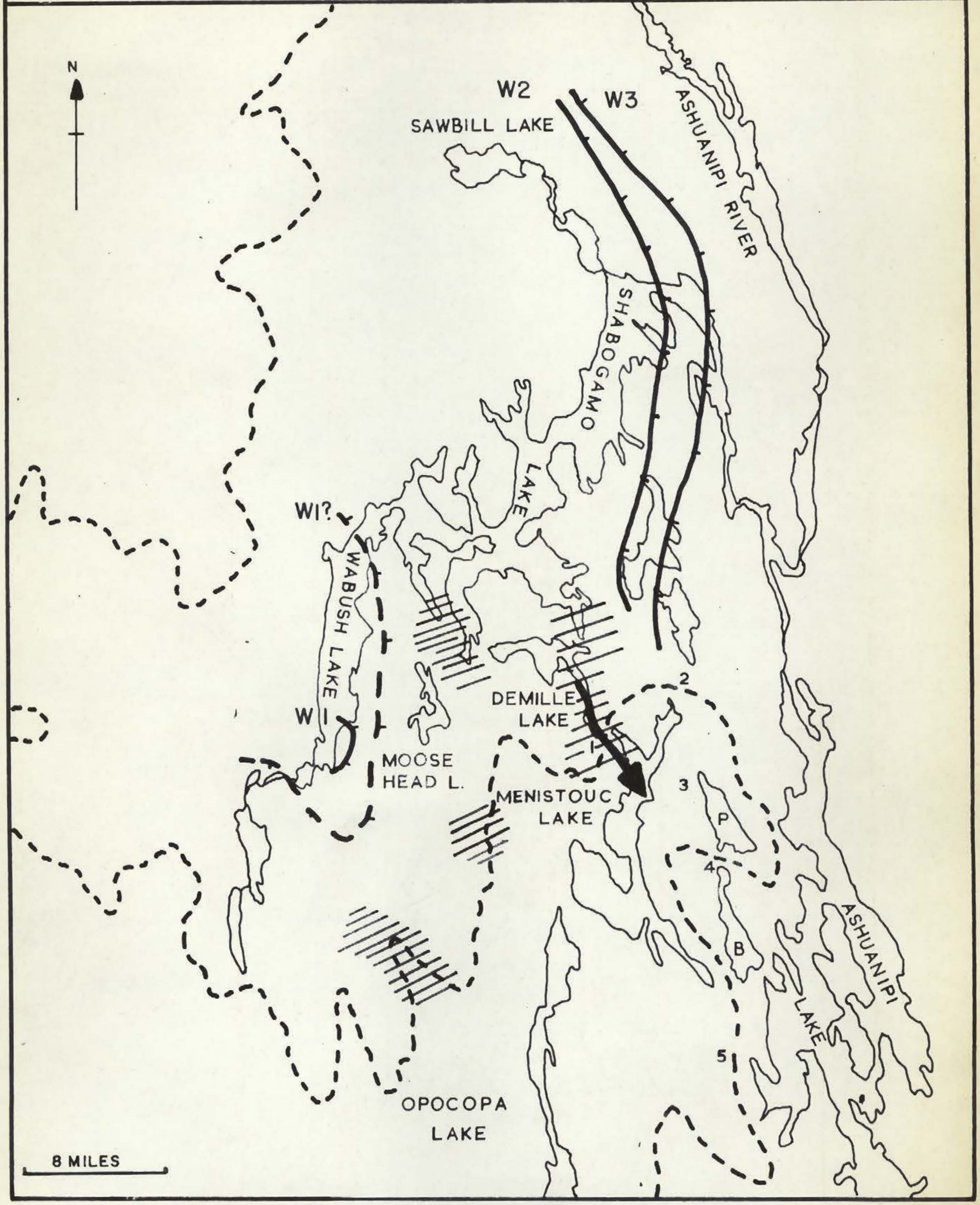
A small lake (W1) formed adjacent to the prominent Wabush Mountain and Wapussakatoo Mountains as the surface of the ice was lowered. The western Lake Plateau then became free of ice except for small ice masses which remained in some of the valleys and in the cols of the watershed. The ice in the Ashuanipi valley was still solid and active and formed the main barrier to the northeast of the Wapussakatoo Glacial Lakes W2 and W3. Glacial lake W2 would have formed first on the western Lake Plateau and extended east and northeast as the small stagnant ice masses melted

THE LOCATION OF THE ICE MARGIN AT THE W1, W2 AND W3 LAKE STAGES

ICE MARGIN — LAKE OUTLET — ISOLATED ICE MASS — SCALE = 1 :506880

NUMBERS REPRESENT COLS IN WATERSHED, P : LAC PETITE-HERMINE B : LAC BAU

MAP II



away revealing more land surface. This lake was drained over an ice barrier in the De Mille-Menistouc col. This ice barrier was stable for two relatively long periods of time and allowed shorelines to form at the W2 and W3 lake levels.

The active ice in the Ashuanipi valley retreated downstream leaving behind an ever increasing fringe of stagnant ice and associated fluvioglacial material. The ice barrier in the De Mille-Menistouc col melted and glacial lakes W2 and W3 were drained. "Glacial" lake W4 formed for a short period of time until the last ice remnants melted away or the debris barrier was breached.

The retreat of the ice down the Ashuanipi valley towards the Menihek Lakes would have opened the normal drainage system in Southwest Labrador but there would still have been some impounding of water by the ice in the Menihek area, resulting in the formation of the Menihek Glacial Lakes.

FUTURE RESEARCH

It has been shown that the study of abandoned glacial lake shorelines provides a useful tool in the investigation of the glacial history of a particular area.

Abandoned glacial lake shorelines are mentioned frequently in the literature of Labrador-Ungava. John McLean of the Hudson Bay Company in 1837 described features in the George River valley cut by waves and tides and these were further described by Prichard (1911) as shorelines of glacial lakes. Government geologist

Low (1895) on his extended traverses across the peninsula found numerous abandoned lake shorelines in the middle reaches of the peninsula's largest river valleys. He describes shorelines lying 20 feet and 35 feet above Lake Michikamau, an esker in Birch Lake notched by eight lake terraces between 20 feet and 60 feet above present lake level and shoreline features around the Menihek Lakes between 10 feet and 65 feet above present lake level. Low also mentions lake terraces in the Kaniapiskau and Koksoak River valleys.

Continued geological exploration in central Labrador-Ungava led to the finding and brief description of numerous abandoned lake shorelines. Slipp (1952) found gravel beaches 50 feet above Petitsikapau Lake. Usher (1953) describes four gravel beaches and terraces around Astray Lake. Bérard (1962) describes high alluvial terraces around Manicouagan and Mushalagan Lakes south of the watershed. Indications of abandoned lake shorelines were found 25 miles south of Cape Wolstenholme by Matthews (1962). Drummond (personal communication 1963) has located lake terraces 600 to 700 feet above sea level around Cambrian Lake, New Quebec and Morrison (personal communication 1963) has found small remnants of shoreline features in the Twin Falls area, Labrador which possibly indicate the extent of former lakes.

Only recently however has any detailed study been made of abandoned lake shorelines and this work has been concentrated in the George River valley, New Quebec (Ives 1960a, Matthew 1961 and Barnett, 1963).

The study of abandoned lake shorelines although plentiful has been so neglected as to give rise to the following statement by Farrand and Gajda (1962).

> Furthermore, some areas (of Canada)* were never affected by marine transgression nor contained glacial lakes, such as western interior of Canada and the centre of the Labrador-Ungava peninsula.

Studies of the shorelines and associated landforms within the above mentioned areas would provide further information as to the pattern of ice retreat and possibly isostatic recovery.

A study of the complex system of glacial lakes in the Menihek Lakes, Astray Lake and upper Hamilton River area would provide a link between the present area of study and the much frequented ice divide northwest of Schefferville.

Measurements of isostatic recovery have been restricted to the east and north-east parts of the peninsula. Further research is essential in the western part of the peninsula in order to provide a more complete pattern of deglacierization and isostatic recovery.

---

* Words in brackets inserted by author.

BIBLIOGRAPHY

Almond, P.
1953 : Julienne Lake – North Wabush Area. Iron Ore Company of Canada, Montreal, P. Q.

Barnett, D. M.
1963 : Some aspects of deglaciation of the Indian House Lake area with particular reference to the former proglacial lakes. Unpublished M.Sc. thesis to be presented to McGill University. (in preparation).

Bérard, J.
1962 : Summary, Geological investigations of the area bordering Manicouagan and Moucalagane Lakes, Saguenay County. Que. Dept. of Nat. Res., Geol. Surv. Branch.

Canadian Javelin Ltd.
1959 : Exploration Report, Wabush Mountain. Canadian Javelin Ltd. 680 Fifth Avenue, New York.

Cooke, H. C.
1930 : Studies of the Physiography of the Canadian Shield, part II, Glacial depression and postglacial uplift. Roy. Soc. Can. Trans., ser. 3, v. 24, sect. IV, 51–87.

Crouse, R. A.
1954 : Mills–Dispute Lake Area. Iron Ore Company of Canada, Montreal, P.Q.

Daly, R. A.
1938 : Architecture of the Earth. New York, Appleton–Century. 211 pages.

DeGeer, G.
1912: A geochronology of the last 12,000 years. International Geol. Congress, 11th Session, Stockholm, 1910, 241–253.

Derbyshire, E.
1962 : The deglaciation of the Howells River valley and adjacent parts of the watershed region central Labrador. McGill Sub–Arctic Research Paper No. 14.

Douglas, M.V. and Drummond, R. N.
1953 : Glacial features of Ungava from air photographs. Roy. Soc. Can. Trans., ser. 3, v. 47, sect. 4, 11-16.

Douglas, M. V. and Drummond, R. N.
1955 : Map of the physiographic regions of Ungava-Labrador. Can. Geog. No. 5, 9-16.

Eckstrand, O. R.
1956 : Scott Bay - FlatRock Lake Area, Labrador. Iron Ore Company of Canada, Schefferville, P.Q.

Farrand, W. R. and Gajda, R. T.
1962 : Isobases on the Wisconsin Marine Limit. Geog. Bull. No. 17, 5-22.

Fischer, I.
1959 : The impact of the Ice Age on the present form of the geoid. J. Geophys. Res., v. 64, 85-87.

Flint, R. F.
1943 : Growth of the North American Ice Sheet During the Wisconsin Age. Geol. Soc. Am. Bull., v. 54, 325-362.

Flint, R. F.
1945 : Glacial Map of North America. Geol. Soc. Am., Special paper No. 60.

Flint, R. F.
1951 : Highland Centres of former glacial outflow in northeastern North America. Geol. Soc. Am. Bull., v. 62, 21-38.

Flint, R. F.
1957 : Glacial and Pleistocene Geology. New York, John Wiley, 533 pages.

Gastil, G. and Knowles, D. W.
1960 : Geology of the Wabush Lake area, South West Labrador and Eastern Quebec. Geol. Soc. Am. Bull., v. 71, 1243-1254.

Gilbert, G. K.
1898 : Recent Earth Movement in the Great Lakes Region. U.S.G.S. 18th Ann. Rep. (1896-97), part II, 601-647.

Gill, J. E., Bannerman, H. M. and Tolman, C.
1937 : Wapussakatoo Mountains, Labrador. Geol. Soc. Am. Bull., vol. 48, 567-586.

Gleeson, C. F.
1956 : The geology and mineralization of the Pegma Lake area in New Quebec. Unpublished M.Sc. thesis, McGill University.

Grayson, J. F.
1956 : The postglacial history of vegetation and climate in the Labrador-Quebec region as determined by palynology. Unpublished Ph.D. thesis, University of Michigan.

Hanson, G. F.
1943 : A contribution to experimental geology: The origin of eskers. Am. J. Sci., v. 241, 447-452.

Hare, F. K.
1959 : A Photo-Reconnaissance Survey of Labrador-Ungava. Geog. Branch Mem. No. 6.

Henderson, E. P.
1959 : A Glacial Study of Central Quebec-Labrador. Geol. Surv. Can. Bull., No. 50.

Ives, J. D.
1959a: Proposal for the adoption of a standard nomenclature. McGill Sub-Arctic Research Papers No. 6, appendix 11.

Ives, J. D.
1959b: Glacial drainage channels as indicators of late-glacial conditions in Labrador-Ungava. Cahiers de Géog. de Québec., No. 5, 57-72.

Ives, J. D.
1960a: Former Ice-dammed lakes and the deglaciation of the Middle Reaches of the George River, Labrador-Ungava. Geog. Bull., No. 14, 44-70.

Ives, J. D.
1960b: Glaciation and Deglaciation of the Helluva Lake area, Central Labrador-Ungava. Geog. Bull., No. 15, 46-64.

Ives, J. D.
1960c: The Deglaciation of Labrador-Ungava, An Outline. Cahiers de Géog. de Québec, No. 8, v. 4, 323-343.

Jackson, G.
1954 : Report on the Nip Lake - Reid Lake Area, Labrador. Iron Ore Company of Canada, Montreal, P.Q.

Kirby, R. P.
1961 : Movements of the ice in central Labrador-Ungava. Cahiers de Géog. de Québec, No. 10, 205-218.

Lee, H. A.
1959 : Eastward transport of glacial erratics from Hudson Bay. Geol. Soc. Am. Bull., v. 70, 219-222.

Løken, O.
1961 : Deglaciation and Postglacial Emergence of Northernmost Labrador. Unpublished Ph.D. thesis, McGill University.

Low, A. P.
1895 : Report on the explorations in the Labrador Peninsula, along Eastmain, Koksoak, Hamilton, Manicuagan and portions of other rivers in 1892-93-94-95. Geol. Surv. Can. Ann. Rept. 8, 1895, part L.

Low, A. P.
1900 : Report on an exploration of the East Coast of Hudson Bay from Cape Wolstenholme to the south end of James Bay. Geol. Surv. Can. Ann. Rept., New Series, v. 13, part D.

Manley, G.
1955 : A climatological survey of the retreat of the Laurentide ice-sheet. Am. J. Sci. v. 253, 256-273.

Mannerfelt, C. M.
1949 : Marginal drainage channels as indicators of the gradients of Quaternary ice sheets. Geog. Annaler, v. 31, no. 1-2, 194-199.

Matthew, E. M.
1961 : The Glacial Geomorphology and Deglacierization of the George River Basin and adjacent areas in Northern Quebec. Unpublished M.Sc. thesis, McGill University.

Matthews, B.
1962 : Glacial and Post-glacial geomorphology of the Sugluk-Wolstenholme area, northern Ungava. McGill Sub-Arctic Research Papers, No. 12, 17-46.

Mumtazuddin, M.
1958 : Geology of the area between Carol Lake and Wabush Lake, Labrador. Unpublished M.Sc. thesis, McGill University.

Murphy, D. L.
1959 : Preliminary Report on the Mount Wright area, Saguenay Electoral District. Geol. Surv. Branch, Dept. Mines, P.Q., P.R. No. 380.

Murphy, D. L.
1960 : Preliminary report on the Carheil and Le Gentilhomme Lake area, Saguenay Electoral District. Geol. Surv. Branch, Dept. Mines, P.Q., P.R. No. 412.

Neal, H. E.
1950 : Geology of the Dulay Lake - Wabush Lake Area, Labrador. Labrador Mining and Exploration Co. Ltd., Montreal.

Neal, H. E.
1951 : Wabush Lake - Shabogamo Lake Area, Labrador. Iron Ore Company of Canada, Montreal, P.Q.

Pegrum, P. H.
1936 : Geological Report on the Shabogamo Lake and Contact Lake Areas, Labrador. Labrador Mining and Exploration Co. Ltd., Montreal.

Prichard, H. H.
1911 : Through trackless Labrador. Sturgis and Walton, New York, 244 pages.

Slipp, R. P.
1952 : Geological Report, Margo Bay, Cavers, Swamp, Dodette, Point, Gabbro Lakes. Iron Ore Company of Canada, Montreal, P. Q.

Usher, J. L.
1953 : The Geology of Astray Lake Area. Iron Ore Company of Canada, Montreal, P. Q.

Wilson, J. T. et alia
1958 : Glacial Map of Canada. Geol. Assoc. of Canada, Toronto.

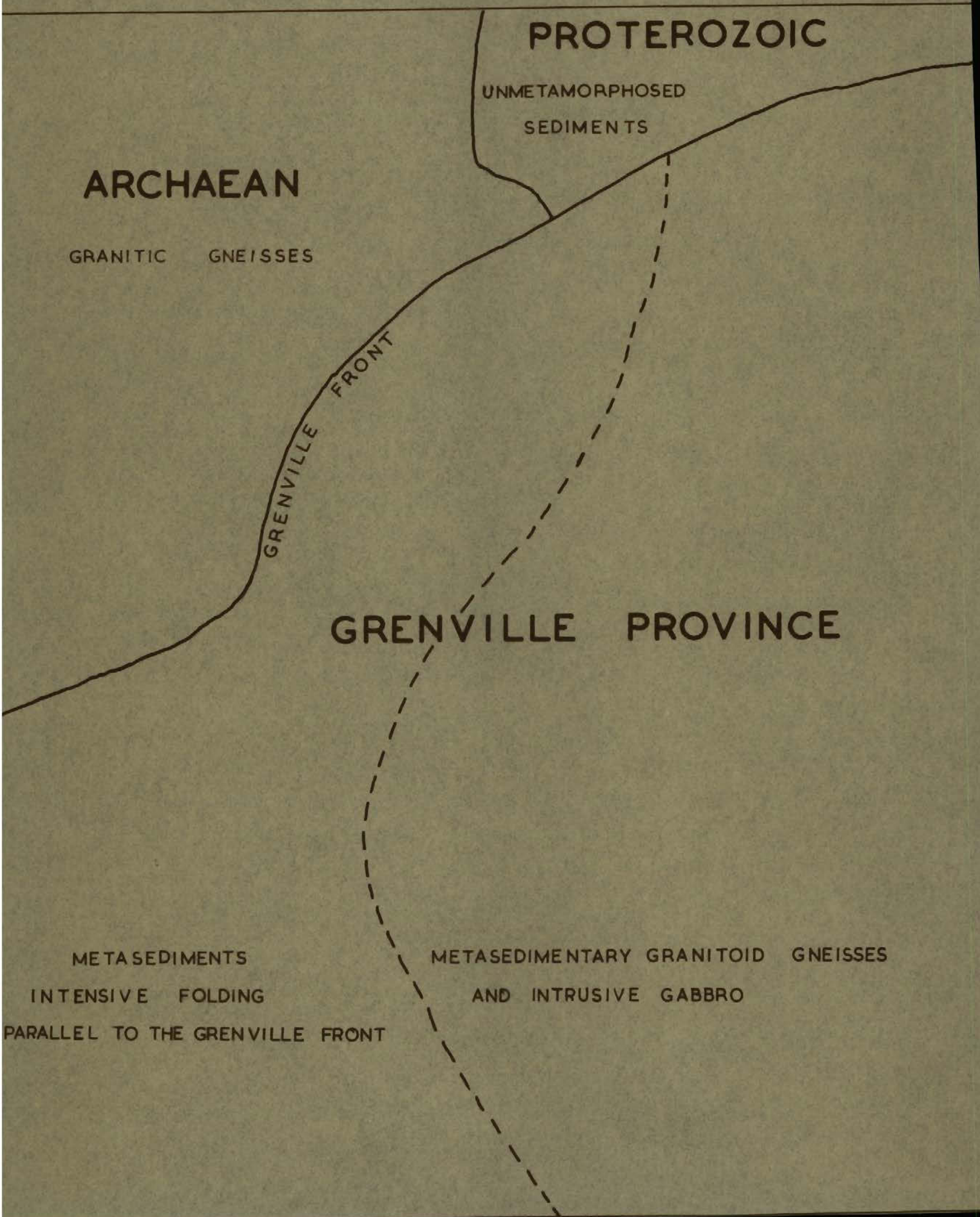
KEY TO MAP 2 "SOUTHWEST LABRADOR"

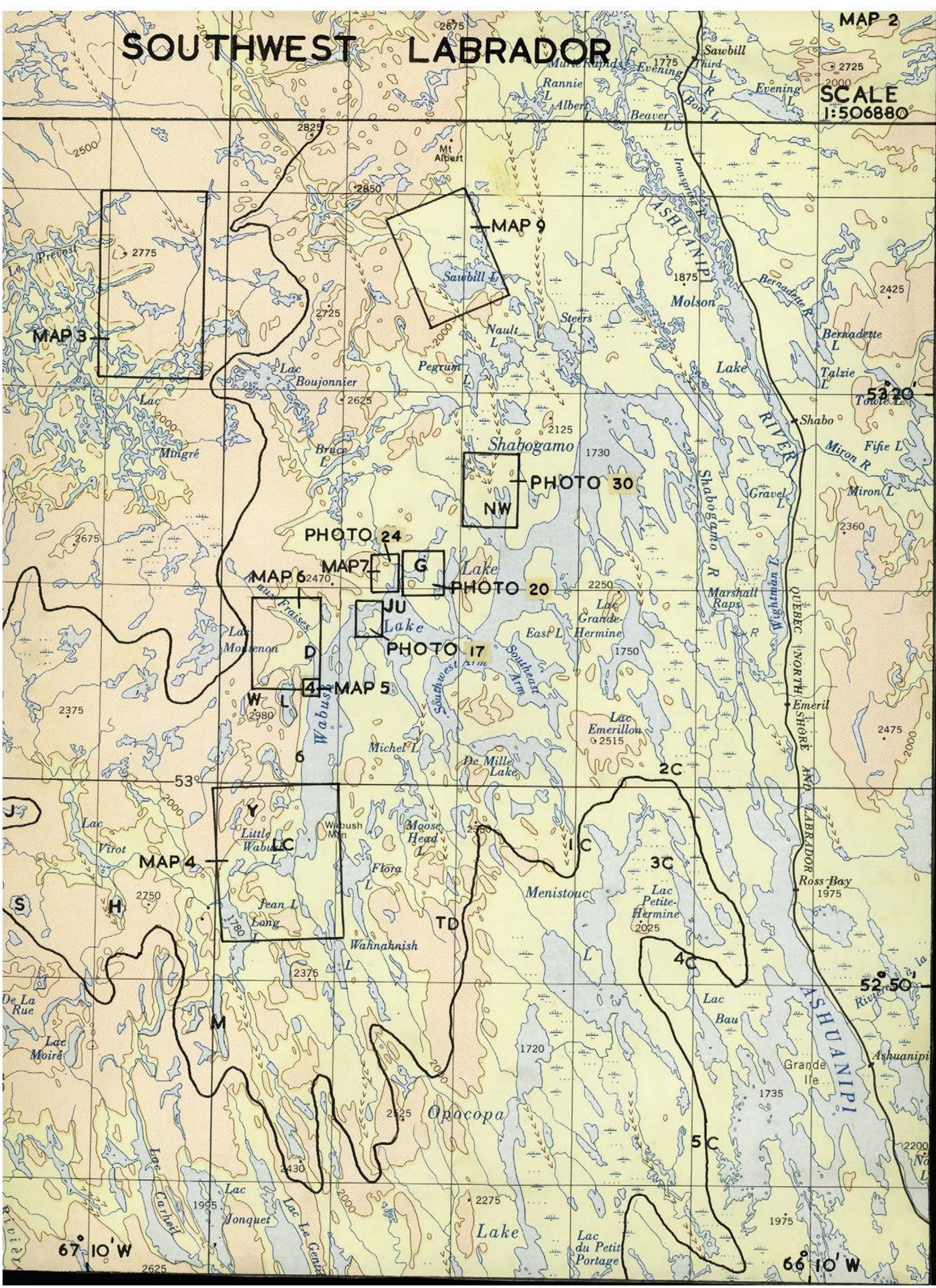
D	D'Aigle Bay.
G	Goethite Bay.
H	Huguette Lake.
J	Jackson Lake.
JU	Julienne Lake.
LC	Labrador City.
M	Mills Lake.
NW	Northwest Arm Shabogamo Lake.
S	Sudbury Lake.
W	Wabush Signal.
Y	Smoky Mountain.
L	Lorraine Lake.
4	Lorraine 4.
6	Wabush 6.
TD	Triangular Deposit.
1C	De Mille - Menistouc Col.
2C	Lac Emerillon - Menistouc Col.
3C	Ashuanipi Lake - Lac Petite-Hermine Col.
4C	Lac Bau - Lac Petite-Hermine Col.
5C	Ashuanipi Lake - Opocopa Lake Col.
———	Watershed.

OVERLAY I

GEOLOGICAL DIVISIONS

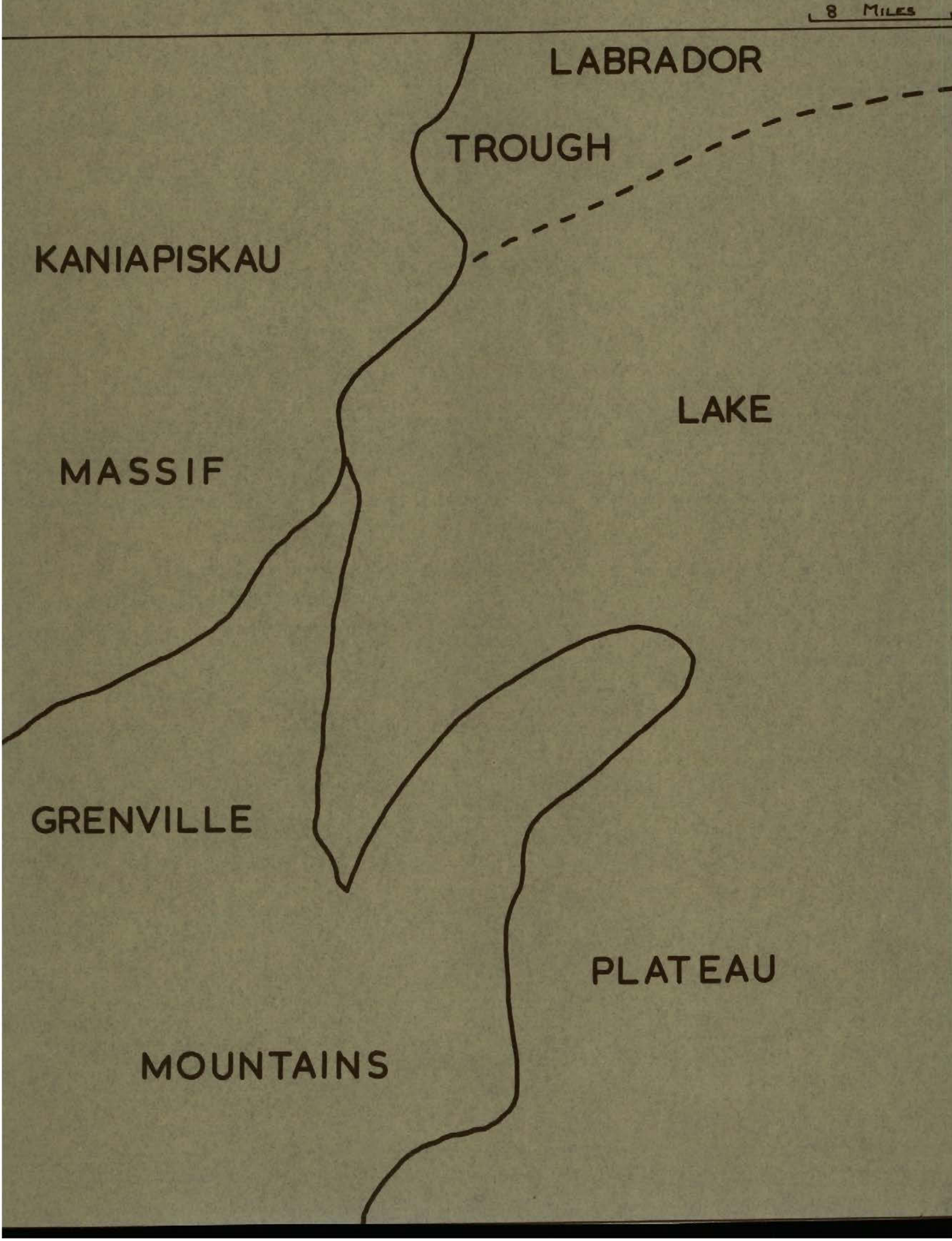
SCALE 8 MILES




SOUTHWEST LABRADOR
MAP 2
SCALE
1:506880
MAP 3
MAP 9
Sawbill L
PHOTO 30
NW
PHOTO 24
MAP7
G
PHOTO 20
MAP 6
JU
PHOTO 17
D
4
MAP 5
W
L
MAP 4
Y
LC
J
S
H
M
TD
2C
1C
3C
4C
5C
53°20'
52°50'
53°
67°10'W
66°10'W
Shabogamo
Lake
Wabush
Ashuanipi
River
Quebec North Shore and Labrador
Lac Boujonnier
Mingré
Lac Virot
Little Wabush L
Jean L
Long
Wahnahnish
Menistouc
Lac Petite-Hermine
Lac Bau
Grande Ile
Opocopa
Lac Carheil
Lac Jonquet
Lac du Petit Portage
Lac Emerillon
De Mille Lake
Michel L
Moose Head L
Flora L
Lac Grande-Hermine
East L
Southwest Arm
Southeast Arm
Marshall Raps
Wightman L
Gravel L
Miron L
Miron R
Fifie L
Towle L
Talzie L
Bernadette L
Bernadette R
Molson Lake
Shabo
Emeril
Ross Bay
Steers L
Nault L
Pegrum L
Bruce L
Mt Albert
Evening L
Sawbill
Beaver L
Ironstrike R
Lac Moiré
De La Rue
Lac Mossenon
Lac Prevost
2675
2725
2825
2500
2850
2775
2725
2625
2000
2125
1730
1875
2425
2360
2470
2250
1750
2475
2515
2375
2980
2750
1780
2375
2025
1720
1735
2525
2430
1995
2275
1975
2200
2625

OVERLAY 2

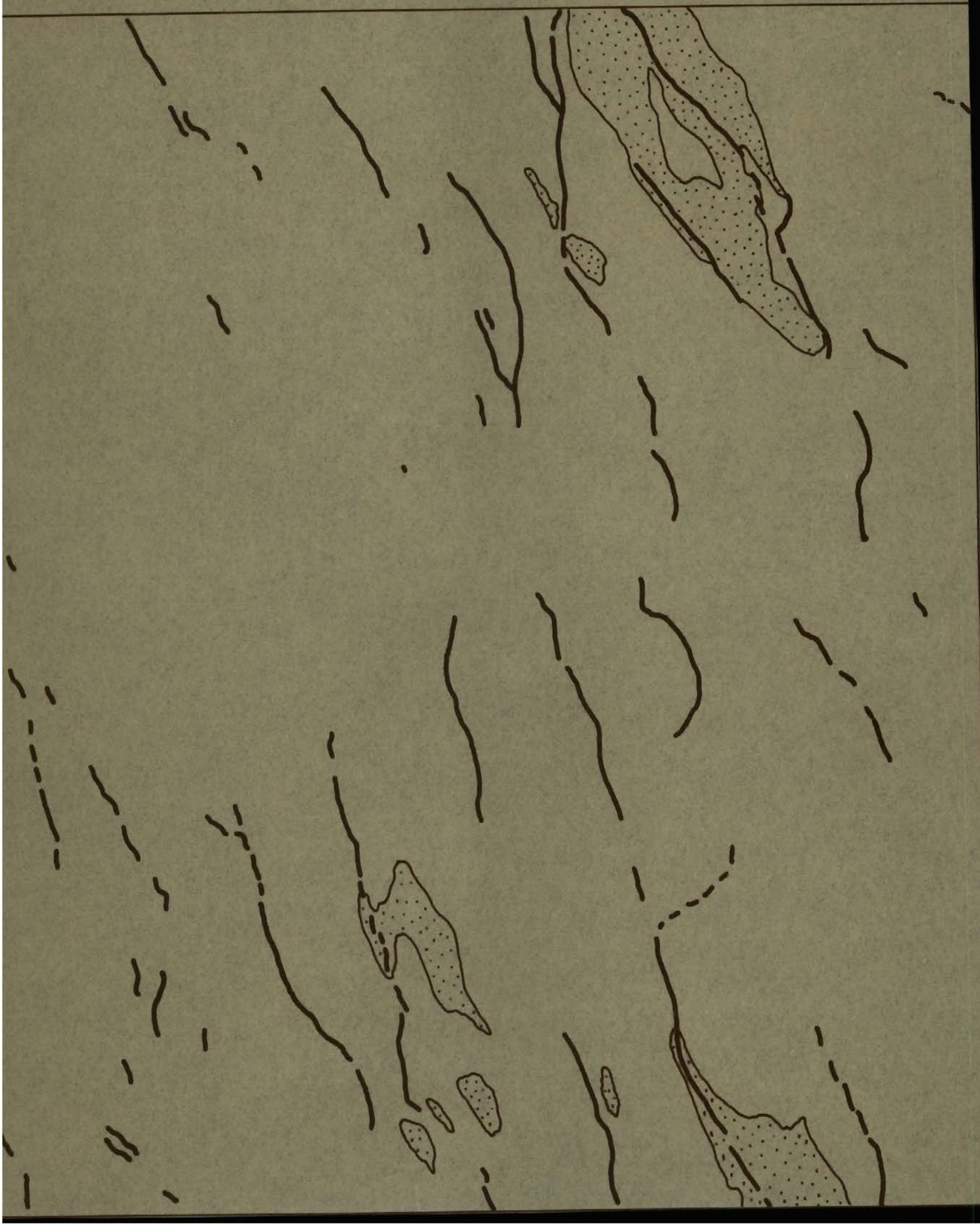
PHYSIOGRAPHIC DIVISIONS



OVERLAY

DISTRIBUTION OF MAJOR ESKER RIDGES AND RIPPLE TILL DEPOSITS 3

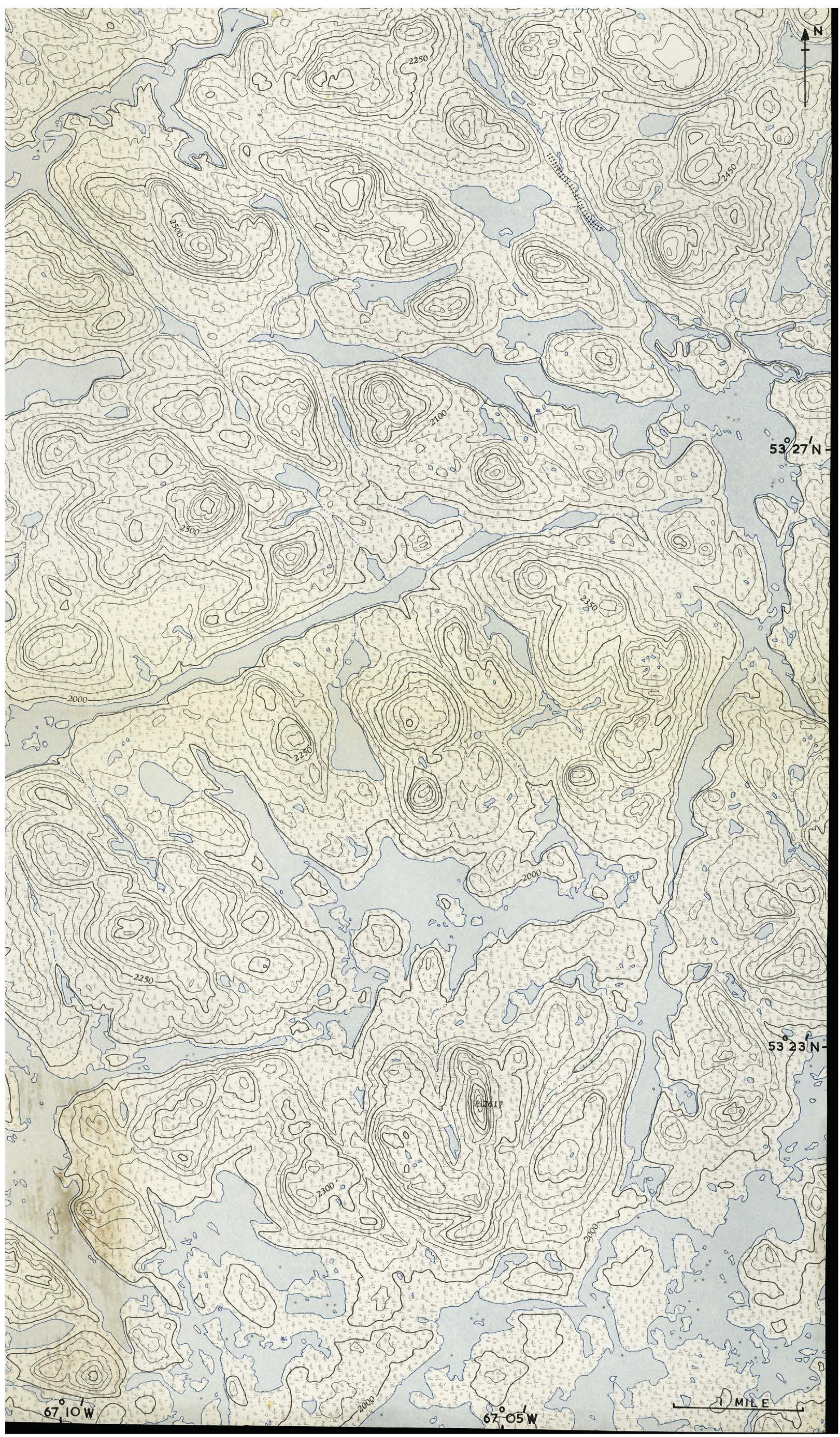
SCALE 8 MILES



KANIAPISKAU MASSIF

LAC LE PREVOST AREA

SCALE 1:50,000 MAP 3


N
2250
2450
2500
2100
53°27'N
2500
2350
2000
2250
2000
2250
53°23'N
2617
2300
2000
67°10'W
2000
67°05'W
1 MILE